EVALUATING THE UNINTENDED IMPACTS OF SOCIO-ECONOMIC AND DEMOGRAPHIC SHIFTS IN TRANSIT SERVED NEIGHBORHOODS ON MODE CHOICE AND EQUITY

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Abstract

EVALUATING THE UNINTENDED IMPACTS OF SOCIO-ECONOMIC AND DEMOGRAPHIC SHIFTS IN TRANSIT SERVED NEIGHBORHOODS ON MODE CHOICE AND EQUITY

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Today the use of transit-oriented development (TOD) is a common strategy for metropolitan areas endeavoring to advance the sustainable communities strategy. At the same time, urban areas in America are experiencing rising energy prices and new geographies of employment, poverty, and wealth. Furthermore, the Millennial generation, and some Baby boomers are changing their residential preference from the suburbs to the central city. These modifications in the urban economy and residential preferences are likely to intensify competition for housing in the central city. Increased demand for housing generates high rents, which often results in the displacement of low-income, transit-dependent population. Consequently, the effectiveness of transit-oriented development is compromised as new affluent households increase vehicle use for home-based trips. Using 1990 and 2010 census data, this research investigated the unintended consequences of TOD policy on mode choice and equitable accessibility in block groups within one mile radius of rail stations in six metropolitan statistical areas. The research employed geographic information systems (GIS) and multivariate regression to analyze

the relationship between socio-economic and demographic change in transit-oriented development and associated effects on mode choice for work commute. The findings reveal that while driving declined between 1990 - 2010, transit use for work commute increased in most metropolitan areas in the study. In addition, transit-oriented developments are associated with a high number of affluent households, college graduates, and White-collar employees, when compared with block groups with no transit-oriented development. However, the percentage of foreign-born residents have increased in transit-oriented development, while the percentage of Black and White population have declined. In addition, block groups within one mile of transit stations show nearly similar levels of transit use and driving when compared block groups within the half mile radius. These findings have significant implications on the long term effectiveness of TOD policy.

Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction

Contemporary urban planners acknowledge that the location of housing, transportation networks, and activity centers cannot be planned separately if sustainable growth is to be accomplished within the modern metropolis (Cervero, Ferrell, and Murphy, 2002; Hemily, 2004; Rose, 2011; Cervero and Sullivan, 2011).

In support of this concept, the Environmental Protection Agency (EPA) and the Federal Transit Administration (FTA) recommend integrated land-use designs and mixed-use developments as an effective approach to supporting sustainable urban growth and development (Cao, Mokhtarian, and Handy, 2009a). Under the guidance of smart growth policy, urban planners are progressively using Transit-Oriented Development (TOD) to promote efficient use of land, advance economic development and improve equitable access to affordable housing and public transportation (Hemily, 2004). Currently, several states including California, Texas, Oregon, New Jersey, Virginia, and Florida have created Regional Transportation Plans (RTP) to leverage the advantages of TOD for purposes of promoting alternative mobility options, control urban sprawl, reduce greenhouse gas emissions, and excess commuting by car. Reconnect America reported that by 2011, there were approximately 643 planned new fixed-guideway projects in 106 metropolitan regions. Most of the areas planning new projects have experienced an upsurge in interest for residential, retail and commercial space in transit served neighborhoods (Ratner and Goetz, 2013).

Transportation studies report that at the peak of the light rail construction boom, transit agencies invested over $25 billion in public transport infrastructure in 14 major cities across the United States (Baum-Snow and Kahn, 2005). A significant portion of this capital was directed toward the expansion of light rail lines and improvement of station areas using TOD. Despite these investments, the percentage of workers using public transit dropped from 12% in 1980 to approximately 5% in 2010 (United States Census, 2010). Likewise, the National Household Travel Survey (NHTS) publications (Santos, McGuckin, Nakamoto, Gray, and Liss, 2011; Bueheler and Pucher, 2012) reported that public transportation accounted for less than 15% of the commuter transportation market. Likewise, the American Public Transportation Association (APTA, 2011) noted that although ridership had grown by 34% since 1995, transit share of the commuter market accounts for less than 6% of mode share; yet, APTA (2012), data found that 36% (10 out of 28) new transit systems had experienced declining ridership since the year 2000 (Governing, 2013). Interestingly enough, the decline occurred some of the newest commuter lines, including Dallas-Fort Worth, which registered a 7.7% percent drop in transit use. Moreover, Kneebone and Berube, (2013, pp 59 -61), found that 77 % of low income suburban neighborhoods have at least one transit stop; yet the typical resident can only reach 25% of the jobs in the metropolitan area within 90 minutes. Overall, in the largest MSAs, 700,000 impoverished suburban households do not have a car and are not served by public transportation of any kind.

These reports underscore a troubling trend that suggests that despite the investment in TOD, public transportation is still not the preferred choice for commuting

among average Americans (American Community Survey, 2010). In addition, the people who need transit most have little or no access to public transportation hubs; and even if they do the services do no connect them to activity centers for employment. Furthermore, vehicle use for work trips still dominates the commuter market, evidenced by over 75% of workers making a daily commute by car, in the United States (ACS, 2010; Santos, et al., 2011; Bueheler and Pucher, 2012).

When tracing the rise of the commute by car, Levy (2009, p. 225) found that whereas 133 million people, owned 25 million cars in the United States in 1945, by 2005, over 295 million people owned 189 million cars. This implies that whereas the population had grown by a factor of 2.2 car ownership increase by greater factor of 7.5. This exponential increase of vehicles per capita means that driving has increased in the country despite transit investments that have provided alternative transportation. In addition, corresponding data from the Federal Highway Administration (FHWA) reveals that vehicle miles traveled (VMT) has been on the rise through the 1990s even though TOD was gaining popularity as a policy (Figure 1-1). The weak growth in public transport and continual rise in VMT raises concerns because several metropolitan areas are showing interest in using TOD as the solution to their traffic problems. Figure 1-2 illustrates that driving in the United States is the highest among several developed nations.

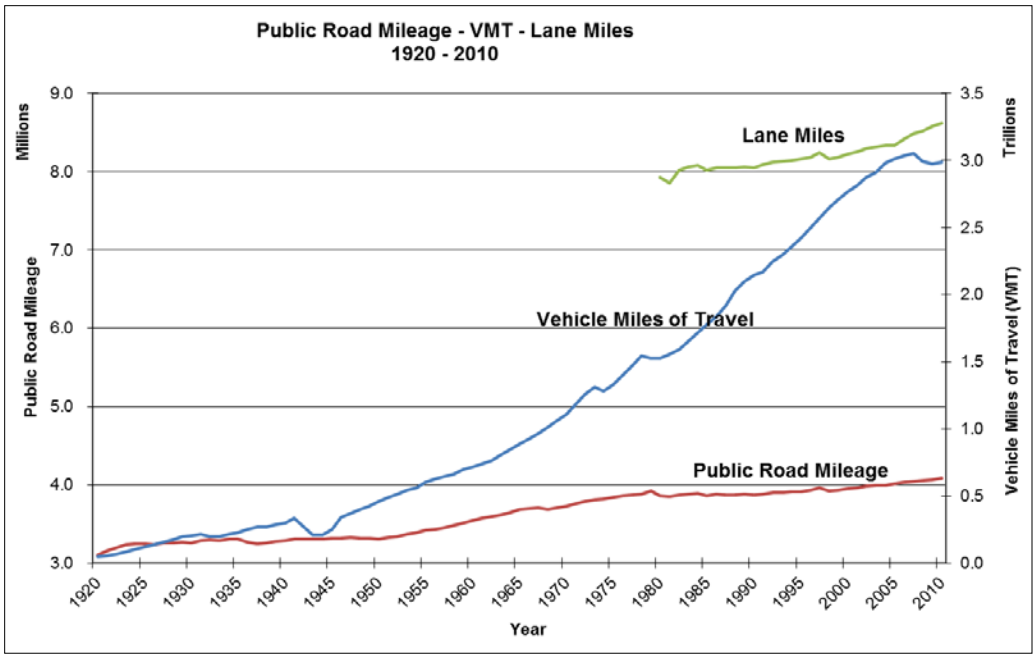

Figure 1-1 Growth of lane miles vehicle miles traveled (FHWA, 2012)

The low market share for public transportation is concerning in an era when rising costs of living and energy prices are expected to motivate commuters to use cheaper modes of transportation. Certainly, one can counter that during the economic recession commuters were relying more on public transportation (APTA, 2012). However, scholars (Tumlin, 2011; Ortuzar and Willumsen, 2011) point out that evaluating the success of a transportation system should incorporate both ridership and mode choice metrics. In fact, Ortuzar and Willumsen (2011) emphasize that mode choice is a key aspect of travel demand analysis because it enables planners to evaluate how much capacity is freed by using alternative modes. In agreement with these recommendations, this research uses mode choice data to investigate the success of the TOD policy in eight states.

The research proposes that local government efforts to develop sustainable transportation systems are in jeopardy due to current demographic and socio-economic

changes in transit served neighborhoods and the static nature of the policy (Pollack, Bluestone, and Billingham, 2010). Demographic trends such as social upgrading through gentrification can potentially lead to displacement and exclude low-income transit-dependent population (TDP) from access to transit (Chapple, Hickey, and Rao, 2007; Pollack et al., 2010).

While modern planners and new urbanists continue to embrace the TOD concept, it appears that the policy has little or no mitigation strategy for long-term demographic shifts within the communities TOD serves. The absence of a specific long term policy could allow occurrence of unintended outcomes such as gentrification and impede transit usage. In addition, the weak growth in mode share could be that transit-oriented development has become *development-oriented*, rather than *community-oriented*. TOD policy seems to incorporate economy and efficiency aspect of sustainability (Campbell, 1996) while doing little for equity. Yet, scholars have continually pointed out that an egalitarian policy that overlooks societal trends can unintentionally become deleterious to communities it seeks to serve (Belzer et al., 2006; Jackson, 1980; Schill and Wachter, 1995; Pollack et al., 2010). Yet, the application of TOD to advance the Sustainable Communities Strategy (SCS) seems to rely mainly on the design of the built environment. The static nature of the built environment implies that the policy cannot respond quickly

enough to socio-economic and demographic changes in communities they seek to serve.

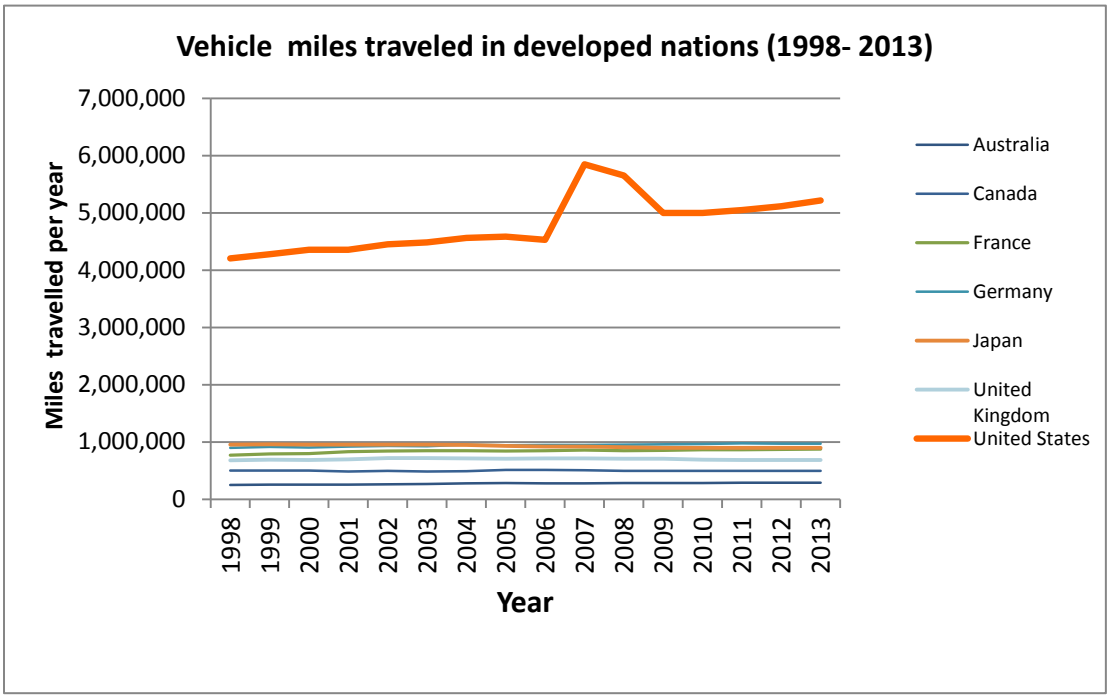

Figure 1-2 Vehicle miles travelled in USA and selected developed countries (ITF 2014)

However, there are complexities involved in the appropriate application of the built environment, which makes it challenging to dismiss the approach. This is because planning for sustainability reflects the interdisciplinary nature of transportation planning which normally incorporates diverse views from planners, architects, engineers, and social scientists. Transportation engineers and architects are predominantly predisposed to Le Corbusier's (1964), ideology on using the physical design and the built environment to improve quality of life (Batty and Marshall, 2009; Noble, 1999). However, if one thinks of planning spatially, then solutions are generally directed toward making space (Perry, 2003). This implies that the smart growth policies might continue

relying on built environment interventions that do not respond fast enough to shifts in demographic and cultural trends.

On the other hand, social scientists expect that community planning should also incorporate both social and spatial engineering to foster social equality and spatial justice (Noble, 1999). Therefore, design of physical space should progress toward improving quality of life and social interactions in addition to equitable accessibility for a diverse group of people. Informed by such considerations of spatial and societal equity, this research frames the study in terms of people-based versus place-based strategies in developing sustainable transportation policy. This concept originates from theoretical underpinnings of spatial justice, critical of a planning approach that often resorts to *spatial fix* while overlooking endemic issues in society. These policies employ the politically correct language of equity, but sometimes advance policy that could produce spatial and social imbalances (Harvey, 1976 and 1997; Sanchez and Brennan, 2007; Soja, 2010; Marcuse, 2009). Of particular interest is the investigation of the systemic displacement and exclusion of the urban poor from public goods. Current research suggests that gentrification in transit zones can be linked to TODs with upscale homes mostly affordable for the middle class, who typically own more than one car. The externalities of expensive housing includes displacement of low-income , carless households, accompanied by more driving and less transit use for commuting (Dominie, 2012; Kahn, 2007; Pollack et al., 2010).

Thus, in the last decade, there has been a growing body of literature investigating the causal links between demographic trends in TOD census geographies and the

occurrence of gentrification (e.g. Renne 2005; Belzer et al., 2006; Danyluk and Ley, 2007; Dominie, 2012; Kahn 2007; Kushto and Schofer, 2008; Lin, 2002; Pollack et al., 2010). These studies form the basis and motivation for this research. The research builds upon the previous studies by evaluating evidence of gentrification in TOD including accompanying impacts on equity and mode choice. The research uses 1990 and 2010 census data from six metropolitan areas to conduct a comprehensive analysis on demographic change and unintended outcomes.

1.1 Current Changes in Urban America

The significance of this research arises from concerns regarding the current changes urban America comprising the rise of the Millennial generation, new geographies of wealth, and suburbanization of poverty (Pew Research Center, 2010; Kneebone and Carr, 2010; Tomer, 2011; Kneebone and Berube; 2013). This research proposes that these changes have significant impact on the effectiveness of smart growth policy in the future development of the millennial metropolis.

During the twentieth century the American dream was defined (among other things) by owning a suburban home and a number of family cars (Renne, 2005). However, the emerging Millennial generation[1] has increasingly demonstrated different residential and transportation preferences compared to their Baby boomer predecessors. These preferences include among many other things a willingness to reside in ethnically diverse neighborhoods of the central city served by public transportation (Ryan, 2007; Kalita and Whelan, 2011; Berkley and Gallick, 2013).

[1] Born between 1980 - 2002 (Pew Research, 2010)

The changes in housing and transportation preferences imply that the policies and paradigms that have hitherto guided urban planners need to adjust and accommodate the new patterns of housing and employment locations. Policies that supported suburban lifestyles and long commutes are becoming anachronistic with upcoming lifestyles of the Millennial City (Ryan, 2007; Pew Research Center, 2010; Kalita and Whelan, 2011; Berkley and Gulick, 2013).

In the mid-twentieth century, Baby boomers and industrial workers migrated to the suburbs to escape the (perception of) deteriorating conditions in the central city (Massey and Denton, 1993; Crowder and South, 2008). However, the diverse Millennials working in the information economy are more likely to choose trendy new urban neighborhoods in the central city that are served by public transportation networks (Davis, Dutzik, and Baxandall, 2012; Florida, 2012; Ryan, 2007). Currently the Millennial population number approximately 80 million, while the Baby boomer population is at 70 million (Pew Research Center, [PRC] 2010; Council of Economic Advisors, 2014). The growing numbers of the millennial generation implies they will incur significant impact on the urban fabric by changing urban trends (suburbs, gated communities, and commute by car) that the Baby boomers created. Moreover, when studying Millennial trends and changes, Moretti (2012) noted that economies and work culture in urban America had changed the housing preferences for workers employed by technology startups.

The shift from the industrial age to the information economy has led to a concentration firms in digital industry within the central city (Florida, 2012; Fainstein,

2003). These firms cluster in places like San Jose and San Francisco because of the available pool of young talent in universities including Stanford and Berkeley. Some knowledge workers in the creative economy now prefer the revitalized central-city neighborhoods offering trendy lifestyles supported by walkable streets in bohemian, artsy neighborhoods (Hutton, 2004; Lund, Cervero, and Wilson, 2010; Florida, 2012; Ryan, 2007). These areas include places such as Castro Valley in San Francisco, Brooklyn in New York, and Bishop Arts in Dallas. However, this sudden appetite for a bohemian lifestyle (Florida, 2012) and urban living creates high demand for new central city housing, usually oriented to public transportation (Pollack et al., 2010).

These trends, however, do not come without accompanying externalities. Today, boom cities such as San Francisco have experienced an uptick in homeless population that could be am outcome of dot com millionaires spiking the cost of rentals (Fujioka, 2011). Moreover, the Harvard Joint Center for Housing Studies (Fernald, 2011), proposes that the high demand for central city housing and rising costs of rents, appear to be a product of the creative economy in places such as San Francisco.

As one writer in *The New Yorker Magazine* recently quipped;

> "White men sporting T-shirts with tech-company logos are, in some ways, the perfect avatars of the incoming population that has transformed the city's (San Francisco's) demographics. They are the wealthy, predominantly white tech employees who have been pouring into the formerly working-class immigrant neighborhoods, driving up the cost of housing, and giving the *property owners* increased incentives to evict longtime tenants from rent-controlled apartments. Between 1990 and 2011, the Mission District lost fourteen hundred Latino households while gaining twenty-nine hundred white *households*; in the same period, the black population of the city was cut in half." (Wong, 2014)

Ultimately, these shifts in demographic characteristics can result in social upgrading which impedes growth in transit by pricing out low-income captive riders (Chapple et al., 2007; Pollack et al., 2010; Dominie, 2012). It also seems that the next generation of workers prefer the options offered by alternative mobility (e.g., biking or walking), though not necessarily inclined to use public transport as the primary mode of transportation (Ryan, 2007).To mitigate escalating costs of housing and displacement of low income groups, local governments sometimes provide incentives to developers to boost supply of affordable housing in transit zones Federal Transit Administration (Wise and Scire, 2009). Yet, private developers tend to avoid certain low-income neighborhoods because of perceived risk. These neighborhoods are often associated with high crime rates, and neighborhood decline that render these places unattractive to developers (Liggett, Loukaitou-Sideris, and Iseki, 2003).

Dunphy, Cervero, Dock, McAvey, and Porter (2005, p.14) acknowledge that transit projects may have focused largely on *briefcase-carrying*, riders rather than transit-dependent population. As such, transit lines tend to link middle-class neighborhoods to centers of employment and shopping centers. Yet, homes in middle income

neighborhoods are too expensive for some low-income transit-dependent groups. Therefore some communities in low-income neighborhoods might be excluded from accessing faster and reliable transit which can connect them to jobs in the suburbs and other areas of the MSA. Some may argue that these communities do have bus connections, however this option is rather slow and more inconvenient when trying to get to work on time during rush hour. In fact, Kneebone and Berube (2013, p. 59 - 60) and Tomer (2011) found that between 2000 -2010 many poor households located to the suburbs. However, most of these locations have inadequate connections to public transportation. Furthermore, over 70% of low-income households living in transit served neighborhoods have access to only 25% of the jobs in the metropolitan area.

Transportation planners expect and prefer that the majority of individuals residing close to transit stations are discretionary riders (Litman, 2011). Discretionary riders are those who generally use transit even though they have the option of driving; on the other hand captive riders may drop the transit option once their status improves. Captive riders include individuals who are too poor, too young or to purchase a car or qualify for a driver's license. Captive riders also include individuals whose physical disability prevents them from driving.

Sixty percent of the captive riders (TDP) consists of minorities living within 0.5 mile (walkable distance) of a public transit station (Pollack et al., 2010). In addition, the American Community Survey (ACS, 2010) reported that the Non-Hispanic Black population currently have the highest rate of public transportation usage, at 11.5%, compared with Non-Hispanic White population, at 3.2%. In addition, ridership among

recent and first generation immigrants (10%) more than doubles the ridership levels of the local born population (4%).

Accessibility to public transit could be hindered as TOD becomes gentrified, leading to displacement of transit-dependent population. Scholars maintain that the incidence of gentrification results in overrepresentation of affluent residents with a high propensity to use motor vehicles (Pollack et al., 2010). In addition, the theoretical underpinnings of travel demand analysis is that as income increases, individuals place a high premium on comfort and privacy for travel in addition to owning more than one car (Papacostas and Prevedouros, 2007). This motivates them to drive more when compared with low-income individuals with no car.

This assertion implies that affluent new residents may not use transit as much as the previous residents. Moreover, in a disaggregate study of TOD in the San Francisco Bay area, Lund (2006) found that new residents who had changed both work and residential locations indicate a variety of mode changes: 11.5% switched from automobile to rail transit, but an almost equal amount switched from transit to automobile. This finding once again suggests that residents attracted to TOD might not continue to use transit as the years go by. This has significant implication for long-term effectiveness of TOD policy.

In summary, the new demand for transit-oriented living ensuing from demographic shifts in metropolitan areas might encourage unintended consequences such as displacement of low income and transit-dependent population These concerns have

motivated this research to investigate the nature of demographic shifts and effects on mode choice within TOD in six metropolitan statistical areas (MSA).

1.2 The Problem

It is important to note that this research is neither taking a stance against smart growth policy nor the use of TOD. Rather, the research seeks to shift attention from overemphasis on the built environment to focus on long term demographic changes within transit zones. While there is wide recognition that TOD policy has many rewards, previous research has largely reported mixed findings on the benefits of TOD to a diverse community. Scholars writing about the rewards of TOD (e.g., Cervero and Kockelman, 1997; Cervero et al., 2002; Ewing and Cervero, 2010; Cervero and Sullivan, 2011; Lund et al., 2010; Smith and Gihring, 2006) emphasize the use of density, design, and distance to encourage public transportation use and reduce vehicle miles traveled. In addition, these scholars rightly promote ancillary benefits of TOD such as appreciation of real estate values and revalorization of public space.

However, a second contingent of skeptical scholars often questions the egalitarianism and effectiveness of TOD scholars (e.g., Crane and Crepeau, 1998; Belzer et al., 2006; Chapple et al., 2007; Danyluk and Ley, 2007; Kahn, 2007; Pollack et al., 2010; Fujioka 2011; Dominie, 2012). These scholars argue that TOD benefits, including appreciation of housing values and the redevelopment of public space, potentially alienates low-income groups. The studies focus on gentrification, housing affordability, and social equity, but often stop short of in-depth analysis of the relationship between rising costs of housing, gentrification, and declining transit use and increased driving.

In the last decade, studies on transportation and gentrification increasingly find that the number of TOD residents saying they do not use public transportation is surprisingly high (Lin, 2002; Kahn, 2007; Pollack et al., 2010; Dominie, 2012). Similarly in Canada, researchers discovered a negative correlation between transit use and demographic change in TOD (Danyluk and Ley, 2007). These trends are paradoxical given the prevailing thought (in transit-friendly cities) that demographic change in TOD block groups based on self-selection should increase the number of residents who patronize public means.

However, some scholars (e.g. Pollack et al., 2010) find that a significantly high number of new residents are not in TOD housing for the sole purpose of advancing alternative mobility. Newer residents seem to prefer the idea of living in a central city with the option of transit, but do not depend on buses or trains as a primary means of transportation.

Studies investigating the relationship between demographic change and mode choice have varied in methodology and data sources, which render most findings contingent upon respective research. These gaps in previous research offer opportunities for additional investigation with improved methods of data extraction and analysis. The areas that require further improvement include the use of narrower geographic boundaries, incorporation of new variables, normalized census data and analyzing the data beyond descriptive statistics. The next paragraphs explore and explain in brief how this research intends to build upon and improve previous efforts by respected researchers.

First, most studies employ census tracts and zip code boundaries which this research considers too broad for neighborhood-level research. Instead, the research uses block group data that offers the narrowest geographical boundary available from the Census Bureau. In addition, previous studies focused on one state or region (e.g., Chapple, 2009; Dominie, 2012; Kushto and Schofer, 2008; Lin, 2002) or simply compared changes in the TOD to the rest of the MSA (e.g., Kahn, 2007; Renne, 2005). Comparing MSA to TOD can magnify differences because of disparities in sample size, geographic boundaries, and treatment with transit infrastructure. This research improves upon previous work by comparing stations with TOD to those without TOD (non-TOD).

Some studies including Lin, (2002), Pollack et al., (2010) and Renne, (2005) used archival census data from 1980 to 2000. This approach presents an issue with regard to maturity of neighborhoods. Except for transit systems in older cities in such as Chicago, San Francisco, and New York, TOD as a policy intervention only began to gain ground in the 1990s (Calthorpe, 1993; Cervero et al., 2004; Utter, 2009). Records from relatively newer transit agencies such as Dallas Area Rapid Transit (DART), Florida's Metrorail, and New Jersey Transit (NJT) reveal that most TOD begun operations between 1990 and 2005. Therefore, any research investigating gentrification with census data from 1980 to 2000 may have conducted the analysis before adequate maturation of neighborhood (Renne, 2005, p.4-6).

Further, the studies did not employ normalized census boundaries (e.g., Pollack et al., 2010) or advanced tools available in GIS software to select block groups within the study area. This approach can produce sampling errors because boundaries change with

every decennial census (ACS, 2010). Finally, most studies also used descriptive statistics, but did not engage methods identifying causal relationships and predictive interactions. This research uses normalized boundaries and goes beyond descriptive statistics, to provide a more granular analysis of the study area.

1.3 Research Goals and Objectives

The objective of this research is to investigate the relationship between vehicle use, public transportation, and gentrification in block groups within 0.5 and 0.5-1.0 mile radius of TOD and non-TOD rail stations in the following six metropolitan statistical areas (MSA):

1. San Francisco-Oakland-Fremont (Bay Area Rapid Transit [BART]),
2. Dallas-Fort Worth-Arlington (Dallas Area Rapid Transit [DART])
3. Washington DC-Arlington-Alexandria – West Virginia (Washington Metropolitan Area Transportation Agency [WMATA])
4. Miami-Fort Lauderdale-Pompano Beach (Metrorail)
5. New York- Northern New Jersey- Long Island (New Jersey Transit [NJT])
6. Portland-Vancouver-Hillsboro, (Tri-County Metropolitan Transportation District of Oregon [TriMet])

The research uses demographic and socio-economic data from the 1990 and 2010 censuses to conduct the study. This information was processed with ArcGIS spatial analyst to extract data from the study area. Next, the research will analyze the data with SPSS statistical software to develop with descriptive statistics, t-tests, correlations, and

regression models. Based on the findings, the research will offer policy recommendations and directions for future research.

The overall objective of this research is to highlight the impacts of socio-economic and demographic changes on TOD policy. The results can improve our knowledge concerning the impacts of neighborhood change on housing, transportation, and sustainability policies. This will help planners design more dynamic polices that adapt to the ever-changing millennial metropolis.

1.3.1 Research Questions

In order to examine the abovementioned issues, this research will explore the following questions:

1. How has the socio-economic and demographic character of communities changed in block groups, which are within 0.5 mile and 0.5-1.0 mile of TOD and non-TOD stations?
2. Is the presence of TOD interrelated with the occurrence of gentrification in block groups within 0.5 and 0.5-1.0 mile of transit stations?
3. How have changes in socio-economic and demographic factors influenced mode choice in block groups within 0.5 and 0.5-1.0 mile radius of TOD and non-TOD stations?
4. What are the differences between socio-demographic characteristics of communities living in TOD compared with communities in non-TOD; further, what differences exist between communities within 0.5 miles of TOD compared with communities living within 0.5-1.0 mile radius?

Using the above questions, the research evaluates the overall effectiveness of TOD policy in supporting a sustainable community. The research also investigates the occurrence of gentrification in TOD block groups with the goal of prescribing policy alternatives to mitigate the potential exclusion of low-income transit-dependent population.

1.4 Significance

Demographic changes in urban America, such as those chronicled in the "*The suburbanization of poverty: Trends in metropolitan America, 2000 - 2008*" (Kneebone and Carr, 2010), suggest that the migration of the new middle class and Millennials to the central city increases demand for housing in trendy, revitalized neighborhoods that are oriented to public transport (Davis et al., 2012; Garret and Taylor, 1999; Haas, Makarewicz, Benedict, Sanchez, and Dawkins, 2006). Some of these urban migrants are of Generation X who are returning to the central city to reinvent themselves; others are conscientious households transitioning toward a simple, sustainable lifestyle by reducing per capita driving, energy use, and cost of living (Kneebone and Carr, 2010; Tomer, Kneebone, Puentes, and Berube, 2011).

However, the relocation from suburb to central city by the middle class and Millennials could increase competition for central city housing. The result is potential displacement of indigent, transit-dependent population living in neighborhoods within the urban core. This creates new geographies of wealth and concentration of poverty leading social and spatial imbalance (Kneebone and Berube, 2013).

In support of the aforementioned, presenters of "*The Market Place"*, a program on National Public Radio (NPR), mentioned that in Virginia, the average prices for homes near transit was almost 10% higher compared with similar property in the suburbs (NPR, 2011). Housing experts speaking on *The Market Place* predicted that the next housing boom would be in transit-oriented neighborhoods because of the promise of lower commuting costs. Increasing demand for transit-oriented living often results in higher cost of housing that may eventually result in the displacement of transit-dependent population. Yet scholars have noted that while the geography of wealth and employment seems to be shifting from suburbs to the central city, not many are asking how this development is affecting accessibility to public transport.

Consequently, this research aims to develop a set of policy recommendations that can mitigate unintended consequences of TOD policy. The research offer policies that provide an optimal balance between economic development and social equity. The research proposes, *inter alia*, that transportation policy should encourage a variety of housing affordable to various income levels, because diversity in transit zones can potentially increase and sustain much needed transit usage (Belzer et al., 2006; Holzer, Quigley, and Raphael, 2002).

Thus, the contribution of this research provides extra insight on demographic change in transit served neighborhoods. These findings could assist transportation planners in forecasting future impact of demographic change on transit use. Overall, the research supports the sustainable communities' strategy to curb greenhouse gas emissions and wasteful commuting by evaluating the efficacy of current policies.

1.5 Content Summary

Chapter 1 discussed the purpose, goal, and rationale behind this research. The chapter also presented an overview and background narrative on the research problem, and its significance. The goals of Chapter 1 were to impress upon the reader why there is need to be concerned about the direction TOD is taking, and to provide an overview of gaps in previous research and need to close these gaps.

Chapter 2, contains the core literature review and background analysis on the historical development of TOD and government policies that have supported TOD growth. The chapter opens with definitions of theoretical and conceptual frameworks in addition to TOD. The subsequent sections detail an abbreviated history of policies and programs used by the federal and local governments to promote the sustainable urban development using smart growth. Next, the research outlines benefits of TOD and presents a discussion of possible unintended outcomes linked to the benefits. The chapter concludes with a review of previous studies on gentrification and TOD. The review identifies gaps in previous research, which provides the justification for further research. This summary segues into the next chapter discussing this research's approach and methods to covering the gaps in previous studies.

Chapter 3 contains the methods section of the research. The chapter opens with a discussion on the propositions, hypothesis, variables, and models and relevant justifications for the use of each variable. Next, is a discussion on the study area and the unit of analysis. This section includes a description of how the research selected the

MSAs in the study including the methods of classifying stations and regions. The chapter concludes with a discussion on data extraction, compilation, and processing for analysis.

Chapter 4 opens the presentation of findings and analysis with descriptive statistics comparing socio-economic and demographic characteristics of the MSA, TOD and non-TOD stations. The chapter presents an overview of the findings regarding demographic change in the study areas using graphs, t-tests and correlation coefficients. The objective is to provide supporting evidence including explanations of the research propositions and hypothesis. The chapter ends with conclusions on findings, and decisions to accept or reject the null hypothesis based on the t-tests.

Next, Chapter 5 uses regression models to analyze the relationships between mode choice (driving and transit use) and demographic change. The research then uses a second set of regression models to analyze the causes of gentrification.

Based on the findings, Chapter 6 offers policy recommendations and conclusions on data analysis. The chapter emphasizes the need to create context-based policies that cater to variations and uniqueness of each MSA and neighborhood.

Chapter 2

Review of Literature

This chapter reviews the literature establishing the theoretical and conceptual foundations for the research. The review begins with conceptual definitions followed by a history of TOD policy. The chapter concludes with a discussion on the benefits and unintended consequences of TOD policy.

2.1 Theoretical Frameworks

2.1.1 Travel Demand

In estimating travel demand, transportation planners use the four-step model of travel demand comprising; trip generation, distribution, mode choice, and traffic assignment. Quantifying trip productions requires aggregate census data comprising, number of cars per household, median income, household size, and population in a traffic analysis zone (Ortúzar and Willumsen, 2011, p.208). Planners often use regression analysis, descriptive statistics, and calculus to calculate trip productions. However, this research employs regression analysis to investigate causal relationships between demographic change and mode choice.

According to Ortúzar and Willumsen (2011, p.207) mode choice is the single most important element in transportation planning. By making available a number of choices, planners can enhance the general efficiency of travel and the amount of space set aside for transportation.

Aggregate choice models postulates that mode choice is a function of individual utility (benefits) versus disutility (costs) such as travel time, travel expenses, and perceptions of comfort, flexibility, and safety (McFadden, 1978; Leroy and Senstolie, 1983; Taylor, Miller, Iseki, and Fink, 2009). Individuals endeavor to maximize their utility by negotiating an optimal balance between housing and transportation costs (O'Sullivan, 2009; Papacostas and Prevedouros, 2004; Chen, Varley, and Chen, 2010). Thus, mode choice is primarily dependent upon individual income and availability of different modes of transportation. This implies that income and proximity to various options for transportation play an important role in determining individual mode choice. Chapter 3 details these interactions when reviewing the variables.

Commuters often choose transportation modes within their budget constraint. When factors such as travel time, income, gasoline prices, employment location change, commuters respond by shifting from one mode to another depending on the available alternatives (Papacostas and Prevedouros, 2007; Chen, et al., 2010).

For instance, a trip to work with strict time constraints and demand for control over departure and arrival times requires a mode that guarantees predictability , flexibility and significant control on route choice; therefore, most commuters (within budget constraints) when given the option, will chose a mode they consider reliable and predictable such as a personal motor vehicle. Some commuters will certainly use transit when the services are very reliable with very short wait and transfer times. However, these commuters most likely do not have to make work based trips; therefore they probably do not need a car during working hours. In some cities like San Francisco

commuters have to sacrifice the comfort of personal cars when , traffic congestion, cost of parking , gasoline and time spent looking for parking incur an inconvenient experience and cost on commuting. In this case, using transit maximizes individual utility because what was previously considered a disutility is annulled by worse circumstances.

Alternatively, modes such as transit, walking and biking mostly satisfy leisurely trips because time, flexibility, and control is a little bit more negotiable. Such considerations represent costs that influence individual choice for work trips that require more control over time and flexibility. Once again, these choices are influenced by, *inter alia*; household income, size, number of cars and trip purpose, and trip costs.

Census data shows that many Americans of varying demographic and socio-economic characteristics prefer motor vehicles for most trips when given the opportunity (ACS, 2010; Chatman, 2013). However, certain demographic categories, including, minorities, households with no car, and low income, are more likely to ride public transit compared with Whites. Therefore, due to budgetary constraints, these individuals might favor cheaper public transport over the comfort and flexibility derived from driving.

2.1.2 Transportation and Land-Use Connection

Unlike traditional transportation and land-use theory, the premise that TOD can influence travel behavior does not rely on exploiting the impact of the transport system on the spatial form of the built environment (Handy, 1996). Rather, the concept works by reordering the direction of the causal link between transportation and land use (Boarnet and Crane, 1998; Handy, 1996).

According to this approach, leveraging density, design, and distance to transit influences mode choice for work, shopping, and leisure trips. Urban planners propose that the design, density and distance of TOD to activity centers encourages non-motor vehicle modes of transportation such as biking , walking and transit (Cervero, Murphy, Ferrell, Goguts, Tsai, Arrington, Boroski …Witenstein, 2004; Ewing and Cervero, 2010; Cao et al., 2009a; Handy, Cao, and Mokhtarian, 2005). Therefore, using the built environment has become a popular approach to increasing alternative mobility options. Moreover, scholars find that individuals living within TOD block groups walk and ride their bikes more when compared with the rest of the MSA (Besser and Dannenberg, 2005).

2.1.2.1 Bid Rent Theory

The need to balance costs of housing and transportation, is partly explained the bid rent theory. The theory postulates that a highly accessible location provides travel cost savings, which intensifies demand for housing at that location. “Bids for rental property will theoretically increase until the travel; cost savings are fully capitalized into the price of the property” (Duncan, 2011, p. 102). Alonso (1964) and O’sullivan (2009) explain how expensive rent in the urban core motivates migration of housing to the outer rings of the MSA where land is cheaper.

This is made possible by availability of multiple lane highways, which reduce the time and distance cost of travel from the suburbs to employment locations in the CBD. However, only well to do households are able to concurrently buy suburban housing, and commute by car (Leroy and Sonstelie, 1983). A few low-income households able to

afford suburban housing opt for public transportation to balance cost of cheap transit and with expensive rents. On the other hand, low-income workers unable to afford CBD or suburban housing have to relocate to interstitial low-income neighborhoods at the edge of the CBD (Park and Burgess, 1967). These are the transit-dependent population who need to be in TOD housing because of the proximity of alternative transportation modes (Haas et al., 2006). Thus, when they are priced out of TOD housing by phenomena such as gentrification, then we could have a problem of spatial mismatch and injustice.

2.2 Conceptual Definitions

2.2.1 Public Transit and Mode Choice

According to the U.S. Census Bureau (2010), public transit includes transportation modes such as bus, trolley, and commuter rail. This research focuses on rail transit (fixed guide way systems)including, light rail, heavy rail, commuter rail, subways, and trolleys.

The term “mode choice” refers to the type of transportation mode (bus, rail, walking, and driving) individuals choose for trips from one point to another (Taylor et al., 2009). Transportation theory states that individual mode choice depends on their utility (rewards) and disutility (costs) involved in using a particular mode (Papacostas and Prevedouros, 2007; Taylor et al., 2009). Factors influencing perceived utility of a mode can include: proximity to transit, income, employment type, cars per household, size of family, and cost of housing (the tradeoff between transportation and rent costs).This research uses mode choice data for block groups within 0.5 and 0.5-1.0 mile radius of a

transit station. The variables in the mode choice models are those parameters theoretically proven to influence trip generation.

2.2.2 Transit-Dependent Population

Individuals who ride public transportation comprise two broad classifications: The first category are transit-dependent population (TDP), or captive riders, who disproportionately tend to be low-income and in a minority group (ACS, 2009). The second category are choice riders (self-selecting or discretionary riders) comprising mainly of middle-to high-income individuals who voluntarily chose to use transit even though they can comfortably afford expensive modes such as driving. The Federal Transit Administration (FTA, 2012) defines transit dependent population as:

i. Households without private transportation
ii. Persons aged over 65
iii. Youths under the age of 18
iv. Persons earning below the median income value stipulated by the United States Census Bureau.

The list of transit dependent population also include households of more than one person who own one car; and households that have one or no car but have family members of working and schooling age. Possessing one car makes it impossible concurrent trips. However, availability of transit services facilitates multiple trips for single car households.

2.2.3 Gentrification

The United States Department of Housing (HUD, 1979, p. 4) defined gentrification as the process by which a neighborhood occupied by lower-income households undergoes revitalization or reinvestment through the arrival of upper-income households."

Gentrification is also "the process by which central urban neighborhoods that have undergone disinvestments and economic decline experience a reversal, reinvestment, and the in-migration of a relatively well-off, middle-and upper middle-class population" (Smith, 1998, p. 198). Hamnett (1984, in Bridge and Watson, 2004) adds that gentrification is simultaneously a physical, social, cultural, and economic phenomenon, which involves succession by the middle class or higher income groups in a predominantly low-income and working-class neighborhood. While the foregoing is an acceptable definition, it is worth exploring the tensions and debates involved in defining the contentious concept of gentrification before providing our working definition (Freeman, 2005).

The complexity involved in defining gentrification arises from contested narratives between the two disciplines of sociology and urban planning. Urban planners tend to focus on the socio-economics and spatial aspect of the process while sociologists focus on social relations and racial and class representation (Lees, Slater, and Wyly, 2010). Urban planners consider gentrification as a process that involves higher-income residents migrating into older but revitalized neighborhoods of the central city (Chapple, 2009). such migration can generate steep rents, and high rates of home ownership.

Nevertheless, Vigdor (2002) points out that there is no consensus among scholars regarding displacement of lower-income households or the extent to which the character of the whole neighborhood changes physically and socio-economically. Therefore, Vigdor rejects how planners frame gentrification and it impacts by recommending a definition that incorporates a finer understanding of demographic changes. Lin (2002) augments this view while arguing that gentrification should encompass the resettlement of poor and older, inner-city neighborhoods by middle class, normally White residents. Here, we see Lin introducing the racial factor which incorporates Vigdor's recommendation.

However, Freeman (2005) employs free market ideology to reject such conjecture. Freeman renders gentrification a positive phenomenon by side stepping the prickly issue of race whilst emphasizing positive outcomes such as job growth. Freeman defines gentrification as a process through which economically depressed areas experience economic revitalization through resettlement by residents who increase investments in neighborhood amenities. Freeman's definition takes a market-oriented position that ignores potential problems such as displacement of working class residents.

This research repudiates the above definitions because they cannot sufficiently operationalize the concept in measurable terms that this research can use. Instead, the research adopts a modified version of Hammel and Wyly's (1996) definition, which states that gentrification is defined by change in racial composition, median income, and educational attainment as a result of increased housing values and rent. Implicit in this definition is the association between rising costs of housing leading the upgrading of

social class. This is a more robust definition when compared with the ones mentioned above. The assumption in this definition, is that displacement of low-income households and minority population is a result of expensive housing —new residents do not directly displace old residents; rather, the old residents move out because housing becomes unaffordable. Therefore, increase in rent is a key dependent variable for the gentrification model.

2.2.4 Equity

The term equity is appropriate for this research because it speaks more to the concept of egalitarianism compared to the term equality. Equality can often denote an ideal situation where disenfranchised groups of individuals attain a better status usually at the expense of penalizing or excluding the privileged majority (Fainstein, 2010). This goes against the utilitarian concept of the greater good for the greater majority. However, equity speaks to fairness and justice based on typical representation of all groups. For instance, requiring developers to set aside affordable housing in a desirable location ensures that low income, unemployed and students retain some access to public transit, whilst allowing the majority of housing at market rates. Therefore, the goal is to ensure that all groups based on income and social stats have reasonable access.

2.2.5 Transit-Oriented Development

Scholars observe that the term *transit-oriented development* (TOD) does not have a single comprehensive definition including its typologies and land use mix (Cervero et al., 2002; Renne and Ewing, 2013). Yet, some planners may argue that it is worth engaging in a rigorous process to devise the best possible definition of TOD (Renne and

Ewing, 2013). However, defining TOD in finite details would require a nationwide project to collect views from stakeholders (e.g., transit agencies, transportation scholars, and practitioners) before agreeing on a bench mark for acceptable mix of housing, retail and commercial use. This endeavor is certainly beyond the scope, time, and resources available for this study. Therefore, the research presents the customary lineup of classical definitions borrowed from respected scholars, and then concludes by offering a working definition.

Most TOD share common traits of which the most notable are: Mixed land-use development with commercial, retail, and residential buildings; and good access to transit stations, services, and amenities through pedestrian walkways (Lund et al., 2010). TODs cover an area ranging from 0.25 - 0.75 mile radius from a transit station. This is the standard distance most American walk to access services and amenities (Cervero et al., 2002).

Figure 2-1 is an excellent schematic of a TOD design from a report from the Office of Management and Budget (Wise and Scire, 2009). The illustration reveals that the TOD design is a throwback reminiscent of Baron Von Haussmann's renovation of Paris, down to embellishment like, fountained plazas and sidewalk eateries. The revival of this concept is popular with advocates of new urbanism disillusioned by drab designs and segregated life styles of suburban gated communities. The younger generation today increasingly yearn for diverse neighborhoods with unlimited options for delightful encounters in the public realm (Ryan, 2007; Pew Research Center, 2010).

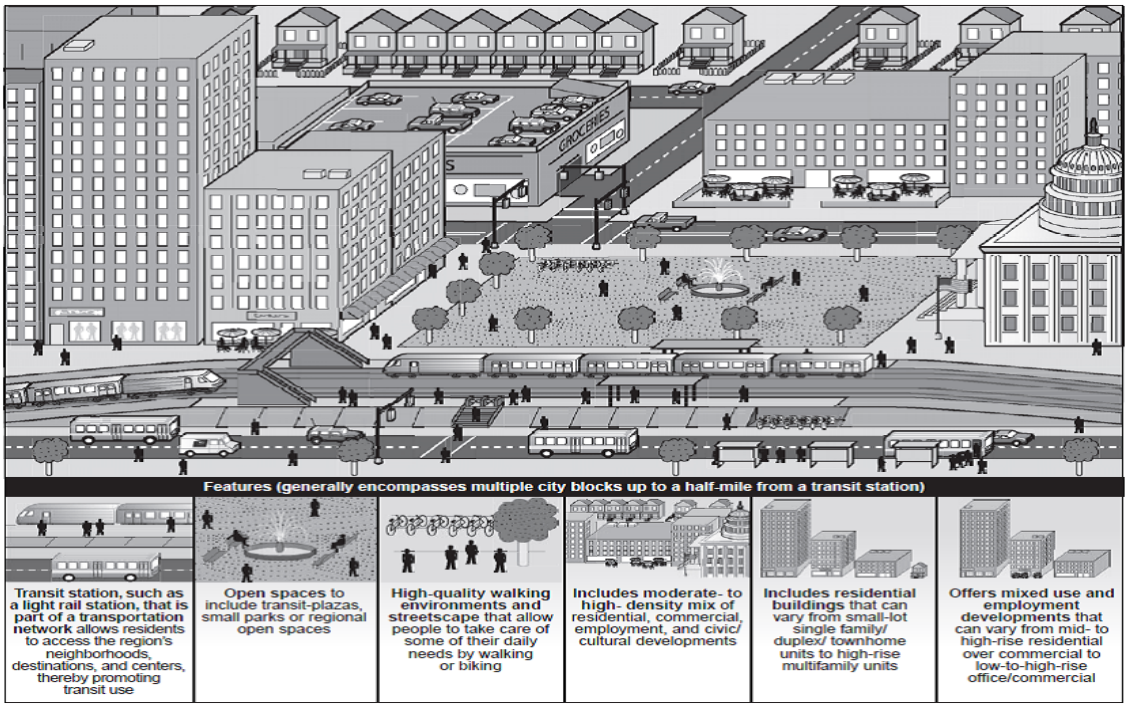

Figure 2-1 Schematic of a typical TOD (Wise and Scire, 2009)

Calthorpe (1993) whose seminal work, *The Next American Metropolis*, galvanized initial enthusiasm for TOD as a particular policy intervention supporting smart growth initiatives, and provided one of the earliest definitions of TOD. Guided by the dictates of new urbanism, Calthorpe focused on the quality of the built environment. He defines that a TOD as;

> "… A mixed-use community within an average 2,000-foot walking distance of a transit stop and core commercial area that mixes residential, retail, office, open space, and public uses in a walkable environment, making it convenient for residents and employees to travel by transit, bicycle, foot, or car." (Calthorpe, 1993, p. 56)

This definition underscores the promotion of multimodal transportation through incorporation of a compact mix of land uses, which had hitherto been lost to sprawl and suburbanization. Calthorpe explains that TOD is not only one building or housing

development. TOD incorporates multiple blocks of mixed use development encompassing residential, commercial, and retail uses. Calthorpe's typology also includes suburban and urban categories for TOD. Urban TOD, which is the most common type, is normally located within ten miles of central business districts. Suburban TODs are usually located in the *edge cities* (Garreau, 1992) of polycentric urban areas.

Bernick and Cervero (1997, p. 5) refined Calthorpe's definition by emphasizing the transportation and mobility aspect. They define TOD as a;

> "mixed-use development, centered on a transit station that, by design, invites residents, workers, and shoppers to drive less and ride mass transit more."

The transit village extends roughly 0.25- 0.5 mile radius from the transit station, a distance that can be covered in 5-15 minutes by able bodied person walking. The significance of this distance is based on empirical evidence that prescribes approximately 0.25 mile (about 2,000 feet) as the distance that most people would walk from transit to work (Ashalalfah and Shalaby, 2007; Lund et al., 2010). The centerpiece of the transit village is the station along with adjacent public spaces. The station offers a nexus connecting the village community to regional activity centers and destinations. Figure 2-2 is a diagram developed by the Miami- Dade County transit authority showing extent of TOD coverage.

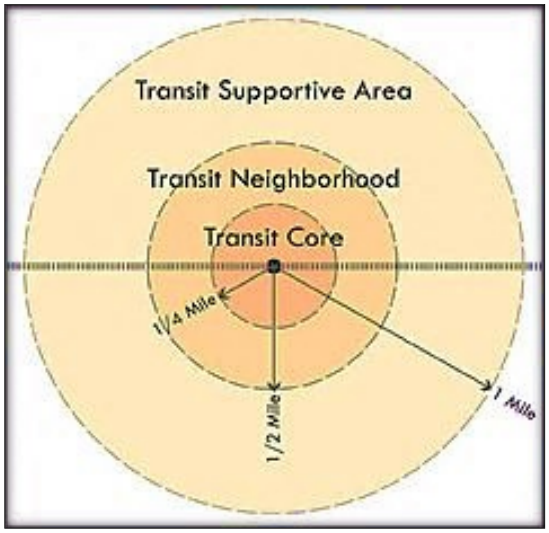

Figure 2-2 TOD service area (Miami-Dade County Transit, 2012)

Based on the above definitions, this research adopts the Calthorpe (1993) definition. To qualify for this research the transit system should have operational TOD for at least ten years. TOD block groups are those that are within a 0.5-1.0-mile radius of a train station with TOD policy instituted by transit agencies.

2.2.6 Standalone Transit Stations (non-TOD)

The term *non-TOD* refers to mixed use development located within 0.25 - 1.0 miles radius of rail stations with no TOD (Gossen, 2005). In other words, these are rail stations (according to transit agencies) that do not have a specific policy intervention utilizing TOD to promote sustainable and multimodal transportation. This classification includes the majority of rail stations in the country. Some scholars, including, Pollack et al., (2010) have referred to these areas as Transit Rich Neighborhoods (TRNs).

TRNs are located in areas supplied by transit infrastructure with mixed-use development, but may not necessarily have specific TOD policy. However, non-TOD stations can still provide significant impact on mode choice.

One provoking thought this research pursues is that non-TOD stations can perform as well as TOD, without necessarily incorporating all the accessories of TOD such as affordable housing and mixed-use if adequate parking and good neighborhood design is developed. The research therefore compares TOD and non-TOD using t-statistics to underscore two uncommon propositions:

a. TOD is not unique in improving public transportation use; any station area when properly designed with parking and a proper access within one mile of residential areas can increase transit use.
b. Investing in TOD alone will not improve ridership numbers. Improving system coverage, bus connections, transit services, and station areas can perhaps provide better results, because it improves access from one mile away (Chatman, 2013).

2.3 The History of TOD Policy

Unlike the European and Asian cities that organically developed density and transit-oriented living, most urban areas in America today consciously allocate approximately 0.5 mile special development zones around transit stations (Smith and Gihring, 2006). In reality, mixed-use developments oriented to transit are not really a new concept in the history of human settlements. Historically, retail and housing developments were drawn to famous transit points such as Grand Central Terminal (New York), the Harrisburg Transportation Center (outside of Philadelphia), and Union Station

(Portland) (Cervero et al., 2004). However, during this period, urban planners did not necessarily prescribe TOD as a means for increasing ridership. Rather, increased ridership was simply a positive externality from the organic clustering of communities around transit for convenience. However, the utilization of TOD as a deliberate policy to counteract sprawl and wasteful commuting began in earnest around the last quarter of the twentieth century (Calthorpe, 1993; Renne 2005).

Interest in sustainable development and energy efficiency was spurred on by events such as the 1970 energy crisis, the anti-sprawl movement, and the rise of new urbanism. Inspired by the likes of Calthorpe and Campbell (1996), planners began promoting smart growth policies such as TOD as viable solutions to mitigate wasteful commuting, sprawl and pollution from smog.

Renne (2005), estimates that recognition of TOD as a policy to promote sustainability, gained ground mainly after 1990. This observation is confirmed by agency archives showing that most TOD along systems such as TriMet (Portland), DART (Dallas), and MetroRail (Miami-Dade), NJT (Northern New Jersey), were built after — or designated as a special development after 1990.

The popularity of TOD increased from 1970 and 1980 when inner cities faced disinvestment, and jobs migrated to the suburbs. The relocation of jobs to the exurbs and edge cities (Garreau, 1992) created a spatial mismatch of jobs and housing, leading to high unemployment rates in the inner cities (Crowder and South, 2008; Massey and Denton, 1993; Kain, 1992). By the 1990s, suburbanization and sprawl in states such as California and New York, generated rising costs of commuting as inner-city residents had

to travel farther and longer for jobs. In response, cities invested in light rail and bus systems to provide alternative, low-cost connections between the inner city and jobs in the suburbs (Haas et al., 2006). However, the extension of new transportation networks generated urban sprawl and excessive commuting. Consequently, in the 1990s, the new urbanists and the sustainability movement presented TOD as a solution the ideal policy for advancing the sustainable communities vision.

From that point onwards, TOD continued to gain popularity in environmentally conscious cities in California, Oregon, and New Jersey. By the mid-2000's, the idea had spread to Texas, Florida, Georgia, and North Carolina. In some of these states, TOD also offered a vehicle for revitalizing dead downtowns and declining cities in the rustbelt. This, I would say was the beginning of the conflation between the policies goals of equity and sustainability, and the desire to net more revenue for the city.

Between 1998 and 2002, 13,500 apartment and condominium units were built within 0.5-mile radius of urban stations in California to meet a growing demand for transit-oriented housing (Cervero, 2007). Similar projects were developed in Washington, DC, Portland, and New Jersey. Today, TOD is the most is foremost policy intervention used by urbanized areas seeking to advance sustainable transportation systems. Yet, as we shall see later, the planning and implementation of TOD project appears to disregard equity for a diverse community.

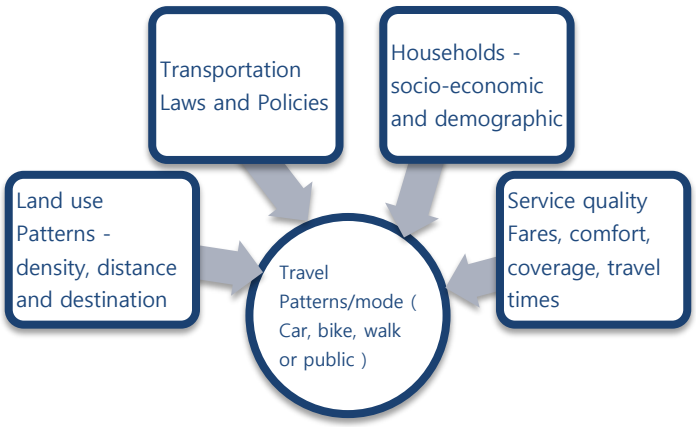

Figure 2-3 Urban Transportation System

2.3.1.1 Growing Popularity of TOD policy

After the passage of the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA), metropolitan planning organizations (MPOs) intensified the use of TOD (Cervero et al., 2002). The MPOs and transit authorities instituted, jointly and singly, policies to support property development through public and private partnerships (TRB, 2011). The MPOs also leveraged federal funding to promote higher densities, mixed-use, and multifamily housing (Kahn, 2007; Rose 2011). The Department of Transportation also offers grants to developers willing revitalize depressed transit served neighborhoods. These strategies encourage real estate entrepreneurs to invest in economically depressed, poor neighborhoods that they would otherwise have avoided. Yet, investing in low-income neighborhoods can produce unintended outcomes, which could jeopardize the objectives and goals of TOD.

From 1995 to 2002, policies—including the Safe, Accountable, Flexible, and Efficient Transportation Equity Act -A Legacy for Users, SAFETEA-LU, and Transportation Equity Act for the 21st Century (TEA-21) — appropriated $36 billion for

transit investments. In addition, the Transportation, Community, and System Preservation (TCSP) program promotes partnerships between public transit projects and private sector initiatives. The New Starts Program funds new construction and expansion of rail projects based on evaluation of proposals from local governments that are exploring new transit lines. The FTA draws up priority projects, which receive funding according to allocations from Congress. (Cervero et al., 2002)

Several states including New Jersey, California, and Oregon were at the forefront of creating enabling legislation to support TOD. The state of California's Senate Bill 375 (2008) instituted policies to support the states sustainable community strategy (SCS). Coordinating land use and transportation planning at a local level is a major goal of these policies. Local governments in California are currently investigating new ways to coordinate zoning laws and land-use regulations that reduce greenhouse gas emissions from motor vehicles (Rose, 2011).

In the Dallas area, the North Central Texas Council of Governments (NCTCOG) Vision 2035 plan for bike and pedestrian mobility options aims to set strategies for providing effective, cost efficient, safe intermodal access for bikes and pedestrians. Dallas Area Rapid Transit Authority (DART) has also been improving services that encourage bikers to use the bus and has developed TODs to promote a pedestrian-friendly environment.

Portland (Oregon) has used the urban growth boundary (UBG) to control sprawl and encourage density oriented to transit (Myung-Jin, 2006). In 2012, the regional government (Metro) redirected highway funds to a regional TOD program. The Portland

initiative appropriated$50,000 - $2,000,000 for TODplanning and site enhancements (TriMet, 2012). The metropolitan government has also financed station area planning on Portland's Westside MAX light rail corridor (Cervero et al., 2002). In the past decade, cities such as Minneapolis, Seattle, and Chapel Hill (NC), have commissioned TOD projects worth millions of dollars.

The New Jersey's Transit Village Initiative advocates for dense development, mixed use, and walkability in developments close to transit stations. Other relevant government policies include California's Senate Bills (SB) 375 and 32, which are intended to reduce greenhouse gas emissions (GHG) to 80% below 1990 levels (Rose, 2011).

The private sector has also became more interested in developing mixed use development in partnership with some cities (Cervero, 2007). These public-private initiatives produced lucrative Transit Joint Developments (TJDs). Examples of transit agencies forging partnerships with the private sector include the Washington Metropolitan Area Transportation Agency (WMATA) and San Francisco's Bay Area Rapid Transit (BART). Since 1980, WMATA has funded 27 development projects worth $2 billion, including the Bethesda complex in Bethesda (MD) (Cervero et al., 2004). The Charlotte Area Transit System (CATS, 2012) has also instituted zoning codes that will encourage transit-oriented development (CATS, 2012). Since going operational, DART's supportive policy has attracted TJD projects worth $800 million (Cervero et al., 2004).

In summary, investing in TOD projects are popular for both developers and regional governments. However, individual MSAs need to adapt the transit policy within

the regional context as opposed to duplicating policies designs that might be effective in some metropolitan areas but require modification for others. For instance, emphasizing walkability in California or Oregon works, yet similar design in Texas or Arizona might not be as effective because of climatic differences; furthermore, some MSA are already dense so they require improving service quality and coverage as opposed to investing on TOD alone. Chapter 6 will provide more details on context based policy design.

2.3.1.2 The Debate on Transit Investments

Despite the growing popularity of TOD, the strategy has attracted considerable attention from critics questioning its egalitarianism. Smith and Gihiring (2006) propose that there are two broad contesting views on the benefits of public transit investments.

The first contesting view originates from free market proponents arguing that transit systems are resource inefficient because they require frequent support from taxpayers (Figure 2-4). This view is validated by reports showing that federal, local, and state governments subsidize nearly 62% of operational costs for transit agencies (APTA, 2011, p. 22).

Other critics argue that estimated value of transportation projects and projected ridership are often erroneous — (Kain, 1990; Flyvbjerg, 2003; Chen, 2006). Kain (1990) provocatively stated that there had been “deception in Dallas” by transportation planners promoting the benefits of DART. To date, it appears DART has not achieved the ridership levels forecasted in 1988.

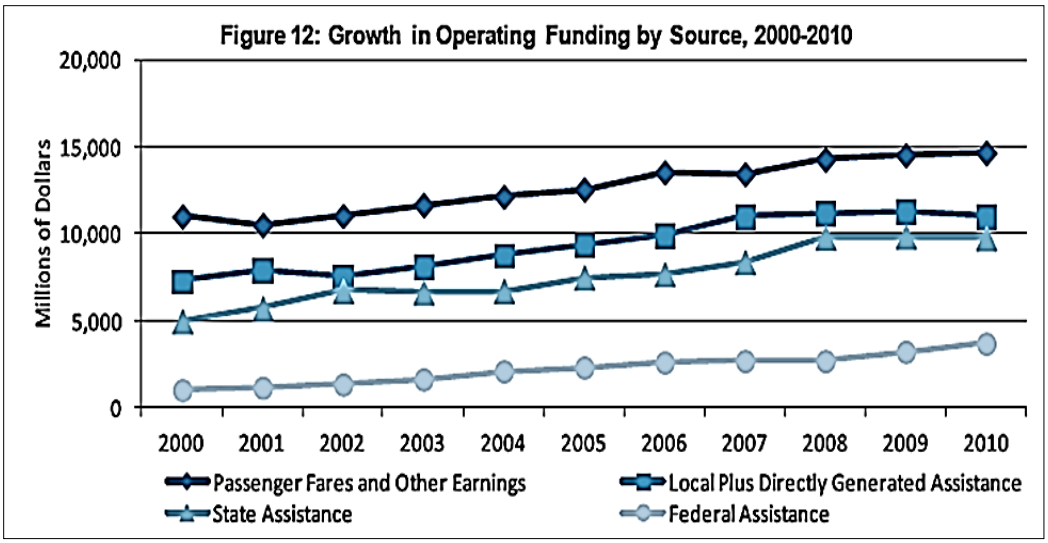

Figure 2-4 Funding Sources for Transit (Source, APTA, 2012)

Proponents maintain that transit is doing well, evidenced by the 34% gain in ridership (Figure 2-5) over the last ten years (APTA, 2011). The report reveals that between 1995 and 2009 the numbers of commuters surveyed who stated that they used public transit regularly for work trips grew by more than 34%. Of these respondents, 40% were White commuters, who have traditionally used transit less compared with Blacks (Neff and Pham, 2007). This finding implies that investing in transit has been rewarding.

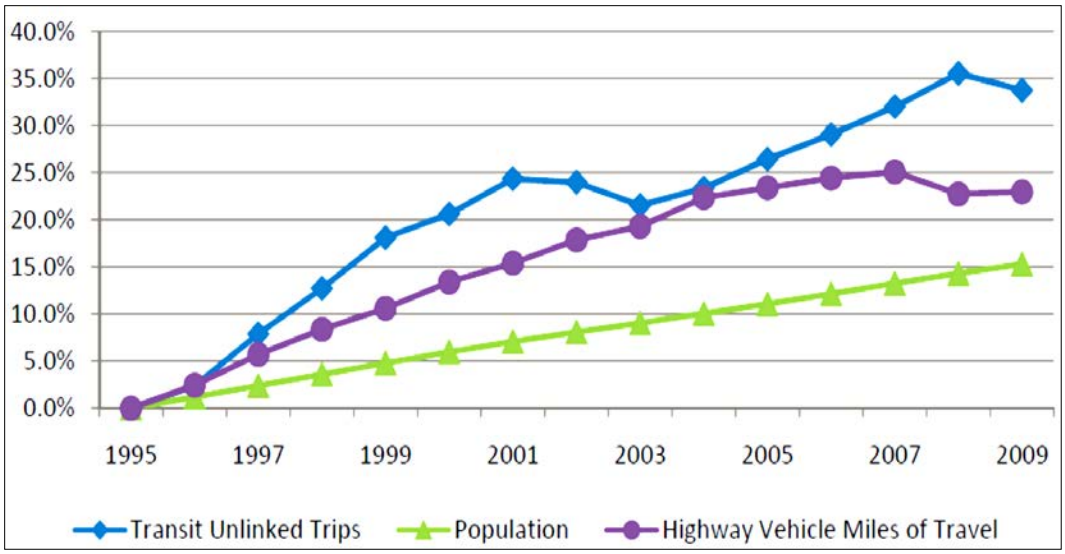

Figure 2-5 Growth in Ridership

In addition to ridership, pro-transit groups argue that there are ancillary benefits that are often intangible but useful for advancing sustainable development. These scholars argue that there are environmental and social benefits available from living in transit-friendly neighborhoods; which, in the end justifies the subsidies (Park, 2000; Cervero et al., 2002). First, using transit reduces emissions of greenhouse gases by increasing alternative mobility such as walking, biking, and transit use. Furthermore, TODs conserve land and reduce sprawl because they are more compact and dense. In addition, TOD integrates activity centers with residential areas (mixed-use), which helps control wasteful commuting, because everything is close. Finally, the pedestrian and bike friendly design of TOD improves public health and increases opportunity for street level interactions (Cervero and Sullivan, 2011).

In sum, TOD is a popular policy for cities promoting sustainability. However, as more cities adopt this approach, it is important to critically examine the egalitarianism of some of the benefits. The next section explores the benefits of TOD and potential impacts on mode choice and social equity.

2.4 TOD Benefits and Unintended Outcomes

This section reviews TODs benefits and then links them to unintended consequences. The section builds upon the research thesis arguing that even though TOD provides short-term rewards, the policy is vulnerable to long-term demographic shifts that eventually compromise its effectiveness.

2.4.1 Increasing Accessibility for Choice Riders

To begin with, a TOD is supposed to increase accessibility for choice riders. Choice riders are individuals who do not necessarily need transit, but opt to use it for various reasons such as the desire to reduce their carbon footprint. Cervero (1994, p. 177) found that for choice riders, the decision to rent or buy a home near a rail station arose from the desire to commute by rail. Similarly, Cervero and Duncan (2002) acknowledged that individuals living in a TOD were most likely to be choice riders or self-selectors. Finally, Lund (2006) found that a number of commuters living near BART stations were motivated by the desire to use transit; yet over time, they used transit less.

However, research from scholars on gentrification suggests that a TOD attracts residents who do not reflect the typical profile of transit-dependent population (e.g., Belzer et al., 2006, Chapple et al., 2007; Pollack et al., 2010; Dominie, 2012). Current research Pollack et al., (2010) and (Dominie 2012) report that newer residents in transit-

served neighborhoods increasingly disclose that they do not use public transport. Pollack et al. (2010) found that transit use did not increase in transit-served neighborhoods that had experienced population growth . These findings suggest that when transit-oriented neighborhoods become popular, they attract affluent households, with high rates of car ownership.This leads to questions regarding the effectiveness of the TOD when gentrifiers prefer to drive. The findings might explain why transit share of the transportation market has dropped from 12% in 1970 to 5.5% by 2010 (Census, 2010). The decline in transit justifies the need for further investigation.

2.4.2 Influence on Property Values

Cervero and Landis (1994), working in cities with perpetual traffic congestion like San Francisco, found that TOD property goes for premium rent because an increasing number of renters are looking for locations close to BART stations in order to cut the time and cost of travel. Furthermore, Cervero and Landis (1994) extended the previous analysis and found that a one-bedroom apartment within 0.25 miles of the BART Pleasant Hill rail station in the suburbs of Contra Costa County attracted rents 10% higher per square foot compared with, one-bedroom units farther from a BART station. In addition, two-bedroom units near the station rented at approximately 16% more per square foot than comparable units in the same general area that were farther away from BART.

Damm et al., (1980) estimated a significant price elasticity of 0.69 for commercial retail properties within 2,500 feet of a Washington Metrorail station. Sales prices per square foot for retail parcels fell by about 7% for every 10% increase in distance from a

station. In Alameda County, California, Diaz (1999) found that for every meter a house was located closer to the nearest BART station, the sale price (in 1990 figures) increased by $2.29/sq. ft. For every meter a house was closer to the nearest BART station in Contra Costa County, the sale price increased by $1.96/sq. ft. The positive influence on property value is beneficial for property owners and city revenues. Finally, Hess and Almeida (2007) also observed that proximity to light rail stations is associated with the appreciation of real estate values in the New York. However, we need to ask what the effect of this rising property value means for transit-dependent population that face exclusion because they cannot find affordable housing.

These findings imply that low-income groups unable to afford housing costs could be denied access to public transportation. Transit-dependent population excluded by high costs have to live farther away from the transit station. That is why the research compares 0.5 and 0.5-1.0 mile, radius to investigate if the socio-demographic characteristics of households living closer to transit reflect the profile of transit-dependent population. The research proposes that the data will show that lower-income groups and minorities may be living further away.

2.4.3 TOD and Revalorization of Public Space

Calthorpe (1993) proposed that TOD should capture a balanced mix of income and demographic groups. Density and mixed-income residential areas, was supposed to bring diverse households closer, while compelling them to interact because of the lack of walls and cars, which often insulates individuals from interaction. Nevertheless, Harvey (1997) argued that a communitarian goal only succeeds in promoting exclusive living

space. Similarly, Noble (1999) criticized smart growth policies for relying on the built environment while ignoring pressing issues regarding social and spatial equity.

When the private sector controls premium public space, they normally opt to pursue upscale developments that are profitable. However, revalorization of public space with high-end restaurants and shops comes at a price to the community (Logan and Molotch, 1987). Unintended outcomes include the exclusion of groups that feel alienated by experiences that appeal only to affluent middle class groups (Kavaratzis and Ashworth, 2005; Abraham, 2004; Hannigan, 2003).

2.4.3.1 Conclusions on transit debates

The previous discussion surveyed literature and explored empirical findings showing that TOD incurs positive benefits on transit use, property values, sustainability and quality of life . As problems such as congestion, pollution, and high energy prices continue to plague American cities, urban planners are increasingly leveraging the advantages of TOD and public transit to promote sustainable urban development . However, some of the benefits of TOD such as the appreciation of property values face criticism for excluding low income groups. This research intends to investigate such points of contention. The next section continues with an examination of the literature on gentrification and transit use.

2.5 Gentrification

This section explores studies on demographic change and transit use that inspired this research. The proposition is that socio-economic and demographic characteristics of commuters influence travel patterns employed in the four-step model in travel demand

management (Ortúzar and Willumsen, 2011). The variables used to forecast mode choice and trips made include socio-economic characteristics (e.g., cars per household, income) and trip purpose. This is why linking demographic change to public transport is the adopted strategy for this research in investigating demographic change in TOD block groups and related effects on transit use for work commute.

The term *gentrification* has become highly contested since Glass (1964) protested the displacement of commoners by English gentry in post-industrial London. Because gentrification has bearing on the highly sensitive issues of race and class struggle, the term has been the subject of debates and revisionism with every new publication on urban change and revitalization. Each succeeding definition seems to suit the ideological persuasion of the scholar. Some scholars (Davidson, 2008; Freeman, 2005; Slater, 2009; Lees et al., 2010) continue to debate whether or not gentrification is good for society. Proponents such as Freeman (2005) and Vigdor (2002) claim that the latest migration trends associated with gentrification is a redress for White flight: an opportunity to reintegrate the White middle class into the melting pot of ethnic enclaves of the inner city. Moreover, supporters argue that the gentrification brings back jobs to low-income inner-city neighborhoods, in addition to reducing crime.

However, communitarians such as Noble (1999) countered by criticizing gentrification for displacing minority groups and excluding indigent populations from the benefits of neighborhood revitalization. Yet, proponents such as Freeman (in Lees et al., 2010) responded to such critiques contesting that gentrification does not always produce negative externalities. Central to the argument is the notion that gentrification improves

disenfranchised inner-city areas and brings back much needed jobs and reinvestment. Revitalization also reduces crime and brings amenities such as parks, grocery stores, and libraries in its wake (Freeman, 2005, p. 488).

While studying neighborhoods in the Bay area of Northern California, Freeman (2005) found that housing prices in gentrifying areas usually appreciate above the regional average accompanied by an increase in educational attainment above the regional average. Average household incomes in these areas are normally at the 40th percentile of regional household income.

Emphasizing the positive socio-economic aspects, Freeman argues that gentrification attracts individuals with higher education attainment in addition to higher property values and household incomes. Freeman contends that these changes should result in better neighborhood quality and social life. However, some of the change is internally driven, when existing residents improve their economic circumstances. This means that lower-income residents with low educational attainment can face displacement.

2.5.1 Gentrification in Transit Served Neighborhoods

Reviewing research on gentrification and transportation policy generally reveals three broad areas of concern: housing affordability, mode choice, and social equity. Within these areas, housing costs are the foremost concern; because escalating rents and housing values are the likely instigators of displacement of working class households.

In the last 10 years, the relationship between gentrification, housing, and mode choice has attracted more scholarly attention as transit ridership and housing affordability

exhibit disturbing trends (Lin, 2002; Renne, 2005; Danyluk and Ley, 2007; Belzer et al., 2006; Kahn, 2007; Kushto and Schofer, 2008; Chapple, 2009; Pollack et al., 2010; Dominie, 2012).

Without discrediting these scholars; there are still some issues with methodology , data, and focus, which create opportunity for improvement with different data sets and methods. These limitations originate in part from the use of census tract boundaries that are too broad (Renne 2005) and the comparison of data between census years without normalization (Pollack 2010; Dominie, 2012). In addition, some studies (e.g., Lin, 2002; Renne, 2005; Kushto and Schofer, 2008) utilized census data from 1980 to 2000; however most transit systems, such as DART, TriMet, and NJT, started developing TOD in the mid 1990's (Utter, 2009). The following paragraphs review these studies including their deficiencies before discussing improvement in the next Chapter.

To begin with, Lin (2002) focused on Northwest Chicago to study whether the presence of transit in poor neighborhoods was causing gentrification. The study employed data from Olcotts Land Values (1975–1991) while using the Alonso's (1964) theory of the concentric urban form as the basis for analysis. The study found that property close to transit stations gained a 20% increase in value compared with similar property in other areas in the Chicago metro area. However, Lin used only property values to predict gentrification. This definition omitted important variables such as median income, education, home ownership, and employment type. In addition, Lin did not investigate how this trend affected transit use.

Noting this deficiency in previous research, Renne (2005) conducted further research incorporating more demographic variables focusing on 103 TODs using census tract data from 1970 to 2000. Renne's work was very similar to the present research because the study also evaluated the impacts of demographic change on mode choice. Renne (2005) noted that the percentage of renters within TOD increased from 58% to 62%, while those in the MSA decreased from 41% to 38%. In addition, transit as mode choice increased in TOD by 11% over a 30-year period. This was significant because transit use decreased in the MSA by 63%. Further, per capita income increased more in TODs compared with MSAs, while poverty values spiraled in TOD. In addition, there was a 7% increase in rented housing accompanied by a 20% decline in car ownership compared to the MSA. However, Renne concluded that evidence from 103 TODs across the country did not show any gentrification,

Although the Renne (2005) covered a wider geographical area compared to Lin (2002), both their findings found that presence of TOD was not associated with gentrification. Nevertheless, Renne used data from 1975 to 1990, when most TODs in Dallas and Portland were in the early years of operation. This implies that the neighborhoods had probably not matured enough to gentrify. Furthermore, the study only employed descriptive statistics to investigate the relationship between demographic change and mode choice. This is a gap that Renne (2005, p. 46) acknowledges will require further research. Finally, Rennes "broad and narrow" approach for extracting data from census tracts is not consistent with conventional methods used by transportation

planners and engineers. This research improves on this anomaly by using the zone centroids as the basis for data extraction.

Danyluk and Ley (2007) went further with a cross-sectional analysis in Vancouver, Toronto, and Montreal to study mode choice for work trips using data from 485 tracts. The study assessed the interrelationship between gentrification and mode-choice use in the central business district of the three cities. The research defined gentrification as:

> "A process involving the movement of distinctive sections of the middle class into historically poorer, inner-city neighborhoods". This includes, housing redevelopment, rising property values, local retail upgrading, transformation of local voluntary organizations and the displacement of long established residents and small businesses." (Danyluk and Ley 2007, p. 2196)

Data analysis employed correlation analysis for income, education, political affiliation, distance to the CBD, and mode choice. The study found that households in gentrified census tracts mostly biked to work. The data also registered a negative correlation between transit use and gentrification. While Danyluk and Ley's (2007) findings are interesting, correlation does not imply causation. therefore, there is need to use a predictive model to investigate the relationship between these variables and mode choice, which this research fulfills.

Kahn (2007) explored 42 census tracts in the United States using data from transit-oriented communities in 14 cities. The study used data on income, education, and home prices from the National Transit Database and Urban Institute. The unit of analysess were census tracts within 20 miles of the CBD of 14 cities. neighborhoods were categorized as "treated" or "non-treated" depending on whether they had a new Park and

Ride or Walk and Ride light rail station. The research investigated how average home prices and education attainment changed in treated tracts compared to control tracts in the MSA without new developments.

The research found that "across the 14-city sample, new transit's local impacts differ significantly. Some cities, such as Boston and Washington, DC, have experienced gentrification in communities with better access to rail transit, especially communities treated with a new." (Kahn 2007, p.169) Treatment of a neighborhood with a walk and ride station increased property prices in comparison to park and ride stations in Boston and Washington DC.

In cities such as Los Angeles and Portland, home prices near park and ride stations dropped because of the perception of traffic noise and congestion (Kahn 2007, p. 169). The study also found that student population tripled in housing within 1.0-mile radius away walk and ride stations. Median income around walk and ride stations increased by 4% while park and ride incomes declined by 2%. Park and ride stations were also associated with decline in college graduates (Kahn 2007, p.174). These results suggest that proximity to transit stations could be linked the process of gentrification. However, Kahn used census tract data that could potentially create ecological fallacy because the boundaries are too wide. Nonetheless, Kahn's method and findings seem to offer strong evidence for gentrification.

Using data for 1990 to 2000 censuses , Kushto and Schofer (2008) investigated whether gentrification affected mode choice in Chicago neighborhoods. The study used variables including aggregate family income, rental units, families with children, and

level of education. Surprisingly, the results revealed that residents used transit more in transit served areas that had gentrified when compared with the rest of the city. However, further analysis revealed that over time, families living in gentrified neighborhoods were likely to switch to automobile use as they prospered in their careers and settled down.

This was a contradictory result, yet the researcher did not make an attempt at further analysis to explain the anomaly. This finding seems to have established that TOD may increase ridership in the medium term; however, over time, as the neighborhood gentrifies, transit use declines. Kushto and Schofer's analysis was significant because it identified a trend that previous studies had missed. Nevertheless, the results were only applicable to Chicago between 1990 and 2000. In addition, Kushto and Schofer did not evaluate in depth the variables affecting transit use. This research uses regression models and more variables to improve on Kushto and Schofer (2008) study.

Finally, Pollack et al. (2010) conducted one of the most comprehensive studies on gentrification and mode choice , which inspired the current research. Using 1990 and 2000 census data, Pollack et al. conducted a cross-sectional analysis of block groups in 42 transit-rich neighborhoods (TRN) in 12 MSAs.

The unit of analysis were neighborhoods within a 0.5-mile radius of light rail station. Using descriptive statistics, the study found that TRN registered 20% more population growth compared to the respective MSAs. Seventy-five percent of the reported growth was from Whites migrating to transit served neighborhoods.

In addition, increase in median income for TRN was 77% higher than MSA rates. Consequently, more than half of the TRN registered a 26% increase for families earning

over $100,000 per year. Moreover, 69% of home values in the study area increased 20% above MSA rates, while construction grew by 82%. Consequently, renting TRN housing was more expensive than average rent in the MSA.

The most significant finding with respect to this research was that new residents increased car ownership rates by 60% . In addition, these residents stated that they did use public transportation as much as regular folks living in close proximity of a transit station. This finding suggested that demographic change in transit served neighborhoods was associated with declining rates of ridership. The research's findings comprising, mounting car ownership, high median incomes, and expensive housing are symptomatic of gentrification trends.

Despite the remarkable results, Pollack et al., (2010) left gaps that providing room for further research; first, Pollack et al. (2010) did not study TOD. Second, Pollack et al. (2010) did not use normalized census boundaries; third, comparing data for 1990 and 2000 censuses using the original boundaries can increase the error because boundaries change between decennial censuses. Finally, block group selection appeared to lack reliability. This research improves these areas.

Dominie (2012, p.17) found that most TODs are located in neighborhoods with predominantly low-income working class households. Likewise, a recent market study by the City Los Angeles (CA), Planning Department found that the TOD amenities attracting new residents to transit served neighborhoods, are a causal factor in displacement of existing residents. "By attracting households with higher incomes, the

potential increases for existing residents to be displaced as housing prices and the cost of living increase" (Dominie, 2012, P.17).

To address such concerns, this research investigates whether demographic change in block groups within one mile of a rail station with a TOD is associated with unintended outcomes such as gentrification and reduced transit use for work commute.

2.6 Conclusions on Literature Review

Since the 1990's TOD has grown to become one of the most popular policies for cities seeking to advance smart growth. Several cities have funded capital improvement programs around transit stations to promote multimodal transportation and cut back on sprawl.

While the policy has detractors, claiming that transit investments are uneconomical because frequent need for tax subsidies, many planners, and scholars maintain that investing in TOD provides significant benefits. Several studies have demonstrated that TOD rewards include; increased ridership, appreciating home values, neighborhood revitalization, and quality of life enhancement; yet, an emerging area of research on equity and transit attempts to draw a link between TOD and gentrification (Table 2-1). These studies point out that the vey benefits of TOD such as higher housing values can produce unintended outcomes such as exclusion of low-income groups who cannot afford the homes.

Table 2-1: Summary of gentrification literature

Author & Title	Year	Study Area	Methods & Data	Findings
Lin, J.: Gentrification & Transit in Northwest Chicago	2002	35 neighborhoods in North West Chicago within one mile Chicago Transit Authority station areas	Used housing values from Olcotts database (1975 -1991) to determine whether proximity to a transit station affect housing values. Employed spatial autocorrelation and regression analysis	Found that property close to transit gained higher value compared to those in the MSA. This suggests possible association with gentrification in areas close to transit infrastructure
Renne J.: Transit-oriented development: Measuring benefits, analyzing trends, & evaluating policy	2005	Census tracts for 103 TOD located in Maryland, Florida, California, New Jersey, & Oregon.	Used GIS analysis, case studies & descriptive statistics. Retrieved Census data (1970 - 2000) on race, income, cars per housing, mode choice, to investigate demographic change & effect on mode choice.	Found few signs of gentrification. However, after the year 2000, poverty rates percentage of renters & transit use increase ; while vehicle ownership declined.
Danyluk & David Ley: Modalities of the New Middle Class. Ideology & behavior in the Journey to work from Gentrified Neighborhoods in Canada	2007	Canada 485 transit census tracts in Montreal, Vancouver & Toronto.	Correlations & descriptive statistics. Data retrieved from Canadian census to calculate correlations between income, education, political affiliation, distance to CBD & mode choice. Also investigate relationship bet'n gentrification & mode choice.	Found that gentrification occurred I n'hoods closer to the city center. New residents prefer to bike or walk, compared to previous low income households, low public transit usage, despite high number of liberal households.
Kahn, M.: Gentrification Trends in new transit oriented communities: Evidence from 4 cities that expanded & built Rail transit systems	2007	42 census tracts in 14 cities within one-mile radius using GIS.	Regression analysis & descriptive statistics. Used Data from National Transportation Database (1970 to 2003) & Urban Institute on income, education, & home prices. Investigate if Walk & Ride [W & R] stations experience greater gentrification than Park & ride [P & R]	Mixed findings on gentrification depending on region. Home prices near park & ride stations increased compared to W & R In LA & Portland&, While Dc & Boston have higher housing values in W & R compared to P & R. Overall, P & R show lower housing values & incomes. This implies living closer to station increases likelihood of gentrification
Kusht,E.: Travel & Transportation impacts of urban gentrification: Chicago Illinois Case Study Unpublished PhD thesis	2008	2000 census tracts in the city of Chicago, Illinois.	Employed descriptive statistics to investigate incidence of gentrification. Used Neighborhood Change Database (1980 - 2000) data on; education, rental units, family size, mode choice, to investigate demographic change & effect on mode choice.	Existence of gentrification linked to transit infrastructure. Gentrified census tracts are closer to the CBD. However households in gentrified tracts used public transit more than MSA.
Pollack et al: Maintaining diversity in America's transit-rich neighborhoods. Tools for equitable neighborhood change	2010	Census tracts in 42 transit rich neighborhoods (TRN) in the whole country in 12 MSA. Within 0.5 miles of light rail stations	Used descriptive statistics & case studies. Census data (1980 - 2000) race, income, cars per housing, mode choice, to investigate demographic change & effect on mode choice.	Median income, cars per household & housing values increased in TRN more than the MSA. Households said they used transit less & construction increased in newer TRN
Dominie, W: Is just growth Smart growth. The Effects of Gentrification on Transit Ridership & Driving in Los Angeles' Transit Station Area Neighborhoods	2012	Census tracts in Los Angeles . Within 0.5 miles of transit stations in Los Angeles county.	Used census data from 1990, 2000 & 2010 on race , income, education to measure gentrification. Employed regression analysis & descriptive statistics.	More high income households in TOD tract compared to MSA. Some gentrification in some stations. High concentration of wealth & increase in education level in TOD compared to MSA. In addition gentrification is associated with more driving & less transit use

Consequently, the ridership goals of TOD might be compromised and low-income working class residents and displaced from TOD. However, the studies have gaps and

inconsistencies in method, scope, and focus into which this research will attempt to provide further insight.

Chapter 3

Methodology

It has become commonplace in urban areas that sprawl, long commutes and pollution have significantly affected sustainable urban development and quality of life. Thus, using transit-oriented development (TOD) has become a popular strategy for cities seeking to promote the sustainable communities strategy. At the same time, urban areas in America are experiencing rapid demographic shifts leading to new spatial distribution of employment, housing, and wealth (Tomer, 2011; Kneebone and Berube, 2013). One example of these demographic shifts includes the migration of low-income households from the central city to the suburbs. Urban scholars suggest that these demographic changes are interrelated with gentrification in TOD block groups because new middle class migrants displace working class residents in the central city. The outcome is less transit use and increased driving for work commute. The goal of this research is to investigate such claims and provide in depth analysis using advanced quantitative methods and GIS spatial analytics.

Chapter 3 presents the research's approach for analyzing demographic change in block groups within 0.5 and 0.5-1.0 miles radius of TOD and non-TOD stations. The research employs descriptive statistics, regression models, comparison of means, and correlations to investigate the following issues:

a) The difference between TOD, MSA, and non-TOD block groups within 0.5 and 0.5-1.0-mile radius of fixed guide way systems.

b) The relationship between gentrification and mode choice in TOD, and non-TOD block groups within 0.5 and 0.5-1.0 mile radius of rail stations.

Figure 3-1 illustrates the 0.5-mile radius and 0.5-1.0 mile radius. This research uses the designation 0.5-1.0 mile radius to refer to the interstitial area between 0.5 mile and 1.0-mile radius. The different radii enable the research to assess whether TOD can be theoretically effective beyond the traditional 0.5 radius. Using two radius also controls for any spurious observations within the traditional 0.5 miles radius.

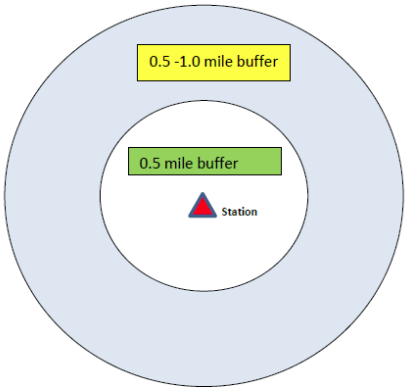

Figure 3-1 Illustration of 0.5 and 0.5-1.0 mile radius

3.1 Dependent Variables for Gentrification and Mode Choice Models

3.1.1 Gentrification and Displacement

There are two significant events in the process of gentrification, (1) rising cost of housing and (2) Displacement of low-income residents (Lees et al., 2009). therefore, this research use two models to analyze the complexities involved in gentrification and displacement. The research modifies Hammel and Wylys' model by adding new variables, to assess the occurrence of gentrification and displacement. These variables include employment type and length or residency within the TOD.

The research use two models to assess; first, the socio- economic and demographic shifts associated with rising costs of housing, and second, the socio-economic and demographic shifts are associated with displacement of low-income transit-dependent population (TDP) *priced out* of the neighborhood because of high rents and housing values.

Because rising costs of housing triggers demographic shifts leading to gentrification, the research's dependent variable for the gentrification model is the block group median rent. In fact, Grube-Cavers and Patterson (2014), note that gentrification is "an event" implying that the onset of gentrification is an event, in time when block groups demographic and socio-economic characteristics are appreciating at a rate faster than the surrounding area. In this research, that event is construction of a new TOD followed by escalating housing values and class upgrading.

The dependent variable for the displacement model is the Black population. The Black population is a proxy for transit-dependent population because transit use among Blacks exceeds the rates for other racial categories in the research (APTA, 2011). Black households also constitute a major proportion of low-income , carless households when compared with White households (ACS, 2010).

3.1.2 Mode choice (Transit and Driving)

For the mode choice models, the dependent variable is the percentage of workers in the block group using public transport or driving for commute trips. These two modes retain the highest proportion of the transportation commuter market (ACS, 2009).

3.2 Independent Variables for Mode Choice and Gentrification

Table 3-1 displays the variables for the mode choice, gentrification, and displacement models. The next section contains a discussion to explain the theoretical basis for including the variables in the respective models.

Table 3-1 Independent variables and predicted direction of effects

			Model 1	Model 2	Model 3	Model 4
Independent variables	**Coded**	**Category**	**Effect on Driving**	**Effect on Transit**	**Gentrification (Rent)**	**Displacement (Black)**
Regional (dummy)	East, West, & South	Regional				
Central business district (dummy)	CBD	Location	-	+	+	-
Central city (dummy)	Central city	Location	-	+	+	-
Suburban (terminus) (dummy)	Suburban	Location	+	-	-	-
Straight line distance to station	DIST	Built environment	-	+	-	-
TOD policy	TOD = 1 & non-TOD = 0	Built environment & Policy	+	-	+	-
Non- Hispanic White	WHITE	Demographic	+	-	+	-
Non-Hispanic Black	BLACK	Demographic	-	+	-	Null
Asian or Pacific Islander	ASIAN	Demographic	-	+	+	-
Foreign-born	Foreign born	Demographic	-	+	-	Null
College degree or higher	EDUC	Demographic	Null	Null	+	-
Block group density	DEN	Demographic	-	+	+	Null
Block group population	POP	Demographic	-	+	+	Null
Median contract rent	MDRENT	Economic	+	-	Null	-
Median income	MDINC	Economic	Null	Null		-
Median housing value	MDHVAL	Economic	Null	Null	+	-
Per capita income	PERCAP	Economic	+	_	+	-
Renter occupied housing	ROH	Economic	-	+	-	+
Owner occupied housing	OOH	Economic	+	-	+	-
Biking & walking	Othermode	Mode choice	-	-		
Driving	DROVE	Mode choice				
Transit	TRANSIT	Mode choice				
White-collar employment	WHTCOLL	Socio-economic	+	-	+	-
Blue-collar employment	BLUCOLL	Socio-economic	-	+	-	+
Household with no car	NOCAR	Socio-economic	-	+	Null	Null
Households with one car	ONECAR	Socio-economic	+	+	Null	Null
Household with two cars or more	TWOCAR+	Socio-economic	+	-	Null	Null
Years station been operation	Years in operation	Time Period	-	+	+	-
Resident since yr. 2000	MVD_A2000	Time Period	+	-	+	-
* Null means the variable is not part of the model						

Percentage of households with no car or more than one car: The number of cars in a household can influence trip frequency and mode choice when the household size is more than two individuals. Large households with more cars are likely to make more trips when compared with carless households (Ortúzar and Willumsen, 2011, p.208). Households without a car tend to be lower-income families bearing a heavy burden from cost of housing. This implies that low-income individuals drive less compared with

affluent households (Haas et al., 2006; Tomer, 2011). Tomer (2011, p. 2) found that over 90% of households with no car live in neighborhoods with access to transit. This surpasses the 68% rate for households with a vehicle suggesting that transit zones attract transit-dependent population.

*Median and per capita income***:** Income is part of the model for assessing the likelihood of a higher percentage of households with several cars, which increases driving for commute. The preference for comfortable travel modes and flexibility implies that affluent individuals are less likely to use transit because they consider transit slow and inconvenient. Household income can influence trip frequency because affluent households are able to afford (and frequently make) more trips when compared with low-income households (Papacostas and Prevedouros, 2007).

Percentage of college graduates: While income can demonstrate whether the neighborhood has become affluent, Freeman (2005) maintains that because of fluctuations in income, educational attainment should be used as a supplementary variable to demonstrate upgrading of social class. In addition, Glass' (1964) found that gentrification brought class change in London neighborhoods previously populated by Blue-collar workers. The change in the number of college graduates indicates a change in category of employees (Blue-collar, White-collar) and earning potential. In sum, because income can change, education and employment type is important in order to identify class upgrading.

*Median housing value***:** the block group median housing values is part of the gentrification model. Urban economic theory shows that high demand for central city properties is associated with ever-rising costs of housing (O'Sullivan 2009). This motivates low-income households to find cheaper housing further from transit service areas. The net effect is less transit use as gentrification occurs and transit-dependent population are displaced (Kahn 2007). In support of this point of view, Freeman (2005) found that housing price in gentrifying areas of San Francisco appreciated 40% above MSA levels.

Median contract rent: Block group median rent values are an independent variable in the mode choice model. Median rent is also a dependent variable for measuring gentrification. TODs are usually located in areas zoned for multifamily rental housing and dense development (Cervero et al., 2004; Danyluk and Ley, 2007; Pollack et al., 2010). When rent increases, lower-income transit-dependent households, are priced out of neighborhoods, causing them to find housing in cheaper neighborhoods with little or no public transportation coverage (Belzer et al., 2006).

Percentage of owner and renter occupied housing: In addition to rent and housing values, occupancy type is a housing variable, which is part of the mode choice and gentrification models. A recent Harvard University study found that rental property market in the central city has the fastest growth rates among minority groups (Fernald, 2011). Since 2001, the numbers of Black, Hispanic, and Asian renters have increased by 45%. In addition, minority populations have contributed to 81% of the growth in rented housing compared with 20% for the White population (Fernald, 2011). On the contrary,

Pollack et al. (2010) associated growth in owner-occupied housing with an increased percentage of White residents in gentrifying neighborhoods. Glaeser, Kahn, and Rappaport (2007) found that rental housing is associated with a high percentage of immigrants (or foreign-born population) leasing apartments close to public transportation networks. Overall, minorities and immigrants register a high rate for renting compared with White population because they have lower incomes and need to live in transit zones to access public transportation.

Racial categories (Percentages for Black and White): Displacement of low-income groups, who disproportionately tend to be people of color, is normally a corollary of gentrification (Hammel and Wyly 1996; Pollack et al., 2010). Previous studies consistently find that minority groups such as the Black population have a higher transit patronage compared with White population (Taylor et al., 2009; APTA, 2012; ACS, 2010). Therefore, this research assumes that an increase in the percentage of White residents in TOD block groups are associated with increase in percentage of workers driving more and using transit less.

Mode choice theory regarding income and trip rates states that affluent individuals tend to own more cars and place a higher utility on use of personal motor vehicle for home-based trips (Papacostas and Prevedouros, 2007). In relation to the foregoing, Harris (1999) suggested that demand by Whites appreciates values.

However, expensive housing excludes low income, working class residents from transit services (Dominie, 2012). Therefore, using block group percentage of Whites,

could potentially prove that gentrification and displacement occurring in TOD block groups.

The second model investigates displacement of transit-dependent population by using the percentage of Black population as proxy for low-income, transit-dependent population. Census data reveals that African Americans tend to dominate the rental market and public transport when compared with other racial categories (Census Bureau, 2010; Fernald, 2011). This is because the percentage of Black population using public transit is highest among racial categories (APTA, 2011). Certainly, transit-dependent populations include senior citizens, high school children, and people with disabilities, etc., (FTA, 2012). However, those variables are outside the scope of this research. The research proposes that increase in housing costs arise from increased percentage of high-income households, White-collar employees, and college graduates. The outcome of this type of neighborhood upgrading is the displacement of transit-dependent population. Based on these postulations, the block group percentage of Black population will represent transit-dependent population.

Percentage of college graduates: Freeman (2005) and Dominie (2012) recommend using education attainment, in addition to income, to evaluate incidences of social upgrading. Whereas median income does indeed quantify neighborhood affluence, Freeman argues that fluctuations in income imply that educational attainment is required to analyze upgrading of social class. Glass (1964) lamented that gentrification produced class change and upgrading of neighborhoods that had previously contained low income, Blue-collar workers. In addition, change in the percentage of college graduates

potentially signifies change in category of employees (Blue-collar and White-collar). In summary: to investigate social upgrading, education and employment type should be part of the analysis (Ley, 1992).

3.3 Location Variables

Using location specific variables is important in controlling mode choice variations in origins and destinations. At least two factors including land use, and urban structure are at play when studying the transportation and land use interaction. Zoning ordinances in metropolitan areas normally designate land for residential, commercial, retail activity. Consequently, each location has different densities, land-use mix, and designs which can influence level of activities, traffic flow and mode choice (Handy, 1996).

The bid rent theory employs the monocentric model which assumes a single central business district with the highest density of employment, retail, and commercial activity. The model is based on Alonso-Muth- Mills, theory of urban structure that assumes an urbanized area with a single central business district (CBD) encircled by four concentric zones (Alonso, 1964; O'sullivan , 2009).The theory assumes that most commuters have to travel from their respective residential locations to the activity centers in the CBD.[2]These stipulations hold significant implications for mode choice based on the concept of time/distance, cost of travel as explained in the next paragraphs.

[2] In the era of polycentricism, the monocentric urban form is not widely applicable. Bearing this limitation in mind, the research uses a monocentric model to keep the analysis simple.

For instance, individuals living close to the central business districts (CBD) with mixed-use developments, walk or use transit because employment centers are close by and transit services are easily accessible (Danyluk and Ley, 2007). On the other hand, workers living in the first-ring suburbs use transit because the distance is short enough for a train or bus ride to employment locations within the CBD.

However, suburban residents live farther from the CBD in areas low transit coverage and frequency of service. In the CBD and central city, departure frequency is spaced in 5-10 minute intervals. However, departures in suburbs span a period of 20 – 30 minutes, which constitutes a long wait for many commuters in a hurry (Dittmar et al., 2004). These long waits motivate suburban dwellers to drive because they have more control over travel time .The option to drive is facilitated by the availability of efficient road networks linking the suburbs to the central city.

The location of the station is also important for assessing susceptibility to gentrification; Chapple (2009) found that neighborhoods in central city areas served by transit are more likely gentrify. This is because locations redeveloped with TOD are mostly located in low-income neighborhoods (Dominie, 2012; City of Los Angeles, 2012). Arising from the aforementioned considerations, the research creates the following dummy variables to account for the influence of location on travel mode and gentrification:

The *CBD* category represents stations in block groups located in a central business district (CBD) of the central city in the MSA. The location of the CBD results from identifying the block groups with highest employment density within the central

city, using the Longitudinal Employer–Household Dynamics (LEHD) data from the Census Bureau (2014).

The *Suburban (terminus)* category represents the last station/s located in block groups with residential land use. The classification of the station depends on the position on the transit route. Land-use mix is predominantly residential, perhaps with some retail and low density office developments.

The Central city category represents stations located in block groups within the central city of the MSA. Central city stations are those with an address within the principal city of the MSA. Because central cities tend to be the main centers of regional activity, the research assumes that a station located in the central city is busier compared with suburban stations (Taylor et al., 2009). In order to avoid errors in analysis station designations are mutually exclusive. Therefore, stations with an address in the Central city are neither suburban nor CBD, and vice-versa.

3.3.1 Regional Variables

Regional variations can also influence the type of mode preferred by commuters (McDonald, 1985; Taylor et al., 2009). MSAs in the Bay Area of California, Northern New Jersey, and Washington, DC, have a high cost of gasoline, congested highways, and high cost of housing. Therefore, households balance transportation and housing costs by using cheap transportation and renting homes close to work (Haas et al., 2006; Glaeser et al., 2007). Conversely, regions with low cost of living (e.g., Northern Texas), cheap gasoline, and an abundance of land to expand encourage commuters to drive more and live farther from work because of the low cost of commute.

3.4 Supporting Independent Variables

3.4.1 Employment Type

This research adds new variables on employment and housing tenure for a more granular analysis. Therefore, the research uses the percentage of workers in Blue-collar employment and White-collar employment. Employment type is important because the research focuses on driving and transit for work trips.

Percentage of workers in Blue-collar employment: The Bureau of Labor Statistics (BLS) defines Blue-collar employment as "the number of hands-on hourly wage professionals who may be skilled or unskilled and may be involved in factory work, building and construction trades, law enforcement, mechanical work or technical installations(Simply Map 2014, metadata)." The decisions to use employment data stems from Tomer et al.'s (2011) and the Istrate, Puentes, and Tomer (2010) studies showing new redistribution income poverty and wealth in central cities. The study also found that employment type influences mode choice for work commute.

White-collar employment: White-collar employment includes the number of salaried professionals such as doctors, lawyers, and engineers as well as employees in administrative, service, industry, retail, outside sales, and clerical positions. (BLS, 2014). Data for White-collar employment is important for the analysis because gentrification results in class upgrading involving income and education attainment; this employment type identifies potential upgrading of neighborhoods.

3.4.2 Length of Residency

Residents since the year 2000: Based on findings from Pollack et al. (2010), this research proposes that new residents who moved into the housing after TOD became operational are responsible for reduced transit use. In brief, Pollack et al., (2010) found that from 2000 – 2010, newer residents in transit served residential areas were less likely to state that they used transit. The research also assumes that individuals who moved to the study area after 1990[3] , are responsible for gentrification in TOD. The research assumes that residents who moved into the TOD since the year 2000 were probably mostly captive riders (Cervero and Duncan, 2002a). However, as the years progressed, the initial transit dependents either became more affluent and started driving more, or experienced displacement by affluent late comers (Lund, 2006).

Number of years thestation has been in operation: Based on the work of Chapple (2009) and Pollack et al. (2010), the research assumes that TODs in close proximity of new stations are more likely to attract more affluent households in the block group who are interconnected with gentrification trends in transit-rich neighborhoods (Pollack et al., 2010). Pollack et al., (2010) noted that transit served areas with developments built between 200 -2010, had a significant number of residents saying that the do not use transit. In addition, Chapple (2009), argues that most transit zones susceptible to gentrify are the ones attracting new developments.Therefore, the research calculates the age of each TOD to assess whether newer TOD (built after 1995) are more likely to gentrify when compared with those built from 1970 -1990. The research assumes that the designs

[3] Which is when newer TODs became operational

modern TOD are intended to support lifestyles of the creative class and nouveau riche (Florida, 2012). Thus, newer TOD serves a middle class interested in high-end housing and community services that are inaccessible to the working class in Blue-collar employment.

Block group population size and density: This variable stems from research showing that densely populated neighborhoods are associated with high transit use (Cervero et al., 2002). Transportation theory indicates that population size and density influences mode choice and ridership (Cervero et al., 2002).

3.5 Research Propositions and Hypotheses

3.5.1 Gentrification Hypothesis

Proposition-1: From 1990-2010, block groups within 0.5 and 0.5-1.0 mile radius of a TOD station have become gentrified with more; expensive housing, white-collar workers, college graduates, affluent households, and lower number of Blacks compared with non-TOD block groups and the MSA. Proposition-1 operates under the assumption that if block groups have experienced gentrification then one outcome could be displacement of low-income, transit-dependent population.

Hypothesis 1: Gentrification and displacement

$H_A > 0$: Demographic and socio-economic shifts in TOD block groups leads to gentrification and displacement, characterized by increase in; housing costs (rent and value), affluent households, in addition to; more White-collar workers, college graduates and fewer, Blacks and Blue-collar workers.

$H_0 = 0$: Demographic and socio-economic shifts in TOD block groups does not bring any changes at all leading to gentrification and displacement of transit-dependent population.

3.5.2 Hypotheses for Mode Choice

Proposition-2: From 1990-2010, block groups within 0.5 and 0.5-1.0 miles radius of a TOD stations experienced increased percentage of workers commuting by car while transit use declined. Proposition-2 operates under the assumption that socio-economic and demographic change in the TOD station block groups is associated with arrival of affluent households who drive the cost of housing up and are less likely to use transit. Thus, the rates of driving are higher within TOD block groups while transit use in non-TOD block groups exceeds TOD rates.

Hypothesis 2: Mode choice (Driving)

$H_A > 0$: Demographic and socio-economic change in TOD block groups results in more workers driving in the study area.

$H_0 = 0$: Demographic and socio-economic change in TOD does not affect percentage of workers choosing cars for work commute in the study area.

Hypothesis 3: Mode choice (Transit)

$H_A < 0$: Demographic and socio-economic change in TOD block groups results in lower percentages of workers commuting with transit in the study area.

$H_0 = 0$: Demographic and socio-economic change in TOD block groups does not affect percentage of workers choosing transit in the study area.

Last proposition 4 states that there is no difference between TOD and Non-TOD. The research predicts similarity in trends for all the key variables such as mode choice, housing values, and rents including demographic and socio-economic parameters.

Hypotheses 4: Differences between TOD and Non-TOD

$H_A \neq 0$: In 2010 demographic and socio-economic characteristics , including mode choice in TOD and non-TOD block groups are not the same.

$H_a \neq 0$: Demographic and socio-economic change in TOD and non-TOD block groups between 1990 and 2010 are different.

$H_0 = 0$: Demographic and socio-economic characteristics and changes, including mode choice in TOD and non-TOD block groups are the same.

3.6 Study Area and Units of Analyses

3.6.1 Study Area

Selecting the study areas required identification of a suitable contiguous geographic area incorporating, the multiple, neighborhoods, zip codes, towns, cities, counties, and states, normally covered by a single transit system. Fortunately, several urbanized regions in the United States plan public transportation under the administration of metropolitan planning organizations (MPO), which coordinate region-wide planning. Therefore, the research uses the MSA as the appropriate Census geography that represents the intersection of regional administration and geographic connections of transit systems.

In order to obtain a reliable list of TOD and non-TOD, the research retrieved data from transit agency websites and Transportation Research Board (TRB) and Transit Cooperative Research Program (TCRP) publications.

This list yielded 252 station areas in six MSAs. One hundred of these are TOD stations, while 152 are non-TOD stations. It is however important to note that identifying an accurate list of TOD is tricky endeavor. Renne (2005, p.6) and Utter (2005) who conducted a similar study noted that of the 3300 stations in the country, only 100 could be categorized as TOD. In addition, finding the exact dates when the TOD went operational was challenging although an educated estimate would identify 2002 as an accurate date for most TOD in this study. Therefore, the research consulted some county appraisal databases and agency websites to retrieve addresses and when the TOD, ad stations became operational. The research also used Google maps and transit agency sites to verify accuracy of the locations.

3.6.2 Unit of Analysis

The units of analysis comprise 4,568 block groups within 0.5 and 0.5-1.0 mile radius of TOD and non-TOD stations in six MSAs (see Table 3-2). Using block groups narrows down geographic boundaries to avoid ecological fallacy (Iceland and Steinmetz, 2003). Broad boundaries such as census tract and zip codes can provide more data but also increases the potential of capturing responses, which are outside the spheres of influence of TOD and non-TOD stations.

The block groups are from the following MSAs and respective transit agencies:

1. Dallas-Fort worth-Arlington (Dallas Area Rapid Transit,-DART),
2. San Francisco-Fremont-Oakland (Bay Area Rapid Transit-BART),
3. Washington, D.C.-Arlington- Alexandria (Washington Metropolitan Area Transportation Authority,-WMATA),
4. Portland–Vancouver–Hillsboro (Tri-County Metropolitan Transportation - TriMet),
5. Miami-Fort Lauderdale-Pompano beach (Metrorail), and
6. New York-Northern New Jersey- Long Island (New Jersey Transit- NJT).

These MSAs own public transit systems, which have been in operation for at least twenty years. Using the time duration of twenty years allows block groups time to mature and experience demographic change. The MSAs should also be applying TOD as specific policy intervention for supporting a sustainable transportation system. Although the research endeavored to include MSAs in all regions of the country, the final list only had transit systems in the West, South, and East of the country. Table 3-2 provides a brief data profile for the study areas.

Table 3-2 Data profile of study areas

		Block group type		Block group distance		
		NO TOD	TOD	One Mile	Half Mile	Total
State	CA	626	661	946	341	1287
	DC	769	134	675	228	903
	FL	239	158	290	107	397
	MD	166	95	193	68	261
	NJ	171	241	310	102	412
	OR	245	182	320	107	427
	TX	353	210	405	158	563
	VA	138	180	222	96	318
N		2707	1861	3361	1207	4568

3.6.3 Data Extraction

The next task was to extract the data from block group centroids within 0.5 and 0.5-1.0 mile radius of a TOD and non-TOD station. The blcoks groups should be those that have had a potential to gentrify.

The research adopted 0.5 – 1.0 mile radius using the concept of proximity, walkable and bikeable distance. The term *proximity* refers to the real distance to facilities and services, from end users who need to have reasonable access with the most readily available means of transportation (Calthorpe, 1993). Transportation planners consider a location accessible if it is reachable by walking within 15-20 minutes. This distance can cover up to 0.5 miles from origin to the destination depending on the normal walking speed of an individual. The Nationwide Personal Transportation Survey (NPTS, 1983. pp. 35 - 38)[4] found that 70% of Americans walk 500 feet for daily trips; 40% are willing to walk up to 1,000 feet; and 10% are willing to walk a distance 0.5 miles. Other scholars have also found most Americans are willing to walk 15 minutes to a destination

[4] Now called The National Household and Transportation Survey

(Alshalalfah and Shalaby, 2007; Schlossberg, Weinstein, Agrawal, Irvin, and Bekkouche, 2007).

Based on these studies, this research uses the distance of a 0.5 mile radius to determine basic distance for transit accessibility and proximity. However, the research extends this distance to 0.5-1.0 miles under the assumption that TOD influence (transit shade) can reach up to 1.0 miles for persons biking or using bus connections. Scholars including Guerra, Cervero, and Tischler (2012) and Chatman (2013) have explored the idea of extending TOD service areas.

A popular method for measuring proximity is by creating buffer zones around a point then measuring the radial distance or straight-line distance from center to circumference (Anjomani, 2012, p.18). The research accomplished this task by drawing a straight line from the geocoded station address point to the surrounding block group centroids within , say, a radius of one-mile or half mile. Next, the centroids within the specified radius was isolated from the original topologically integrated geographic encoded and referenced (TIGER) shape file to create a new layer for further processing.

This straight-line method is conducive because it enables the research to include as many block groups as possible within 0.5 and 0.5-1.0 mile radius from a TOD and non-TOD address to a block group centroid. The centroid is a point used in trip generation stage of travel demand analysis. Transportation planners assume all trips originate from a centroid of a traffic analysis zone (Ortúzar and Willumsen, 2011, Pp. 130- 131). A zoning system is used to aggregate individual households into equally sized traffic analysis zones (TAZ). Zones (in this case block groups) are represented in the (GIS)

models under the assumption that, zone attributes and properties are concentrated in single point called the zone centroid. The zone centroid is best thought of as, floating in space, and not physically on the map (Ortúzar and Willumsen, 2011, p.131).

While this approach is not error free, using the centroid ensures that the researcher is capturing the largest portion of data points within a study area (Dominie, 2012; Renne, 2005). Other methods used in spatial analysis may include calculating the ratio of the area within the unit of analysis with a weighted average. However, ratios add weights and values to data points, which may increase the margin of error. The research experimented with these methods but found the results rather unreliable and inconsistent with general trends in demographic change.

3.6.3.1 Method of Extraction

Data extraction began by joining the 1990 census data tables with normalized boundaries to the Census Bureau's TIGER shape files for 2010 block groups. The research used normalized block group boundaries to even out changes made to block group boundaries at every decennial census. Normalization is a process in spatial analytics that transform geographic census data (from different decennial censuses) into uniform geographic boundaries. Next, the research projected the shape files into the North America Albers Equal Areas Conic system. This coordinate system enables the research to use metric units to measure distances of 0.5 and 0.5-1.0 mile radius.

Following projection, the point distance tool for spatial analysis was applied to generate a distance table with all data points within 0.5 miles and 0.5 -1.0 miles radius from the block group centroid to the geocoded station address. The final product was a

database table with information from 4,568 block groups in six MSAs ready for input into SPSS Statistics. Figure 3-2 presents a simple GIS map showing buffer zones within 0.5 miles and 0.5-1.0 miles radius from the block group centroid to station address.

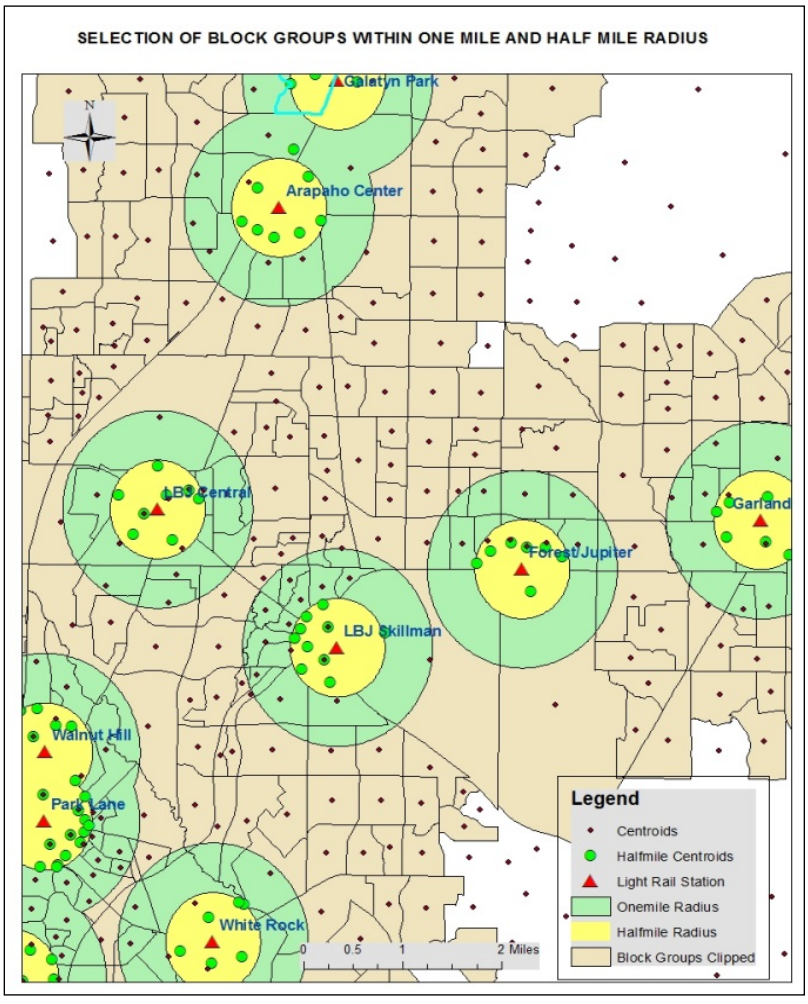

Figure 3-2 Selection of block groups—1.0 mi. radius, TOD and non-TOD

3.6.4 Classifying Station Types by Location and Employment Density

Following data extraction, the next step was to classify station types with ArcGIS using employment density, and geocoded address of stations. The result are three station

typologies: CBD, Central City, and Suburban (terminus). The next section discusses the process of classification and data analysis in detail.

Before proceeding with categorization, there were three issues requiring consideration. First, some studies use population density to identify the CBD (McDonald, 1987). However, as McMillen and Lester (2003) point out, this approach can cause errors because a residential area can be denser than the CBD. Therefore, McMillen and Lester (2003) recommend using employment density as a key parameter to determine the location of the CBD instead of using population density alone.

Secondly, each region exhibits variations in employment densities. For example, the research determined that densities in the Dallas metropolitan area at an average of 500 jobs per square mile, while the Washington, DC averages approximately 5,000 jobs per square mile. This implies that for each region, classification of a block group as part of the CBD is contingent upon regional uniqueness in density. Therefore, the research separately identified the CBD based on the unique employment density of individual MSAs.Last, some blocks in the CBD are also located within the Central City.

Therefore, these blocks could have two classifications: CBD or a Central City. In such cases and to minimize errors, the research endeavored to allocate the station to one classification by selecting only stations in block groups that are roughly within two miles radius of the designated CBD. Any station that is designated as CBD is not part of the Central City category and vice versa. This ensures that the stations classifications are mutually exclusive to make it easier to create dummy variables for analysis.

3.6.4.1 Approach for Station Categorization.

Identification of CBD began with downloading employment data files from the Census Bureau's Longitudinal Employer-Household Dynamics (LEHD) database and the LEHD Origin-Destination Employment Statistics (LODES) database. Next, ArcGIS was used to join block shape files to the origin and destination (OD) data files from LODES. The joined block shape file and OD data tables were converted to a raster file. This made it possible to calculate points with highest density using the Kernel Density tool. The Kernel Density tool is a built-in function of spatial analyst in ArcGIS.

Using the Kernel Density tool, the research identified points with highest number of jobs per square mile, which was designated as the CBD. The final step was to join the shape files to geocoded station address to enable identification of the station by name and verify if the station is part of a TOD or non-TOD block group. The final product is a *heat map* symbolized to show different gradations of employment density by color.

Figure 3-3 illustrates the location of the employment center within Washington, DC metropolitan area. In this case, the areas (dark brown) around the Archives and Federal Triangle stations had the highest density of approximately 7,000 jobs, per square mile.

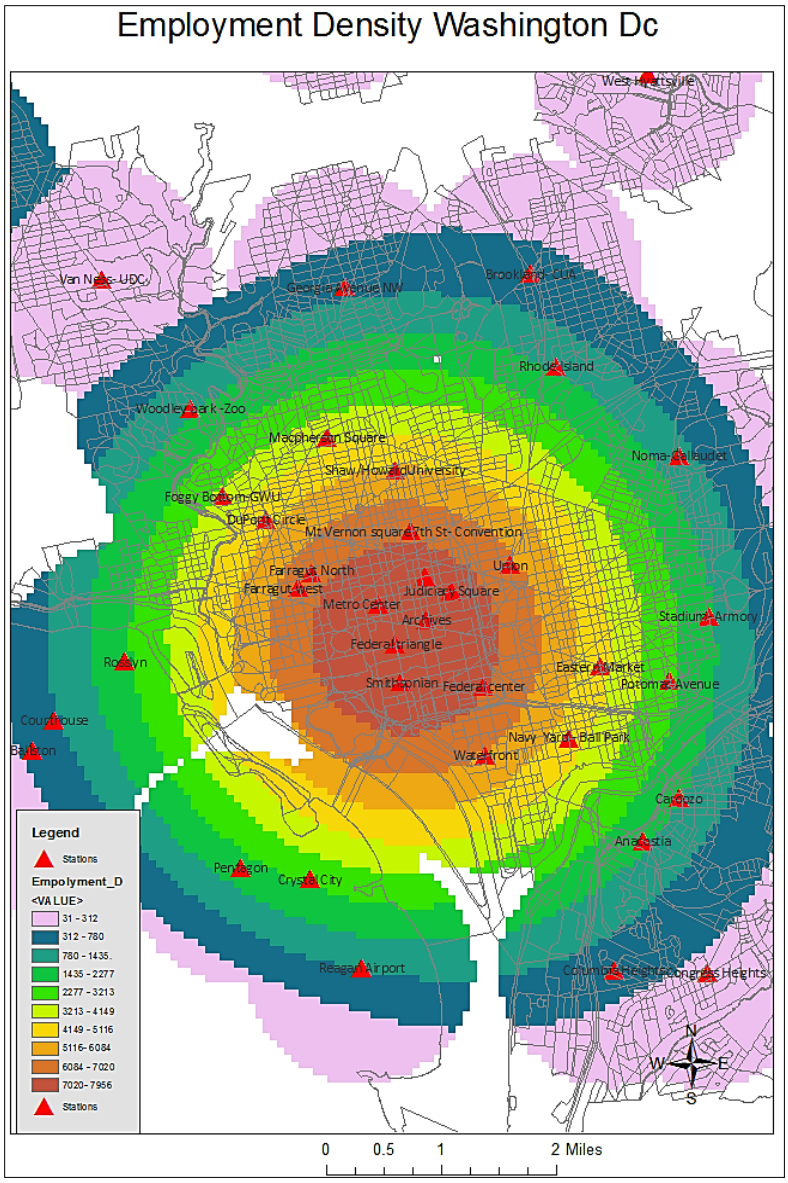

Figure 3-3 CBD stations in Washington, DC, MSA (LEHD, 2010)

Categorizing the Central city station was achieved by using the geocoded addresses and transit system maps. Finally, the Suburban (terminus) station category is identified by consulting the transit system map. This category includes the last station or stations located in a suburban area with predominantly residential land use. The research

used land use maps to verify that area had mainly residential housing. The eventual products are three dummy variables for each of the categories:

1. Central Business District station (CBD)
2. Central city stations (located in the Central city within the MSA)
3. Suburb (final station or stations along a rail line located in a predominantly residential area)

3.6.4.2 Regional Variables

To account for possible variations by region, the research developed the following dummy variables in SPSS :

1. San Francisco-Oakland-Fremont MSA and Portland-Vancouver-Hillsboro – WEST
2. Dallas-Fort worth-Arlington-Plano and Miami-Fort Lauderdale-Pompano Beach — SOUTH
3. Washington DC-Arlington –Alexandria and New York-Northern New Jersey-Long Island – EAST (this is also the reference category)

Figure 3-4 summarizes the methodology used in data collection, extraction, and processing.

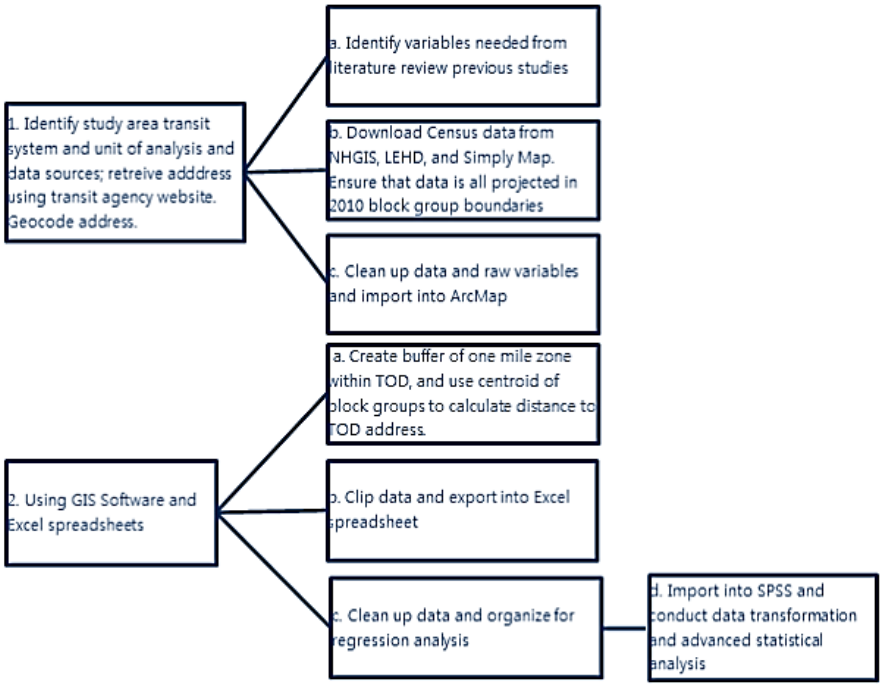

Figure 3-4 Data collection and analysis

3.6.5 Data Processing

In SPSS, data transformation and coding involved creating dummy variables for TOD and non-TOD stations in addition to a station dummy variable based on distance and location. The next data transformation entailed converting the dollar amounts (rent, income, and housing) into 2010 current dollars using the Consumer Pricing Index from the Bureau of Economic Analysis (BEA). The research also used SPSS to calculate the percentage difference for variables by subtracting the 1990 values from 2010. For rent, income, and housing values, change in values is a calculation of percentage change. For future studies, the researcher intends to use percentage change for all variables and absolute values in regression analysis.

3.6.6 Data Analysis

Data analysis proceeded with the assumption that after 20 years of operation, TOD policy might create unintended consequences such as; gentrification, and increased commuting by driving while commuting with public transportation declines. Furthermore, twenty years is also an ideal period because affordable housing policy covers a period of 15 years (Wise and Scire, 2009), which means that this research is using data at the most opportune moment. The first step involved developing descriptive statistics with comparison of means to identify the difference between TOD, non-TOD, and MSA block groups. Next, the research conducted a correlation analysis to evaluate the relationships between variables and identify potential for multi-collinearity. Finally, the research ran linear regression models to develop predictive models for gentrification and mode choice.

The approach to data analysis extends previous studies by using different but not exclusive methodology as follows. First, the research uses normalized block group data (1990-2010) that narrows down the sampling frame as compared with some studies (e.g., Dominie, 2012; Kahn, 2007; Renne, 2005) which employed census tract data. Secondly, the research compares TOD to non-TOD block groups in both 0.5 and 0.5-1.0 mile radius.

Previous research on gentrification and mode choice only compares TOD with MSA, which this research considers insufficient because of differences in geographic scale. Finally, the research incorporates new variables such as the year residents moved into their home, change in employment type, and age of the TOD. Table 3-3displays a list of data sources.

Table 3-3 Data sources

Agency	Abbreviations	Data type
American Public Transportation Association	APTA	Ridership & mode choice reports
U.S. Bureau of Economic Analysis	BEA	Consumer pricing index
U.S. Bureau of Labor statistics	BLS	Definitions on employment
Center for Transit-Oriented Development	CTOD	List of TOD and Non-TOD stations
County Appraisal Districts	CAD	Years Stations and TOD were built
Federal Transit Administration	FTA	Transportation policies and programs
U.S. Energy Information Administration	EIA	Gas prices and VMT
Google Maps & Earth	Google	Addresses and Coordinate API
Minnesota Population Center (National Historic GIS)	NHGIS	MSA data
National Household and Travel Survey	NHTS	Ridership & mode choice data
National Transit Database	NTD	Ridership & mode choice data
SimplyMap Database	SimplyMap	Normalized census data & boundaries
Transportation Research Board	TRB	List of TOD and Non-TOD stations
Transit Agencies		Station type, name, addresses, &maps
U.S. Census Bureau	Census Bureau	Census data & GIS TIGER files

Chapter 4

Descriptive Statistics

This chapter presents results from data analysis for block groups within 0.5 and 0.5 - 1.0 mile radius of TOD and non-TOD stations. The chapter begins by presenting charts and tables comparing TOD with MSA, followed by comparisons of TOD with non-TOD block groups. Overall, the data in the next section reveals that TOD block groups have a lower percentage of workers using transit compared with non-TOD-block groups. Conversely, non-TOD block groups retain a lower percentage of workers driving compared with TOD. Furthermore, the percentage change in housing costs, education attainment, and median income in TOD block groups exceed rates within non-TOD block.

These observations support findings from previous studies demonstrating that socio-economic and demographic change in TOD is associated with the occurrence of gentrification and declining transit ridership (Dominie, 2012; Pollack et al., 2010). However, the findings vary depending on region and transit system, as presented in the next section.

4.1 Comparing TOD and MSA (2010)

The presentation of descriptive statistics begins with an examination of block groups with TOD compared with block groups in the Metropolitan Statistical Area (MSA) using 2010 data. For ease of presentation, the names of the MSA and respective transit system are in short form as follows:

i. San Francisco-Oakland-Fremont, MSA (Bay Area- Bay Area Rapid Transit — BART)

ii. Dallas-Fort Worth-Arlington, MSA (DFW- Dallas Area Rapid Transit — DART)

iii. Washington DC-Arlington (VA) -Alexandria (MD) - West Virginia, MSA (DC-VA-MD, Washington Metropolitan Area Transit Authority —WMATA)

iv. Miami-Fort Lauderdale-Pompano Beach, MSA (Miami — Metrorail)

v. New York-Northern New Jersey-Long Island, MSA (Northern NJ, New Jersey Transit — NJT)

vi. Portland-Vancouver-Hillsboro, MSA (Portland -Tri-county Metro Area Transit —TriMet)

The research will also occasionally use the name of the principal city in the analysis to generally refer to the entire MSA.

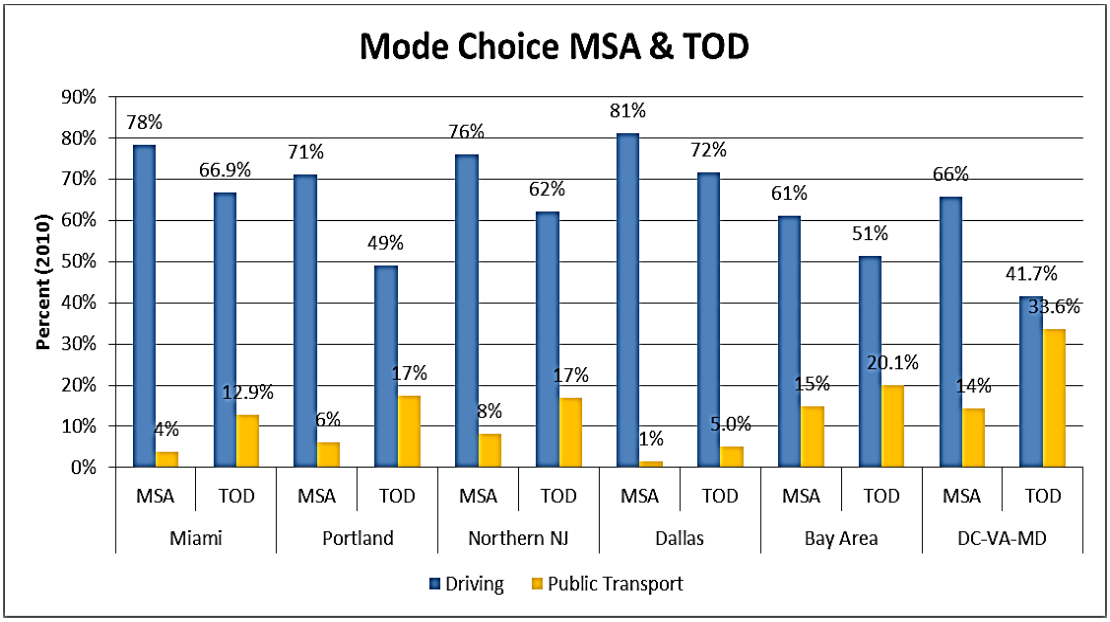

Figure 4-1 Driving and transit MSA and TOD—BG, 1.0-mi. radius (2010)

Figure 4-1 reveals that in 2010, more workers in TODs chose public transportation compared to all workers in the MSAs. Not surprisingly therefore, the MSAs had more workers driving compared to the TOD. Dallas and Miami MSAs had the lowest percentages for transit use as well as the highest percentage for workers driving. However, Washington DC and Bay Area registered the highest transit usage in the MSA and TOD. This is possibly because San Francisco Bay Area and Washington, DC have high cost of living and traffic congestion, which encourages transit use. On the other hand, Dallas Fort worth MSA has low gas prices, and traffic congestion, which encourages driving.

However, it is surprising that the San Francisco Bay Area TOD only surpassed the Bay Area MSA by approximately 10% for transit and driving. The research was expecting a difference greater than 10 % between TOD and MSA, because BART has a

robust public transportation program reaching out to communities by offering various incentives for transit riders (Cervero et al., 2004).

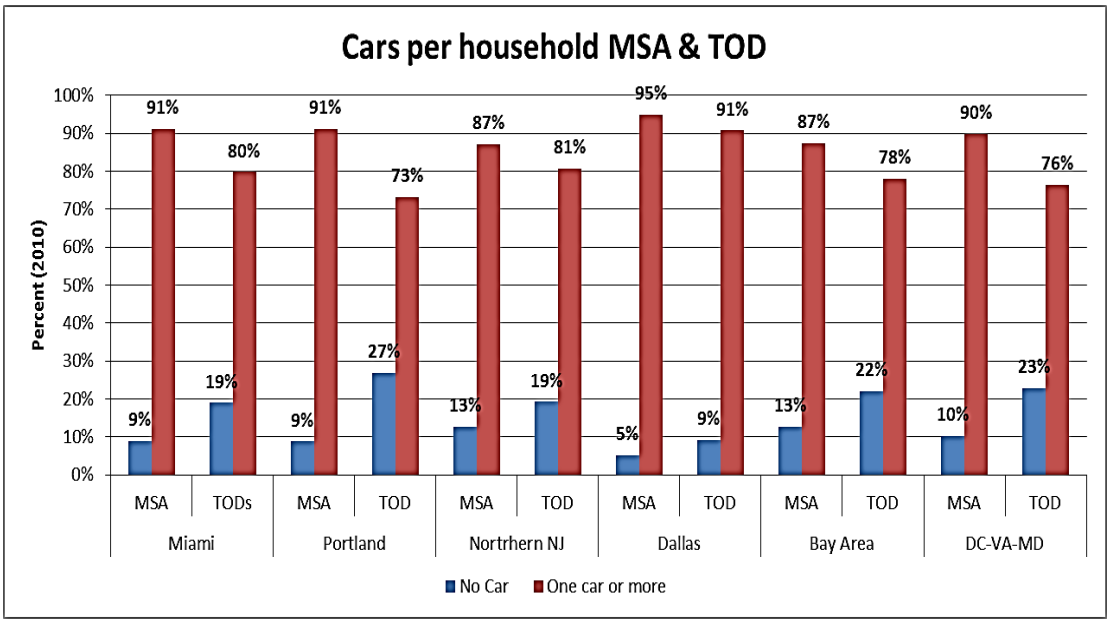

Figure 4-2 Cars per household MSA & TOD—BG, 1.0 mi. radius (2010)

Figure 4-2 reveals that in 2010, TOD block groups had more households with no cars and fewer households with one car or more, compared to the MSA. These results support previous findings from research such as Glaeser et al. (2007) and Cervero et al. (2004) showing that transit-dependent population comprising low-income households with no cars are concentrated around station areas.

One of the key assumptions this research makes is that gentrification predominantly an outcome of expensive housing, which excludes low-income working class residents. Therefore, Figure 4-3 presents data comparing median housing values in TOD block groups and MSAs.

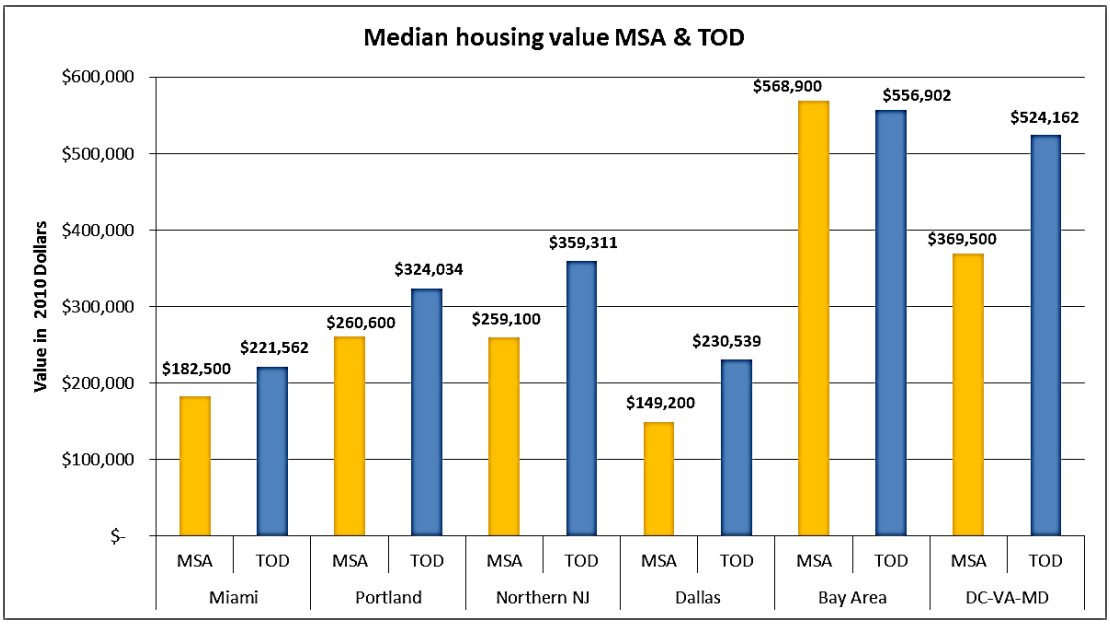

Figure 4-3 Median housing values MSA and TOD—BG, 1.0 mi. radius (2010)

The data indicates that in 2010, median housing values for TOD block groups surpassed MSA averages with the exception of the BART. These results corroborate findings from previous studies showing that housing in close proximity to TOD have higher prices compared with the MSAs market rates (Damm, Lerman, Lerner-Lam and Young, 2007). Interestingly, while TriMet (Portland) has a policy that supports affordable housing in TOD (Cervero et al., 2002, Cervero et al., 2004), TOD block groups retained higher housing values, compared to the MSA. This is probably because the urban growth boundary has limited the options available to develop new housing within the City of Portland. This policy could potentially lead to high cost of housing (Myung-Jin, 2006). Limited land supply is linked increase in property rents because of constricted land supply to meet demand for new housing (O'Sullivan, 2009).

However, the above observations could also mean that demand for TOD housing is high in Portland because of the strong transit culture within the city. The 2010 data indicates that households in TOD block groups (except Miami) were on average more affluent compared to households in the MSA (Figure 4-4).

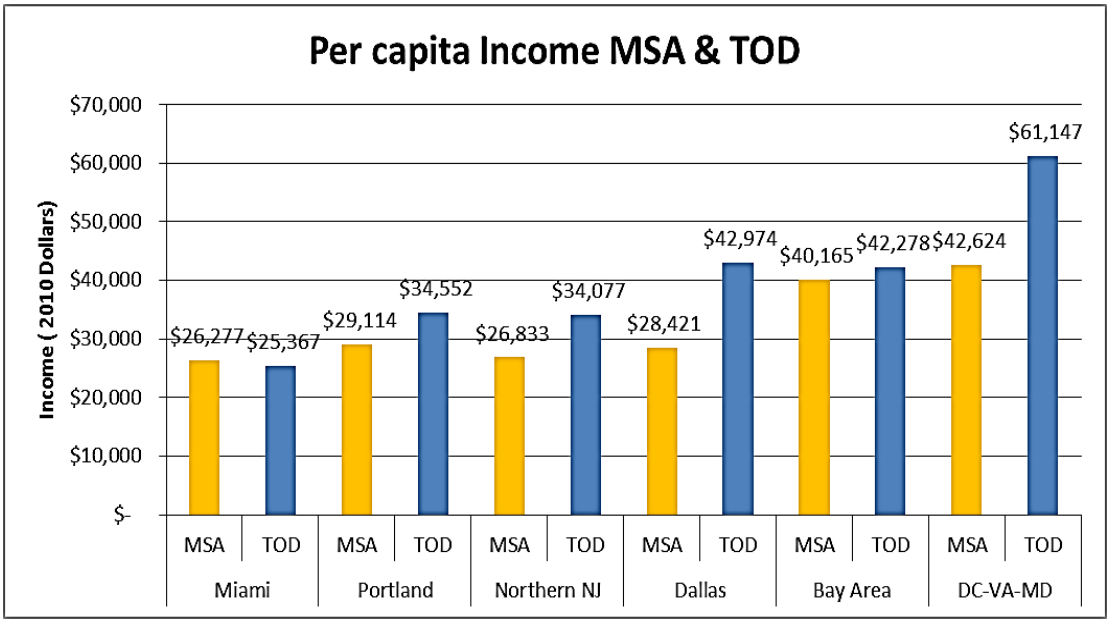

Figure 4-4 per capita income—MSA & TOD block groups, 1.0 mi. radius (2010)

The above finding suggests that TOD block groups have become enclaves of wealth. It is indeed remarkable that residents in transit served neighborhoods are prospering after decades of capital flight (Freeman, 2005). However, these neighborhoods can become outposts for re-colonization and displacement of transit-dependent households (Pollack et al., 2010). The revanchist moves the new middle class lose perhaps a taking back of ground in the 1960s to minority groups. A case in point is the Mockingbird district in Dallas, which is the epitome of revalorization and possible privatization of public space.

The neighborhoods around Mockingbird station appear to cater to the upper middle class frequenting the upscale Knox-Henderson entertainment district. Yet, the imagery and price of access offered by upscale establishments can alienate working class citizens who find the experiences unaffordable. The meanings embedded in the design of TOD require reimagining keeping public space widely accessible and vibrant. Wong, 2014, makes a similar observation while investigating the city of San Francisco's parks and recreation centers frequented by the Bay Area's creative class from Silicon Valley.

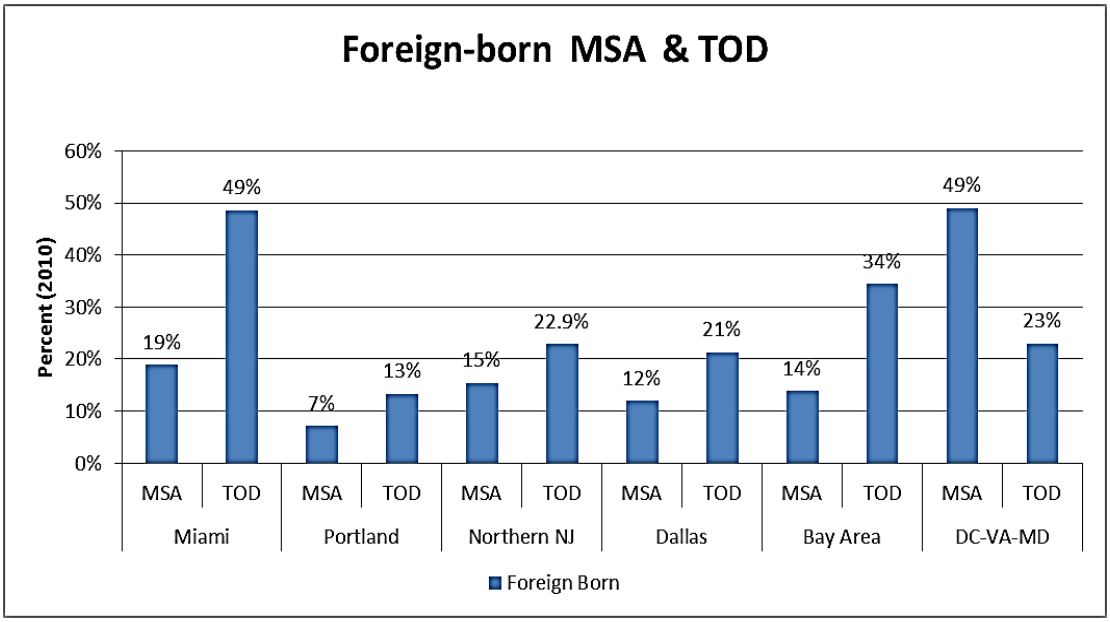

Figure 4-5 Foreign-born population—MSA and TOD, 1.0-mi. radius (2010)

Figure 4-5 indicates that, in 2010, the percentage of foreign-born residents in TOD exceeded the MSA numbers. Foreign-born individuals and especially new immigrants tend to patronize transit more than local population (ACS, 2009). In concurrence with the foregoing, DC-MD-VA, MSA have a higher percentage of foreign-born population . The region hosts several embassies and international organizations

which might attracts a number of immigrants and expatriates using the services or working in the MSA.

Finally, Figure 4-6 reveals that the percentage of the White population surpasses that of Blacks in both the TOD and MSA block groups. Washington, DC MSA registers the highest percentage of Black population, while Miami and Washington, DC TOD block groups show highest percentage of Black population. Moreover, the population size for Blacks exceeds that of Whites, in the Washington DC MSA.

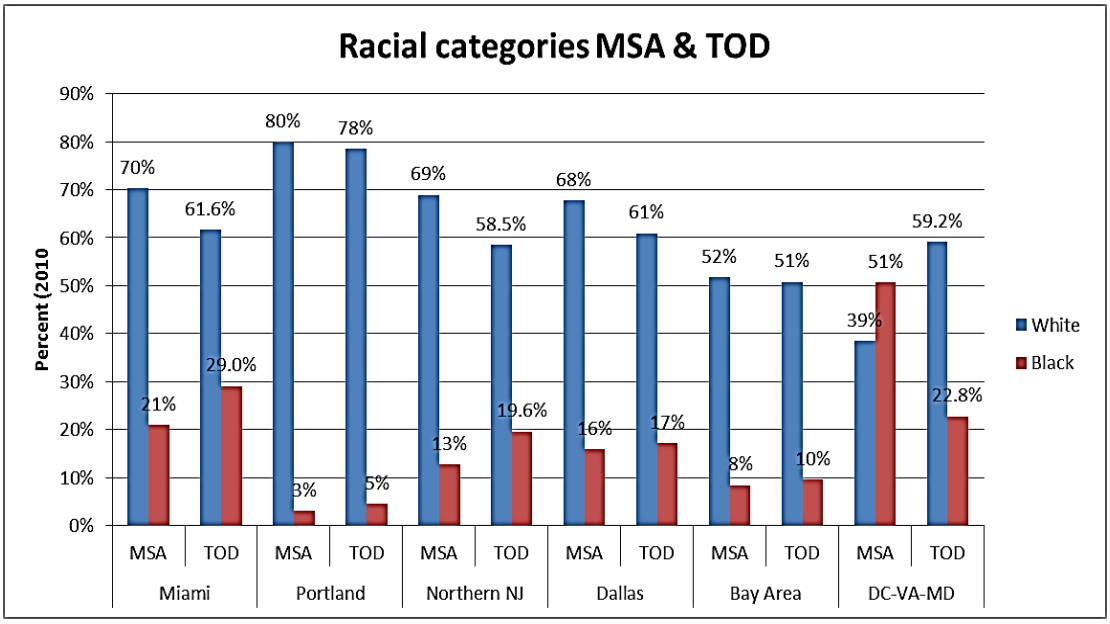

Figure 4-6 White and Black Population—MSA and TOD, 1.0 mi. radius (2010)

Figure 4-6 also reveals that racial representation in TOD block groups reflects the approximate demographic representation in the country; suggesting that there are no significant disparities in equitable accessibility. Moreover, White representation in the TOD is far below the normal proportions. This observation is important for this research because we use the percentage of Black population as a proxy for low-income transit

dependent population (TDP). Therefore, the data in Figure 4-6, suggests that some categories of TDP do in fact have reasonable access to transit.

4.1.1 Comparison of Means in MSA and TOD

The previous section offered a descriptiveoverview of differences between the MSA and TOD block groups. However, it is premature to draw conclusions regarding the differences between MSA and TOD without further verification with comparison of means. Table 4-1 displays results from the comparison of means between MSA and TOD. The data reveals significant differences between MSA and TOD block groups for all variables except median income. Most importantly, the rents and housing values are higher in TOD by an average of 10%.

Table 4-1 Comparison of means MSA and TOD —BG, 1.0 mi. radius (2010)

VARIABLES (2010)	MSA block groups		TOD block groups(one mile)		
	Mean	N	Mean	N	Sig.
% Foreign-born	19.3	12809	27.0	1861	.000***
% White	65.6	12809	56.0	1861	.000***
% Black	15.7	12809	19.1	1861	.000***
% Asian	9.2	12809	16.6	1861	.000***
% Drove	69.0	12791	50.1	1861	.000***
% Transit	10.6	12791	22.5	1861	.000***
% Bike	0.9	12791	2.6	1861	.000***
% Walk	0.4	12791	10.1	1861	.000***
% College graduates	36.9	12807	40.3	1861	.000***
% Owner occuppied HH	62.9	12785	38.8	1861	.000***
% Renter occuppied HH	37.1	12785	61.1	1861	.000***
Median contract rent (2010 $)	1105	11076	1171	1861	.000***
Median income (2010 $)	71445	12772	70404	1861	0.617
Median housing value (2010 $)	398698	12311	411311	1861	.000***
p ≤ 0.01(*) .001(**) .000(***)		*N= 12311*		*N= 1861*	

This finding suggests that block groups within stations areas have unaffordable housing, which could exclude lower-income transit-dependent population. However, due

to the high percentage of minorities and foreign-born the research cannot draw conclusions about gentrification because we cannot establish causality and associations among the variables. This will require regression analysis and correlations to make definite inferences.

4.2 Comparing TOD and non-TOD Stations for 0.5 Mile Radius

Having observed the broad differences between MSA and TOD block groups, the research now proceeds to a narrower and more realistic comparison between TOD and non-TOD station area block groups. The research conducts a comparison between TOD and non-TOD block groups within 0.5 miles of transit stations. With the exception of TriMet and NJT, the percentage of commuters using transit is higher in non-TOD block groups compared with TOD (Figure 4-7). In addition, the percentage of commuters driving is higher in TOD block groups when compared with non-TOD.

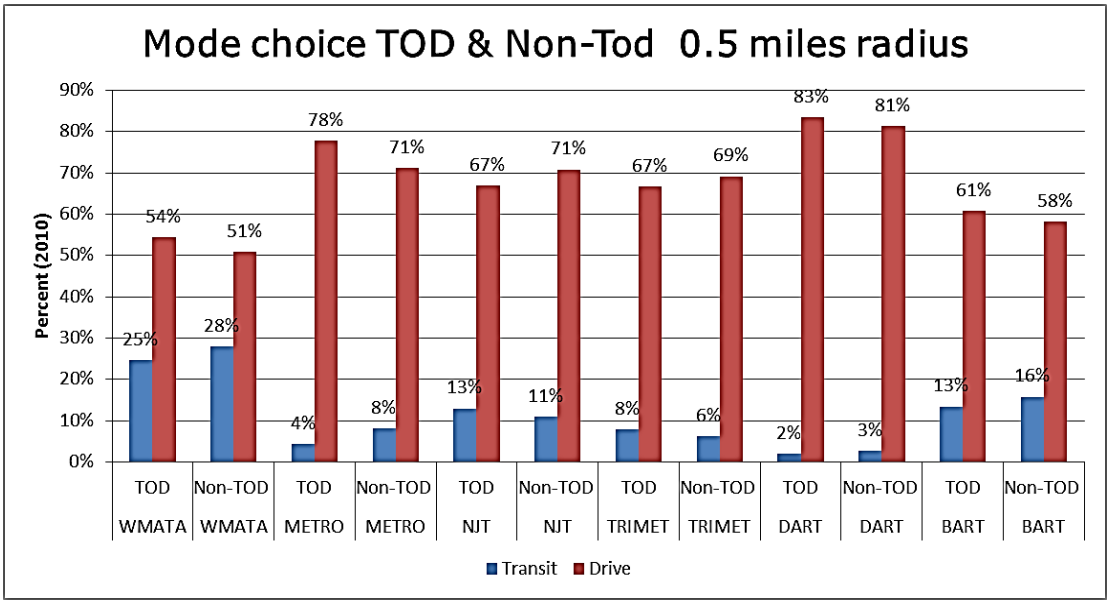

Figure 4-7 Transit and driving TOD and non-TOD —BG, 0.5-mi. radius (2010)

These observations suggest that the use of TODs are equally as effective in improving mode choice compared with a lone station with good accessibility. However, it is possible that some of the non-TOD block groups have transit joint developments (TJDs), which may improve mode choice to TOD levels. Except for NJT and BART, Figure 4-8 indicates that non-TOD block groups contain a higher percentage of households with no cars compared with TOD block groups. Only the TriMet TOD and non-TOD block groups, showed equal percentages for households with no car. The observation that non-TOD household have few cars raises questions regarding the exclusivity of TOD policy in reducing vehicle use when it does not show marked difference from non-TOD. Coupled with data from previous section, the results suggest TOD policy may not be unique in discouraging car ownership and reducing vehicle miles traveled when compared with non-TOD.

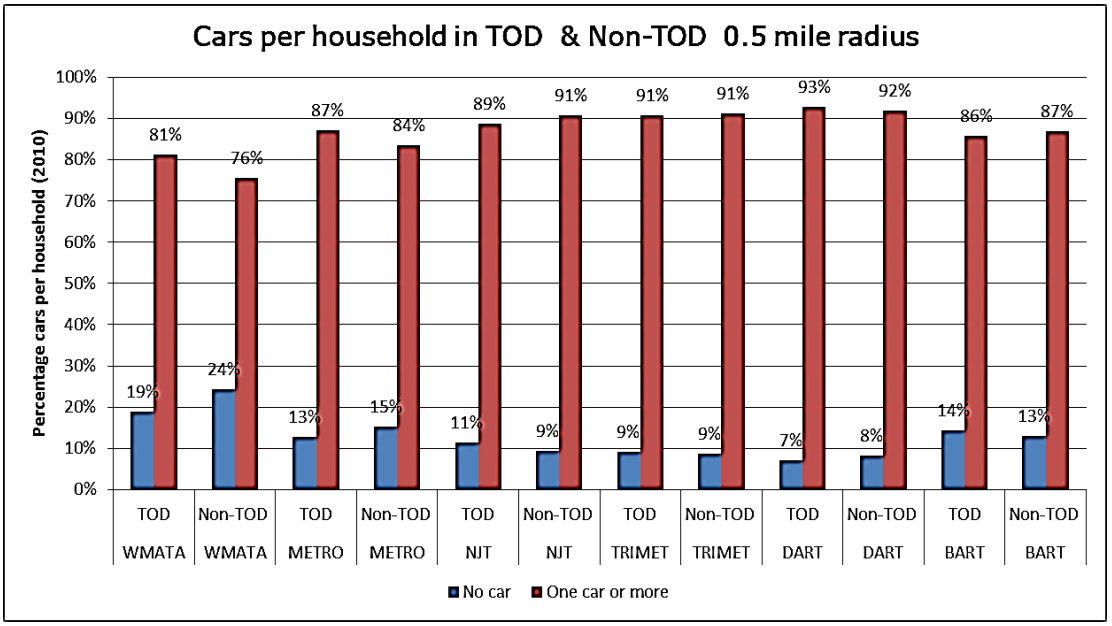

Figure 4-8 Cars per household TOD and non-TOD —BG, 0.5-mi. radius (2010)

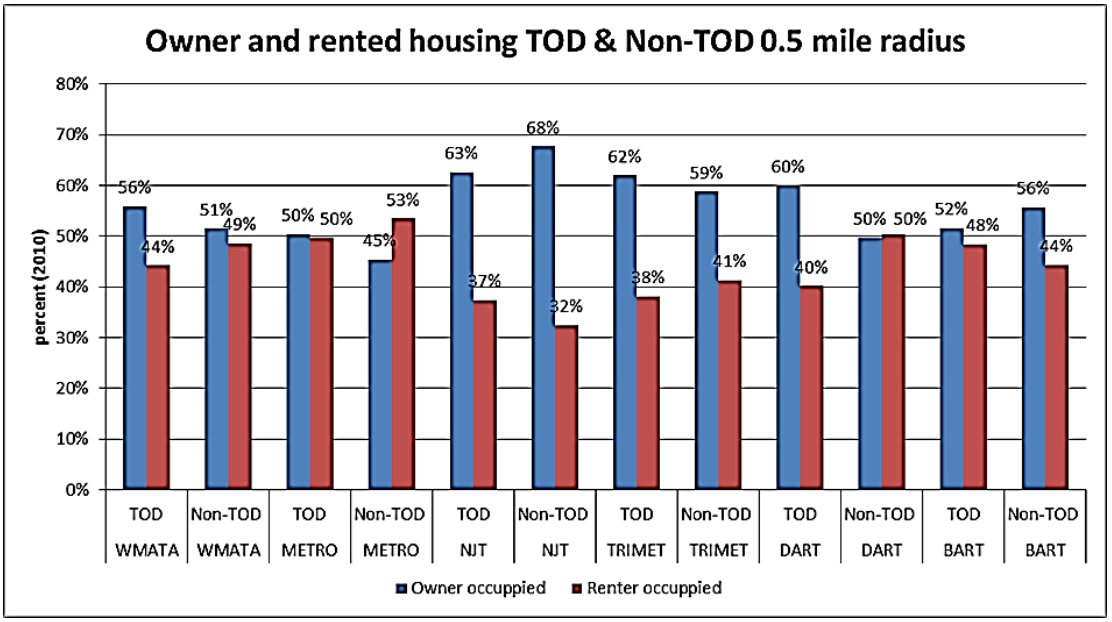

Figure 4-9 Occupancy type—TOD & non-TOD block groups, 0.5 mi. radius (2010)

Except for BART and NJT, Figure 4-9 reveals that a significant percentage of homes in TOD block groups are owner occupied when compared with non-TODs at 0.5

miles radius. The high percentages for owner-occupied homes in TOD suggests a significant number of households with incomes above that of transit-dependent population. Excluding BART and NJT, non-TOD block groups show slightly higher percentages for renter occupied housing within 0.5 miles, when compared with TOD at 0.5 miles radius. This is an interesting finding when compared with data in Figure 4-10. The results shows that the BART and NJT TODs are the only ones with rent lower than Non-TOD and lower percentage of renters, when compared with the other MSAs. The connection between BART and NJT occupancy rates and low rent values, possibly explains why the non-TOD block groups exhibit lower percentages of renters.

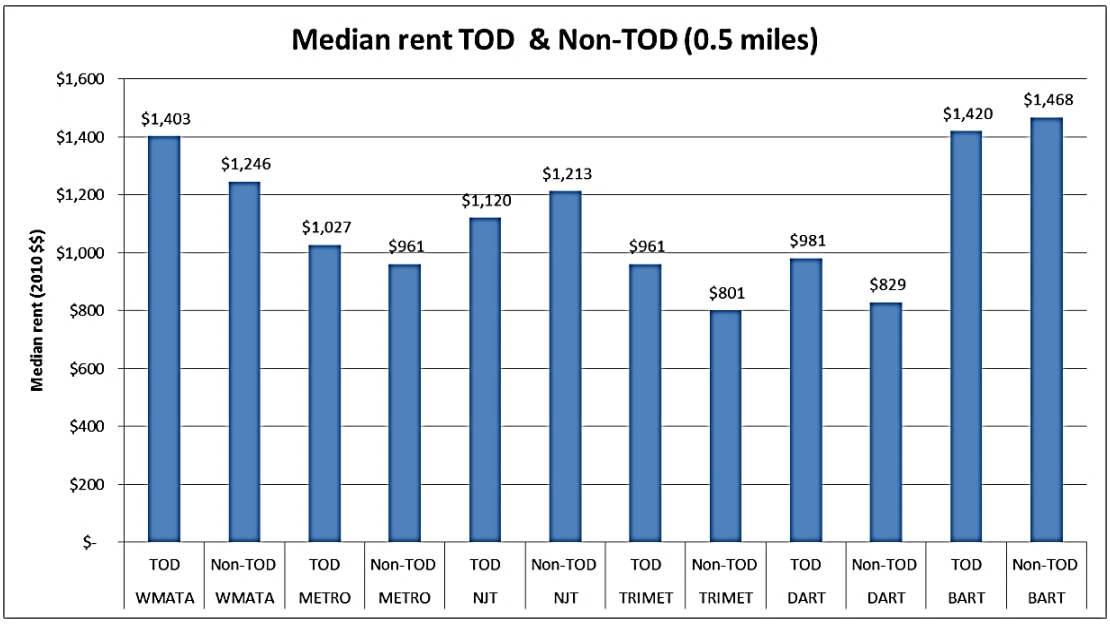

Figure 4-10 Median rent—TOD and non-TOD block groups, 0.5 mi. radius (2010)

4.2.1 Comparison of Means for TOD and non-TOD in 0.5 Mile Radius

It is often challenging to make accurate conclusions regarding differences between comparison groups using only tables, charts, and graphs. Fortunately, statistical

analysis offers the comparison of means to validate significant differences between comparison groups. Therefore, the research ran a single sample comparison of means in SPSS. Table 4-2, reveals that the percentages for households with one or more cars, are higher in TOD block groups, whereas non-TOD areas average higher percentages of households with no car. Consequently, the percentage of workers using transit is higher in non-TOD block groups compared with TOD block groups.

Table 4-2 Comparison of means—TOD & non-TOD, 0.5-mi. radius (2010)

Variables 0.5 miles (2010)					
Variables	Non-TOD (block groups)		TOD (block groups)		Sig.
	Mean	N	Mean	N	
% No car	29.54	699	21.55	508	.000***
% One Car	40.82	699	45.72	508	.000***
% Two cars or more	29.49	699	32.53	508	.001***
% Transit	25.98	699	22.92	508	.002***
% Driving	45.78	699	51.53	508	.000***
% College graduate	38.43	699	42.28	508	.007***
% White-collar employment	65.06	699	67.78	508	.048**
% Blue-collar employment	13.86	699	12.70	508	0.161
% White	52.84	699	58.19	508	.000***
% Black	22.76	699	16.41	508	.000***
% Foreign-born	11.57	699	11.55	508	.000***
% Asian	29.06	699	27.86	508	0.276
% Owner occupied housing	36.71	699	30.26	508	.000***
% Renter occupied housing	63.15	699	69.54	508	.000***
Median Rent (2010 $)	1123	699	1209	508	.002***
Median housing value (2010 $)	381301	680	423949	487	.004***
Median household Income (2010 $)	65782	698	71880	507	.009***
Per capita income (2010, $)	40464	698	43701	507	.031**
p ≤ 0.10 (*) .05(**) .01(***)	Total N = (699)		Total N = (508)		

These differences support the research proposition stating that TODs have a lower transit use compared with non-TODs. In addition, the data indicates higher percentage for driving in TOD block groups compared with higher percentage for transit use in non-TOD block groups. The data also reveals a higher percentage of Whites in TOD (58%) compared to 52 % for non-TOD. On the other hand, the percentage of Blacks are 7% higher in non-TOD compared to TOD. These results suggest that Blacks might not have access to TOD because they cannot afford rents closer to transit stations. Belzer et al.

(2006) and Pollack et al., (2010) found that costly housing in transit served neighborhoods excludes low-income transit dependent population. Nonetheless, the comparison of means for racial categories reflects the approximate demographic representation for African Americans in the country. Therefore, the research cannot claim at this point unequal accessibility based on racial representation. Belzer et al. (2006) noted that TODs are some of the most diverse neighborhoods in the country.

The data indicates that housing values, rents, and income are, on average, higher in TOD block groups when compared with the non-TOD block groups. Furthermore, individuals with White-collar jobs also register slightly higher percentages in TOD block groups, while workers in Blue-collar employment show lower percentages compared with non-TOD at 0.5-mile radius. TOD block groups also show a higher percentage for college graduates. However, the percentage of owner-occupied housing is higher in non-TOD block groups compared with TODs. This result also makes it uncertain to claim imbalances in housing accessibility at this point in the analysis; still, most results within 0.5-mile radius, including the descriptive statistics in the previous section, appear to reinforce the research hypotheses that presence of TODs could be associated with unintended consequences (e.g., high costs of housing, more driving) compared with non-TODs.

Based on these observations, the research rejects the null hypothesis-4 stating that there is no difference between TOD and non-TOD block groups within 0.5 mile radius of a transit station. The research also rejects null the hypothesis -1, stating that the presence of TOD does not cause gentrification.

4.3 Comparing TOD and non-TOD 0.5-1.0 Mile Radius

The charts and tables in this section present data extracted from block groups within the 0.5 - 1.0 miles radius of TOD and non-TOD stations. The purpose of adding data from the 0.5-1.0 mile radius is to control for any spurious effects observed at 0.5 miles radius. A secondary objective is to determine whether TOD and non-TOD stations show similar results for mode choice and housing affordability beyond the traditional 0.5 miles radius. These findings could offer supporting evidence regarding the extension of the TOD service area to a 1.0 mile radius. Most researchers focus on the 0.5 miles radius because it is considered the standard walking distance for the average American (Alshalalfah and Shalaby, 2007; Cervero et al., 2002). However, this research proposes that some potential transit riders such as students would bike or ride a bus to a station up to one mile. This implies that the TOD service area can expand to meet latent demand up to 1.0 mile from the rail station. The data presented in this section is intended to strengthen the research recommendation regarding the extension of TOD service areas. The presentation begins with results on mode choice because it is a key area of interest for the extension analysis.

At 0.5-1 .0 miles radius, results from WMATA, BART, NJT, METRO, and TriMet reveal nearly similar percentage rates for transit use in both TOD and non-TOD areas (Figure 4-11).

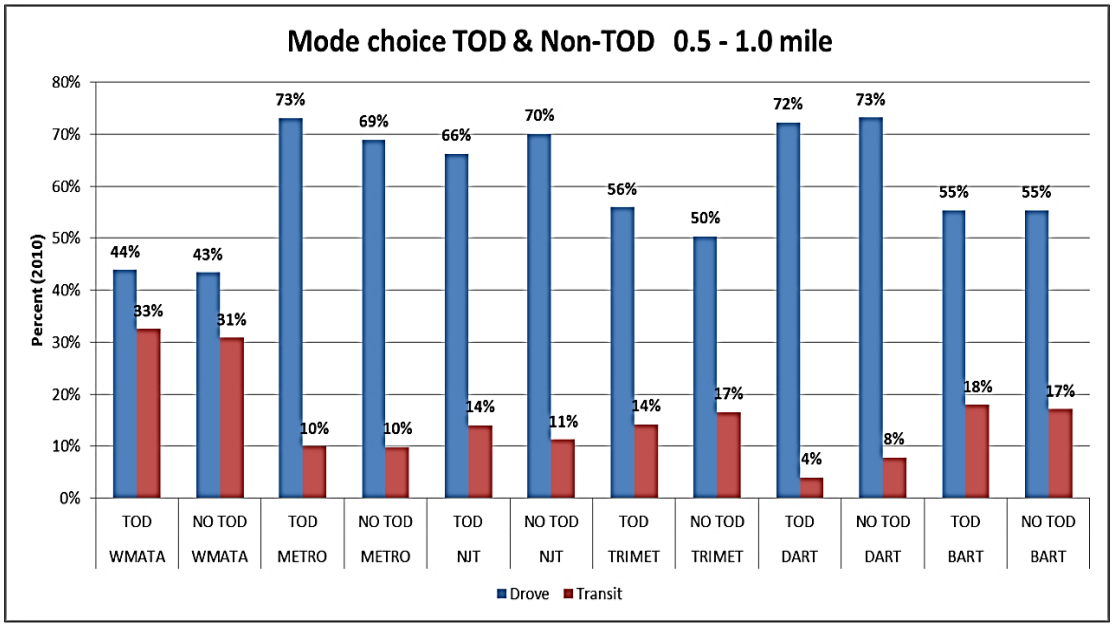

Figure 4-11 Driving & transit-TOD & non-TOD block groups, 0.5-1.0 mi. radius (2010)

Besides, only DART shows transit usage rates below 10%. The low transit usage supports earlier observations for DART block groups showing signs of gentrification such as high housing values and high number of household with more than one car, compared to other MSAs. Overall, the results indicate that transit use in station areas beyond 0.5 miles surpasses national averages of 5% (ACS, 2010) and is almost at par with usage rates within the traditional 0.5 miles radius seen in the previous section. This observation provides some support for the research's supposition that TOD can have a positive impact on transit use within 0.5-1.0-mile radius.

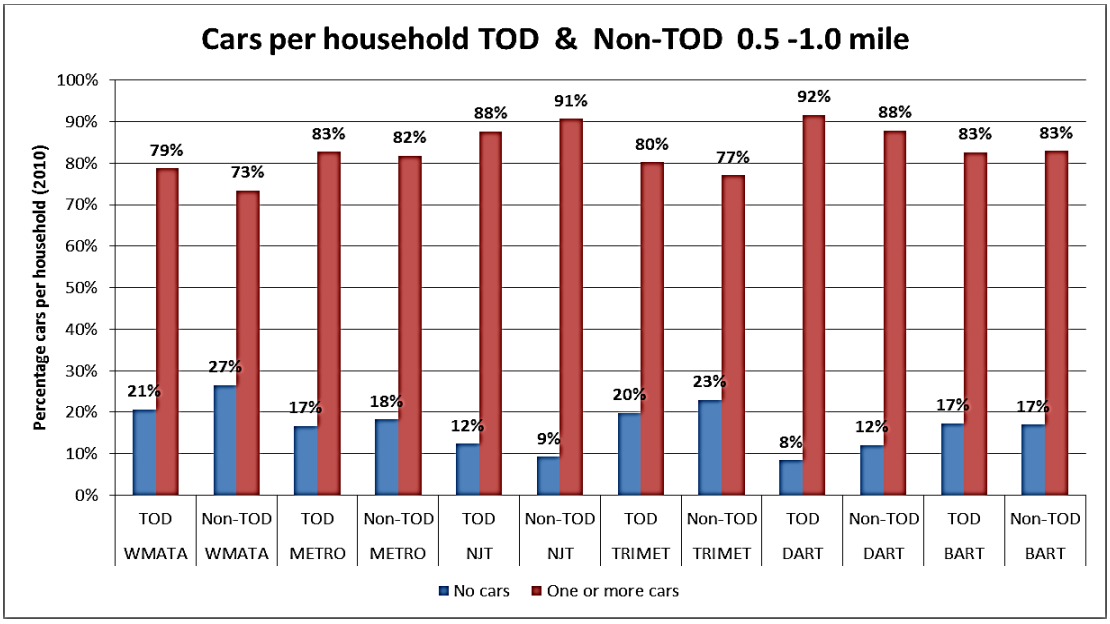

Figure 4-12 Cars per household—TOD & non-TOD block groups, 0.5-1.0 mi. radius (2010)

Except for NJT, further analysis reveals slightly higher percentages for households with no car in non-TOD compared with TOD block groups (Figure 4-12). Once again, at 0.5-1.0 miles radius, the data shows similar results when comparing TOD block groups to non-TOD block groups. This suggests that the observations at 0.5 miles radius were not simply coincidental . However, the percentage of vehicles per households, though slightly higher, is nearly equal to rates observed at 0.5 miles radius, while surpassing the MSA average.

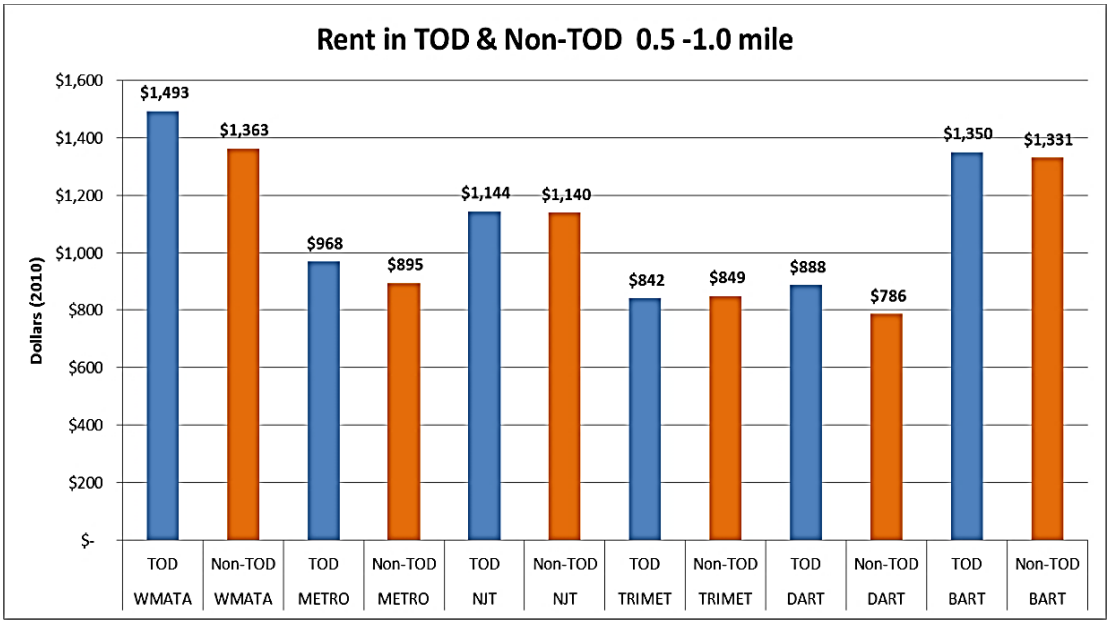

Figure 4-13 Median rent—TOD and non-TOD block groups, 0.5-1.0 mi. radius (2010)

Figure 4-13 reveals that at 0.5-1.0 miles radius, rent is higher in TOD block groups when compared with non-TOD block groups; the exception is TriMet. Even at 0.5-1.0 miles radius, there appears to be some spillover effects from TOD block groups at 0.5 miles where rent is higher. Overall, the data in this section shows some interesting results that increasingly support the research propositions. However, it is important to conduct a comparison of means before drawing conclusions.

4.3.1 Comparison of Means for TOD and non-TOD , 0.5-1.0 Miles

The comparison of means reveals interesting variations between the two typologies (Table 4-3). On average, the number of households with no car are in non-TOD block groups exceeds those in TOD block groups. Furthermore, TOD block groups retain 4.5% more households with two cars or more, compared with non-TOD block groups.

These findings show 6.6% lower driving rates within non-TOD block groups when compared with TODs. The data also reveals that transit use is 4.0 % higher in non-TOD compared to TOD. The results corroborate trends in the data showing that non-TOD block groups have more transit riders compared to TOD. For socio-economic variables (Table 4-3) the data for owner-occupied housing, per capita income, and housing values show mixed results regarding gentrification trends:

First, the percentage of homeowners within non-TOD exceeds those in TOD. However, housing values and rents are higher in TOD block groups. One would expect that high rates of homeownership in non-TOD should be complemented by high rents. This is because high number of owner occupied homes usually indicates a significant presence of affluent middle-income households, which can result in appreciation of rent (Pollack et al., 2010); yet, the results in Table 4-3 suggest that non-TOD housing is more expensive that TOD.

It is important to note however, that the data is for 0.5 -1.0 miles radius, which is farther way from the transit station. This means that perhaps owner occupied homes closer to transit sells for less, due to perceptions of crime and noise (Plano, 1993).

Secondly, demographic data reveals that the percentage of White population is significantly higher in TOD block groups, while the Black population is higher in the non-TOD block groups. However, there is no significant difference for percentage of foreign-born population in both typologies.

Last, the TOD block groups have 1.8% more college graduates compared with non-TOD. On the other hand, non-TOD registered lower median and per capita income values, compared with TOD block groups.

These observations indicate a potential upgrading in social class within TOD block groups based on income and education.

Freeman (2005) recommends that increase in education attainment should be used concurrently with income to establish whether neighborhood has experienced gentrification. This is because incomes can fluctuate due to unemployment, but an individual's level of education is constant. However, percentages for employment type and foreign-born population are insignificant. This presents a rather complex and mixed picture that indicates that claims for upgrading of social class are contingent upon which variables used at 0.5 -1.0 miles radius.

Overall, because most of the coefficients show significant difference between TOD and non-TOD for key variables, the research rejects hypothesis 4 stating that there is no difference between the two types. The results suggest that non-TOD at 0.5 -1.0 miles radius has significantly higher rates of transit use and less for driving.

Table 4-3 Comparison of means in TOD and non-TOD at 0.5-1.0 mi. radius (2010)

Variables 0.5 -1.0 mi (2010)					
Variables	Non-TOD (block groups)		TOD (block groups)		
			Mean	N	Sig.
% No car	27.4	1966	20.4	1395	.000***
% One Car	41.5	1966	43.9	1395	.000***
% Two cars or more	31.1	1966	35.6	1395	.000***
% Transit	24.1	1966	20.1	1395	.000***
% Driving	47.6	1966	54.2	1395	.000***
% College graduate	40.3	1966	42.1	1395	0.039**
% White-collar employment	67.5	1966	68.0	1395	0.537
% Blue-collar employement	13.0	1966	13.2	1395	0.647
% White	53.7	1966	59.1	1395	.000***
%Black	23.8	1966	15.4	1395	.000***
% Foreign born	27.6	1966	27.5	1395	0.815
% Asian	2.8	699	4.2	508	.009**
% Owner occupied housing	40.3	1966	37.2	1395	.000***
% Renter occupied housing	59.6	1966	62.7	1395	.000***
Median rent (2010 $)	1150	1966	1211	1395	.000***
Median housing value (2010 $)	408114	1934	445521	1363	.000***
Median household income (2010 $)	70452	1965	75027	1393	.000***
Per capita income (2010, $)	42410	1965	44466	1393	0.027**
Sig: 0 .05 p ≤ 0.10 (*) .05(**) .01(***)	Total N = 1966		Total N= 1395		

In general, the results from 0.5 -1.0 mile radius corroborates most of the observations for 0.5-mile radius regarding mode choice are not spurious. TOD block groups and contiguous areas seem to exhibit signs of unintended outcomes when compared with non-TOD block groups. Based on the majority of the data showing expected differences, the research rejects the null hypothesis 4 claiming no difference between TOD and non-TOD block groups at 0.5 - 1.0-mile radius.

4.3.2 Conclusions on 2010 Data

Taken as a whole, the results for 2010 data in 0.5 and 0.5-1.0 miles radius show that driving in TOD block groups is lower than the MSAs, but transit use is higher. This finding implies that proximity to transit still is associated with less driving and increased transit use.

The comparison of means reveal that non-TOD averages higher percentages for transit use and less driving when compared with TOD at 0.5 miles radius. However, data for TOD block groups show higher percentages of renters and households with one car. Yet, non-TOD block groups have more households with no cars. This result suggests that TOD policy has not been exceptional in discouraging vehicle use, compared with non-TOD stations.

Another significant observation reveals that within 0.5-1.0 miles radius, transit usage nearly equals the usage rate at 0.5 miles radius. This finding potentially implies that TOD boundaries could be extended up to 1.0 mile to capture more riders.

When contrasting averages in TOD and non-TOD block groups, the t-tests produced largely similar observations for variables operationalizing the concept of gentrification. TOD block groups showed higher percentages of college graduates, housing costs, income, and White population at 0.5 -1.0 miles radius. However, TOD also had lower percentage of owner occupied housing and high percentage of renters at the same radius; the data showed almost similar results at 0.5 miles. Therefore, based on 2010 data, the research rejects the hypothesis stating that TOD cannot be associated with gentrification within block groups within 0.5 and 0.5 -1.0 mile radius.

4.4 Change in MSA and TOD Variables

The previous section presented data for 2010. Nevertheless, we need to probe how the block groups changed from 1990 to 2010 by calculating the difference between 1990 and 2010 figures. The 2010 data only shows the latest decennial census at that one point

in time. However, the descriptive statistics does not reveal how socio-economic and demographic variables changed from 1990 to 2010.

The goal of this section is to assess whether the change in variables strengthen the research's hypothesis on gentrification, decline in transit use, and rise in driving for work commute. To begin with, the data indicates that driving dropped in all TOD block groups within one mile of rail stations, while MSA rates of driving for work commute increased (see Figure 4-14).

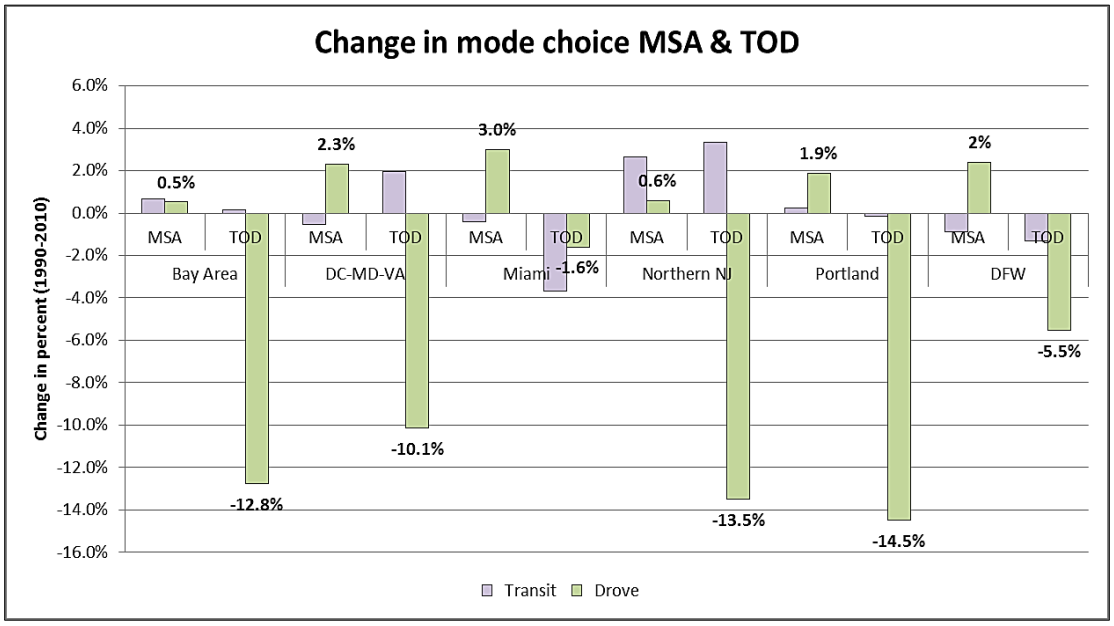

Figure 4-14 Change in percent of transit & driving—MSA &TOD-BG, 1.0 mi. (1990-2010)

Only Dallas Fort worth (DFW) and Miami TOD block groups show decline for both driving and transit. Portland shows a decline for both transit and driving; the rest of the TOD block groups consistently show a percentage increase in transit use even when compared with most MSA. Most of the MSAs showed increase in driving: Washington

DC, Dallas and Miami TOD, in particular shows a decline in transit use. The results suggest that TOD policy is significantly associated with declining percentages for workers driving compared with the MSAs. However, it is crucial to conduct further comparison with non-TOD block groups at the same geographic level (block groups within one mile) to assess whether these are not spurious observations.

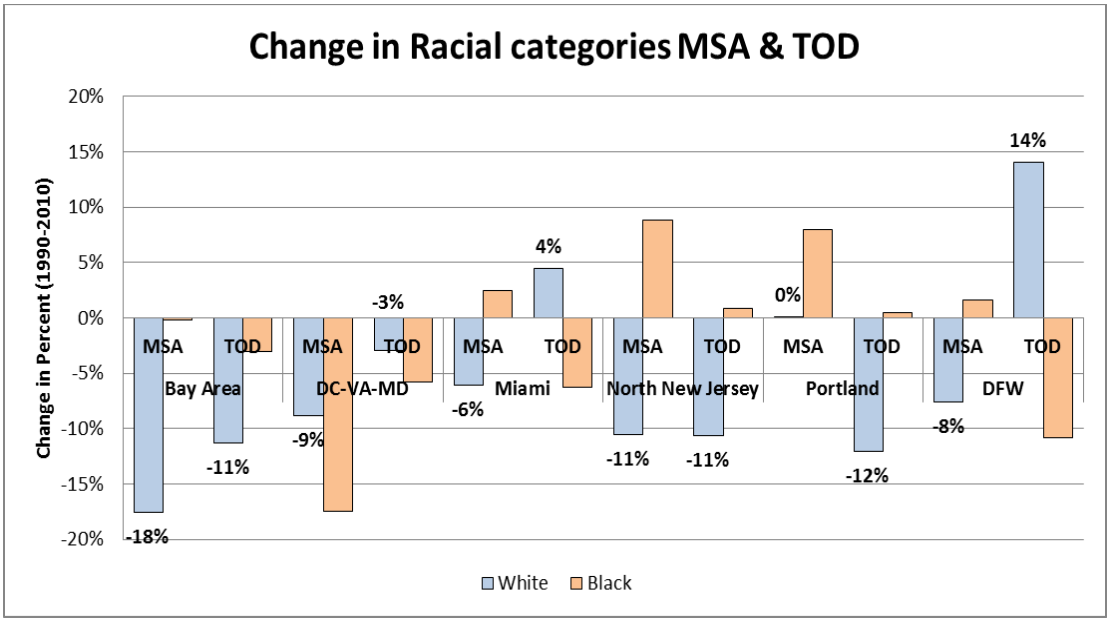

Figure 4-15 Change in percentage— White and Black, MSA &TOD, BG, 1.0 mi. (1990-2010)

Figure 4-15 displays results for the percentage change in Black and White racial compositions within MSAs and TOD block groups. The purpose of analyzing the change in racial representation is to operationalize the social equity factor the research investigates. Further, it is important to assess accessibility to transit services for the Black population, which this research uses as a proxy for transit-dependent population.

It appears that data from TOD block groups reflect the demographic shifts in the country; that is, the continual decline in the percentage of Whites as the share of total population. The Census Bureau (2012) predicted that, at the current growth rate, by 2060 the non-Hispanic White population will have dropped by 20.6 million while the Black population will have grown by 20 million. While the non-Hispanic White population increased numerically over the 10-year period from 2000 to 2010, its percentage of the total population dropped from 75% to 72%. Hence, the United States is expected to become a minority nation by 2043.[5]

Based on these trends, the observations regarding decline in White population cannot be possibly solely be attributed to TOD. However, the decline of Black population around TOD block groups in the Bay Area, Washington, DC, and DFW is an anomaly that does not reflect demographic trends in the country.

Meanwhile, median rent (Figure 4-16) increased significantly higher in TOD block groups when compared with the MSAs, with the exception of Miami and Bay Area. The increase in median rent above MSA averages again strengthens the research position that presence of TOD can be interrelated with unintended consequences. Scholars (e.g., Dominie, 2012; Pollack et al., 2010) have pointed out TOD neighborhoods that showed gentrification had rent significantly higher that the MSA.

Figure 4-17 reveals that median income (excluding the Miami and Northern New Jersey MSAs) grew at a higher rate in TOD block groups when compared with the MSA. In the DC-VA-MD and Portland MSAs, the percentage change in median income for

[5] https://www.census.gov/newsroom/releases/archives/population/cb12-243.html. Retrieved 10/09/2014

TOD is positive, but MSAs show decline in median income. It is not clear why median income dropped in the Washington, DC and Portland MSAs. However, the explanation could be that between 2006 and 2010, the country faced high unemployment rates and economic decline. Ttherefore, some of the observations could be an artifact of the economic recession (APTA, 2012).

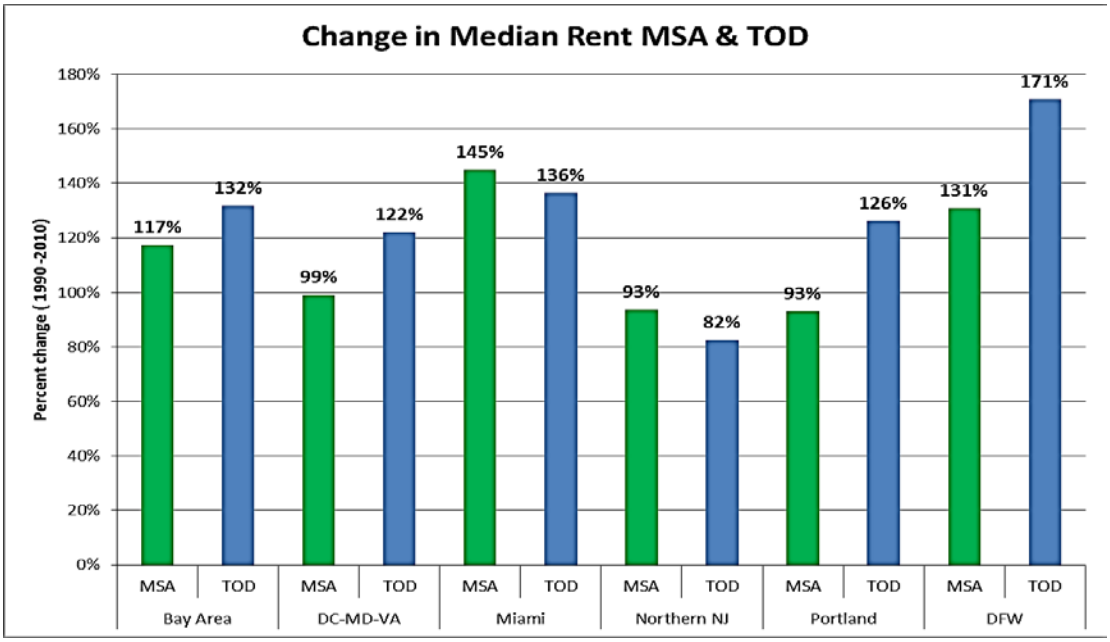

Figure 4-16 Percentage change median rent—MSA and TOD block groups, 1.0 mi. (1990- 2010)

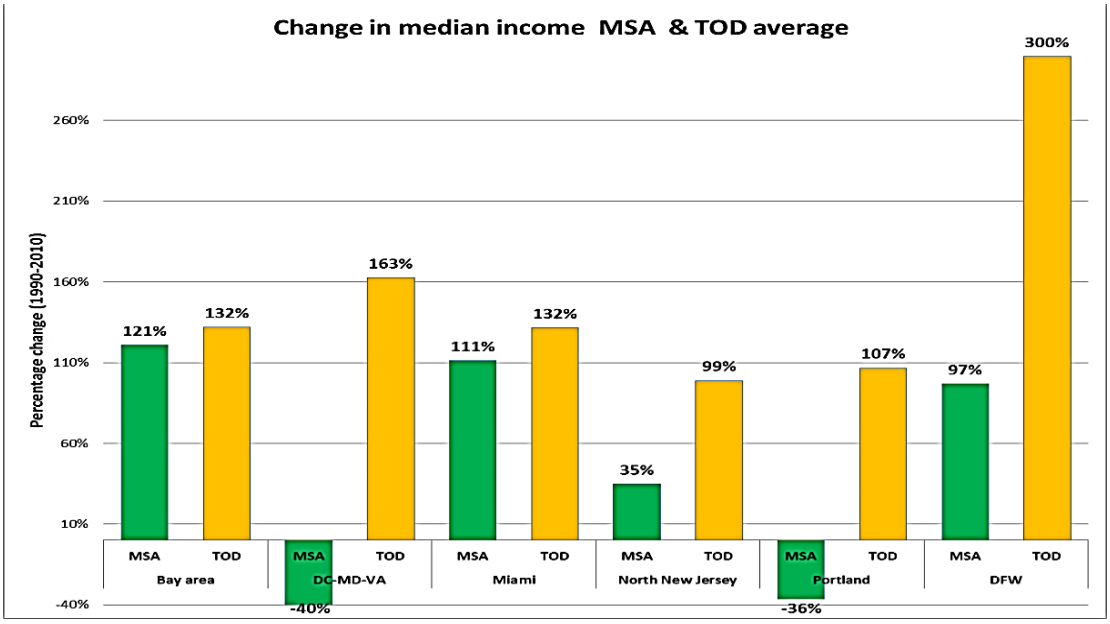

Figure 4-17 Percentage change in median income, MSA and TOD —BG, 1.0 mi. (1990 -2010)

In general, the percentage change in income and rent values in the study areas strengthen research propositions that TOD block groups could become enclaves of affluence that exclude indigent, transit-dependent population.

4.5 Change in TOD and non-TOD Block Groups

The next section presents data comparing TOD and non-TOD block groups at 0.5-mile radius. Although there are major differences between the MSAs and TOD block groups, it is important to investigate these differences in areas with rail infrastructure and similar geographic extent. The MSA covers a wider geographic area (up to hundreds of square miles) while a neighborhood with a TOD might cover as little as one block. In addition, not every area in the MSA have transit lines within one-mile radius.

Therefore, the research uses the comparison of TOD and non-TOD to provide a narrower comparison.

4.5.1 Change in Percentage for Variables within 0.5 Miles Radius of TOD and non-TOD Stations (1990-2010)

The change in the percentage of workers driving and using transit in TOD and non-TOD block groups reveals almost similar results for both typologies in most systems except for DART and TriMet (Figure 4-18). DART and TriMet[6] block groups show a decline in the percentage of workers driving and a decline in the percentage using transit. For DART (Dallas Fort Worth MSA), this is expected because the DART already shows an emerging pattern of unintended outcomes such as high percentage of households with more than one car. Yet, it is surprising that TriMet (Portland-MSA) would register decline in transit use when the MSA has one of the most successful public transportation systems in the country (Cervero et al., 2004). One explanation could be that some households are biking or walking to work more often. The residents of Portland are quite famous for their love for biking (Portland Bureau of Transportation, 2014). In fact, Table A-2 in the Appendix reveals that Portland MSA registered the highest percentage increase for individuals biking or walking to work. Therefore, the percentage of workers biking or walking could be affecting transit use.

[6] Because the research is analyzing data in block groups along the light rail lines, I use the name of the transit system only when comparing TOD and Non-TOD

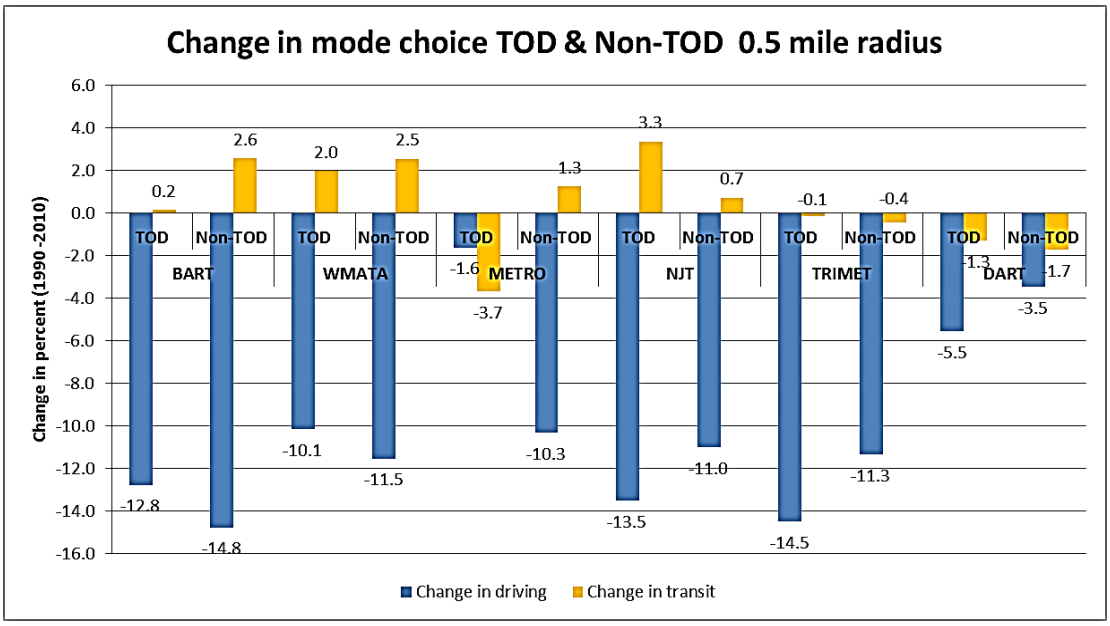

Figure 4-18 Change in percent Driving and Transit -TOD and non-TOD, 0.5 mi. (1990-2010)

Figure 4-19 , reveals mixed results change in cars per household. Due to the numerous variations in the data, it is difficult to isolate a major observation, except that percentage of households with more than one car seems to have increased in TOD block groups compared with non-TOD.

Examining the percentage change in racial categories Figure 4-20 reveals interesting patterns. With the exception of WMATA (Washington, DC) and METRO (Miami), the percentage of White population dropped in both TOD and non-TOD block groups. However, the percentage of foreign-born population increased, and the percentage of Black population show mixed results.

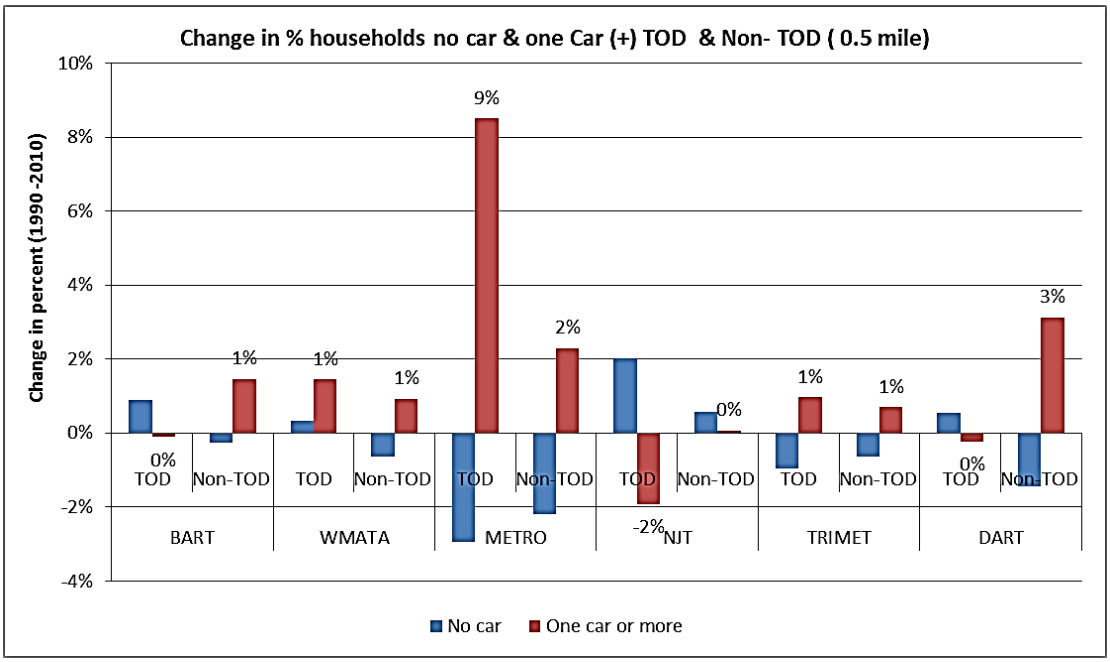

Figure 4-19 Change in percentage of cars per household, TOD and non-TOD block groups, 0.5-mi. radius (1990-2010)

The finding within the 0.5-mile radius raises questions whether the reduction in the percentage of workers driving is a result of the decline of the White population. Normally, the White population have more cars per household compared with the Black population (ACS, 2010). Therefore, one would assume that a rise or decline in percentage of workers driving will rise and fall along with percentage of White population.

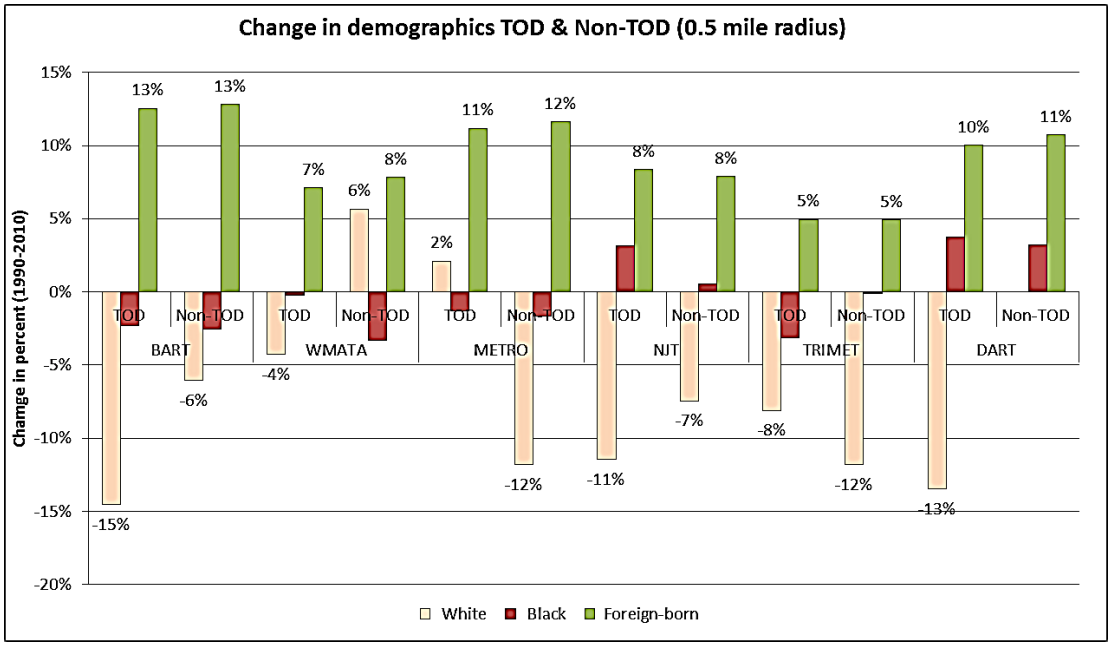

Figure 4-20 Change in percentage for demographics in TOD and non-TOD, block groups, 0.5-mi. radius (1990-2010)

However, the data also reveals a decline in the percentage of Blacks within both TOD and non-TOD block groups. Therefore, it is premature at this point to assume that the decrease for the block group percentage for the White population is the sole cause for declining percentage of workers driving. The comparison of means and correlation coefficient will provide a more complete answer

The change in median rent values (Figure 4-21) is significantly higher in most TOD block groups compared with non-TOD within the 0.5-1.0 miles radius. The exceptions are, WMATA (Washington, DC) and perhaps BART (Bay Area) TOD. The rent higher values within TOD block groups in most of the study areas suggest potential spillover effects from the 0.5 miles radius. It would interesting to conduct future research and observe change values for every meter one moves farther from the transit station.

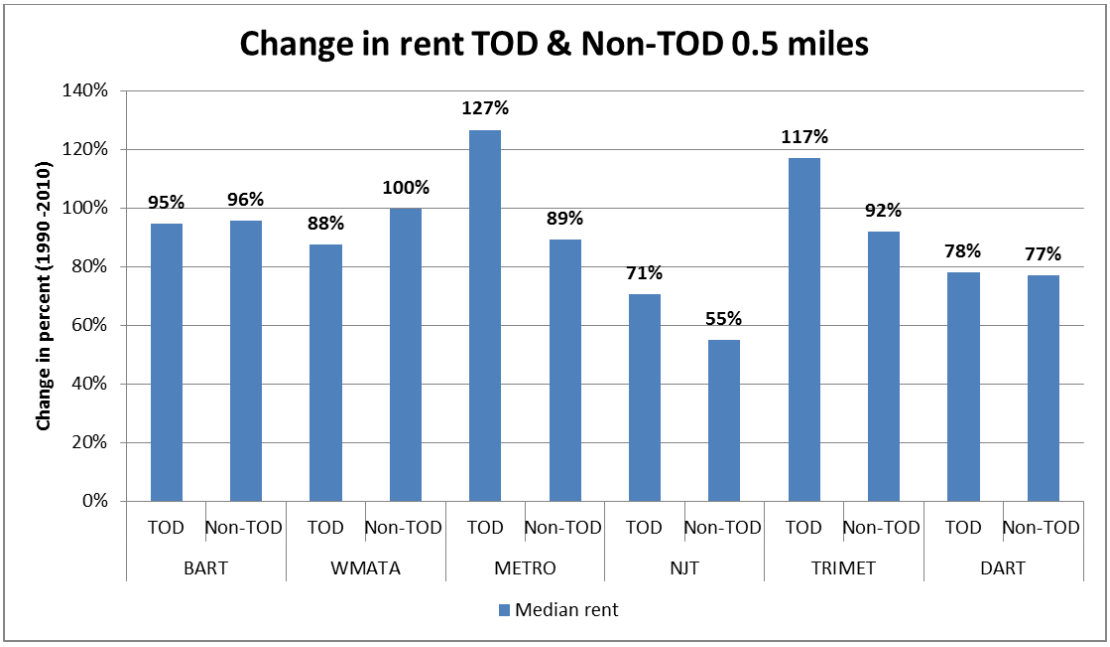

Figure 4-21 Percentage change in median rent—TOD and non-TOD block groups, 0.5 mi. radius (1990-2010)

Moreover, Diaz (1999) found that for every meter a house in Alameda County, California was located closer to the nearest BART station, the sale price (in 1990 figures) increased by $2.29/sq. ft. In addition, for every meter a house was closer to the nearest BART station in Contra Costa County, the sale price increased by $1.96/sq. ft. It would be interesting to use current data to see if this finding still holds.

The purpose of examining change in the percentage of college graduates is to fulfill the research's goal to investigate class upgrading. Scholars researching gentrification trends in urban America recommend that data on education attainment should complement income to operationalize neighborhood social class (Freeman, 2005; Lees et al., 2010).

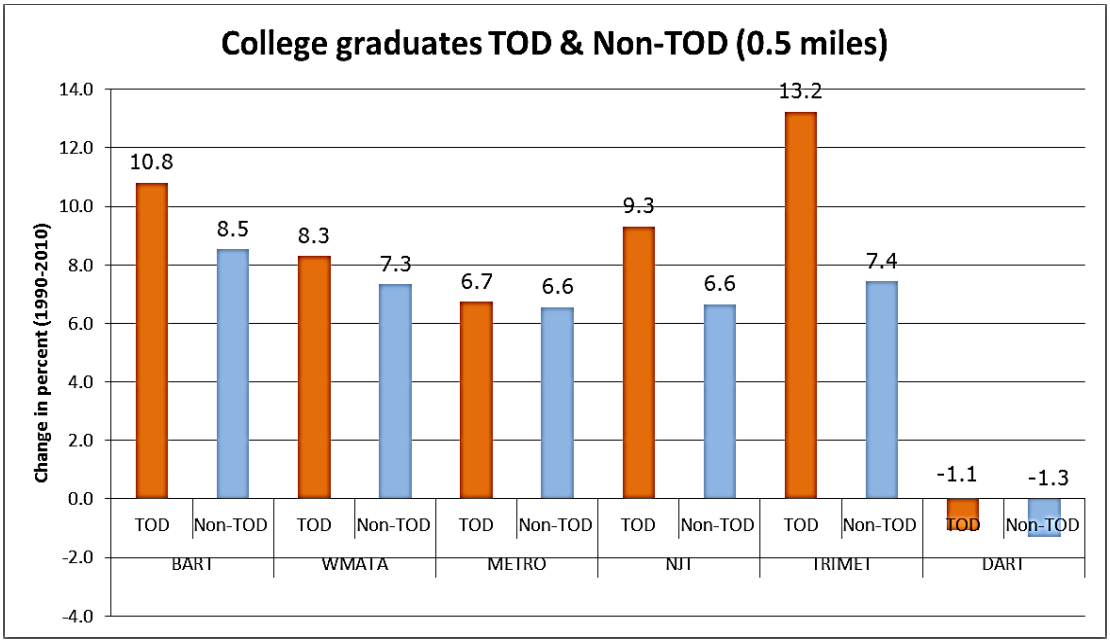

Figure 4-22 Change in percentage of college graduates—TOD and non-TOD block groups, 0.5 mi. radius (1990-2010)

Figure 4-22 shows that the percentage of college graduates increased more in TOD compared with non-TOD. Interestingly, only DART shows a decline in the percentage of college graduates. This is quite confounding because up to this point, DART block groups have exhibited signs of gentrification (high cost of housing, income) in all study areas. Therefore, it could be concluded that social upgrading does not comprise higher education attainment in the Dallas area.

At this point, it is worth pointing out that the data consistently shows mixed results for variables depending on transit system. This has significant policy implications regarding application of a universal TOD policy for improving mode choice options and housing affordability. It seems a context-based approach is better option.

4.5.2 Comparison of Means for Change in Variables within 0.5 Mile Radius

Simply assessing data for change in descriptive statistics may convey the impression that TOD and non-TOD block groups are quite similar. However, the data in Table 4-4 reveals that there are some significant differences in change in variables when comparing TOD to non-TOD.

To begin with, the coefficients are significant for the percent change for households with no car and two or more cars. Specifically, TOD block groups show a higher percentage increase in households with two or more cars, and a higher reduction in the percentage for households with no car. However, the percentage value for households with one car is not significant. Consequently, non-TOD block groups register a higher percentage change for workers using transit compared with TOD.

These results offer possible support for the research proposition stating that between 1990 and 2010, change within TOD block groups can encourage in unintended consequences such as increased driving. The data suggests that transit use increased more in non-TOD block groups while driving declined more compared with TOD. The research therefore rejects the mode choice null hypothesis stating that demographic changes within TOD block groups (in 0.5 miles radius) does not affect mode choice leading to more driving.

Table 4-4 Comparison of means for change in variables in TOD and non-TOD block groups, 0.5 mi. (1990-2010)

Change in variables 0.5 miles (1990-2010)					
Variables	Non-TOD (block groups)		TOD (block groups)		Sig.
	Mean	N	Mean	N	
Change in % No car	-2.93	699	-4.43	508	.068*
Change in % One Car	3.10	699	4.03	508	0.280
Change in % Two cars or more	0.43	699	3.43	508	.000***
Change in % Transit	2.21	699	0.65	508	.041**
Change in % Driving	-10.19	699	-7.07	508	.003***
Change in % College graduate	9.26	682	12.34	491	.002***
Change in % White-collar employment	3.21	699	7.26	508	.000***
Change in % Blue-collar employment	-24.00	699	-24.22	508	.001***
Change in % White	-1.91	699	-2.25	508	0.774
Change in % Black	-7.56	699	-4.04	508	.000***
Change in % Foreign-born	8.36	699	4.71	508	.000***
Change in % Asian	2.77	699	4.15	508	.009**
Change in % Owner occupied housing	1.06	699	1.44	508	0.635
Change in % Renter occupied housing	-0.63	699	0.93	508	0.140
% Change median rent	137.6	695	137.6	493	0.727
% Change median housing Value	160.2	615	159.6	493	0.938
% Change Median income	160.0	615	159.0	492	.018**
% Change Per capita income	201.7	615	243.7	492	.067*
p ≤ 0.10 (*) .05(**) .01(***)	Total N = (699)			Total N = (508)	

The coefficients for percentage change in median housing values and median rent are insignificant. This observation raises questions on the research proposition stating that presence of TOD is associated with high cost of housing that can result in gentrification.

The data shows that the percent change for the White population is insignificant, while the percentage of foreign-born persons increased more in non-TOD, compared with TOD block groups. However, the percentage of Black population declined more in non-TOD block groups, which is puzzling because research shows that this group also has a high rate of transit use. Last, the percentage of persons in White-collar employment increased more in TOD block groups while percentage of workers in Blue-collar employment decreased more in TOD. This finding also can provide an explanation for

limited growth in transit use in TOD, because White-Collar workers earn enough to drive more compared to Blue-Collar workers.

The results however indicate that housing values are not significantly different between the two typologies. This is important because housing values and rent is a key variable in the gentrification model. Therefore, the research accepts the null hypothesis-1 stating that that TOD block groups cannot be associated increase in rent and housing values that can encourage gentrification at 0.5 miles radius.

4.5.3 Change in TOD and non-TOD at 0.5-1.0 Mile (1990-2010)

Within the 0.5-1.0-mile radius, the percentage change in variables in TOD and non-TOD block groups exhibited almost similar results compared with the 0.5-mile radius. The research presents this data to investigate whether TOD and non-TOD stations can effectively improve mode choice up to 1.0 mile when compared with 0.5-mile radius. Additional details are in the Appendix A.

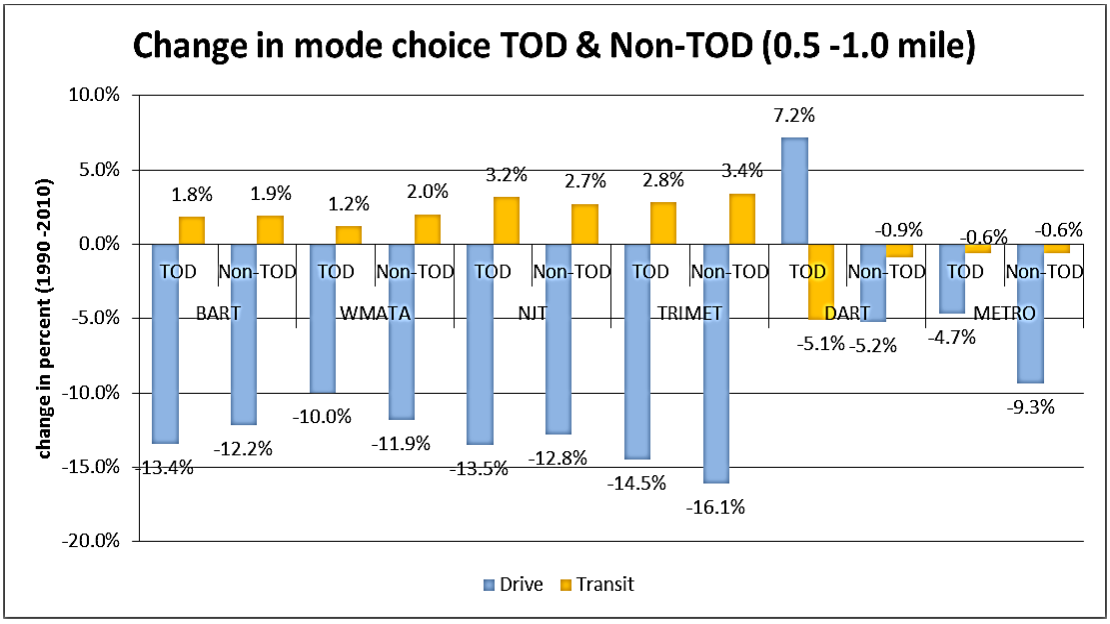

Figure 4-23 Change in mode choice in TOD and non-TOD block groups, 0.5-1.0 mile radius (1990-2010)

Figure 4-23 reveals a general decline in the percentage of workers driving in both TOD and non-TOD block groups, with the exception of the DART TOD. In addition, the percentage of workers using transit increased for all study areas except for DART (Dallas) and METRO (Miami); METRO also had the lowest decline for transit use within 0.5-1.0 miles radius.

Figure 4-24 indicates a general rise in cars per household for most study areas at 0.5-1.0 mile radius; NJT is the exception. On the other hand, percentage of households with no car declined the most in the DART and METRO station block groups. However, there it is difficult to tell whether TOD had better results compared with non-TOD. The above results suggest that beyond 0.5 miles radius, TOD and non-TOD station could increase transit use for work commute.

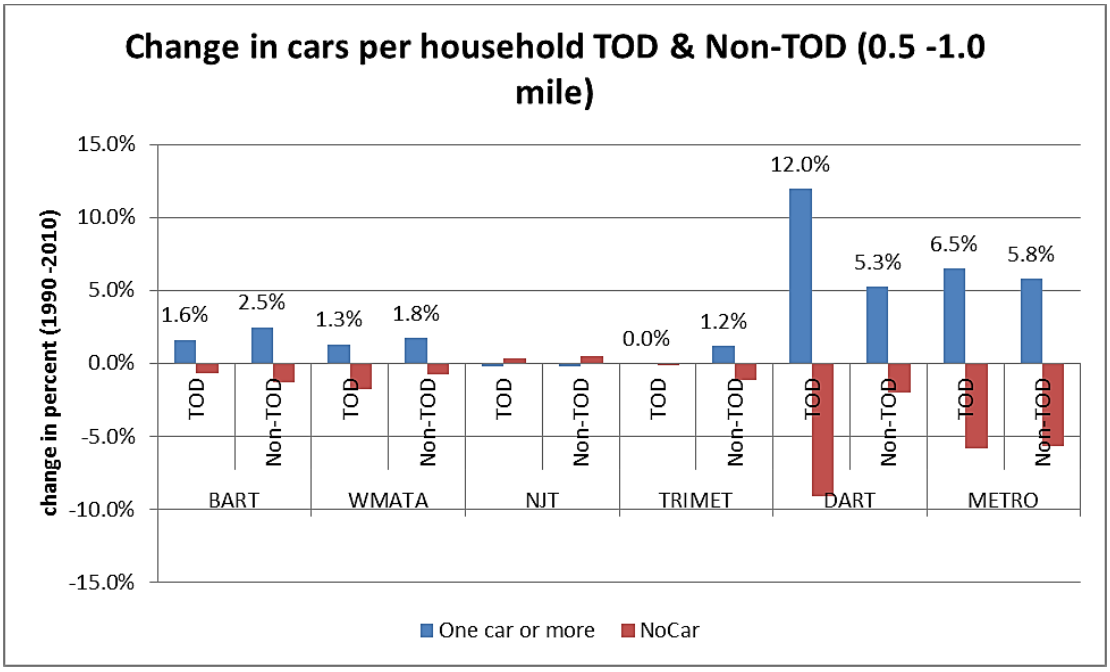

Figure 4-24 Change in cars per households in TOD and non-TOD block groups, 0.5-1.0 mile radius (1990-2010)

4.5.4 Comparison of Means for Change in Variables, TOD and non-TOD, 0.5 – 1.0 Mile Radius (1990-2010)

Comparison of means for 0.5 - 1.0 mile radius indicates a higher decline in percentage of households with no car within TOD block groups, and a higher percentage increase in households with one or more cars. It is therefore not surprising that the percentage change for workers driving declined more within non-TOD block groups.

Although driving decreased more in non-TOD compared to TOD, change transit use was insignificant. Therefore, the research accepts the null hypothesis – 4 (in part) stating that there is no difference between TOD and non-TOD block groups regarding transit use. However, the percentage for households with more one car and change in

transit use are not significant. Housing values, rents, occupancy type, and per capita income have insignificant coefficients within 0.5 -1.0 miles radius.

Table 4-5 Comparison of means for change in variables in TOD and non-TOD block groups, 0.5—1.0-mile radius

	Change in variables 1990 -2010 (0.5 -1.0 miles)				
Variables	NON-TOD (block groups)		TOD (block groups)		
	Mean	N	Mean	N	Sig.
Change in % No car	-2.21	2008	-3.13	1353	0.045**
Change in % One car	2.69	2005	2.78	1350	0.863
Change in % Two cars or more	0.42	2008	2.06	1353	.000***
Change in % Transit	0.68	2008	0.10	1353	0.187
Change in % Drove	-11.24	2001	-9.07	1346	.000***
Change in % Bike & walking	0.00	1920	-0.97	1320	.014***
Change in % College graduate	9.49	1964	10.61	1312	0.039**
Change in % White-collar employment	3.69	2007	6.16	1352	.000***
Change in % Blue-collar employment	-22.79	2005	-23.96	1347	.048**
Change in % White	-0.75	2001	-3.15	1352	.000***
Change in % Black	-7.61	2007	-4.49	1349	.000***
Change in % Asian-Pacific Islander	7.43	2006	6.17	1346	.000***
Change in % Foreign-born	2.74	1952	3.50	1330	.000***
Change in % Owner occupied housing	1.65	1997	1.42	1344	0.624
Change in % Renter occupied housing	-1.21	1999	-0.52	1348	0.203
% Change Median Rent	133	2008	123	1353	.002***
% Change Median Housing value	169	1868	162	1248	0.253
% Change Median Household Income	140	2008	134	1353	0.294
% Change Per capita income	195	2008	194	1353	0.986
p ≤ 0.10 (*) .05(**) .01(***)	Total N = 2008		Total N= 1353		

4.5.5 Conclusion on Descriptive Statistics

The data reveals that the percentage of workers driving in both TOD and non-TOD block groups decreased significantly while transit use increased. The research therefore rejects the mode choice null hypothesis stating that demographic changes within TOD block groups (in 0.5-1.0 miles radius) does not affect transit use and driving. These findings are consistent with results reported in current research such as Davis et al. (2012), Puentes and Tomer (2008) showing that per capita driving among younger Americans has been on the decline; further, Halsey (2012) suggests that the passion has gone out of America's love affair with the automobile. The Millennial generation appears

to be comfortable with using alternative means such as transit, biking, and walking to work (Pew Research, 2010) . Furthermore, several workers today work from home nowadays, which affects driving rates. However, it is also possible that the observed change in mode choice is an artifact of the recession and driving simply declined because of the high unemployment rates (APTA, 2010).

Nevertheless, percentage of workers driving in TOD for work is greater than non-TOD rates; while percentage of workers using transit is lower in TOD compared with non-TOD. Even though the growth in transit use is weak, the results still constitute a validation the TOD policy. However, the fact that the percentage of households with no car declined, while those with one or more cars increased within TOD is an issue that could explain the low transit growth.

In addition, there is a general decline in the percentage of White and Black population while the percentage of Asian and foreign-born population increased within TOD and non-TOD block groups (See Table A-2 Appendix). The rise in foreign-born population supports Belzer et al.'s (2006) research showing that TOD are the most diverse neighborhoods in the MSA. Overall, the data reveals that gentrification in TOD is a diverse phenomenon with most ethnic and racial categories contributing to the social upgrading.

In summary, examining change in rent and housing values (at 0.5 mile radius) provides some evidence of gentrification. The data in shows a higher percent change in rent and median income in TOD compared with the MSA and non-TOD. This finding suggests that housing is becoming less affordable within TOD block groups, potentially

creating resulting in displacement of low-income transit-dependent population. Therefore, the research rejects the null hypothesis stating that demographic changes within TOD cannot cause gentrification.

4.6 Correlations

This section presents results from the Pearson correlation coefficients for change in variables (Table 4-6). The purpose of the correlation analysis is to identify associations and relationships between variables before building the regression models. The second objective is to identify variables that are highly correlated with each other within range of (+/-) 0.70 -1.0 for elimination from regression model. The variables falling in this area are the percentage changes in rent and in median income. Generally, the correlation coefficients (Table 4-6) support the research propositions and hypothesis regarding the link between gentrification, transit use and driving for work in TOD block groups. First, the percentage of White population within the block groups indicates a positive correlation with percentage change in rents, housing value, and income. The positive association of change in White population with socio-economic changes leading to gentrification suggests that the White population could cause gentrification. The White population tends to have higher incomes compared with the Black population (ACS, 2010); therefore, they are more likely to afford and compete for housing with higher rents. Unfortunately, this implies that if planners are to develop an egalitarian policy, they may have to use a contentious strategy such as affirmative action to provide more opportunity for minorities.

Secondly, the percentage of Black population is negatively correlated with housing values and income. This finding supports previous research suggesting that the presence of Black population in a neighborhood is associated with declining or stagnant property values (Massey and Denton, 1992; Harris, 1999; Crowder and South 2008). Not surprisingly, therefore, the percentage of Whites has a significant negative correlation with households with no car and public transit, while it registers a positive correlation with driving and change in the percentage for households with more than two cars. Once again, this finding supports the proposition that households with high income such as the White population can be linked to the occurrence of gentrification and increase driving within TOD block groups. This explanation is reinforced by the data showing that change in the percentage of Black population has a positive correlation with the percentage of households with no car, and percentage increase in transit. These findings support the proposition that increase in lower-income groups such as the Black population can be linked to more transit use in block groups within 0.5-mile radius of TOD block groups. The result of the correlation analysis validates the research's use of the percentage of Black population as proxy for transit-dependent population.

Percentage change in income, rent, and housing value are negatively correlated with the percentage of households with no car. These results suggests that a rise in housing value, rent, and income can be associated with displacement of persons with no car and reduction in transit use. Alternatively, housing value, rent, and income are positively correlated with households with one car or more, including workers for driving.

The supporting variables (e.g., employment type, years of residence) also reveal interesting and significant direction of relationship as proposed by the research. The percentage change for persons in White-collar employment registered a negative correlation with the percentage change in transit use, while it is positively correlated with change in driving, rent, and housing value. On the other hand, change in the percentage of workers in Blue-collar employment has a negative association with driving, housing values and rents. This finding implies that type of employment is interrelated with variables influencing mode choice and gentrification within the study areas.

Table 4-6 Pearson correlation coefficients for change in variables for TOD block groups in 0.5 mi-radius

% Change in Variables	No Car	oneCar	Two Cars +	Transit	Drive	MDRENT	MDHVAL	MDINC	Per capita	College Grad	WhiteColl	BlueColl	White	Black	ForeignBorn
No Car	1	-.566**	-.483**	.312**	-.256**	-.317**	-.161**	-.469**	-.413**	-.340**	-.308**	.361**	-.415**	-0.003	.169**
oneCar	-.566**	1	-.444**	-.122**	.100**	.276**	.123**	.316**	.292**	.288**	.331**	-.329**	.317**	-0.02	-.116**
Two Cars or more	-.483**	-.444**	1	-.211**	.168**	.055*	0.043	.173**	.161**	.071*	-0.015	-0.049	.121**	0.02	-.062*
Transit	.312**	-.122**	-.211**	1	-.433**	-.231**	-.115**	-.307**	-.277**	-.180**	-.192**	.194**	-.308**	0.038	.191**
Drive	-.256**	.100**	.168**	-.433**	1	.099**	-.095**	.148**	.238**	0.049	.159**	-.057*	.174**	-0.028	-.199**
OtherMode	0.014	0.033	-0.038	-.208**	-.336**	.162**	.193**	.117**	-0.023	.155**	.105**	-.146**	.098**	-0.051	-0.03
MDRENT	-.317**	.276**	.055*	-.231**	.099**	1	.077**	.760**	.572**	.446**	.458**	-.304**	.488**	-.060*	-.292**
MDHVAL	-.161**	.123**	0.043	-.115**	-.095**	.077**	1	.162**	.068*	.317**	.235**	-.222**	.274**	0.03	-.053*
MDINC	-.469**	.316**	.173**	-.307**	.148**	.760**	.162**	1	.658**	.521**	.548**	-.348**	.515**	-.061*	-.255**
Percapita	-.413**	.292**	.161**	-.277**	.238**	.572**	.068*	.658**	1	.469**	.389**	-.314**	.482**	-0.01	-.270**
College Graduate	-.340**	.288**	.071*	-.180**	0.049	.446**	.317**	.521**	.469**	1	.637**	-.443**	.412**	-0.05	-.218**
WhiteColl	-.308**	.331**	-0.015	-.192**	.159**	.458**	.235**	.548**	.389**	.637**	1	-.643**	.437**	-.087**	-.391**
BlueColl	.361**	-.329**	-0.049	.194**	-.057*	-.304**	-.222**	-.348**	-.314**	-.443**	-.643**	1	-.383**	0.052	.312**
White	-.415**	.317**	.121**	-.308**	.174**	.488**	.274**	.515**	.482**	.412**	.437**	-.383**	1	-.143**	-.337**
Black	.041*		-0.044*	0.38*	-0.035*	-.060*	0.03	-.061*	-0.01	-0.05	-.087**	0.052	-.143**	1	0.008
ForeignBorn	.169**	-.116**	-.062*	.191**	-.199**	-.292**	-.053*	-.255**	-.270**	-.218**	-.391**	.312**	-.337**	0.008	1
Owner Occ HH	-.205**	.085**	.129**	-.191**	.177**	.285**	.086**	.435**	.343**	.209**	.255**	-.160**	.277**	-.078**	-.187**
Renter Occ HH	.204**	-.082**	-.129**	.190**	-.177**	-.284**	-.086**	-.435**	-.341**	-.207**	-.255**	.160**	-.273**	.075**	.186**
Population	-0.032	.062*	-0.02	-0.025	-0.024	.101**	-0.001	.078**	.066*	.115**	.074**	-.098**	0.025	-0.024	0.035
Distance	0.007	-0.009	0.003	0.014	.070*	-0.05	-0.043	-0.008	-0.027	-.092**	-.070*	0.043	0.007	-0.009	0.034
** Correlation is significant at the 0.01 level (1-tailed).															

Finally, the coefficients for households who have resided in the block group since the year 2000, register a negative relationship with coefficients for transit and a positive relation with driving. These results suggest a reasonable association between newer residents and percentage of households with more than one car. This is an important finding because previous research(Pollack et al. 2010; Dominie 2012) found that some residents who moved into TOD from the year 2000 were less likely to use transit. Likewise, the research incorporates this variable into the regression equation expecting some expecting a negative association with transit use.

In conclusion, the correlation coefficients convey a logical association between the variables, in addition to validation of the research hypotheses regarding gentrification and presence of TOD. However, correlation does not imply causation. Therefore, the research will run a regression analysis, in the next chapter to determine causal relationships between dependent and independent variables.

Chapter 5

Regression Analysis

The data presented in the previous chapter revealed that driving has declined and transit use has increased in the study areas. In addition, the percentage of households without cars decreased in TOD block groups while percentage of households with more than two cars has increased. Furthermore, change in housing values and per capita income and was generally higher in TOD block groups when compared with the MSA and non-TOD block groups. These results suggest that the presence of TOD could be associated with gentrification in the study areas. The next step is to evaluate the causal nature of the relationships between the variables using regression analysis.

Before running the regression analysis, the research conducted a series of data transformations and coding in SPSS. The first step was to create dummy variables for TOD (1) and non-TOD (0) stations in addition to locational and regional variables. Next, the 1990 values for rent, income, and housing were converted into 2010 dollars using the Consumer Pricing Index from the Bureau of Economically Analysis. The research then obtained the data for change in percent by calculating the difference between the 1990 and 2010 values. Change in rent, income, and housing values were derived by a simple percentage calculation.

Finally, data screening and quality control involved eliminating outliers and extreme values using the data validation tool in SPSS. Because validity analysis registered a high correlation (0.76) between median income and median rent, the research replaced median income with per capita income for regression analysis.

To account for possible variations by region, the research created three dummy variables for the East, West, and South states in the study area. Because the research was unable to obtain a reliable list for TOD in the North, the results include data from the following three regions:

- San Francisco-Oakland-Fremont (MSA) and Portland-Vancouver-Hillsboro (MSA) – West
- Dallas-Fort worth -Arlington (MSA) and Miami-Fort Lauderdale-Pompano Beach (MSA) – South
- Washington DC-Arlington -Alexandria (MSA) and New York- Northern New Jersey- Long Island (MSA) – East (this is also the reference category).

In addition, the location variables are three separate dummies for each of the following categories:

1. Central business district station (CBD)—located in block groups with highest employment density within the central city of the MSA.
2. Central city stations — located in the central city within the MSA, but not within the CBD or the Suburb.
3. Suburban (terminus) — final station or stations along a rail line located in a predominantly residential area. This is the reference category.

Table 5-1displays the predicted direction of influence for all independent variables (IV) on the dependent variables (DV). The research considered using education attainment in the mode choice models; however, previous research (e.g. Kuby, Barranda,

and Upchurch, 2004, p.245) found that education attainment has little or no impact on mode choice and ridership.

The signs next to variables show expected direction of influence in the regression models. These signs were determined by consulting the correlation table and plotting a line of fit. It is unknown however, how the variables will interact once they are in the model. These interactions could produce unexpected directions of influence.The research also found normality, hetero-scedasticity, and linearity in the data. Furthermore, the Durbin-Watson test, Eigen values and condition indices divulged no instances of autocorrelation, and extreme collinearity, respectively. Following the above tests, the research can assume that our data is valid and reliable enough for regression analysis without expecting serious errors.

Table 5-1 Expected direction of influence in the models

			Model 1	Model 2	Model 3	Model 4
Independent variables	**Coded**	**Category**	**Effect on Driving**	**Effect on Transit**	**Gentrification (Rent)**	**Displacement (Black)**
East region (dummy) NY-NJ-PA	East	Regional	-	+	Null	Null
West region (dummy) CA-OR	West	Regional	-	+	Null	Null
South region (dummy) TX- FL	South	Regional	+	-	Null	Null
Central business district (dummy)	CBD	Location	-	+	+	-
Central city (dummy)	Central city	Location	-	+	+	-
Suburban (terminus) (dummy)	Suburban	Location	+	-	-	-
Straight line distance to station	DIST	Built environment	-	+	-	-
TOD policy	TOD = 1 & non-TOD = 0	Built environment & Policy	+	-	+	-
Non- Hispanic White	WHITE	Demographic	+	-	+	-
Non-Hispanic Black	BLACK	Demographic	-	+	-	Null
Asian or Pacific Islander	ASIAN	Demographic	-	+	+	-
Foreign-born	Foreign born	Demographic	-	+	-	Null
College degree or higher	EDUC	Demographic	Null	Null	+	-
Block group density	DEN	Demographic	-	+	+	Null
Block group population	POP	Demographic	-	+	+	Null
Median contract rent	MDRENT	Economic	+	-	Null	-
Median income	MDINC	Economic	Null	Null		-
Median housing value	MDHVAL	Economic	Null	Null	+	-
Per capita income	PERCAP	Economic	+	_	+	-
Renter occupied housing	ROH	Economic	-	+	-	+
Owner occupied housing	OOH	Economic	+	-	+	-
Biking & walking	Other mode	Mode choice	-	-		
Driving	DROVE	Mode choice				
Transit	TRANSIT	Mode choice				
White-collar employment	WHTCOLL	Socio-economic	+	-	+	-
Blue-collar employment	BLUCOLL	Socio-economic	-	+	-	+
Household with no car	NOCAR	Socio-economic	-	+	Null	Null
Households with one car	ONECAR	Socio-economic	+	+	Null	Null
Household with two cars or more	TWOCAR+	Socio-economic	+	-	Null	Null
Years station been operation	Years in operation	Time Period	-	+	+	-
Resident since yr. 2000	MVD_A2000	Time Period	+	-	+	-
** Null means the variable is not part of the model*						

5.1 Regression Models for Transit and Driving

5.1.1 Regression Model for Mode Choice in Block Groups within 0.5 Mile Radius (2010)

This section presents the regression results for driving and transit use for block groups within 0.5- mile radius of TOD and non-TOD stations. The research uses the 0.5-mile radius to evaluate TOD because the policy is supposed to be most effective within this distance (Cervero, et al., 2002 & 2004; Renne, 2005; Cervero and Ewing, 2010).

Table 5-2 displays unstandardized coefficients for the independent variables regressed against block group percentage for workers driving and using transit for home-based commute trips. Model-1 has an adjusted r squared (.73), implying that 73% of

variance in the driving within TOD block groups is explained by changes in the independent variable. Model-2 has an adjusted r -squared (.59), which indicates that 59% of the variance in transit use arises from the independent variables in the model. Suffice to say, the models have a moderately strong prediction power.

To begin with, demographic variables including race, employment type, foreign-born, population size and density are insignificant in the predicting percentage of workers driving. Nonetheless, most demographic variables are significant in predicting transit use except for White-collar employment, foreign-born population, including residents who moved to the block group from 2000 - 2010.

A percent increase in the Black population yields a 0.11% increase in transit use compared with a 0.08% rate for the White population. Even though both racial categories register a positive association with transit, the data shows that the number of Blacks in the block group is a more reliable predictor for transit use.

Unexpectedly, however, a 1% increase in Blue-collar employment, results in a .09% reduction in transit use, while White-collar employment is insignificant in predicting transit use and driving for 2010 data.

Table 5-2 Regression models for driving and transit-0.5-mi. radius (2010)

		% Driving (2010)_Model 1			% Transit (2010)_ Model 2		
		B	t	Sig.	B	t	Sig.
	Constant	43.540	8.635	0.000	16.06	3.30	0.001
	Demographic						
%	White-collar employment	0.003	0.22	0.830	0.00	-0.21	0.835
%	Blue-collar employment	0.028	0.83	0.406	-0.09	-2.93	0.003***
%	White	-0.002	-0.08	0.939	0.08	2.95	0.003***
%	Black	-0.015	-0.48	0.634	0.11	3.85	.000***
%	Foreign Born	-0.021	-0.71	0.476	0.008	0.30	0.765
%	Resident since yr .2000	0.151	5.10	.000***	0.03	0.94	0.346
	Block group population density	0.000	-1.07	0.285	0.00	2.96	0.003***
	Block group population	0.000	0.82	0.411	0.00	-1.74	0.082*
	Socio-economic						
%	No car	-0.161	-4.27	.000***	0.22	6.54	.000***
%	Two cars or more	0.160	4.22	.000***	-0.11	-2.98	0.003***
%	Biking or Walking	-0.496	-15.57	.000***	-0.36	-12.60	.000***
%	Owner occupied housing	0.178	7.41	.000***	-0.07	-3.30	0.001***
	Median rent ('000)	-0.001	-1.15	0.249	0.002	1.56	0.119
	Per capita income (' 0000)	0.000	-1.51	0.130	0.000	-0.02	0.985
	Location dummy						
	TOD	1.402	1.80	0.072*	-0.55	-0.79	0.429
	CBD station	-5.274	-4.41	.000***	3.64	3.41	0.001***
	Central City station	-9.208	-8.73	.000***	10.12	10.74	.000***
	Regional dummy (MSA)						
	West	-0.067	-0.19	0.849	-0.44	-1.38	0.168
	South	18.367	12.58	.000***	-20.22	-15.47	.000***
	Other						
	Distance from station	0.005	2.25	0.025**	0.00	-2.10	0.036**
	Years in operation	-0.230	-5.53	.000***	0.25	6.81	.000***
		ADJ R = .73			**AdJ R = .59**		
	Sig: 0 .05: p ≤ 0.10 (*) .05(**) .01(***)	N Total block groups = 1206			N Total block groups = 1206		
	Suburban stations are reference for location & East region is reference for region						

These interaction of employment and transit were unexpected because the correlation coefficients specified that Blue-collar employment incurs a positive impact on transit use. The research assumes that Blue-collar workers receive lower incomes; hence, they should prefer cheap public transportation over driving because transit is within their budget constraint.

However, a possible explanation for this anomaly could be that transit services do not sufficiently provide access from residential areas to employment locations, causing low-income workers to drive. This finding identifies a possible issue with TOD policy

which could exclude certain transit dependent groups. Besides, Dunphy et al., (2005, p. 14) stated that TOD projects catered to *briefcase-carrying riders* in some metropolitan areas. Moreover, Tomer (2011) and Kneebone and Berube (2013, p.59 -62) found that while transit systems reach 77% of low income neighborhoods, the networks connect only 25% of these neighborhoods to jobs within 90 minutes of travel time. These assertions substantiate high rates of driving among Blue-collar workers, who possibly have poor access to employment locations using transit.

The fact that the percentage of White, Black, and foreign-born individuals are insignificant is puzzling; this is because this research had assumed that the linkage between immigrant status, employment and income should generate an indirect effect on mode choice. This assumption is arises from evidence in studies (e.g. Glaeser, et al. 2007; ACS, 2009; Kneebone and Berube, 2013) demonstrating that ridership rates for Blacks, and foreign-born residents are higher than usage rates among other demographic groups.

Nonetheless, some location and socio-economic variables are significant at the 0.10 level or better, in predicting driving. Controlling for other factors, a 1% increase in households with no car is associated with a 0.16% decrease in driving. On the other hand, a 1% increase in households with two or more cars is associated with a 0.16% increase in driving. Both are statistically significant at the 90% accuracy level. The data also indicates that a 1% increase in owner-occupied housing is associated with a 0.18% increase in driving; however, median rent and per capita income are insignificant in predicting driving or transit use; for every1.0% increase in residents since the year 2000,

driving increased by 0.15%; however, a single year increase in operation of a rail station is associated with 0.23% decrease in driving.

The data on newer residents support the research proposition that households moving into the TOD after several years, might not be captive riders. The data suggests that these new residents might not be enthusiastic patrons of transit.

Next in the analysis are location variables. First, TOD block groups have 1.4% more workers commuting by car compared to non-TOD block groups. However, transit usage in TOD and non-TOD block groups is not significantly different. This revelation supports the research proposition stating that the presence of TOD could be linked to unintended consequences such commute by car. This discovery further suggests that a station with a TOD does not perform any better than a station without a TOD. Yet, it is worth pointing out that non-TODs might have joint developments which can boost transit (Cervero et al 2002 and 2004).

Secondly, the CBD block groups have 5.0% fewer workers commuting by driving, while the Central city has 9.0% fewer drivers compared to the Suburbs. Lower driving rates in the Central City and the CBD is normal because location densities and coverage of transit networks facilitates access to public transportation compared with the suburbs.

Finally, the Southern block groups have 18% more workers commuting by driving, compared to the East. However, commuting by driving in the West coast is not significantly different from the East coast. This trend is normal because cost of living and traffic congestion in California and Oregon are almost similar to Washington DC,

Maryland, and New Jersey. In contrast, Southern states such as Texas have less traffic congestion and lower gas prices; therefore, workers in the Dallas Fort Worth MSA are more likely to drive compared to those in the Washington DC and Northern New Jersey MSAs.

Additional location variables such as distance from station are also positively associated with the increase in driving—the farther away from a rail station, the higher the percentage of driving to work. The distance interactions support previous research stating that proximity to transit stations reduces driving among residents living within a half-mile radius (Cervero et al., 2004; Kuby et al., 2004).

Surprisingly, though, the coefficients for socio- economic variables reveal that per capita income and median rent is not significant in predicting mode choice. The research was expecting significant relationships because the correlation results specified a positive relationship between rent, income, and driving; and a negative relationship with transit use. This is important because median rent and income are core variables for investigating unintended consequences in TOD block groups. Therefore we can conclude that for 2010 data, block groups values for income and rent do not support the research hypothesis.

5.2 Regression Model for Change in Mode Choice in 0.5 Mile (1990-2010)

Table 5-3, displays results for Model 1, which has an adjusted r-squared of 0.27, explaining 27% of variance in driving ; and Model-2 with an r-squared explaining 21% of variance in transit. Notably, the models do not have strong prediction power; probably because the research transformed variables by calculating the percent change. Future

research can incorporate absolute values which might produce a model with a stronger predictive power.

Nevertheless, the data reveals that from 1990 and 2010, a 1% increase in percentage of White-collar employees generated a 0.16% increase in driving. In addition, a 1% increment in Blue-collar employees, added 0.11% more workers driving, while expanding transit use by 0.10% . The positive impact of White-collar workers on transit use is unexpected, because the research assumes that White-collar employees can afford and prefer to drive. This unexpected result might have something to do with regional variations; a significant number of block groups in the research are from East and West coast states with high congestion levels and cost of living. It is possible the unexpected results arise from skewed responses from White-collar workers in the East and West coast using cheap public transport to offset the high cost of living and commuting.

More unexpected results for transit use can a be observed in the data for the length of residency. Holding other conditions constant, the coefficients convey that a 1% of residents moving into the block group since the year 2000 yielded a 0.06% increase in transit use. This was not expected because the research had predicted that newer residents arriving after the year 2000 were not good clients for public transportation.

The next sets of parameters are socio-economic variables including income, housing costs, occupancy type, and number of cars. Except for income and rent, the socio-economic variable are all significant in predicting change in driving.

Holding other variables constant, a 1% percent increases in block group per capita income results in a 0.25% decline in transit use; further, a 1% increment for percentage of

households with no car produces a 0.19% reduction in driving compared to 0.15% improvement in transit use. Not surprisingly though, households with two or more cars are associated with a 0.09% growth in driving, while shrinking transit use by an equal rate. This seems to imply that workers driving transferred mode choice preferences from transit use.

The results for income and car ownership suggest that, when the neighborhood becomes more affluent fewer workers commute by transit. Notably, households with no car account for the second highest impacts on mode choice. However, the rising percentage of workers walking and biking surpasses rates of car ownership in influencing mode choice. A 1% change in the number of workers walking and biking cuts back driving by 0.44% compared with 0.15% drop in transit use. This finding suggests that walking and biking impacts driving more than transit. It is also encouraging that there are significant numbers of workers walking and biking, which improves public health (Besser and Dannenberg, 2009).In the next set of variables, the data reveals that with a 1% increase in homeowners (owner occupied housing), reduces transit by 0.07%, while increasing driving by 0.10%.

Table 5-3 Regression model for change in driving and transit-0.5-mile radius (1990-2010)

	Change in % (Driving) Model 1			Change in % (Transit) Model 2		
	B	t	Sig.	B	t	Sig.
Constant	-8.84	-3.41	0.001	-0.49	-0.24	0.807
Change in Demographic						
% White-collar employment	0.16	4.68	.000***	0.04	1.73	0.083*
% Blue-collar employment	0.11	3.12	.002***	0.10	4.10	.000***
% White	0.00	-0.07	0.945	-0.02	-1.03	0.304
% Black	-0.03	-1.20	0.230	0.02	0.85	0.396
% Foreign-born	-0.13	-3.47	0.001***	0.13	4.27	.000***
% Resident since yr .2000	-0.02	-0.85	0.397	0.06	3.11	0.002***
Change BG population density	0.00	2.34	0.02**	0.00	0.11	0.911
Change BG population	0.00	-2.14	0.033**	0.00	-0.36	0.720
Change in Socio-economic						
% No car	-0.19	-4.64	.000***	0.15	5.31	.000***
% Two cars or more	0.09	2.16	0.031**	-0.09	-2.86	0.004***
% Biking or Walking	-0.44	-11.75	.000***	-0.19	-6.92	.000***
% Owner occupied housing	0.10	2.87	0.004***	-0.07	-2.79	0.005***
% Change Median rent	-0.25	-0.54	0.591	-0.48	-1.29	0.198
% Change Percapita income	0.07	0.52	0.600	-0.25	-2.43	0.015**
Location dummy						
TOD (policy)	1.26	1.41	0.160	-1.26	-1.75	0.08*
CBD station	5.07	3.98	.000***	-1.63	-1.61	0.108
Central City station	1.46	1.25	0.213	-0.85	-0.91	0.362
Regional dummy						
West	-0.51	-1.48	0.140	0.63	2.31	0.021**
South	2.94	2.19	0.029**	-2.63	-2.53	0.012***
Other						
Distance from station	-0.01	-0.26	0.795	-0.001	-2.49	.013***
Years in operation	-0.038	-1.679	0093*	0.07	2.00	.046**
	ADJ R = .272			ADJ R = .21		
Sig: 0 .05 p ≤ 0.10 (*) .05(**) .01(***)	N = 1206			N = 1206		

This finding implies that homeowners are more likely to drive compared to renters, possibly because they are more affluent. In fact, the correlation results (Chapter 4) reveals that rented housing has a negative association with driving while percentage of homeowners indicates a negative interaction with percentage of worker using transit.

The results also show that a percentage change in per capita income results in a decrease in transit use by 0.25%. This finding corroborates the previous claim regarding the interaction between number of owner occupied housing, income and driving.

There are 1.3% fewer workers commuting by transit from TODs compared to non-TODs from 1990 -2010. However, change in driving rates from TOD and Non-TOD was insignificant. Similarly, differences in driving and transit use for the Central City and Suburb, were also insignificant. However, from 1990 – 2010, there were 5.0% more workers in the CBD, commuting by driving compared to the Suburbs. This outcome was unexpected because theory maintains that driving rates within suburbs should be higher.

Driving might have increased because of demographic shifts produced by middle class residents migrating from suburbs; In a publication titled *"Confronting suburban poverty in America,"* Kneebone and Berube (2013), found that between 2000 -2010, a significant number of suburban residents migrated to the urban core because of lifestyle changes. Thus, neighborhoods within the central city have become targets of revitalization projects (Chapple, 2009; Pollack et al., 2010) to cater for the new residents who displace low-income Blue-collar workers (Dominie, 2012). These trends could explain the unusual surge in driving from the city center.

Nonetheless, commuting by driving in the South rose 3.0% higher than the driving in the East, while transit use dropped 2.6% more than the East. On the other hand, transit use in the West increased 0.6% more than the East, while percentage of workers driving was not significantly different between the East coast and West coast. These trends are normal because the MSAs in the East and West Coast similar condition such as severe traffic congestion and high cost of living. These factors motivate more workers to use public transportation.

On the other hand, it is likely that station areas in Southern MSAs experienced demographic and socio-economic shifts which encourage more driving; for instance, the bar graphs in Chapter 4 illustrated that the percent change in income and housing values in Dallas Fort Worth MSA significantly surpassed other MSAs . In addition, TODs in Dallas and Miami MSA, consistently registered lower transit usage for both 0.5 and 0.5 – 1.0 miles radius compared with the other MSAs. Overall, the variations in regional and location results signify that a context-based policy may be more effective in promoting alternative mobility.

5.3 Gentrification and Displacement Models One Mile Radius

The research uses the block group contract rent (Model – 3) and block percentage for Black population (Model – 4) as dependent variables to assess the causal link between gentrification and displacement.

In addition, the research uses the 1.0-mile radius based on the assumption that gentrification is a phenomenon that cannot be contained within 0.5 mile radius. Therefore, there are potential spillover effects from adjacent neighborhoods once change takes place. The research expects that CBD and Central city block groups should show a high propensity to gentrify. This is because most mixed-use development projects with new housing are located in the Central city neighborhoods (Chapple, 2009; Dominie, 2012).

On the other hand, Suburban block groups might be less likely to gentrify according to previous research showing that working class households are migrating to the suburbs while the middle class is shifting residential preferences to the central city (Kneebone and Berube, 2013; Kneebone and Carr, 2010).

5.3.1 Rent and Gentrification

Model-3 identifies causal relationships between variances in socio-economic and demographics variables and change in median rent within the block group. The research assumes that changes in the independent variable should lead to an increase in block group median rent, which linked to displacement of lower-income groups. Findings from Lees et al. (2010), research demonstrates that increase in median rent is associated with displacement of low-income groups in gentrified neighborhoods.

Model-3 reveals that rent values in TOD block groups exceed non-TOD values by 49%. This implies that the TOD policy is less effective in keeping housing costs down compared with non-TOD. The outcome is expected because the test of means and descriptive statistics demonstrated that soaring rents in TOD can be linked to demographic change in the respective block groups. The finding suggests that the presence of TODs could be linked with the occurrence of gentrification triggered by rising costs in housing.

Furthermore, the demographic variables are quite significant in predicting rent values except for percentage of workers in Blue-collar employment. Holding other conditions constant, the model predicts that a percent increase in White-collar employees results in a 0.62% rise in rent. However, a 1% gain in college graduates raises rent by

5.4%; this is surprisingly greater than the rates for White-collar workers. The last two findings suggest that class upgrading within the study area does in fact produce conditions that can create gentrification. Likewise, a percent increase residents since the year 2000, is associated with a 3.8 % increase in rent. These observations support the research hypothesis claiming that demographic change in TOD block groups escalates costs of housing. The percentages of workers in Blue-collar employment are insignificant in predicting change in rent, whereas growth in White –collar employment raises rent by 0.17%.

Interestingly, the results for racial categories presents some unexpected findings; a 1.0% increase in White population results in a 3.8% reduction in median rent while an increase in Black population leads to a 4.2% decline in rent. This finding is unexpected because scholars, (e.g., Harris, 1999) argue that the growth in number of White residents yields higher housing values, while a rise in Black residents results in a decline in housing values.

However, the data shows the contrary probably because of the trends observed in the descriptive statistics; whereas the percentage of Black population declined in the study area, the percentage of White population declined, even more (see p. 120, Figure 4-20). Therefore, the research cannot attribute rising cost of housing to race. First, the descriptive statistics indicate that the decline in the number of White populations far exceeds that of the Black populace. Secondly, the comparison of means shows that percentage of Blacks in TOD exceed non-TOD and MSA rates.

Therefore, gentrification within the study areas seem to have little or no racial component; gentrification in TOD block groups (from 1990 -2010) is a diverse phenomenon with households of various racial and social backgrounds leading to upgrading of neighborhood social class.

Table 5-4 Regression model for gentrification and displacement in block groups, 1.0-mi (2010)

	Rent _Model 3			% Black (2010)_ model 4		
	B	t	Sig.	B	t	Sig.
Constant	278.880	4.948	0.000	76.497	34.267	0.000
Demographic						
White -collar employment	0.615	2.852	0.004***	0.028	2.919	0.004***
Blue-collar employment	0.817	1.511	0.131	-0.311	-13.180	.000***
White	-3.810	-10.885	.000***	-0.780	-73.831	.000***
Black	-4.294	-12.948	.000***			
College graduate	5.446	13.572	.000***	-0.023	-1.277	0.202
Resident from yr. 2000	3.757	8.386	.000***	-0.034	-1.691	0.091*
% Socio-economic						
Owner occupied housing	5.477	18.238	.000***	0.082	5.805	.000***
Median housing value ('0000)	0.000	4.741	.000***	-0.203	-16.912	.000***
Median rent ('00)				-0.800	-12.567	.000***
Per capita income (000)	6.000	18.523	.000***	0.000	12.622	.000***
Location dummy variables						
TOD policy	49.043	4.768	.000***	-2.064	-4.500	.000***
Distance to station	-0.027	-2.061	0.039**	0.001	2.217	0.027**
Central city	28.329	2.720	0.007**	8.719	17.242	.000***
Suburban (Terminus)	-7.837	-0.375	0.708	-4.483	-4.842	.000***
Years in operation	4.842	9.420	.000***	-0.192	-8.386	.000***
	ADJ R: 0.553			ADJ R: 0.694		
Sig: 0 .05 p < 0.10 (*) .05(**) .01(***)	N = 4538			N = 4538		

For socio-economic variables, the coefficients indicate that a unit increase in per capita income is associated with a 6.0% increase in block group median rent. A 1% rise in percentage of homeowners (owner occupied housing) is associated with a 5.5% increment in block group median rent. Further, for every year a station has been in operation, rent increases by 4.8%. These observations are expected because property is supposed to appreciate with time. However, the latter observations support the

proposition that increasing rent in TOD might lead to displacement of transit dependent groups. Finally, a percent increase in block group median housing values leads to a .20% increase in rent.

These results support the research hypothesis that socio-economic changes in TOD block groups could signal the onset of gentrification. For location parameters, CBD stations are the reference category. Central City rent is 28% more expensive than CBD rent; however, Suburban rent is 8% cheaper than CBD rent. The research did not expect that rent values within the Central city would exceed CBD rates. The bid rent theory stipulates that competition for properties in the CBD eventually generate expensive rents and highest land value in the MSA (Park and Burgess, 1967; O'Sullivan, 2009). Eventually, retail and commercial activity, outbids residential use for expensive CBD property. Consequently, residents who are unable to afford hiked up rents are obliged to migrate to inner city neighborhoods at the edge of the CBD. In doing so, displaced residents intensify competition for rental housing in which in turn escalates rents.

Based on this theory, Central city block groups probably exhibit superior growth in rent because of a greater concentration of apartments at the edge of the CBD. Consequently, lower income working-class residents who are priced out of the CBD drift towards the outer zones of the central city to maintain access to transit. This intensifies competition for apartments in inner city neighborhoods among carless households trying to remain close to transit networks (Park and Burgess, 1967; Wassmer, 2000; Glaeser et al., 2007; O'sullivan, 2009). The above reasons could explain why locations in the Central city registered higher increases in rent compared to the CBD.

5.3.2 Displacement Model

Model-2 presents variables used to predict displacement of Black population (Table 5-4). The research uses the percentage of Black population as a proxy for transit dependency because the demographic profile of African-American population disproportionately displays characteristics of low-income, carless households with high transit usage (ACS, 2010; APTA, 2011).

To begin with, the data indicates that TOD block groups have 2.1% fewer Blacks compared with non-TOD block groups. However, the percentage of individuals with a college education is not significant in predicting the size of the Black population within the study area.

Nonetheless, a 1% increase in the number of Blue-collar employees is associated with a 0.31% decline in the percentage of Blacks, while an increase in the number of White-collar employees results in .03% increase in the number of Blacks. Conventional knowledge would stipulate that more Blacks should be in Blue-Collar employment; census databases (ACS, 2012) report that 64% of the Black women hold “white-collar jobs” compared to 30% of Black men. Therefore, only 45% of Blacks hold white collar jobs. However, the results showing that percentage of white-collar employees rises with that of Blacks suggests that a significant number of the Black populace in TOD block groups hold White-collar jobs.

A 1% increase in percentage of the White populace results in approximately 0.80% drop in Black population. Concurrently, a 1% increase in block group median rent

is associated with a 0.80% decline in percentage of Blacks. This is very interesting because of the similar direction and percentage change;

Correlation results (Chapter 4) revealed that the percentage of Whites has a positive impact on housing costs, education attainment, and White-collar employment. Conversely, the number of Blacks are negatively associated with the same variables (Table 4-6 Pearson correlation coefficients for change in variables). Thus, the percentage of Whites possibly accounts for the largest decrease in the Black populace, because Whites generally command higher incomes and therefore can outbid Blacks for TOD housing. Hence, the growing number of Whites in the block groups might have some latent interaction with rents, which eventually results in displacement of Blacks.

The next set of variables reveal that from 1990 -2010, Central city blocks groups have 8.0% more Blacks compared with the CBD; while the Suburbs have 4.0% fewer Blacks compared with the CBD. This finding suggests that the Black populaces are more likely to cluster in the Central city because they cannot afford to live in the suburbs.

Finally, longstanding stations are associated with a 0.20% decline in Black population per year of operation –, while the percentage of residents who moved into the block group since the year 2000 produces a 0.03% drop in the percentage of Blacks. This outcome suggests that over time, newer residents drive up housing costs leading to displacement of transit dependent groups. As the stations remain longer in operation, newer residents lead to displacement of Blacks

Overall, the results from Model–4 demonstrates interrelationships with data from Model–3, which underscores the complexity of measuring gentrification and

displacement. The models provide supporting evidence suggesting that demographic and socio-economic shifts in TOD block groups could be interrelated with rising costs of housing and displacement of transit dependent groups. Overall, the regression models demonstrate that gentrification—or the cumulative changes in income, education attainment and cost of housing (1990 – 2010), — can be associated with the presence of TOD within block groups in the study area.

5.4 Conclusion on Data Analysis

This research was motivated by previous studies (Chapple 2009; Pollack et al., 2010; Dominie, 2012) reporting that decline in public transportation can be associated with gentrification trends in transit-served areas. The research employed historical census data (1990, 2010) to investigate the relationships and effects of demographic change in TOD and non-TOD block groups on mode choice and equitable accessibility to public transportation. Data analysis began with presentation of descriptive statistics examining change in socio-demographics in block groups with TOD and non-TOD at 0.5 miles and 0.5-1.0 miles radius of transit stations. Finally, the research used regression analysis to investigate relationships between variables. With all the analysis completed, the next section summarizes research findings by answering the research questions, and outlines possible contributions to theory, followed by policy recommendations.

5.4.1 Conclusions Research Questions

1. *How has the socio-economic and demographic character of communities changed in block groups, which are within 0.5 mile and 0.5-1.0 mile of TOD and non-TOD stations*?

The research findings are contingent upon region and location of the station area within the MSA. However, there are some general observations with significant implications. First, the results suggest that from 1990 -2010, TOD and non-TOD, experienced class upgrading evidenced by rising rents, car ownership and per capita income; in addition to, higher percentage of college graduates, and White-collar employees in TOD. Concurrently, there was a significant decline in the percentages of Blacks and Blue-collar employees, although percentage of Whites declined as well. In addition, the percentages of foreign-born and Asian populace increased within TOD and non-TOD block groups respectively (see Table A-2 in the appendix).

Therefore, the 2010 data indicates that Whites average nearly 80 % of residents in TOD block groups, while the Black population average less than 10%. Whereas these results seem to suggest social imbalance, the reader is cautioned in interpreting the results as a sign of displacement for the following reasons.

Even though the block group percentage of the Black population declined, the percentage of the White population declined even more. Nevertheless, the Black populace retains a higher proportion of households within the 0.5-mile radius. This makes it a complex issue to claim displacement of minorities and transit-dependent population based solely on racial imbalances. Future research should examine these results by region

and transit system to isolate unique changes. Furthermore, the percentage of groups that are usually dependent on transit such as the foreign-born population increased within TOD block groups when compared with the MSAs. However, median income increased above MSA levels, while the percentage of White-collar workers increased significantly in TOD block groups compared with MSAs.

The results for housing variables varied by; first, renting housing in TOD block groups is more expensive than renting homes located in non-TOD block groups; in addition, housing values in TOD were higher than non-TOD, yet non-TOD had more owner occupied homes. However, there was no difference for change in housing variables between the TOD and non-TOD. Last, there were more homeowners within 0.5 miles radius of TOD block groups, compared to the 0.5 -1.0 mile radius. These results suggest that costlier housing in close proximity of TOD excludes low-income Blue-collar workers. Finally, there was a general decline in the number of households with no car, while percentage households with one car or more increased. These results support the research hypothesis stating that presence of TOD could be associated with the process of gentrification.

2. *Is the presence of TOD interrelated with the occurrence of gentrification in block groups within 0.5 and 0.5-1.0 mile of transit stations?*

This answer also depends on the region and location of TOD. In general, descriptive statistics suggest that the presence of a TOD could be associated with gentrification within the study area. The gentrification models demonstrated that the percentage of population with a college education, high incomes, and White-collar

employment significantly increase cost of housing, which, in turn, can be associated with the decline of transit-dependent population (i.e. Black population).However, some trends in the demographic data including (percentage of foreign-born, Blue-collar employment) do not entirely support the research's' propositions and hypothesis regarding gentrification.

Nonetheless, change in socio-economics variables (cars per household, income, rent, and housing values) point toward gentrification in TOD block groups. In the displacement model, most variables except per capita income, owner-occupied housing, and White-collar employment support the research hypothesis that change in socio-demographics is associated with displacement of low-income transit riders.

On the other hand, income, owner-occupied housing, and White-collar employment are negatively associated with increase in transit-dependent population. This finding implies that interpretation of displacement is contingent upon the variable used. In general the findings suggest that occurrence of gentrification within the study area can be linked to the presence of TOD.

Yet, when the research deconstructed the data to the MSA and transit system, it was clear that not all the areas experienced similar change in socio-economic and demographic characteristics. MSAs such as San Francisco-Oakland and New Jersey did not show signs of gentrification. While, Portland-Hillsboro and Washington DC showed mixed results; on the other hand, changes in Dallas-Fort worth and Miami-Fort Lauderdale revealed definite signs of gentrification. These assorted findings suggest that

policy prescriptions need to adhere to a context-based approach depending on neighborhood.

3. *How have changes in socio-economic and demographic factors influenced mode choice in block groups within 0.5 and 0.5-1.0 mile radius of TOD and non-TOD stations?*

The results suggest that TODs are likely to contain more workers driving and fewer workers using transit compared to non-TODs. However, percentage of workers driving declined in all the study areas, while those using transit increased. This is surprising because housing became more expensive, while the number of households with two cars or more increased as well. The research had predicted that more cars per household and higher housing values would cause percentage of workers using transit to drop.

The regression models demonstrate that the demographic variables (e.g. White, college graduates, and population density) were mostly unreliable and inconsistent in predicting the percentage of workers driving except for residence since 2000 and employment type. However, an increase in the percentage of Blue-collar workers and Black residents increased transit use, while a rise in White-collar employment increased driving. In addition, the percentage of households in owner-occupied housing consistently registered a positive association with driving and a negative relationship with transit ridership.

Not surprisingly, the variables most consistent in predicting mode choice were the percentages of households with no car and households with more than one car. Households with no car have a positive impact on transit ridership and a negative effect on driving. Households with one car showed mixed results, while those with more than one car registered a negative impact on transit and positive one on driving. It may seem redundant to mention these observations; however, the reader is reminded that TODs are supposed to discourage driving, increase transit use and opportunity for carless households. Therefore, the fact that we are even talking about a surge in cars per household suggests that the policy might not be that effective in discouraging car ownership and driving.

The research also found a positive correlation between residents since the year 2000, with education attainment, median income, and cars per household and driving. Furthermore, using correlation analysis and t-tests alone support most of the research hypothesis regarding demographic change in TOD and the unintended effects on mode choice. However, the results from regression models were largely mixed and inconsistent.

In summary, the evidence in this paper supports the claim that demographic change within TOD block groups can lead to higher rates of driving. However, it is possible that decline in driving in TOD and non-TOD block groups may be an outcome of the economic recession and rising energy prices (Lane, 2010). Data from the Federal Highway Administration (Santos et al., 2011) corroborates research showing that driving for most trip types has declined since 2001. Nevertheless, while there is some growth in

transit use in TOD and non-TOD block groups, the growth rate has not been encouraging in the last 25 years.

4. *What are the differences between socio-demographic characteristics of communities living in TOD compared with communities in non-TOD; further, what differences exist between communities within 0.5 miles of TOD compared with communities living within 0.5-1.0 mile radius?*

According to the descriptive statistics in Chapter 4, there are certainly significant differences between socio-economic and demographic characteristics of communities living in TOD and non-TOD block groups. The results indicate that non-TOD block groups registered higher averages for transit use and less for driving compared to TOD. In addition, TODs contain households with a higher median income, education attainment in addition to more home owners. These results suggest gentrification.

The comparison of means revealed that TOD and non-TOD block groups vary in mode choice although it appears that non-TOD stations have outperformed TOD in increasing transit use while reducing driving to work. The explanation could be that Non-TOD stations also have transit joint development (TJD), which could also help increase transit use (Cervero et al., 2002 and 2004). Therefore, it is possible that non-TOD stations register high rates of transit use because of the support of mixed-use joint development.

Nevertheless, comparing TOD performance at 0.5-mile radius to the 0.5-1.0 miles radius indicates that TODs are still effective and slightly better within the 0.5-mile radius.

Table A-3, in the appendix indicates that compared to the 0.05 -1.0 miles radius. At 0.5 miles radius TOD had lower rents, housing values and driving rates, in addition to higher transit ridership, percentage of Blacks, foreign born, and Asians. However the reader is reminded , again that when compared to non-TOD or the MSA, the results show that TOD have signs of unintended outcomes that might compromise the sustainable urban development.

The research reiterates that the above findings rely on aggregate data. A disaggregate assessment by MSA and transit system reveals that the study areas varied in socio-economic and demographic change from 1990 to 2010. For example, California and New Jersey TOD block groups showed higher transit use and almost no sign of gentrification ; yet,Texas and Miami TOD registered significant decline in transit use and higher values of rent compared to the other MSA in the study.

5.5 Possible Contributions to Theory

The findings from this research provide the following theoretical contributions. First, the comparison of means and descriptive statistics suggests that communities living farther away in the 0.5-1.0 mile radius use transit nearly as much as those living within 0.5 mile radius. This finding implies that the TOD's area of service can expand from 0.5 miles radius to 1.0-mile radius. This proposal has been explored by researchers such as Guerra et al. (2012) and Chatman (2013) suggesting that the traditional 0.25 - 0.75 mile radius may need revisiting.

Extending the boundary of TOD (with walkways and bike lanes) from 0.5 miles to 1.0 miles radius can potentially increase accessibility for households living farther from the rail station. Secondly, while stations with TOD encourage transit use, non-TOD stations performed almost as well or even better. This finding suggests that TOD policy alone is necessary but not sufficient for improving transit use. Improving transit coverage and frequency of service is possibly a stronger option.

Thirdly, the research finds that planners cannot simply frame the occurrence of gentrification within 0.5 miles radius of TOD block groups in the context of race alone, if at all. In the past, scholars associated fluctuation in housing costs with racial representation in neighborhood (Crowder and South 2008; Harris, 1999; Lees et al., 2010). Some of these studies argued that an increase in the percentage of Black residents often results in White flight, which in turn results in lower property values as demand plunges. However, the data does not entirely support these claims. In some cases, the percentage of Black population increased concurrently with housing values; in other instances, the cost of housing increased even though the block group percentage for White population declined.

Last, demographic variables including race, education, and employment type were not significant in predicting commute by driving. However, the variables did show some influence on transit use. Overall the findings in this research, suggest that most workers in the study area prefer to drive for work regardless of race, income, or education attainment.

Chapter 6

Policy Iimplications

Transportation planners can draw lessons from cities using TOD in the last 25 years so that future TOD policies can account for negative externalities arising from demographic change. Some scholars have advocated for improved policies to deal with increasing demand for transit-oriented living. The following statement best summarizes this view:

> "Policy-makers need to be aware that America's current transportation policy—dominated by road building—is fundamentally out of touch with the transportation patterns and expressed preferences of growing numbers of Americans. It is time for policy-makers to consider the implication of changes in driving habits for the nation's transportation infrastructure decisions and funding practices, and consider a new vision for transportation policy that reflects the needs of the 21st century." (Davis et al., 2012, p. 1)

Bearing this quote in mind, the research proceeds to the next section with policy recommendations.

6.1 Context-Based Policy

Because of the results varying by location and region, the research recommends that policies should be guided by the demographic and socio-economic uniqueness of the MSA, city and neighborhood. Before proceeding, with recommendations, there are general observations which need recapitulation:

1. Regression results and descriptive statistics suggest that a station with a TOD is not significantly better in encouraging transit use compared to non-TOD stations. The latter registered almost similar levels of transit use, although this might be because they also have transit joint development (TJD).

2. Transit as the preferred mode choice increased between 1990 -2010; however, the increments were below projected rates, in light of significant expenditure on improvements. Moreover, most transit systems still require the government to subsidize 60% of their operational budget (APTA, 2012). This possibly means that the growth in ridership is not enough to pay for operational costs.
3. The percentage of households with two or more cars generally increased in most TOD block groups when compared with non-TOD.
4. Housing values and rents in TOD generally increased above MSA rates.

Moreover, correlation coefficients confirm that the direction of association between independent and dependent variable had relationships that suggest the change in factors (such as cost of housing, education, income, and number of cars) can affect transit use negatively. These findings support the research hypothesis and propositions that socio-economic and demographic change in TOD block groups can lead to unintended outcomes such as less transit use and high costs of housing.

Finally, the regression models largely displayed mixed results, but still with significant takeaways:

1. Most demographic variables such as race, education, and employment type were not significant in predicting commute by driving. However, the variables did show some influence on transit use. This makes sense in light of the fact that most Americans still prefer to drive for work regardless of race, income, or education attainment.

2. For socio-economic variables, the number of cars per household and workers walking or biking is the most important variables affecting transit use.
3. The gentrification and displacement models demonstrated that rise in income, education, attainment, and rents do in fact lead to reduction of households who are transit-dependent.

Therefore arising from the above, this research recommends that there should be a shift from development-oriented transit to community-oriented transit, that endeavors to understand the dynamics in community demographics rather than relying on the built environment alone (Chatman 2013).

To achieve success, transit planners should endeavor to support the social bond that exists between public transportation and the community it serves (Cervero et al., 2002). However, the transportation plans sometimes focus on politically acceptable routes, which may not be based on need (Dunphy et al., 2005). A case in point is the new Orange line of the Dallas Area Rapid Transit (DART), which serves affluent areas such as Las Colinas, Plano, and Richardson. Yet, DART does not appear to provide adequate light rail coverage in the south and east Dallas, where most low-income communities reside. Bus coverage is moderate; however, traveling by bus implies long wait times that are not conducive for work commute. Certainly, middle and upper middle income communities should also have the right to access public transportation; however, transit infrastructure should be more accessible for neighborhoods that have transit-dependent population (Sanchez and Brennan, 2007).

Federal and local governments constantly endeavor to develop sustainable transportation systems and provide affordable housing to communities in need. Yet urban scholars argue that a benevolent policy can often lead to unintended consequences that may harm the population they seek to serve (Jackson, 1985; Schill and Wachter, 1995).

It appears that transportation planners employ a universal policy design as opposed to context-based policy. Block groups within one mile of TOD stations have experienced varying demographic changes that require policies that are location sensitive and serve the needs of groups within the neighborhood context. These results are outcomes of previous policies designed to improve accessibility and mobility for diverse groups.

It is worth reviewing some of the current policies to provide some normative arguments and background as a basis for the research's position on future policy. The first area of concern is the current implementation of some of the affordable housing policies which quite possibility may not improve accessibility for transit-dependent population. One concern regarding the current TOD strategy is in the name of the policy itself; The TOD concept appears to focus mainly on *transit* and *development* with little on emphasis on *community* and *equity* (Sanchez and Brennan, 2007; Rose et al., 2011). The policy itself should perhaps change its name to development-oriented transit because it revolves around development of the built environment.

This research advocates for demographics and community to add a *D* to the five D's: density, diversity (mixed use), distance, destination, and demand. Perhaps planners should even change the name of the policy to community-oriented development.

The stipulations of the prevalent paradigm have also influenced the federal transit program promoted by the U.S. Department of Transportation. This influence however, does not augur well for sustainability of these policies. The focus on the built environment while overlooking community involvement can prove to be problematic because of gentrification. This research has demonstrated that the mere provision of affordable housing alone will not significantly improve transit as a mode choice.

This is because there is nothing to indicate that low-income residents who had benefited from low-income housing could change commuting preferences once their income increases. Furthermore, housing only remains affordable for 10-15 years; after that, high housing costs will drive out low-income groups as noted by the Association of American State Highway Officials (Bailey, et al., 2010). Therefore, there is a need to focus more on a long-term policy that ensure persistent affordable housing. Currently, the Federal Transit Administration's (FTA) New Starts program has specified six new project justification and scoring criteria for developers seeking government funding for transit-oriented development (Spotts, 2013). The rules and guide come from the 2010 revision of the Major Capital Improvements Program (49, CFR, Part 611).

The rules evaluate projects on the following criteria:

i. *Mobility improvements*: Assess the number of incremental trips taken by transit-dependent population.
ii. *Economic development*: Assesses the extent to which affordable housing and community development are parts of the project goals. Furthermore, the policy encourages transit joint development with private developers. The policy broadens the scope of the project to benefit various sectors of the community.
iii. *Environmental preservation*: In the interest of sustainable community strategy, the TOD project should have an impact on reducing emissions, vehicle miles traveled, and economical land use.
iv. *Land use design*: Project will be assessed based on the mixed-use developments and presence of affordable housing
v. *Cost effectiveness*: Includes cost benefit assessment of the project. Benefits that improve energy use, reduce emissions, and provide affordable housing can also save costs.
vi. *Congestion Relief*: The TOD project's ability to reduce traffic congestion and vehicle miles traveled.

While the FTA expects developers to build low-cost housing, the criterion does not explicitly emphasize housing affordability or social equity (Sanchez and Brennan, 2007) and community involvement. One does not get the impression that social and spatial equity is a fundamental goal for FTAs capital improvement program. Certainly,

this research recognizes that the FTA does realize the need for low-income housing, but this latest policy document highlights the fact that FTA does not make egalitarianism a centerpiece of it development policy.

6.1.1 Demographic Change and Social Equity

Campbell (1996) appealed for a more balanced approach between economic development, environmental sustainability, and social equity. Using the "planner's triangle," Campbell (1996) examines the tensions that exist between economic development and social justice, whilst pursuing sustainability and spatial justice. However, TOD projects sometimes focus on revitalization projects that could exclude low-income groups (Kahn, 2007; Chapple, 2009; Pollack, 2010).

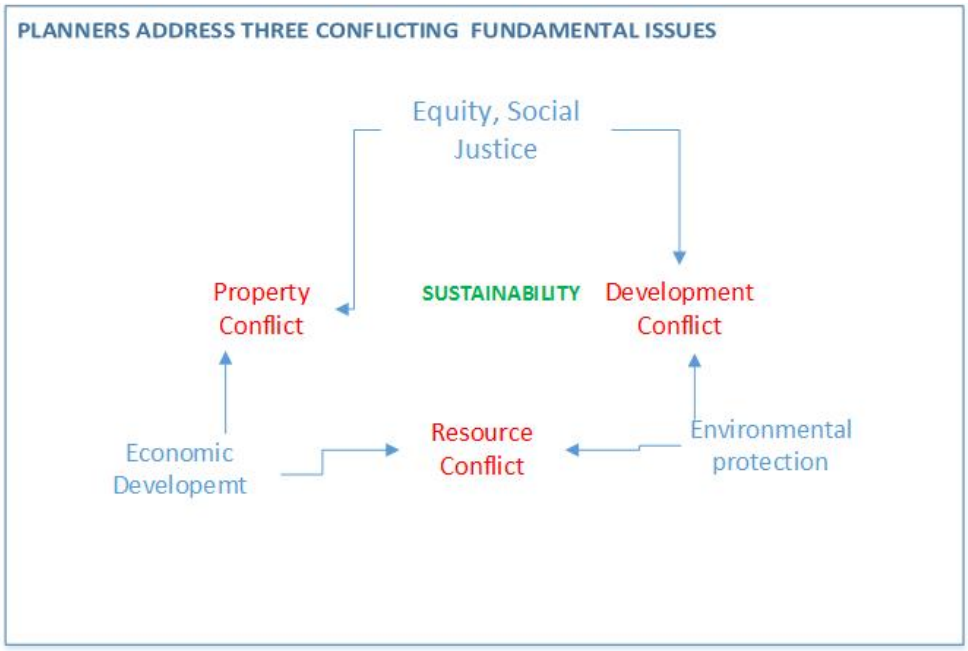

Figure 6-1 The Planner's Triangle (Campbell, 1996)

Fujioka (2011) and Wong (2014) raise this concern, while criticizing San Francisco's redevelopment of transit served neighborhoods to serve the rising populations

of tech-company employees. Apparently, the new housing developments disproportionately pander to the whims of the nouveau riche of Silicon Valley while driving the immigrant population to the margins of the central city. Fujioka concludes that the booming real estate market transformed the demographic makeup of several Bay Area neighborhoods by "pricing-out" working class Asian and Hispanic immigrants.

These observations by Fujioka (2011) exposes new urbanism for overemphasizing the built environment in advancing sustainable communities strategy; yet , this approach might ignore important issues social equity and community involvement in planning (Lin and Gau, 2004; Sanchez, Stolz, and Ma, 2004).

Some critics of physical planning have termed this as *spatial fix*. This term refers to the place-based versus people-based debate in which advocates for the latter criticize the overreliance of planners on the built environment at the expense of social equity and "building community" (Crane and Crepeau, 1998; Harvey, 1976). When redevelopment of public space relies excessively on physical infrastructure, we have to expect that the policies might produce unintended outcomes that affect the welfare of vulnerable communities (Logan and Molotch, 1987; Sanchez et al., 2004).

Yet this issue cannot be framed solely in such a reductionist stance, because the matter of development is rather complex. To be fair, developers and municipalities rightfully seek a reasonable return on investment because of much needed profits and tax revenue.

Consequently, spiraling property values and rents within transit-oriented development can become a desired outcome for both the local government and private sector seeking more gain. However, as the data revealed, expensive rents can be linked with the occurrence of gentrification and displacement of lower-income transit dependent households.

Most planners tend to focus on providing affordable housing, yet few seem to question the long-term effectiveness of these policies when the neighborhood succumbs to market forces and demographic shifts (Belzer et al., 2006). Therefore, it is important to understand the implications of changes within TOD and its ability to provide benefits to transit-dependent population in the long-term horizon of 15 years after development (Cowing et al., 2012). This is an important issue because one primary goal of TOD should be to provide affordable housing and access to amenities such as schools and parks for diverse groups of people. However, Wise and Scire (2009) reporting for the Government Accountability Office criticize the inadequacy of federal government policies saying,

" . . . HUD and FTA programs allow local and state agencies to promote affordable housing near transit, but rarely provide direct incentives to target affordable housing in transit-oriented developments" (Wise and Scire, 2009).

The quote is quite revealing about how little attention current government programs provide toward the effect of TOD on egalitarianism.

Haughney and Sherriff (2010) point out that HUD requirements for housing affordability only spans 10-15 years, which in the urban context is barely enough time for

neighborhood change. Therefore, affordable housing stock should remain beyond 15 years to serve the transit dependent population.

This concern is rather complex when one considers the need to balance market forces and social engineering (Utter, 2009). This entails the contested ground between the need to provide affordable housing while allowing market forces to provide developers a reasonable return on investment (Vigdor, 2002; Freeman, 2005; Slater, 2010; Utter, 2009). Furthermore, cities are increasingly leveraging the creative class model to revitalize their economies. Many cities facing a declining downtown and disinvestment adopt the revitalization concepts made by Calthorpe (1993) and Florida (2002). The expected result is more tax dollars to fund economic development programs.

Some proponents of gentrification such as Freeman (2005) doing work in San Francisco (CA) argues that gentrification increases diversity. Therefore, the more important issue is finding the middle ground between social equity and development goals. Therefore, urban planners should ask if the creative class and revalorization of public space is compatible with social equity goals. As this research has shown, simply using one strategy to fight displacement of vulnerable groups cannot withstand evolving demographic nature of neighborhoods overtime.

6.1.2 Improving Service and Coverage

Some of the reasons commuters often mention for avoiding public transportation is because they consider it unsafe, uncomfortable, unreliable, and inconvenient. Even though TODs stimulate ttransit ridership, Cao et al. (2009b) and Taylor et al. (2009) note that service levels, frequency of service and fares are probably more important.

Accordingly, the primary policy direction this research suggests, is improving quality of service and transit coverage. The research maintains that funds intended to develop TOD could produce more rewards if spent on improving the system levels and quality of service.

Cities with poor transportation services can expect to have low ridership and mode choice. For instance, the DART systems show the most dismal performance. It is not surprising that this is the case; I used DART for a 20 mile trip from Arlington to Dallas lasting one hour and five minutes including wait time; yet, a similar trip with BART could have lasted only 25 minutes during peak hours. This is because BART has one of the best services in the country in terms of coverage and frequency. Therefore, transit agencies planning to use TOD alone should consider improving quality of service as well as investing in TOD. Quality here means better system coverage, shorter wait times, and faster travel times.

6.1.3 Disincentives to Drive

Normally, planners create incentives to use transit or discourage driving. However, in a country where the American dream and freedoms are defined by car ownership, providing disincentives to drive is not a very popular approach. Yet the

research finds that the number of cars per household was the single most influential factors affecting mode choice.

Although findings from previous research indicate that most TOD residents are self-selecting (e.g. Arrington and Cervero, 2008; Cervero and Duncan, 2002a), there is evidence from this study demonstrating that the number of households with more than one car increased in TOD while those without a car declined. The research also found that TODs can be associated with increased driving and reduced transit use. Arising from these findings it seems like a significant number of households are not in TOD for the sole purpose of using transit; the residents might like the idea of transit as an option, although they would rather to drive to work.

In sum, the problem with slow growth in transit could be the growing number of households with cars negatively affecting transit use. Therefore, the research recommends development of more housing with less parking facilities to discourage driving. However, scholars have found that private developers simply are not very supportive of building homes without adequate parking facilities in a country that still depends heavily on and prefers personal automobiles (Arrington and Cervero, 2008; Utter, 2009. Therefore, the challenge is to provide incentives to drive less such as transit free passes, and promoting limited parking such as allowing only one car per household.

6.1.4 Diversifying Housing and Parking

One policy prescription that has been extensively researched is the provision of affordable housing. Therefore, I will not discuss housing affordability since several scholars and HUD have exhaustively explored various dimensions of this policy for the

last 10 years (Cervero et al., 2002; Danyluk and Ley 2002; Renne, 2005; Belzer et al., 2006; Lipman, 2006; Wise and Scire, 2009; Pollack et al., 2010; Quigley, 2010; Dominie; 2012 , etc.).

This research found that whereas cost of housing increased between 1990 -2010, transit share for work trips increased as well. Moreover, neighborhoods offering affordable housing still registered escalating cost of housing after ten years. Therefore, it seems like the provision affordable housing is really a normative issue to improve equity; but not necessarily a requirement to improve ridership. In other words, do we really need affordable housing to improve transit use if is only effective for 15 years.

One direction that could be explored is developing parking structures rather than housing. Certainly, Shoup (1997) argued that parking is not cheap because there are hidden costs of development and maintenance. However, compared with the cost of finishing an apartment, parking structures are cheaper. Further, Shoup (1997) conducted the study in Southern California around University of California, which is has a high cost of living because of its proximity to Hollywood.

Based on research data, it appears that individuals who are more likely to use transit live in the periphery of the one-mile service area. In addition, when the cost of housing increases, transit-dependent population are eventually priced out of the neighborhood within 0.5 miles radius. It may be of more efficient and economical to invest in mixed-use Park and Ride stations with retail and office space rather than housing (Kahn, 2007).

The parking structure can provide cheaper rates for transit users while generating income from people coming to use services in the area. Parking structures might be cheaper, and more units can be built per square acre when compared with housing units whose values can increase exponentially. In this way, planners can be certain that whoever is using the parking is most likely a transit rider. To ensure for posterity, the design of parking structures should make it easy for adaptive reuse as multifamily units as populations grow.

6.1.5 Coordination of Land-Use Policy

Regarding land-use policy, two findings from this research provide some insight into some future changes.

First, the research demonstrated that up to a one-mile radius workers in TOD and non-TOD block groups used transit more when compared with the rest of the MSA. This implies that the traditional policy focusing on the 0.5-mile radius is anachronistic with current changes, because nowadays commuters can ride or drive to a Park and Ride. Likewise, Guerra et al. (2012) questioned whether the 0.5-mile radius is really practical anymore. Their study found that the network distance does not make much difference.

Currently, planning authorities designate mainly a 0.5-mile radius from a transit station as a special TOD zone, which is a comfortable walkable and bikeable distance. However, based on the research findings, this distance might require expansion up to one mile to capture potential transit users able to bike or take bus connections.

Furthermore, metropolitan planning organizations need to expand focus from to providing affordable housing beyond the half-mile radius. Thus far, affordable housing and mixed-use developments are located within a few central city neighborhoods. However, transit systems span multiple governmental jurisdictions including towns, cities, counties, and sometimes States (e.g., WMATA and NJT). In order to improve efficiency of transit, there has to be contiguous density and mixed use along the whole transit route.

Policies intended to promote transit can be hindered if land-use regulations and zoning codes are not well coordinated along a bus route or rail line. Take the example of North Texas where transit declined in the last 25 years: cities such as Arlington with no support for public transportation have frustrated efforts to integrate the Dallas-Fort Worth region with mass transit (Li and Apell 2010).

In addition, the current assortment and fragmentation of zoning laws in some regions require coordination to improve region-wide efforts to promote land-use density and mixed use developments. It is simply not effective for one city to promote land-use policies that support density, mixed-use developments, multifamily housing, and pedestrian/bike friendly streets when some other cities along the transit line do not support this approach (Bailey et al., 2006). This problem exists in the Dallas MSA where one city, Arlington has rejected public transport in three separate elections (Li and Apell, 2010).

Even though most MPOs receive metropolitan-wide mandates in regional transportation plans, they exercise little control over local politics and land-use development patterns (Rose, 2011). MPOs use models that assume build out for metropolitan areas; however, the details and future patterns of growth are unknown (Bailey et al., 2006). Furthermore, development of local trip generators such as entertainment, shopping, schools, and housing development at the local level is subject to a complexity of issues such as local politics, developers' preferences, and support (or lack thereof) by elected officials. All these issues complicate location-efficient modeling of transit routes. Achieving success of transit systems will require reexamining power structures and decision making processes to better support long-term planning for public transport (Rose, 2011). A possible solution could be providing MPOs more leverage in land assembly and land-use decisions.

6.1.6 Market Segmentation and Location Specific Policies

Hemily (2004) recommends a market-based approach, which considers the neighborhood context in terms of demographics and socio-economic character. Planners should focus on groups such as the Millennial generation who have smaller families and do not mind using public transport (Ryan, 2007; Pew Research Center, 2010).

The weak growth of market share probably arises from lack of connection between demand and services. While local and federal governments promote affordable housing, while the private developers, who are largely responsible for real estate development, tend to avoid investing in low-income communities because of a perception

of high risk (Liggett et al., 2003). The risk is defined by high crime rates and neighborhood decline.

Dunphy et al. (2005 p.14) acknowledge that transit projects may have largely focused more on neighborhoods with briefcase-carrying, choice riders rather than transit-dependent population. As such, new TOD housing, retail, and commercial developments are disproportionately located in middle-class neighborhoods where property values and rents systemically filter out low-income households. The outcome is less accessibility for captive riders, which traditionally constitute a reliable market for public transport.

6.1.7 Community Awareness and Involvement in Planning

One of the challenges with expecting TOD residents to use transit is that some are not even aware of or do not support the goals and objectives of living close to transit (Li and Clower, 2012). Therefore, there is need to increase public awareness through information sharing about TOD projects and its goals.

Community involvement in planning should not be a nice catch phrase with no serious intention to hand over power and decision making authority as articulated by Arnstein (1969) in "*A Ladder of Citizen Participation*." Dialogue with stakeholders should promote a sense of ownership for a TOD project, rather than engaging in token public input. While talking to some TOD residents informally, the researcher found that residents in some Dallas TODs were unaware that the one of the goals of their rental units is to promote alternative mobility options. Additionally, some residents expressed incredulity at the suggestion that anyone would expect them to use public transportation, which they considered crime-prone and a very inefficient mode of traveling. Survey

respondents in research done by Li and Clower (2012) among DART TOD residents expressed these sentiments as well. Because of the disconnect between TOD goals and the actual outcomes, authorities need to take note and intensify public outreach for communities living within a one mile radius of transit hub to promote support for TOD (Bailey et al., 2006).

There are several success stories regarding this recommendation, Reconnecting America, a pro-TOD, non-profit organization, reports that while planning Mission Meridian Village, South Pasadena, California, the developer sought the feedback from residents before putting up a high-density mixed-use TOD in a single-family neighborhood that had been against high density and multifamily units. "…through cultivating their interest, input and enthusiasm the developer succeeded in getting their support for what became a catalytic and immensely popular development that activated and improved the entire neighborhood" (Center for Transit Oriented-Development [CTOD], 2010).

In San Diego, California, the Barrio Logan TOD involved the community development corporation in planning daycare centers. The list of transit villages, which includes ones Georgia and New Jersey, shows that involving the community does, in fact, increase the likelihood of success of TODs.

6.2 Limitations and Future Research

Like any study of this magnitude, the researcher cannot possibly account for all the variables that explain causality. This is mainly due to limitations of the census data structure and lack of resources to collect disaggregate data from six MSAs. Furthermore, several factors can influence transit use such as culture, gross metropolitan product, time of travel, and quality of service (Taylor et al., 2009). Some MSAs may have a significant portion of residents who are environmentally conscious and therefore support transit to reduce their carbon footprint. Further, the research uses data from part of a period (2006-2010) when the country was experiencing an economic recession. A sudden increase in transit use could have been a temporary artifact of commuters cutting back on transportation costs (APTA, 2011 and 2012). On the other hand, some MSAs such as San Francisco and Washington, DC may have a high cost of living, which motivates a significant percentage of community to use public transport.

These factors have not been included due to limitations in time and resources to collect quality data on these variables. In addition, comparing TOD and non-TOD stations that are in the same block group means that they may show similar results in mode choice because of aggregation. All issues means that the results presented here are contingent upon conditions being constant.

Using aggregate data implies the results do not accurately reflect the travel habits and demographic character of distinct neighborhoods, households, and individuals within the study area. Furthermore, normalizing 1990 data into 2010 boundaries causes small

errors from rounding which may increase the margin of error (Geolytics, 2013).[7] In addition, there could be errors from sampling bias even though the research has made every attempt to avoid this problem by selecting TOD and non-TOD block group data from different states and regions. Last, the study uses TODs identified by previous research. There is not a widely accepted database for TODs in the United States (Cervero et al., 2004; Renne, 2005). Therefore, designation of a neighborhood as a TOD is highly dependent on the transit agency and previous studies; however, using data from previous studies ensures that at least there is consensus among the body of scholars on classification of TODs until there is a national standard.

In conclusion, the inferences made from this research are an approximation that builds on previous studies and does not constitute a final word on what influences mode choice for work commute or the relationship between TODs and gentrification. The research offers possible factors that influence mode choice and the characteristics of the relationships between demographic change and mode choice using regression. These findings will add to the body of knowledge in transportation planning, which can potentially help planners to better understand the relationship between neighborhood change and transit use.

[7] GeoLytics is an organization, providing demographic data, census demographics, market research data, and geocoding for social researchers and business marketing since 1996.

Future research should investigate in detail why the rise in income and cost of housing does not lead to less transit use in TOD. This research had expected that rising cost of housing should result in displacement of low-income residents. However, this was not the case; while rents and housing values increased, in addition to decline of Black population, transit use still grew between 1990 -2010. Perhaps rising costs of housing causes households to cut back on driving in order to use cheaper public transport.

Future studies could conduct a disaggregate survey of residents living in TODs and ask questions about non-work trips and distance to work that the census does not ask. Variables used in the research should break down income further by category and include other variables of transit-dependent population such as seniors, school age children, and poverty rates.

Appendix A

Supplementary Data Tables

Table A-1 Change in variables in TOD and non-TOD, 0.5-1.0 miles (1990-2010)

Onemile		BART		WMATA		NJT		TRIMET		DART		METRO	
Variables		TOD	Non-TOD	TOD	Non-TOD	TOD	Non-TOD	TOD	Non-TOD	TOD	Non-TOD	TOD	Non-TOD
Change in %	No Car	-0.7%	-1.2%	-1.8%	-0.8%	0.3%	0.5%	-0.1%	-1.1%	-9.1%	-2.0%	-5.8%	-5.7%
Change in %	One Car	0.9%	-0.8%	-0.6%	3.9%	0.7%	0.0%	2.9%	4.0%	14.4%	0.9%	5.7%	6.9%
Change in %	One car or more	1.6%	2.5%	1.3%	1.8%	-0.2%	-0.2%	0.0%	1.2%	12.0%	5.3%	6.5%	5.8%
Change in %	Two cars	0.8%	3.3%	1.9%	-2.1%	-0.9%	-0.3%	-2.9%	-2.8%	8.8%	4.4%	0.9%	-1.1%
Change in %	Transit	1.8%	1.9%	1.2%	2.0%	3.2%	2.7%	2.8%	3.4%	-5.1%	-0.9%	-0.6%	-0.6%
Change in %	Drive	-13.4%	-12.2%	-10.0%	-11.9%	-13.5%	-12.8%	-14.5%	-16.1%	7.2%	-5.2%	-4.7%	-9.3%
Change in %	Other Mode	0.1%	-0.9%	0.3%	0.2%	-0.8%	-1.1%	1.9%	4.0%	-7.2%	-2.9%	-2.5%	-2.3%
Change in %	White	-14.0%	-10.8%	-4.2%	-1.5%	-10.1%	-13.3%	-12.3%	-7.0%	9.2%	-1.9%	6.0%	4.2%
Change in %	Black	-3.4%	-6.1%	-4.5%	-7.0%	0.6%	2.5%	0.3%	-3.7%	-11.4%	-4.0%	-7.7%	-4.8%
Change in %	Asian	8.1%	7.0%	3.9%	2.4%	3.3%	4.0%	2.5%	1.9%	2.3%	3.0%	0.7%	0.4%
Change in %	Foreign-born	-10.8%	-12.0%	-4.1%	-7.8%	-8.1%	-10.0%	-6.8%	-5.1%	-7.5%	-12.2%	-13.8%	-6.5%
Change in %	College education	12.4%	10.6%	9.0%	9.6%	9.3%	8.6%	12.8%	14.9%	18.4%	3.5%	4.3%	6.4%
Change in %	White-collar	3.7%	0.4%	5.6%	3.8%	0.0%	1.0%	4.4%	6.6%	14.4%	-1.3%	2.0%	2.9%
Change in %	Blue-collar	-23.0%	-21.4%	-17.9%	-19.4%	-15.9%	-15.6%	-24.3%	-26.2%	-26.2%	-19.3%	-24.4%	-28.3%
Change in %	Owner occupied housing	-1.2%	-1.9%	2.8%	3.2%	-1.0%	-0.6%	-1.5%	2.0%	5.9%	-2.7%	-0.9%	-1.8%
Change in %	Renter occupied housing	1.6%	0.9%	-3.4%	-2.8%	1.0%	0.5%	1.4%	-2.0%	0.9%	5.9%	1.5%	1.9%
% Change	Median rent	86%	95%	88%	100%	56%	45%	99%	95%	112%	76%	102%	98%
% Change	Median housing value	97%	99%	125%	118%	92%	84%	268%	310%	139%	88%	138%	136%
% Change	Median income	92%	87%	114%	98%	68%	73%	75%	85%	175%	94%	81%	72%
% Change	Per capita income	113%	105%	129%	121%	75%	78%	100%	107%	323%	186%	84%	90%

Table A-2 Change in variables in TOD and non-TOD, 0.5 miles radius (1990-2010)

Halfmile		BART		WMATA		METRO		NJT		TRIMET		DART	
		TOD	Non-TOD	TOD	Non-TOD	TOD	Non-TOD	TOD	Non-TOD	TOD	Non-TOD	TOD	Non-TOD
Change in %	No car	1%	0%	0%	-1%	-3%	-2%	2%	1%	-1%	-1%	1%	-1%
Change in %	One car or more	0%	1%	1%	1%	9%	2%	-2%	0%	1%	1%	0%	3%
Change in %	One car	-1%	-1%	1%	5%	8%	4%	2%	0%	8%	5%	4%	1%
Change in %	Two cars or more	1%	2%	1%	-4%	0%	-2%	-3%	0%	-7%	-5%	-4%	2%
Change in %	Transit	0%	3%	2%	3%	-4%	1%	3%	1%	0%	0%	-1%	-2%
Change in %	Drove	-13%	-15%	-10%	-12%	-2%	-10%	-14%	-11%	-14%	-11%	-6%	-3%
Change in %	OtherMode	-1%	0%	0%	0%	-1%	-1%	-1%	-1%	2%	3%	-1%	-2%
Change in %	White	-15%	-15%	-6%	-4%	6%	2%	-12%	-11%	-7%	-8%	-12%	-13%
Change in %	Black	-2%	-3%	0%	-3%	-1%	-2%	3%	1%	-3%	0%	4%	3%
Change in %	Asian	8%	8%	3%	3%	0%	0%	3%	6%	3%	1%	4%	2%
Change in %	Foreign-born	13%	13%	7%	8%	11%	12%	8%	8%	5%	5%	10%	11%
Change in %	College graduate	11%	9%	8%	7%	7%	7%	9%	7%	13%	7%	-1%	-1%
Change in %	White-collar	1%	4%	3%	3%	1%	-3%	1%	0%	8%	7%	-7%	-6%
Change in %	Blue-collar	-22%	-20%	-17%	-20%	-19%	-24%	-14%	-15%	-24%	-22%	-12%	-15%
Change in %	Owner occuppied HH	0%	-3%	1%	2%	1%	-2%	-2%	0%	-1%	-2%	-2%	-1%
Change in %	Renter occupied	0%	3%	0%	-1%	5%	2%	2%	0%	1%	2%	2%	2%
% Change	Median rent	95%	96%	88%	100%	127%	89%	71%	55%	117%	92%	78%	77%
% Change	Median housing value	96%	115%	102%	135%	193%	116%	97%	101%	286%	258%	67%	70%
% Change	Median household income	95%	97%	109%	105%	82%	68%	94%	93%	80%	79%	54%	76%
% Change	Percapita income	115%	114%	117%	125%	74%	93%	100%	88%	97%	102%	71%	86%

Table A-3 Comparing means in TOD 0.5 mile and 0.5-1.0 mile radius (2010)

2010 Data	OneMile		Halfmile		Total		
	Mean	N	Mean	N	Mean	N	Sig.
NoCar	20.18	1353	21.6	508	20.55	1861	0.134
OneCar	42.74	1353	45.7	508	43.55	1861	.000***
TwoCars_more	36.86	1353	32.5	508	35.68	1861	.000***
Transit	19.25	1353	22.9	508	20.25	1861	.000***
Bike	2.36	1353	2.6	508	2.43	1861	0.341
Walk	7.80	1353	9.4	508	8.23	1861	.000***
Drove	54.95	1353	51.5	508	54.02	1861	.000***
MDRent	1195	1353	1209	508	1199	1861	0.582
Mdhval	438534	1353	406424	508	429769	1861	0.023**
Mdhinc	74593	1353	71739	508	73814	1861	0.198
Percap	43388	1353	43615	508	43450	1861	0.867
Educ	41.10	1353	42.3	508	41.42	1861	0.356
WhtColl	68.17	1353	67.3	508	67.93	1861	0.469
BlueColl	13.80	1353	12.7	508	13.50	1861	0.134
White	59.07	1353	58.2	508	58.83	1861	0.487
Black	15.15	1353	16.4	508	15.49	1861	0.256
Asian	11.19	1353	11.5	508	11.29	1861	0.614
Fborn	27.80	1353	27.9	508	27.82	1861	0.949
OOH	39.29	1353	30.3	508	36.83	1861	.000***
ROH	60.49	1353	69.5	508	62.96	1861	.000***
Sig: p ≤ 0.10 (*) .05(**) .01(***)							

Table A-4 Test of means in TOD 0.5 and 0.5-1.0 mile radius (1990-2010)

	OneMile		Half mile		Total		
Change in Variables	Mean	N	Mean	N	Mean	N	Sig.
No Car	-3.1	1353	-4.4	508	-3.5	1861	0.065**
one Car	2.8	1353	4.0	508	3.1	1861	0.12
Two cars	2.1	1353	3.4	508	2.4	1861	0.046**
Transit	0.1	1353	0.6	508	0.3	1861	0.381
Drive	-9.0	1353	-7.1	508	-8.5	1861	0.044**
Other Mode	-1.0	1353	-0.6	508	-0.9	1861	0.606
% Δ MdRent	1.3	1326	1.4	492	1.3	1818	0.018**
%Δ MdHval	1.6	1248	1.6	435	1.6	1683	0.684
%Δ MdInc	1.4	1327	1.6	492	1.4	1819	0.011**
%Δ Percapita	2.0	1328	2.4	492	2.1	1820	0.10*
Educ	10.3	1352	11.9	508	10.7	1860	0.043**
Whtcoll	6.2	1353	7.3	508	6.5	1861	0.284
BluColl	-23.9	1353	-24.2	508	-24.0	1861	0.684
White	-3.2	1353	-2.3	508	-2.9	1861	0.374
Black	-4.5	1349	-3.7	508	-4.3	1857	0.295
Fborn	6.1	1353	4.7	508	5.7	1861	0.032**
Asian	3.4	1353	4.3	508	3.7	1861	0.035**
Hispanic	7.3	1353	5.8	508	6.9	1861	0.043**
Owner Occuppied HH	1.4	1353	1.4	508	1.4	1861	0.965
Renter occuppied HH	-0.5	1353	0.9	508	-0.1	1861	0.124
05 p ≤ 0.10 (*) .05(**) .01(***)		N= 1353					

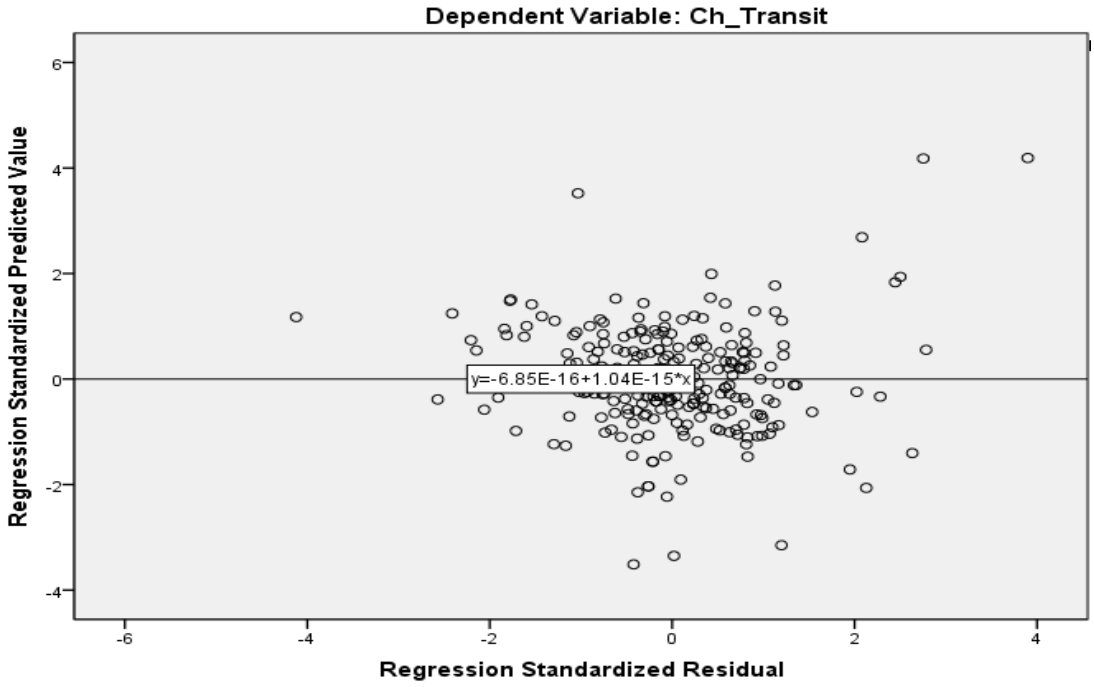

Figure A-1 Testing for error in model using residual plots for transit

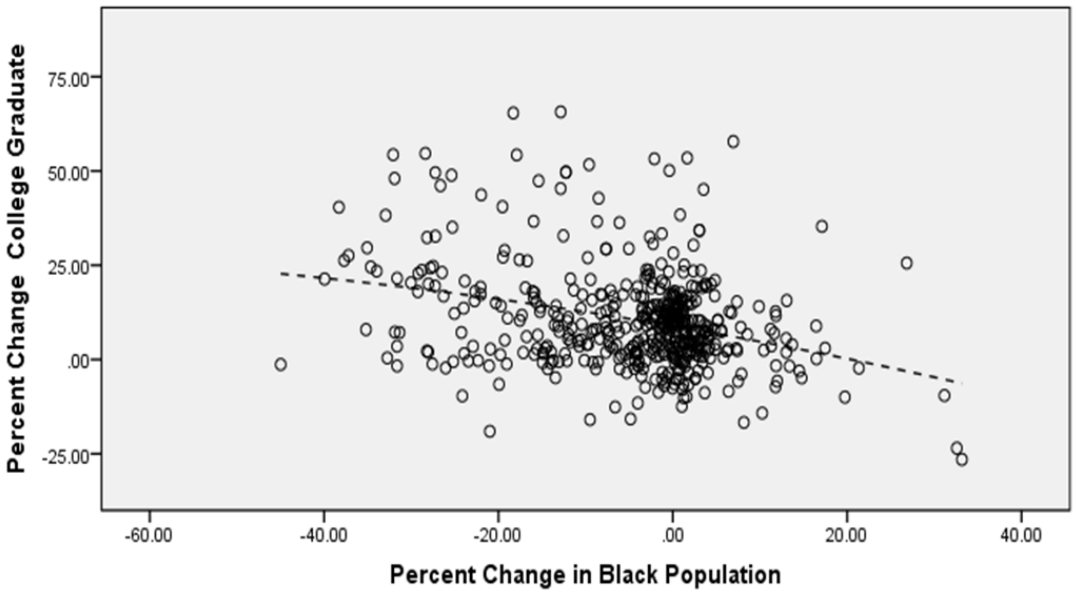

Figure A-2 Line of fit for Black and college graduate

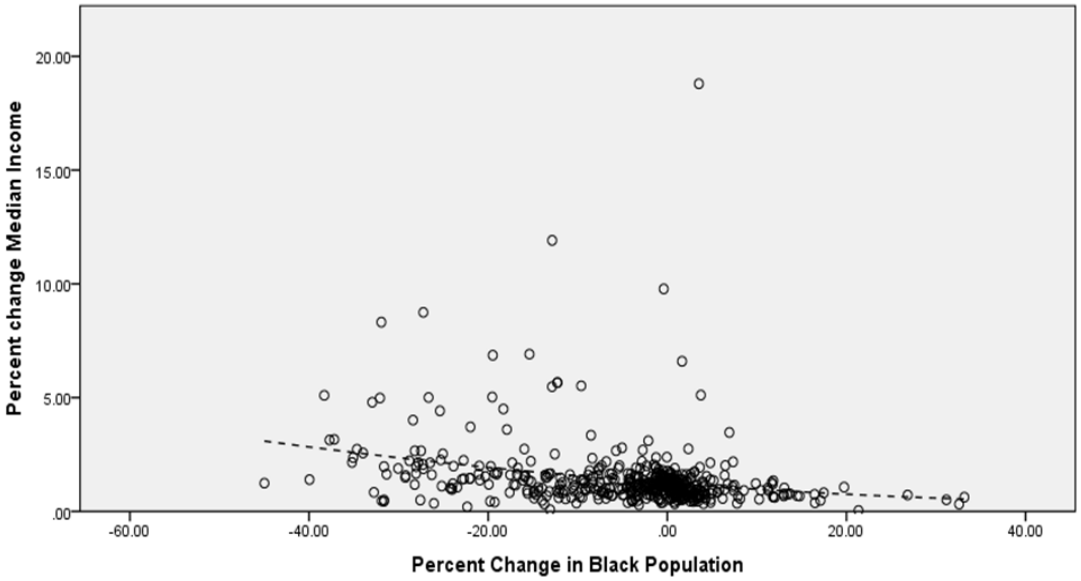

Figure A-3 Plotted line of fit for Black population and median income

Appendix B

Addendums and Postscript

In 2013, the United States Department of Housing and Urban Development (HUD) issued a letter to the City of Dallas complaining about allocation of funds for affordable housing. The letter was displayed in the local online daily (Dallas News 12/02/2013) The charge states, "The Department concludes that the city (Dallas) is in non-compliance with Title VI of the 1964 Civil Rights Act," HUD wrote in a letter of findings dated November 22, 2013. The complaint focuses on the approach the city has been investing HUD funds for low-income housing in South Dallas, which has the highest percentage of low-income households and minorities. In addition, the city had issued a moratorium on construction of affordable housing in downtown Dallas.

The HUD indictment seems like an illogical point of view because one would question, the optimal location for a low-income capital investment, if not in a poor neighborhood. However if this indictment is analyzed further, the issue about spatial equity should be considered. While it may be commendable that the city is building homes in low-income areas, the HUD letter raises interest in an issue that this research has been highlighting. The provision of public goods such as housing and transportation networks should provide access to diverse groups of people metropolitan wide in locations that are connected to opportunities for better schools, jobs and other amenities such as libraries, parks and grocery stores.

The Dallas case reflects a policy that encourages concentrated poverty and reduces accessibility to amenities in the central city. Perhaps if affordable housing is located in central city areas then more low income households can use transit more to access jobs. Transportation networks in the central city are more dense and reliable with

light rail compared to the bus connections. While transit authorities continually praise increasing ridership, perhaps one other question planners should be asking is whether these benefits are accessible across income and ethnic demographic groups. This research found that demographics and economic indicators around some TOD block groups are moving towards a direction that may exclude transit dependent groups. Yet, the results also show that predominantly that each region and transit system seems to experience different demographic and socio-economic changes that may become problematic to increasing alternative mobility options. For instance in Dallas, it appears that housing costs are driving transit use down, while in California it appears that minority groups are living in TOD becoming wealthier and using transit less and as explained by the fact that immigrant and Asian population had the highest percentage growth.

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