IMPACTS OF TRANSIT ORIENTED DEVELOPMENTS (TOD) AND MIXED USE CENTERS (MUC) IN DALLAS-FORT WORTH METROPLEX ON HOUSING VALUES AND DEMOGRAPHIC COMPOSITION

by

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ABSTRACT

IMPACTS OF TRANSIT ORIENTED DEVELOPMENTS (TOD) AND MIXED USE CENTERS (MUC) IN DALLAS-FORT WORTH METROPLEX ON HOUSING VALUES AND DEMOGRAPHIC COMPOSITION

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Suburban sprawl was attributed to be the cause of number of problems such as traffic congestion, depletion of natural resources, and decreasing air quality. Over the past two decades, policy makers and smart growth proponents encouraged Transit-Oriented Developments (TOD) and Mixed Use Centers (MUC) to increase transit ridership and development density; revitalize inner-city neighborhoods; improve environmental quality and livability; and to counteract suburban sprawl and real estate market forces in various communities in the U.S. Though many policy makers, urban planners, environmentalists see significant opportunities in sustainable development, there have been concerns related to affordability of housing combined with transportation, possibly resulting in social inequality in terms of income, race, and ethnicity in sustainable developments in DFW Region. This researchstudy primarily focuses on analyzing the change housing values of MUCs and TODs in the four core counties (Dallas, Tarrant, Collin, and Denton) of the Dallas Fort Worth (DFW)

region and its effects on income, race, ethnicity of persons living in housing in MUCs and TODs in the DFW region between 2000 and 2009.

The results of the study identified several significant independent or explanatory variables that affect the changes in housing values, median income, and minority percentages in the four-county study area. The groups of variables affecting the above factors include Demographic Variables, Location Variables, Transportation Access Variables, Development Variable, and Housing Supply Variables. These groups include specific variables such as percentage of persons working in professional occupations, distance to parks, number of major employers per square mile, type of development, etc. All these variables were statistically significant in explaining the variation in housing values, changes in income, and changes in minority percentage. Conclusions and policy recommendations were derived from the research study providing a stepping stone for further analysis in this research area.

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CHAPTER 1

INTRODUCTION

Due to suburban sprawl, U.S. residents are effected by a number of transportation and environmental problems including traffic congestion, longer commute times, decreased air quality, depletion of farmland, open space, and natural habitats, and policymakers often respond to these problems by enacting zoning, planning, and growth management policies and practices (DeGrove 1984). Smart growth, sustainable development, and transit oriented development are gaining increasing popularity to address the problems associated with urban sprawl. In 2009, the partnership between the U.S. Housing and Urban Development, Department of Transportation, and Environmental Protection Agency, HUD-DOT-EPA Interagency Partnership for Sustainable Communities announced Livability Principles that will guide Federal housing, transportation, and environmental policy, programs, and funding towards equitable, affordable, transit-oriented, and mixed use neighborhoods. In Dallas-Fort Worth (DFW) Region, the North Central Texas Council of Governments (NCTCOG) and various local governments provided incentives to develop mixed use and transit oriented developments to reduce vehicle miles traveled, improve air quality, and enhance quality of life.

Nationally, various research studies indicated that property values significantly increase due to the development of TODs, mixed use and new urbanist developments (Song and Knaap 2003; NCTCOG and University of Texas at Arlington 2009). Higher property values indicate higher housing prices and rents making those properties unaffordable to low to moderate income households. Numerous research studies are available on the effects of sprawl on racial and income disparities and concentration of poverty, especially related to racial and ethnic segregation, have postulated underclass theory (Santiago and Wilder 1991; Rosenbaum,Popkin, and Kaufman 1991; Massey and Denton 1993). There is very limited to no

literature available on the effects of MUCs and TODs accommodating mix of income, race, or ethnic groups. Various federal, state, and local incentives and programs are promoting MUCs and TODs but there were no empirical studies conducted on the income, race, and ethnic compositions of MUCs and TODs. Very limited number of studies that exist focus on the impacts of MUCs and TODs on property values and tax revenues.

1.1. Purpose of the Research

The current research study will examine the changes in housing values (2000-2009) of MUCs and TODs in the four core counties (Dallas, Tarrant, Collin, and Denton) of the Dallas Fort Worth (DFW) region and its effects on income, race, ethnicity of persons living in housing in MUCs and TODs in the DFW region, compared to other parts of the region.

1.2. Research Questions

This research primarily focuses on the differences in the change in median housing value (2000-2009) in MUCs and TODs as compared to the rest of the region, and their impacts on income, race, and ethnicity of persons living in housing in MUCs and TODs. The study will evaluate and test the following two research questions:

Research Question 1: Does the percentage change in median housing value (2000-2009) in MUCs and TODs different from the rest of the region and what are the significant factors effecting the percentage change in Median Housing Value?

Research Question 2. Do persons living in housing in MUCs and TODs exhibit different income, race, and ethnic of characteristics than those in the rest of the four-county study area?

1.3. Significance of Research

Dallas-Fort Worth Region is home to over 100 MUCs and a number of TODs, and majority of those were developed after 2000. Appendix A shows a dataset of MUCs and TODs in DFW Region received from the NCTCOG. The NCTCOG funded over $120 million in infrastrustruture and planning of MUCs and TODs in the region, and a significant amount of local government and private funding was expended in the construction of sustainable

developments. But at this point there is no survey data that measures, housing prices, affordability, income, race, and transit usage of such developments. Various research studies outlined in the literature review utilized the 2000 Census data, which is over 10 years old and does not capture the real estate trends after 2000. The current research study provides insight on the characteristics and impacts of mixed use and transit oriented developments in terms of income, race, affordability, and transit usage between 2000 and 2009 for the DFW Region. This research study contributes to theory and policy in the following ways:

- The research will contribute to literature in smart growth and sustainable development by empirically evaluating the concerns on higher housing prices in MUCs and TODs, possibly resulting in segregation of income, race, and ethnicity of persons living in housing in the DFW region.
- If the results show statistically significant relationship between housing prices in MUCs and TODs to income, race, and ethnicity, the thesis would have major policy implications on affordability and housing equity issues in TODs and MUCs in DFW Region, and in other regions in the U.S.
- If the research finds relationship between change in median housing value and changes income, race, and ethnic groups in TODs and MUCs in the DFW Region, theoutcome and the policy recommendations may be shared and recommended to policy makers in the DFW Region.
- The policy implications may be applicable to other large metropolitan areas, thus providing guidance to developing affordable, equitable, mixed use, transit-oriented communities in other geographies in the nation.

CHAPTER 2

LITERATURE REVIEW

Chapter 2.1 provides a general introduction definitions, and history of TODs and MUCs. Chapter 2.2 provides a summary of theories and empirical studies for each research question. The summary of literature provides a background on the research question and outlines the major theories and research studies related to each question. The Bibliography shows a list of literature pertaining to the research.

2.1. Concept of of TODs and MUCs

2.1.1. Definition of Transit-Oriented Development (TOD)

According to a 2009 report released by Urban Land Institute (ULI), *Transportation for a New Era: Growing More Sustainable Communities*, a TOD typically includes a variety of services within walking distance of the transit station, good pedestrian connections to transit and between buildings, and buildings that are outwardly oriented toward the street rather that inwardly oriented toward parking. The key point behind TOD is that rail transit has the potential to add value to the station location as well as the overall system by generating incremental investment and new transit riders.

The NCTCOG defines TOD as “a style of land planning and building orientation that is geared towards encouraging pedestrian activity that results from the passenger rail station. The boundary of a TOD can extend at least from a ¼ to ½ mile radius around the passenger rail station. The main form of development present in the boundary is mixed use and is designed to encourage people to bike and/or walk from the station and surrounding area to

the development. A network of road ways, bike lanes, and sidewalks connect the developments to the station. The density of the development is relatively moderate to high".

Various theories and empirical studies on the reasons for success of MUCs and TODs, such as addition of property values, access to transit station, mix of uses, walkability, and other factors are discussed in Chapter 2.2. It is a common practice to define low, moderate, and high densities in local government land use codes or zoning ordinances but the definitions vary for each city. There are different measurements of density in planning practice such as dwelling units per acre, Floor Area Ratio (FAR), or population density (Campoli and MacLean, 2007). This research does not focus on various definitions of density by local government codes in the Dallas-Fort Worth Region, and uses the data provided by the NCTCOG's Development Monitoring data and half-mile radius of existing rail stations for the database of MUCs and TODs in the study area.

2.1.2. Definition of Mixed Use Center (MUC)

According to the research document produced by Vision North Texas visioning process in the DFW Region, *North Texas 2050 (2009),* Mixed Use Centers are categorized as: "Regional, Metropolitan, Community and Neighborhood. The four centers reflect areas with a variety of uses (including both employment and housing), at least a moderate intensity of development and, for some, and their roles as distinct or traditional centers of communities".

According to the definition provided by NCTCOG (2011), Mixed use projects should contain both commercial (office and retail) and residential uses in the same building vertically or commercial developments with office and retail within a quarter mile of residential. A mixed use development should meet all the following criteria:

- A mix of residential and office and/or retail uses
- Mix of uses can be vertical or horizontal mix
- If horizontal mixed use, the residential use should be within a quarter mile of the commercial use

- Different land uses should have pedestrian linkages in the mixed use development
- Should not develop industrial uses
- They should provide a significant portion of each use within the mix

Mixed use developments should exclude, but not limited to, the following types of developments, single-family detached development with standalone shopping centers, standalone hotel/residential, studio/light industrial combination, parking structures with ground floor retail, single use dominant developments with minimal auxiliary uses. Residential, office, and/or retail uses should not be just auxiliary or supportive uses in a mixed use development. Figure 1.1 shows the concept of MUC and TOD in terms of mix of residential and commercial uses and multi-modal transportation connections in within ¼ or ½ mile radius for a TOD.

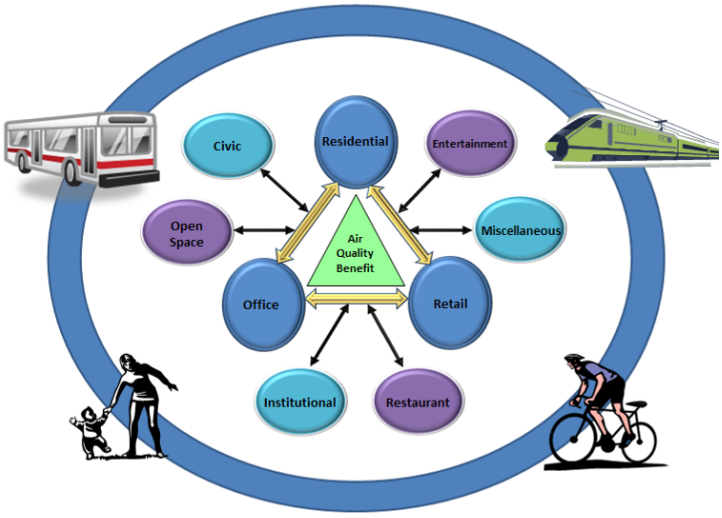


FIgure 1.1 Mixed Use and Transit Oriented Development
Source: NCTCOG, Mobility Plan 2035: The Metropolitan Transportation Plan for the North Central Texas (2011)

There is no national consensus on the definitions for MUCs and TODs and the above regional definitions were used for this research study. The term “Mixed Use Center” was used in the study instead of Mixed Use Development or Project because a Mixed Use Center may

contain multiple mixed use developments. Since the study was performed at a census tract level, this macro level term was used for the purposes of the study.

2.1.3. History of MUCs and TODs

Over the past 20 years, many of the young Sunbelt cities like Dallas and Phoenix have struggled on location choices of infrastructure spending to maximize the efficiency of their overall transportation and land use while also serving the needs of the current and future population (TCRP Report, 2004). The major debates have been in land use and transportation areas; whether to build mixed use, infill, and transit oriented developments or suburban developments; and invest in mass transit or in highway infrastructure. During the 1990's, a number of regions (including DFW Metropolitan Area) started building commuter light-rail lines to promote public transportation. With this new infrastructure in place, the debate has begun to shift from discourse on the type of infrastructure toward how to increase ridership on the first-generation rail system. Proponents of sustainability encourage more transit-oriented master planning (NCTCOG alternative transportation futures) while suburban politicians and city planners steered more traditional courses (more roads and sub urban neighborhoods) (NCTCOG, 2011). It remains an active debate: transit involves massive public funding and future-oriented policies and decision making while providing current services that satisfy the needs of the individual citizen as well as potentially influence a city's economic and social future as energy prices increase and household incomes struggle in a difficult economy. One subset of the transit debate is the phenomenon of transit-oriented development (TOD). The report released by the Transit Cooperative Research Program (TCRP), *Transit-Oriented Development in the United States (2004)* refers to TOD as "a pattern of dense, diverse, pedestrian-friendly land uses near transit nodes that, under the right conditions, translate into higher ridership." (p 10) Generally, TOD is intended to support transit connectivity, walkability, and a positive overall pedestrian environment with a mix of uses.

Transit-Oriented Development (TOD) is not a new concept in America or, for that matter, the industrialized world. During the 18th century, cities such as Philadelphia, New York, and Chicago were built around ports and the jobs markets that served them. In 1807, John Fulton invented the steamboat. During the rest of the 19th century, cities like New Orleans and Cincinnati flourished as river trade brought jobs and people to their cities. In the 1850's and 60's, massive investment in intercontinental rail lines begin to reshape and expand all of the US markets by connecting cites and creating new ones. For the next hundred years, the railroad served as the major trade route for all goods, connecting all markets to the major US cities and ports. These types of TODs are based on the functionality of access to jobs and goods movement. The railroad would dominate into the 1950's, until the compounding effects of falling gas prices, innovations in the internal combustion engine, and a massive federal investment is highways would make truck and car transport a more efficient, cost effective, and convenient transportation method. This type of transport opened up more areas and markets for trade, work, housing, and travel. Unlike any other time in American history, people were able to cheaply, quickly, and efficiently move goods long distances into areas that before were either unreachable or cost-inefficient. These new transportation methods combined with new infrastructure systems allowed for a substantial decentralization of most American cities.

While studies of rail transit and development have been ongoing since the creation of the first rail lines, the underpinnings of transit-oriented development as we know it today were first introduced in 1998 by Michael Bernick and Robert Cervero called *Transit Villages for the 21st Century*. Since that time, academics, planners, and cities have struggled to define the term and focus their efforts on encouraging it. According to a 2009 report released by Urban Land Institute (ULI), *Transportation for a New Era: Growing More Sustainable Communities*, the overarching goal of transit-oriented development has stayed somewhat constant: "to create better communities and reduce driving by making walking and transit a more realistic opion."

The definitions of MUCs and TODs for the purposes of this research were provided in

Chapters 2.1.1 and 2.1.2.

2.1.4. Benefits and Criticisms of MUCs and TODs

2.1.4.1. Benefits of MUCs and TODs

A TOD typically includes a variety of land uses (residential, office, and retail) within walking distance of the transit station, good pedestrian connections to transit and between buildings, and buildings that are outwardly oriented toward the street rather that inwardly oriented toward parking. The key point behind TOD is that rail transit has the potential to add value to the station location as well as the overall system by generating incremental investment and new transit riders. Subsequently, “development adjacent to a transit station that does not promote the use of transit burdens the community with costs of higher-density development without the offsetting transportation benefits.” (TCRP Report, 2004). Many of the policy debates revolve around whether and how this potential is realized.

According to the TCRP Report, *Transit-Oriented Development in the United States (2004),* the benefits of TOD’s are numerous and can be social, environmental, and fiscal. Table 2.1 categorizes benefits of TODs into public and private sector benefits and divides the benefits into primary benefits and secondary benefits. Some of those benefits, such as increased affordable housing, accrue to both the public and private sectors. Various benefits listed in the table are due to the increased density of mixed use developments. Benefits like reduced infrastructure costs, preservation of open space, and lower parking costs are typical to any program that promotes sustainable development, reduces suburban sprawl and automobile usage.

A TOD strives to have work, play, and live uses all within walking or biking distance. The “play” uses, such as restaurants, theaters, institutions, health, and beauty shops, can help maintain an area vibrant through most of the day as people visit those locations without need of using a car and rather walking or biking to reach destinations.

Having these amenities close to work and/or home creates an ideal housing option for many lifestyles where a car may not be needed and therefore reducing personal transportation costs. TOD households are twice as likely to not own a car and own about half as many cars compared to households not living in TODs (Arrington and Cerveo, 2008).

Table 2.1 Benefits of TODs

	Primary Recipient of Benefit:	
Class of Benefit:	Public Sector	Private Sector
Primary	1. Increase ridership and fare-box revenues	5. Increase land values, rents, and real-estate performance
	2. Provide joint development opportunities	6. Increase affordable housing opportunities
	3. Revitalize neighborhoods	
	4. Economic development	
Secondary/Collateral	A. Less traffic congestion and VMT-related costs, like pollution and fuel consumption (1)	G. Increase retail sales (1, 2)
	B. Increase property- and sales tax revenues (5)	H. Increase access to labor pools (A, 6)
	C. Reduce sprawl/conserve open space (1, 3, 6)	I. Reduced parking costs (C, 2)
	D. Reduce road expenditures and other infrastructure outlays (1)	
	E. Reduce crime (3, 4)	
	F. Increased social capital and public involvement (3, 4)	J. Increased physical activity (C, E, F)

Note: Values in parentheses represent primary benefits and/or secondary benefits that are the source(s) of the secondary/collateral benefit listed.

Source: Cervero et al., 2004, TCRP Report 102, Transit-Oriented Development in the United States (2004), p 120.

The integration of transportation, housing, and environmental policies has received the attention of the federal, state, and local governments. NCTCOG has created the Center of Development Excellence (CODE) to promote quality growth in North Central Texas that promotes mixed use infill and TODs. At the federal level, the Environmental Protection Agency (EPA), U.S. Department of Housing and Urban Development (HUD), and the U. S. Department of Transportation (DOT) partnered in 2009 on “Livability” issues to promote equitable and

affordable TODs nationwide. According to the NCTCOG's Mobility 2030: The Metropolitan Transportation Plan for the Dallas-Fort Worth Area, many developments in the Dallas Fort Worth region incorporate sustainable strategies such as mixed-use development, TODs served by multimodal transportation options, infill developments that conserve resources, and unique communities with a sense of place. These trends contribute to the region's increasing emphasis on sustainable development and the likelihood of reaching air quality attainment. Mixed use communities and TODs reduce VMT by improving the accessibility of different land uses through transit and/or pedestrian amenities; infill developments utilize existing facilities and vacant parcels within a built-up area for future construction and community revitalization or redevelopment.

Smart growth and New Urbanism Principles from the Congress for the New Urbanism strongly support mix of uses that includes shops, offices, apartments and homes along with a diversity of people of age, income levels, cultures, and races served by pedestrian friendly and transit oriented transportation facilities (Duany et al., 2000)

2.1.4.2. Criticisms of MUCs and TODs

Drawbacks of TOD were pointed out by various research studies. According to the 2009 ULI Report, transit becomes viable and works best serving high-density, generally low-income communities located close to a major downtown, like New York-communities that developed before automobile travel was an option. Transit may not be viable in low-density, auto-oriented Sunbelt suburbs. This is the conundrum of TODs in DFW Metropolitan Area. As lower-density cities build transit infrastructure, they struggle to increase ridership because the necessary higher density urban form is not in place to support it.

Others oppose TODs because those warrant heavy public subsidies to build infrastructure and amenities such as park-and-ride facilities (Dueker, 2002) and these costs could be very high where the land costs and densities are higher. Gordon and Richardson (1997) argued that low-density living is a predominant choice of American residents which has

resulted in lower density suburbs. The study stated that consumption of public funds to promote transit and TOD were wastage of resources and contrary to the popular public choice of low density living. Ewing's (1997) article described various types of developments and pointed that consumer preference splits evenly between low and medium density living. Boarnet and Crane's research study (2001) concluded that land use policy may have very low impact in effecting auto-dependence.

According to the TCRP Report (2008), baby boomers, Generation X'ers (aged 24-34), empty-nesters (couples without children) and foreign immigrants are driving the demand for more urban real estate options. Households with children typically do not choose housing in TODs because other interest drives their housing choices such as school districts, open space for children to play in, neighborhoods with children, and housing with greater square feet (Arrington and Cerveo, 2008). Other criticism to TOD is public resistance to higher density development at local level (Levine and Inam, 2004)

Other criticisms pointed out by Todd Litman in *Evaluating Criticism of Smart Growth* (2004) include: consumer preference to low-density development, reduced freedom in real estate development, reduction in affordability, and increase in congestion. Todd Litman evaluated these criticisms and pointed out that each of these criticisms were based on faulty data, overlook geographic scales, and ignore overall factors effecting land use and transportation efficiency. Public preference to TODs is increasing over the past two decades with increasing gasoline prices and traffic congestion levels. TODs and compacts land uses increase transportation efficiency and reduce costs of higher infrastructure investments in operation and maintenance of highways to support car transportation. The awareness of the adverse environmental consequences of low density development and single-occupancy vehicle use is increasing resulting in more demand for sustainable development.

2.2. Literature Review Related Specifically to Research Questions

The following Chapter provides a summary of theories and empirical studies for each research question. The summary of literature provides a background on the research question

and outlines the major theories and research studies related to each question. The factors and significant variables ideantified in the literature provided a foundation to the quantitative measures identified in the next Chapter on Methodology.

Research Question 1: Does the percentage change in median housing value (2000-2009) in MUCs and TODs different from the rest of the region and what are the significant factors effecting the percentage change in Median Housing Value?

Change in median housing value (2000-2009) is an indicator used to measure the variation in property values, or housing and land prices. MUCs contain a mixture of residential and commercial uses and various economic theories attempt to explain the relationship between increase or decrease in residential property values due to the proximity of commercial uses. One of the barriers for affordability of Mixed Use developments as listed by the Center for Neighborhood Technology (2007) is the proximity to office and retail in mixed uses, typically increases the residential property values. This raise in property values makes the residential units unaffordable to lower income groups. Related to TODs and land prices, there are other set of economic theories that explain the relationship of land prices to accessibility to transportation improvements and transit. The above two sets of theories will be discussed in relation to Research Question 1.

2.2.1. Theories - Change in residential land prices due to proximity to commercial and other land uses

Mills (1979) in the discussion of zoning as a tool to minimizing “externalities” stated that land has unique characteristics compared to other economic goods: the supply of land is fixed by location, and the use of a parcel of land affects the use and value of surrounding parcels, which is called an “externality” of land use. The early theories of Ricardo and Von Thunen have laid the foundation of land price that explained the variations of land rents from differences in fertility and land quality. Land of a higher quality generates surpluses over land with a lower quality. These surpluses are paid as rent to the landlord due to competition at the land market

and at the market for agricultural products. Von Thunen's model included location, transportation costs, fertility, and other characteristics of a parcel.

As stated by the Central Place theory certain locations become more attractive than others due to their size, location, and as the spacing of centers change (Christaller, 1966). The theory assumes that consumers visit the nearest central places that provide the function which they demand and consumers minimize the distance to be travelled. The attractiveness of a location translates into property values. Central Place theory was refined by Berry (1970) and conducted empirical studies and found that rents of locations depend on their order in the hierarchy, and the internal zoning within the centers determines the hierarchy of places. Based on this theory, access to a location plays a major role in determining the attractiveness, values, or rents.

The bid rent theory is based on microeconomic theory, which was originally developed by Von Thunen in the19th century and was further developed in the context of urban land uses and urban land values by Alonso (1964) and Mills and Hamilton (1994). The bid rent function in the theory explains the relation between urban land uses and urban land values. This theory stated that households and companies make a trade-off between the land price, transportation costs and the amount of land.

Two opposing concepts of urban economic theory are found in literature review on the question of the effect of proximity to commercial use on residential prices. Microeconomic theory applied to urban land holds that land values are determined by transportation costs. As distance to an "attractor" use (e.g. work or shopping) decreases, transport cost decreases and land cost increases. Consequently, residential properties located closer to retail use should, all else being equal, have a higher price than residential property farther away because travel cost to the retail use is lower.

Another theoretical concept predicts prices will decrease with proximity because of disamenities associated with commercial development, such as traffic congestion and noise.

The notion of “externalities” is an important concept developed in welfare economics. An “externality” is a “consequence of an economic activity that spills over to affect a third party” (Miller, 1999). Zoning is a governmental police power that regulates land use to minimize external economies “spilling” from one type of land use to another; usually from nonresidential to residential uses (Mills, 1979). Zoning ordinances seek to minimize these externalities by first segregating land uses from one another and also by design controls imposed to minimize spill over of diseconomies (e.g. noise) from one zone to another. In terms of MU zoning districts, selected types of commercial uses are allowed in residential districts.

2.2.2. Appraisal Studies and Empirical Studies on Proximity of Residential to Commercial

Appraisal Studies: Real property appraisal literature is not conclusive on the effects of commercial on residential prices. For example, Hosch & Koehlinger find a large real property appraisal firm active in the northern Mid-west States stated that the value of a new single-family residential property is lower when it is adjacent to commercial developments, but they did not analyze the effects on the existing residential property due to the adjacent land use changes (Hosch & Koehlinger, 1997).

Another study in the town of Henniker, New Hampshire, found that there is no negative impact on homeowners’ property values when a neighborhood type retail project is built nearby (Crafts, 1998). Many other studies and real estate literature generally noted that there is a positive influence on residential location when they are supplemented with shopping (Kahn & Case, 1977).

Empirical Literature: Empirical literature includes both positive and negative effects of proximity to nonresidential uses on the price of housing. Many of these studies rely on hedonic price modeling developed through the cumulative work of Griliches (1961), Lancaster (1966), and Rosen (1974). Crecine, Davis, and Jackson (1967) conducted a study using Pittsburgh property sales data and the study did not find any evidence of externalities - or negative influence on residential property values. Mills (1979) stated that for “most nonresidential

activities studied, the effects seem remarkably small. Even when significant, most effects are found to be small and decline rapidly with distance". The conclusions stated that zoning might be effective. Second, he points out that commercial and industrial development does produce jobs and shopping. Proximity to these uses is valuable; residential land values may even fall with distance from a nonresidential site.

According to Levy and Lassault (2003), property values depend on spatial accessibility dictated by supply and demand factors. The transport spatial network and technology on the supply side, personal values, natural constraints, and socio-economic acceptability on the demand side attribute to the changes in property values.

Bowes and Ihlanfeldt (2001) also study the effects of proximity to transit stations on residential property values. This study found a one-quarter mile distance from transit stations to be significant. They also find that positive effects extend further than do negative effects. For middle- and high-income neighborhoods, the commuting cost savings provided by transit exceed any costs caused by negative externalities" (Bowes & Ihlanfeldt, 2001, p. 21). The measures of distance in this study are concentric rings drawn one-quarter, one-half, one mile, and so on from stations. In a research study Grether and Mieskowski (1980) analyzed effects on the prices of home sales near a single nonresidential land use: industry, commercial, high-density dwellings, and highways. Regressions of physical characteristics of the dwelling distance from the non-residential use, and the date of sale for each transaction on sales price show no systematic relationship between nonresidential land use and housing prices.

Li and Brown (1980) provide a study that assessed the influences of "micro-neighborhood variables - aesthetic attributes, pollution levels, and proximity" to industries, thruways, and commercial establishments - on housing prices. The study concluded that the Accessibility at this micro level is normally thought to increase the value of a house and the proximity to some of these non-residential uses can also be accompanied by "external diseconomies such as congestion, noise, and air pollution that affect the value of residential

property."Nelson and McClesky (1990) use the Li and Brown model to examine the price effect of proximity to elevated transit stations in Atlanta. The study noted that proximity to elevated transit stations has a positive price effect arising from convenience which outweighed a negative effect due to exposure to traffic, noise, and other nuisance. Frew and Judd (2003) also look at property prices at a micro or neighborhood level. They found that an increase in level of commercial activity in the "neighborhood" (zip code), measured by total payroll in the zip code, is associated with a reduction in property value - but the reduction is not statistically significant. In Seattle, a study by Franklin and Waddell examined the influence of accessibility to different types of employment on single-family residential property values. The results show that access to commercial and university uses is positively associated with sales prices, while proximity to local schools and industries is negatively associated with sale prices (Franklin & Waddell, 2003).

In conclusion, the literature shows both positive and negative effects of the proximity of residential uses to commercial on residential values. Design, density, and the type of commercial uses can all affect this kind of performance.

2.2.3. Theories and Empirical Studies - Change in residential land prices due to proximity to transportation access (TOD)

The quality of urban transportation has been documented to affect residential and commercial property prices. Urban Economic theory points out that the value of real estate is determined by its internal factors and external environments. In addition, land-use changes and the location of residential and commercial uses depend on the trade-off between land rent and transportation costs. Thus, we can understand the connection between land use and transportation by examining variations in property values and changes in land use (Ryan, 1999).

The impact of urban highways on neighborhoods has been studied in depth for several years. Based mainly on econometric results, studies confirm that urban highway networks significantly determine the locations of firms and households (Boarnet, 1998; Boarnet and Chalermpong, 2001). Rapid population and employment growth must be accompanied by a

capitalization of the accessibility benefits by of nearby properties and highways. A study conducted in California concluded that the impact of highway investments on land use depends on the network structure and the patterns of economic growth (Boarnet and Haughwout, 2000). Transportation investments have positive effects on the land value curve (Giuliano, 2004). Site attributes also influence the local variation of property value effects that highways create, because the limited amount of commercial land available near highway interchanges—and its greater visibility, exposure, and ease of site access—tends to increase its property value (Voith, 1993).

Public transit impacts represent another aspect of land use and transportation studies. Despite the financial burden of transit investment, proponents argue that public transit enhances the accessibility of inner cities and attracts firms and households in declining inner cities. Public transit is also expected to help increase access to job markets for low-income residents (O'Regan and Quigley, 1999; Holzer, Quigley, and Raphael, 2003).

Most studies of the impact of heavy rail systems on land value have produced clear results that rail transit impacts vary with specific local contexts and institutional constraints. Studies of San Francisco's Bay Area Rapid Transit (BART) found considerable variation in land-price impact, with dramatic benefits accruing to downtown San Francisco commercial properties, but few to suburban residential property (Cervero and Landis, 1997). Research on Miami's Metrorail revealed no discernable land-price effects owing to low transit demand and the distribution of low-rise property markets over wide service areas (Gatzlaff and Smith, 1993). Another study, however, showed that the opening of Chicago's Midway Line increased housing prices, with local variation over time (McMillen and McDonald, 2004). The immediate benefits of new transportation investments are reflected in real estate prices, while land-use impacts tend to unfold over the longer term, partly due to institutional lags (e.g., in obtaining building permits and zoning amendments) (Perez et al., 2003).

Theorists hold that traditional bus transit services generate weak effects on urban structure and land-use patterns because they fail to confer significant accessibility benefits. A study of dedicated-lane BRT services in Los Angeles found weak negative impacts on residential values, and small premium effect on commercial parcels (Cervero, 2004). A study of the more substantial BRT system in Bogota, Colombia, confirmed substantial land-value benefits (Rodriguez and Targa, 2004). Creating pedestrian-friendly environments near BRT bus stops tends further to appreciate land value within the service areas of BRT (Estupinan and Rodriguez, 2008).

An empirical study confirms that heterogeneous neighborhood attributes can alter the impacts of car and public transport travel time on residential property prices (Du and Mulley, 2006). Another empirical study suggests that clustering transit stops strengthens the central status of places with more commercial and mixed development (Zhou and Kockelman, 2008). A Hedonic Pricing Analysis conducted by Bartholomew and Ewing (2010) indicates that transit and pedestrian access and local environmental quality effect real estate values. The study showed that infrastructure amenities of TODs such as mixed land use and pedestrian improvements tend to increase land values independent of transit access.

According to a summary of literature conducted by the City of Cleveland (2001) on changes in property values due to light rail and commuter rail, 18 studies showed increase in property value, one study showed decrease in value, and three studies showed no change in value. The summary of literature included the studies conducted on property values near transit stations in Washington D.C., Atlanta, San Francisco, New York, Boston, Los Angeles, Philadelphia, Santa Clara, Portland, and San Diego. Table 2.2 provides a summary of literature on the factors effecting property values and identifies Land Use, Location, Transportation Access, and Development Variables, which provided input into the selection of independent variables discussed in Chapter 3, Methodology.

Table 2.2 Summary of Literature for Research Question 1
- Factors Effecting Property Values

Theory/Literature	Factors and Significant Variables Effecting Property Values
Mono-Centric City Model	land price and distance to CBD or accessibility variable
Ricardo and Von Thunen's model	location, transportation costs, fertility, and other characteristics of parcel (size, surrounding uses, etc)
Central Place theory-Christaller (1966) and empirical study by Berry (1967)	central locations, hierarchy based on location, and access
Marshall (1890), Bid-Rent theory by Alonso (1964), Muth (1969), and Mills and Hamilton (1994)	proximity to retail, proximity to other destinations or "attractors", transportation costs and the amount of land
Hansen (1959) and Des Rosiers et al 2000	Accessibility to goods and services such as distance from retail, educational institution, employers, park, etc
Guiliano (2004), Levy and Lassault (2003)	transportation accessibility and spatial network: road and transit linkages
Mills (1979)	land uses and zoning- "attractors or externalities"
Crecine, Davis, and Jackson (1967), Kahn & Case (1977), Hosch & Koehlinger (1997), Crafts (1998)	proximity to commercial, industrial, and other land uses
Bowes and Ihlanfeldt (2001), Bartholomew and Reid (2010)	proximity to transit stations
Grether and Mieskowski (1980)	single nonresidential land use: industry, commercial, high-density dwellings, and highways
Li and Brown (1980)	micro-neighborhood variables - aesthetic attributes, pollution levels, and proximity" to industries, and commercial establishments

Table 2.2 – *Continued*

Franklin & Waddell (2003)	access to commercial and school and university uses
Boarnet (1998) Boarnet and Chalermpong (2001), Voith (1993)	access to highway and transportation network
Cervero and Landis (1997), Gatzlaff and Smith (1993)	proximity to transit stations
Rodriguez and Targa (2004), Estupinan and Rodriguez (2008)	transit access and pedestrian improvements
Du and Mulley (2006) Zhou and Kockelman (2008)	transportation access, travel times, surrounding land uses, and development type

Research Question 2. Do persons living in housing in MUCs and TODs exhibit different income, race, and ethnic of characteristics than those in the rest of the four-county study area?

2.2.4. Theories and Empirical Studies on Household Segregation by Race and Income

Household sorting has often been considered an underlying cause of racial segregation. Households are attracted to communities that cater to their needs of housing, community, and local public services that best match their choices (Tiebout, 1956). Householders' abilities to acquire units of a public good determine the income and racial composition of the neighborhood. Race has been linked to income in many ways; for example, whites have higher average incomes than African-Americans, Hispanics, or other minorities. As a result, whites are able to afford to live in neighborhoods that provide higher levels of public and other amenities. Whites tend to relocate or segregate into predominantly white neighborhoods and bid higher for properties located in white neighborhoods (Galster 1982; Kain 1985; Clark 1991). In this case, high income minorities would sort into the same neighborhoods as high income households, unless there is an underlying barrier to assimilation of different races and ethnicities.

Various social scientists analyzed the impact of racial segregation on the performance of the segregated group in terms of income, education, poverty, etc. and the reasons for the

resulting phenomenon. The literature on the relationship between personal choices and residential outcomes for racial and ethnic groups in metropolitan areas is split into different groups. A number of scholars hypothesized that the choices and preferences of whites and minorities that make communities racially segregated. This set of researchers proposed that White and minorities self-segregate into neighborhoods because they prefer to live with people of their own race, and the preferences for amenities dictate the self-segregation. Various empirical studies provide the evidence self-segregation hypothesis. In a study conducted in New Haven, Connecticut, King and Mieszkowski (1973) found that African-Americans are willing to pay more for housing in the ghetto than in racially mixed areas, while whites are willing to pay less for housing in racially mixed areas than in white areas. In another study conducted in St. Louis, Galster (1982) finds the findings of African-American aversion to live in predominantly black neighborhoods, and the white aversion to living in neighborhoods with African-Americans. The empirical studies conducted by Ihlanfeldt and Scafidi (2002) in Atlanta, Detroit, and Los Angeles concluded that blacks' preferences to live with their own peers has a minor effect on the racial composition of predominantly African-American neighborhoods.

Another group of theorists contend that along with household preferences, complex market forces and non-market forces result in racial segregation. Differences between whites and minorities in housing-demand factors like income, employment, poverty, information availability, and supply factors such as housing costs, have an impact on the racial composition of neighborhoods. The non-market forces include discrimination in the mortgage lending and "steering", "redlining" or other discriminatory practices in real estate markets (Massey and Denton 1993; Galster, 1988; Schill and Wachter 1995; Galster and Godfrey 2005). Various federal and local housing policies such as public housing policies and subsidized housing programs increase the concentration of income groups and racial groups (Schill and Wachter 1995). Hammell and Wyly (1996) proposed a model for identifying gentrification using Census data. Using step-wise discriminant analysis, the research tested the changes in demographic,

housing, and socio-economic variables.

The model predicted how accurate these variables will be in predicting gentrification over time. Based on the research, Hammell and Wyly confirmed that income, rent, employment, and profession census variables were significant in demonstrating gentrification.

Research conducted by Jeffrey Lin (2002) on “gentrification and Transit in Northwest Chicago” proposed a theory that the presence of transit in combination with declining automobile costs leads to gentrification of inner-city and transit-served neighborhoods” (Lin 2002). This research states that gentrification can be measured by market variables such as changes in housing values, renovations, permits, and sales and household variables such as household size, structure, income, and education. The research concluded that distance to transit station had strong negative effect in property value change, which in turn resulted in gentrification. However Lin’s study only concentrated on property value data and ignored the changes in household status in the study area. Table 2.3 provides a summary of literature on the factors effecting changes in demographic composition including race, ethnicity, and income, which provided input into the selection of independent variables discussed in Chapter 3. Methodology.

Table 2.3 Summary of Literature for Research Question 2 – Factors Effecting Changes in Demographic Composition (Race, Ethnic, and Income)

Theory/Literature	Changes in Demographics and possible gentrification are determined by the following variables
Tiebout (1956)	Meet needs of housing (values, rents, supply of desired type of housing, access to employment), community (similar racial and income groups), and local public services (transportation access, schools, parks, etc.)
King and Mieszkowski (1973), Galster (1982), Ihlanfeldt and Scafidi (2002)	Existing race, ethnic, and income groups in location choice
Massey and Denton (1993)	White flight, disinvestment in minority neighborhoods, lack of proximity of employment and education, discrimination in the mortgage lending
Galster (1988), Schill and Wachter (1995), Galster and Godfrey (2005)	Market forces: income, employment, poverty, information availability, and supply factors such as housing costs, have an impact on the racial composition and Non-market forces: discrimination in the mortgage lending and “steering”, “redlining” or other discriminatory practices
Hammell and Wyly (1996)	Socio Economic Variables: Median household income, change in median household income, percentage of workers in managerial, professional, or technical occupations, percentage of persons with 4+ years college education, change in percentage of persons with 4+ years college education Housing variables: Median rent, change in median rent, median value, and change in median value Population variables: Persons, employed persons, workers in technical and managerial occupations, persons with 4+ years college education

Table 2.3 - *Continued*

Jeffrey Lin (2002)	Market variables such as changes in housing values, renovations, permits, and sales and household variables such as household size, structure, income, and education and location such as distance to transit station and transportation facilities

CHAPTER 3

METHODOLOGY

As discussed in Chapter 2, the research methodology and variables were based on several sources. This Chapter provides details on the datasets used in the research, boundaries of the study area, various quantitative measures, variables, and techniques used to address the research questions.

3.1. Datasets

3.1.1. U.S. Census data

The Decennial data and American Community Survey data (2005-2009) from U.S Census provide information on housing values, housing prices, rents, race, income, at census tract level for 2000 and 2010. For this research, the following variables will be utilized for the study:

- Race or ethnicity – White Non-Hispanic, African-American, Hispanic, and other races
- Median Income
- Housing value
- Housing rent

3.1.2. Development Monitoring Data

The North Central Texas Council of Government's (NCTCOG) Development Monitoring database monitors major developments that are over 8,000 square feet or 80 employees. This dataset includes developments in the existing, under construction, announced, or in the conceptual stages. These datasets were further supplemented to categorize the mixed use developments by the Vision North Texas, a regional visioning process and TOD research

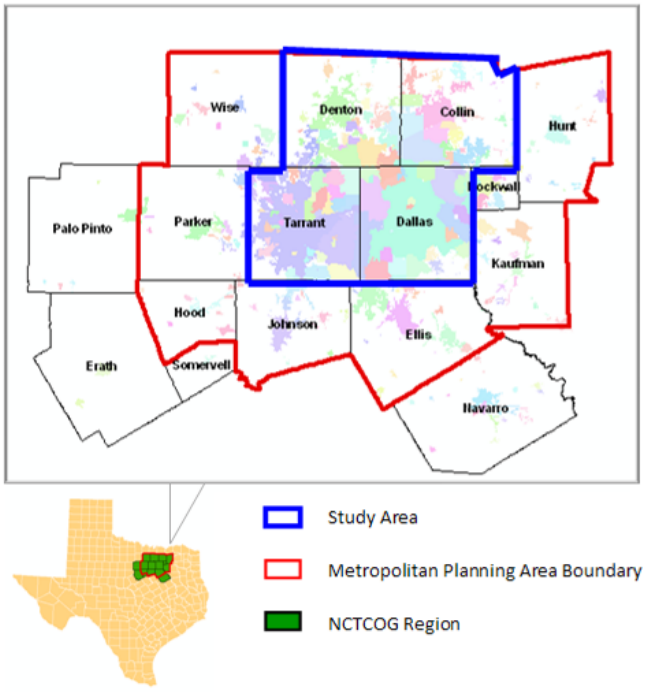
conducted by the UTA architecture department. Appendix A shows the development monitoring data provided by NCTCOG that includes a list of MUCs and TODs.

3.1.3. Other Data Variables

Other base data variables for the research such as roads, rail, rail stations, major employers, population, employment forecasts, will be gathered from NCTCOG and various other sources.

3.2. Study Area and Unit of Study

The research includes four counties within the Dallas-Fort Worth (DFW) Urban Area: Collin, Dallas, Denton, and Tarrant Counties) and the analysis will be conducted at Census Tract Level. All variables are not available at Block Group level. Census Tract data was used for consistency among various variables. Most of the MUCs and TODs developed in the DFW region are located in these four counties. The blue boundary in Map 3.1 illustrates the limits of the study area.



Map 3.1 Study Area Boundary

3.3. Descriptive Analysis and Statistical Tests

3.3.1. Research Question 1

Does the percentage change in median housing value (2000-2009) in MUCs and TODs different from the rest of the region and what are the significant factors effecting the percentage change in Median Housing Value?

3.3.1.1. Difference in Medians

The research question will be reviewed through descriptive statistics through the direct comparisons through changes in median housing value (2000-2009) in MUCs and TODs compare to the rest of the region. Kruskal Wallis test will be conducted to test whether the difference among the median housing values (2000-2009) in single use, mixed use non-TOD, and TOD census tracts are statistically significant.

3.3.1.2. Regression

The following function shows various sets of independent variables to examine and analyze the research question 1 to predict the changes in the dependent variable:

Percentage Change in Median Housing Value (2000-2009) = f (Land Use Variables, Location Variables, Transportation Access Variables, Development Variables)

The null hypothesis is that the change in median housing value (2000-2009) does not have a significant relationship to Land Use, Location, Transportation Access, and Development variables. Multivariate regression analysis will be conducted for the following regression equation to analyze Research Questions 1. The analysis will be at census tract level. A Pearson correlation, test for multicollinearity, and stepwise regression will be conducted for the research.

H_0: $\beta = 0$

H_a: $\beta \neq 0$

Dependent Variable: The dependent variable for the regression equation 1 will be median housing value, which is an indicator of property values, housing, and land prices. The median housing value at census tract level will be obtained from the U.S. Census data from 2000 and

2010. The cases or observations will be for each census tract. The above dataset is available at census tract level. Though few variables used in the study may be available at parcel or block group level, various other variables are not available at this smaller geographic level, and the analysis was conducted at census tract level for consistency.

Independent Variables: Based on the literature review summarized in Table 2.2, Land use variables (residential, commercial, MU); Location variables (distance from downtown, distance from schools, major employers, amenities such as schools and parks); and Transportation access variables (distance from highways or rail station), and Development Type (Single-family, multifamily or mixed use) were identified as some of the variables that influence land price. The following independent variables may be significant to determine the variation in median housing value that will be examined for this research question:

Land Use Variables: The following variables will be derived from 2005 Land Use data provided by the NCTCOG. The percentage of each land use type in each census tract of the total area of the Census Tract was summarized for each Census tract and added as three separate variables for residential, office and retail percentages.

- Percentage of residential
- Percentage of office
- Percentage of retail

Location Variables: The following location variables were calculated from the Centroid of each census tract to each point feature locations (Downtown, school, major employer, and park) using an ArcGIS tool to calculate shortest distance through road network. The downtown, schools, major employers, and park locations were obtained from the GIS shapefiles provided by NCTCOG.

- Distance from Center of Downtown
- Distance from the nearest school
- Distance from the nearest major employer

- Distance from the nearest park

Transportation Access Variables: The following location variables were calculated from the centroid of each census tract to the nearest highway and existing rail station using an ArcGIS tool to calculate shortest distance through road network. The highway and existing rail station GIS shapefiles were obtained from the NCTCOG datasets.

- Distance from nearest Highway

- Distance from nearest rail station

Development Variables: Two Dummy variables will be used for the following three development types of census tracts

- Single Use census tracts

- Mixed Use Non-TOD census tracts

- Mixed Use TOD census tracts

Table 3.1 Two Development Type Dummy Variables

	MU Dummy (MUdummy)	TOD Dummy (TODdummy)
Single Use Census Tract	0	0
Mixed Use Census Tract	1	0
TOD Census Tract	0	1

The two Dummy Variables will be Mixed Use Dummy Variable (MUdummy) and TOD Dummy Variable (TODdummy). Table 3.1 shows the assignment of values for the Dummy Variables.

3.3.2. Research Question 2

Do persons living in housing in MUCs and TODs exhibit different income, race, and ethnic of characteristics than those in the rest of the four-county study area?

3.3.2.1. Difference in Median and Mean

The research question will be reviewed through descriptive statistics through the direct comparisons through changes in median household income (2000-2009) and the changes in

percentage of minorities (2000-2009) in MUCs and TODs compare to the rest of the region. Kruskal Wallis test will be conducted to test whether the difference among the median household incomes (2000-2009) in single use, mixed use non-TOD, and TOD census tracts are statistically significant. The Analysis of Variance (ANOVA) test will be conducted to test whether the difference among the percentage change in minorities (2000-2009) in single use, mixed use non-TOD, and TOD census tracts are statistically significant.

3.3.2.2. Regression

The following sets of variables were identified from the literature review summarized in Table 2.3. The following functions show various sets of independent variables to examine and analyze in the research question 2 to predict the changes in the dependent variable:

Percentage Change in Median Income (2000-2009) = *f* (Demographic Variables, Location Variables, Transportation Access Variables. Development Variables, Housing Supply Variables)

The null hypothesis is that the median income does not have a significant relationship to Demographic, Location, Transportation Access, Development, and Housing Supply variables.

Percentage Change in Minority (2000-2009) = *f* (Demographic Variables, Location Variables, Transportation Access Variables, Development Variables, Housing Supply Variables)

The null hypothesis is that race and ethnicity do not have a significant relationship to Demographic, Location, Transportation Access, Development, and Housing Supply variables.

Dependent Variables: Median Income, and race, and ethnicity by census tracts will be used as depended variables in regression equations 2 and 3, to determine the relationship of income, race, and ethnicity due to the groups of independent variables. The dependent variables at census tract level will be obtained from the U.S. Census data from 2000 and 2009. The cases or observations will be for each census tract. The above dataset is available at census tract level. Median Income, and race, and ethnicity by census tracts will be used as

depended variables in regression equations 2 and 3, to determine the relationship of income, race, and ethnicity due to the groups of independent variables that will be used for the regression equations.

Independent Variables: Based on the literature review, existing racial composition of the area (preference to live with same race), existing income groups in the area (preference to live with same income class and affordability reasons), access to transportation, access to downtown and major employers, access to parks and trails, and supply factors such as housing costs and housing units are some of the significant factors contributing to income, race, and ethnic composition of communities. The following independent variables may be significant to determine the variation in income, race, and ethnicities which will be examined for this research question:

Demographic variables: The following demographic variables were calculated for each census tract from the census datasets. The 2000 Census data and the 2005-2009 American Community Survey (ACS) datasets were used to calculate the following variable for each census tract.

- Percentage Change of Minorities (2000-2009)
- Percentage change in Median Household Income (2000-2009)
- Percentage of population with college education (4+ years)
- Percentage of population employed in professional and technical occupations

Location Variables: The following location variables were calculated from the Centroid of each census tract to each point feature locations (Downtown, school, major employer, and park) using an ArcGIS tool to calculate shortest distance through road network. The downtown, schools, major employers, and park locations were obtained from the GIS shapefiles provided by NCTCOG.

- Distance from Center of Downtown
- Distance from the nearest school

- Distance from the nearest major employer
- Distance from the nearest park

Transportation Access Variables: The following location variables were calculated from the Centroid of each census tract to the nearest highway and existing rail station using an ArcGIS tool to calculate shortest distance through road network. The highway and existing rail station GIS shapefiles were obtained from the NCTCOG datasets.

- Distance from nearest Highway
- Distance from nearest rail station

Development Variable: The two Dummy Variables will be Mixed Use Dummy Variable (MUdummy) and TOD Dummy Variable (TODdummy) to capture three development types below. Table 3.1 shows the assignment of values for the Dummy Variables.

- Single Use or other development
- Mixed Use Non-TOD
- Mixed Use TOD

Housing Supply Variables: The following demographic variables were calculated for each census tract from the census datasets. The 2000 Census data and the 2005-2009 American Community Survey (ACS) datasets were used to calculate the following variable for each census tract.

- Median housing value
- Median rent

CHAPTER 4

DESCRIPTIVE ANALYSIS AND RESULTS

This Chapter provides details on the descriptive analysis related to each research and analyzes various datasets using Geographic Information Systems (GIS) software and draws conclusions based on interpretation of GIS maps and aggregation of various attributes pertaining to the research questions. The results of the test for difference in medians and regression analysis will be presented in Chapter 5.

4.1. Descriptive Analysis

Various datasets listed in Chapter 3 were collected from the U.S. Census 2000, U.S. Census 2010, and 2005-09 American Community Survey, and the NCTCOG. The four county study area contains a total of 938 census tracts. Based on the GIS datasets of the NCTCOG funded and completed mixed use developments and other existing mixed use developments in the region extracted from the NCTCOG's Development Monitoring data, a combined mixed use development dataset was created for the study area. All census tracts within half-mile radius of mixed use developments were selected to obtain a dataset of "Mixed Use Census Tracts" containing 152 census tracts. A quarter of a mile limit is considered the typical walking distance for bus transit, and half a mile is considered the typical walking distance for rail transit, dependent though on environment and directness of the route (Renee, 2009; USDOT-UMTA, 1979). Based on the locations of existing transit stations in the study area, all mixed use census tracts within half-mile radius of transit stations were selected to create a dataset of "TOD Census Tracts" containing 59 census tracts. Road network distances were used to select the census tracts.

Figure 4.1 shows an example of the half-mile radius GIS buffer around mixed use centers to create Mixed Use Census Tracts and half-mile radius GIS buffer around to create a dataset of TOD census tracts. The Census Tracts shown in dark green color are TOD Census Tracts, light green are Mixed Use Census Tracts, and the beige color are all other Census Tracts.

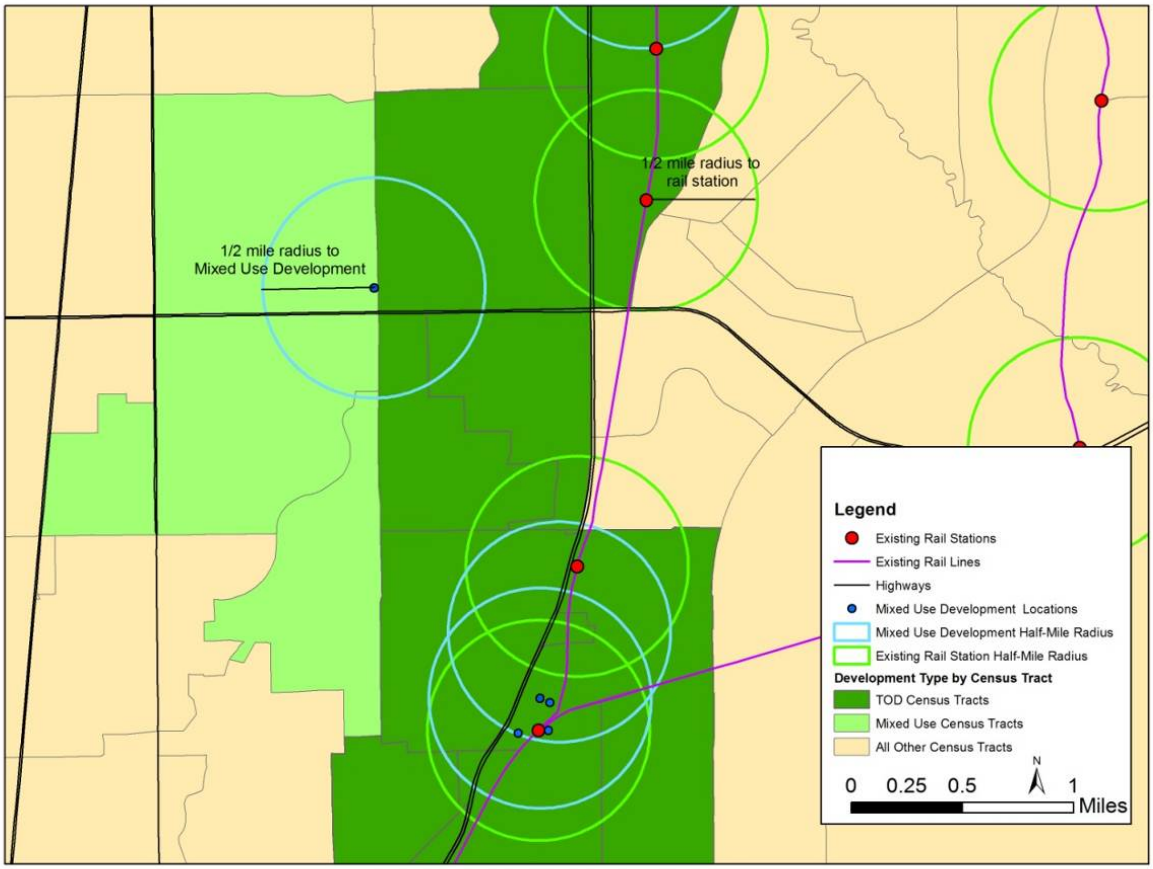
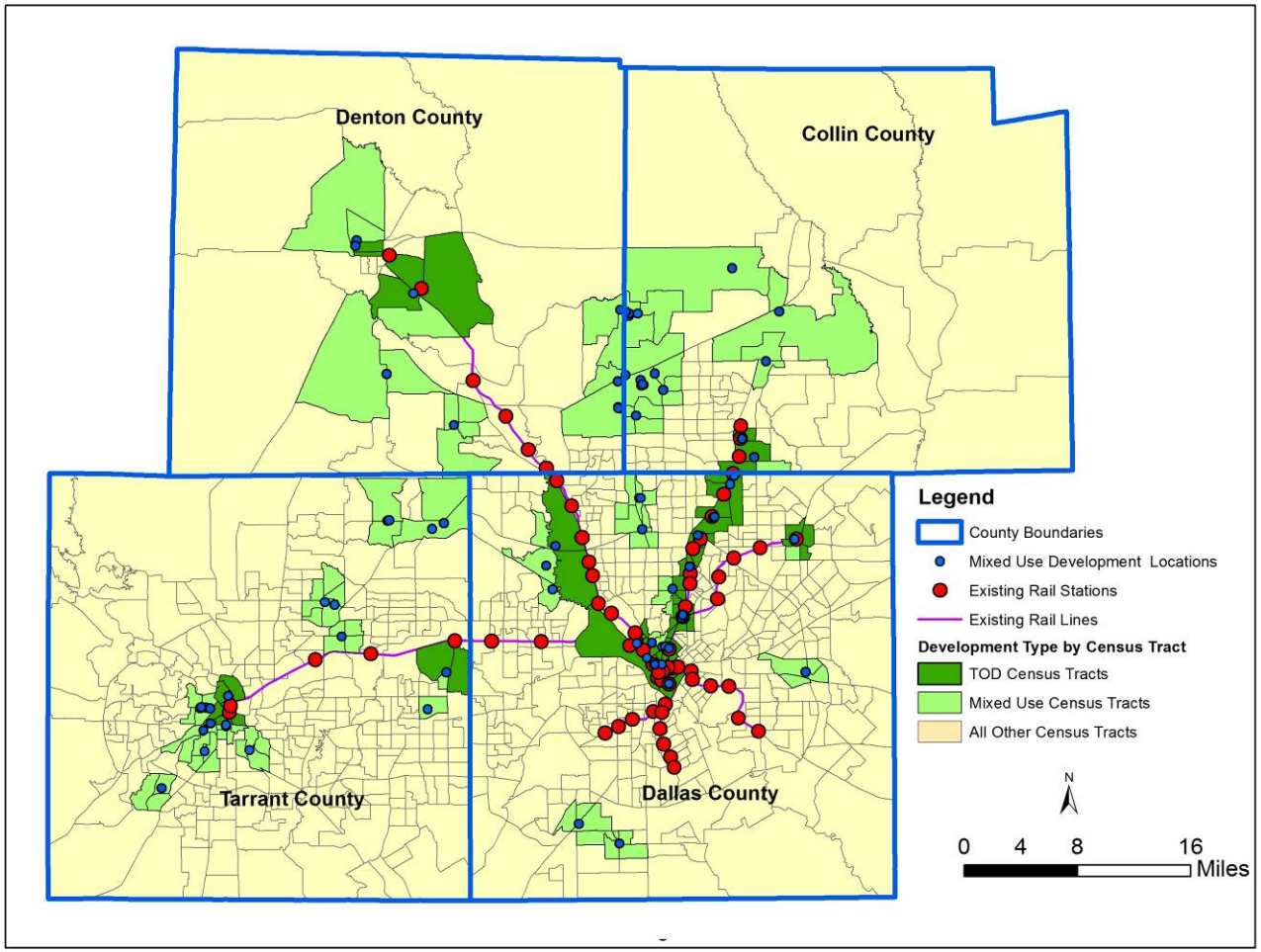


Figure 4.1 Selection of Mixed Use and TOD Census Tracts

Map 4.1 shows the locations of Mixed Use census Tracts, TOD Census Tracts, mixed use development, and rail station locations in the study area.



Map 4.1 Mixed Use and Transit Oriented Development Locations
Source: U.S Census and NCTCOG datasets

4.1.1. Research Question 1

Does the percentage change in median housing value (2000-2009) in MUCs and TODs different from the rest of the region and what are the significant factors effecting the percentage change in Median Housing Value?

Table 4.1 shows that Median Housing Value in Mixed Use and TOD Census Tracts were higher than other census tracts in the study area in 2000 and 2009.. Median Housing Value in TOD Census Tracts increased by $67,027 or 49.9 percent between 2000 and 2009. Median Housing Value in Mixed Use Census Tracts increased by $60,652 or 40.3 percent and this increase in other census tracts was $39,749 or 37 percent. The percentage increase in Median Housing Value was 12.9 percentage points higher in TOD Census Tracts and 3.3 percentage points in Mixed Use Census Tracts in comparison to all other census tracts in the study area.

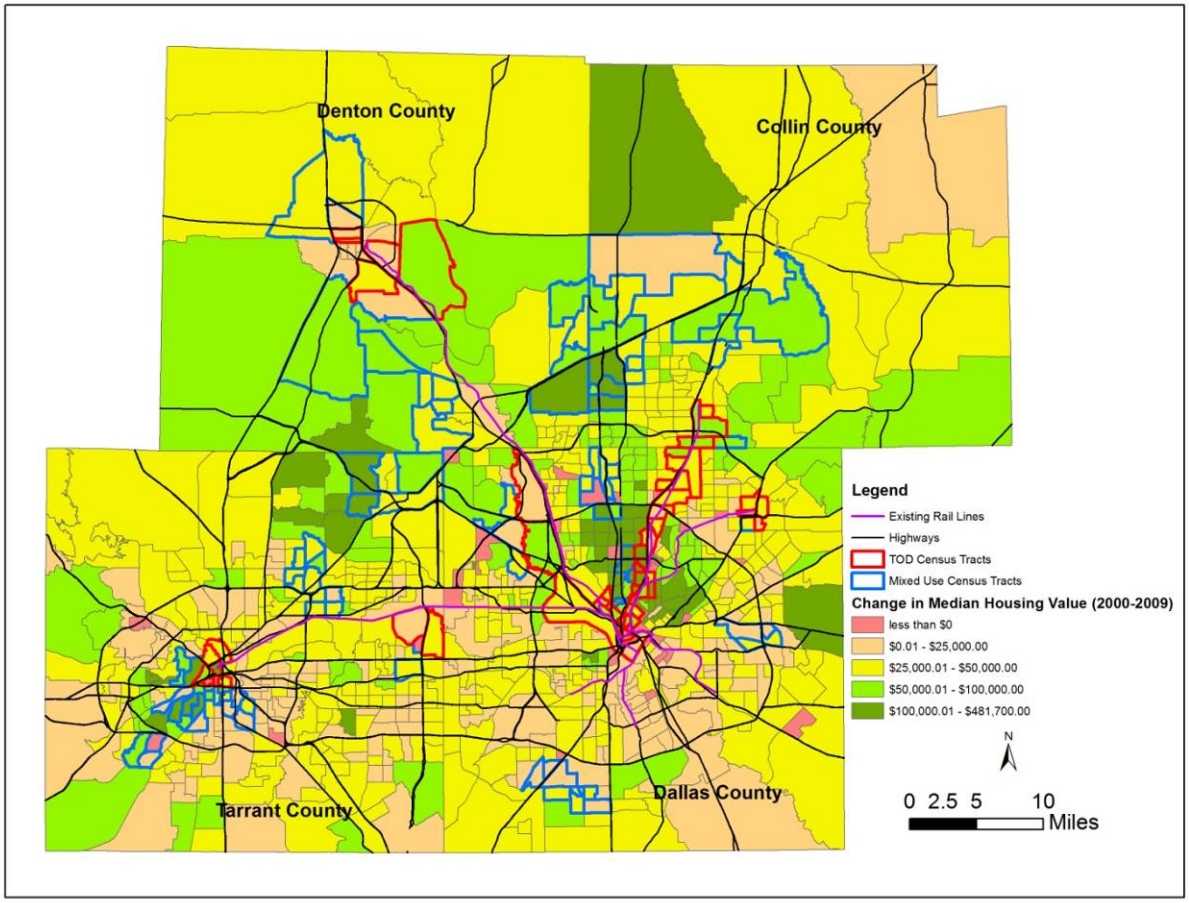
Table 4.1 Median Housing Value and Median Contract Rent by Development Type of Census Tracts

Variables	Mixed Use Census Tracts (n=152)	TOD Census Tracts (n=59)	All Other Census Tracts (n=727)
Median Housing Value 2000	$150,414	$134,247	$107,345
Median Housing Value 2009	$211,066	$201,275	$147,094
Change in Median Housing Value 2000-2009	$60,652	$67,027	$39,749
Percent Change in Median Housing Value 2000-2009	40.3%	49.9%	37.0%
Median Contract Rent 2000	$691	$662	$613
Median Contract Rent 2009	$805	$810	$713
Change in Median Contract Rent 2000-2009	$114	$148	$100
Percent Change in Median Contract Rent 2000-2009	16.4%	22.4%	16.3%

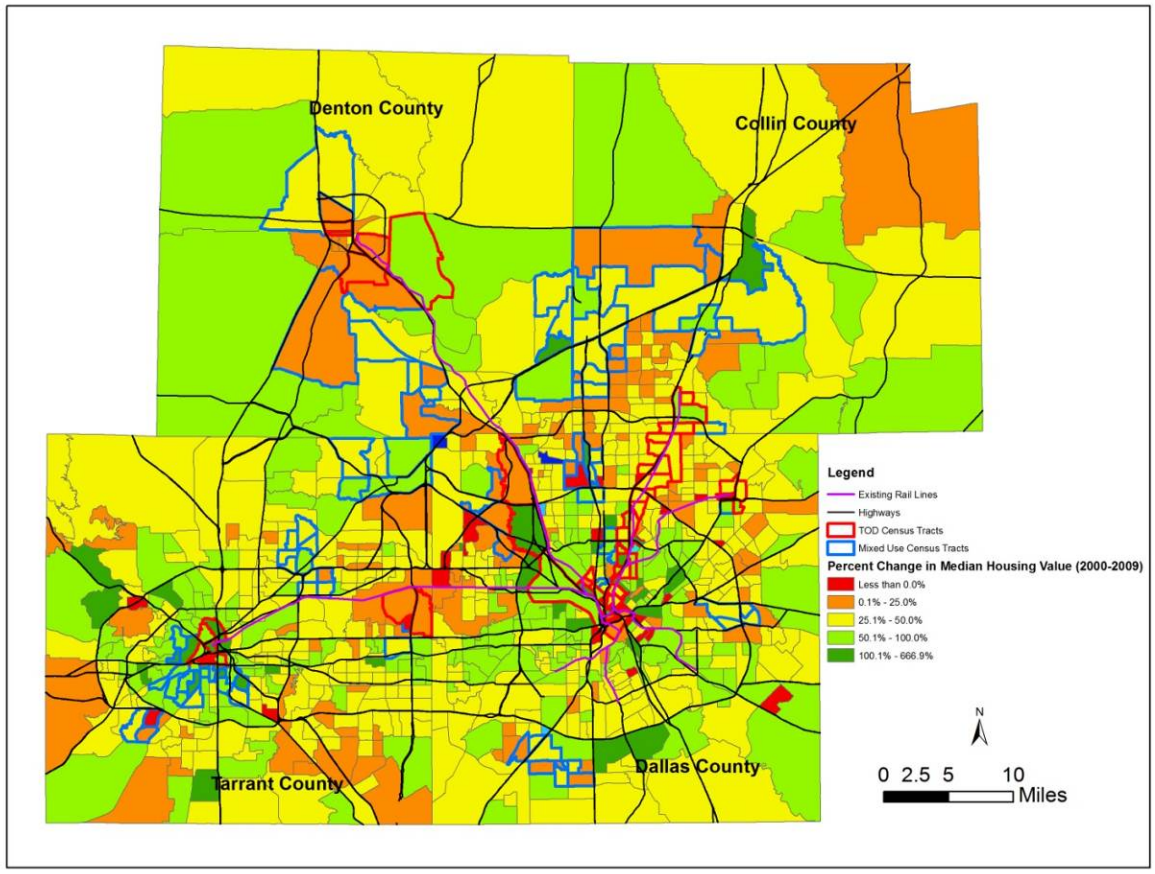
Source: 2005-09 American Community Survey data from the U.S. Census

Similar trends were found in the increases in Median Contract Rent between 2000 and 2009. TOD Census Tracts experienced a higher increase of Median Contract Rent at 22.4

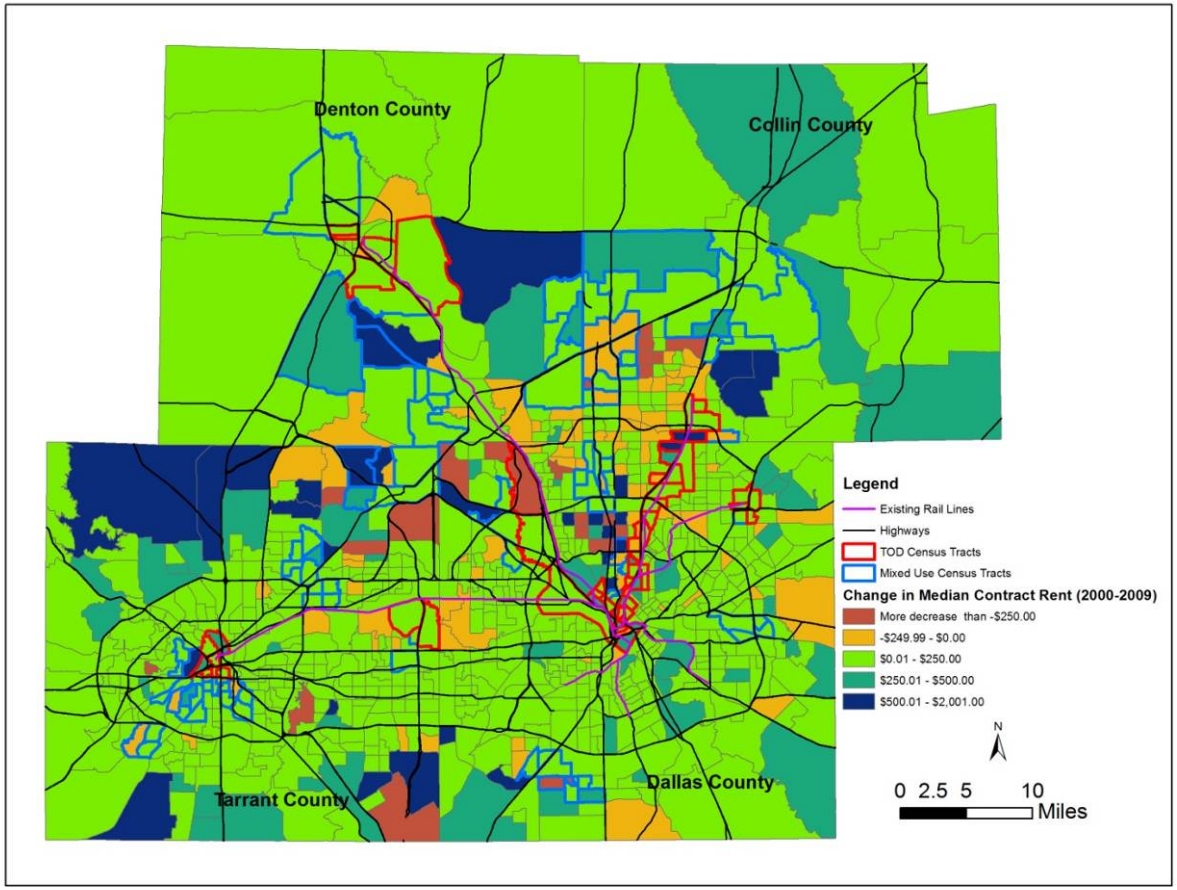
percent during the period. This increase was 16.4 percent in Mixed Use Census Tracts and 16.3 percent in other census tracts in the study area. Maps 4.2 and 4.3 show the magnitude of change and the percentage of change in median housing value, by census tract, between 2000 and 2009. Maps 4.4 and 4.5 show magnitude of change and percentage change in median contract rent by census tract between 2000 and 2009. Statistical tests to compare the significance of differences in medians and regression analysis are included in Chapter 5.



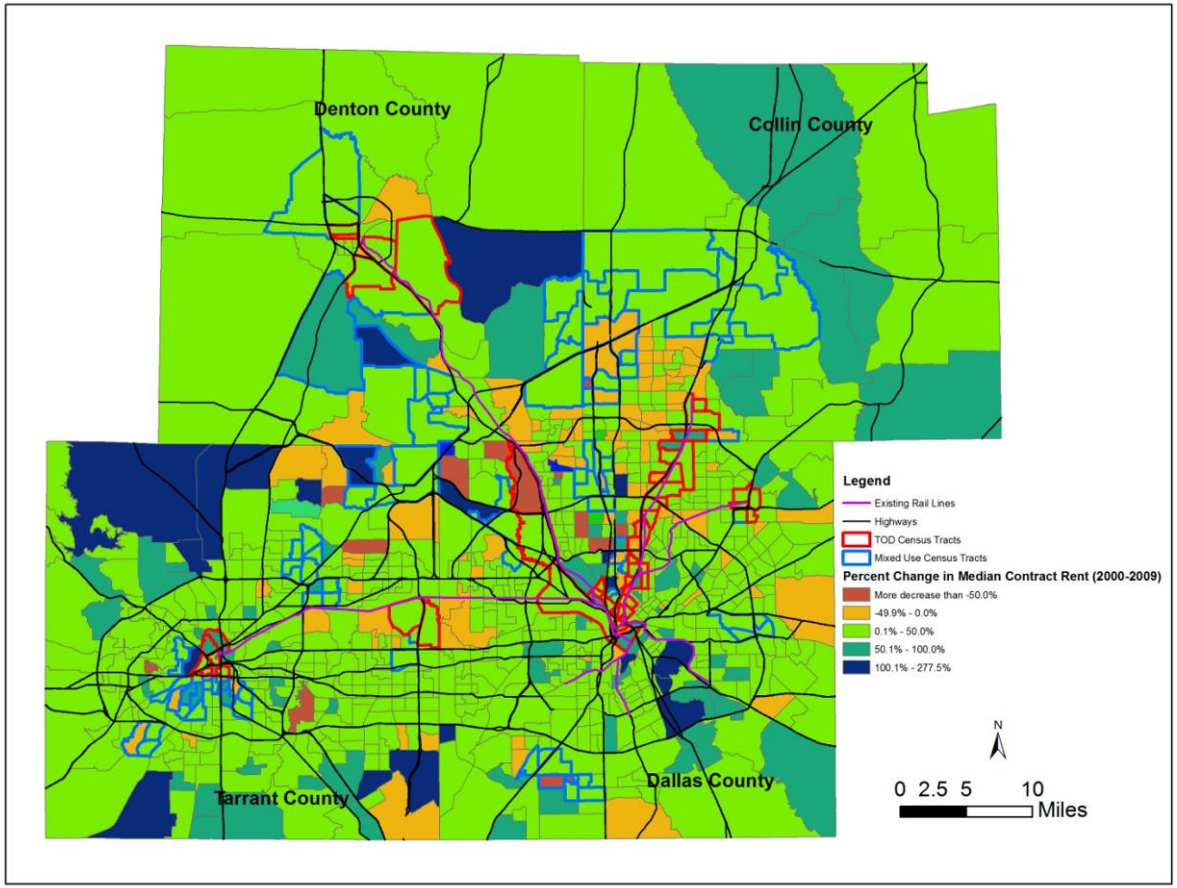
Map 4.2 Change in Median Housing Value (2000-09)
Source: U.S Census and NCTCOG datasets



Map 4.3 Percent Change in Median Housing Value (2000-09)
Source: U.S Census and NCTCOG datasets



Map 4.4 Change in Median Contract Rent (2000-09)
Source: U.S Census and NCTCOG datasets



Map 4.5 Percent Change in Median Contract Rent (2000-09)
Source: U.S Census and NCTCOG datasets

4.1.2. Factors influencing Median Housing Values

Various factors may be attributed to influence the higher increases in housing values in TOD and Mixed Use Census Tracts. Some of the factors based on the literature review were analyzed based on the datasets provided by the NCTCOG and U.S. Census.

Table 4.2 Aggregate Values of key variables by Development Type of Census Tracts

Variables for Census Tracts	Mixed Use (n=152)	TOD (n=59)	Other Tracts (n=727)
Count	93	59	786
Average Distance to Downtown (miles)	2.2	2.1	2.5
Average Distance to Park (miles)	0.4	0.4	0.5
Average Distance to Rail Station (miles)	3.8	0.4	4.4
Average Distance to Highway (miles)	1.0	0.6	1.0
Average of number of major employers (250+) per Square Mile	6	21	3
Average of number of schools per Square Mile	2	3	2
Average percent of residential land use (2005)	33.1%	28.7%	38.9%
Average percent of retail land use (2005)	4.9%	5.5%	4.3%
Average percent of office land use (2005)	2.9%	5.1%	1.4%
Average percent of commercial land use (2005)	7.8%	10.6%	5.6%
Percentage of age under 18*	27.2%	20.8%	28.7%
Percentage of age over 65*	8.0%	8.6%	8.0%
Percentage of Persons with at least Bachelor's Degree*	45.7%	37.7%	28.9%
Percentage of Persons with Professional Job*	46.4%	40.6%	33.6%
Percent of Single-Family Housing Units*	67.2%	64.2%	40.8%
Percent of Multifamily Housing Units*	25.5%	29.1%	50.6%

Source: All variables are from NCTCOG datasets except the datasets marked '*' are from the 2005-09 American Community Survey data from the U.S. Census.

This section provides a descriptive analysis of those factors. Table 4.2 shows aggregate values of various key variables and highlights general characteristics of census tracts within half mile of

mixed use developments and TODs. Further analysis on these factors will be described in regression analysis section of this Chapter.

As shown in Table 4.2, the average distance that residents within Mixed Use and TOD Census Tracts have to commute to a downtown or a park is lower compared to residents other parts of the four county study area. The distance variables are measured as the distances through the road network rather than the straight line distances. The average distance between Mixed Use Census Tracts and the nearest downtown is 0.3 miles lower than for other developments. The average distance between TOD Census Tracts and a nearest downtown is 0.4 miles lower than for the other developments. On an average, parks are 0.1 miles closer in Mixed Use and TOD Census Tracts compared to other census tracts in the region.

Average distance to a rail station is 0.6 miles lower in Mixed Use Census Tracts and 4.0 miles lower in TOD Census Tracts than for the developments census tracts in the study area. On an average, the census tracts within half mile to TODs are also 0.4 miles closer to highways. The average number of major employers (over 250 employees) per square mile in TOD Census Tracts is 21, compared to six major employers in TOD Census Tracts and three major employers in other census tracts in the study area. TOD Census Tracts have three schools per square mile compared to two schools in Mixed Use and other census tracts.

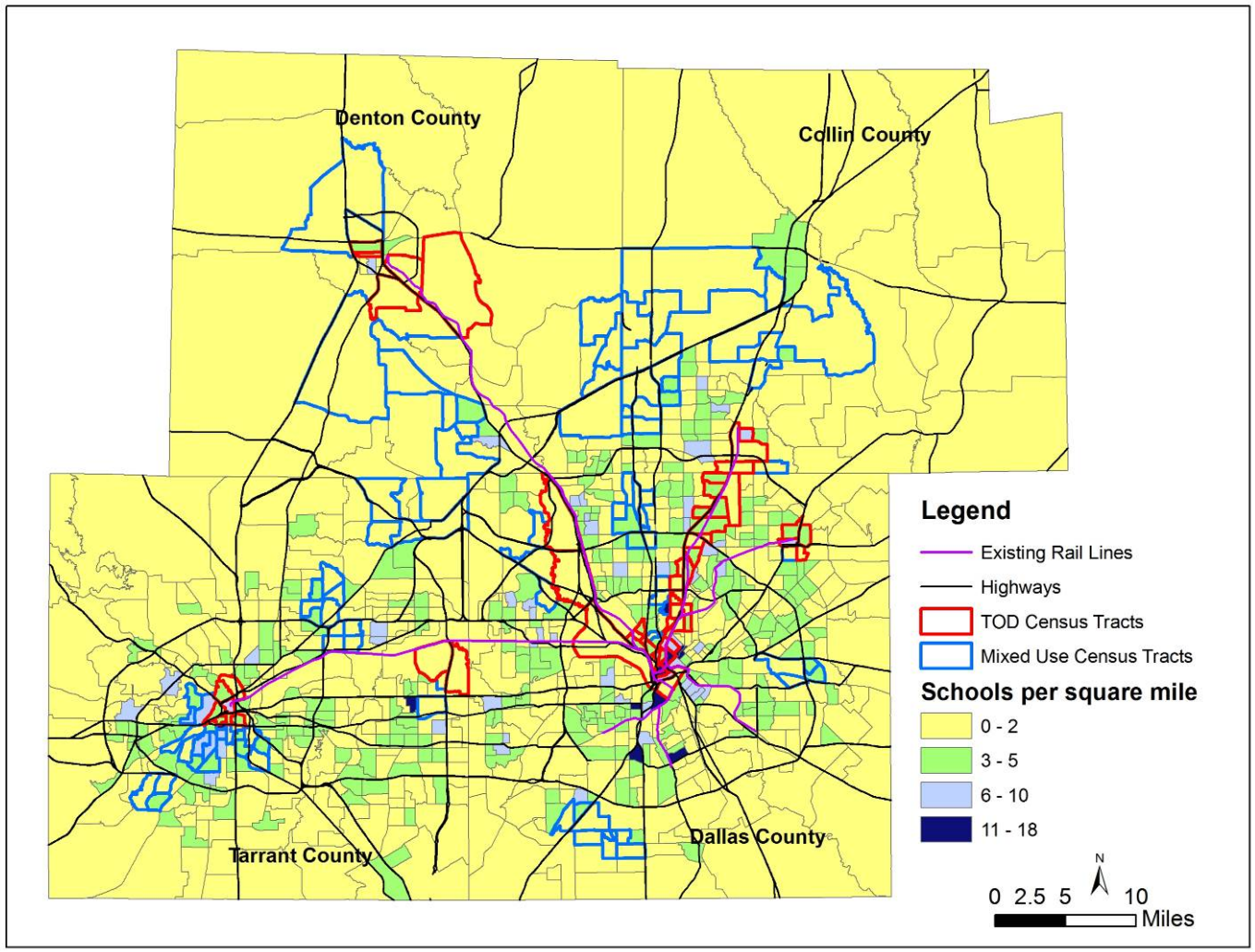
According to the 2005 land use data provided by the NCTCOG, Mixed Use and TOD Census tracts have higher percentages of commercial land uses when compared to other census tracts in the study area. The percentage of commercial land use of the total area of census tract is 2.2 percentage points higher in Mixed Use Census Tracts and 5.0 percentage points higher in TOD Census Tracts in comparison to other census tracts in the study area. The percentage of residential land use of the total area of census tract is 5.8 percentage points lower in Mixed Use Census Tracts and 10.1 percentage points lower in TOD Census Tracts in comparison to other census tracts in the study area.

According to 2005-09 American Community Survey data shown in Table 4.2, lower percentages of children (under age of 18) and higher percentage of elderly (overage of 65) lived in TOD Census Tracts, compared to Mixed Use and other census tracts. The average percentage of children in is 7.9 percentage points lower in TOD Census tracts and 1.5 percentage points lower in Mixed Use Census Tracts in comparison to other census tracts in the study area. The average percentage of elderly population is 0.6 percentage points higher in TOD census tracts in comparison to Mixed Use and other census Tracts in the study area.

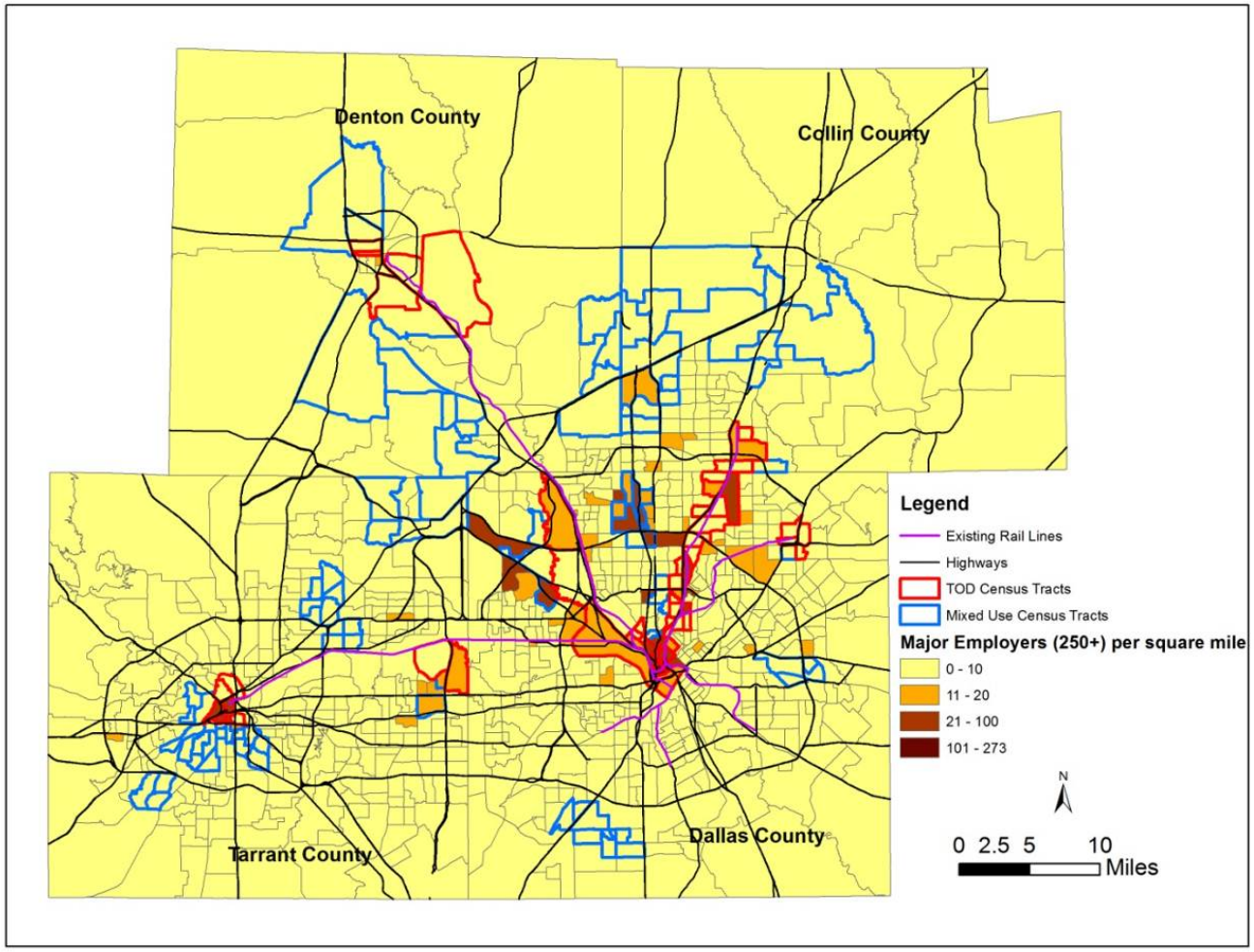
According to 2005-09 American Community Survey data, higher percentages of persons in Mixed Use Census Tracts and TOD Census Tracts have at least a Bachelor's degree and work in professional occupations. The percentage of population with Bachelor's Degree is 12.8 percentage points in Mixed Use Census Tracts and 6.9 percentage points higher in TOD Census, compared to other census tracts in the study area. The percentage of population working in a professional occupation is 16.8 percentage points in Mixed Use Census Tracts and 8.8 percentage points higher in TOD Census, compared to other census tracts in the study area.

TOD and Mixed Use Census tracts have higher percentage of multifamily housing compared to other census tracts in the study area. The percentage of multifamily units in Mixed Use Census Tracts is 4.4 points higher and that of TOD Census Tracts is 24.9 percentage points higher than other census tracts.

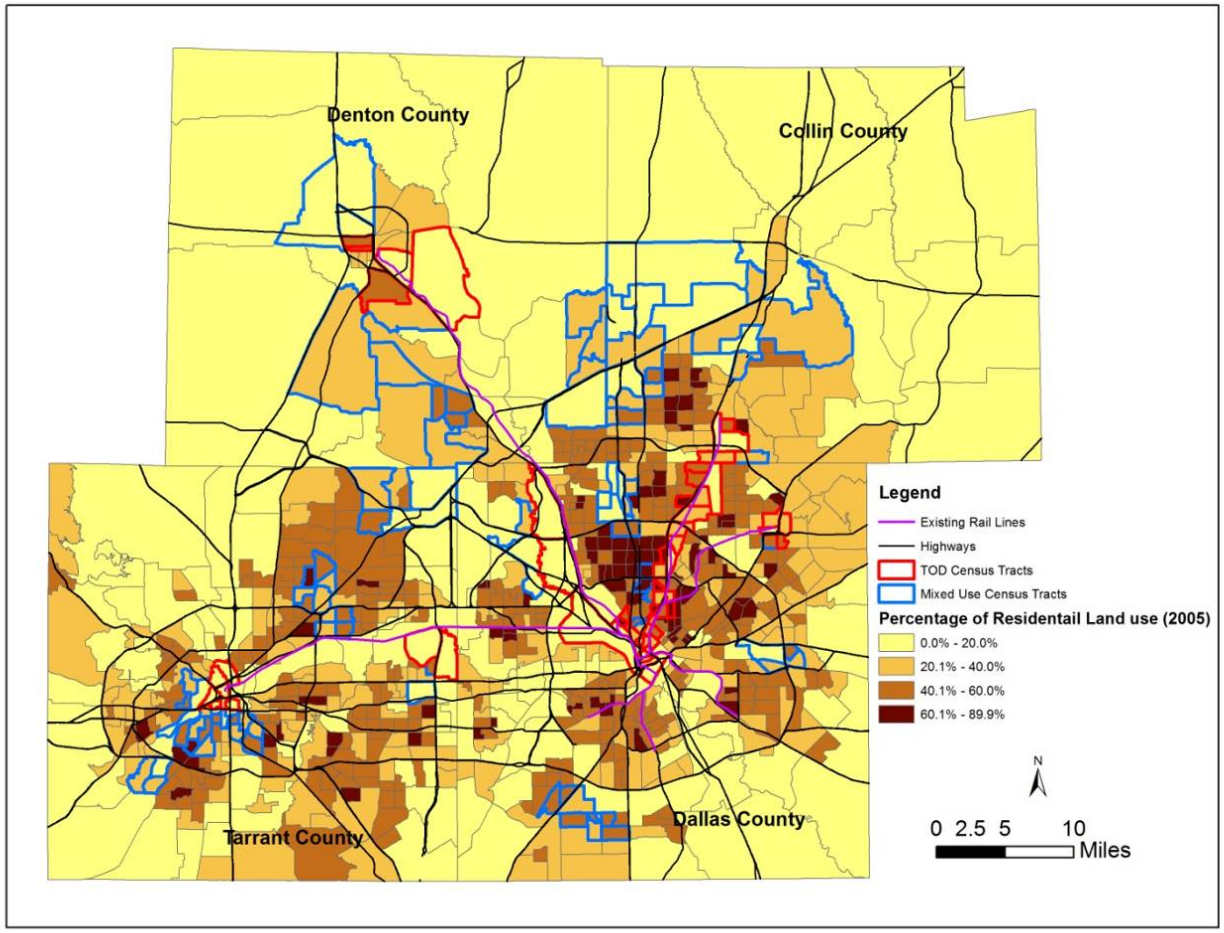
Maps 4.6 through 4.11 show various key datasets collected such as highways, rail lines, number of schools per square mile, number of major employers (250+ employees) per square mile, percentage of residential and commercial land uses, and the percentage of persons with degree a Bachelor's degree and professional occupation.



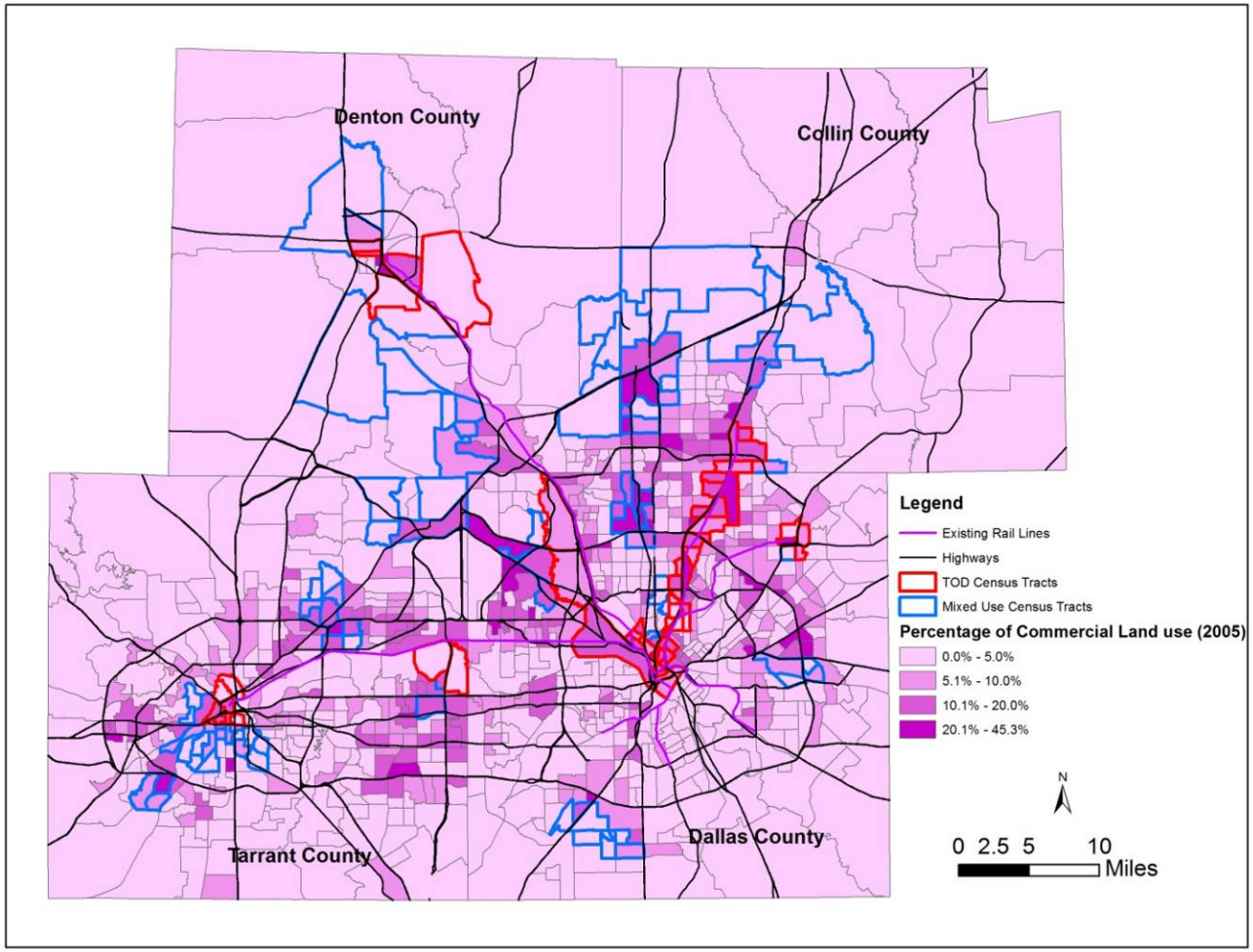
Map 4.6 Educational Institutions per Square Mile (2011)
Source: U.S Census and NCTCOG datasets



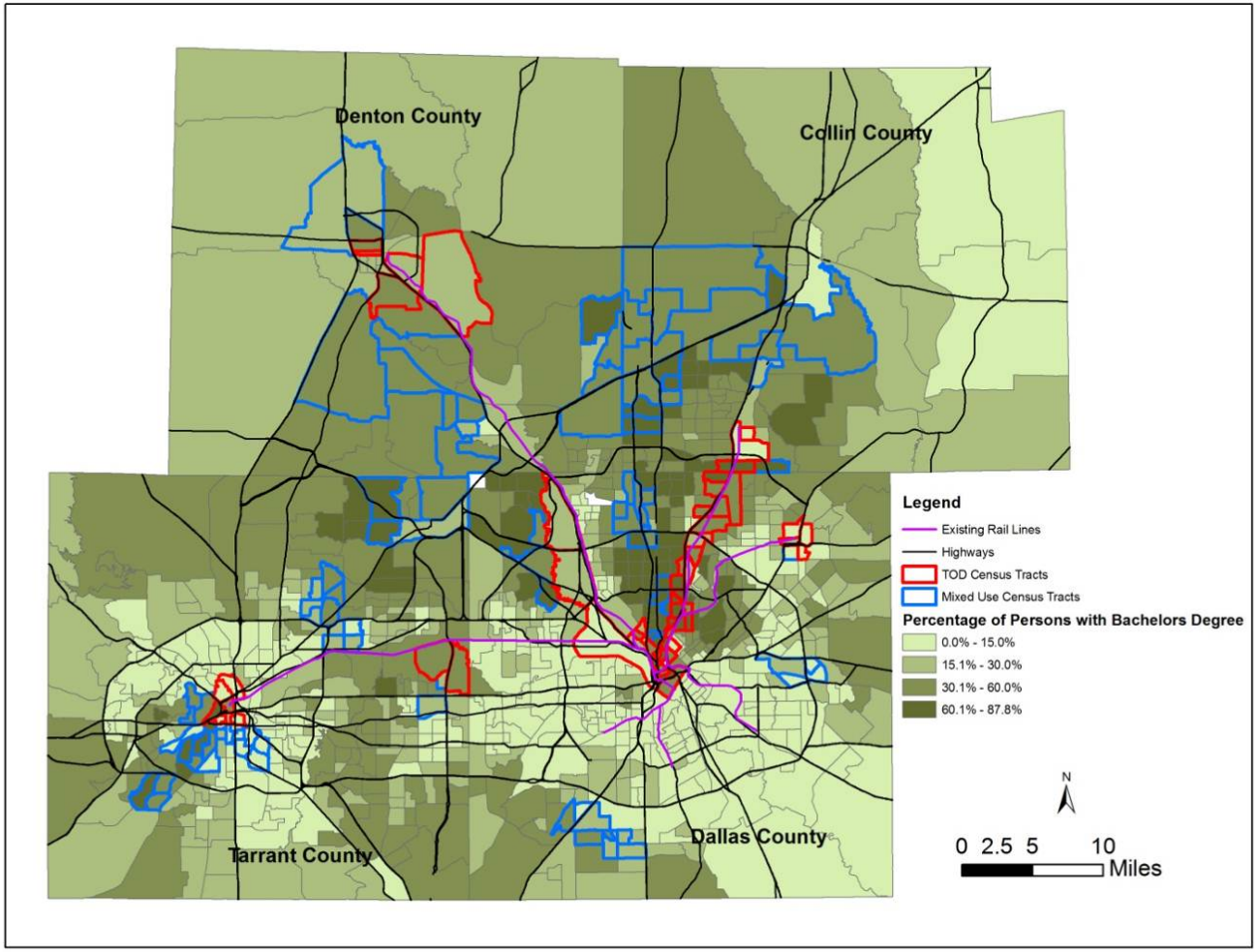
Map 4.7 Major Employers (250+ employees) per Square Mile (2011)
Source: U.S Census and NCTCOG datasets



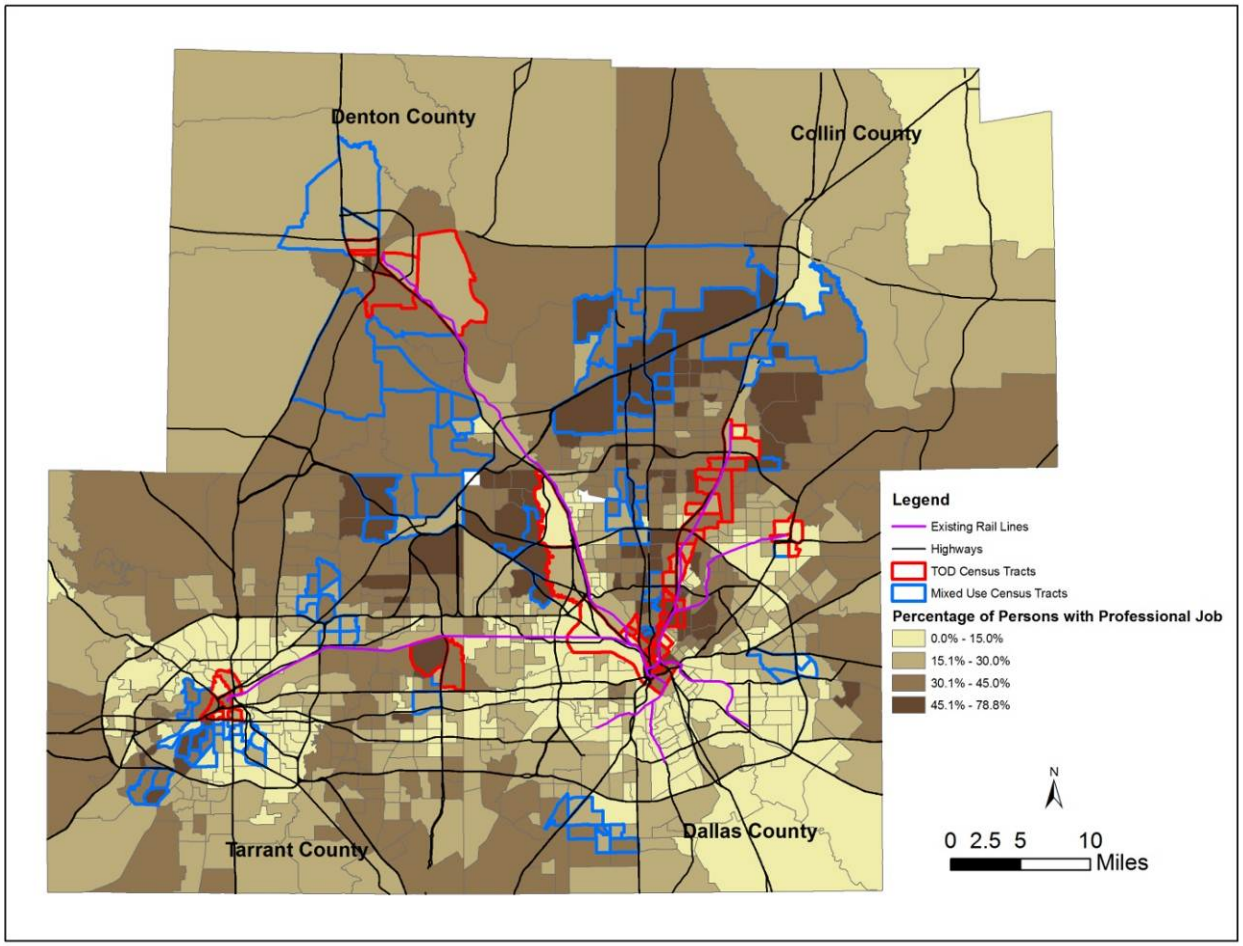
Map 4.8 Percentage of Residential Land Use (2005)
Source: U.S Census and NCTCOG datasets



Map 4.9 Percentage of Commercial Land Use (2005)
Source: U.S Census and NCTCOG datasets



Map 4.10 Percentage of Persons with Bachelor's Degree (2005-09)
Source: U.S Census and NCTCOG datasets



Map 4.11 Percentage of Persons with Professional Job (2005-09)
Source: U.S Census and NCTCOG datasets

4.1.3. Research Question 2

Do persons living in housing in MUCs and TODs exhibit different income, race, and ethnic of characteristics than those in the rest of the four-county study area?

The Census data was summarized for the Mixed Use, TOD, and all other census tracts within the study area to examine the percentage of minorities and median income levels in 2000 and 2009. Overall, the percentage of minorities is lower in TODs and Mixed Use Centers as compared to the rest of the census tracts in the study area. But the percentage of minorities is growing at a higher rate in mixed use centers when compared to TODs and all other census tracts.

As shown in Table 4.3, the percentage of minorities in Mixed Use Census Tracts was 13.5 percentage points lower, and the same figure in TODs is five percentage points lower, than all other census tracts in the study area. Mixed Use Centers experienced 64.4 percent increase

Table 4.3 Race, Ethnicity, and Income by Development Type of Census Tracts

Variables	Mixed Use	TOD	All other census tracts
Percent Minority 2000	28.8%	45.5%	45.6%
Percent Minority 2009	34.4%	47.9%	52.9%
Change in Minority Population (2000-2009)	64,456	92,338	16,437
Percentage change in Minorities (2000-2009)	64.4%	15.0%	35.0%
Percent African-American 2000	9.2%	13.4%	15.8%
Percent African-American 2010	9.6%	13.5%	15.9%
Percent Hispanic 2000	13.6%	25.6%	23.9%
Percent Hispanic 2010	16.2%	27.1%	30.1%
Percent White Non-Hispanic 2000	71.2%	54.5%	54.4%
Percent White Non-Hispanic 2010	65.6%	52.1%	47.1%
Median Household Income 2000	$62,185	$47,225	$50,409
Median Household Income 2009	$70,933	$55,513	$55,831
Change in Median Household Income 2000-2009	$8,747	$8,289	$5,422
Percent Change in Median Household Income 2000-2009	14.1%	17.6%	10.8%

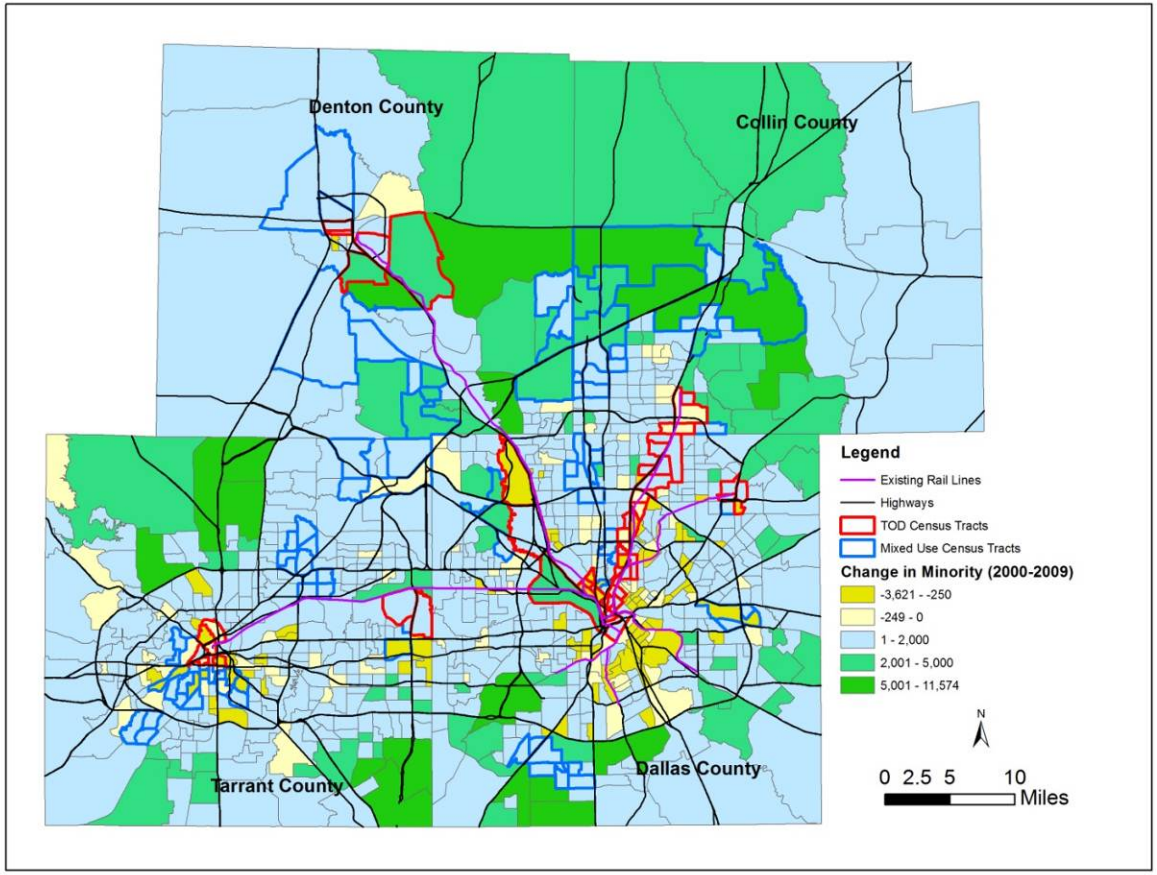
Source: 2005-09 American Community Survey data from the U. S. Census.

in minorities between 2000 and 2009, compared to 15 percent in TOD census tracts, and 35 percent in all other census tracts.

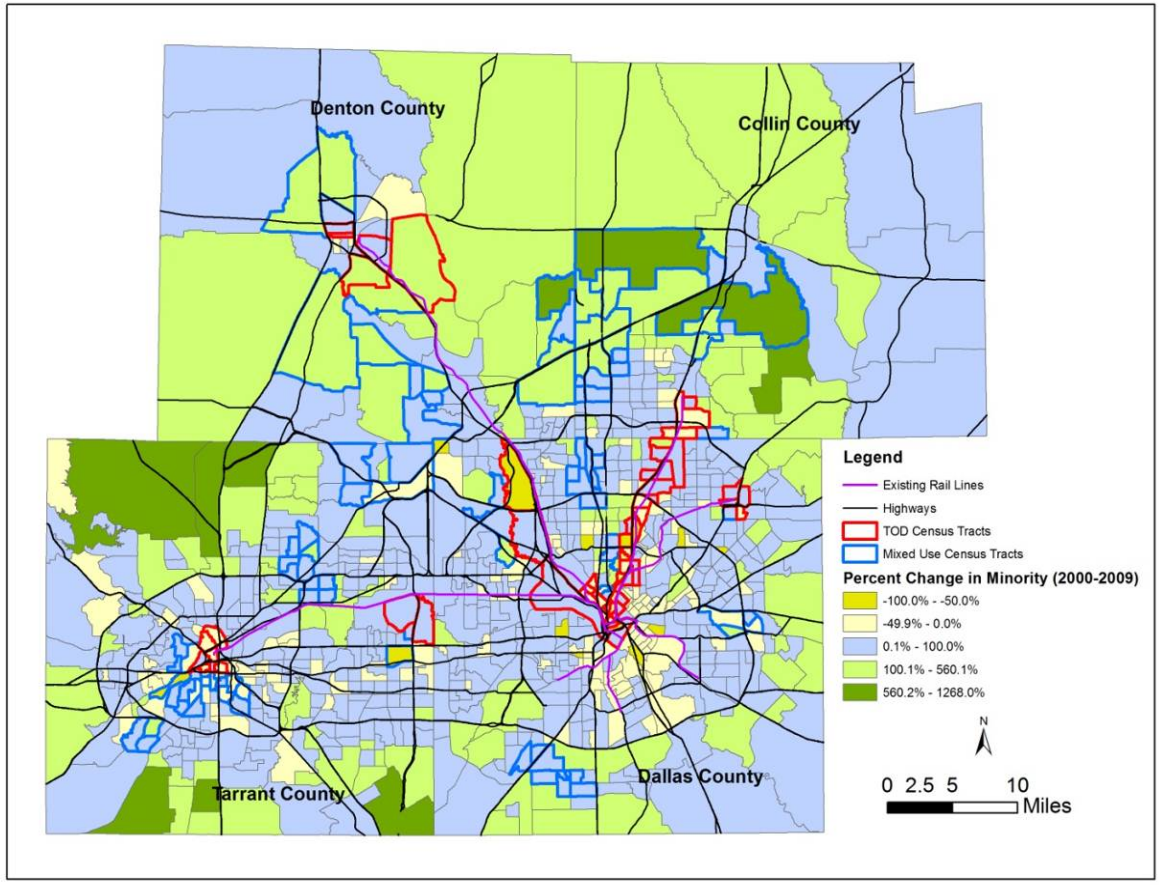
Overall, the percentage of African-Americans remained same in all three types of census tracts. The percentage of Hispanics increased higher (seven percentage points) in all other census tracts, and increased about three percentage points in Mixed Use and TOD census tracts during the ten year period. The decrease of White Non-Hispanic population was lower in TOD Census Tracts at two percentage points, compared to seven percentage points in Mixed Use and all other census tracts.

Median Household Income in Mixed Use census tracts was approximately $15,000 higher than TOD Census Tracts and all other census tracts in the study area in 2009. Median household income increased at a higher rate in TODs as compared to Mixed Use and all other types of census tracts between 2000 and 2009. The percentage increase in Median Household Income was 6.8 percentage points higher in TOD Census Tracts and 3.3 percentage points higher in Mixed Use Census Tracts as compared to all other census tracts in the study area.

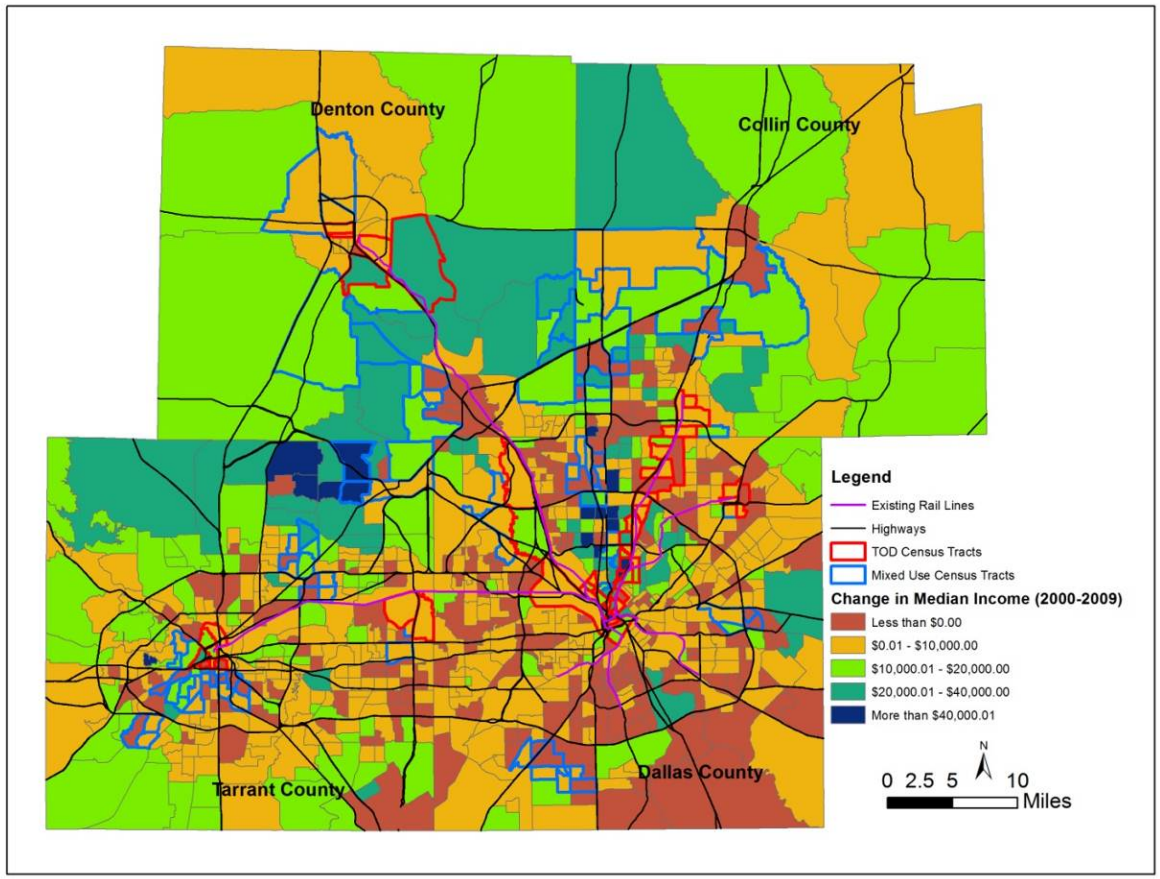
Maps 4.12 and 4.13 on the following pages illustrate the magnitude of change and the percentage change in minority population between 2000 and 2009. Maps 4.14 and 4.15 illustrate the magnitude of change and the percentage change in Median Household Income between 2000 and 2009. Statistical tests to compare the significance of differences in medians and regression analysis are included in Chapter 5.



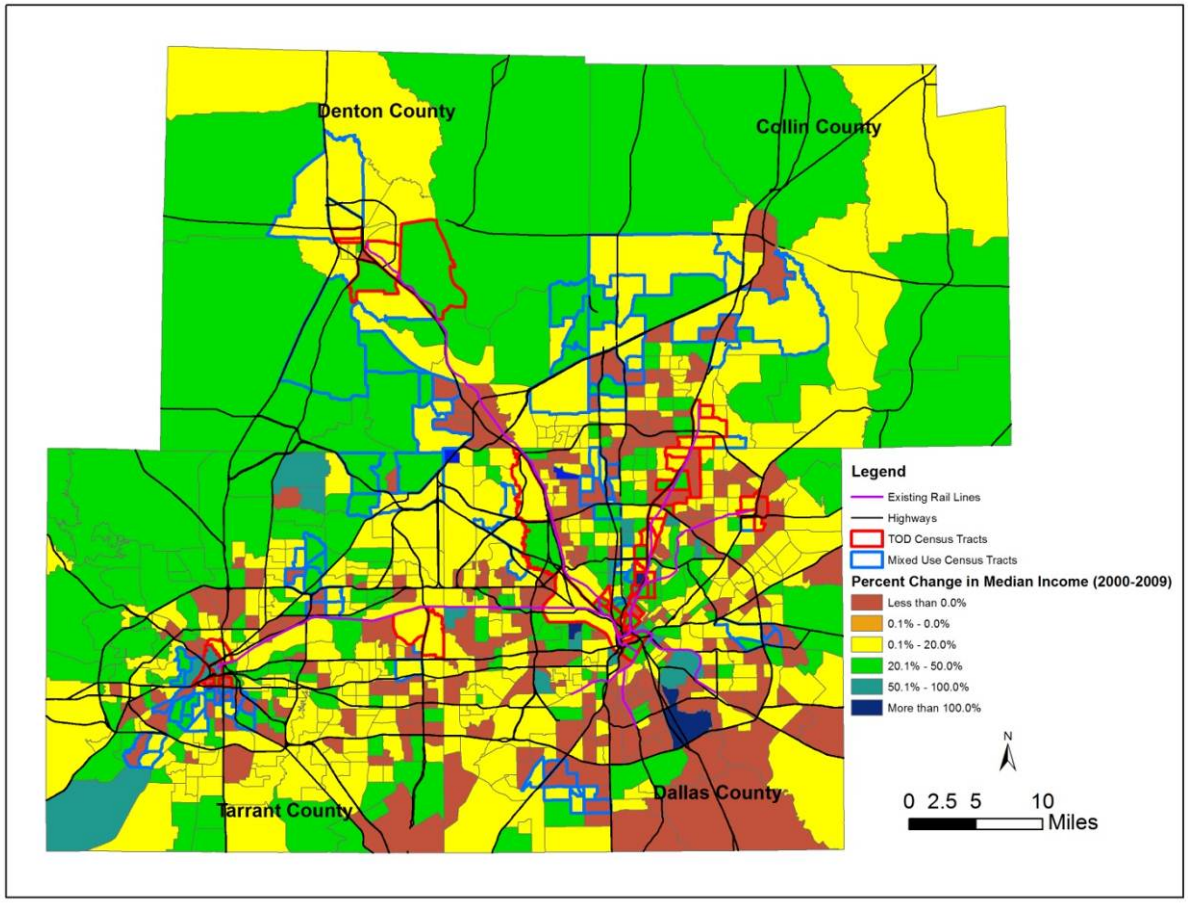
Map 4.12 Population Change in Minorities (2000-09)
Source: U.S Census and NCTCOG datasets



Map 4.13 Population Percentage Change in Minorities (2000-09)
Source: U.S Census and NCTCOG datasets



Map 4.14 Change in Median Household Income (2000-09)
Source: U.S Census and NCTCOG datasets



Map 4.15 Percent Change in Median Household Income (2000-09)
Source: U.S Census and NCTCOG datasets

CHAPTER 5

STATISTICAL TESTS - COMPARISON OF MEANS AND MEDIANS, AND LINEAR REGRESSION MODELS

This chapter describes statistical tests and models to compare the significance of differences by development of census tracts and linear regression models for each research question, the dependent and independent variables and estimates the significance of the explanatory variables contributing to the variation in the dependent variables.

5.1. Statistical Tests for Research Question 1

Research Question 1 - Does the percentage change in median housing value (2000-2009) in MUCs and TODs different from the rest of the region and what are the significant factors effecting the percentage change in Median Housing Value? The following sections provide the results of Kruskal Wallis Test and regression analysis.

5.1.1. Kruskal Wallis Test – Research Question 1

The descriptive statistics in the previous chapter showed that there are differences among the increase in median housing values between single use, mixed use, and TOD census tracts. Kruskal Wallis test was conducted to test whether the difference among the median housing values (2000-2009) in single use, mixed use non-TOD, and TOD census tracts are statistically significant.

The null hypothesis is that there is no significant difference between the changes in median housing values (2000-2009) between the single use, mixed use, and TOD census tracts. Alternative hypothesis is the categories are significantly different from each other.

Ho: $M_{SU} = M_{MU} = M_{TOD}$ (where μx represents median housing value of each type of development of census tract, SU-Single Use, MU-Mixed Use, TOD-Transit Oriented Development

Ha: $M_{SU} \neq M_{MU} \neq M_{TOD}$

Where: Ho is the null hypothesis

Ha is the alternative hypothesis

The observations are changes in median housing values by census tract. Geographic Information Systems software was used to randomly select 30 census tracts out of single use and mixed use census tracts to test this hypothesis. The analysis resulted in Kruskal Wallis chi-square value of 55.4 is less than the critical value of 4.83 and p value of 0.00 which is significant at 0.01 level. The null hypothesis can be rejected and there are significant differences in the changes in housing values between single use, mixed use, and TOD census tracts between 2000 and 2009. Table 5.1 shows Kruskal Wallis Test results for Research Question 1.

Table 5.1 Kruskal Wallis Test Results for Research Question 1

Source	d.f.	Kruskal Wallis chi-square	p-value
Devtype	2	55.4	0.00

5.1.2. Regression and Variables - Research Question 1

Does the percentage change in median housing value (2000-2009) in MUCs and TODs different from the rest of the region and what are the significant factors effecting the percentage change in Median Housing Value?

The following groups of independent variables will be used to examine and analyze the research question 1:

Percent Change in Median Housing Value (2000-2009) = *f* (Land Use Variables, Location Variables, Transportation Access Variables, Development Variable)

Dependent Variable: The abbreviations of the variable are provided in parenthesis after the variable name. The dependent variable for the regression equation 1 is the percentage change in Median Housing Value between 2000 and 2009 (Pchmval), which is an indicator of property values, housing, and land prices. The percentage change is the difference in Median Housing Value from the initial year to the end year all divided by the Median Housing Value in the initial year (i.e.: (Median Housing Value $_{2009}$ - Median Housing Value $_{2000}$)/ Median Housing Value $_{2000}$), The median housing value at census tract level was obtained from the U.S. Census data from 2000 and 2009. The unit of study is census tract.

Independent Variables: The abbreviations of the variables are provided in parenthesis after each variable name. The following independent variables were used in the regression analysis to determine the variation in median housing value that will be examined for this research question:

Land Use Variable:

- Percentage of residential (PResi)
- Percentage of office (POffc)
- Percentage of Retail (PRet)

Location Variables:

- Distance from Center of Downtown (Distdntwn)
- Distance from the nearest park (Distpark)
- Number of educational institutions per square mile (Edsqm)
- Number of major employers per square mile (Empsqm)

Transportation Access Variable:

- Distance from nearest Highway (Disthwy)

Development Variable: Two Dummy Variables (MUdummy and TODdummy) will be used for the three types of development types of census tracts, Single Use Census Tracts, Mixed

Use Census Tracts, and TOD Census Tracts. Table 5.2 shows the assignment of values for the Dummy Variables.

Table 5.2 Two Development Type Dummy Variables

	MU Dummy (MUdummy)	TOD Dummy (TODdummy)
Single Use Census Tract	0	0
Mixed Use Census Tract	1	0
TOD Census Tract	0	1

The null hypothesis is that the percentage change in median housing value (2000-2009) does not have a significant relationship to changes in Land Use, Location, Transportation Access, and Development variables.

H_0: $\beta = 0$

H_a: $\beta \neq 0$

5.1.2.1. Pearson Correlation - Multicollinearity Test

Table 5.3, shows Pearson correlations for the variables used in the analysis for Research Question 1. The results were analyzed for the possibility of multicollinearity. The correlation between dependent and independent variables was more than the correlation between two independent variables. So, the correlations did not flag multicollinearity problem.

High positive correlations were noted between dependent variable the percentage change in Median Housing Value (2000-2009), with the number of educational institutions per square mile (0.798), and the number of major employers per square mile (0.791). These correlations indicate that housing values increase by the proximity to schools and major employers. Moderate correlations were noted between the percentage change in Median Housing Value (2000-2009), with the percentage of residential (0.612), the percentage of retail (0.600), and the distance to downtown (0.597). These correlations indicate that housing values increased more in the neighborhoods away from downtown locations and residential neighborhoods with mix of retail.

Table 5.3 Pearson Correlations

		PResi	POffc	PRet	Distdntwn	Distpark	Edsqm	Empsqm	Disthwy	MUdummy	TODdummy	Pchmval
PResi	Pearson Correlation	1										
	Sig. (2-tailed)											
POffc	Pearson Correlation	-.075(*)										
	Sig. (2-tailed)	.034										
PRet	Pearson Correlation	-.089(**)	.153(**)									
	Sig. (2-tailed)	.000	.000									
Distdntwn	Pearson Correlation	-.307(**)	.004	.264(**)								
	Sig. (2-tailed)	.000	.910	.000								
Distpark	Pearson Correlation	.579(**)	-.280(**)	-.228(**)	-.318(**)							
	Sig. (2-tailed)	.000	.000	.000	.000							
Edsqm	Pearson Correlation	.539(**)	-.086(*)	-.220(**)	-.324(**)	.431(**)						
	Sig. (2-tailed)	.000	.015	.000	.000	.000						
Empsqm	Pearson Correlation	-.494(**)	.475(**)	.520(**)	.566(**)	-.342(**)	.509(**)					
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000					
Disthwy	Pearson Correlation	.318(**)	.302	.435(**)	.520(**)	.219(**)	.451(**)	.323(**)				
	Sig. (2-tailed)	.000	.954	.000	.000	.001	.000	.000				
MUdummy	Pearson Correlation	-.543(**)	.117(**)	.214(**)	.531(**)	-.251(**)	-.254(**)	.440(**)	.310(**)			
	Sig. (2-tailed)	.000	.001	.002	.000	.000	.003	.000	.000			
TODdummy	Pearson Correlation	-.296(**)	.392(**)	.400(**)	.152(**)	-.293(**)	-.211(**)	.500(**)	.282(*)	.476(**)		
	Sig. (2-tailed)	.000	.010	.001	.000	.000	.000	.004	.020	.000		
Pchmval	Pearson Correlation	.612(**)	.547(**)	.600(**)	.590(**)	-.547(**)	.798(**)	.791(**)	.401(**)	-.532(**)	.478(**)	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	

*Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed).

5.1.2.2. Linear Regression Model – Regression Equation 1

A Linear Regression model was run on Statistical Program for Social Sciences (SPSS) software and the model was built through multiple iterations by adding significant variables from literature and adding additional variables to evaluate the model output. Various theories and empirical studies supported Location Variables as the significant independent variables to determine the changes in median housing values. As described in Chapter 2.2, the theories and studies supporting location variables include Mono-Centric City Model, Ricardo Von Thunen's model, Central Place theory-Christaller (1966), Berry (1967), Marshall (1890), Bid-Rent theory by Alonso (1964), Muth (1969), and Mills and Hamilton (1994). Location Variables such as distance to downtown, distance to park, number of schools per square mile, number of employers per square mile were included in the model initially. Land use and Development variables were added at a later step because various studies such as Mills (1979), Crecine, Davis, and Jackson (1967), Kahn & Case (1977), Hosch & Koehlinger (1997), and Crafts (1998) supported the significance of those variables. Land Use and Development Variables included are percentage of residential, percentage of office, and percentage of retail, and MU and TOD Dummy Variables. Transportation Access Variable, distance to highway was added as a final step. The literature that supported transportation access included Boarnet (1998), Boarnet and Chalermpong (2001), Voith (1993), Cervero and Landis (1997), Gatzlaff and Smith (1993), Rodriguez and Targa (2004), Estupinan and Rodriguez (2008), Du and Mulley (2006), and Zhou and Kockelman (2008).

Table 5.4 shows the descriptive statistics of the variables used in the model. The average of percentage change in median housing value is 18.4 percent. The average percentage of residential is 33.6 percent, average percentage of office is 3.1 percent, and average percent of retail is 4.9 percent. The average distance from centroid of census tracts to downtown is 2.3 miles, distance to park is 0.4 miles, and distance to highway is 0.9 miles.

Table 5.5 shows Model Summary for the final model run. The coefficient of determination, R^2 is the percent of the variation in the dependent variable is explained uniquely or jointly by the independent variables. R^2 value increased from 0.625 to 0.844 in the final model. This means that 84.4 percent of the variation in the dependent explained uniquely or jointly by the independent variables. Adjusted R^2 adjusts the values of R^2 to the independent variables. The Adjusted R^2 value was 0.843 in the final model.

Table 5.6 shows the Analysis of Variance (ANOVA) and the significance of the model. The model is significant at 0.05 level and 0.01 level or the model is significant at 95 percent and 99 percent levels. The analysis of variance shows that the significance associated with the F value is (0.000) and less than 0.05 and 0.01, which means that the group of independent variables does show a statistically significant relationship with the dependent variable. Therefore, the groups of independent variables reliably predict the variation in median housing value between the years 2000 and 2009.

Table 5.7 shows the coefficients and their corresponding significance values. By the addition of various independent variables in the model iterations it is observed that the added variables are significant and the addition of variables improved the significance in other variables. All the independent variables are significant at 0.05 level. Null Hypothesis can be rejected at 95 percent confidence level. The final model results following Regression Equation 1:

Pchmval = 0.035 + 0.796 PResi + 1.662 POffc + 1.343 PRet + 0.583 Distdntwn - 0.77 Distpark + 0.235 Edsqm + 0.324 Empsqm +0.36 Disthwy +1.33 MUdummy + 1.41 TODdummy

From the above equation, the following conclusions can be drawn: One percentage increase in office use will increase the median housing value by 1.662 percentage points, holding the other independent variables constant. One percentage increase in percentage of

retail use will increase Median Housing Value by 1.343 percentage points, holding the other independent variables constant. The presence of mixed use development in half mile radius will increase Median Housing Value by 1.32 percentage points, holding the other independent variables constant. The presence of TOD in half mile radius will increase Median Housing Value by 1.41 percentage points, holding the other independent variables constant. Similar conclusions can be drawn for the other independent variables keeping other independent variables constant.

Table 5.4 Descriptive Statistics – Regression Equation 1

	Mean	Std. Deviation	N
Pres	33.6	18.0	938.0
POffc	3.1	3.2	938.0
PRet	4.9	4.6	938.0
Distdntwn	2.3	1.3	938.0
Distpark	0.4	0.5	938.0
Edsqm	2.3	2.2	938.0
Empsqm	10.0	14.7	938.0
Disthwy	0.9	0.7	938.0
MUdummy	Dummy Variable		
TODdummy	Dummy Variable		
Pchmval	18.4%	32.8%	938.0

Table 5.5 Model Summary – Regression Equation 1

R	R Square	Adjusted R Square	Std. Error of the Estimate
.919	.844	.843	.0459446

Predictors: (Constant), PResi, POffc, PRet, Distdntwn, Distpark, Edsqm, Empsqm, Disthwy, MUdummy, TODdummy

Table 5.6 Analysis of Variance (ANOVA) – Regression Equation 1

	Sum of Squares	F	Sig.
Regression	9.017	610.263	.000
Residual	1.661		
Total	10.679		

Predictors: (Constant), PResi, POffc, PRet, Distdntwn, Distpark, Edsqm, Empsqm, Disthwy, MUdummy, TODdummy

Table 5.7 Coefficients and Significance - Regression Equation 1

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	Tolerance	VIF
(Constant)	0.035	0.024		1.472	0.141
Pres	0.796	0.036	0.412	22.215	0
POffc	1.662	0.034	0.623	35.656	0
PRet	1.343	0.022	0.723	32.143	0
Distdntwn	0.583	0.258	0.034	2.263	0.01
Distpark	-0.77	0.023	-0.454	-22.223	0
Edsqm	0.235	0.019	0.339	17.338	0
Empsqm	0.324	0	0.111	6.216	0
Disthwy	0.36	0.01	0.33	17.38	0
MUdummy	1.33	0.013	0.653	2.123	0
TODdummy	1.41	0.001	0.293	3.143	0

a Dependent Variable: *Pchmval*

5.2. Research Question 2-Income

Research Question 2-Income: Do persons living in housing in MUCs and TODs exhibit different income, race, and ethnic of characteristics than those in the rest of the study area?

Kruskal Wallis Test to compare medians and ANOVA test to compare means were conducted to test the significance of difference for each of the differences in median household income and percentage of minority variables between 2000 and 2009. The following sections 5.2.1 and 5.3.1 provides the details of the results.

5.2.1. Kruskal Wallis Test - Income Differences

The descriptive statistics in the previous chapter showed that there are differences among the increase in median household incomes between single use, mixed use, and TOD census tracts. Kruskal Wallis test was conducted to test whether the difference among the median household incomes (2000-2009) in single use, mixed use non-TOD, and TOD census tracts are statistically significant.

The null hypothesis is that there is no significant difference between the changes in median household incomes (2000-2009) between the single use, mixed use, and TOD census tracts. Alternative hypothesis is the categories are significantly different from each other.

Ho: $M_{SU} = M_{MU} = M_{TOD}$ (where μx represents the difference in median household incomes (2000-2009) of each type of development of census tract, SU-Single Use, MU-Mixed Use, TOD-Transit Oriented Development)

Ha: $M_{SU} \neq M_{MU} \neq M_{TOD}$

Where: Ho is the null hypothesis

Ha is the alternative hypothesis

The observations are changes in median housing values by census tract. Geographic Information Systems software was used to randomly select 30 census tracts out of single use and mixed use census tracts to test this hypothesis. The analysis resulted in Kruskal Wallis chi-square value of 122.6 is less than the critical value of 4.83 and p value of 0.00 which is significant at 0.01 level. The null hypothesis can be rejected and there are significant differences in the changes in median household incomes between single use, mixed use, and TOD census tracts between 2000 and 2009. Table 5.8 shows Kruskal Wallis Test results for Research Question 2.

Table 5.8 Kruskal Wallis Test Results for Research Question 2

Source	d.f.	Kruskal Wallis chi-square	p-value
Devtype	2	122.6	0.00

5.2.2. Regression and Variables – Research Question 2

Do persons living in housing in MUCs and TODs exhibit different income, race, and ethnic of characteristics than those in the rest of the study area?

The following groups of independent variables will be used to examine and analyze the research question 2:

Percentage Change in Median Income (2000-2009) = *f* (Demographic Variables, Location Variables, Transportation Access Variables, Development Variables, Housing Supply Variables)

The null hypothesis is that the percentage change in median household income (2000-2009) does not have a significant relationship to changes in Demographic, Location, Transportation Access, Development, and Housing Supply variables.

H_0: $\beta = 0$

H_a: $\beta \neq 0$

The following groups of independent variables will be used to examine and analyze the research question 3:

Percentage Change in Minorities (2000-2009) = *f* (Demographic Variables, (Location Variables, Transportation Access Variables, Development Variable, Housing Supply Variables)

The null hypothesis is that the percentage change in minorities (2000-2009) does not have a significant relationship to changes in Demographic, Location, Transportation Access, Development, and Housing Supply variables.

H_0: $\beta = 0$

H_a: $\beta \neq 0$

Dependent Variables: The percentage change in Median Income (Pchmhi) and the percentage change in Minorities (Pchmin) were used as depended variables in Regression Equations 2 and 3, to determine the relationship of income, race, and ethnicity due to the groups of independent variables. The dependent variables at census tract level will be obtained from the U.S. Census data from 2000 and 2009. The cases or observations were for each census tract. The above dataset is available at census tract level.

Independent Variables: Based on the literature review, existing racial composition of the area (preference to live with same race), existing income groups in the area (preference to live with same income class and affordability reasons), access to transportation, access to downtown and major employers, access to parks and trails, and supply factors such as housing costs and housing units are some of the significant factors contributing to income, race, and ethnic composition of communities. The following independent variables were examined to determine the variation in income, race, and ethnicities which will be examined for this research question:

Demographic variables:

- Percentage change in minorities included in Regression Equation 2
- Percentage change in Median Household Income (2000-2009) included in Regression Equation 3
- Percentage of population with at least Bachelor's Degree included in Regression Equations 2 and 3
- Percentage of population employed in professional and technical occupations included in Regression Equations 2 and 3

Location Variables:

- Distance from Center of Downtown (Distdntwn)
- Distance from the nearest park (Distpark)
- Number of educational institutions per square mile (Edsqm)
- Number of major employers per square mile (Empsqm)

Transportation Access Variable:

- Distance from nearest Highway (Disthwy)

Development Variable:

Two Dummy Variables will be used for the three types of development types of census tracts, Single Use Census Tracts, Mixed Use Census Tracts, and TOD Census Tracts. The

two Dummy Variables will be Mixed Use Dummy Variable (MUdummy) and TOD Dummy Variable (TODdummy). Table 5.9 shows the assignment of values for the Dummy Variables.

Table 5.9 Development Type Dummy Variables

	MU Dummy (MUdummy)	TOD Dummy (TODdummy)
Single-Use Census Tract	0	0
Mixed Use Census Tract	1	0
TOD Census Tract	0	1

Housing Supply Variables:

- Percentage Change in Median housing value 2009 (Perchmhv)
- Percentage Change in Median Contract Rent 2009 (Perchmcr)
- Number of existing multifamily units (Mf)

5.2.3. Research Question 2-Income

Percentage Change in Median Income (2000-2009) = *f* (Demographic Variables, Location Variables, Transportation Access Variables, Development Variables, Housing Supply Variables)

The following section provides the results of the correlation and regression analysis for Regression Equation 2.

5.2.3.1. Pearson Correlation

Multicollinearity Test: Pearson correlations were analyzed for the possibility of multicollinearity for the variables in Research Question 2. The correlation between dependent and independent variables was more than the correlation between two independent variables. The correlations between percentage change in Pchmhv and Pchmcrent was higher than the correlation of Pchmcrent with the Dependent Variable, Perchmhi. Pchmcrent was removed from the analysis to avoid multicollinearity. The rest of the correlations did not flag multicollinearity problem. Table 5.10 shows Pearson correlations for the variables in Research Question 2.

5.2.3.2. Linear Regression Model - Regression Equation 2

A Linear Regression model was run on Statistical Program for Social Sciences (SPSS) software and the model was built through multiple iterations by adding significant variables from literature and adding additional variables to evaluate the model output. According to Tiebout (1956) meeting the needs of housing (values, rents, supply of desired type of housing, access to employment), community (similar racial and income groups), and local public services (transportation access, schools, parks, etc.) determine the changes in income levels and demographics of a community. Housing Supply Variables such as percentage change in median housing value, median contract rent, and Location Variables such as distance to downtown, distance to park, and the number of employers per square mile were included in the model initially as independent variables to determine the changes in median household income. Other theories and empirical studies indicate socio-economic variables as the determining factors for changes in income levels in a community, and variables such as percentage change in minorities, percentage of population with Bachelor's Degree, and percentage of population with professional occupations were added to the model. The literature that supported socio-economic variables as significant independent variables included Massey and Denton (1993), Galster (1988), Schill and Wachter (1995), Galster and Godfrey (2005), Hammell and Wyly (1996), and Jeffrey Lin (2002).

Table 5.11 shows the descriptive statistics of the variables used in the model. The average of percentage change in median household income is 14.1 percent. The average percentage of persons with Bachelor's Degree is 37.4 percent, average percentage change in minorities is 38.1 percent, and average percent of persons with professional education is 40.2 percent. The average distance from centroid of census tracts to downtown is 2.3 miles, distance to park is 0.4 miles, and distance to highway is 0.9 miles.

Table 5.12 shows Model Summary for the final model run. The coefficient of determination, R^2, is the percent of the variation in the dependent explained uniquely or jointly

by the independent variables. R^2 value increased from 0.677 to 0.8423 in the final model with the removal of independent variables such as Mf and Pchmcrent. This means that 84.2 percent of the variation in the dependent explained uniquely or jointly by the independent variables. Adjusted R^2 adjusts the values of R^2 to the independent variables. The Adjusted R^2 value was 0.841 in the final model.

Table 5.10 Pearson Correlations

		Pchmin	Pbach	Pofc	Distdntwn	Distpark	Pchmval	Empsqm	Disthwy	MUdummy	TODdummy	Pchmhi
Pchmin	Pearson Correlation	1										
	Sig. (2-tailed)											
Pbach	Pearson Correlation	-.066(*)										
	Sig. (2-tailed)	.022										
Pofc	Pearson Correlation	-.089(**)	.153(**)									
	Sig. (2-tailed)	.000	.000									
Distdntwn	Pearson Correlation	.234(**)	.003	.132(**)								
	Sig. (2-tailed)	.000	.910	.000								
Distpark	Pearson Correlation	.579(**)	.280(**)	-.228(**)	-.318(**)							
	Sig. (2-tailed)	.000	.001	.000	.000							
Pchmval	Pearson Correlation	-.539(**)	.086(*)	.220(**)	.324(**)	-.431(**)						
	Sig. (2-tailed)	.001	.013	.000	.000	.000						
Empsqm	Pearson Correlation	.494(**)	.475(**)	.520(**)	-.566(**)	.342(**)	.509(**)					
	Sig. (2-tailed)	.000	.000	.002	.000	.001	.000					
Disthwy	Pearson Correlation	-.318(**)	.302	-.435(**)	-.520(**)	.219(**)	.451(**)	-.323(**)				
	Sig. (2-tailed)	.000	.954	.000	.000	.001	.000	.000				
MUdummy	Pearson Correlation	.543(**)	.117(**)	.214(**)	.531(**)	-.251(**)	.254(**)	.240(**)	.310(**)			
	Sig. (2-tailed)	.000	.001	.001	.000	.003	.002	.000	.000			
TODdummy	Pearson Correlation	.296(**)	.392(**)	.410(**)	.352(**)	-.293(**)	.221(**)	.300(**)	.282(*)	.456(**)		
	Sig. (2-tailed)	.000	.000	.000	.000	.004	.000	.003	.030	.000		
Pchmhi	Pearson Correlation	-.598(**)	.583(**)	.610(**)	.588(**)	-.501(**)	.733(**)	.641(**)	.443(**)	-.514(**)	.501(**)	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed).

Table 5.13 shows the Analysis of Variance (ANOVA) and the significance of the model. The model is significant at 0.05 level and 0.01 level or the model is significant at 95 percent and 99 percent levels. The analysis of variance shows that the significance associated with the F value is (0.000) and less than 0.05 and 0.01, which means that the group of independent variables does show a statistically significant relationship with the dependent variable. Therefore, the groups of independent variables reliably predict the variation in median household income between the years 2000 and 2009.

Table 5.14 shows the coefficients and their corresponding significance values. By the addition of various independent variables in the model iterations it is observed that the added variables are significant and the addition of variables improved the significance in other variables. All the independent variables are significant at 0.05 level. Null Hypothesis can be rejected at 95 percent confidence level.

The final model results following regression equation:

Pchmhi = 0.049 - 0.489 Pchmin + 1.445 Pbach + 1.342 Pprofoc + 0.32 Distdntwn - 0.228 Distpark + 0.332 Pchmval + 0.521 Empsqm +0.36 Disthwy + 1.411 MUdummy +1.201 TODdummy

From the above equation, the following conclusions can be drawn: One percentage increase in the percentage change in minorities will increase the median household income by 0.489 percentage points, holding the other independent variables constant. One percentage increase in percentage of population with Bachelor's Degree will increase Median Household Income by 1.445 percentage points, holding the other independent variables constant. The Median Household Income within half mile radius mixed use development will increase Median Housing Value by 1.411 percentage points, holding the other independent variables constant. The presence of TOD in half mile radius will increase Median Household Income by 1.201

percentage points, holding the other independent variables constant. Similar conclusions can be drawn for the other independent variables keeping other independent variables constant.

Table 5.11 Descriptive Statistics – Regression Equation 2

	Mean	Std. Deviation	N
Pchmin	38.1%	28.3%	938
Pbach	37.4%	21.1%	938
Pprofoc	40.2%	17.6%	938
Distdntwn	2.3	1.3	938
Distpark	0.4	0.5	938
Pchmval	18.4%	32.8%	938.0
Empsqm	10.0	14.7	938
Disthwy	0.9	0.7	938
MUdummy	Dummy Variable		
TODdummy	Dummy Variable		
Pchmhi	14.1%	42.8%	938

Table 5.12 Model Summary – Regression Equation 2

R	R Square	Adjusted R Square	Std. Error of the Estimate
.918	.842	.841	.0462306

Predictors: (Constant), Pchmin, Pbach, Pprofoc, Distdntwn, Distpark, Pchmval, Empsqm, Disthwy, MUdummy, TODdummy, Pchmhi

Table 5.13 Analysis of Variance (ANOVA) – Regression Equation 2

	Sum of Squares	F	Sig.
Regression	9.007	707.421	.000
Residual	1.672		
Total	10.679		

Predictors: (Constant), Pchmin, Pbach, Pprofoc, Distdntwn, Distpark, Pchmval, Empsqm, Disthwy, MUdummy, TODdummy, Pchmhi

Table 5.14 Coefficients and Significance - Regression Equation 2

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	Tolerance	VIF
(Constant)	0.049	0.023		1.472	0.175
Pchmin	-0.489	0.036	-0.409	-22.215	0.002
Pbach	1.445	0.045	0.646	35.656	0
Pprofoc	1.342	0.045	0.545	32.143	0

Table 5.14 – *Continued*

Distdntwn	0.32	0.022	0.454	2.263	0.001
Distpark	-0.228	0.012	-0.385	-22.223	0.004
Pchmval	0.322	0.019	0.336	17.338	0
Empsqm	0.521	0.011	0.109	6.216	0
Disthwy	0.36	0.041	0.066	17.38	0
MUdummy	1.411	0.031	0.533	20.1	0.001
TODdummy	1.201	0.027	0.486	32.2	0

a Dependent Variable: Pchmhi

5.3. Research Question 2 – Race and Ethnicity

Research Question 2 – Race and Ethnicity: Do persons living in housing in MUCs and TODs exhibit different income, race, and ethnic of characteristics than those in the rest of the study area? Two ANOVA tests were conducted to test the significance of difference for each of the income and minority variables between 2000 and 2009. The sections 5.2.1 and 5.3.1 provides the details of the results.

5.3.1. ANOVA - Race and Ethnicity Differences

The descriptive statistics in the previous chapter showed that there are differences among the changes in the percentage of minorities between single use, mixed use, and TOD census tracts. The Analysis of Variance (ANOVA) test was conducted to test whether the difference among the percentage of minorities (2000-2009) in single use, mixed use non-TOD, and TOD census tracts are statistically significant.

The null hypothesis is that there is no significant difference between the changes in the percentage of minorities (2000-2009) between the single use, mixed use, and TOD census tracts. Alternative hypothesis is the categories are significantly different from each other.

Ho: $\mu_{SU} = \mu_{MU} = \mu_{TOD}$ (where μx represents the difference in the percentage of minorities (2000-2009) of each type of development of census tract, SU-Single Use, MU-Mixed Use, TOD-Transit Oriented Development)

Ha: $\mu_{SU} \neq \mu_{MU} \neq \mu_{TOD}$

Where: Ho is the null hypothesis

Ha is the alternative hypothesis

The observations are the difference in the percentage of minorities by census tract between 2000 and 2009. Geographic Information Systems software was used to randomly select 30 census tracts out of single use and mixed use census tracts to test this hypothesis. The analysis resulted in F ratio of 52.1 with (2, 97) degrees of freedom which is less than the critical value of 4.83 and p value of 0.00 which is significant at 0.01 level. The null hypothesis can be rejected and there are significant differences in the changes in household incomes between single use, mixed use, and TOD census tracts between 2000 and 2009. Table 5.15 shows the ANOVA results.

Table 5.15 ANOVA Results for Research Question 2 (Race/Ethnicity)

Source	d.f.	Sum of Squares	Mean Square	F-ratio	Sig.
Between	2	1.54E+03	7.68E+02		
Within	97	1.64E+03	1.69E+01		
Total	99	3.25E+03		52.1	0.00

Research Question 2 - Minorities: The following groups of independent variables will be used to examine and analyze the research question 2 related to change in minorities:

Percentage Change in Minorities (2000-2009) = *f* (Demographic Variables, Location Variables, Transportation Access Variables, Development Variables, Housing Supply Variables)

The following section provides the results of the correlation and regression analysis for Regression Equation 3.

5.3.2. Pearson Correlation - Multicollinearity Test

Pearson correlations were analyzed for the possibility of multicollinearity for the variables in Research Question 3. The correlation between dependent and independent variables was more than the correlation between two independent variables. The correlations between percentage change in Pchmcrent and Distdntwn was higher than the correlation of Pchmcrent with the Dependent Variable, Perchmin. Pchmcrent was removed from the analysis to avoid multicollinearity. The rest of the correlations did not flag multicollinearity problem. Table 5.16 shows Pearson Correlation Coefficients for this Research Question.

5.3.3. Linear Regression Model – Regression Equation 3

A Linear Regression model was run on Statistical Program for Social Sciences (SPSS) software and the model was built through multiple iterations by adding significant variables from literature and adding additional variables to evaluate the model output. According to Tiebout (1956) meeting the needs of housing (values, rents, supply of desired type of housing, access to employment), community (similar racial and income groups), and local public services (transportation access, schools, parks, etc.) determine the changes in race and ethnic composition and demographics of a community. Housing Supply Variables such as percentage change in median housing value and Location Variables such as distance to downtown and the number of employers per square mile were included in the model initially as independent variables to determine the percentage change of minorities.

Other theories and empirical studies indicate socio-economic variables as the determining factors for changes in race and ethnic composition of a community, and variables such as percentage change in median household income, percentage of population with Bachelor's Degree, and percentage of population with professional occupations were added to the model. The literature that supported socio-economic variables as significant independent variables included Massey and Denton (1993), Galster (1988), Schill and Wachter (1995), Galster and Godfrey (2005), Hammell and Wyly (1996), and Jeffrey Lin (2002).

Table 5.17 shows the descriptive statistics of the variables used in the model. The average of percentage change in minorities is 38.1 percent. The average percentage of persons with Bachelor's Degree is 37.4 percent, average percentage change in median household income is 14.1 percent, and average percent of persons with professional education is 40.2 percent. The average distance from centroid of census tracts to downtown is 2.3 miles, and distance to highway is 0.9 miles.

Table 5.18 shows Model Summary for the final model run. The coefficient of determination, R^2, is the percent of the variation in the dependent explained uniquely or jointly by the independent variables. R^2 value increased from 0.632 to 0.833 in the final model with the removal of variables such as Percent Multifamily units (Mf) and Distance to Park (Distpark), and Percentage change in Median contract rent (Pchmcrent). This means that 83.3 percent of the variation in the dependent explained uniquely or jointly by the independent variables. Adjusted R^2 adjusts the values of R^2 to the independent variables. The Adjusted R^2 value was 0.832 in the final model.

Table 5.19 shows the Analysis of Variance (ANOVA) and the significance of the model. The model is significant at 0.05 level and 0.01 level or the model is significant at 95 percent and 99 percent levels. The analysis of variance shows that the significance associated with the F value is (0.000) and less than 0.05 and 0.01, which means that the group of independent variables does show a statistically significant relationship with the dependent variable. Therefore, the groups of independent variables reliably predict the variation in median household income between the years 2000 and 2009.

Table 5.16 Pearson Correlations

		Pchmin	Pbach	Pofc	Distdntwn	Pchmval	Empsqm	Disthwy	MUdummy	TODdummy	Pchmhi
Pchmin	Pearson Correlation	1									
	Sig. (2-tailed)										
Pbach	Pearson Correlation	-.066(*)									
	Sig. (2-tailed)	.022									
Pofc	Pearson Correlation	-.089(**)	.153(**)								
	Sig. (2-tailed)	.000	.000								
Distdntwn	Pearson Correlation	.234(**)	.003	.132(**)							
	Sig. (2-tailed)	.000	.910	.000							
Pchmval	Pearson Correlation	-.539(**)	.086(*)	.220(**)	.324(**)						
	Sig. (2-tailed)	.001	.013	.000	.000						
Empsqm	Pearson Correlation	.494(**)	.475(**)	.520(**)	-.566(**)	.509(**)					
	Sig. (2-tailed)	.000	.000	.002	.000	.000					
Disthwy	Pearson Correlation	-.318(**)	.302	-.435(**)	-.520(**)	.451(**)	-.323(**)				
	Sig. (2-tailed)	.000	.954	.000	.000	.000	.000				
MUdummy	Pearson Correlation	.543(**)	.117(**)	.214(**)	.531(**)	.254(**)	.240(**)	.310(**)			
	Sig. (2-tailed)	.000	.001	.001	.000	.002	.000	.000			
TODdummy	Pearson Correlation	.296(**)	.392(**)	.410(**)	.352(**)	.221(**)	.300(**)	.282(*)	.456(**)		
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.003	.030	.000		
Pchmhi	Pearson Correlation	-.598(**)	.583(**)	.610(**)	.588(**)	.733(**)	.641(**)	.443(**)	-.514(**)	.501(**)	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000	

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed).

Table 5.20 shows the coefficients and their corresponding significance values. By the addition of various independent variables in the model iterations it is observed that the added variables are significant and the addition of variables improved the significance in other variables. All the independent variables are significant at 0.05 level. Null Hypothesis can be rejected at 95 percent confidence level.

The final model results following regression equation:

Pchmin = -0.031 - 0.61 Pchmhi - 1.384 Pbach - 1. 2 Pprofoc + 0.26 Distdntwn - 0.287 Pchmval + 0.287 Empsqm -0.31 Disthwy +1.436 MUdummy +1.262 TODdummy

From the above equation, the following conclusions can be drawn: One percentage increase in the percentage change in median household income will decrease minorities by 0.61 percentage points, holding the other independent variables constant. One percentage increase in percentage of population with Bachelor's Degree will decrease the percentage change in Minorities by 1.384 percentage points, holding the other independent variables constant. The presence of a mixed use development within half mile radius will increase percentage change in Minorities by 1.436 percentage points, holding the other independent variables constant. The presence of TOD in half mile radius will increase percentage change in Minorities by 1.262 percentage points, holding the other independent variables constant. Similar conclusions can be drawn for the other independent variables keeping other independent variables constant.

Table 5.17 Descriptive Statistics – Regression Equation 3

	Mean	Std. Deviation	N
Pchmhi	14.1%	42.8%	938
Pbach	37.4%	21.1%	938
Pprofoc	40.2%	17.6%	938
Distdntwn	2.3	1.3	938
Pchmval	18.4%	32.8%	938.0
Empsqm	10.0	14.7	938
Disthwy	0.9	0.7	938
MUdummy	Dummy Variable		
TODdummy	Dummy Variable		
Pchmin	38.1%	28.3%	938.0

Table 5.18 Model Summary – Regression Equation 3

R	R Square	Adjusted R Square	Std. Error of the Estimate
.912	.833	.832	.0475467

Predictors: (Constant), Pchmhi, Pbach, Pprofoc, Distdntwn, Pchmval, Empsqm, Disthwy, MUdummy, TODdummy

Table 5.19 Analysis of Variance (ANOVA) – Regression Equation 3

	Sum of Squares	F	Sig.
Regression	8.891	1310.886	.000
Residual	1.788		
Total	10.679		

Predictors: (Constant), Pchmhi, Pbach, Pprofoc, Distdntwn, Pchmval, Empsqm, Disthwy, MUdummy, TODdummy

Table 5.20 Coefficients and Significance - Regression Equation 3

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	Tolerance	VIF
(Constant)	-0.031	0.003		-9.063	0
Pchmhi	-0.61	0.036	0.425	22.721	0
Pbach	-1.384	0.005	-0.543	-32.223	0
Pprofoc	-1.2	0.013	-0.652	-31.122	0

Table 5.20 – *Continued*

Distdntwn	0.26	0.024	0.551	21.266	0
Pchmval	-0.231	0.01	-0.39	-22.065	0
Empsqm	0.287	0.017	0.3	17.272	0
Disthwy	-0.031	0.003	-0.132	-9.063	0
MUdummy	1.436	0.022	0.325	23.431	0
TODdummy	1.262	0.004	0.243	21.223	0

a Dependent Variable: Pchmin

CHAPTER 6

FINDINGS, CONCLUSIONS, AND FUTURE RESEARCH

The current research study examined the changes in housing values (2000-2009) of MUCs and TODs in the four core counties (Dallas, Tarrant, Collin, and Denton) of the Dallas Fort Worth (DFW) region and its effects on income, race, ethnicity of persons living in housing in MUCs and TODs in the DFW region, compared to other parts of the region. The previous two chapters evaluated and tested the following two research questions:

> Research Question 1: Does the percentage change in median housing value (2000-2009) in MUCs and TODs different from the rest of the region and what are the significant factors effecting the percentage change in Median Housing Value?
>
> Research Question 2. Do persons living in housing in MUCs and TODs exhibit different income, race, and ethnic of characteristics than those in the rest of the four-county study area?

This study provided a comprehensive review of empirical structure on the changes in property values and changes in race and income groups. This research study provided a descriptive analysis of factors contributing to MUCs and TODs DFW metropolitan region, based on data obtained from NCTCOG and the U.S. Census. The analysis in Chapter 4 provides spatial analysis and descriptive statistics for MUCs and TODs in comparison to the four county study area. Chapter 5 included multiple regression models to interpret the variations in housing values, income groups, and minorities. The results of this study confirm some of the findings and significant variables identified in the literature review.

The datasets used in the analysis are most recent datasets and this is the first study that was conducted to examine demographic changes and housing values around MUCs and

TODs in the DFW metropolitan area. This chapter will provide a discussion of those variables found significant in the previous chapter. Their implications to sustainable development policies and programs will be discussed, in addition to a summary of major findings and conclusions.

6.1. Findings

6.1.1. Research Question 1

Does the percentage change in median housing value (2000-2009) in MUCs and TODs different from the rest of the region and what are the significant factors effecting the percentage change in Median Housing Value?

The descriptive analysis showed that the percentage change in Median Housing Value in Mixed Use and TOD Census Tracts were higher than other census tracts in the study area in 2000 and 2009. Median Housing Value in TOD Census Tracts increased by $67,027 or 49.9 percent between 2000 and 2009. Median Housing Value in Mixed Use Census Tracts increased by $60,652 or 40.3 percent and this increase in other census tracts was $39,749 or 37 percent.

Based on Regression Equation 1, the independent or explanatory variables that are statistically significant in effecting the percentage change in Median Housing Value are listed below and conclusions were derived from the analysis:

Land Use Variables:

- Percentage of residential (PResi): This variable has a positive effect on housing values indicating that areas with higher percentage of residential land use had higher housing values. The coefficient for this variable at 0.8 is lower than the percentage of office (1.7) and retail land uses (1.3).
- Percentage of office (POffc): Office land use had higher effect on housing values than residential or retail land uses. This indicates that there is higher demand for residential-office mixed use than residential and retail mixed use.
- Percentage of Retail (PRet): Retail land use had lower effect in increasing housing values than Office use but had higher effect in increasing housing values than

residential uses. This indicates that housing values in residential-retail mixed use developments increase at a higher rate than single-use residential neighborhoods.

Location Variables:

- Distance from Center of Downtown (Distdntwn): This variable had a positive effect in increasing housing values. The residential neighborhoods farther from central cities appreciated in value at a higher rate than those nearer to downtowns.
- Distance from the nearest park (Distpark): This variable had a negative effect in increasing housing values. This indicates that the residential neighborhoods accessible to parks appreciated in value at a higher rate than other housing in the study area.
- Number of educational institutions per square mile (Edsqm) and Number of major employers per square mile (Empsqm): These two variables had positive effect on housing values. Access to school locations and major employment locations significantly improved housing values.

Transportation Access Variables:

Distance from nearest Highway (Disthwy): The proximity to highways from the Centroid of the Census Tracts, measured through the road network, decreased housing value and the proximity to TODs increased housing value. This shows higher demand for transit oriented development than proximity to a highway in the region.

Development Variables:

Type of Development (MUdummy and TODdummy): The proximity to Mixed Use and TODs increases housing values than single use neighborhoods. Proximity to TODs increases housing values higher than mixed use neighborhoods.

6.1.2. Research Question 2

Do persons living in housing in MUCs and TODs exhibit different income, race, and ethnic of characteristics than those in the rest of the four-county study area?

The descriptive analysis showed that the percentage of minorities in Mixed Use Census Tracts was 13.5 percentage points lower, and the same figure in TODs is five percentage points lower, than all other census tracts in the study area. Mixed Use Centers experienced 64.4 percent increase in minorities between 2000 and 2009, compared to 15 percent in TOD census tracts, and 35 percent in all other census tracts.

Median Household Income in Mixed Use census tracts was approximately $15,000 higher than TOD Census Tracts and all other census tracts in the study area in 2009. Median household income increased at a higher rate in TODs as compared to Mixed Use and all other types of census tracts between 2000 and 2009. The percentage increase in Median Household Income was 6.8 percentage points higher in TOD Census Tracts and 3.3 percentage points higher in Mixed Use Census Tracts as compared to all other census tracts in the study area.

Based on the regression analysis, the independent or explanatory variables that are statistically significant in affecting the percentage change in Median Housing Value are listed below and the following conclusions were derived:

Demographic variables:

- Percentage change in minorities and Percentage change in Median Household Income:

  The percentage change in minorities had a negative effect on household income levels. The areas with higher percentage of minorities had lower percentages of increases in income between 2000 and 2009.

- Percentage of population with at least Bachelor's Degree: This variable has a positive effect on income and negative effect on the percentage change in minorities. This indicates that areas with higher persons having a Bachelor's degree had higher increases in housing values and those areas had lower percentage of minorities.

- Percentage of population employed in professional and technical occupations: This variable has a positive effect on income and negative effect on the percentage change

in minorities. This indicates that areas with higher persons working in a professional job had higher increases in housing values and those areas had lower percentage of minorities.

Location Variables:

- Distance from Center of Downtown (Distdntwn): This variable had a positive effect on both the percentage change in minorities and income. This indicates that the areas of higher growth of minorities and also neighborhoods with higher increases in household incomes are farther from downtown.
- Distance from the nearest park (Distpark): This variable does not have a significant effect on the percentage change in minorities but has negative effect on the changes in household income. This indicates that housing nearer to park locations appreciated higher in value.
- Number of major employers per square mile (Empsqm): This variable has positive effect on increase in minorities and increase in household income, which shows access to employment centers promotes income and increase of minority populations.

Transportation Access Variables:

- Distance from nearest Highway (Disthwy): This variable has positive effect on changes in incomes and negative effect on minorities. This indicates that higher income populations preferred to locate away from highways and minority populations preferred to locate nearer to highways.

Development Variable:

Type of Development (MUdummy and TODdummy): These variables have positive effect on changes in minorities and changes in income. Income levels and minority percentages increased higher in mixed use locations than TOD or single use neighborhoods.

Housing Supply Factors

- Percentage Change in Median housing value 2009 (Perchmhv) and Percentage Change in Median Contract Rent 2009 (Perchmcr): The median housing value has positive effect on changes in income and negative effect on change in minorities. This indicates that housing values increased higher in the areas with higher income groups and decreased in the areas where minority percentages increased.

6.2. Implications to Sustainable Development Policies and Programs

This study identifies more fundamental questions about market demand for TOD, consumer choice, and equity issues related to income, race, and ethnicity. Dallas-Fort Worth Region is at an interesting position in terms of sustainable development. While the transit infrastructure to support TODs is in place, the auto-oriented infrastructure still dominates. As prices of commodities including oil and gas continue to rise, the cost benefit of transit becomes more apparent and the rent premiums of sustainable development become more deserved.

6.2.1. Housing Values and Affordability

The literature review, descriptive statistics, and statistical analysis support that housing values in the proximity of mixed use developments and TODs increased significantly compared to neighborhoods in conventional developments in the four county study area in the Dallas-Fort Worth region. The higher increases housing values and rents in MUCs and TODs indicate market preference and demand for these types of developments.

According to the Center for Neighborhood Technology's (CNT) Housing and Transportation Affordability Index, residents in the Dallas Region spent 57 percent of household income and residents in Fort Worth Region spent over 52 percent of household income, on housing and transportation expenses combined in 2000. Because most of the MUCs and TODs were developed in the last 10 years, along with economic downturn and relatively affordable housing market, housing values increased moderately in the immediate surroundings of these developments during the period. Once the housing market will be restored, the housing values

in these development and the surrounding neighborhoods can increase more rapidly, and may become unaffordable to working class households. Regional and local governments should continue to further policies and programs to promote MUCs and TODs in the region. Housing costs for land and structures can be significantly reduced through more compact growth patterns.

TODs can improve housing affordability by reducing combined household transportation expenditures. Regional and local governments can promote affordable and accessible mixed use housing and TODs through various developer incentives that promote development near transit stations in exchange for affordable units. Various incentives to promote affordable and equitable mixed use developments and TODs in exchange of affordable units include:

- Government funding to pre-construction activities such as plan, design, and landbanking
- Government funding to construct supporting public infrastructure amenities such as street construction with pedestrian amenities, plazas, landscaping, bicycle and pedestrian trails, and intersection improvements
- Changes in zoning codes to remove barriers and encourage compatible mix of uses
- Reduction of minimum parking requirements
- Density bonuses
- Property tax abatements
- Affordable housing tax credits
- Expedited review and permitting processes
- Fee waivers.

The above incentives can be utilized in exchange of a percentage of affordable units and a period of affordable rents within mixed use developments and TODs. Additional incentives can be provided to develop mixed use and TODs near major employer locations to reduce the number of work commute trips in the region. The increase in values of properties in the

proximity of mixed use developments and TODs provides increasing opportunities for land purchase, landbanking, and value capture for the local and regional government so that the increase in land values can be utilized for public improvements as developments occur in vacant parcels.

6.2.2. Mix of Uses

The higher increases in median housing value in the areas with residential-office mix shows the demand for live-work development opportunities in the study area. Since higher proportion of trips are home-work trips, employment opportunities near residential locations can reduce the number of vehicle miles traveled and improve air quality in the region. Also, accessibility variables, such as distance to parks, number of schools per square mile, number of major employers per square mile play an important role in the viability of integrated land uses in MUCs and TODs to create live, work, and play environments. Developer incentives outlined for affordable housing can also be used to promote mix of uses and higher density developments. Location-efficient mixed use housing and employer assisted housing near TODs and major employers can provide mix of uses to meet the demands of the market.

6.2.3. Income, Race, and Equity

The income levels in the proximity of mixed use developments and TODs also have increased significantly when compared to the overall changes in the four county area. The percentage of minorities around TODs did not increase as much as the mixed use or single use developments. Minorities and specifically Hispanic population increased rapidly near TODs and transit stations that tend to utilize public transit more than other groups. The efficient public transportation system connecting employment centers and other key destinations has a positive impact on the growth of TODs. Policies which aim to improve the public transit network through regional and comprehensive transportation policies and planning are essential in the DFW Metroplex and in the other regions in the U.S. Various policy tools and programs can be utilized

to encourage location choices of mix of income groups, family types, race, and ethnic groups to ensure social equity and fair housing choice in mixed use development and TODs such as:

- Survey research to identify demographics and travel behavior of residents of mixed use developments and TODs
- Analysis of Home Mortgage disclosure Act (HMDA) data to identify any disparities related to home loan approvals and denials in the areas containing mixed use developments and TODs
- Creation of fair housing and affordable housing policy for mixed use developments and TODs in the Dallas Fort Worth Region
- Location efficient mortgages and provide assistance with mortgages (loan guarentees, closing cost assistance) to encourage mixed income mixed use development and TODs
- Outreach and education of fair housing policies for the real estate professionals working with mixed use developments and TODs
- Other developer incentives as outlined under Housing Values and Affordability section to encourage affordable housing in mixed use developments and TODs

6.2.4. Transit Connection

Public transit system plays a key role in increasing housing values and rents in TODs. Policies to improve and expand the public transportation system in the region will also help to improve the viability of growth of MUCs and TODs. Transit ridership is a factor of both income and accessibility. Since a majority of mass transit trips are between home and work, accessibility is determined by housing and work locations, availability of connection, availability of parking facilities, fares, and schedules. Higher incomes provide more housing options to select the most affordable housing and accessible transit options. Lower income people have fewer affordable housing options as well as a greater need for mass transit due to the reduced costs to maintain a car. Thus, lower income populations have the highest likelihood to ride

transit and benefit from TOD living. The results of the study supported that the percentage of Hispanics in TODs increased at a higher rate in TODs than mixed use developments or other areas.

The greatest challenge for TOD in the DFW Region is and will be changing consumer preferences for transit and transit accessible areas. Several mixed use and TOD projects have laid the groundwork for such future development but more are needed. TOD policy must be designed to encourage long-term investment analysis and public policy support which will favor, both economically and politically, more mixed use developments and TODs.

6.3. Limitations of the Study

A key limitation of this research is that many of the MUC and TOD developments were complete in the last ten years. The projects may need additional time to mature and market their benefits and positive factors in the housing market within the DFW Metroplex and also for the people to experience the benefits of TODs as compared to single use neighborhoods. There is a need to replicate this study to assess the changes in housing values and rents after 10 more years.

A regionally accepted and current list of MUCs and TODs was not available at the time of performance of this study. The list of MUCs used in the study may not be a comprehensive list of MUCs in the study area, and was compiled based on the review of NCTCOG funded sustainable development projects and Development Monitoring database, and a list prepared by Vision North Texas Process for the purposes of this study. TODs were selected based on half mile distance from an existing rail station.

The effects of changes in housing values and rents may also be masked partially by the economic downturn and turmoil in the real estate market. There is a need to conduct further research after the economic climate comes back to its prior state. Also, further research could be conducted to assess the effects of changes in real estate market including variables such as

foreclosure rates, unemployment rates and other factors that take into account of the current economic climate.

Another limitation of the study is the use of census tract level data. A household survey conducted in MUCs and TODs and other control sites can capture the changes in housing values, rents, and race, ethnicity, and income of occupants more accurately. More research and performance measures should be conducted in this relatively young research area.

6.4. Recommendations for Future Research and Next Steps

With this research data to support the belief that people living in mixed use and TODs pay higher towards their housing costs than their neighbors in conventional developments, public officials and government regulators have the evidence needed to develop policies and programs to promote affordability of mixed use developments and TODs. Development of residential TODs based on an accurate assessment traffic impacts and housing market analysis should result in sustainable communities with increased transit ridership and affordable housing. To help realize the benefits of mixed use developments and TODs this research recommends the following next steps:

i. New public-private partnerships should be sought to develop and implement new research and guidance to develop equitable and affordable housing policies for mixed use developments and TOD-housing in the Dallas Fort Worth Region.

ii. Broadly distributing the results of the research can help to publicize the need for affordability and fair housing policies and programs related to mixed use and TOD housing in the Dallas Fort Worth region and other states in the U.S. The findings will also be shared with other researchers doing similar research in the U.S to provide the findings as a case study research and basis for policy development related to affordability and equity of sustainable development.

iii. This research performs analysis at census tract level and the research can improved if household level surveys can be performed to understand the population, race, income, and other characteristics and demographics of mixed use centers and TODs.

iv. The list of MUCs was prepared based on the review of NCTCOG funded sustainable development projects and Development Monitoring database, and a list prepared by Vision North Texas Process for the purposes of this study. The study may be repeated if a full list of MUCs will be prepared by NCTCOG.

v. There is very little research conducted on location decisions in mixed use developments and

TODs. As a starting point phone interviews of residential and commercial leasing agents and tenants in these development types to understand the role of transit, mix of uses, and TOD in location decisions.

vi. Research on the impact of design features (e.g., bicycle and pedestrian amenities, traffic calming, round-abouts, short blocks, street furniture) on housing values, location decisions of income and racial groups, family types. Intuitively design elements increase the attractiveness of developments and also increase pricing, which is a deterrent for demand. But there is very little data to show the impact of design on location decisions to live in a mixed use development or TOD and the types of design features that may have the greatest impact.

APPENDIX A

LIST OF MUCS AND TODS

List of Mixed Use Developments in DFW Region from the NCTCOG's Development Monitoring database and Vision North Texas Process

1 Addison (includes Addison Circle and Vitruvian Park)
2 Adriatica at Stonebriar
3 Alliance Town Center
4 Austin Ranch
5 Berry/Riverside
6 Berry/University
7 Bishop Arts District
8 Brick Row
9 Cedar Station/Southside
10 Centennial Park
11 Cityville at Carlisle
12 Craig Ranch
13 Dallas Design District TIF
14 Desoto Town Center
15 Downtown Arlington
16 Downtown Carrollton
17 Downtown Cedar Hill
18 Downtown Denton
19 Downtown Frisco
20 Downtown Garland
21 Downtown Grand Prairie
22 Downtown Irving
23 Downtown Lewisville
24 Downtown McKinney
25 Downtown Plano
26 Duncanville Townhomes
27 Eastside
28 Evans and Rosedale
29 Fair Park
30 Fairfield on Main Street Grapevine
31 Fairview
32 Firewheel Town Center
33 Fort Worth Avenue
34 Frisco Square
35 Galatyn Park
36 Garland TOD
37 Grapevine
38 Greenville Avenue
39 Hemphill/Berry
40 Home Town North Richland Hills
41 Keller Town Center
42 Las Colinas
43 Legacy Town Center
44 Magnolia Village

45 Mesquite Peachtree Town Center
46 Mockingbird Station
47 Northwest Corridor
48 Oak Lawn
49 Old Town Plaza Lewisville
50 One Arts Plaza
51 Park Lane Place
53 Plano Transit Village
54 Polytechnic/Wesleyan
55 Prestonwood
56 Razor Ranch Towncenter
57 Ridglea Village
58 Six Points
59 Southlake Town Square
60 Southwestern Medical District
61 The Harbor
62 Trinity Bluff
63 Trinity Mills Station
64 Unicorn Lake
65 Uptown Dallas
66 Uptown Village at Cedar Hill
67 Vickery Meadows
68 Victory Plaza
69 Village at Allen
70 Village at Camp Bowie
71 Village at Colleyville
72 Village on the Green
73 Watters Creek at Montgomery Farm
74 West Berry
75 West Rosedale
76 West Seventh Street
77 Woodall Rodgers MU

Note: The list above may not be a comprehensive list of MUCs in the study area, and was compiled based on the review of NCTCOG funded sustainable development projects , NCTCOG's Development Monitoring database, and a list prepared by Vision North Texas Process for the purposes of this study.

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BIOGRAPHICAL INFORMATION

Narasimha Pratap Mandapaka was born in India in 1978 where he finished his Bachelor's Degree in Architecture from Andhra University and graduated in the year 2000. Pratap also completed a Diploma in Fine Arts and Advanced Certification in Architectural Computer Aided Design and Drafting (CADD) by 2000. Pratap studied at the University of Texas at Arlington in the U.S., completed his Master's Degree in City and Regional Planning and Advanced Certification in Geographical Information Systems (GIS) in 2003, and started working on his PhD in Urban Planning and Public Policy. Pratap has been working as a professional planner since 2002 and has obtained Planning Certification, American Institute of Certified Planners (AICP). Pratap has worked in planning positions in both private and public sectors, in GIS, housing, community development, transportation, and sustainable development areas. Pratap (Patrick) is currently working as a Senior Transportation Planner at the North Central Texas Council of Governments (NCTCOG) in the sustainable development program area. Pratap will continue his work in city and regional planning and related research, in particular, in the sub-fields of sustainable development, housing, transportation, and the applications of analytical techniques and GIS in city and regional planning.