URBAN BUILT ENVIRONMENT AND TRAVEL BEHAVIOR: UNDERSTANDING GENDER AND SOCIO-ECONOMIC DISPARITIES IN ACCESSIBILITY AND MOBILITY OF URBAN TRANSPORTATION

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ABSTRACT

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Urban transportation studies have shown that the ease of accessing urban opportunities in a compact community, characterized with higher density, mixed land uses, and high connectivity, are extremely crucial for urban residents to lead full and active lives. While researchers have also increasingly recognized the differences in travel behavior based on gender and different socioeconomic and ethnic/racial composition, the realities confronted by lower-income, urban minorities, and particularly women, in neighborhoods experiencing disinvestment and decline have been overlooked in most studies. In this context, this study focuses on the Detroit region (SEMCOG), which is recognized as one of the most decentralized and racially segregated metropolitan areas in the U.S. Six neighborhoods in the Detroit region were selected based on socio-demographic and urban built environment characteristics; with two urban Detroit neighborhoods, communities experiencing extreme disinvestment and decline, being compared to four wealthy suburban neighborhoods.

This Ph.D. dissertation explores the linkage between specific urban built environment characteristics and individual travel behavior, in order to identify the neighborhood typologies defining neighborhood-level differences in travel patterns. The analysis also examines gender differences in travel behavior after controlling for urban built environment, socioeconomic and

demographic factors. Two main datasets were used for this dissertation: (1) built environment data from field surveys and inventories; and (2) individual or household travel data from a mail survey.

First, the results from the multivariate regression analysis, using 1,106 road network buffers (RNBs), confirmed the positive effects of RNBs that maintained a greater density, diverse land uses, highly connected road networks and more bus stops in promoting non-motorized travel while reducing motorized travel. Next, three neighborhood typologies—the higher density urban Detroit neighborhood group, the higher density suburban neighborhood group, and the lower density suburban neighborhood group—were defined for the within neighborhood analysis. In addition to the significant effects of income and personal vehicle access to a person's travel pattern that were revealed from the OLS regression analysis, the discriminant analysis differentiated urban Detroit neighborhoods by their lower socioeconomic characteristics, by poor neighborhood environment quality for pedestrian activities and by their pedestrian dominant travel patterns. Lastly, the results from the OLS regression and Analysis of Covariance showed that the traditional gender role was still reflected in women's daily travel in the Detroit region in that women traveled more frequently and longer distances for household responsibilities, and married women traveled to shop more frequently and longer distances than married men across all three neighborhood typologies. The findings also revealed travel burdens of the socially marginalized populations in terms of the extensive travel distances necessary to reach daily destination due to the decentralization of urban amenities in the Detroit region.

This thesis is dedicated to
My parent, Hyojong Lee and Okju Kang,
and
Ivan J. Ramirez and Emmanuel Ramirez-Lee

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

The quality of life of urban residents is inextricably linked with that of urban areas that offer amenities and associated opportunities, such as employment, education, retail, and personal and public services. It is not only the distribution of urban activities, but the ease of accessing these opportunities that is also extremely important for residents to lead full and active lives (Boarnet & Crane, 2001; Cervero & Kockelman, 1997; Ewing and Cervero, 2001; Frank, 2000; and Naess, 2006). According to many urban transportation researchers, it has been argued that a dense, mixed land use and highly connected urban area is more likely to encourage the use of more sustainable modes of transport, such as walking, cycling and public transit. These alternative forms of transportation also potentially contribute to maintaining people's healthier life-styles, encouraging regular participation in moderate physical activities, such as walking and biking (Frank, 2000, 2004; Frank et al., 2006; Handy, 1996, 2002, 2005; Saelens et al., 2003a; Sallis et al., 2004; and Vojnovic et al., 2006). In short, the argument is that residents living in a compact urban community—characterized by higher densities, mixed land uses and connected street networks—with an effective and robust transportation system, tend to be healthier than residents living in a sprawled suburban area with a singular vehicle travel mode, the private automobile.

In recent years, transportation researchers have been also increasingly interested in differences in travel behavior based on gender and different socio-economic and ethnic composition (Johnston-Anumonwo, 1992, 1997; McLafferty and Preston, 1997; and Wyly, 1996, 1998). Since people make their travel decisions depending on the location of, and distance to, various daily destinations, examining different sets of urban spatial opportunities is critical to understanding people's travel behavior. Suburbanization in the U.S.—along with its resulting built environment topology characterized by low densities, single-use zoning, and disconnected street networks—has created an automobile dependent urban transportation system. In addition, with unequally distributed urban amenities across U.S. metropolitan areas (including supermarkets and healthy restaurants options), various income, race and ethnicity, age and gender groups face different sets of choices for their travel destinations, which may produce distinctive travel behaviors with differential cost implications (temporal and/or monetary). Therefore, ensuring equitable accessibility and mobility is essential to allow all people to reach their economic, social, and recreational opportunities (Handy et al., 2005; Hanson and Hanson, 1981; Hanson and Johnston, 1985, Hanson, 1986, Johnston-Anumonwo, 1989, 1997; MacDonald, 1999; McLafferty and Preston, 1997; Rosenbloom, 1985, 2005; and Wyly, 1996, 1998, 1999).

However, socio-economic, ethnic, and gender dynamics of accessibility and mobility have not been explicitly understood. Longer distances between dispersing destinations (including jobs, stores and public services) in most U.S. urban areas aggravate the conditions of the disadvantaged, including women, minorities, and lower-income populations. For instance, women's travels have been greatly associated with their household responsibilities as the traditional caregiver. Driving their children to school and various recreational activities, taking care of their parents, and running errands means that they travel short distances, but many times on a daily basis. That is, women tend to travel shorter distances than men, but they make more trips than men over any given time period (Hanson, 1986; Hanson, 2010; and Turner and Neimeier, 1997).

In this context, women who live in a household with just one, or no car, struggle with their household responsibilities due to their constrained mobility (Hanson, 1986; Hanson, 2010; and

Turner and Neimeier, 1997). Particularly, low income, single mothers greatly suffer from constrained mobility considering their dual roles as house maker and breadwinner (Johnston-Anumonwo, 1989; and McLafferty and Preston, 1997). Nevertheless, despite the social and urban consequences of these gendered travel patterns, problems in women's travel and their urban opportunities have been marginalized in urban transportation research.

In order to understand gender and socio-economic disparities in accessibility and mobility of urban transportation, six neighborhoods in the Detroit region were selected based on socio-demographic and urban built environment characteristics. Here, the Detroit region refers to the Southeast Michigan Council of Governments (SEMCOG) and includes Macomb, Oakland, Wayne, St. Clair, Livingston, Washtenaw, and Monroe counties. The six neighborhood sites are located in the counties of Wayne (two urban Detroit neighborhoods), Washtenaw (one Ann Arbor neighborhood), and Oakland (three neighborhoods, one each in Birmingham, Bloomfield Hills, and West Bloomfield). The two urban Detroit neighborhoods were selected particularly for exploring individual travel behavior, and subsequent travel burdens, in communities experiencing extreme disinvestment and decline.

With the rapid consumption of open space, as much as 13 times faster than population growth in the area, the Detroit region has been recognized as one of the most decentralized metropolitan centers in the U.S. (Vojnovic 2006; Vojnovic et al., 2006; and Vojnovic and Darden, 2013b). In addition, the Detroit region has a deep history of racial segregation, a spatial separation of the white population in the region, living largely in the suburbs, isolated from the black population, living largely in the city (Darden et al., 1987).

The pattern of out-migration of whites into the Detroit suburbs has led to uneven economic growth throughout the region. As Detroit's auto industry relocated their production lines into suburban Detroit, the city of Detroit lost not only its population, but also economic opportunities, such as employment. The city of Detroit lost more than half of its population since the 1950s, when the population peaked at about 1.85 million with a population density of 13,249 people per square mile (1950). The current population is about 700,000 (713,777 in 2010, declining from 951,270 in 2000) with the population density of 5,170 people per square mile in 2010 (U.S. Bureau of Census, 2011) (see figures 1 to 4).

In contrast, Detroit's suburbs have been gaining population and capital investment. For example, in 2000, the per capita taxable assessment in Bloomfield Hills (located in Oakland county) was $165,794, while the per capita taxable assessment in the city of Detroit was $7,573 in 2000 (SEMCOG, 2003). Hence, the suburbanization of the population resulted in the decentralization of its tax base and a polarized fiscal capacity between the city and the wealthy suburbs, which, subsequently, impacted opportunities for social mobility, and particularly among the city's minority population.

Figure 1 Disinvestment and decline in the city of Detroit (A). Photographed by Jieun Lee (taken in 2010).

Figure 2 Disinvestment and decline in the city of Detroit (B). Photographed by Jieun Lee (taken in 2010).

Figure 3 Disinvestment and decline in the city of Detroit (C). Photographed by Jieun Lee (taken in 2010).

Figure 4 Disinvestment and decline in the city of Detroit (D). Photographed by Jieun Lee (taken in 2010).

1.1. Research Focus and Dissertation Structure

This Ph.D. dissertation will examine the difference in travel behavior between men and women within the context of differing urban built environment characteristics in the Detroit region in order to evaluate women's accessibility and mobility in urban space. As for the research objectives, this dissertation aims to understand the linkage between urban built environments and individual pedestrian travel behavior, to identify the neighborhood typology that defines neighborhood-level differences in travel patterns, and lastly to examine gender differences in travel behavior after controlling for urban built environment and socio-economic and demographic factors.

This study involves several corresponding research hypotheses. In urban neighborhoods characterized by higher-densities, mixed land uses, and high connectivity, people tend to utilize non-motorized modes of travel. Next, concerning trip generation, residents living in neighborhoods with greater income levels and automobile access tend to travel more frequently and longer distances by car. In addition, comparing neighborhoods with similar urban density and connectivity characteristics, residents living in neighborhoods with more diverse urban opportunities and safer pedestrian environments (e.g. perception of fear of walking) will have improved access to daily activities. Lastly, it is hypothesized that women's travels are more related to household responsibilities within the urban built environment. Within this context, in accessing daily destinations, lower-income, urban minority women tend to rely on walking and public transit more than other women's groups, such as wealthier women in suburban neighborhoods, due to lower access to a car among the lower-income Detroit women.

1.2. Research Objectives and Questions

In this dissertation, the research objectives are;

1) To understand the causal relationships of the urban built environment in promoting pedestrian trips and reducing automobile use

2) To identify the neighborhood typology that helps explain differences in travel behavior between urban and suburban neighborhoods

3) To examine gendered travel patterns and their relationship with urban built environment characteristics and socio-economic and demographic factors

Accordingly, I have developed several research questions corresponding to the research objectives;

1)-1. Do people utilize non-motorized travel modes such as walking and biking more in urban neighborhoods characterized by higher-densities, mixed land uses, and high connectivity?

1)-2. Do people reduce automobile travel in urban neighborhoods characterized by higher-densities, mixed land uses, and high connectivity?

2)-1. Which socio-economic and demographic factors significantly influence total trip generation?

2)-2. Which neighborhood group, among urban Detroit, higher-density suburban, and lower-density suburban neighborhoods, is differentiated against others in terms of socio-economic and demographic characteristics, travel patterns, and neighborhood quality for pedestrians?

3)-1. How do women travel differently from men within similar urban built environments?

3)-2. How are lower-income urban minority women's travels more disadvantaged than other women's groups living in the suburban Detroit neighborhoods?

Two main datasets were used for this dissertation; (1) built environment data from field surveys and inventories in the six Detroit region neighborhoods; and (2) individual or household travel data from a mail survey. Both datasets were collected as a part of National Science Foundation funded study project (HSD Award # 0624263) that was active between the years 2007 and 2010.

For this PhD dissertation, first I identify the significant associations between various built environment factors, including urban density, land use mix, street connectivity, bus stops and individual travel behavior, both non-motorized and motorized. Multivariate regression analysis was used to explore travel behavior among the entire data sample (n=1,106) without neighborhood groupings. Next, the differences in the three neighborhood groupings—higher density urban Detroit neighborhoods, higher density suburban neighborhoods and lower density suburban neighborhoods—were examined within the context of different socio-economic and demographic characteristics, neighborhood quality (perception of fear) and travel patterns. Multivariate regression analysis and discriminant analysis, as well as descriptive analysis, were used to illustrate the differences in travel.

Lastly, the study explored different travel patterns, and resulting costs, among women themselves based on the neighborhood typology, after controlling for socio-economic and demographic factors. For each neighborhood grouping—higher density urban Detroit neighborhoods, higher density suburban neighborhoods, and lower density suburban neighborhoods—a set of multivariate regression analyses were used to analyze travel behavior. In the analysis, I focused on travel mode, travel distance, and travel frequency for the various daily activities. The data set enabled the analysis into the distinctive pattern of women's travels from the array of trips, both work and nonwork. Also, the analysis explored the unique burdens confronted by lower-income minority women in their daily travel activities.

I divided my dissertation into six chapters. Chapter 1 is the introduction to the dissertation. Chapter 2 presents a background review of the travel behavior literature pertinent to this study, along with a review of the study region, the Detroit region (Michigan). The chapter includes a general introduction into travel demand analysis and its evolution, an overview of the literature on urban built environment characteristics and individual travel behavior, an assessment of gendered urban transportation mobility literature and a review of the existing work on urban form, pedestrian travel behavior, and obesity.

Chapter 3 examines the association between urban built environment factors and individual travel behavior across the Detroit region neighborhoods. Pedestrian and automobile trips are explained in relation to urban density, land use mix, street connectivity and bus stop density. In addition, the relative effects of urban built environment characteristics are tested for promoting pedestrian trips and reducing automobile trips.

Chapter 4 identifies the neighborhood typology in terms of socio-economic and demographic characteristics, neighborhood quality and travel patterns. Discriminant analysis demonstrates the differences between three neighborhood groups in terms of socio-demographic factors, travel patterns, and fear of crime and traffic. Next, descriptive analysis of travel patterns explores the differences in travel patterns between neighborhood groupings, analyzing how built environment characteristics shape travel distance, travel frequency and mode of travel.

Chapter 5 explores gendered travel behavior and the social dynamics of women's travels. Multivariate OLS regression results examine gendered differences in travel frequency and travel distances for different types of travel activities, work and nonwork. Analysis of Covariance results, in turn, add another significant explanation to gendered travel behavior by incorporating marital status into the analysis. Exploring travel behavior within the differing neighborhood typologies provides another dimension to the analysis, identifying the particular burdens that urban Detroit neighborhood residents confront, and particularly urban minority women, in accessing necessary daily destinations. Chapter 6 discusses the key findings of the study, readdresses my research questions, and presents concluding thoughts and implications for policy and for future research.

CHAPTER 2: BACKGROUND RESEARCH

2.1. Theoretical Background: The Urban Built Environment and Travel Patterns

2.1.1. Transportation demand analysis

Specific characteristics in the urban built environment influence people's travel patterns, as evident in trip frequency, trip distance, mode choice, and total vehicle miles traveled (VMT) (Cervero, 2002; Domencich and MacFadden, 1996; Frank, 2004; and Handy et al., 2006). Early urban transportation research attempted to predict the total number of trips made using the gravity model (Manheim, 1979; Martin, Memmott, and Bone, 1967; and Meyer and Miller, 1984). The model was used for allocating a certain amount of trips by origin-destination pairs based on the attractive forces of a zone, such as population, employment or the intensity of land use. To estimate a friction factor between an origin and destination, interzonal distance—such as travel time or distance—was added to the model (Martin, Memmott, and Bone, 1967). Although the model accounted for competition for trips between different land uses, the model was unable to capture social and economic characteristics of zonal populations (Martin, Memmott, and Bone, 1967; and Meyer and Miller, 1984). As an application of a simple physical law to social behavior, a tremendous number of trips may be predicted between two neighboring zones due to the proximity of both centroids (Martin, Memmot and Bone, 1967). The intention here is not to criticize Martin, Memmott and Bone's work, but to illustrate how this area of research has evolved from this early study.

The next generation of urban transportation research expanded the model with socioeconomic factors (Boarnet and Crane, 2001b; Domencich and McFadden, 1996; and Hanson, 1986). The Urban Transportation Model System (UTMS), developed in the 1970s, is an aggregate demand model consisting of four sequential steps, trip generation, trip distribution, modal split and trip assignment (Manheim, 1979; Martin, Memmott, and Bone, 1967; Meyer and Miller, 1984; Hanson, 1986; and Hanson and Giuliano, 2004). Travel behaviors are aggregated into three dimensions of zones, peaks and homogenous groups. As the spatial dimension, zonal characteristics are used to explain total flows of people between different parts of the urban area. Peaks are the temporal components of travel flows that are established by converting a continuous variable to a discrete, nominal variable. Lastly, homogeneous groups are used for understanding the similarities in travel behavior of a specific population. Such categorizing variables include family income, automobile ownership, and family size (Manheim, 1979; and Meyer and Miller, 1984). Although the UTMS was the first large-scale, computer based urban transportation demand model, the aggregate models do not allow urban transportation researchers to understand the within-zone, or between-household, variations in trip making (Hanson, 1986; and Meyer and Miller, 1984).

Several limitations of aggregate models were identified, based on behavioral theory, in that the assumptions of aggregate trip generation model were biased to a specific transportation user group. The models assumed a stereotypical multiple-occupant household headed by a male worker commuting from the suburbs to the CBD (central business district) (Hanson, 1986; and Meyer and Miller, 1984). Since the models were inherently biased toward a group of suburban male commuters driving on highways to the CBD, the explanatory variables for the models concerning household travel behavior might no longer be relevant, considering drastic demographic changes during the past four or so decades (Hanson, 1986; Hanson and Giuliano, 2004; and Meyer and Miller, 1984).

In addition, it was assumed that people picked the alternative that had the maximum value of utility for participating in various activities located at the destination points of their journeys (Manheim, 1979; and Meyer and Miller, 1984). From the perspectives of behavioral theory, it was argued that the fixed levels of utility maximization often confined the researchers to seeking the underlying causes of travel choice, such as travelers' preferences over goods, the relative costs of those goods, and available trip making resources (Boarnet and Crane, 2001b). Thus, more flexible variables were required to explain several other important urban travel choices, such as trip chaining, non-home based trips, and multiple-worker household trip making (Meyer and Miller, 1984).

Furthermore, the continuing suburbanization of U.S. metropolitan areas has brought about new challenges for transportation planners. Rapidly increasing retail, service, office and residential developments in suburban jurisdictions generate intrasuburban and intersuburban trip making; trips between and within suburban nodal centers (Meyer and Miller, 1984). Thus, it is critical to assess different populations' accessibilities to urban amenities between municipalities throughout the metropolitan areas in order to address critical issues of equitable urban transportation.

Multidimensional disaggregate models were suggested to improve aggregate demand functions by incorporating more realistic behavioral factors, models which exhibit the multiple dimensions of choice. Various parameters for individuals or household characteristics were required for comprehending the motivations, and relative values of trip purpose, time of day, route, and mode in shaping trip making (Martin, Memmott, and Bone, 1967). These approaches permitted flexibility in grouping schemes for identifying the socioeconomic and demographic determinants of an individual trip, and so helped researchers to understand whether a specific groups' transportation experience was an expression of choice or of constraints (Hanson, 1986; and Hanson and Guiliano, 2004).

In making travel-decisions, certain personal and household characteristics can be constraints on an individual's choice of trips. First, advancing age often reduces the levels of total trips and multistop trips, and alters the purposes and timing of trips (Administration on Aging, 1998; Alsnih and Hensher, 2003; Cao et al., 2008; and Collia et al., 2003). Second, the availability of an automobile, which can be a function of culture or income, plays a critical role for trip making (Vojnovic et al., 2013; forthcoming). As people travel farther by automobile than by other modes, they can access a greater choice of workplaces and activity sites (Giuliano and Dargay, 2005; Preston and McLafferty, 1999; and Pucher and Renne, 2003). Accordingly, trip frequencies distinctively differ for those with access to a car versus those without access to a car (Blumenberg, 2004; Giuliano and Dargay, 2005; and Paaswell, Recker and Milione in Hanson, 1986). Furthermore, if there is only one car available in a household, the person working will generally take the car, while the rest of the household rely on other modes for transport (Hanson, 1986; Hanson, 2010; and Turner and Neimeier, 1997).

Third, gender is a factor that generates differences in trip making (Golob and McNally, 1997; Hanson, 1986; Hanson and Hanson, 1980; Hanson and Johnston, 1985; Johnston-Anumonwo, 1992; Kwan, 1999; Schwanen et al., 2008; and Wyly, 1998). Women tend to travel shorter distances, work closer to home, resist devoting much time to a long commute, and undertake more travel for shopping and personal needs, while men emphasize travel to work and recreation (Hanson, 1986; Hanson and Hanson, 1980;and Hanson and Johnston, 1985). As women travel to fulfill their multiple social roles of housewife, caregiver, and paid-laborer, they tend to be more reliant on public transportation and walking, when compared to men, who make greater use of the private automobile (Hanson and Hanson, 1980; Hanson and Johnston, 1985; Hanson, 1986; Manheim, 1979; and Meyer and Miller, 1984).

Another meaningful socioeconomic and demographic factor in shaping travel behavior is race and ethnicity. Ethnic and racial minorities living in central cities with lower income levels use different modes of transportation and travel longer distances on the journey to work (Hanson and Johnston, 1985; Johnston-Anumonwo, 1992; and Wyly, 1998). With implications for space-time use, longer distances and longer trip times to work reveal significantly lower mobility levels among racial and ethnic minorities.

Disaggregate research approaches to travel also allow studies to predict trip making behavior by alternative travel modes at a finer-scale of analysis. At the aggregate level, at relatively large-scales—such as traffic analysis zones (TAZ)—travel behavior by alternative travel modes to the private automobile were often obscured and ignored since people tend to walk or bike for closer destinations. Thus, disaggregate approaches at a finer-scale are particularly important to identify the relationship between land use configurations and people's choice of alternative, and more robust, selections of travel mode (Boarnet and Crane, 2001b; Hanson, 1986;and Manheim, 1979). Disaggregate data also help the models to detect the effects of certain changes in the built environment on travel behavior (Hanson, 1986; Cervero and Kockelman, 1997; Cervero, 2002; Handy, 2005a; Vojnovic, 2006; and Vojnovic et al., 2006). Since it is only possible at the street or neighborhood level to detect changes in pedestrian environment characteristics, these disaggregate approaches are critical to evaluate the effects of improved pedestrian streetscape environments on people's participation in physical activity (Handy, 2005a; Handy et al., 2006; and Vojnovic et al., 2006).

2.1.2. The Urban built environment and travel behavior

Research has shown that the pattern of urban development—whether daily activities are spread out or more compact—has an effect on how one travels. Researchers have suggested a diverse set of indicators of urban built environment characteristics to explain their effects on travel. Urban transportation studies have shown a clear link between urban form and travel mode, where people who live in higher-density, mixed-use, and connected neighborhoods drive less, and walk and take public transit more often (Boarnet and Crane, 2001b; Cervero, 2002; Ewing and Cervero, 2001; Frank, 2004; Handy, 2005a, 2006a, and 2006b; and Saelens et al., 2003). Because certain urban forms alter each travel mode's relative costs and convenience level, people make different decision on their daily trips according to the built environment within which they travel.

Therefore, certain characteristics in urban form, for instance, single use zoning, low residential and employment densities, and disconnected street networks, result in a greater dependence on private vehicle travel due to the increased distances between necessary daily destinations. These destinations can include going to work, to shop, to school or travelling for personal service needs, such as going to a bank, a pharmacy or a medical doctor.

Ewing and Cervero (2001) illustrated that people drive less and walk more in communities with greater variety and greater proximity between destinations. In addition, Handy et al. (2006) defined specific characteristics in the urban built environment that affect travel behavior, including accessibility, proximity between destinations, physical activity options, safety, attractiveness and the chance of socializing. Vojnovic (2006) also explored the association between built environment characteristics and travel, concluding that characteristics such as increased residential and employment densities, mixed land uses, increased connectivity, as well as design strategies reducing pedestrian barriers and increasing pedestrian safety and comfort, contribute to decreasing trip length, promote walking and biking, and reduce per capita automobile ownership.

In particular, researchers have found significant causal relationship between compact urban forms, various design strategies improving quality of the streetscape and reduced automobile use (Frank and Pivo, 1995; Handy, 2005a; and Handy et al., 2005). Frank and Pivo (1995) found significant relationships between residential density, land use mix and the proportion of household trips that were in single occupant vehicles, on transit, and on foot, after controlling for socio-economic and demographic factors.

From their study of the Seattle area, Moudon and colleagues (2005) suggest the significantly increased likelihood of walking or biking if there was a greater presence of destinations within a walkable distance from one's residence. To confirm the causal link between the built environment and travel behavior, Handy et al. (2005) used the indicators of 'regional accessibility.' The study found that traditional pedestrian neighborhoods showed higher accessibility, socializing and attractiveness characteristics for both work and nonwork travel, and a decrease in driving distances and/or driving trips. The higher accessibility created a decrease in the cost of walking, in terms of distance and time, and so contributed to residents substituting driving for walking. Handy revealed that there was a statistically significant causal link between travel behavior and neighborhood design, emphasizing the greater impact of neighborhood design on walking trips when compared to driving trips (Handy, 2006a).

Since the characteristics of the urban built environment at different geographic scales have different impacts on travel, it is also important to explore the complexity of travel behavior at various spatial scales. Starting with the premise that walking is a neighborhood-scale mode of travel while driving is a regional-scale mode of travel, researchers addressed the need for a comprehensive and systematic regional approach to community design in order to promote alternative urban transportation modes that should be competitive with driving (Handy, 2006a; and Vojnovic, 2006).

At the regional scale, monocentric or polycentric urban spatial structures encourage pedestrian travel activity around the urban activity centers with mixed urban functions. Also, mixed land uses with residential, commercial, and retail, and potential employment opportunities throughout an urban region, create different and more equitable commuting patterns. At the city scale, urban density, mixed land uses, and greater connectivity are fundamental elements to encourage more pedestrian activity (Vojnovic, 2006). As Handy (2006a) notes, the concentration of functions in (neo-) traditional neighborhoods makes travel distances shorter, lowers the travel costs and time for walking, and encourages pedestrian travel modes when compared to automobile-oriented, modern suburban neighborhoods. Thus, at the city scale, ensuring connectivity between and within neighborhoods becomes important in encouraging non-motorized travel.

Finally, at the city block scale, microscale-built environment characteristics—contributing to the comfort, safety and attractiveness of place—become important variables in encouraging pedestrian travel (Handy, 2006a; Vojnovic, 2006; and Vojnovic et al., 2006). There is a statistically significant effect of microscale built environment characteristics on walking (Handy, 2006a). Certain community design elements that increase pedestrian activity include proximity between destination end-points and a residence, the pedestrian streetscape itself (formed by the building and lot width, building configuration, and building mix), and the quality of the walking environment.

Building materials and colors, and detailed architectural elements also enhance the quality of the streetscape for pedestrians. Large building set-backs and large, elongated building and block widths in modern suburbs, which facilitate large parking lots, hinder pedestrians' access between buildings and destinations, and also reduce their sense of safety. Thus, safer street environments, facilitated by on-street parking along sidewalks and street lighting, as well as high visual interest along a street, are critical in encouraging pedestrian travel (Vojnovic, 2006; and Vojnovic et al., 2006).

2.1.3. Transportation equity: gendered urban transportation mobility

As people’s travel generating trip frequencies and purposes are closely associated with their socioeconomic situation, how a person reaches their activities is also related to his or her socioeconomic condition. However, mobility, the ability to reach activity sites of opportunities, is also a fundamental component in fulfilling the travel demand as well as ‘accessibility,’ the availability of urban opportunities within a certain distance or travel time. Certain barriers, such as less availability of diverse transportation modes, longer distances or poor access between necessary destinations, are well recognized transportation-related impediments (Hanson and Giuliano, 2004). Thus, variations in transportation and transportation choices are likely to have substantial impacts on individual access to all the necessary social and economic opportunities.

Furthermore, improved mobility can support active interactions within communities by connecting people to diverse social and recreational points with ease. If the access to locations becomes poorer and distances greater due to urban decentralization, people will be more dependent on privately owned vehicles and less accessible to the destinations without a car. Therefore, differences in mobility can be seen as a spatial consequence of urban built environment designs.

Gender plays a key role in understanding societal trends and their impacts on transportation demand and behavior. While the gap between women’s and men’s aggregate travel behavior has been narrowing, it is still far from equal on a number of measures and trends, with women having more variety in their travel patterns compared to men (Rosenbloom, 2005). There have been several drastic changes in socio-economic structure suggesting new challenges to urban transportation researchers. First, there has been a significant increase in the participation of women in the paid labor force. Almost 62% of all U.S. women aged 16 and over were in the labor force in 2002, which increased by 20% from 1975 (Rosenbloom, 2005). Thus, ‘trip to work’ travel behavior is no longer applied only to men. If women work, however, the location of their jobs tends to be closer to home when compared to those of men (Hanson and Johnston, 1985; Johnston-Anumonwo, 1992; and Wyly, 1998). As Hanson consistently illustrates in her studies (1980, 1981 and 1986), women’s work trips are significantly shorter than men’s in both travel distance and travel time.

However, women’s participation in paid employment has added to the burden of their daily travel, especially for married women with children. The majority of all mothers work outside the home, with 71% of married women with children working full time in 2003 (Rosenbloom, 2005). Accordingly, their travel demands and choices of job location tend to be significantly different from that of their partners. Especially in explaining women’s travel behavior, such as trip chaining for their multiple roles as homemaker and employed laborer, requires parameters other than conventional variables used under the assumption of utility maximization.

The differences in work trip time also reflect on women’s unique travel burdens. Women were unwilling or unable to devote much time to a long commute due to their dual roles as homemaker and employed laborer (Hanson and Hanson, 1980; and Hanson, 1986). Traditional gender roles and associated trip making behaviors are also reflected in trip purposes. In examining travel activity patterns of only full time employed women and men, male-female differences in travel purposes are apparent in that women undertake more travel for shopping and personal business, while men emphasize travel for work and recreation (Golob and McNally, 1997; Hanson, 1986; Kwan, 1999b; Schwanen et al., 2002; and Schwanen et al., 2008).

Lastly, there are a growing number of nontraditional households, single parent family households in particular, which also generate unique travel patterns. In 2003, single parent households accounted for almost 24% of all family households. Often, single mothers are placed in significantly disadvantages positions within nontraditional households (Rosenbloom, 2005). Considering women's greater dependence on public transit and walking when compared to men, transportation needs of women of diverse socioeconomic composition, ethnic backgrounds and family structure should be addressed in detail (Hanson and Hanson, 1980; Hanson and Johnston, 1985; and Hanson, 1986). Therefore, a disaggregate analysis on different groups of women is necessary in urban transportation research to account for the gender differences in travel by socioeconomic status and ethnicity.

Sprawled urban spaces cause women to spend more time and money on their travel since women must drive longer distances to meet their personal and household needs within these built environments. Women in compact communities, in contrast, spend less time and money on their travel between destinations, as their trips are characterized by shorter distances. Disaggregate analyses using individual or household level travel behavior data have shown that women make more trips by car, make fewer walking trips, are less likely to choose an alternative to driving for their trips, but still drive fewer vehicle miles than men overall (Elliott and Joyce, 2004; Hanson and Hanson, 1981; Hanson and Johnston, 1985; Hanson and Pratt, 1991; and MacDonald, 1999).

Handy et al. (2005) found that women still take on more of the responsibility for household duties. Not only do these responsibilities restrict free time for women, but they also necessitate additional travel needs. A report by the Surface Transportation Policy Project (1999) found that women made two-thirds of all trips to chauffeur people around, such as driving children to soccer practice or an older parent to the doctor. Such family responsibilities are especially burdensome for women in the 'sandwich generation', with responsibilities for both dependent children and aging parents. In the context of women's frequent travel for multiple household responsibilities, the car seems to provide more mobility in space and flexibility in time. Thus, if a woman has no access to a private automobile and holds multiple responsibilities, her ability is extremely limited to reach necessary destinations and meet basic daily needs.

Once disaggregated, studies have revealed that women have different travel patterns by income, ethnicity, age, and marital status (Hanson and Hanson, 1981; Johnston-Anumonwo, 1989, 1997; McLafferty and Preston, 1997; Rosenbloom, 1989, 2005; Rosenbloom and Raux, 1985; and Wyly, 1996). Hanson and Hanson (1981) found that Swedish married women were likely to make more shopping and domestic trips than their spouses, while they make fewer social and recreational trips. Furthermore, Rosenbloom and Raux's study (1985) focused on the Netherlands, France and the Unites States found that women's travel patterns varied significantly with the age of their youngest child and associated needs in all three countries.

In a study of single mothers in Worcester, Massachusetts, Johnston-Anumonwo (1989) found that women were more likely to make their work trips in cars even though they maintained lower car ownership rates when compared to men. The study also found that single mothers had longer work trips than comparable married women. Rosenbloom (1989) found similar patterns with single mothers in Houston and Dallas, Texas. At all income levels except below $5,000 a year, single mothers traveled a greater distance and more often in a car than comparable married women.

Studies have also found a racial and ethnic dimension to travel behavior among women. McLafferty and Preston (1992) explored the relationship between commuting time, job search, and labor market segmentation, earnings, and travel modes. They found that white women had shorter commutes to work compared to black women in the same job category. Similarly, Wyly (1996) examined the spatial entrapment among all groups of women using work trip distance and controlling for travel modes. He found that women made localized commutes to shorten the trip time to their workplaces. Using the estimates of one-way work trip mileage by different travel modes, he found that work trip costs were greater for women, and that African American women showed a distinctive and costly commute pattern. Since urban decentralization has taken most of the jobs to the suburbs, and yet suburban housing markets favor specific socioeconomic and racial groups, urban racial and ethnic minorities have suffered from unemployment and longer commutes to suburban industrial and service jobs.

It has been argued that women's 'spatial entrapment' is a consequence of urban economic restructuring and spatial shifts (Johnston-Anumonwo, 1997; McLafferty and Preston, 1992, 1996a, 1996b, 1996c, 1997; MacDonald, 1999; and Elliot and Joyce, 2004). Research by Johnston-Anumonwo (1997) on travel differences by gender, ethnicity and socioeconomic status was based on classifying commute types by income (more than $25,000 or less than $25,000) and commute time (longer than 20 minutes or less than 20 minutes) using multivariate analysis with PUMS 1990 data. In addition to the lower use of the private automobile by African American commuters, there were clear racial and gender differences in commute times. While both black and white women tended to have lower incomes compared to men, black women traveled a longer time to reach their suburban jobs than suburban white women with similar earnings and in the same occupation. MacDonald (1999) claimed that women's commuting patterns are constrained by limited mobility and a lack of convenient jobs due to occupational and industrial segmentation. While a highly localized and segmented labor market results in relatively short work trip distances for suburban white women, low income minority women in the inner-city suffer from the long reverse commute to low skilled and entry-level suburban jobs.

With respect to the costs of travel, there is the added dimension of access to specific transportation modes. Elliott and Joyce (2004) used OLS multivariate regression analysis to identify the spatial constraints on women's commuting in both the suburbs and the inner-city. Using a Multi-City Survey of Urban Inequality (MCSUI) 1992-1994 and face-to-face interviews in Los Angeles, Boston, and Atlanta, Elliott and Joyce found that single women tended to commute longer than married women with children, and that there was significant racial difference in commute times.

Particularly relevant to differences by ethnicity, this study showed the racial disparity in commuting mode and time, in that black women relied more on public transit and had significantly longer commute times than white women. In addition, black and Latina mothers of teenagers exhibited the longest commute times. Due to relatively lower income level of single mothers and their low car ownership rates, they suffer from living in areas with limited access to effective public transit systems.

Within the literature on travel behavior and gender, it is important to recognize that although nonwork travel is essential for determining a person's quality of life, women's nonwork travels have not been extensively studied. Kwan (1999a, 1999b) has studied the space-time constraints on women's accessibility. She claims that women's day time fixity constraints were interrelated with their household responsibilities, employment and non-employment activities. Utilizing a 'space-time travel frame' constructed from survey respondents' travel diaries, she found that the spatial boundaries of women's non-employment travels were more confined than men due to the effect of temporal fixity on achieving their diverse responsibilities. However, there has been little known about women's non-work travel patterns in detail, as well as those of different social groups by income, race/ethnicity, and age.

Lastly, safety should be addressed as another important aspect of mobility equity. Since walking and bicycling often becomes a necessity rather than a choice to low income and minority households, safety in walking, cycling, or using public transit is quintessential for women if they are to have appropriate mobility. Since women are more concerned about their personal safety and feel less safe than men when using sidewalks and public transit, they tend to perceive cars to be the safest mode and form of transportation (Carter in TRB 2005; Ingalls et al., 1994; Koskela and Pain, 2000; Loukaitou-Sideris and Flink, 2009; Schulz and Gilbert, 1996; and TRB, 2005a, 2005b). This perception may eliminate alternatives to driving from consideration and make non-motorized modes particularly burdensome for women who do not have access to a car. In addition, low income and minority women who live predominantly in central locations of metropolitan areas, which are, or might be perceived as unsafe, have impaired mobility associated with safety concerns. Thus, the comfort and the safety of a neighborhood becomes an integral aspect of any study on gendered travel behavior.

2.1.4. The urban built environment, physical activity and overweight/obesity

The literature on the urban built environment and travel behavior, especially pedestrian activity, also has implications on public health through the linkage of physical activity and obesity (Cutts et al., 2009; and Frank et al., 2005). As the geographic separation of living, working, shopping, and leisure destinations throughout the urban periphery has required increased car use, the modern urban built environment has contributed to reducing opportunities for active living within American metropolitan centers. From a public health perspective, there have been adverse effects resulting from automobile-oriented built environments, such as increased air pollution, noise, traffic congestion, road injury risk, and increased greenhouse gases (Barla et al. 2010; Marshall et al. 2009; and Giles-Corti et al. 2011). Especially people living in areas characterized by low density residential developments—with single land uses and disconnected road networks—tend to get less exercise as part of their daily travel routines. A neighborhood becomes 'obesogenic' when its layout prevents or discourages physical activity (Frank and Engelke, 2001).

Half of the trips in America can be completed within a 20-minute bike ride, and a quarter of trips are within a 20-minute walk, and yet, the vast majority of these short trips are taken by automobile (FHA National Household Travel Survey 2001 in Hu, P. S., and T. R. Reuscher, 2004). Approximately 70% of American adults were overweight (34% obese), and 19% of all teenagers and 17% of all children between ages 6 and 11 were overweight (CDC, 2010). Obesity is a major risk factor for many of our most deadly diseases. The number one cause of death in the U.S. is heart disease, and five of its six risk factors are associated with obesity: excessive weight, inactivity, high blood pressure, high cholesterol, and diabetes.

In the United States in 2005, there were 1.5 million new diagnoses of diabetes for which obesity is the number one risk factor (CDC, 2008). In addition, in 2007, less than half of all Americans met the CDC's recommendations for physical activity from work, transportation, or leisure time exercise, and 13.5% did not get any physical activity at all (CDC, 2008). America's social metabolism—people's participation in physical activity—is influenced by the built environment in which they live, by the social environment, and by personal factors such as gender, age, ability, and motivation (Edwards and Tsouros, 2006). In particular, the major changes in American social metabolism can be explained by a reduction in physical activity in the transportation sector. Americans made almost 90% of trips in cars, and spent on average more than 30 miles driving every single day (FHA, 2001). Within this context, urban transportation researchers have been advocating for an ACTIVE TRANSPORT movement, aimed at increasing the level of physical activity by encouraging people to use non-motorized travel modes and reversing the trends from America's activity deficit.

There is growing evidence documenting the adverse health impacts of post-World War II, automobile oriented land use patterns in the U.S. (Frank and Engelke, 2005; Frank et al.,2006; Frumkin, Frank, and Jackson, 2004; and Handy, et al., 2002). People who live in "traditional" or "walkable" neighborhoods reported that they walked about 30 minutes and more for their travel each week (Saelens et al. 2003) and are involved more in physical activity compared to those who live in less walkable suburban neighborhoods (Frank, et al. , 2005; King et al., 2003; and Sealens et al., 2003a, 2003b).

Studies on walkability have examined and detailed the specific forms of neighborhoods that are more suitable for people to walk. Lawrence Frank and colleagues (2005) showed that a 5% increase in the level of land use mix, residential density, street connectivity, and retail floor to land area ratio was associated with a 32% increase in walking, ¼ point reduction in BMI, 6.5% increase in physical activity, and 5.5% reduction in per capita emissions of oxides of nitrogen and volatile organic compounds (Frank et al., 2006). The study results also showed a 20% increase in the likelihood that someone walked with each addition of a recreational and institutional facility within a 1 kilometer network distance from their residence.

The unprecedented national obesity epidemic and its ties to the automotive 'monoculture' are now far too serious to ignore. In 2007-2008, some 33.8% of American adults were obese, with figures for American adult women (at 35.5% obese) being higher than for adult men (at 32.2% obese) (Flegal et al., 2010). With more than 60% of women in the United States not engaging in the recommended amount of physical activity, and more than 26% of women not being active at all, these figures are consistent with wider national trends (CDC, 2010). In addition to this gender dimension to obesity, there is also an ethnic component to being overweight. Between 2003 and 2006, for instance, the age-adjusted obesity rates among American women older than 20 years varied strongly by ethnicity. While 53.3% of non-Hispanic black women were obese, only 41.8% of Mexican-American women, and 31.6% of non-Hispanic white women, were classified as obese (CDC, 2010).

Since community design can play an important role in increasing women's physical activity, providing safe and pleasing walking environments is critical in making walking a more attractive choice for women. Indeed, studies on physical activity have shown that enjoyable scenery is associated with increased walking activity among women. Handy et al. (2005) found that women living in traditional walkable neighborhoods walked to the store more than twice as often as women in suburban, low-density, automobile oriented neighborhoods. Therefore, it is important to address equitable access and improved mobility of all social and ethnic groups, with specific considerations provided for the needs of both men and women, in addressing issues of socio-economic conditions and public health.

2.2. Statement of Problem

In order to understand people's travel behavior, urban transportation researchers have suggested diverse indicators to measure the effects of urban built environment characteristics on travel, including land use density, land use diversity, proximity between destinations, and micro-scale design elements. Studies have found links between residents living in compact, mixed land-use, and connected neighborhoods and walking more often over shorter distances (Frank and Pivo, 1995; Handy, 2006a; Handy et al., 2006; Saelens et al., 2003a, 2003b; Sallis et al., 2004; Vojnovic, 2006; and Vojnovic et al., 2006). Urban transportation research, however, has focused on major cities experiencing significant urban economic transformation into robust service economies; cities such as Chicago, Seattle, Boston and San Francisco.

However, there has been little research on travel patterns performed in traditional industrial cities in the Midwest and the Rustbelt, cities like Detroit, which are confronting a rapidly declining urban core. Urban minorities in such cities find few employment opportunities in the urban core and confront great distances to reach potential employment in the suburbs. In addition to the economic forces, Detroit also confronts social and racial segregation, and political fragmentation in the metropolitan area that has administratively separated the urban region along social and racial lines. In such deteriorated inner-city neighborhoods, the implications of higher densities, mixed land-uses, and connected neighborhoods on travel behavior and physical activity have not been explored.

The existing literature has shown a meaningful relationship between increased participation in physical activity and compact urban neighborhoods (characterized with higher density, mixed land uses, and more connected road networks). However, in declining urban cores, such as central in the city of Detroit, residents often participate less in daily physical activity and subsequently show higher BMI levels in spite of similar compact urban built environment settings. This is where the proposed research will fit into the larger literature on urban form, travel behavior, and physical activity. The proposed dissertation intends to examine the unsynchronized relationship between densely developed urban communities, and travel, emphasizing gender differences while also taking into account socio-economic and ethnic variables.

In addition, there are few studies on differential travel patterns focused on gender, and how these variations by gender might also be affected by income, ethnicity, age, household types, and neighborhood structure. Moreover, urban travel patterns beyond commutes to work have not been examined in detail. Since nonwork trips tend to be more dynamic and associated with people's social roles and responsibilities, it is important to understand the difference in travel activities between social groups, as they access shops, restaurants, personal services (such as a pharmacy, doctor or bank) and various leisure destinations. While it is generally understood that urban minorities, and women in particular, have suffered for decades from spatial constraints of entrapment in the central city—due to racial segregation and decentralizing jobs, services, and residential development—their full range of transportation demands and realities have not been explored explicitly within the context of declining urban cores.

Few critical urban transportation researchers have examined urban minorities' impaired mobility, and even fewer have targeted a declining inner-city like Detroit (Blumenburg, 2004; Grengs, 2010; Sanchez et al., 2004; and Turner, 1997). However, in these studies, gender disparities along with their ethnic and socio-economic distinctions have not been explored in detailed neighborhood level analyses, and particularly within the context of a full array of travel destinations (from work to shopping to leisure) and associated trip constraints in terms of distance, time, frequency and travel mode. In addition, most studies have been developed with aggregate data at conventional TAZs (traffic analysis zones), such as counties or MSAs. Thus, it has been difficult for existing studies to examine gender, along with individual socioeconomic, and racial and ethnic variables, in shaping travel choices.

2.3. Study Area and Research Data

2.3.1. Study area: the Detroit region, Michigan

Decentralization in the Detroit region[1]has been at the forefront of the discussions of U.S. suburbanization since World War II. From 1960 to 1990, the area of developed urban land which was converted from agricultural and natural lands has increased as much as 13 times faster than population growth in the Detroit area (Vojnovic et al., forthcoming). In addition, the average residential development density in the region dropped substantially during the 1990s, with new construction being built at 1.3 housing units per acre, a significant decline from the 2.8 housing units per acre that was the average in 1990 (SEMCOG, 2003). Considering the slow population growth in the region, and an actual population decrease in the city of Detroit, urban decentralization in south-east Michigan is continuously and rapidly consuming open space, whether natural lands or agricultural lands, while at the same time abandoning existing developed urban spaces (Vojnovic et al., 2006).

The decentralization of the Detroit region can be explained with the review of three driving forces—economic, political and social variables. First, economic globalization and deindustrialization has facilitated the region's economic decline, and particularly in manufacturing. As the region's single dominant industry, automobile production, the locations of

[1] In this dissertation, Detroit region is referred to the SEMCOG (Southeast Michigan Council of Governments) region. Throughout the dissertation, this will make reference to as the Detroit region which consists of Macomb, Oakland, Wayne, St. Clair, Livingston, Washtenaw, and Monroe counties.

the Big Three (GM, Ford, and Chrysler) automobile companies and related transportation manufacturing have determined the economic rise and fall of metro Detroit. Since Ford started relocating manufacturing plants from the city of Detroit during the 1940s, auto industry producers have dispersed their production lines into the Detroit suburbs, the southern U.S. states and abroad in order to reduce labor costs (Gallagher, 2010; and Martelle 2012). In addition, the economic restructuring during the 1980s reinforced the uneven development of the region, as more jobs were created in the suburban retail and office locations, following the outward movement of the suburban population.

Second, outward decentralization was facilitated by public policy. These included such policies as FHA loans (Federal Housing Administration**)**, the G.I. Bill of the U.S. Department of Veterans Affairs (The Servicemen's Readjustment Act of 1944), and IHA (The 1956 Interstate Highway Act), all facilitating an institutionalized form of class and racial discrimination (Darden et al., 1987; Darden et al., 2009; Thomas, 1997; Vojnovic, 1999; 2000b, 2000c; 2009). In addition, new homebuyers appeared to favor the purchase of new housing in the suburbs over housing in the central city. Moreover, competition between municipalities for new development encouraged many homebuyers and businesses to locate outside of urbanized boundaries, as they pursued lower property tax rates and growing public subsidies in undeveloped peripheral jurisdictions (Vojnovic, 2006). In this political situation, characterized by excessive inter-municipal competition for new developments, problems associated with the building of socially sustainable and healthy communities are often ignored by local policy makers (Vojnovic et al., 2006).

Finally, social and racial tension has spurred the decentralization of Detroit. During the post war years, thousands of single family homes and strip malls were built in the suburbs in an attempt for the suburbanites to distance themselves from violence, crime, and the minority populations that they considered a threat. On the other hand, the city's black population increased from 75 percent of the city's entire population in 1990 to 83 percent by 2010 (U.S. Bureau of Census, 2011). As research on Detroit region's segregation and suburbanization have explained, segregation and suburbanization in the region resulted from racial discrimination in the housing market that was controlled by apartment managers, real estate brokers, and builders (Darden et al., 1987, 2009; Sugrue, 1996; Thomas, 1997; and Vojnovic and Darden, 2013a).

As a result, Detroit has become the one of the most extreme examples of urban decline, urban disinvestment and decentralization. The city of Detroit has lost about 25 percent of its population during the last decade (with the population being at 951,270 in 2000 and dropping to 713,777 in 2010); a population less than half of its population highs reached in the 1950s, when the population peaked at about 1.85 million. Accordingly, the population density in the city of Detroit fell from 13,249 people per square mile in 1950 to 5,170people per square mile in 2010 (U.S. Bureau of Census, 2011).

In addition, the suburbanization of the population resulted in the decentralization of its tax base and imprinted a landscape with a polarized fiscal capacity between the city and the wealthy suburbs. The per capita income of Detroit city was $14,976 in 2008 while in the Detroit-Warren-Livonia Metropolitan area the per capita income was $27,624 (U.S. Bureau of Census, 2010). In terms of the tax base, while the per capita taxable assessment in the city of Detroit was $7,573 in 2000, the per capita taxable assessment in Bloomfield Hills, located in Oakland County, was $165,794 (SEMCOG, 2003). Simply put, the city of Detroit has become one of the poorest cities in the U.S. while its suburbs have been gaining population and investment, and subsequently, a greater tax base. Oakland County, one of Detroit's suburbs, is one of the richest counties in the country (Darden et al., 2007, 2009).

The local pressure in the city's service provision is effectively illustrated with public education. Less than 25% of students graduated from the Detroit City School District in the 2003-2004 academic year, the lowest among the 50 largest U.S. cities (Vojnovic et al., forthcoming). In fact, the city of Detroit has been described as the most distressed urban core with an increasing concentration of unemployment, poverty, and racial and ethnic minorities due to outmigration of middle- and upper-income Whites to the suburbs, a pattern particularly evident since the 1960s.

2.3.2. Research Data: Household Travel Survey

For this study, 6 neighborhoods were selected within the Detroit region, specifically falling within the boundary of SEMCOG (Southeast Michigan Council of Governments). The 6 neighborhoods were selected from Oakland, Washtenaw, and Wayne counties, southeastern Michigan, with the purpose to isolate for specific urban built environment characteristics, and social and ethnic population compositions (figure 5). The neighborhoods were selected based on socio-economic and demographic characteristics, racial composition (isolating wealthy and white communities in the suburbs and poor and black communities in the inner-city), as well as specific conditions in the urban built environment (including urban density, land-use mix, and connectivity).

From the six neighborhoods, there were 3200 surveys mailed-out to 1600 households within the inner-city Detroit neighborhoods, and 1600 surveys mailed-out to 800 households for each of the four suburban neighborhoods. Two surveys were sent to each household to capture travel behavior variations, including travel variations between men and women aged over 18 in the households. There were a total of 1191 respondents' surveys collected in the mail survey (table 1). Sample households were randomly selected by geographic stratification to ensure sample representation by age, race and gender. The return rate was approximately 20% of the actual potential sample, which is considered a good response rate for a mail survey sent out to the general population (Sommer and Sommer, 1997).

Table 1 Surveys from Each Neighborhood (total: 1191)

Detroit 1	Detroit 2	Ann Arbor	Birmingham	Bloomfield Hills	West Bloomfield
128	158	297	211	201	196

For the entire survey sample, 63% of the survey respondents were women and 37% were men, 61.8% were married and 38.2% were not married. In addition, 72.8% of the respondents were white and 27.2% were non white (table 2). The average age of the survey respondents was 53.8 years old and the average annual personal income was $52,200. On average, the survey respondents were responsible for less than one (0.7) dependent children per individual. With respect to automobile ownerships, the average number of the personal automobiles was more than one car (1.2) per individual (table 3).

Table 2 Descriptive analysis of the survey sample by neighborhood groups (categorical variables)

		Total	Urban Detroit	Higher density suburban	Lower density suburban
N		1,191	286	508	397
Categorical variables					
Gender	Women	63.0%	74.0%	61.9%	56.8%
	Men	37.0%	26.0%	38.1%	43.2%
Marital status	Married	61.8%	23.8%	71.3%	76.0%
	Not-married	38.2%	76.2%	28.7%	24.0%
Race	White	72.8%	8.1%	94.7%	88.6%
	Non-white	27.2%	91.9%	5.3%	11.4%

*DT1: Detroit 1; DT2: Detroit 2; AA: Ann Arbor; BM: Birmingham; BH: Bloomfield Hills; and WB: West Bloomfield.

Table 3 Descriptive analysis of the survey sample by neighborhood groups (continuous variables)

		Total	Urban Detroit	Higher density suburban	Lower density suburban
N		1,191	286	508	397
Continuous variables					
Age	Min.	18.0	18.0	19.0	18.0
	Max.	94.0	94.0	93.0	92.0
	Mean	53.8	52.0	51.8	57.3
	Median	53.0	52.5	51.0	56.0
	St.Dv	15.8	16.7	15.7	14.8
Personal income (in $1,000)	Min.	3.3	3.3	7.5	4.5
	Max.	160	125	160	160
	Mean	52.2	23.6	58.1	63.9
	Median	52.4	15.0	55.0	65.6
	St.Dv	31.7	20.3	26.6	32.3
The number of dependent children under 18	Min.	0.0	0.0	0.0	0.0
	Max.	8.0	8.0	3.0	5.0
	Mean	0.7	0.8	0.6	0.7
	Median	0.0	0.0	0.0	0.0
	St.Dv	1.1	1.3	0.9	1.1
Personal vehicle(s) available	Min.	0.0	0.0	0.0	0.0
	Max.	6.0	5.0	6.0	4.0
	Mean	1.2	0.8	1.3	1.4
	Median	1.0	1.0	1.0	1.0
	St.Dv	0.7	0.8	0.6	0.7

Breaking down the entire sample by neighborhood groups reveals a clear socioeconomic difference between urban Detroit neighborhoods and suburban neighborhoods, both higher density and lower density (tables 2 and 3). The most striking difference between the urban Detroit neighborhood group and the suburban neighborhood groups was the racial composition. While suburban neighborhood groups were predominantly white (94.7% for the higher density suburban neighborhood group and 88.6% for the lower density suburban neighborhood group), the urban Detroit neighborhood group was predominantly non-white (91.9%).

Disparity in average personal income between neighborhood groups was also clearly shown between the urban Detroit and the suburban neighborhoods. The average personal income in the urban Detroit neighborhood group was $23,600, which was less than half of the average personal income when compared to both the suburban neighborhood groupings ($58,100 in the higher density suburban neighborhood group and $63,900 in the lower density suburban neighborhood group). The lower income status of the urban Detroit neighborhood group was also reflected in lower average automobile access per individual. There was less than one car (0.8) that was available to a respondent in the urban Detroit neighborhoods whereas each suburbanite had access to more than a car (1.3 for the higher density suburban neighborhood group and 1.4 for the lower density suburban neighborhood group).

The majority of urban Detroit respondents were not married (76.2%) while more than 70% of the suburban respondents from both neighborhood groups were married (71.3% for the higher density suburban neighborhood group and 76.0% for the lower density suburban neighborhood group). There was no significant distinction in terms of other demographic characteristics such as gender, age, and the number of dependent children under the age of 18 between the three neighborhood groupings.

In sum, the urban Detroit neighborhood group was characterized as low income, predominantly non-white with low access to a private automobile. In contrast, the two suburban neighborhood groups, the higher density suburban and lower density suburban groups, were characterized by higher incomes, predominantly white with greater access to a car. As seen in tables4and 5, there is a clear distinction between the two urban Detroit neighborhoods and the four suburban neighborhoods in terms of socioeconomic and demographic profiles.

In terms of other demographic characteristics, the average age of the survey respondents in the urban Detroit neighborhoods were 54 and 50 (table 5).In addition, only about 25% of the respondents were married or living with a partner (20.8% for Detroit 1 and 26.2% for Detroit 2) (table 4). From the profile of the survey respondents and the neighborhood surveys, it was also clear that the urban Detroit neighborhoods were shaped by years of disinvestment and decline.

Unlike the predominantly black, low-income urban Detroit neighborhoods, four suburban neighborhoods were selected as the higher income and predominantly white communities in this study. Except West Bloomfield (84.6%), all three suburban neighborhoods' respondents were over 90% white (95.1% for Ann Arbor, 94.1 % for Birmingham, and 92.4% for Bloomfield Hills). The average annual personal incomes were well above $60,000 for the suburban neighborhoods (about $63,000 for Birmingham and West Bloomfield, and $65,000 for Bloomfield Hills) in 2008. Ann Arbor's annual average personal income was slightly lower (averaging about $55,000) (table 5). The income gap between the urban Detroit neighborhoods and suburban neighborhoods, thus, is more than double, and almost triple between the Detroit 2 neighborhood and the Bloomfield Hills neighborhood.

As one might expect, the average automobiles per capita in the suburban neighborhoods was 1.3 (except for the Bloomfield Hills neighborhood where the per capita ownership was 1.4 automobiles per individual), which is greater than that of urban Detroit respondents (0.8 for Detroit 1 and 0.7 for Detroit 2). Demographically, the average ages of the suburban respondents range from 49 (Ann Arbor) to 59 (Bloomfield Hills),and the majority of the respondents in the suburbs were married or living with a partner (71.5% for Ann Arbor, 71% for Birmingham, 70.8% for Bloomfield Hills, and 81.4% for West Bloomfield) (table 4).

Between the urban Detroit neighborhoods and the suburban neighborhoods, there was no substantial difference in terms of gender or the number of dependent children under the age of 18. However, the respondents in the urban Detroit neighborhoods had slightly more dependent children (0.9 for Detroit 1 and 0.8 for Detroit 2) than suburban residents (0.5 and 0.6 for Ann Arbor and Birmingham, and 0.7 for Bloomfield Hills and West Bloomfield). Also, in the survey sample, there were more women respondents in both the urban Detroit neighborhoods (over 70%) when compared to the suburban neighborhoods (approximately 60%, ranging from 56.2% in Bloomfield Hills to 64.2% in Ann Arbor).In sum, the residents in the urban Detroit neighborhoods were predominantly non-white, not married, and low income, with poor access to a personal automobile when compared to the predominantly white, married, and higher income respondents in the suburbs.

Table 4 Descriptive analysis of the survey sample by neighborhood (categorical variables)

		Total	Urban Detroit		Higher density suburban		Lower density suburban	
			DT1	DT2	AA	BM	BH	WB
N		1,191	128	158	297	211	201	196
Categorical variables								
Gender	Women	63.0%	73.1%	74.7%	64.2%	58.5%	56.2%	57.5%
	Men	37.0%	26.9%	25.3%	35.8%	41.5%	43.8%	42.5%
Marital status	Married	61.8%	20.8%	26.2%	71.5%	71.0%	70.8%	81.4%
	Not-married	38.2%	79.2%	73.8%	28.5%	29.0%	29.2%	18.6%
Race	White	72.8%	4.4%	11.1%	95.1%	94.1%	92.4%	84.6%
	Non-white	27.2%	95.6%	88.9%	4.9%	5.9%	7.6%	15.4%

*DT1: Detroit 1; DT2: Detroit 2; AA: Ann Arbor; BM: Birmingham; BH: Bloomfield Hills; and WB: West Bloomfield.

Table 5 Descriptive analysis of the survey sample by neighborhood (continuous variables)

		Total	Urban Detroit		Higher density suburban		Lower density suburban	
			DT1	DT2	AA	BM	BH	WB
N		1,191	128	158	297	211	201	196
Continuous variables								
Age	Min.	18.0	21.0	18.0	19.0	23.0	23.0	18.0
	Max.	94.0	94.0	89.0	90.0	93.0	92.0	84.0
	Mean	***53.8***	***54.4***	***50.1***	***49.4***	***55.2***	***59.1***	***55.4***
	Median	53.0	54.0	51.0	47.0	54.0	59.0	54.0
	St.Dv	15.8	15.8	17.1	15.4	15.6	15.8	13.5
Personal income (in $1,000)	Min.	3.3	4.5	3.3	7.5	9.0	12.5	4.5
	Max.	160	125	105	160	160	160	160
	Mean	***52.2***	***24.7***	***22.8***	***54.7***	***63.0***	***64.5***	***63.1***
	Median	52.4	15.4	15.0	52.4	65.0	67.6	60.0
	St.Dv	31.7	20.7	20.0	24.5	28.6	30.5	34.2
The number of dependent children under 18	Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Max.	8.0	5.0	8.0	3.0	3.0	4.0	5.0
	Mean	***0.7***	***0.9***	***0.8***	***0.5***	***0.6***	***0.7***	***0.7***
	Median	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	St.Dv	1.1	1.3	1.3	0.9	0.9	1.0	1.1
Personal vehicle(s) available	Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Max.	6.0	5.0	3.0	4.0	6.0	4.0	4.0
	Mean	***1.2***	***0.8***	***0.7***	***1.3***	***1.3***	***1.4***	***1.3***
	Median	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	St.Dv	0.7	0.9	0.6	0.6	0.7	0.7	0.6

*DT1: Detroit 1; DT2: Detroit 2; AA: Ann Arbor; BM: Birmingham; BH: Bloomfield Hills; and WB: West Bloomfield.

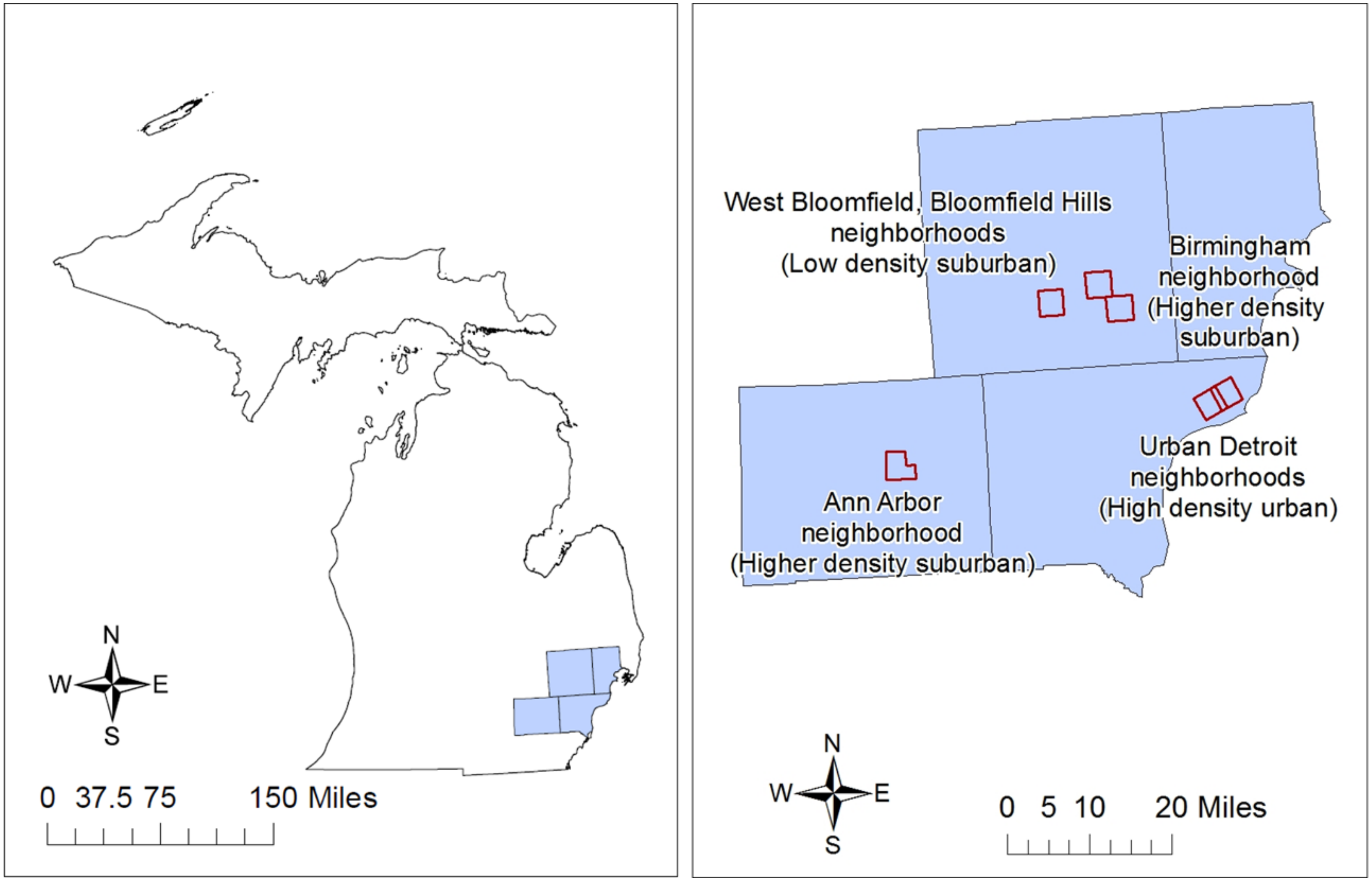


Figure 5 Six study neighborhoods in the Southeast Michigan (Macomb, Oakland, Washtenaw, and Wayne). Maps produced by Jieun Lee

Lower density suburban: West Bloomfield (left) and Bloomfield Hills (right), MI.

Higher density suburban: Ann Arbor (left) and Birmingham (right), MI.

Higher density urban: Detroit 1 (left) and Detroit 2 (right), MI

Figure 6 Study area: The six Detroit region neighborhoods

The six neighborhoods were also selected to demonstrate specific conditions in the urban built environment, including specific distinctions in urban density, land-use mix and connectivity (figure 6). The urban Detroit neighborhoods and the higher density suburban (Ann Arbor and Birmingham) neighborhoods were selected as the higher density neighborhoods with diverse land uses and connected road networks. In contrast, the two lower density suburban neighborhoods, West Bloomfield and Bloomfield Hills, were selected as typical automobile oriented suburban neighborhoods that are characterized by low densities, single land uses (residential) and disconnected road networks.

Table 6 Urban structure density and connectivity in the study area by neighborhood groups

Units per sq. km	Urban Detroit	Higher density suburban	Lower density suburban
Urban structure density			
Single family detached home	501	577	375
Semi-detached home	0	1	0
Apartments	1	12	8
Townhomes/ Row houses	3	5	9
Retail	2	5	4
Personal services	11	11	6
Public Institution	9	5	2
Industrial	1	0	0
Abandoned	55	0	0
Connectivity			
Intersections	32	16	3

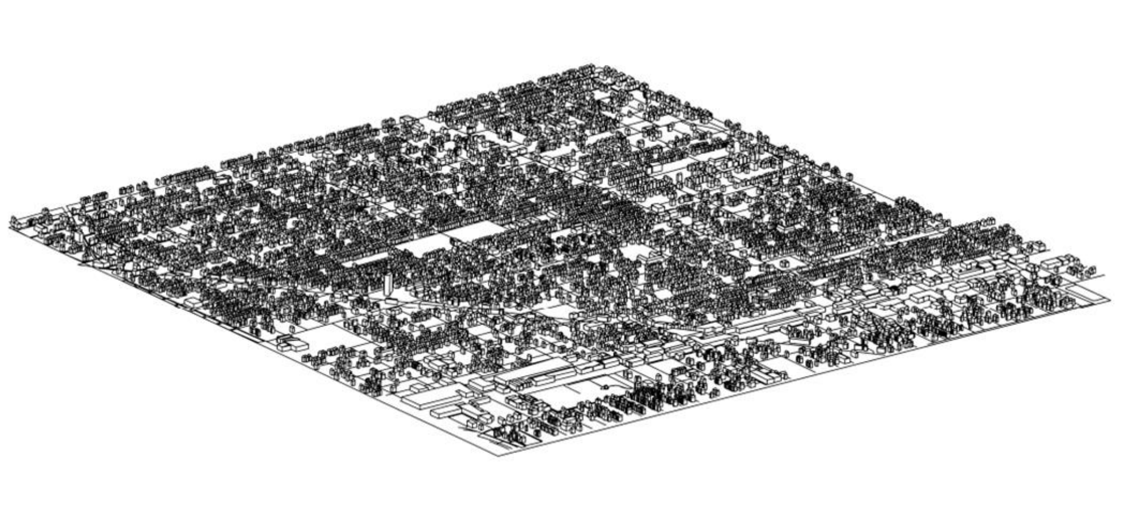
Table 7 Urban structure density and connectivity in the study area by neighborhoods

	Urban Detroit		Higher density suburban		Lower density suburban	
Units per sq. km	DT1	DT2	AA	BM	BH	WB
Urban structure density						
Single family detached home	595	396	608	547	163	277
Semi-detached home	0	1	3	0	0	7
Apartments	1	5	3	7	10	12
Townhomes/ Row houses	1	2	17	8	7	3
Retail	2	1	2	8	0	0
Personal services	14	7	12	10	0	1
Public Institution	12	5	8	3	0	0
Industrial	1	1	1	0	0	0
Abandoned	65	43	0	0	0	0
Connectivity						
Intersections	30	19	12	16	2	2

*DT1: Detroit 1; DT2: Detroit 2; AA: Ann Arbor; BM: Birmingham; BH: Bloomfield Hills; and WB: West Bloomfield.

As seen in table 6, both the urban Detroit and the higher density suburban neighborhood groups were characterized by higher density developments, a diverse land use mix and highly connected road networks when compared to the low density suburban neighborhood group. Both the urban Detroit and the higher density suburban neighborhood groups maintain more than 500 single family detached homes per square kilometer, while the low density suburban neighborhood group maintains only 375 structures per square kilometer.

More nonresidential structures were also evident in the urban Detroit and the higher density suburban neighborhoods (more than 20 retail, personal services, and public institutions versus 12 nonresidential structures in the low density suburban neighborhood group). In terms of street connectivity, there were more 4-way intersections per square kilometer in the urban Detroit (32 per square kilometer) neighborhood group and the higher density suburban (16 per square kilometer) neighborhood group than in the lower density suburban neighborhood group (3 per square kilometer). Despite of higher density developments and the more connected road networks, the urban Detroit neighborhood group was distinguished from the higher density suburban neighborhood because of fewer retail establishments and more abandoned structures in this neighborhood grouping. Neighborhood characteristics of urban density, land use mix, and street connectivity are shown by individual neighborhoods in table 7.



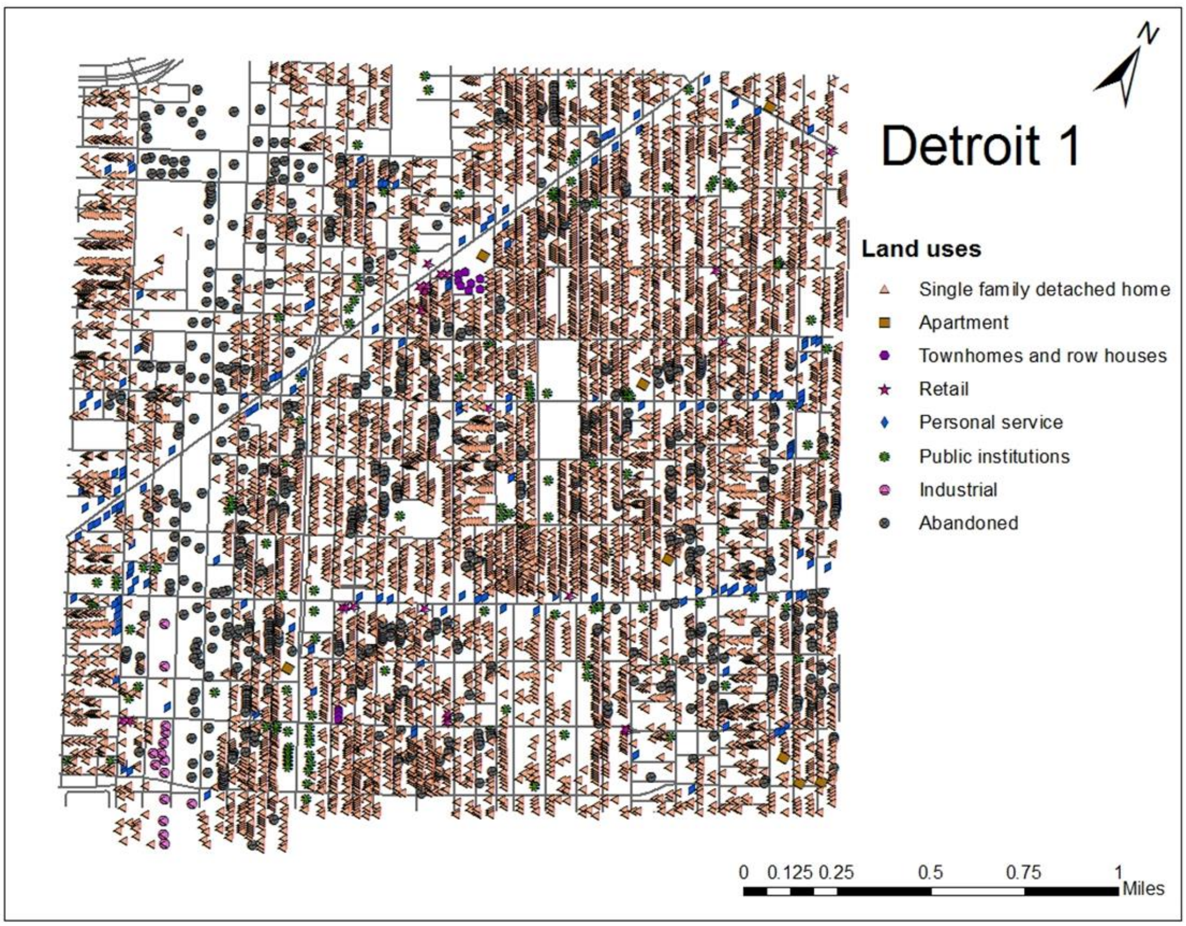


Figure 7 Land use density and types in Detroit 1 neighborhood (higher density urban). Maps produced by Jieun Lee.

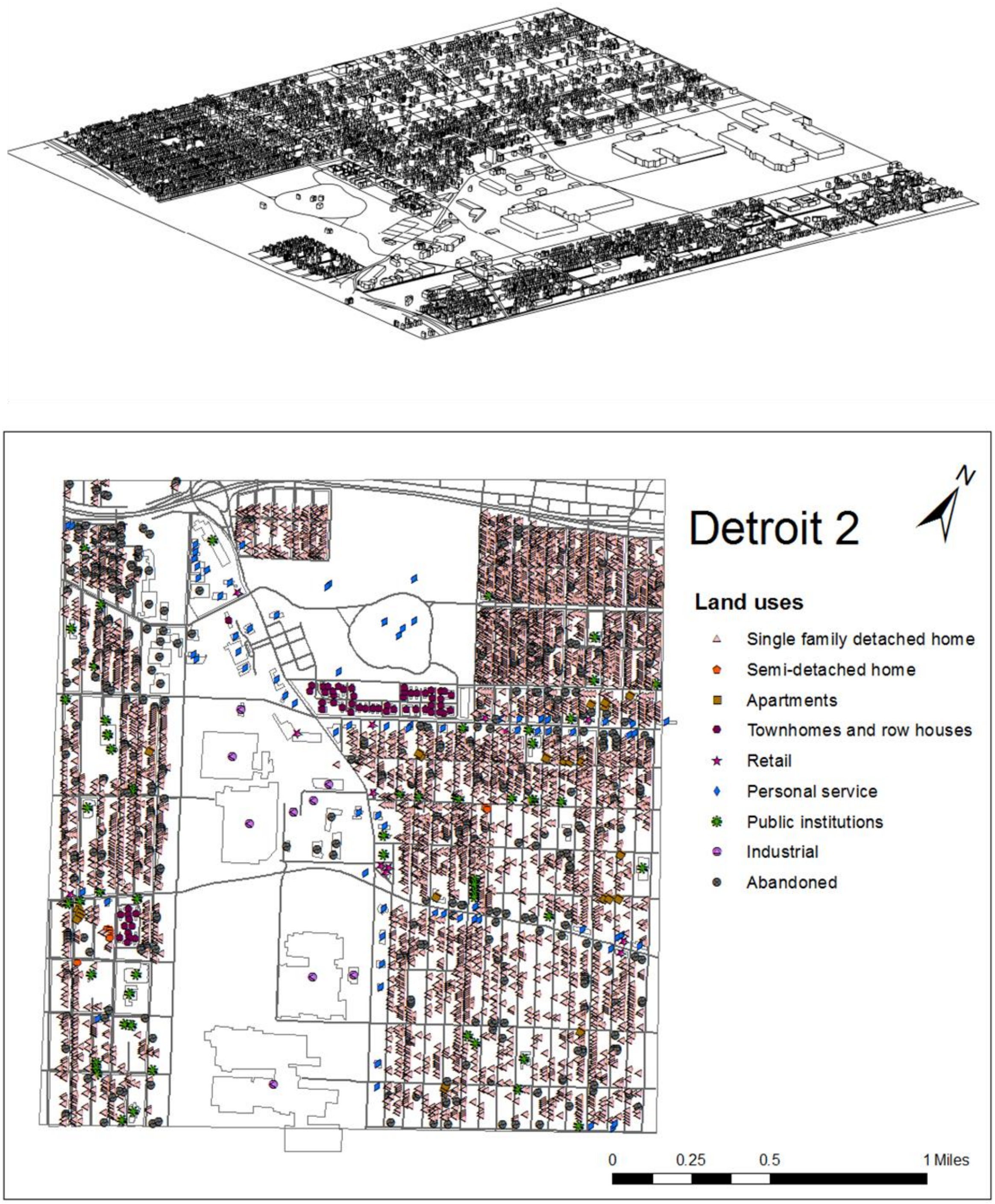


Figure 8 Land use density and types in Detroit 2 neighborhood (higher density urban). Maps produced by Jieun Lee.

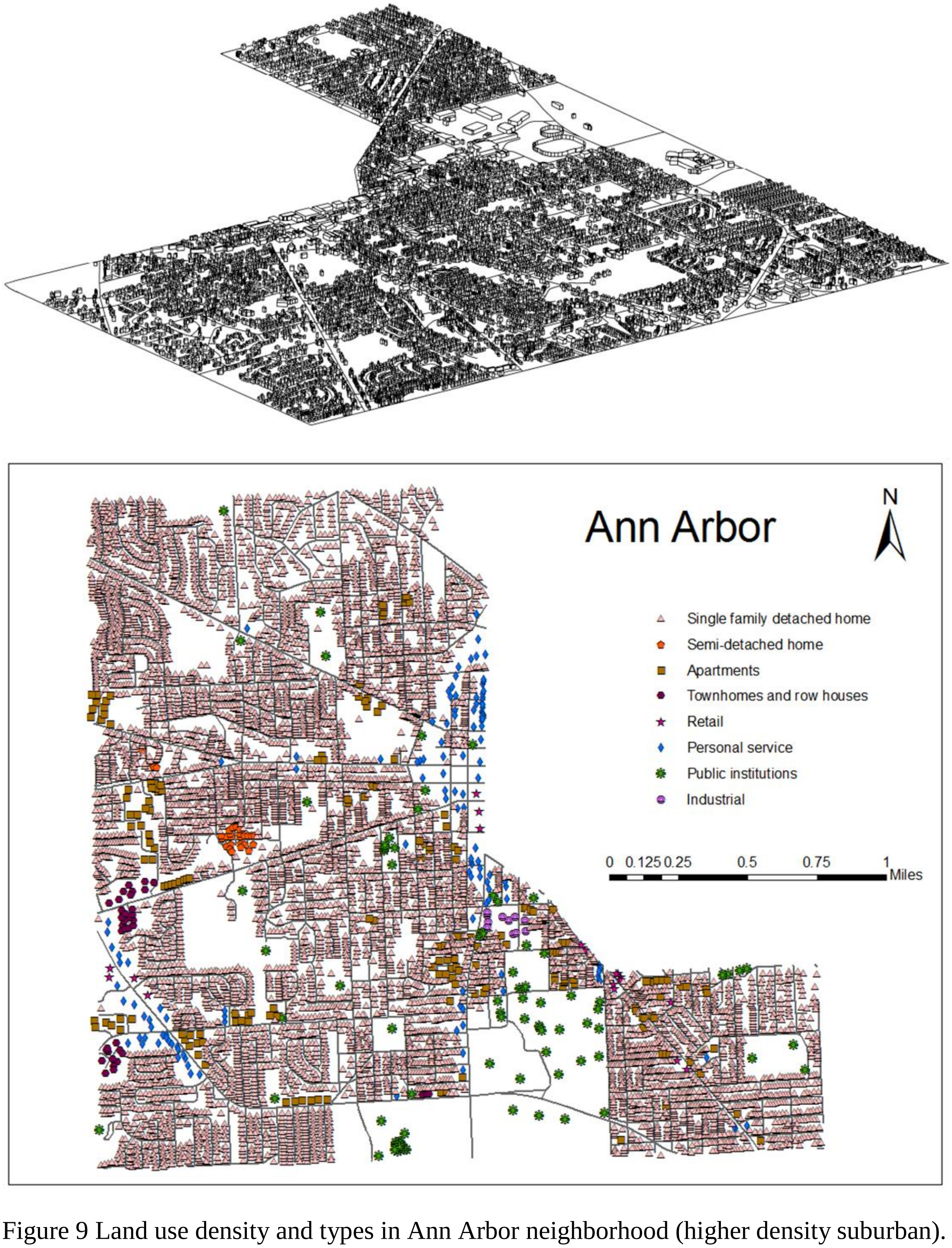


Figure 9 Land use density and types in Ann Arbor neighborhood (higher density suburban). Maps produced by Jieun Lee.

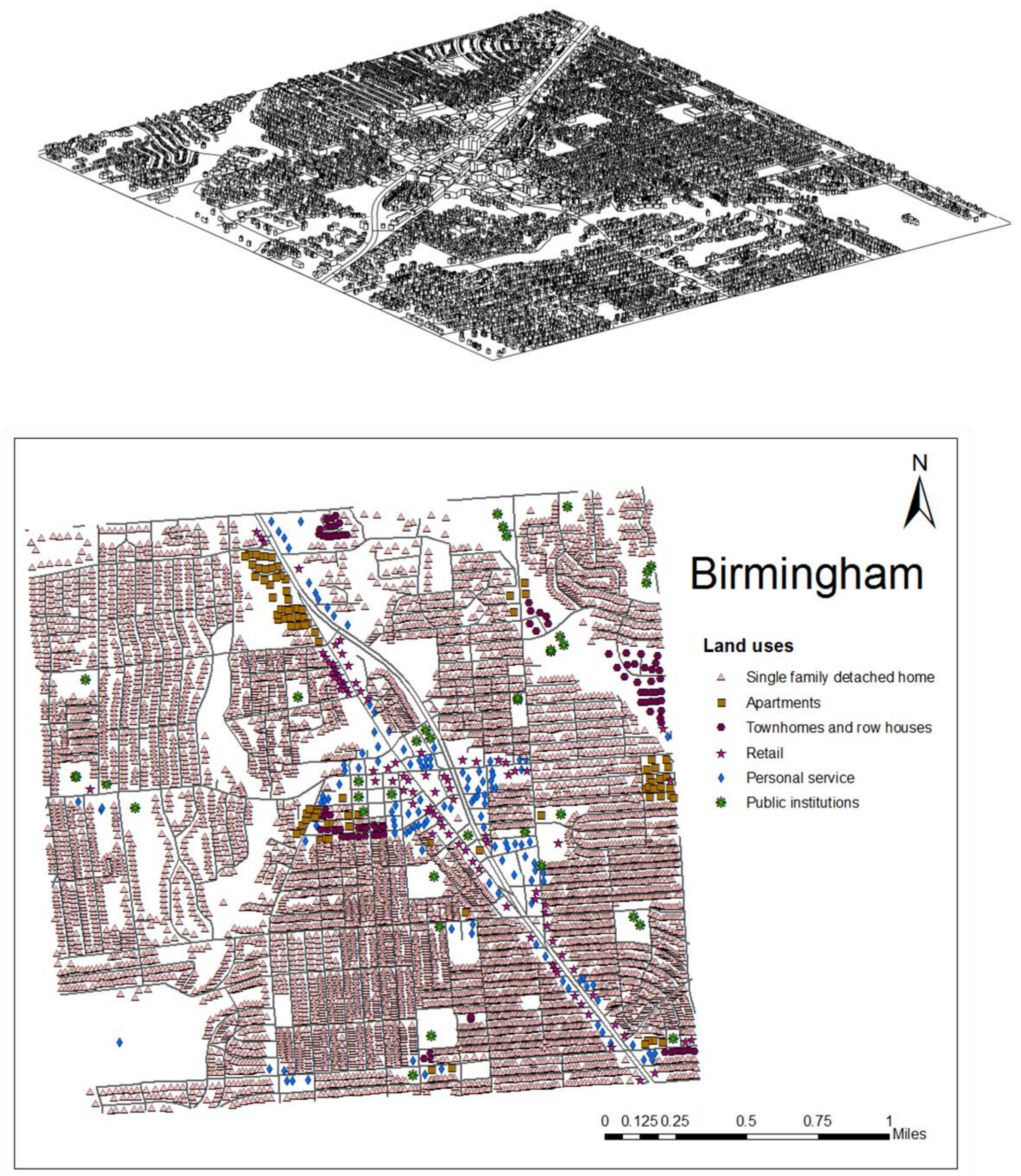


Figure 10 Land use density and types in Birmingham neighborhood (higher density suburban). Maps produced by Jieun Lee.

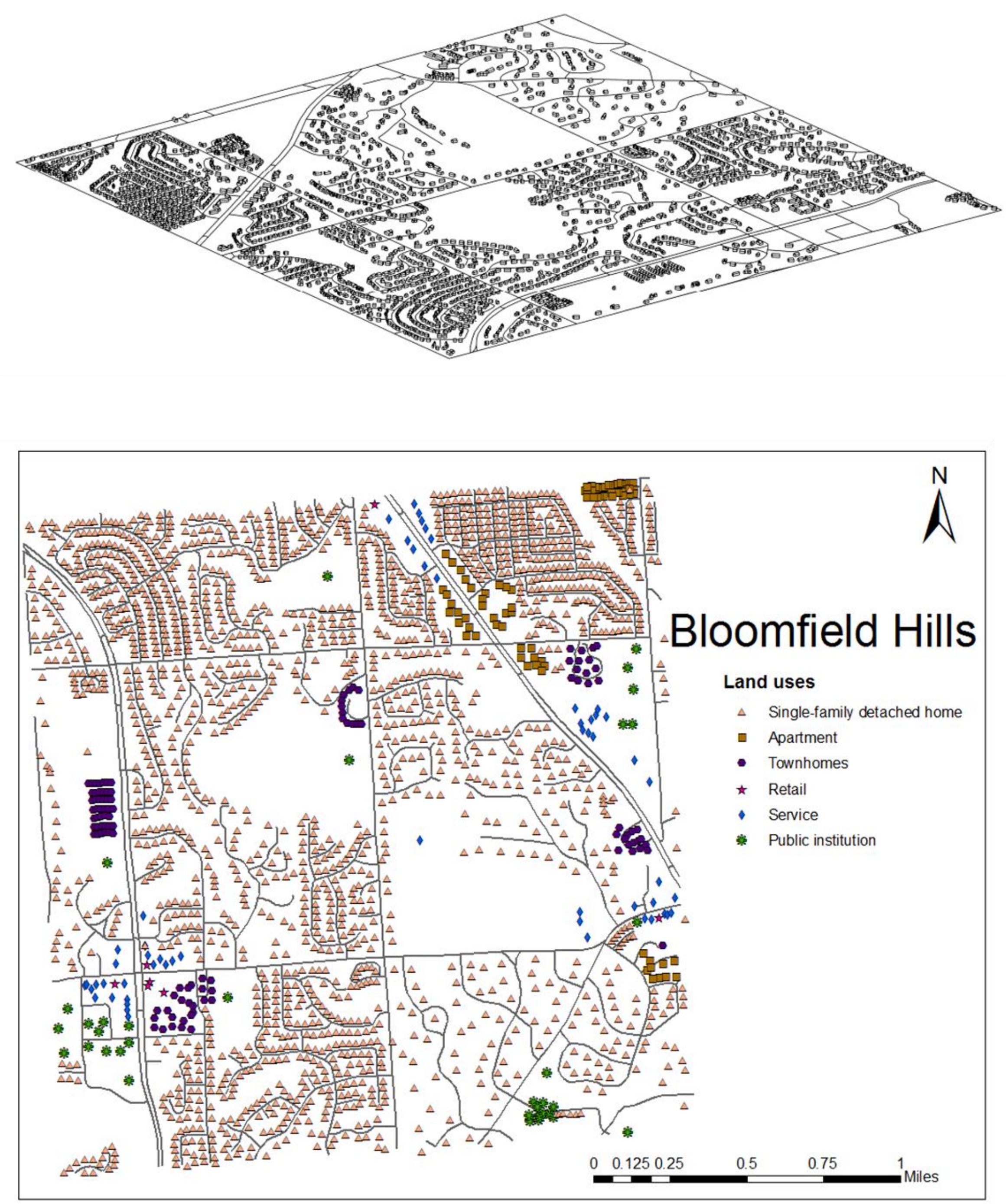
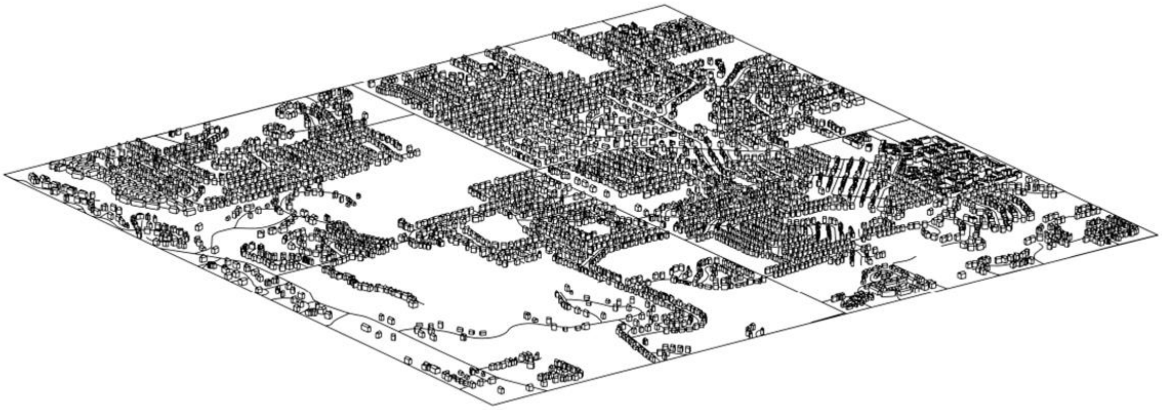


Figure 11 Land use density and types in Bloomfield Hills neighborhood (lower density suburban). Maps produced by Jieun Lee.



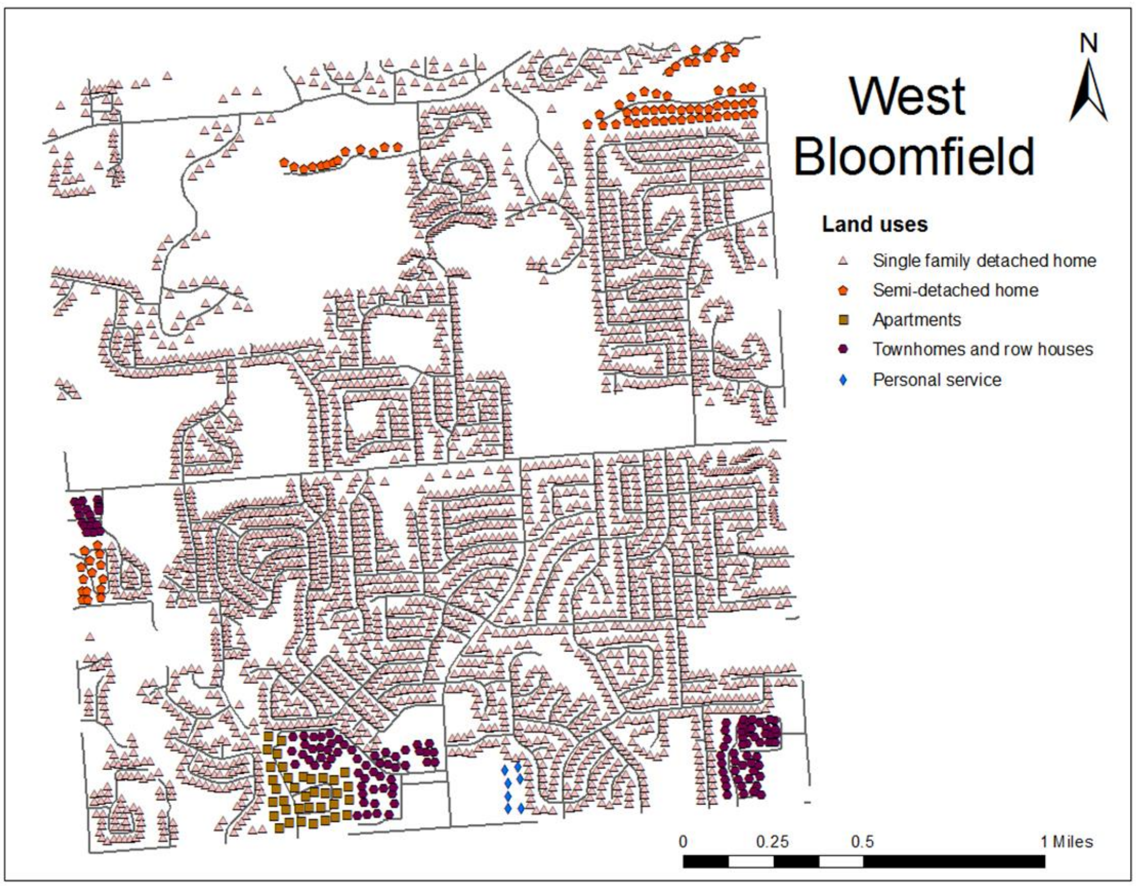


Figure 12 Land use density and types in West Bloomfield neighborhood (lower density suburban). Maps produced by Jieun Lee.

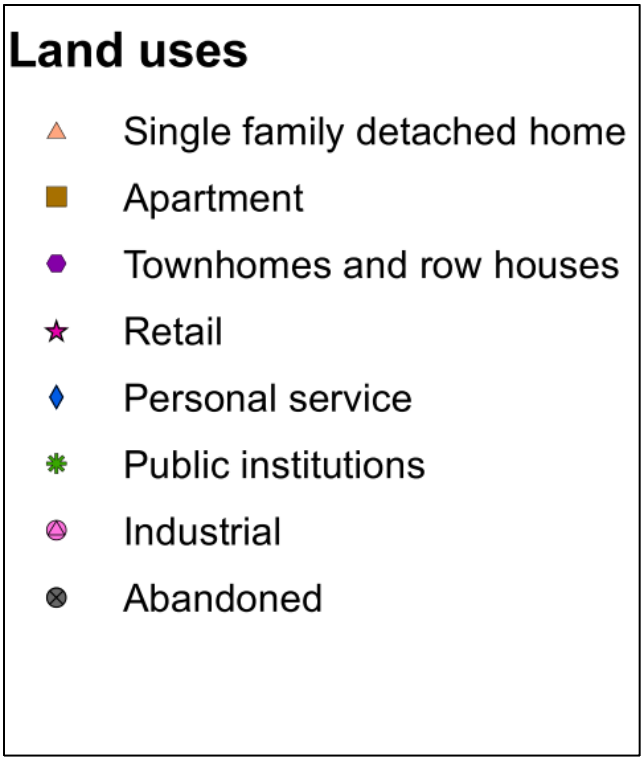
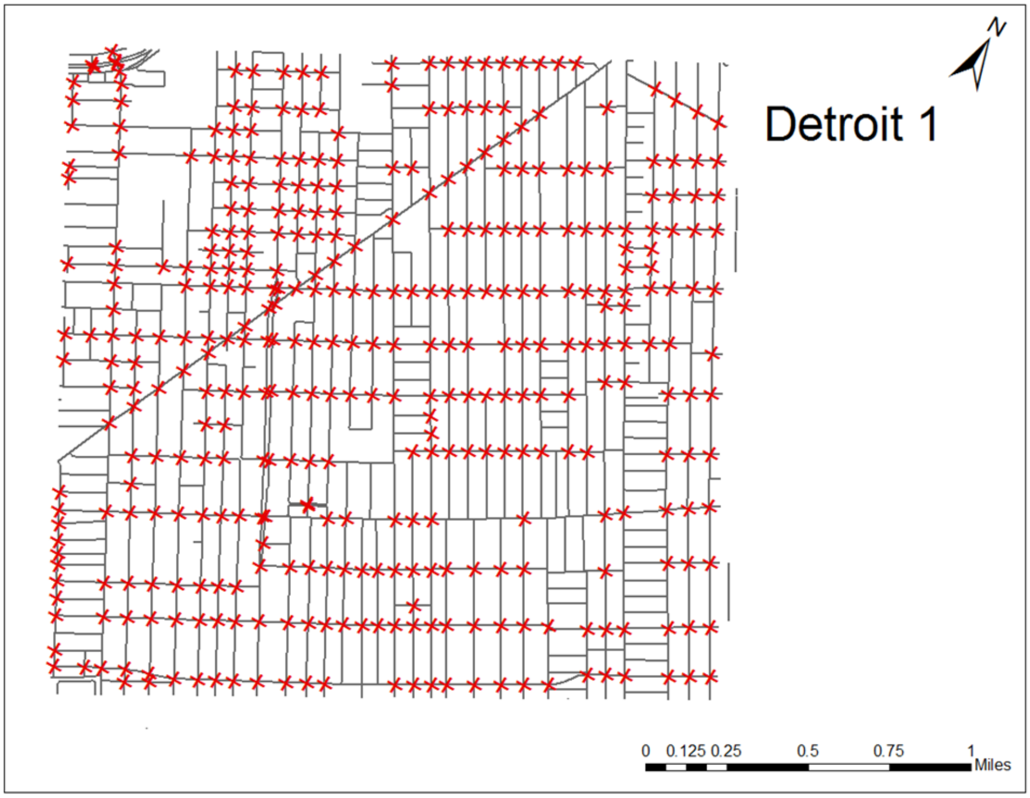


Figure 13 Land use type legend.



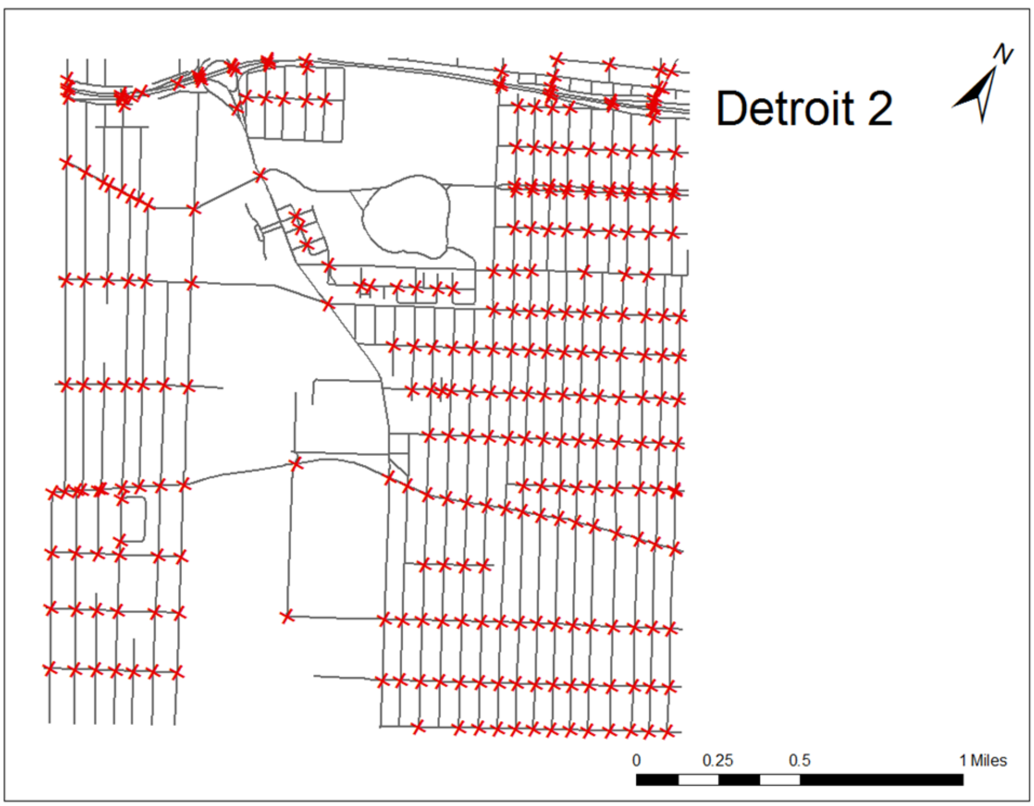
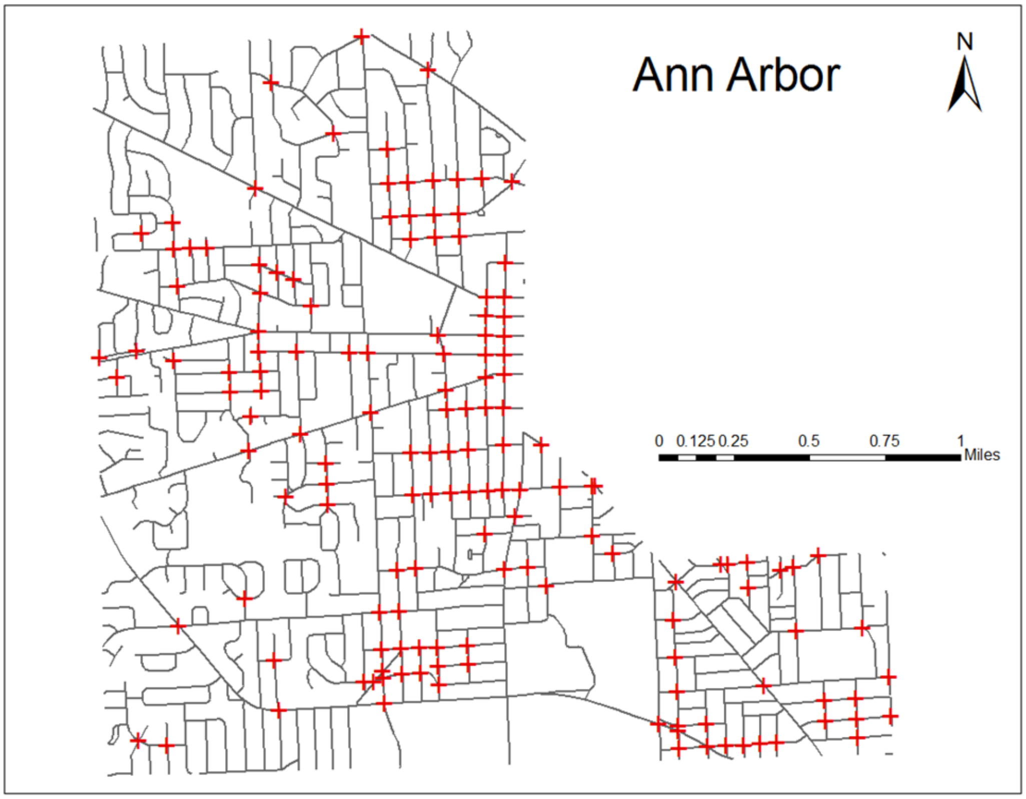


Figure 14 4-way intersection density in Detroit 1 and 2 neighborhoods (higher density urban). Maps produced by Jieun Lee.



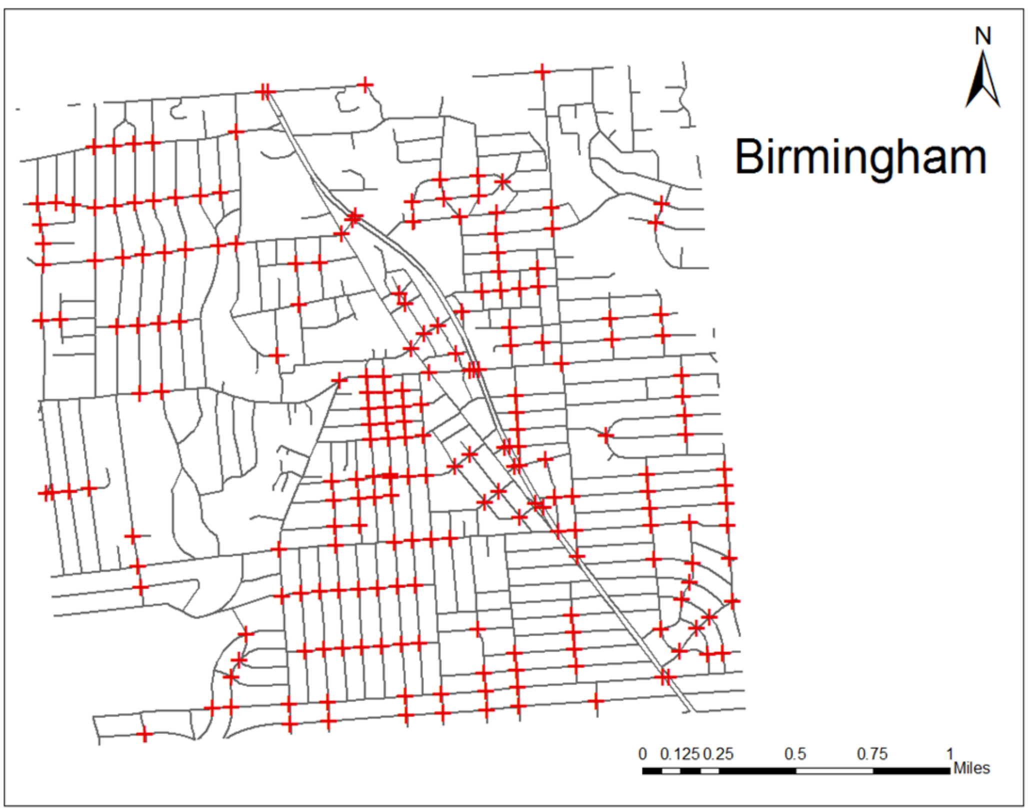
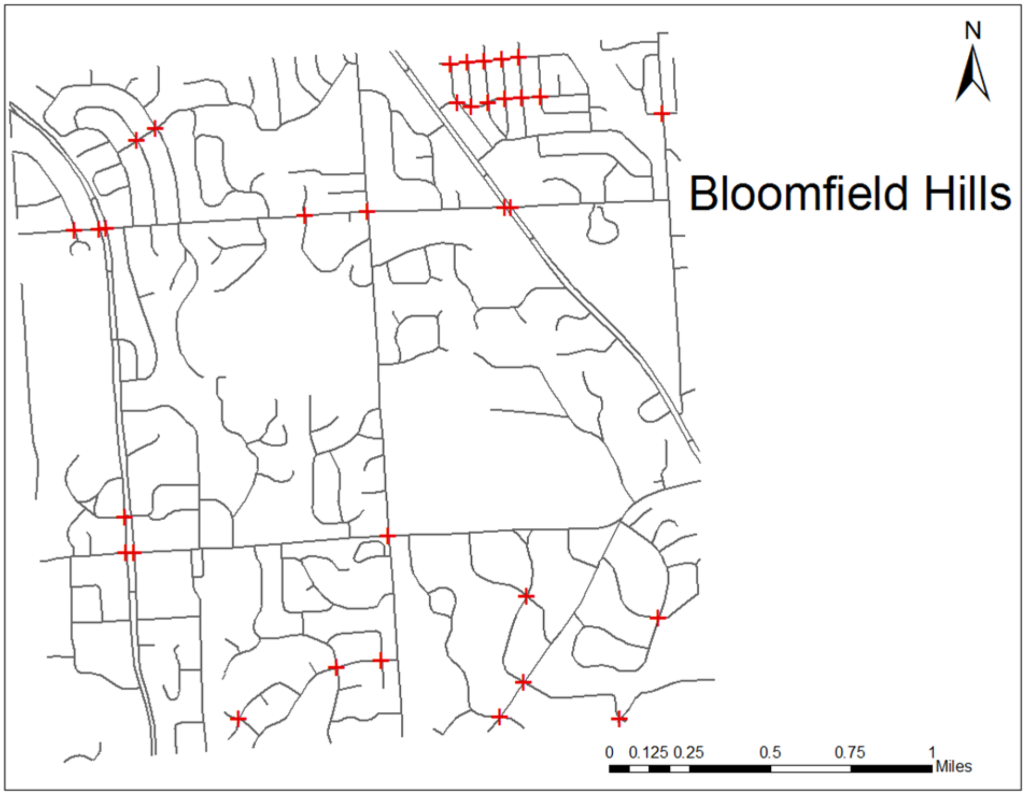


Figure 15 4-way intersection density in Ann Arbor and Birmingham neighborhoods (higher density suburban). Maps produced by Jieun Lee.



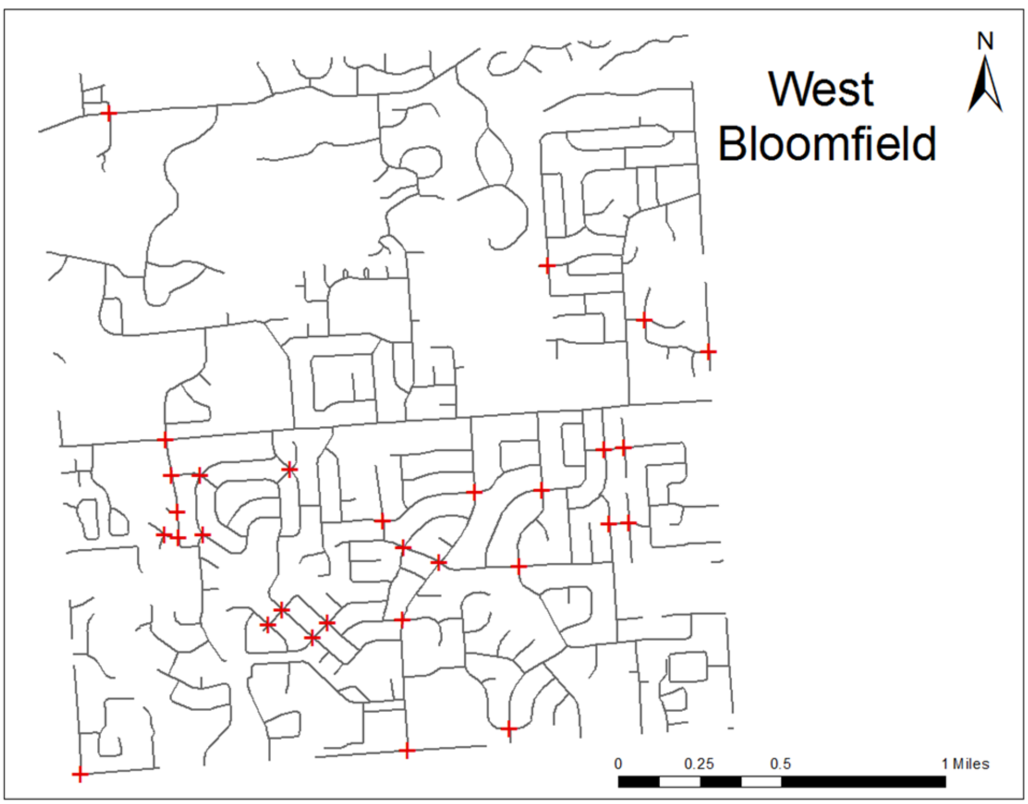


Figure 16 4-way intersection density in Bloomfield Hills and West Bloomfield neighborhoods (lower density suburban). Maps produced by Jieun Lee.

Despite of the higher density of urban amenities, the level of abandonments among the residential and nonresidential uses in the urban Detroit neighborhoods was also high (figures 17 to 24). On average, there were 65 visible abandoned structures per square kilometer in Detroit 1 and 43 visible abandoned structures per square kilometer in Detroit 2, whereas there were no visible abandoned structures in either of the higher density suburban neighborhood groupings.

Comparing nonresidential landscapes leads to an even clearer understanding of differing neighborhood qualities between the urban Detroit and the higher density suburban neighborhoods (figures 21, 22 and 23, 24). Accordingly, the extreme level of abandonment and the poor supply of certain commercial outlets results in a low-quality pedestrian environment in the urban Detroit neighborhoods (figures 25, 26 and 27, 28). Therefore, it becomes increasingly important to examine the qualitative dimensions of the neighborhood built environments, in addition to quantifying measurements such as urban density, land use mix, and road network connectivity, in order to understand the relationship between the urban built environment and individual travel behavior.

Accordingly, as the first step in chapter 3,relationships between urban built environment characteristics and individual travel behavior (pedestrian and driving trips) will be explored in the Detroit region, in order to examine at a fine spatial scale (i.e. walkable area from an individual’s residential location using actual road networks) the relationships between urban form and travel. Following this analysis, in chapter 4, three neighborhood typologies will be defined with regard to socioeconomic and demographic factors, neighborhood quality and travel patterns. Lastly, in chapter 5, the differences in daily travel between women and men will be analyzed after controlling for the neighborhood typology.

Figure 17 Abandoned residential and nonresidential structures in Detroit city's neighborhoods (A). Photographed by Jieun Lee (taken in 2010).

Figure 18 Abandoned residential and nonresidential structures in Detroit city's neighborhoods (B). Photographed by Jieun Lee (taken in 2010).

Figure 19 Residential areas in higher density suburban neighborhoods (Ann Arbor). Photographed by Jieun Lee (taken in 2010).

Figure 20 Residential areas in higher density suburban neighborhoods (Birmingham). Photographed by Jieun Lee (taken in 2010).

Figure 21 Commercial structures in Detroit city's neighborhoods (A). Photographed by Jieun Lee (taken in 2010).

Figure 22 Commercial structures in Detroit city's neighborhoods (B). Photographed by Jieun Lee (taken in 2010).

Figure 23 Commercial structures in higher density suburban neighborhoods (Ann Arbor). Photographed by Jieun Lee (taken in 2010).

Figure 24 Commercial structures in higher density suburban neighborhoods (Birmingham). Photographed by Jieun Lee (taken in 2010).

Figure 25 Pedestrian-hostile environment in Detroit city’s neighborhoods (A). Photographed by Jieun Lee (taken in 2010).

Figure 26 Pedestrian-hostile environment in Detroit city’s neighborhoods (B). Photographed by Jieun Lee (taken in 2010).

Figure 27 Pedestrian-friendly environment in higher density suburban neighborhoods (Birmingham). Photographed by Jieun Lee (taken in 2010).

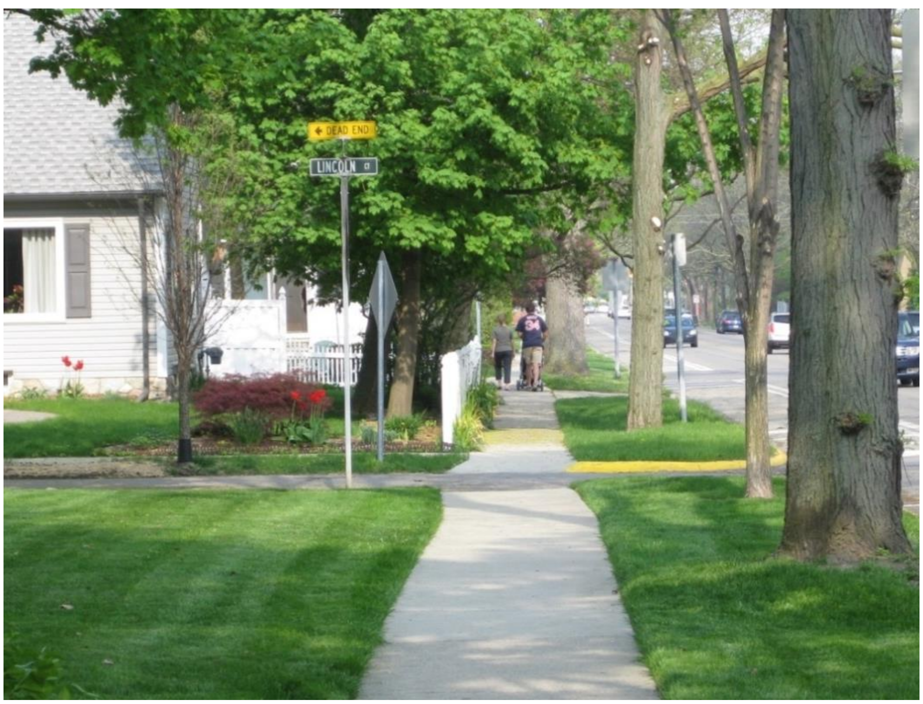


Figure 28 Pedestrian-friendly environment in higher density suburban neighborhoods (Ann Arbor). Photographed by Jieun Lee (taken in 2010).

CHAPTER 3: Built Environments and Individual Travel Behavior

In this part of the dissertation, I seek to examine how specific built environment characteristics (such as density, land use mix and connectivity) affect individual travel behavior, with a specific focus placed on pedestrian and driving trips in the Detroit region. The study hypothesis is that residents in higher density neighborhoods characterized by mixed land uses and connected road networks will travel more by non-motorized transportation modes. The results will identify built environment characteristic(s) that are most strongly associated with promoting pedestrian travel in the Detroit region, while discouraging driving.

Recently, with connections made to public health, there has been considerable research interest in studying the relationship between the built environment and travel behavior, and particularly pedestrian activity (Frank and Engelke, 2001, 2005; Frank et al., 2006; Frumkin et al., 2004; Handy et al., 2002; Handy et al., 2005; LFC, 2005; and Saelens et al., 2003a, 2003b). Previous studies have also investigated the potential causal links between specific built environment characteristics and travel behavior, stressing the natural environmental impacts of our resource intensive automobile travel patterns (Cervero and Gorham, 1995; Cervero and Kockelman, 1997; Ewing, 1997a; Frank and Pivo, 1995; Handy, 1996; and Kockelman, 1997). There have also been a variety of empirical works that have shown useful and rigorous ways to associate particular urban form characteristics with travel behavior (Boarnet and Crane, 1996, 2001; Cervero, 1996, 2002a; Cervero and Kockelman, 1997; Crane and Crepeau, 1998; and Kockelman, 1997).

The literature on the urban built environment and travel behavior shows that residents living in neighborhoods characterized by higher densities, better accessibility, and pedestrian-oriented designs are more likely to engage in non-motorized travel and travel less by automobile than residents living in neighborhoods characterized by lower densities, poor accessibility, and automobile-oriented designs (Boarnet and Crane, 2001a, 2001b; Cervero, 2002; Ewing and Cervero, 2001; Frank and Pivo, 1995; Frank, 2004; Handy, 2005a, 2006a, and 2006b; Saelens et al., 2003a, 2003b; Vojnovic, 2006; and Vojnovic et al., 2006; 2007; 2013). Initially, a variety of urban density measures (such as population and employment density, dwelling units, or building floor areas) were estimated to explain travel (Frank and Pivo, 1995; Levinson and Kumar, 1997; Cervero, 1996; Cervero and Kockelman, 1997; Boarnet and Crane, 2000b; and Ewing and Cervero, 2001). For example, the increased concentration in jobs within a short driving commute time was estimated to reduce daily household VMT (vehicle miles traveled) (Cervero and Kockelman, 1997). Cervero (1996) also found that people are less likely to drive to work and more likely to use transit if jobs are located nearby housing, and hence neighborhoods. Boarnet and Crane (2000) also showed that a greater concentration of commercial structures is associated with fewer nonwork automobile trips.

While many of these studies have shown significant relationships between density and trip frequency, average trip lengths, or travel mode split, the links between travel and density measures should be approached cautiously. Specifically, the results of density and travel analysis at aggregate levels of analyses—such as a city or a metropolitan area—which dominate existing literature are limited since average density of a city masks variations in density within this large geographic unit, and in turn, fails to reveal differences in land-use patterns and design characteristics between places with the same density (Newman and Kenworthy, 1989; and Handy, 1996). Moreover, as a travel measure, VMT per capita or household is often low in high-density places (such as the city of Detroit) mainly because of lower incomes (Crane, 1996).

Thus, it is crucial to incorporate density measures with other urban form factors to improve our understanding of the link between the built environment and travel behavior more accurately.

As a second set of urban form indicators, researchers have used ‘accessibility measures’ (Boarnet and Crane, 2001b; Cervero, 1996; Cervero and Kockelman, 1997; Frank and Pivo, 1995; Ewing and Cervero, 2001; Holtzclaw, 1994; Kitamura et al., 1994; and Messenger and Ewing, 1996). Accessibility measures include analyses on the diversity of land uses, such as retail, commercial uses, public institutions, industrial, or employment indicators. Different land uses are represented in the count, land area, or floor area. The entropy measure is also an important and popular diversity measure, where low values indicate single-use environments and higher values reveal more diverse land uses (Frank et al., 2004; and Ewing and Cervero, 2001). Destination accessibility, as an accessibility measure, represents ease of access to trip attractions. Handy (1993), for instance, uses the distance between one’s home and the closest store as a local accessibility measure.

Previous studies have found credible evidence in the links between accessibility and diversity measures and travel behavior. Cervero (1996), in exploring how land use mix affects work trip mode, found that people are less likely to travel by automobile to work and more likely to take transit if commercial, or other non-residential uses, are nearby. Boarnet and Crane (2001b) also explained, using regressions, the significant link between diverse commercial concentrations and less frequent non-work automobile trips. Land use diversity has particularly strong associations with the frequency of walking trips (Ewing and Cervero, 2001). In addition, mixed land uses are also related to shorter VMT in Ewing and Cervero’s (2001) study.

Connectivity measures are another urban built environment variable that is incorporated in travel behavior literature (Boarnet and Crane, 2001b; Cervero and Gorham, 1995; Ewing and Cervero, 2001; Handy, 1996; Vojnovic, 2006; Vojnovic et al., 2006). Connectivity measures represent street network characteristics within an area. Street networks vary from dense urban grids of highly connected, straight streets to suburban networks of curvilinear streets, cul-de-sacs and sparse intersections. Connectivity measures include average block size, proportions of four way intersections, and densities of intersections per areal unit. Ewing and Cervero (2001), for example, found that VMT is strongly associated with the design metrics of intersection density and street connectivity.

Individual (or household) travel behavior, however, is not only affected by built environment characteristics. It is also influenced by socioeconomic and demographic attributes of individuals or households. Using disaggregate measures of both urban form and individual (or household) socioeconomic and travel characteristics, therefore, emerges as a critical dimension to understanding the variations in individual travel. Notice, however, that travel research using aggregate measures for metropolitan areas, cities or zones does not allow for an exploration of underlying factors of behavioral conditions, or the mechanisms by which urban form affects individual decisions on trip making (Handy, 1996). Thus, disaggregate and neighborhood analyses are more revealing of the complexities in travel behavior by incorporating urban from measures into a transparent behavioral framework (Crane, 2000). Controlling for independent influences, such as household income, travel demands, and mode availability, multivariate disaggregate studies can isolate and explain more precisely the role of individual features of the built environment on travel (Crane, 2000).

Frank and Pivo (1995), for instance, estimated how different aspects of urban form are significantly related to different types of travel, while Handy (1993) used socio-economic characteristics of households—such as household income and car ownership—as explanatory variables to understand travel characteristics. Using regression analyses of individual travel data, Cervero and Kockelman (1997) also addressed the significant relationship between VMT per household, mode choice, and land use near a person's residence after controlling for individual socio-economic and demographic variables. Other researchers such as Kockelman (1999), Boarnet and Crane (2001b), Boarnet and Sarmiento (1998), and Crane and Crepeau (1998) expanded urban from and travel studies by incorporating travel cost variables as choice variables, and found that trip demands in each travel mode decrease significantly with increasing travel time and cost.

However, the existing literature has its limitations. First, most of the studies have focused on specific regional areas in the U.S., and particularly West Coast cities, such as San Francisco, San Diego, Los Angeles (California) and Seattle (Washington). Thus, the current literature on urban form and individual travel behavior has offered a limited understanding of urban travel within the U.S. metropolitan context. Particularly relevant for this research has been the absence of mid-West cities, many of which are experiencing disinvestment and decline within their neighborhoods. The Detroit region provides just such an example.

For instance, in metropolitan areas that are experiencing extreme urban decentralization, the pattern of suburban residents' longer commutes may be less valid since employment opportunities increase in the adjacent suburban areas, instead of the central city location. Furthermore, urban minorities in central cities face longer commutes to suburban employment locations due to disappearing employment opportunities near their homes in the city (Friedman et al., 1994; Crane, 2000; Kain, 1968; Vojnovic and Darden, 2013b). In addition, a proper geographic scale is critical to understand how urban form factors influence individuals' pedestrian travels (Crane 2000). As Utermann (1984) argued, smaller geographic scales (for example, covering one-quarter mile or so) are the appropriate scale to explore walking trips. Therefore, the incorporation of disaggregate built environment measures at a finer scale is fundamental to explain how an individual's walking trips are influenced by specific urban form factors within a walking distance from their residential location. This is why it is important to understand how urban density, land use mix and connectivity operate within a neighborhood level to answer these questions.

3.1. Research Objectives, Questions, and Hypotheses

This particular chapter seeks to understand the effects of the urban built environment in promoting pedestrian trips and reducing automobile use. It is hypothesized that people tend to use non-motorized modes of travel more in urban neighborhoods characterized by higher densities, mixed land uses and high connectivity. Subsequent research questions are whether non-motorized travel modes such as walking and cycling were utilized more in the neighborhoods that are characterized by higher-densities, mixed land uses and high connectivity while automobile travel was reduced in such neighborhoods for daily activities.

3.2. Built Environment and Travel Research Data and Method

3.2.1. Built environment and travel research data

To identify differing built environment characteristics in the Detroit region, three urban form factor categories were selected. These urban form factors were used in the analysis as independent variables to explain how individual travel behavior, and particularly pedestrian and driving trips, was influenced by the surrounding urban physical environment. First, urban development density was measured as the number of residential and non-residential structures in the neighborhood. Next, land use mix indices were created to describe a proportion of a land use to all land use types, ranging from three to eight categories. Lastly, connectivity was calculated using the number of 4-way intersections and bus stops.

In the Detroit region, 2 by 2 mile neighborhoods (about a 4 sq. mile area) were selected with differing built environment characteristics. Two Detroit urban neighborhoods and two higher density suburban neighborhoods (one in Ann Arbor and in Birmingham) were selected as the higher density urban development neighborhoods that were also characterized by highly connected road networks and mixed land uses. In contrast, the lower density suburban neighborhoods (one from Bloomfield Hills and one from West Bloomfield) were selected as the neighborhoods representing typical low density urban developments, characterized generally by a single dominant land use (residential) and disconnected road networks.

An added dimension of this study involved collecting and recording built environment elements, land uses and bus stops for an area covering half a mile distance from each neighborhood boundary. This additional process was necessary to obtain built environment characteristics that were within an area with a walking distance of half a mile from a respondent's address. In total, spatial data of built environment characteristics for six 3 by 3 mile neighborhoods, about 9 sq. miles each, in the Detroit region were created.

To configure the density and land use mix, the entire built environment within the neighborhoods were digitally created from the 2005 US Geological Survey digital orthophoto quarter quads datasets (DOQQs) that were obtained from the Michigan State's Geographic Data

Library (http://www.mcgi.state.mi.us/). Using ESRI ArcGIS 10.1, I digitized each single structure for the entire area of the six neighborhoods, and I calculated X and Y coordinate for each structure's centroid. On average, there were 12,647 building structures in each urban Detroit neighborhood, whereas the higher density suburban neighborhoods had 12,860 building structures, and the lower density suburban neighborhood had 5,137 building structures.

To assign a land use type to a single structure, site surveys of the neighborhoods were carried out to record the land uses. From these field surveys, land uses were categorized into 10 classes; single-family detached homes, semi-detached homes, apartments, townhomes/row houses, retail, personal services, public institutions, industrial, abandoned, and others. As shown in table 8, these land uses were grouped into 6 subsets—residential, commercial, public institutions, industrials, abandonment, and others. Abandoned structures were included in the dataset in order to capture a specific quality in the neighborhoods; built environments that are experiencing urban disinvestment and decline.

In terms of the land-use mix, on average, in the urban Detroit neighborhoods, 89.1% of the total structures were residential, while 95.9% were residential in the lower density suburban neighborhoods and 93.3% were residential in the higher density suburban neighborhoods (table 9). This is expected given the built environment characteristics of the high density, mixed land use urban Detroit neighborhoods. However, the Detroit figures are also influenced by the higher proportion of abandonment (5.0%, 1,266 building structure counts) in urban Detroit; illustrating the extent to which these neighborhoods are experiencing severe disinvestment and decline.

Table 8 Neighborhood built environment characteristics by neighborhood in the Detroit study region

Count (%)[1]	Higher density urban		Higher density suburban		Lower density suburban	
	DT1	DT2	AA	BM	BH	WB
URBAN DENSITY with land use types						
Residential	11,589 (86.9)	10,984 (91.9)	11,908 (90.4)	12,085 (96.4)	3,974 (92.9)	5,875 (98.0)
Single-family detached home	11,345 (85.0)	10,861 (90.9)	11,204 (85.0)	11,828 (94.3)	3,676 (85.9)	5,497 (91.7)
Semi-detached home	2 (0.0)	8 (0.1)	31 (0.2)	0 (0.0)	21 (0.5)	142 (2.4)
Apartments	199 (1.5)	46 (0.4)	553 (4.2)	128 (1.0)	105 (4.0)	78 (1.3)
Townhomes/ Rowhouses	43 (0.3)	69 (0.6)	120 (0.9)	129 (1.0)	172 (4.0)	158 (2.6)
***Nonresidentia*l**	583 (4.4)	454 (3.8)	1171 (8.9)	453 (3.6)	298 (7.0)	115 (1.9)
Retail	108 (0.8)	114 (1.0)	100 (0.8)	106 (0.8)	42 (1.0)	63 (1.1)
Personal service	245 (1.8)	210 (1.8)	787 (6.0)	272 (2.2)	156 (3.6)	31 (0.5)
Commercial	353 (2.6)	324 (2.7)	887 (6.7)	378 (3.0)	198 (4.6)	94 (1.6)
Public institution	215 (1.6)	121 (1.0)	272 (2.1)	75 (0.6)	100 (2.3)	21 (0.4)
Industrial	15 (0.1)	9 (0.1)	12 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Abandoned	754 (5.7)	512 (4.3)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.0)
Others	415 (3.1)	3 (0.0)	100 (0.8)	2 (0.0)	7 (0.2)	2 (0.0)
TOTAL	13,341 (100)	11,953 (100)	13,179 (100)	12,540 (100)	4,279 (100)	5,994 (100)
Connectivity and Bus Stops						
4-way intersection	770	574	317	399	75	57
Bus stops	386	321	372	108	29	51

1. The percentages of each land use category based on the TOTAL urban built structures within the neighborhood.
*DT1: Detroit 1; DT2: Detroit 2; AA: Ann Arbor; BM: Birmingham; BH: Bloomfield Hills; and WB: West Bloomfield.

Table 9 Neighborhood built environment characteristics by neighborhood group in the Detroit study region

Count (%)[1]	Higher density urban	Higher density suburban	Lower density suburban
URBAN DENSITY with land use types			
Residential	22,573 (89.1)	23,993 (93.3)	9,849 (95.9)
Single-family detached home	22,206 (87.7)	23,032 (89.6)	9,173 (89.3)
Semi-detached home	10 (0.0)	31 (0.1)	163 (1.6)
Apartments	245 (1.0)	681 (2.6)	183 (1.8)
Townhomes/ Rowhouses	112 (0.4)	249 (1.0)	330 (3.2)
Nonresidential	1,037 (4.1)	1,624 (6.3)	413 (4.0)
Retail	222 (0.9)	206 (0.8)	105 (1.0)
Personal service	455 (1.8)	1,059 (4.1)	187 (1.8)
Commercial	677 (2.7)	1,265 (4.9)	292 (2.8)
Public institution	336 (1.3)	347 (1.3)	121 (1.2)
Industrial	24 (0.1)	12 (0.0)	0 (0.0)
Abandoned	1,266 (5.0)	0 (0.0)	2 (0.0)
Others	424 (1.7)	102 (0.4)	9 (0.1)
TOTAL	25,324 (100)	25,719 (100)	10,273 (100)
Connectivity and Bus Stops			
4-way intersection	1,299	716	132
Bus stops	591	480	80

1. The percentages of each land use category based on the TOTAL urban built structures within the neighborhood.

The differing neighborhood qualities become even clearer when the number, and proportion, of retail establishments in the neighborhoods are compared. In spite of the similar higher density characteristics, and the similar connectivity in the road network among the urban Detroit and higher density suburban neighborhoods, there were more retail and commercial establishments in the higher density suburban neighborhoods than in the urban Detroit neighborhoods (tables 8 and 9). Categories of land uses are used to calculate land use mix indices for each road network buffer in order to understand the relationship between the land use mix and pedestrian (or driving) trips.

With regard to the street connectivity measures, information on 4-way intersections was also collected. To obtain the number of 4-way intersections in the neighborhoods, I used the ESRI ArcGIS 10.1 Geometric Network tool to create a shapefile of 'real node' points (intersections). A 'real node' is a connectivity measure that represents a network point connecting two links, as opposed to a 'dangle node' with a link such as a dead-end or cul-de-sac (Dill and Voros, 2007). Of the intersecting nodes, I intentionally chose 4-way intersections as a more strict measure of connectivity, because a 3-way intersection can be a 'dangle node,' which predominantly exists in low density suburbs with disconnected road networks. There were 1,299 'real node' points detected–4-way (or more) intersections—in urban Detroit neighborhoods (770 in Detroit 1 and 574 Detroit 2), and 716 were evident in the higher density suburban neighborhoods (317 in Ann Arbor and 399 in Birmingham). However, as expected, there was a much smaller number, only 132 4-way and more intersections in the lower density neighborhoods (75 in Bloomfield Hills and 57 in West Bloomfield) (see tables 8 and 9).

Lastly, local and regional bus stop information was included in the analysis as a connectivity measure to public transit. In order to establish a dataset of public transit, the latitudes and longitudes of bus stops in the study area neighborhoods were collected. Two bus stops on each side of the road were counted as separate bus stops. For two urban Detroit neighborhoods, the geographic coordinates were obtained from the Detroit Department of Transportation (www.detroitmi.gov). Using X and Y coordinates, bus stops in the urban Detroit neighborhoods were digitally located in ArcGIS 10.1. Geographic coordinate information of bus stops in the Ann Arbor neighborhood was collected from the Ann Arbor Transportation Authority (http://www.theride.org/). The list of bus stops in the lower density suburban neighborhoods, Bloomfield Hills and West Bloomfield, were also established digitally from Google Maps online (https://maps.google.com/), as were the geographic coordinates of each bus stop.

Table 8 shows clear distinctions between the three neighborhood groups. The four higher density urban and suburban neighborhoods were characterized with a higher level of built development structures, 4-way intersections and bus stops. The two higher density suburban neighborhoods, however, differ from the two Detroit urban neighborhoods in terms of their greater variety of land uses in the neighborhoods. Again, this was the dimension of the research design that allows for the assessment of travel behavior in neighborhoods experiencing disinvestment and decline. Unlike the urban Detroit and higher density suburban neighborhoods, the two lower density suburban neighborhoods had fewer built structures, little or no variation in land uses (the neighborhoods were predominantly residential) and fewer 4-way intersections and bus stops.

To demonstrate the effects of built environment characteristics on individual travel behavior, I constructed a variety of 'walkability' measures within a walking distance from an individual's residential address. Walkability is an estimation of how conducive the built environment is to pedestrian activity as an active transportation (Forsyth and Southworth, 2008; Frank et al., 2005; Frank et al., 2009; Leslie et al., 2007; Moudon et al., 2006; Owen et al., 2004; and Sallis et al., 2004). I defined a 'walkable area' of a half a mile (about 0.8 km) distance from a survey respondent's residential address (Ewing, 1998, 2000; O'Sullivan and Morrall, 1996; and Sallis et al., 2004). With the ArcGIS geocoding process, 1,106 residential addresses of survey respondents were located. Then, using the ESRI ArcGIS Network Analyst, I created 'road network buffers (RNBs)', each being a service area of a half a mile distance, running in different in-network directions from a residential location using the actual road network (see figure 29 to 34). The RNBs boundaries are determined by a series of a half mile distances in all road network directions from each residence, with the half mile distance based on the actual in-network road distance. The spatial linear data of the actual road network system were downloaded from the US Census Tiger Line data. Table 10 shows how many RNBs were created for each study area neighborhood.

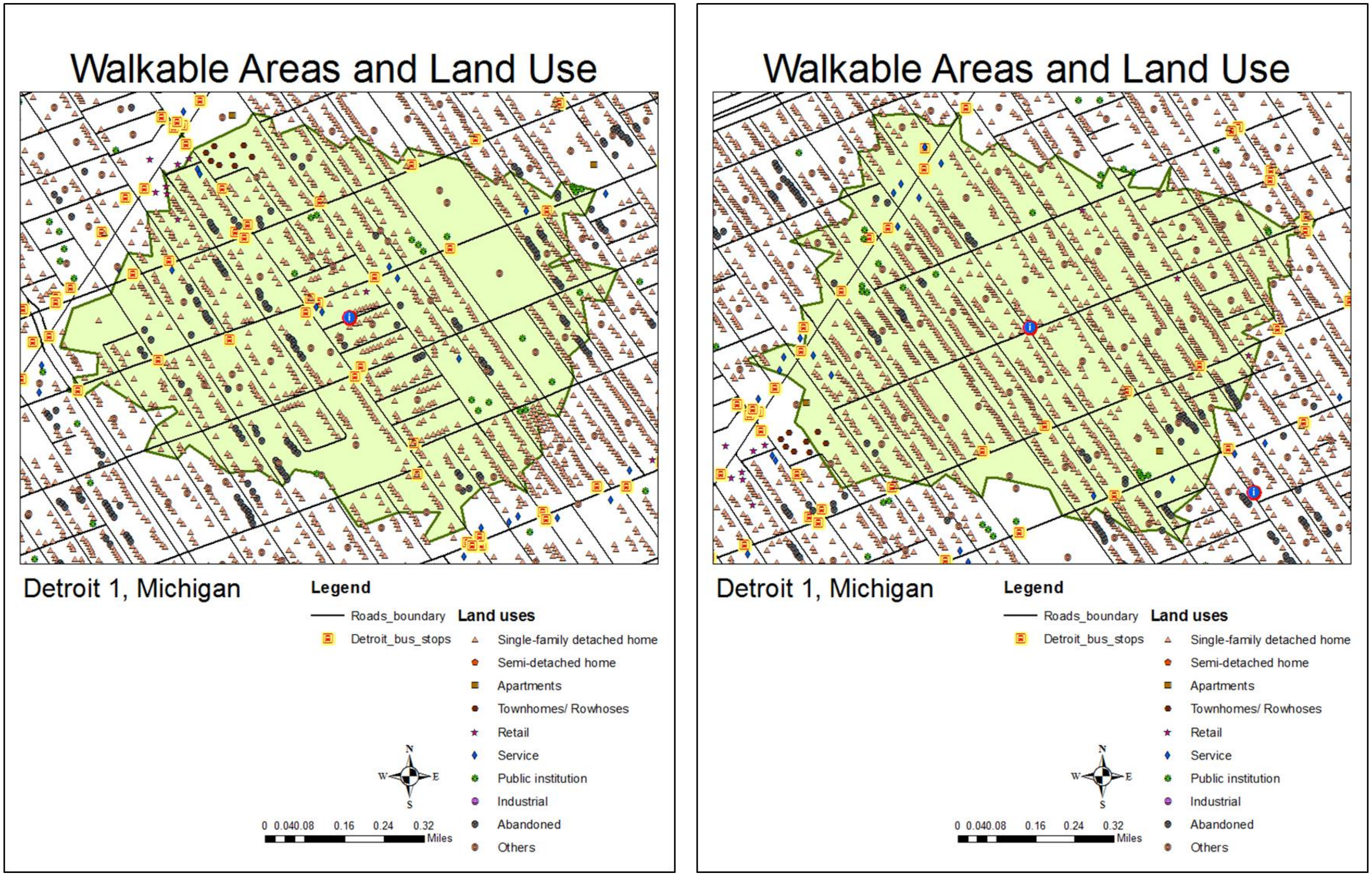


Figure 29 Two examples of road network buffers (RNBs) in the Detroit 1 neighborhood. The light green shaded area is the road network buffer. The blue circle with the red outline in the middle of the road network buffer is a residential location of a survey respondent. Map produced by Jieun Lee.

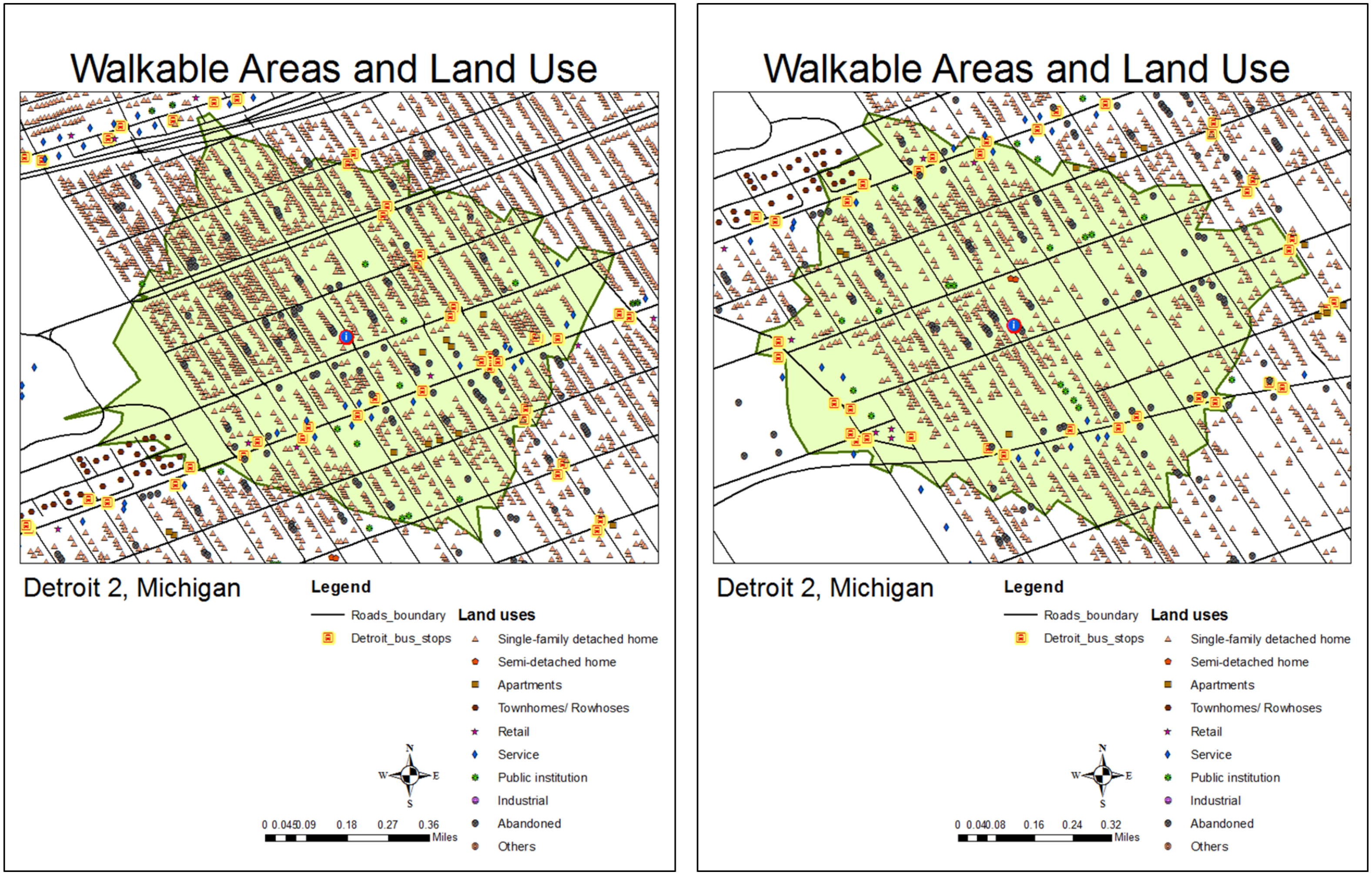


Figure 30 Two examples of road network buffers (RNBs) in the Detroit 2 neighborhood. The light green shaded area is the road network buffer. The blue circle with the red outline in the middle of the road network buffer is a residential location of a survey respondent. Map produced by Jieun Lee.

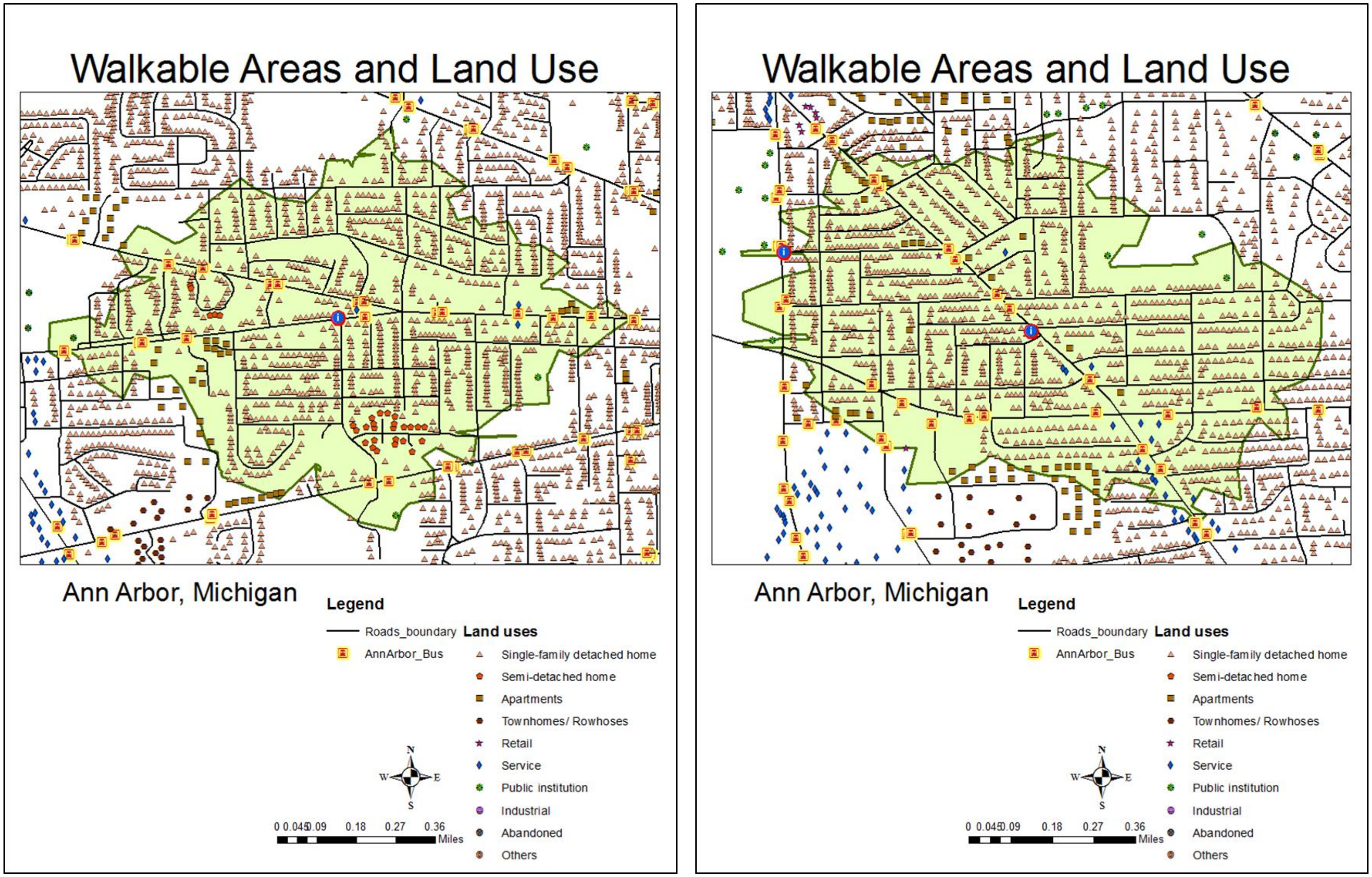
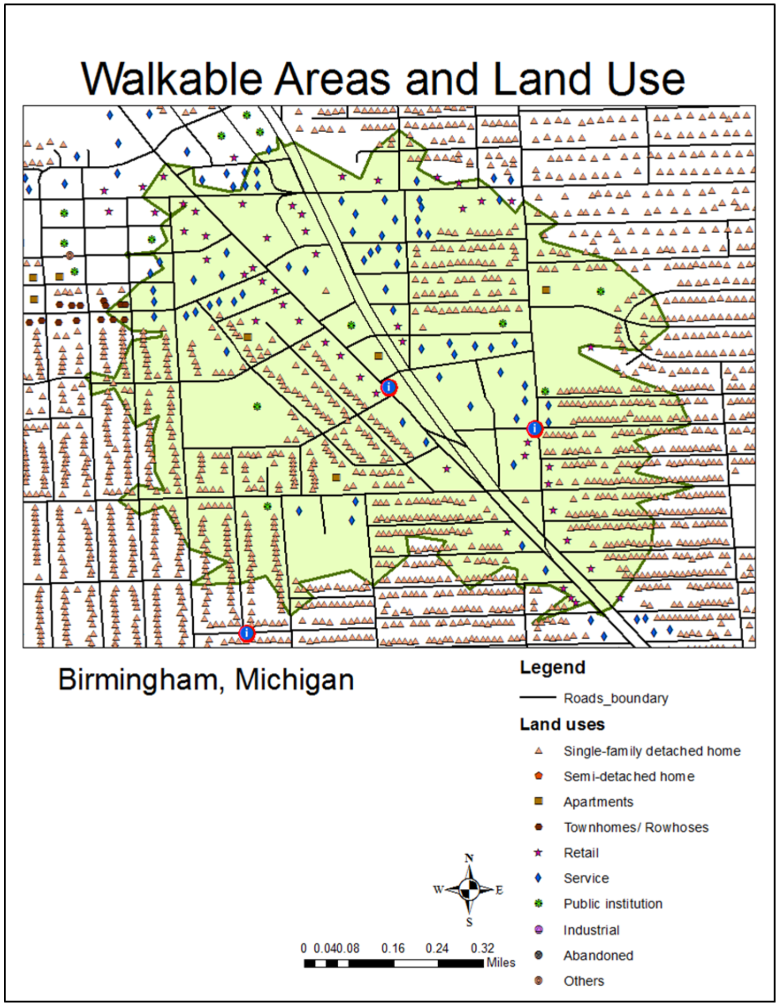


Figure 31 Two examples of road network buffers (RNBs) in the Ann Arbor neighborhood. The light green shaded area is the road network buffer. The blue circle with the red outline in the middle of the road network buffer is a residential location of a survey respondent. Map produced by Jieun Lee.



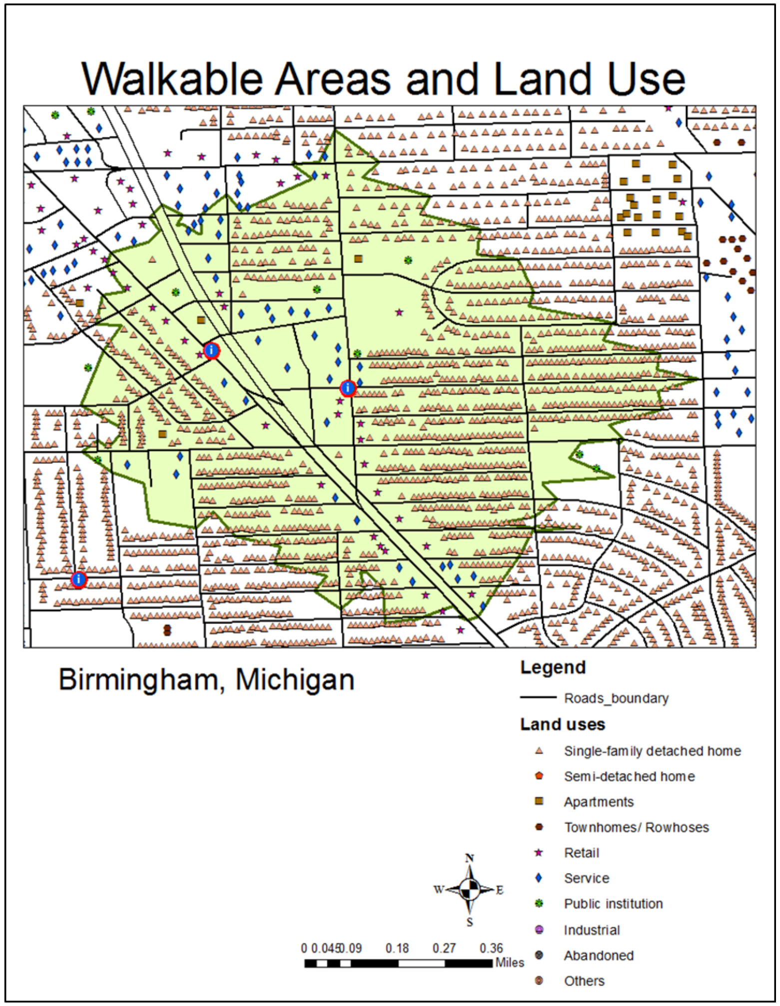


Figure 32 Two examples of road network buffers (RNBs) in the Birmingham neighborhood. The light green shaded area is the road network buffer. The blue circle with the red outline in the middle of the road network buffer is a residential location of a survey respondent. Map produced by Jieun Lee.

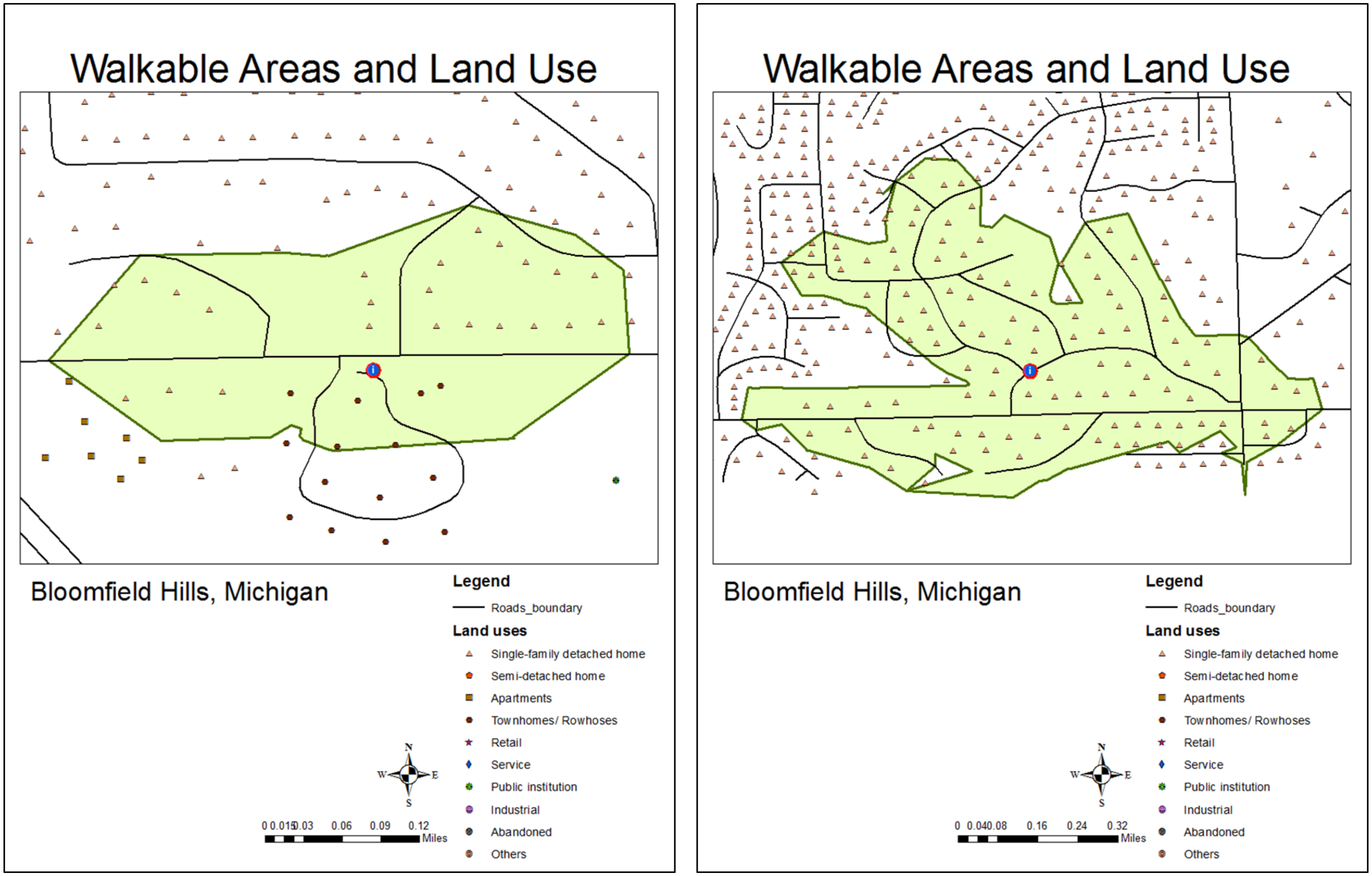


Figure 33 Two examples of road network buffers (RNBs) in the Bloomfield Hills neighborhood. The light green shaded area is the road network buffer. The blue circle with red outline in the middle of the road network buffer is a residential location of a survey respondent. Map produced by Jieun Lee.

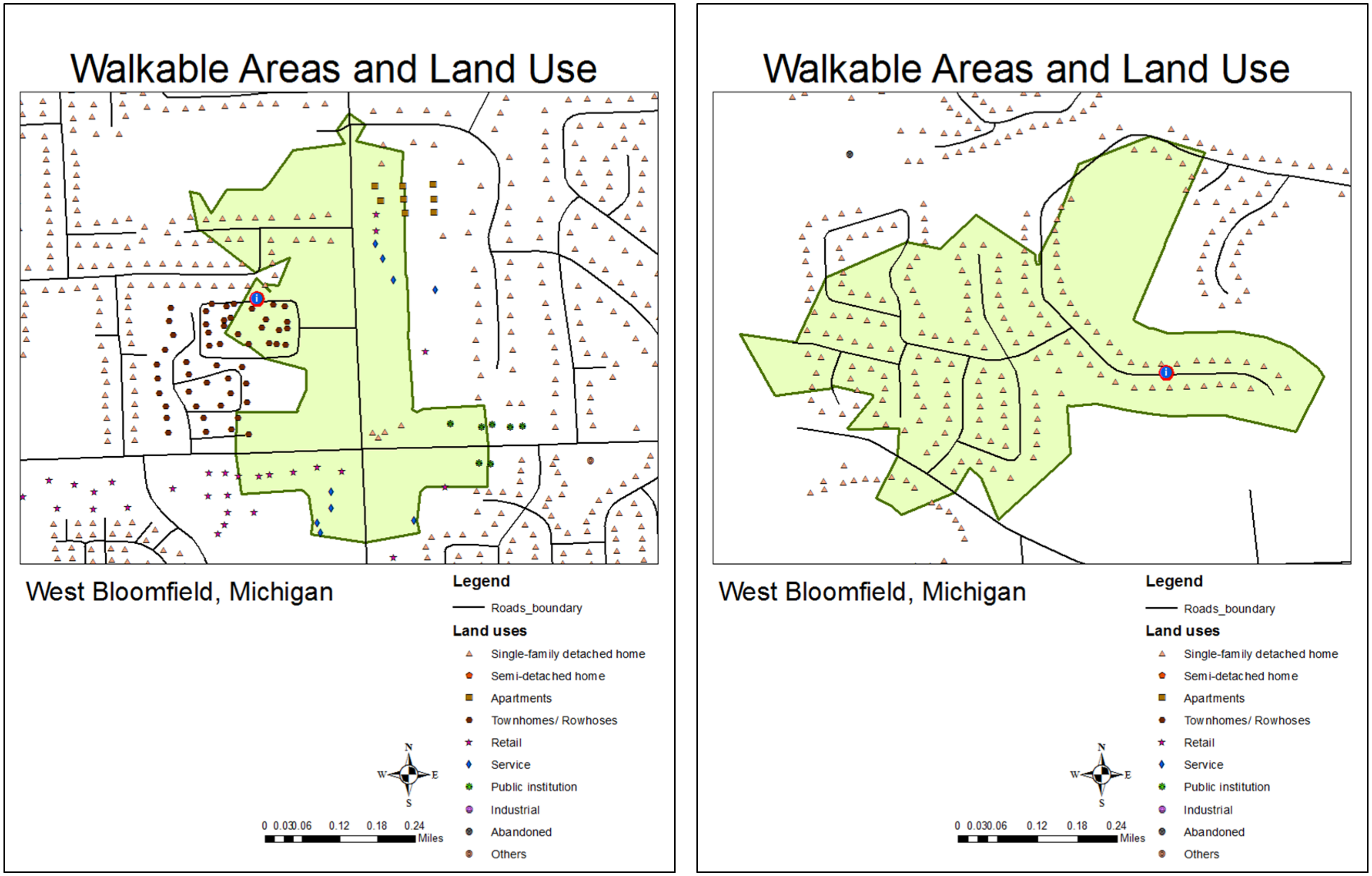


Figure 34 Two examples of road network buffers (RNBs) in the West Bloomfield neighborhood. The light green shaded area is the road network buffer. The blue circle with the red outline in the middle of the road network buffer is a residential location of a survey respondent. Map produced by Jieun Lee.

Table 10 Total number and average area of the road network buffers (RNB) by neighborhood

	Higher density urban		Higher density suburban		Lower density suburban		
	DT1	DT2	AA	BM	BH	WB	Total
The number of RNBs	122	107	279	195	205	198	1,106
The average area of RNB (sq. mi)	0.438	0.410	0.357	0.365	0.256	0.245	0.334

*DT1: Detroit 1; DT2: Detroit 2; AA: Ann Arbor; BM: Birmingham; BH: Bloomfield Hills; and WB: West Bloomfield.

In this study, the total of 1,106 road network buffers (RNBs) were created from respondents' residential addresses that were geocoded using street address line data for the entire survey sample in all six neighborhoods. By looking at the average areas of road network buffers by the neighborhoods (table 10), it becomes evident that a pedestrian can reach a larger area in densely developed neighborhoods with connected road networks. For example, the average area per Detroit urban RNB is larger than the average area per suburban RNB. Also, the average area of each higher density suburban RNB is larger than the average area of a lower density suburban RNB. This means that within the RNB—the boundaries of which, once again, are determined by walking for a half a mile along the road network in different directions from one's home—a resident in the Detroit urban neighborhoods can potentially cover an area of 0.44 sq. mile (Detroit 1) and 0.41 sq. mile (Detroit 2) as opposed to covering an area of 0.36 sq. mile in Ann Arbor and Birmingham, and 0.25 sq. mile in West Bloomfield and 0.33 sq. mile in Bloomfield Hills.

Differences in built environment characteristics are also evident when comparing the average numbers (counts) of structures by land use types (table 11) within these individual half mile buffer zones. On average, in the RNBs of urban Detroit and higher density suburban neighborhoods, there were substantially more residential structures as well as non-residential structures within the individual half mile buffer zones. While there were 800-plus residential structures on average in each RNB in the higher density neighborhoods, there were only about 300 residential structures on average in each lower density neighborhood RNB.

Table 11 Average number of structure by land use type per road network buffers (RNB) by neighborhood

Average count (%)	High density urban		Higher density suburban		Lower density suburban	
	DT1	DT2	AA	BM	BH	WB
Single-family detached home	891 (82.3)	956 (88.1)	850 (92.8)	782 (93.9)	255 (86.8)	328 (92.7)
Semi-detached home	0 (0.0)	1 (0.2)	6 (0.6)	0 (0.0)	0 (0.0)	4 (3.2)
Apartments	3 (0.3)	5 (0.5)	21 (2.4)	8 (1.1)	15 (4.8)	0 (0.0)
Townhomes/ Rowhouses	3 (0.3)	5 (0.5)	2 (0.3)	9 (1.1)	14 (3.8)	5 (2.7)
Retail	4 (0.4)	5 (0.6)	4 (0.4)	11 (1.3)	3 (0.8)	1 (0.6)
Personal service	19 (2.0)	14 (1.5)	24 (2.5)	20 (2.1)	14 (3.1)	1 (0.4)
Public Institutions	19 (2.0)	10 (1.2)	8 (0.9)	5 (0.5)	3 (0.6)	0 (0.0)
Industrial	1 (0.1)	0 (0.0)	1 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)
Abandoned	91 (8.4)	74 (7.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Others	46 (4.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

*DT1: Detroit 1; DT2: Detroit 2; AA: Ann Arbor; BM: Birmingham; BH: Bloomfield Hills; and WB: West Bloomfield.

In terms of the variety of housing structures, urban Detroit neighborhood RNBs were predominantly occupied by single-family detached homes. RNBs in the higher density suburban neighborhoods offered more diverse housing types, including semi-detached homes, apartments, and townhomes, than the urban Detroit and lower density suburban RNBs. In addition, RNBs in the lower density suburbs maintained a greater variety of housing types when compared to the urban Detroit neighborhood RNBs. In the higher density neighborhood RNBs, there were also more retail and personal service destinations on average. However, urban Detroit neighborhood RNBs provided fewer commercial opportunities within walking distance of one's residence when compared to the higher density suburban neighborhood RNBs.

Finally, it should be noted that there was a stark difference in the presence of abandoned structures in the RNBs between urban Detroit and both the higher density and lower density suburban neighborhoods. On average, in the urban Detroit neighborhoods, about 8% of the structures present within the RNB were abandoned (8.4 in Detroit 1 and 7.5 in Detroit 2), whereas there were no abandoned structures in the RNBs in the higher density and the lower density suburban neighborhoods.

3.2.2. Built environment and travel behavior research methods

In order to understand the effects of different built environment characteristics on an individual's pedestrian trips, I utilized OLS regression analysis (table 12). Each built environment element category (density, land use mix, and connectivity) was applied in the OLS regression model to depict its relationship to pedestrian—and driving—trip making in the Detroit region. After being separately estimated for each urban form category, a stepwise regression was used to test which built environment characteristics are most strongly associated with pedestrian or driving trips.

The dependent variable, total trip frequency per person on a weekly basis, was collected for each mode, pedestrian and driving. For the analysis, I chose trip activities that had a specific destination, such as trips to work, shopping, restaurant visits, and personal services. Active transport has become a particularly important aspect of research in recent years because of its positive contribution to public health.

Table 12 Built environment and individual travel behavior analysis data and method

Built Environment and Individual Travel Behavior Analysis		
Model	Dependent variables	Independent variables (predictors)
OLS regression (Detroit region)	Pedestrian Travel • Trip frequency • Mode split • Trip distance Driving Travel • Trip frequency • Mode split • Trip distance	Density • The # of residential structures (Z-score) • The # of non-residential structures (excluding abandonments, Z-score) Mixed land use • Land use mix index with 3 land use categories • Land use mix index with 7 land use categories • Land use mix index with 8 land use categories Connectivity • The # of 4-way intersections (Z-score) • The # of bus stops (Z-score) Socio-economic and demographic factors • Income (logarithm transformed) • Age

The dependent variable, weekly total trip frequency of each mode (pedestrian and driving), was also transformed using square-root in order to achieve as normal a distribution as possible. Another dependent variable was cumulative trip distance per person on a weekly basis by each mode. Again, the cumulative trip distance was transformed using logarithm to avoid the skewedness in the distribution. In addition to trip frequency and distance, I also used the percentage of trips of total trips by mode (walking and driving) as a dependent variable. The 'mode share' or 'mode split' figure is important to measure the effects of neighborhood types (higher density urban, higher density suburban and lower density suburban) on how individuals choose a mode of travel (Cervero, 1996; Cervero and Gorham, 1995; Cervero and Kockelman, 1997; Ewing et al., 1994; Frank and Pivo, 1995; Friedman et al., 1994; and Kain and Fauth, 1977).

As independent variables, for the urban development density category, I used the number of residential and non-residential structures within the road network buffer (RNB). Specifically, abandoned structures were excluded from calculating the number of non-residential structures since they were not potential destinations to which a pedestrian or driver would travel to. Both residential and non-residential structure counts were standardized using the z-score to measure the variation among the samples.

To illustrate how mixed land uses affect an individual's pedestrian—or driving—trips, I created three separate Land Use Mix Indices. The land use mix index was developed with areas of each land use category as the percent of the area covered by impervious surfaces in each RNB (Frank et al., 2004). This entropy measure reflects the evenness of distribution of several land-use types within the area or region (Frank et al., 2005; and 2006). The index is calculated as follows using the n categories of land in each region:

(Equation 1)

$$\text{Land mix} = -1\left(\sum Pi \times \ln(Pi)\right) / \ln(n)$$

where n is the number of different land use type categories in the area and Pi is the proportion of land in type i in the area. This land use mix index varies from 0, for homogeneous or single land use, to 1 for a greatest variety or mixture in land uses.

First, I grouped a variety of land uses into 3 categories (LUM3); residential, commercial, and public institutions. The residential land use group (1) includes single family homes, semi-detached homes, townhouses and row houses, and apartments. The commercial land use group (2) includes retailers and personal services. The last land use group includes public institutions (3). In order to demonstrate whether a variety of residential structures affects individual pedestrian—or driving—trip making, I created the second Land Use Mix Index with 7 land use categories (LUM7); single family homes (1), semi-detached homes (2), townhouses and row houses (3), apartments (4), retail (5), personal services (6), and public institutions (7). Finally, by adding industrial land use structures, the model can afford to depict the significance, or insignificance, of industrial land uses in promoting pedestrian or driving trips. Thus, the last Land Use Mix Index is with 8 land use categories (LUM8), including industrial structures in addition to all land uses for Land Use Mix Index 7. Here, each land use structure was counted as frequency instead of impervious land use area. Thus, it was assumed that each land use count was equal to land use area.

As for the connectivity measure, the number of 4-way intersections and bus stops were used in the model. Both intersection and bus stop counts were standardized using the z-score. In this way, each RNB in the Detroit region can be assigned with a specific position in terms of the connectivity measure distribution in the Detroit region.

In addition to the built environment factors, two sociodemographic variables were included in the model. Sociodemographic variables are particularly important to understand the differences in individuals' travel choices and demand (Boarnet and Crane, 2001b; Crane, 1996, 2000; Handy, 1993, 1996; Handy et al., 2005; and Holtzclaw, 1994). Income and age were added to the regression analyses to control the independent influences of behavioral conditions.

3.3. Urban Density

3.3.1. Urban density and non-motorized travel

With respect to travel mode, as table 13 shows, residents in the Detroit region were more likely to travel as pedestrians for their daily activities if there were more residential and non-residential structures within a walking distance of half a mile. While both residential and non-residential structure densities are significantly associated with more walking trips, non-residential structure density was more strongly related to walking trips throughout the Detroit region (*B*= 2.741, p-value = 0.002 for residential density, and *B*= 3.725, p-value = 0.000 for non-residential density). Also, survey respondents were likely to significantly increase the frequency of walking if both residential and non-residential densities increased within the walking distance buffer zone.

Similar patterns are evident between mode of travel and trip frequency. Non-residential density (*B*= 0.186, p-value = 0.000) is more strongly associated with walking trip frequency than residential density (*B*= 0.069, p-value = 0.046). Thus, the results illustrate that in the Detroit region, walking trips for employment, shopping, restaurant visits, and personal services are more influenced by non-residential density in the neighborhoods. This pattern is consistent to findings in the existing literature which maintain that urban density is positively related to pedestrian trips, and the number of non-residential structures in the neighborhood influences pedestrian trips more strongly (Frank and Pivo, 1995; Levinson and Kumar, 1997; Cervero, 1996; Boarnet and Crane, 2001a, 2001b; and Ewing and Cervero, 2001).

Table 13 Urban density and individual pedestrian travel in the Detroit region

Density						
Dependent variables		Independent variables (predictors)	N	Coefficient	S.E	p-value
Pedestrian travel	Percentage of trip	Constant	920	52.291	12.166	.000
		Residential[3]		2.741	.866	.002
		Non-residential[4]		3.725	.770	.000
		Income[5]		-3.051	1.091	.005
		Age		-.134	.050	.008
	Trip frequency[1]	Constant	955	1.184	.489	.016
		Residential[3]		.069	.035	.046
		Non-residential[4]		.186	.032	.000
		Income[5]		.001	.044	.977
		Age		-.010	.002	.000
	Trip distance[2]	Constant	269	.775	1.009	.443
		Residential[3]		-.046	.066	.485
		Non-residential[4]		-.011	.051	.828
		Income[5]		.051	.094	.589
		Age		.002	.005	.609

1. Square-root transformed weekly total trip frequency for work, shopping, restaurant visits, and personal services
2. Logarithm transformed weekly cumulative trip distance (mile) for work, shopping, restaurant visits, and personal services
3. Z-score of total number of residential structures (including single-family homes, semi-detached homes, townhomes and row houses, and apartments)
4. Z-score of total number of non-residential structures excluding abandonments (including retailers and personal services, public institutions, and industrial structures)
5. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.600 for all predictors.

Trip distances reveal another set of patterns shaped by residential and non-residential density. Greater residential and non-residential densities decrease pedestrian trip distances. Thus, Detroit region residents walked shorter distances to reach a potential destination if there were more residential and non-residential structures in the road network buffer. This relationship between shorter walking distances and increased urban density, however, were not statistically significant. The results, thus, offer evidence that the likelihood of walking more frequently increases due to shorter distances between destinations, as neighborhoods are more densely developed, a pattern consistent with the existing literature on the built environment and physical activity (Cervero, 1996; Cervero and Kockelman, 1997; Handy, 1993; and Ewing and Cervero, 2001).

3.3.2. Urban density and motorized travel

In the Detroit region, survey respondents were less likely to travel by driving if there were more residential and non-residential structures within walking distance (table 14). Both residential and non-residential structure densities are negatively associated with percentage of driving trips, and at a significant level (*B*= -4.462, p-value = 0.000 for residential density, and *B*= -4.046, p-value = 0.000 for non-residential density). However, non-residential density is slightly more associated with decreases in driving trips. Both residential and non-residential densities also negatively influenced survey respondents' driving trip frequency in the Detroit region. Therefore, residents decreased the frequency of driving trips in the neighborhoods with greater residential and non-residential structures present. Only residential density, however, was significantly associated with a decrease in driving trip frequency (*B*= -0.204, p-value = 0.000).

People in Detroit region also drove fewer miles if there were more residential and non-residential structures present in the RNB (road network buffer), which, once again, was based on an in-networked walking distance of .5 mile. While both densities were negatively associated with driving trip distance, only residential density significantly affected the miles that survey respondents traveled for their daily activities (*B*= -0.255, p-value = 0.000). Accordingly, as previous studies have shown, the results also displayed the pattern of less driving trips in densely developed neighborhoods (Ewing, 1997a).

Table 14 Urban density and individual driving travel in Detroit region

Density						
Dependent variables		Independent variables (predictors)	N	Coefficient	S.E	p-value
Driving travel	Percentage of trip	Constant	920	2.521	13.697	.854
		Residential[3]		-4.462	.975	.000
		Non-residential[4]		-4.046	.867	.000
		Income[5]		6.908	1.228	.000
		Age		.135	.057	.017
	Trip frequency[1]	Constant	955	-.655	.547	.231
		Residential[3]		-.204	.039	.000
		Non-residential[4]		-.052	.036	.147
		Income[5]		.383	.049	.000
		Age		-.012	.002	.000
	Trip distance[2]	Constant	864	1.719	.636	.007
		Residential[3]		-.255	.044	.000
		Non-residential[4]		-.014	.038	.723
		Income[5]		.219	.057	.000
		Age		-.016	.003	.000

1. Square-root transformed weekly total trip frequency for work, shopping, restaurant visits, and personal services
2. Logarithm transformed weekly cumulative trip distance (mile) for work, shopping, restaurant visits, and personal services
3. Z-score of total number of residential structures (including single-family homes, semi-detached homes, townhomes and row houses, and apartments)
4. Z-score of total number of non-residential structures excluding abandonments (including retailers and personal services, public institutions, and industrial structures)
5. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.600 for all predictors.

3.4. Mixed land use

In the Detroit region, it is evident that mixed land uses were positively associated with more frequent pedestrian trips. With respect to driving trips, mixed land uses were negatively related to car use. However, different land use mix indices—LUM3, LUM7, and LUM8—demonstrated the differing effects of the diverse mix of land uses on individual's pedestrian and driving travel patterns.

3.4.1. Mixed land use (LUM3) and non-motorized travel

In the analysis, LUM3 was used to understand how land uses—specifically *residential, commercial, and public institutions*—in the neighborhoods shape individual travel behavior. As shown in the table 15, survey respondents were likely to significantly increase the percentage of walking trips as part of weekly total trips if there was greater diversity in land use types, residential, commercial, and public institutions (*B*= 34.037, p-value = 0.000). Respondents also tended to walk more frequently to reach a destination in the neighborhood with a greater balance between the three land use categories. In other words, there is a greater likelihood of walking when the neighborhood offers more retailers, personal services, and public institutions mixed-in with the houses (*B*= 1.535, p-value = 0.000). Moreover, respondents walked shorter distances between destinations if more diverse land use types were available within walking distance. However, the relationship between walking trip distance and LUM3 was not statistically significant.

Table 15 Mixed land use (LUM3) and individual pedestrian travel in Detroit region

Mixed land use, LUM3						
Dependent variables	Independent variables (predictors)		N	Coefficient	S.E	p-value
Pedestrian travel	Percentage of trip	Constant	920	60.632	11.910	.000
		LUM3[3]		34.037	5.585	.000
		Income[4]		-4.031	1.064	.000
		Age		-.161	.050	.001
	Trip frequency[1]	Constant	955	1.428	.472	.003
		LUM3[3]		1.535	.231	.000
		Income[4]		-.034	.042	.417
		Age		-.011	.002	.000
	Trip distance[2]	Constant	269	.726	.989	.464
		LUM3[3]		-.417	.447	.352
		Income[4]		.059	.092	.520
		Age		.003	.005	.577

1. Square-root transformed weekly total trip frequency for work, shopping, restaurant visits, and personal services
2. Logarithm transformed weekly cumulative trip distance for work, shopping, restaurant visits, and personal services
3. Land use mix index with three land use categories (residential, commercial, and public institutions)
4. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.600 for all predictors.

3.4.2. Mixed land use (LUM7) and non-motorized travel

A land use mix index with 7 categories was also used to understand the significance of more detailed land use categories and their impact on individual travel behavior (table 16). In addition to commercial structures and public institutions, industrial land use was added to the model as the seventh category. Residential structures were also separated into 4 categories, including single family homes, semi-detached homes, townhomes and row houses, and apartments). Similar to LUM3, LUM7 also significantly increased the pedestrian mode share in weekly total trips that residents in the Detroit region made (*B*= 22.885, p-value = 0.000). Thus, a greater variety in land uses increased the possibility of Detroit region residents walking to reach their destinations.

LUM7 also has a significantly positive effect on walking trip frequency (*B* = 1.054, p-value = 0.000). That is, the Detroit residents walked more frequently when there was a greater balance in these 7 land use categories in the RNB. Interestingly, they walked a longer distance with a greater LUM7 in the walkable area (RNB). It is likely because a greater variety in 'residential' land uses does not in itself necessarily mean a greater land use mix (residential, commercial and industrial) that facilitates shorter walking distances to reach destinations for the resident's daily needs. In addition, one can also assume that the presence of industrial structures within the RNB does not have the significant effect of shortening walking distances to most daily destinations, including shopping, restaurant visits, and personal services. The positive effect of LUM7 on walking trip distance, however, is not statistically significant.

Table 16 Mixed land use (LUM7) and individual pedestrian travel in Detroit region

Mixed land use, LUM7						
Dependent variables	Independent variables (predictors)		N	Coefficient	S.E	p-value
Pedestrian travel	Percentage of trip	Constant	920	70.807	11.886	.000
		LUM7[3]		22.885	5.633	.000
		Income[4]		-4.896	1.069	.000
		Age		-.163	.051	.001
	Trip frequency[1]	Constant	955	1.900	.471	.000
		LUM7[3]		1.054	.233	.000
		Income[4]		-.075	.043	.080
		Age		-.011	.002	.000
	Trip distance[2]	Constant	269	.586	.979	.550
		LUM7[3]		.109	.491	.824
		Income[4]		.066	.092	.474
		Age		.002	.005	.614

1. Square-root transformed weekly total trip frequency for work, shopping, restaurant visits, and personal services
2. Logarithm transformed weekly cumulative trip distance for work, shopping, restaurant visits, and personal services
3. Land use mix index with seven land use categories (single family homes, semi-detached homes, town homes and row houses, apartments, commercial, public institutions, and industrial)
4. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.600 for all predictors.

3.4.3. Mixed land use (LUM8) and non-motorized travel

Lastly, the LUM8 was introduced to the model with 8 land use categories in order to explore in more detail the impact in the diversity of ‘commercial’ land uses (table 17). Within this analysis, retailers, and personal services were separately added into the land use mix index, in addition to the 4 residential land uses, public institutions, and industrial structures. Similar to the results in the analysis of LUM3 and LUM7, the Detroit residents tend to increase the percentage of pedestrian trips for their commutes and chores when the road network buffer offered a greater variety in the 8 land use types (B = 25.086, p-value = 0.000).

Residents were also likely to walk more frequently with the greater mixture in the 8 land use categories in the RNB (B = 1.143, p-value = 0.000). Therefore, consistent with the effects of LUM3 and LUM7 land use mix indices on walking trips, a greater mix of land uses in the neighborhood increased pedestrian activity. However, residents also walked longer distances to their daily chores when the neighborhood had a greater mixture in the 8 land use categories. Again, as explained in the previous section on the LUM7 mix, it is assumed that a greater variety in ‘residential’ land uses has little influence on creating a shorter walking distance to reach daily destinations, such as shopping, going to the bank, or dropping off dry cleaning.

The results from the analyses on land use mix and walking trips revealed that people were likely to walk more—both in terms of the percentage (mode share) of trips and the trip frequency—if there were more diverse land uses present within walking distance of residents as potential destinations. However, the effects of the land use mix on walking distance were rather vague since none of the land use mix indices was significantly associated with walking distance. Furthermore, LUM3 was the only land use mix measure that reduced walking distance whereas increases in LUM7 and LUM8 were positively related to walking distance. This is likely because a greater mixture in residential land uses, as already noted, might not necessarily reduce the distances between destinations that are relevant for completing daily chores, such as going to work, shopping, or reaching personal service destinations.

Table 17 Mixed land use (LUM8) and individual pedestrian travel in Detroit region

Mixed land use, LUM8						
Dependent variables	Independent variables (predictors)		N	Coefficient	S.E	p-value
Pedestrian travel	Percentage of trip	Constant	920	70.675	11.880	.000
		LUM8[3]		25.086	5.989	.000
		Income[4]		-4.893	1.068	.000
		Age		-.163	.051	.001
	Trip frequency[1]	Constant	955	1.896	.471	.000
		LUM8[3]		1.143	.247	.000
		Income[4]		-.074	.042	.080
		Age		-.011	.002	.000
	Trip distance[2]	Constant	269	.586	.979	.599
		LUM8[3]		.125	.520	.240
		Income[4]		.065	.092	.715
		Age		.002	.005	.505

1. Square-root transformed weekly total trip frequency for work, shopping, restaurant visits, and personal services
2. Logarithm transformed weekly cumulative trip distance for work, shopping, restaurant visits, and personal services
3. Land use mix index with eight land use categories (single family homes, semi-detached homes, town homes and row houses, apartments, *retailers*, *personal services*, public institutions, and industrial)
4. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.600 for all predictors.

3.4.4. Mixed land use (LUM3) and motorized travel

With regard to driving trips, significant effects of increases in mixed land use on reducing automobile trips were observed. First, with an increase in LUM3—a greater balance between residential, commercial, and public institutions—resulted in Detroit region residents significantly reducing the percentage of driving trips as part of weekly total trips (B = -35.658, p-value = 0.000) (table 18). They also tend to drive less frequently for their daily commutes and chores if the neighborhood offers a greater variety in the 3 land use types (B =-0.658, p-value = 0.012)—that is a greater variety in residential, commercial and public institution land uses.

In addition, not only did the residents drive fewer times, they drove fewer miles when there were more diverse destinations available, such as retail outlets, personal services, and public institutions within the RNB. In addition, the effect of LUM3 on reducing driving miles was statistically significant (B = -0.840, p-value = 0.003). Thus, in the Detroit region neighborhoods, consistent with findings in the exiting literature, a greater mix of land uses tends to discourage driving trips.

Table 18 Mixed land use (LUM3) and individual driving travel in Detroit region

Mixed land use, LUM3						
Dependent variables	Independent variables (predictors)		N	Coefficient	S.E	p-value
Driving travel	Percentage of trip	Constant	920	-12.224	13.549	.367
		LUM3[3]		-35.658	6.354	.000
		Income[4]		8.503	1.211	.000
		Age		.176	.057	.002
	Trip frequency[1]	Constant	955	1.490	.535	.005
		LUM3[3]		-.658	.261	.012
		Income[4]		.449	.048	.000
		Age		-.010	.002	.000
	Trip distance[2]	Constant	864	1.089	.636	.087
		LUM3[3]		-.840	.279	.003
		Income[4]		.279	.057	.000
		Age		-.014	.003	.000

1. Square-root transformed weekly total trip frequency for work, shopping, restaurant visits, and personal services
2. Logarithm transformed weekly cumulative trip distance for work, shopping, restaurant visits, and personal services
3. Land use mix index with three land use categories (residential, commercial, and public institutions)
4. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.600 for all predictors.

3.4.5. Mixed land use (LUM7) and motorized travel

The LUM7[2] land use mix also negatively affects driving trips of residents in the Detroit region (table 19). Similar to LUM3 and driving trips, a greater mix in the 7 land use categories negatively influenced the percentage of driving trips as part of weekly total trips that were made by survey respondents (B = -20.350, p-value = 0.002). The Detroit residents were also likely to travel less frequently by driving if the neighborhood offered a more diverse land use mix within walking distance. In addition, residents drove fewer miles to reach their destinations for daily chores if there was a greater evenness in the distribution of the 7 land use categories. However, neither relationship—effects on driving trip frequency and driving trip distance—was statistically significant.

[2]Land use mix index with seven land use categories (single family homes, semi-detached homes, town homes and row houses, apartments, commercial, public institutions, and industrial)

Table 19 Mixed land use (LUM7) and individual driving travel in Detroit region

Mixed land use, LUM7						
Dependent variables	Independent variables (predictors)		N	Coefficient	S.E	p-value
Driving travel	Percentage of trip	Constant	920	-23.155	13.528	.087
		LUM7[3]		-20.350	6.411	.002
		Income[4]		9.394	1.216	.000
		Age		.176	.058	.002
	Trip frequency[1]	Constant	955	-1.699	.528	.001
		LUM7[3]		-.357	.261	.171
		Income[4]		.466	.048	.000
		Age		-.010	.002	.000
	Trip distance[2]	Constant	864	.846	.632	.181
		LUM7[3]		-.424	.279	.129
		Income[4]		.298	.057	.000
		Age		-.014	.003	.000

1. Square-root transformed weekly total trip frequency for work, shopping, restaurant visits, and personal services
2. Logarithm transformed weekly cumulative trip distance for work, shopping, restaurant visits, and personal services
3. Land use mix index with seven land use categories (single family homes, semi-detached homes, town homes and row houses, apartments, commercial, public institutions, and industrial)
4. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.600 for all predictors.

3.4.6. Mixed land use (LUM8) and motorized travel

With a greater LUM8[3] land use mix, survey respondents were also likely to significantly decrease the percentage of driving trips as part of their weekly total trips (B = -22.299, p-value = 0.001) (table 20). That is, residents in the Detroit region tend to choose driving less as a means of transportation for their commutes and daily errands if there were more diverse land uses available within walking distance. A greater variety in the 8 land use categories within the walkable area (RNB) also influenced the respondents' frequency in driving; the greater the mix of land uses, the less frequently that respondents drove for their daily activities. The Detroit residents also drove fewer miles for their commutes and daily chores if there was a greater diversity in the 8 land use types within the RNB. However, the effects of LUM8 diversity on both driving trip frequency and driving trip distance were not statistically significant.

[3]Land use mix index with eight land use categories (single family homes, semi-detached homes, town homes and row houses, apartments, *retailers, personal services*, public institutions, and industrial).

Table 20 Mixed land use (LUM8) and individual driving travel in Detroit region

Mixed land use, LUM8						
Dependent variables	Independent variables (predictors)		N	Coefficient	S.E	p-value
Driving travel	Percentage of trip	Constant	920	-23.039	13.524	.089
		LUM8[3]		-22.299	6.818	.001
		Income[4]		9.391	1.216	.000
		Age		.176	.058	.002
	Trip frequency[1]	Constant	955	-1.696	.528	.001
		LUM8[3]		-.404	.278	.145
		Income[4]		.466	.048	.000
		Age		-.010	.002	.000
	Trip distance[2]	Constant	864	.849	.632	.179
		LUM8[3]		-.478	.297	.108
		Income[4]		.298	.057	.000
		Age		-.014	.003	.000

1. Square-root transformed weekly total trip frequency for work, shopping, restaurant visits, and personal services
2. Logarithm transformed weekly cumulative trip distance for work, shopping, restaurant visits, and personal services
3. Land use mix index with eight land use categories (single family homes, semi-detached homes, town homes and row houses, apartments, *retailers*, *personal services*, public institutions, and industrial)
4. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.600 for all predictors.

In summary, for all the land use mix indices, a greater variety in land use mix in the RNB resulted in greater pedestrian activity as a travel mode, and also resulted in more frequent pedestrian trips for daily activities. Additionally, the positive relationships were statistically significant for all three LUM indices. However, with regard to walking distance, only LUM3 was negatively associated with walking trip distance. Furthermore, none of the land use mix indices was statistically significant in explaining walking trip distance.

All three LUM indices negatively affected driving trips, in terms of percentage of driving trips, driving trip frequency and trip distance. All LUM indices significantly decreased the percentage of driving trips as part of weekly total trips made. However, while all three LUM indices were negatively associated with driving trip frequency and distance, only LUM3 was statistically significant in explaining both driving trip frequency and driving trip distance. Subsequently, the degree of the land use mix among the three land use categories (residential, commercial, and public institutions) demonstrated the strongest relationship between mixed land use activity and individual travel behavior in the Detroit region.

The results from my analyses consistently support the existing literature, in that a greater land use mix results in greater walkability, both greater pedestrian mode share and more frequent walking trips. This indicates that there is a greater possibility to carry out pedestrian trips to access daily activity when there are more accessible destinations in a neighborhood and more diverse land use options within walking distance.

The results are also consistent with previous studies that argue that certain land use types are more relevant and significant in understanding the effects of promoting pedestrian travel as a form of 'active transport.' For example, the presence of industrial land use types in the walkable area does not necessarily mean a greater availability of potential pedestrian destinations for daily chores. This outcome might have been different, however, if local residents were actually employed in these factories. Moreover, a greater variety in 'residential' land use types has little influence in decreasing walking distance to reach destination. Finally, the results also found that reduced automobile use and less driving trips in the neighborhood were associated with a greater mix of land uses. This, once again, is a research outcome that is similar to previous studies.

3.5. Street Connectivity and Bus Stops

Across the neighborhoods in the Detroit region, the survey respondents were likely to make more pedestrian trips when the roads were more connected and when more bus stops were present in the neighborhood. In addition, the respondents tend to drive less with an increasing number of 4-way intersections and bus stops within walking distance.

3.5.1. Street connectivity and non-motorized travel

In table 13, more 4-way intersections positively influenced the percentage of pedestrian trips as a component of total trips that the respondents made on a weekly basis. Thus, the Detroit residents chose to walk more for daily activities if the roads are connected better with more 4-way intersections in walking distance (RNB) (*B* = 3.159, p-value = 0.002). Residents in Detroit region were more likely to walk frequently when the number of 4-way intersections increased in the RNB (*B* = 0.075, p-value = 0.070). An increased number of 4-way intersections within the RNB also decreased the distance that the residents traveled as pedestrians to reach a destination. However, the relationship between 4-way intersection density and walking trip distance was not statistically significant (table 21).

3.5.2. Street connectivity and motorized travel

Unlike the relationships between 4-way intersection density and nonmotorized travel, driving trips were discouraged with an increasing number of 4-way intersections in the road network buffer (table 22). In the Detroit region, the percentage of driving trips as part of weekly total trips decreased significantly with an increase in 4-way intersections within walking distance (B = -4.348, p-value = 0.000), that is within the RNB.

Driving trip frequency, in contrast, was negatively associated with an increased number of intersections (B = -0.177, p-value = 0.000, table 22). Driving trip distance also tends to decrease with more connected road networks in the road network buffer. However, the relationship between 4-way intersection density and driving trip distance was not statistically significant (table 22).

3.5.3. Bus stops and non-motorized travel

The density of bus stops in the road network buffer positively influenced the percentage of pedestrian trips as part of total trips that the respondents made during a week (table 21). The Detroit residents, therefore, were more likely to choose nonmotorized modes for daily activities if more bus stops were present within the RNB (B = 4.770, p-value = 0.000). With more bus stops within a walking distance, the respondents in Detroit region also tended to walk more frequently. The number of bus stops increased significantly the likelihood of more frequent walking for daily chores (B = 0.215, p-value = .000).

The residents in the Detroit region, however, tend to walk longer distances to a destination for their daily activities when more bus stops were present within the RNB. This pattern may be an outcome of fewer urban opportunities—such as retailers and personal services—available in the distressed Detroit urban neighborhoods. Even though more bus stops were available within their reach, urban Detroit residents still had to walk a longer distance, or walk to take a bus since there were fewer commercial and institutional destination in their neighborhood. However, the effect of bus stop density on changes in walking distance was not statistically significant.

3.5.4. Bus stops and motorized travel

Increasing density of bus stops, on the other hand, discouraged driving trips in the Detroit region. As shown in table 15, the percentage of driving trips as part of weekly total trips decreased significantly with more bus stops within the road network buffer (*B* = -5.775, p-value = 0.000). The Detroit residents were likely to drive fewer times when there were more bus stops present in the road network buffer (*B* =-0.110, p-value = 0.013, table 22). Not only did the residents drive fewer times, residents also drove fewer miles to reach a daily activity destination with more bus stops within the RNB. The effect of the number of bus stops on reducing driving trip distance was statistically significant (*B* = -0.274, p-value = 0.000).

Table 21 Connectivity and individual pedestrian travel in Detroit region

Street connectivity and bus stops						
Dependent variables		Independent variables (predictors)	N	Coefficient	S.E	p-value
Pedestrian travel	Percentage of trip	Constant	920	33.836	12.453	.007
		4-way intersections[3]		3.159	1.014	.002
		Bus stops[4]		4.770	.950	.000
		Income[5]		-1.493	1.119	.183
		Age		-.087	.050	.084
	Trip frequency[1]	Constant	955	.476	.508	.349
		4-way intersections[3]		.075	.041	.070
		Bus stops[4]		.215	.039	.000
		Income[5]		.056	.046	.220
		Age		-.008	.002	.000
	Trip distance[2]	Constant	269	.603	1.065	.572
		4-way intersections[3]		-.023	.082	.775
		Bus stops[4]		.033	.068	.624
		Income[5]		.062	.100	.532
		Age		.003	.005	.537

1. Square-root transformed weekly total trip frequency for work, shopping, restaurant visits, and personal services
2. Logarithm transformed weekly cumulative trip distance (mile) for work, shopping, restaurant visits, and personal services
3. Z-score of total number of 4-way intersections
4. Z-score of total number of bus stops
5. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.500 for all predictors.

Table 22 Connectivity and individual driving travel in Detroit region

Street connectivity and bus stops						
Dependent variables		Independent variables (predictors)	N	Coefficient	S.E	p-value
Driving travel	Percentage of trip	Constant	920	25.071	13.972	.073
		4-way intersections[3]		-4.348	1.138	.000
		Bus stops[4]		-5.775	1.066	.000
		Income[5]		5.039	1.255	.000
		Age		.085	.056	.130
	Trip frequency[1]	Constant	955	-.085	.570	.882
		4-way intersections[3]		-.177	.046	.000
		Bus stops[4]		-.110	.044	.013
		Income[5]		.322	.051	.000
		Age		-.012	.002	.000
	Trip distance[2]	Constant	864	1.969	.652	.003
		4-way intersections[3]		-.013	.053	.797
		Bus stops[4]		-.274	.047	.000
		Income[5]		.202	.059	.001
		Age		-.018	.003	.000

1. Square-root transformed weekly total trip frequency for work, shopping, restaurant visits, and personal services
2. Logarithm transformed weekly cumulative trip distance (mile) for work, shopping, restaurant visits, and personal services
3. Z-score of total number of 4-way intersections
4. Z-score of total number of bus stops
5. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.500 for all predictors.

In conclusion, Detroit residents walked more often when there were more 4-way intersections and more bus stops present within walking distance. They walked shorter distances to access a destination if roads were more connected. However, more bus stops influenced positively the walking distance in the neighborhood. The Detroit residents also drove less in RNBs with more connected road networks and bus stops. They not only drove less frequently, but also fewer miles for their commutes and daily chores when more 4-way intersections and bus stops were present in the RNB. This pattern is also consistent to existing literature on built environment characteristics, connectivity and travel behavior (Cervero and Keckelman 1997; and Ewing and Cervero, 2001, 2010**)**.

However, the results showed a positive relationship between the number of bus stops and walking trip distance. In this particular study, this is likely due to specific socio-economic and physical conditions of the Detroit urban neighborhoods, which have the most bus stops. In other words, compared to the high-income suburban neighborhoods, the low-income residents in the urban Detroit neighborhoods were more likely to walk a longer distance, or walk to ride a bus for their chores, since urban amenity options were limited in their neighborhoods. Furthermore, the urban Detroit residents walked more miles to take a bus since they used public transit more often than higher income suburban residents, due to the lower incomes and lower levels of private automobile access.

3.6. Built environment factors and individual travel behavior

In addition to exploring the effects of each urban form attribute on individual trip making, a stepwise regression analysis was used to test the relative importance of the different urban form characteristics and their degree of influence on promoting motorized or non-motorized trips. Therefore, urban density, connectivity measures, and land use mix indices were incorporated in the model simultaneously. Also, each LUM was included separately into the stepwise regression in order to identify the differing significance of the land use mix indices in explaining pedestrian and driving trips.

3.6.1. Built environment factors and non-motorized travel

Among urban density, land use mix, and connectivity measures, the number of bus stops and intersections, and LUM3 significantly influenced the percentage of walking trips as part of weekly total trips that Detroit region residents made (table 23). All three built environment variables were positively related to increases in walking trip percentages. However, the density of bus stops within walking distance was most strongly associated with walking trip shares as part of weekly total trips. Then, the diversity in the three land use types (residential, commercial, and public institutions) was the second most influential variable in increasing the percentage of walking trips.

By incorporating LUM7 instead of LUM3, all three urban form factors were still significantly related to the percentage of walking trips in the Detroit region (table 24). The land use mix, however, became less important than bus stop and intersection densities in explaining the changes in walking trip percentages as part of weekly total trips. The same pattern was also evident in the model in explaining the walking trip percentages in the Detroit region with urban form variables including LUM8 (table 25). Among the significant relationships, bus stop density was most strongly associated with walking trip percentages. Next, the density of 4-way intersections in the RNB was more influential in increasing walking trip percentages than the land use mix index with 8 land use categories.

With regard to pedestrian trip frequency, only the bus stop density and the land use mix indices were found to be significantly influential. In table 16, the number of bus stops was most strongly associated with increasing walking trip frequency in the Detroit region, and the LUM3 was second. However, the diversity in the 7 land uses was no longer significant in explaining the frequency of walking trips in the Detroit region (table 24). Interestingly, the incorporation of retail and personal service land uses separately in the model reassured the importance of the land use mix to explain the changes in walking trip frequency (table 25). Therefore, the results confirm the relative significance of commercial land uses—retail and personal services—to promote walking.

The analysis, however, produced no significant relationship between urban form factors and walking trip distance. After controlling for personal income and age, none of the urban density, land use mix indices, and connectivity measures emerged in the models as a significant factor in changes in walking trip distance (table 23, 24, and 25).

Table 23 The built environment and individual pedestrian travel with LUM3

Dependent variables		Independent variables (predictors)	N	Coefficient	S.E	p-value
Pedestrian travel	Percentage of trip	Constant	920	33.658	12.400	.007
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]		2.497	1.034	.016
		Bus stops[6]		4.237	.963	.000
		LUM3[7]		17.795	5.950	.003
		Income[8]		-1.615	1.115	.148
		Age		-.100	.050	.045
	Trip frequency[1]	Constant	955	.621	.483	.199
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]				
		Bus stops[6]		.205	.034	.000
		LUM3[7]		1.039	.241	.000
		Income[8]		.034	.043	.427
		Age		-.009	.002	.000
	Trip distance[2]	Constant	269			
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]				
		Bus stops[6]				
		LUM3[7]				
		Income[8]		.067	.091	.463
		Age		.002	.005	.602

1. Square-root transformed weekly total trip frequency for work, shopping, restaurant visits, and personal services
2. Logarithm transformed weekly cumulative trip distance (mile) for work, shopping, restaurant visits, and personal services
3. Z-score of total number of residential structures (including single-family homes, semi-detached homes, townhomes and row houses, and apartments)
4. Z-score of total number of non-residential structures excluding abandonments (including retailers and personal services, public institutions, and industrial structures)
5. Z-score of total number of 4-way intersections
6. Z-score of total number of bus stops
7. Land use mix index with three land use categories (residential, commercial, and public institutions)
8. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.500 for all predictors.

Table 24 The built environment and individual pedestrian travel with LUM7

Dependent variables		Independent variables (predictors)	N	Coefficient	S.E	p-value
Pedestrian travel	Percentage of trip	Constant	920	34.714	12.415	.005
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]		3.041	1.012	.003
		Bus stops[6]		4.467	.953	.000
		LUM7[7]		14.949	5.527	.007
		Income[8]		-1.722	1.118	.124
		Age		-.098	.050	.049
	Trip frequency[1]	Constant	955	.782	.484	.106
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]				
		Bus stops[6]		.237	.033	.000
		LUM7[7]				
		Income[8]		.019	.043	.657
		Age		-.009	.002	.000
	Trip distance[2]	Constant	269	.586	.977	.550
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]				
		Bus stops[6]				
		LUM7[7]				
		Income[8]		.067	.091	.463
		Age		.002	.005	.602

1. Square-root transformed weekly total trip frequency for daily activities
2. Logarithm transformed weekly cumulative trip distance (mile) for daily activities
3. Z-score of total number of residential structures (including single-family homes, semi-detached homes, townhomes and row houses, and apartments)
4. Z-score of total number of non-residential structures excluding abandonments (including retailers and personal services, public institutions, and industrial structures)
5. Z-score of total number of 4-way intersections
6. Z-score of total number of bus stops
7. Land use mix index with seven land use categories (single family homes, semi-detached homes, town homes and row houses, apartments, commercial, public institutions, and industrial)
8. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.500 for all predictors.

Table 25 The built environment and individual pedestrian travel with LUM8

Dependent variables		Independent variables (predictors)	N	Coefficient	S.E	p-value
Pedestrian travel	Percentage of trip	Constant	920	34.751	12.412	.005
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]		3.038	1.011	.003
		Bus stops[6]		4.443	.954	.000
		LUM8[7]		16.377	5.886	.006
		Income[8]		-1.731	1.118	.122
		Age		-.099	.050	.048
	Trip frequency[1]	Constant	955	.783	.484	.106
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]				
		Bus stops[6]		.236	.033	.000
		LUM8[7]		.839	.245	.001
		Income[8]		.019	.043	.661
		Age		-.009	.002	.000
	Trip distance[2]	Constant	269	.586	.977	.550
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]				
		Bus stops[6]				
		LUM8[7]				
		Income[8]		.067	.091	.463
		Age		.002	.005	.602

1. Square-root transformed weekly total trip frequency for daily activities
2. Logarithm transformed weekly cumulative trip distance (mile) for daily activities
3. Z-score of total number of residential structures (including single-family homes, semi-detached homes, townhomes and row houses, and apartments)
4. Z-score of total number of non-residential structures excluding abandonments (including retailers and personal services, public institutions, and industrial structures)
5. Z-score of total number of 4-way intersections
6. Z-score of total number of bus stops
7. Land use mix index with eight land use categories (single family homes, semi-detached homes, town homes and row houses, apartments, *retailers, personal services*, public institutions, and industrial)
8. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.500 for all predictors.

3.6.2. Built environment factors and motorized travel

In the Detroit region, connectivity measures were most important in explaining changes in driving trips. The density of bus stops and the number of 4-way intersections negatively influenced the Detroit region residents in selecting driving to access a destination. The number of bus stops was more strongly associated with a decrease in driving trips as part of weekly total trips regardless of which land use mix index was incorporated in the models. In other words, the diverse land uses in the RNB had no influence on the changes in the driving trip percentages as part of weekly total trips (tables 26, 27, and 28).

In tables 26, 27 and 28, Connectivity was also important in understanding the changes in driving trip frequency in the Detroit region. However, unlike the driving trip percentage, the number of intersections was most strongly and only related to driving trip frequency, regardless of the land use mix indices in the models. The Detroit residents were less likely to drive if there were more intersections within walking distance from their residential address. Again, there was no observed impact of the land use mix effect on the change in driving trip frequency in the Detroit region.

Table 26 Built environment and individual driving travel with LUM3

Dependent variables		Independent variables (predictors)	N	Coefficient	S.E	p-value
Driving travel	Percentage of trip	Constant	920	25.071	13.972	.073
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]		-4.348	1.138	.000
		Bus stops[6]		-5.775	1.066	.000
		LUM3[7]				
		Income[8]		5.039	1.255	.000
		Age		.085	.056	.130
	Trip frequency[1]	Constant	955	-.203	.570	.722
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]		-.243	.038	.000
		Bus stops[6]				
		LUM3[7]				
		Income[8]		.328	.051	.000
		Age		-.011	.002	.000
	Trip distance[2]	Constant	864	2.183	.635	.001
		Residential[3]		-.150	.047	.001
		Non-residential[4]				
		4-way intersections[5]				
		Bus stops[6]		-.214	.044	.000
		LUM3[7]				
		Income[8]		.183	.057	.001
		Age		-.018	.003	.000

1. Square-root transformed weekly total trip frequency for daily activities
2. Logarithm transformed weekly cumulative trip distance (mile) for daily activities
3. Z-score of total number of residential structures (including single-family homes, semi-detached homes, townhomes and row houses, and apartments)
4. Z-score of total number of non-residential structures excluding abandonments (including retailers and personal services, public institutions, and industrial structures)
5. Z-score of total number of 4-way intersections
6. Z-score of total number of bus stops
7. Land use mix index with three land use categories (residential, commercial, and public institutions)
8. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.500 for all predictors.

Table 27 Built environment and individual driving travel with LUM7

Dependent variables		Independent variables (predictors)	N	Coefficient	S.E	p-value
Driving travel	Percentage of trip	Constant	920	25.071	13.972	.073
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]		-4.348	1.138	.000
		Bus stops[6]		-5.775	1.066	.000
		LUM7[7]				
		Income[8]		5.039	1.255	.000
		Age		.085	.056	.130
	Trip frequency[1]	Constant	955	-.203	.570	.722
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]		-.243	.038	.000
		Bus stops[6]				
		LUM7[7]				
		Income[8]		.328	.051	.000
		Age		-.011	.002	.000
	Trip distance[2]	Constant	864	2.183	.635	.001
		Residential[3]		-.150	.047	.001
		Non-residential[4]				
		4-way intersections[5]				
		Bus stops[6]		-.214	.044	.000
		LUM7[7]				
		Income[8]		.183	.057	.001
		Age		-.018	.003	.000

1. Square-root transformed weekly total trip frequency for daily activities
2. Logarithm transformed weekly cumulative trip distance (mile) for daily activities
3. Z-score of total number of residential structures (including single-family homes, semi-detached homes, townhomes and row houses, and apartments)
4. Z-score of total number of non-residential structures excluding abandonments (including retailers and personal services, public institutions, and industrial structures)
5. Z-score of total number of 4-way intersections
6. Z-score of total number of bus stops
7. Land use mix index with seven land use categories (single family homes, semi-detached homes, town homes and row houses, apartments, commercial, public institutions, and industrial)
8. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.500 for all predictors.

Table 28 Built environment and individual driving travel with LUM8

Dependent variables		Independent variables (predictors)	N	Coefficient	S.E	p-value
Driving travel	Percentage of trip	Constant	920	25.071	13.972	.073
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]		-4.348	1.138	.000
		Bus stops[6]		-5.775	1.066	.000
		LUM8[7]				
		Income[8]		5.039	1.255	.000
		Age		.085	.056	.130
	Trip frequency[1]	Constant	955	-.203	.570	.722
		Residential[3]				
		Non-residential[4]				
		4-way intersections[5]		-.243	.038	.000
		Bus stops[6]				
		LUM8[7]				
		Income[8]		.328	.051	.000
		Age		-.011	.002	.000
	Trip distance[2]	Constant	269	2.183	.635	.001
		Residential[3]		-.150	.047	.001
		Non-residential[4]				
		4-way intersections[5]				
		Bus stops[6]		-.214	.044	.000
		LUM8[7]				
		Income[8]		.183	.057	.001
		Age		-.018	.003	.000

1. Square-root transformed weekly total trip frequency for daily activities
2. Logarithm transformed weekly cumulative trip distance (mile) for daily activities
3. Z-score of total number of residential structures (including single-family homes, semi-detached homes, townhomes and row houses, and apartments)
4. Z-score of total number of non-residential structures excluding abandonments (including retailers and personal services, public institutions, and industrial structures)
5. Z-score of total number of 4-way intersections
6. Z-score of total number of bus stops
7. Land use mix index with eight land use categories (single family homes, semi-detached homes, town homes and row houses, apartments, *retailers, personal services*, public institutions, and industrial)
8. Logarithm transformed family-structure adjusted personal income

For all models, the tolerance values were above 0.500 for all predictors.

The changes in driving trip distance, however, were significantly influenced by urban density and connectivity measures. The density of bus stops was most strongly associated with a decrease in driving trip distances, no matter which land use mix index was used in the model (tables 26, 27, and 28).

A condition unique to driving trip distance, the residential density within the RNBs negatively influenced driving trip distance. In other words, the Detroit residents were likely to reduce automobile travel miles if the neighborhood was densely developed with an increasing number of residential units. In fact, driving trip distance was the only travel behavior measure that was influenced by urban density.

In conclusion, both pedestrian and driving trips were most influenced by connectivity, the 4-way intersection density, and by the number of bus stops within walking distance of one's residence. However, the respondents in the Detroit region were more likely to choose a pedestrian mode of travel for daily activities if the neighborhood offered more diverse land uses as potential destinations in addition to connected road networks and more bus stops. In addition, commercial land uses—retailers and personal services—seemed more influential in increasing the walking trip frequency. Moreover, among the land use mix indices, LUM3 was most strongly associated with both the walking trip percentage and the walking trip frequency in the Detroit region. However, there was no significant change in walking trip distance by urban form factors.

Driving trips were also influenced strongly by street connectivity and bus stops. The Detroit residents were less likely to choose driving for daily activities if there were more bus stops and more 4-way intersections present within walking distance, that is, within the RNBs. Residents also tended to drive less frequently if road networks were connected better with more

4-way intersections within walking distance. A greater street connectivity and presence of bus tops was also important in decreasing driving trip miles. Detroit residents tend to reduce driving trip miles substantially when more bus stops were present within walking distance. They were also likely to drive fewer miles if there were more residential structures in the adjacent neighborhood. Unlike pedestrian trips in the Detroit region, the degree of land use mix had no effect on the change in driving trip percentage, frequency, and/or distance.

3.7. Conclusion and Discussion

As explored in the existing literature on the built environment and transportation patterns, potential links between urban form in the Detroit region and individual travel behavior were examined in this chapter. Previous studies have found significant causal links between built environment characteristics and travel behavior using multivariate analysis with strong behavioral foundations (Boarnet and Crane, 2001a, 2001b; Cervero, 1996; Cervero and Kockelman, 1997; Crane, 2000; Crane and Crepeau, 1998; Ewing, 1997a; Frank and Pivo, 1995; Handy et al., 2005; Kitamura et al., 1994; Kockelman, 1999; and Messenger and Ewing, 1996).

Since the majority of the travel behavior literature has focused on areas in the U.S. West Coast, studies have paid little to no attention to urban travel patterns in metropolitan areas that are experiencing substantial population loss and urban disinvestment, such as in the case of Detroit or other mid-Western cities (Friedman et al., 1994; Crane, 2000; Vojnovic, 2006; and Vojnovic et al., 2006). Furthermore, a reconstitution of urban form factors into an appropriate scale—such as road network buffers representing not only the unique walkable areas for each agent, but also the unique built environment characteristics of each household—is crucial to examine the effects of built environment characteristics on pedestrian travel (Crane, 2000; and Utermann, 1984).

The other advantage of this research is the utilization of disaggregate analysis at a finer scale of road network buffers (RNB). Disaggregate analysis permits the models to predict the effects of the built environment on individual travel behavior more accurately by controlling for socio-economic and demographic characteristics, variables that are also important in influencing travel demand (Cervero and Kockelman, 1997; Crane, 2000; and Handy, 1993, 1996a).

To estimate change in travel behavior, a multivariate OLS regression analysis was applied to answer how a variety of urban form factors influence individual's pedestrian and driving trips. Three trip measures, including mode split, trip frequency and trip distance (length)—for daily activities such as commutes to work, shopping, restaurant visits, and personal services—were used as the dependent variable. Three urban form dimensions were incorporated in the models as the independent variables; urban density, mixed land use, and connectivity. In order to synchronize the geographic scale of both travel measures and urban form measures, road network buffers (RNBs) were created using ArcGIS 10.1 Network Analyst with a walking distance of about a half a mile from a respondent's residential address. This allowed the models to capture the specific built environment characteristics around each of the 1,106 residence.

For the urban density measures, both residential and non-residential structure densities within the RNB were determined. For the land use mix measures, 3 land use mix indices (LUMs) were calculated using an entropy measure. A range of 3 to 8 land use types were separately included in the land use mix indices to evaluate the relative importance of each land use type. Finally, the number of 4-way intersections and the number of bus stops within the RNB was used in the models. In addition to the urban form indicators, socio-economic and demographic characteristics—personal income and age—were included as controlling factors in the analysis.

The Detroit region residents were more likely to walk to access a daily activity destination if the neighborhood was more densely developed. Both residential and non-residential structure densities were positively related to the percentage of walking trips as part of weekly total trips and at a significant level. Urban density also positively influenced the frequency of walking trips after controlling for socio-economic and demographic factors. While both residential and non-residential densities significantly affected the walking trip share and walking trip frequency, non-residential density was more strongly associated with walking trips.

Residents also walked shorter distances to reach their daily chores with a higher density in urban structures; however, the relationships were not statistically significant. In the neighborhoods that were more densely developed, the survey respondents were likely to use automobiles significantly less for their daily activities. They not only chose to use automobiles less, but they also drove fewer times and fewer miles to reach destinations. Among the urban density measures, it was residential density that had the strongest influence in reducing automobile travel.

In the Detroit region, residents were also more likely to walk for daily activities in the neighborhoods with more diverse land uses. All 3 land use mix indices positively influenced walking trip percentage and frequency, that is the respondents tended to choose walking more as a transportation mode if there were more diverse destination options within walking distance of their home. Also, they were likely to walk more frequently in such neighborhoods. All 3 land use mix indices were significantly related to waking trip percentage and walking frequency after controlling for income and age.

In terms of walking distance, however, only LUM3 (a mixture of residential, commercial, and public institutions) was negatively associated with walking distance. In other words, there was no effect on reduced walking distance between destinations in cases when residential land uses were separated into different types (single-family housing, apartments, rowhouses, and so on). Additionally, the inclusion of industrial land uses also had no impact on changes in walking distance

Greater diversity in land uses in the road network buffer tends to also discourage automobile use in the Detroit region. The negative relationships between the driving trip percentage, selecting the car as mode of travel, and all 3 land use mix indices were statistically significant. More mixed land uses within walking distance also negatively affected the frequency and distance of driving trips. However, given that only LUM3 was statistically influential in defining driving trip frequency and distance, it confirms that a greater balance between residential, commercial, and public institutions, as part of the land use mix, was most important in both reducing automobile use and promoting pedestrian trips.

Connectivity measures also increased the walking trip percentage and walking frequency in the Detroit region. The survey respondents were more likely to choose a pedestrian mode for daily activities if the roads were better connected with more 4-way intersections and if bus stops were located within walking distance. Bus stop density in the RNB was more strongly associated with an increase in walking trips, both percentage and frequency, than 4-way intersection density. However, only the 4-way intersection density was negatively related to walking trip distance. In other words, residents in the Detroit region walked longer distances to reach a destination in the neighborhood with more bus stops. Hence, the pattern of longer walking distance in the neighborhood with more bus stops might support the argument that there were fewer potential destinations available within walking distance in the Detroit urban neighborhoods. The pattern might also confirm that Detroit urban residents walked to take public transit more often than residents in the higher income suburban neighborhoods.

Greater connectivity within the walking buffer zones also negatively influenced automobile use. The Detroit residents were less likely to choose an automobile as a form of transportation if the neighborhood was more connected with greater intersection densities and had more bus stops. Residents also drove less frequently and drove fewer miles to access a daily activity destination if there was a higher concentration of 4-way intersections and if there were more bus stops in the ½ mile buffer zones. However, the relationship between 4-way intersection density and driving trip distance was not statistically significant.

Finally, I used stepwise regression analysis to test the relative strength of each of the urban form factors in influencing individual travel behavior. The Detroit residents were more likely to choose a pedestrian mode if there were more intersections, more bus stops and diverse land uses. The percentage of walking trips as part of weekly total trips was most strongly associated with bus stop density. Four-way intersection density and mixed land uses were also significantly related to walking trip share. However, unlike LUM7 and LUM8, LUM3 influenced the walking trip percentage to a greater extent than 4-way intersection density. Walking trip frequency was also most strongly associated with bus stop density regardless of land use mix indices. Among the land use mix indices, only LUM3 and LUM8 were significantly related to an increase in walking trip frequency. Thus, the results confirmed the relative importance of non-residential land uses, and particularly commercial land uses, in increasing walking trip frequency.

In the Detroit region, bus stops and street connectivity significantly influenced decreased levels of automobile travel. Specifically, the number of bus stops was more strongly associated with reduced automobile use for daily activities than the number of 4-way intersections. The Detroit residents were also likely to drive less frequently for their daily activities if the roads were more connected with a greater intersection density within walking distance, within their RNBs. They also drove fewer miles if there were more bus stops present within walking distance of their home. Driving trip distance was negatively associated with increasing residential density. In other words, residents tend to use an automobile less frequently and they drove fewer miles if they lived in densely developed neighborhoods with more bus stops and connected road networks. In the Detroit region, the degree of land use mix had a relatively weak influence on driving trips, since none of the land use mix indices emerged as significant in the stepwise regression models to explain driving trip percentages, frequency, or distance.

In conclusion, the analysis results confirmed the significant links between built environment characteristics and individual travel behavior. First, a densely developed neighborhood of RNBs with diverse land uses, connected road networks, and bus stops increased pedestrian travel. In addition, automobile use for daily activities was substantially reduced in the densely developed RNBs with a greater land use mix, more intersections, and bus stops. People also tend to walk more and drive less if the immediate built environment has a better balance of land uses—and particularly a mix of residential, commercial, and public institution. Finally, among the built environment factors, the number of bus stops and 4-way intersections were most strongly associated with individual travel behavior.

The analysis results not only confirm the previously addressed relationships between urban form characteristics and individual travel behavior, but also expand the understanding of urban travel with more elaborate dimensions in neighborhood characteristics, such as disparities in the neighborhoods and extreme divergences in income status. Unlike the existing studies, the results explored the relationship between built environment and travel behavior in a region characterized by a rapidly declining urban core, that of the Detroit region, with extreme urban decentralization and disinvestments in the central city. Consequently, the results were able to reveal how individual's travel was actually affected in neighborhoods experiencing disinvestment and decline.

For example, as confirmed in the analysis, a greater walking trip distance associated with increasing bus stop density may imply a longer distance between fewer destination options in the Detroit urban neighborhoods where substantially more bus stops were present than suburban neighborhoods. The greater walking distance in the neighborhoods may also be a result of the low income status and limited automobile access in the urban Detroit neighborhoods. To meet their daily needs, the urban Detroit residents had to walk more and longer distances to take public transit whereas the suburban residents would mostly drive to their more distant destinations.

The results also reaffirmed the importance of the land use mix in promoting pedestrian travel and reducing automobile use. Three land use indices (LUM3, 7, and 8), with different numbers of land use types were employed in the analyses. From the different indices, the commercial land uses—retail and personal services—were most strongly associated with greater pedestrian activity and reduced automobile trips. A greater balance between residential, commercial, and public institutional land uses (i.e. LUM3) was more important than a greater mixture in housing types, or the presence of industrial land uses in the neighborhood (i.e. LUM7 or LUM8), in increasing pedestrian trip activity and in decreasing automobile use.

However, similar to the findings in the existing literature, the models explain poorly the entire variation in travel behavior in that the R^2 was generally low, around 0.2 or lower for the models. Thus, other urban form measures, such as the shortest distance to a store for shopping trips, may enhance the explanatory power. Also, in addition to built environment characteristics, the neighborhood quality measures will also improve the model. For example, incorporating neighborhood crime rates or street aesthetic measures will offer more elaborate explanations to individual travel behavior and choice. Subsequently, using more socio-economic or demographic factors may also improve the model. Household structure or car ownership, for example, may offer a better explanation of individual or household travel demand.

Furthermore, the models explain pedestrian trip distance poorly. None of the urban from factors was significantly associated with walking trip distance in the Detroit region. As noted above, the incorporation of pedestrian environment quality measures may help the model understand the variation in walking trip distance more precisely. Moreover, the scarcity of potential destinations within walking distance probably deterred one's desire to choose a pedestrian mode for daily chores. Additional consideration, such as who walked to where and for what purpose, may also be useful to understand the actual variation in walking trip distance.

Finally, in the model, there was no distinction made between work trips and nonwork trips. Trip activities such as commutes to work, shopping, restaurant visits, and personal services, were included in the model to capture pedestrian travel behavior. However, travel choices and travel demand could differ between work trips and nonwork trips, since individuals have more flexibility in decisions for nonwork trips compared to work trips. Also, in constantly decentralizing metropolitan areas like Detroit, the conventional commute patterns may be less valid in that urban minorities travel often reversely, with a longer distance to suburban employment locations. Including locational factors (e.g. destinations) of work and nonwork trips might improve the understanding of urban travel within the Detroit metropolitan context.

In future research approaches, therefore, work trips and nonwork trips can be explored in separate models. Even further separation of nonwork trips into separate trip purposes could more precisely reveal the patterns in individual travel behavior. Furthermore, individual characteristics, such as gender and car ownership, or household characteristics such as marital status, might also further explain individual travel behavior choices and travel behavior demands. Some of these issues, in fact, will be addressed in subsequent chapters. Also, additional information on travel destinations can be added in the model, such as a dummy variable distinguishing between a central city or a suburban location. This way, the model can examine not only the travel flows within the metropolitan region, but also exhibit the travel burdens of racial or ethnic minorities in declining urban cores, including reverse commutes and longer shopping trip distances to suburban retail locations.

CHAPTER 4: Neighborhood Typology and Travel Behavior in the Detroit region

In chapter 4, I will discuss the value of defining the neighborhood typology in examining individual travel behavior. Traditionally, urban transportation researchers have defined the relationships between socio-economic and demographic characteristics of population sub-groups and their travel patterns (e.g., trips to work or non-work related activities) aggregated at the county, city or traffic analysis zone (TAZs)[4] levels (Krizek 2003; Manheim, 1979; Martin et al., 1967; Martin and McGuckin, 1998; McNally, 2000). While aggregate *patterns* of travel by certain sub-populations provides important information about zonal averages of trip generation, such aggregate measures obscure the actual travel *behavior* and subsequent demands of particular sub-populations (Krizek, 2003; Handy 1996). Thus, in order to understand the effects of socio-economic and demographic characteristics on individuals' travel behavior, it is also useful to explore travel patterns at a finer scale, such as individual-, household-, or neighborhood scales of analysis.

In fact, a particular area of interest that is under-represented in existing travel behavior literature is the analysis into travel for population sub-groups located in declining neighborhoods, i.e., neighborhoods that are experiencing population loss, disinvestment and economic decline. With a disappearing population and a loss in urban amenities, it is particularly important to understand how certain socio-economic and demographic factors, such as gender, income and access to a private automobile affect daily travel in terms of commutes to work, accessing food, or reaching leisure destinations in declining neighborhoods. Even if one lives in

[4] A traffic analysis zone is a spatial unit that is commonly used in conventional transportation planning models. TAZs are constructed by census block information that contain socio-economic data such as the number of automobiles per household, household income, and employment within these zones (Miller, Harvey J. and Shih-Lung Shaw. (2001) Geographic Information Systems for Transportation, Oxford University Press US. p. 248)

a higher density neighborhood that is highly connected and maintains a mix of land uses—a neighborhood typology that is expected to increase accessibility to daily destinations—individuals' travel patterns might vary considerably depending on the destination opportunities within the neighborhood. In addition, an individual's options of travel modes (e.g., being forced to walk or to take public transit or having access to a private automobile) can also shape the nature of travel.

Exploring individuals' travel behavior within a neighborhood—instead of, for instance, aggregating individual trip patterns into a traffic analysis zone—is also important in identifying how certain characteristics in the neighborhood environment influence travel, and pedestrian trip making in particular (Hanson, 1996). For instance, perception of fear from crime or the intensity of traffic volume varies in differing urban neighborhood environments; people in declining inner-city neighborhoods have a greater sense of fear from crime compared to suburban neighborhoods with similar built environment characteristics. Thus, exploring individuals' travel behavior within specific neighborhood characteristics can have a significant implication on urban design and planning, if practitioners are to build neighborhoods with balanced transportation options for their residents.

Lastly, the disaggregation of travel behavior into a comprehensive array of diverse travel activities, and particularly differentiating by gender, offers meaningful information on the complexity of women's daily travel based on their socio-economic status and their multiple roles within the household (Freedman and Kern, 1997; Hamilton and Jenkins, 1990; Hanson 1995; Hanson and Hanson, 1980a, b; Hanson and Johnston, 1985; Hanson and Giuliano, 2004; Hu and Young, 1999; Jones, 1990; Johnston-Anumonwo, 1992; Kwan, 1999a, 1999b, 2000; McFadden and Reid, 1975; Schintler et al., 2000; Santos et al., 2011; Pickup, 1985, 1990). Hence, measuring the easiness of reaching various destinations within the neighborhood is crucial to identifying the travel burdens of women as they accomplish their daily household and employment responsibilities. By disaggregating travel activities at a neighborhood level, the differences in trip making between women and men can be more accurately explored. Similarly, such disaggregation can allow for differences among women with different socio-economic and demographic profiles to be explored more precisely.

4.1. Research Objectives, Questions, and Hypotheses

This chapter aims to identify the neighborhood typology that helps explain differences in travel behavior between urban and suburban neighborhoods. First, it is hypothesized that residents living in neighborhoods with greater income levels and automobile access tend to travel more frequently and longer distances by car. The second hypothesis is that residents living in neighborhoods with more diverse urban opportunities and safer pedestrian environments will have improved access to daily activities when compared to neighborhoods with similar urban density and connectivity characteristics. Hence, subsequent research questions are which socio-economic and demographic factors significantly influence total trip generation and which neighborhood group, among urban Detroit, higher-density suburban, and lower-density suburban neighborhoods is differentiated against others in terms of socio-economic and demographic characteristics, travel patterns, and neighborhood quality for pedestrians.

4.2. Neighborhood Typology Analysis Data and Method

In order to address the social dynamics of individuals' travel behaviors, I performed three different analyses: (1) OLS regression for modeling trip generation among the general population in the Detroit region; (2) discriminant analyses for discerning neighborhood groups based on socio-economic and demographic characteristics, travel patterns, and built environment typologies; and (3) descriptive analyses for illustrating the mean difference in disaggregate travel activities by the different neighborhood typologies (see table 29).

First, in order to identify the effects of socio-economic and demographic factors on individual trip making, it is important to select predictors that explain the general travel patterns among the population. Using Ordinary Least Squares (OLS) regression, I examined the specific socio-economic and demographic variables that have significant explanatory power to explain travel patterns. Second, three discriminant analyses showed the differing characteristics of the urban neighborhood density groups in terms of socio-economic and demographic profile, travel patterns and degree of sense of fear as a proxy of differing urban environment quality characteristics. Lastly, the average trip frequencies and trip distances are discussed for each travel activity, including trips to work, shopping, restaurant visits, personal services, and leisure activities.

Defining the neighborhood typology is particularly important in order to understand the travel burden of individuals throughout a metropolitan region, and particularly in neighborhoods experiencing disinvestment and decline. Travel opportunities—such as reaching employment, retail, or personal services—are neither equally distributed nor equally accessible across the neighborhoods. Income disparities across the neighborhoods also create different utilization of travel modes. For example, populations in lower-income neighborhoods often travel more by public transit and less by car. Therefore, disaggregating individual travel behavior within neighborhoods will provide a better understanding of travel constraints of socially marginalized populations, and particularly lower-income women in the declining urban neighborhoods, one of the principal areas of research interest in this dissertation.

Table 29 Variables for neighborhood typology and travel behavior models

Models	Dependent Variables	Independent Variables (Predictors)
4-(1). Aggregate travel patterns		
OLS regression (*All* neighborhoods)	Total trip frequency[1] Cumulative trip distance[2] • All activities • Work trip • Non-work trip	Income[3] Age[4] # of personal vehicles available # of dependent children[5]
4-(2). Different populations and their travels in differing urban neighborhoods		
Discriminant Analyses (*All* neighborhoods)	Neighborhood density groups • High Urban • High Suburban • Low Suburban	Income[3] Age[4] # of personal vehicles available[5] # of dependent children[6]
		Total trip frequency[1] Cumulative trip distance[2] Walking and cycling Driving
		Sense of fear from crime[6] Day time and Night time Sense of fear from traffic[6] Day time and Night time
4-(3). Description of travel activities in differing urban neighborhoods		
Descriptive Analysis (*Within* neighborhoods)	Total trip frequency[7] Cumulative trip distance[8] • All activities • Work trip • Shopping trip • Restaurant trip • Service trip • Leisure trip	

1.Weekly total trip frequency by all modes, 2.Weekly cumulative trip distance by all modes, 3.Household structure adjusted family income, 4.Adults who are 18 years old and older, 5.Children who are younger than 18 years old, 6.OnLikert scale, 1=none, 2=low, 3=moderate, and 4=high, 7.Weekly total trip frequency by all modes and each mode (walking and cycling, public transit, and driving), 8.Weekly cumulative trip distance by all modes and each mode (walking and cycling, public transit, and driving).

4.3. Aggregate travel patterns in the Detroit region

Across the Detroit region neighborhoods, the average age was 54 years old with less than one dependent child under the age of 18 years old in the household. On average, the Detroit region respondents had access to approximately one car (PVHC = 1.2) and in 2008 maintained a household income of $52,200 USD (table 30). On average, these respondents traveled 12 times a week for 45 miles for all activities by all modes. Specifically they traveled 5 times a week for 42 miles for work trips and 10 times per week for 27 miles for non-work trips by all modes (table 30).

Table 30 Descriptive statistics of socio-economic and demographic and travel pattern variables in the Detroit region

	N	Minimum	Maximum	Mean	Std. Dv.
Independent variables: socio-economic and demographic characteristics					
AGE	1116	18.0	94.0	53.8	15.8
INCOME[1]	1009	3,338.1	160,000.0	52,201.4	31,721.4
NCHILD	1075	0.0	8.0	0.7	1.1
PVHC	1068	0.0	6.0	1.2	0.7
Dependent variables: aggregate travel pattern					
TTLFREQUENCY2	1087	1.0	76.0	12.1	8.7
TTLDISTANCE3	1068	0.0	349.0	45.3	51.6
WTTLFREQ[4]	620	1.0	23.0	5.0	2.2
WTTLDIST[5]	540	0.1	965.0	42.3	60.6
NWTTLFREQUENCY[6]	1076	1.0	76.0	9.7	8.0
NWTTLDISTANCE[7]	1058	0.3	349.1	26.6	33.5

1. Household structure adjusted family income, USD in 2008;
2. Total trip frequency per person for all activities by all modes on a weekly basis (trip count);
3. Cumulative trip distance to destinations for all activities by all modes on a weekly basis (mile);
4. Total trip frequency per person for work trips by all modes on a weekly basis (trip count);
5. Cumulative trip distance to destinations for work trips by all modes on a weekly basis (mile);
6. Total trip frequency per person for non-work trips by all modes on a weekly basis (trip count);
7. Cumulative trip distance to destinations for non-work trips by all modes on a weekly basis (mile)

OLS regression results (table 31) of the aggregate travel pattern analysis for all activities and work and non-work trips by all travel modes revealed a strong relationship between all socio-economic and demographic characteristics and trip frequencies (n = 848), as well as cumulative distances (n=834) . Specifically income (*B* = 0.141, p-value = 0.056 and *B* = 0.253, p-value = 0.056) and the number of personal vehicles available (*B* = 0.177, p-value 0.058 and *B* = 0.126, p-value = 0.003) positively predicted the number of trips and distances at a significant level. In other words, with increasing income and number of personal vehicles available, the number of trips and cumulative trip distances also increased. With increasing age however, trip frequency and travel distance decreased (*B* = -0.015, p-value 0.003 and *B* = -0.017, p-value = 0.003). Interestingly, with an increasing number of dependent children in the household, trip frequency declined (*B* = -0.082, p-value = 0.039) but trip distances slightly increased (*B* = 0.007, p-value = 0.039) for all activities by all modes.

For work trips (model II in the table 31), only income explained the number of trips significantly (*B* = 0.088, p-value = 0.015); a person with greater income tended to make more work trips (n = 502). A person with greater income was also more likely to travel longer in miles and at a significant level (*B* = 0.217, p-value = 0.041). The increasing age, however, negatively affected the trip frequencies for work and distance (only significantly for trip distance with *B* = -0.013, p-value = 0.008) (n = 439). The positive effect of income and the negative effect of age on trip making continued for nonwork trips (model III in the table 31). For both trip frequency (n = 843) and distance (n = 832) for nonwork trips, older respondents were less likely to make trips and at a significant level (*B* = -0.006, p-value = 0.032, and *B* = -.004, p-value = 0.097 respectively). However, increasing income had a positive effect only on trip distance associated with nonwork trips at a significant level. In addition, while the effects were not significant in the models, the number of available personal vehicles also positively affected non-work trip frequency and distance. From the regression results, income and age were able to explain the general travel patterns significantly at an aggregate level in the six Detroit region neighborhoods.

Table 31 OLS regression results of aggregate travel pattern analysis in the Detroit region

	Total trip frequency[1]		Cumulative trip distance[2]	
	Coefficient	S.E.	Coefficient	S.E.
Aggregate travel pattern analysis I: For All activities by All modes				
(Constant)	2.511***	.606	1.291**	.609
Income[3]	.141**	.056	.253***	.056
Age	-.015***	.003	-.017***	.003
# of personal vehicle accessible	.117**	.058	.126**	.058
# of dependent children	-.082**	.039	.007	.039
N[4]	848		834	
Aggregate travel pattern analysis II: For Work trips by All modes				
(Constant)	1.306***	.388	1.119	1.137
Income[3]	.088**	.036	.217**	.106
Age	-.001	.002	-.013***	.005
# of personal vehicle accessible	-.025	.033	.135	.091
# of dependent children	.023	.022	.030	.061
N[4]	502		439	
Aggregate travel pattern analysis III: For Nonwork trips by All modes				
(Constant)	2.510***	.598	1.788***	.594
Income[3]	.068	.055	.105*	.055
Age	-.006**	.003	-.004*	.003
# of personal vehicle accessible	.026	.057	.030	.057
# of dependent children	-.060	.038	-.003	.038
N[4]	843		832	

1. Total trip frequency per person on a weekly basis (trip count, square root transformed);
2. Cumulative trip distance to destinations per person on a weekly basis (mile, logarithm transformed);
3. Household structure adjusted family income (USD in 2008, logarithm transformed);
4. N = number of resident men and women;

Statistical significance at the 90% (*), 95% (**), and 99% (***) level, respectively.

4.4. Different populations and their travel patterns in the different neighborhoods

To address differing characteristics of neighborhood groups in the Detroit region, I used discriminant analyses to study the socio-economic and demographic characteristics, travel patterns, and the degree of sense of fear related to crime and traffic. Variables of fear from crime and traffic were adopted to represent differing characteristics of the neighborhood environment that deterred individuals from walking in the neighborhood. Discriminant analysis is used to define differences among the neighborhood groups with three categories—urban Detroit, higher density suburban, and lower density suburban neighborhoods. Discriminant analysis involves identifying the linear combination of attributes, known as canonical discriminant functions, which maximize group separation (Biles and Pigozzi, 2000; Burns and Burns, 2008; King 1970; McConnell, 1979).Unstandardized discriminant coefficients (b in the equation 2) maximize the distance between the means of the dependent variable and standardized discriminant coefficients predicts the variables that have the strongest discriminatory power between groups (Burns and Burns, 2008). An example of the discriminate equation or function used in this analysis of travel behavior is provided below.

(Equation 2)

$$D = b_1X_1 + b_2X_2 + b_3X_3 + \cdots\cdots + b_iX_i + a$$

Where D = discriminant function

b = the discriminant coefficient or weight for that variable

X = respondent’s score for that variable

a = a constant

i = the number of independent variables

The first discriminant analysis was conducted to examine whether four socio-economic and demographic characteristic variables—age, income, the number of dependent children and the number of personal vehicles could predict neighborhood differences (see model I in table 32). As Wilks' Lambda is the proportion of the total variance in the discriminant scores not explained by differences among groups, the smaller lambda (at a significant level) indicates that group means appear to differ significantly. For example, $\Lambda = 0.57$, χ^2 (8, N = 876) = 493.39, $p < 0.01$, indicates that overall the predictors differentiated significantly among the three neighborhood density groups, with an unexplained variance of about 57% by the two functions combined.

(Equation 3)

$D_{socio\text{-}demographic1}$ = (1.474 × Income) + (0.008 × Age) + (0.564 × #of personal vehicles) + (-0.098 × #of dependent children) – 16.699.

$D_{socio\text{-}demographic2}$ = (-0.172× Income) + (0.054× Age) + (0.213× #of personal vehicles) + (0.471× #of dependent children) – 1.627.

In table 32, the within-groups correlations between the predictors and the discriminant functions were presented as well as the standardized weights. Based on these coefficients, the income variable (0.900) demonstrates the strongest relationship with the first discriminant function and the number of personal vehicles (0.391) was the second strongest. Age (0.823) and the number of dependent children (0.502) showed the strongest relationship with the second discriminant function. Accordingly, the first and second discriminant functions were named as 'income' and 'life cycle', respectively.

Table 32 Standardized coefficients and correlations of predictor variables with the two discriminant functions by socio-economic and demographic profile

	Correlation coefficients with discriminant functions		Standardized Coefficients for discriminant functions	
	Function 1	Function 2	Function 1	Function 2
Discriminant analysis I: Socio-economic and demographic profile grouping				
Income[1]	.905	-.116	.900	-.105
Age[2]	.085	.852	.115	.823
# of personal vehicle accessible	.429	.157	.391	.147
# of dependent children[3]	-.075	.526	-.104	.502

Dependent Variable (categories): urban density neighborhood groups (Urban Detroit neighborhoods, Higher density suburban neighborhoods, and Lower density suburban neighborhoods)

1. Household structure adjusted family income (USD in 2008, logarithm transformed);
2. Adults who are 18 years old and older;
3. Children who are younger than 18 years old.

Canonical scores of group means (centroids, from figure 35) show that the urban Detroit neighborhood group (coded as 1) was separated by function 1, for the lower 'income' level compared to the other two suburban neighborhood groups. By function 2, the higher density suburban neighborhood group (coded as 2) was separated by the earlier 'life cycle' stage, with younger and fewer dependent children. The discriminant functions were able to classify 76.3% (n = 876, see table 33) of the total survey sample for socio-economic and demographic characteristic variables.

Table 33 Group statistics by socio-economic and demographic characteristic variables

	Urban Detroit		Higher density suburban		Lower density suburban	
	Mean (Std.Dv)	N	Mean (Std.Dv)	N	Mean (Std.Dv)	N
Income	9.76 (.754)	192	10.85 (.530)	366	10.93 (.601)	318
Age	51.76 (16.757)	192	51.62 (15.240)	366	56.58 (14.229)	318
# of personal vehicle accessible	0.73 (.786)	192	1.29 (.655)	366	1.38 (.671)	318
# of dependent children	0.82 (1.228)	192	0.55 (.913)	366	0.74 (.119)	318

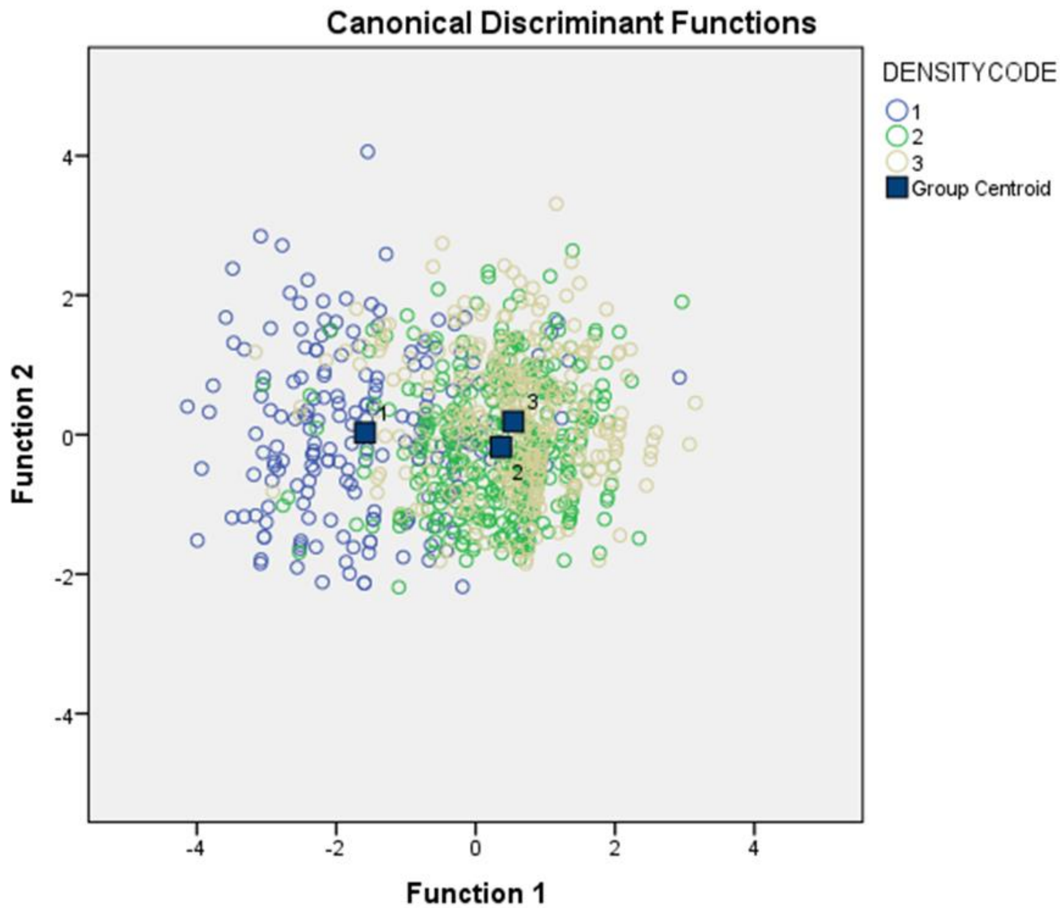


Figure 35 Separation of groups on discriminant functions by socio-economic and demographic profile

The second discriminant analysis was conducted to examine whether travel pattern variables—total trip frequency by walking and driving, and cumulative trip distance by walking/cycling and driving—could predict neighborhood differences (table 34). As Wilks' Lambda is the proportion of the total variance that is not explained by differences among groups in the discriminant scores, a smaller lambda at a significant level indicates that group means appear to differ significantly. Here, $\Lambda = 0.85$, $\chi^2 (8, N = 322) = 53.501$, $p < 0.01$, indicates that overall the predictors differentiated significantly among the three neighborhood density groups with an unexplained variance of about 85% by the two functions combined. Although total trip patterns—frequency and distance—for all activities combined explained only 15% of the variance in travel behavior in the Detroit region, the functions explained the differences between group means at a significant level.

(Equation 4)

$D_{\text{total travel patterns1}}$ = (-0.920× Total pedestrian frequency) + (-0.029×Total driving trip frequency) + (0.579×Cumulative pedestrian trip distance) + (0.348×Cumulative driving trip distance) + 0.213.

$D_{\text{total travel patterns2}}$ = (0.282 × Total pedestrian trip frequency) + (0.187 × Total driving trip frequency) + (0.791 × Cumulative pedestrian trip distance) + (-0.093 × Cumulative driving trip distance) – 1.968.

In table 34, based on the within-groups correlations and standardized coefficients between the predictors, the variable of total pedestrian trip frequency for all activities (-0.869) demonstrates the strongest relationship with the first discriminant function. Both pedestrian and driving distances for all activities (0.615 and 0.448, respectively) were also strongly associated with the first function. With the second discriminant function, cumulative pedestrian trip distance (0.840) and total pedestrian trip frequency (0.267) show the strongest relationship. Due to the strong opposite relationship between pedestrian trip frequency and driving distance, the first function was labeled as the ‘driving-dominant aggregate travel pattern.’ For the second discriminant function, the label the ‘pedestrian-dominant aggregate travel pattern’ was given accordingly.

Table 34 Standardized coefficients and correlations of predictor variables with the two discriminant functions by travel pattern

	Correlation coefficients with discriminant functions		Standardized Coefficients for discriminant functions	
	Function 1	Function 2	Function 1	Function 2
Discriminant analysis II: Travel pattern grouping				
Total trip frequency, pedestrian[1]	-.670	.645	-.869	.267
Total trip frequency, driving[2]	.252	.109	-.033	.217
Cumulative trip distance, pedestrian[3]	.237	.951	.615	.840
Cumulative trip distance, driving[4]	.627	-.046	.448	-.119

Dependent Variable (categories): urban density neighborhood groups (Urban Detroit neighborhoods, Higher density suburban neighborhoods, and Lower density suburban neighborhoods)

1. Total trip frequency for all activities by walking and cycling on a weekly basis;
2. Total trip frequency for all activities by driving on a weekly basis;
3. Cumulative trip distance for all activities by walking and cycling on a weekly basis;
4. Cumulative trip distance for all activities by driving on a weekly basis.

In figure 36, the lower density suburban neighborhood group (coded as 3) was separated as the ‘driving-dominant travel pattern’ group (by function 1) for the greater canonical score than was the case with the other two high density neighborhood groups. The urban Detroit neighborhood group (coded as 1) was, in contrast, separated by function 2, for the greater canonical score of the ‘pedestrian-dominant travel pattern’ compared to its suburban counterparts. The discriminant functions, however, were able to classify only 28% (n = 322) of the total survey sample for the aggregate travel patterns for all activities.

Table 35 Group statistics by aggregate travel pattern variables

	Urban Detroit		Higher density suburban		Lower density suburban	
	Mean (Std.Dv)	N	Mean (Std.Dv)	N	Mean (Std.Dv)	N
Total trip frequency, pedestrian[1]	2.46 (1.217)	57	2.15 (.932)	189	1.66 (.718)	76
Total trip frequency, driving[2]	2.94 (1.407)	57	2.87 (1.053)	189	3.15 (1.211)	76
Cumulative trip distance, pedestrian[3]	1.73 (1.192)	57	1.21 (.963)	189	1.55 (1.189)	76
Cumulative trip distance, driving[4]	2.67 (1.509)	57	2.69 (1.253)	189	3.40 (1.178)	76

1. Total trip frequency for all activities by walking and cycling on a weekly basis;
2. Total trip frequency for all activities by driving on a weekly basis;
3. Cumulative trip distance for all activities by walking and cycling on a weekly basis;
4. Cumulative trip distance for all activities by driving on a weekly basis.

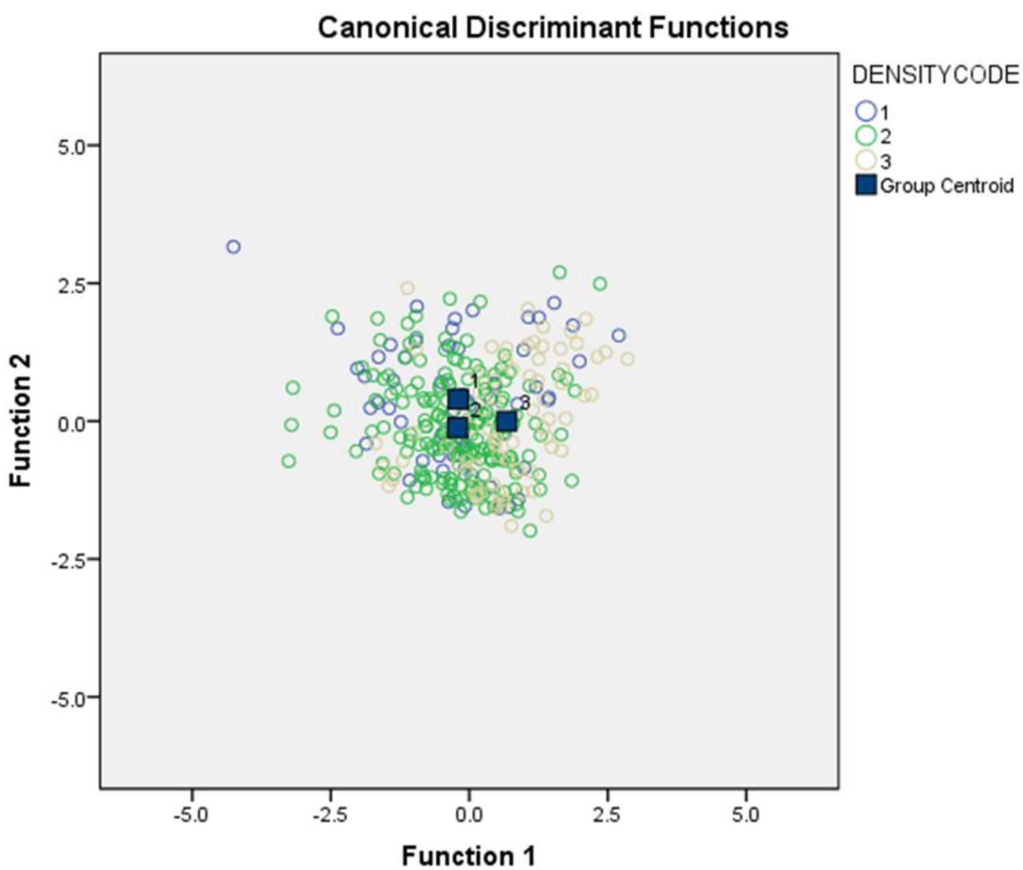


Figure 36 Separation of groups on discriminant functions by aggregate travel pattern variables

In order to exhibit different environmental characteristics between neighborhood groups, the degree of fear from crime and traffic variables were used in the last discriminant analysis (table 36). This measurement is particularly important in order to understand the effects of differing neighborhood environments on individual pedestrian travel, given that fear from crime and traffic volume discourages walking in the neighborhood. Wilks' Lambda, $\Lambda = 0.55$, χ^2 (8, N = 1077) = 53.501, $p < 0.01$, denotes the fear variables significantly discerned the neighborhood density groups by the two functions combined (unexplained variance of about 55%).

(Equation 5)

$D_{\text{sense of fear1}}$ = (.821×fear from crime, day) + (.842×fear from crime, night) + (-.208×fear from traffic, day) + (.207×fear from traffic, night) – 3.039.

$D_{\text{sense of fear2}}$ = (.500× fear from crime, day) + (-1.037× fear from crime, night) + (-.449× fear from traffic, day) + (1.434× fear from traffic, night) – .764.

In table 36, based on the within-groups correlations and standardized coefficients between the predictors, the sense of fear from crime variable during the day and night (0.618, and 0.502, respectively) shows the strongest relationship with the first discriminant function. For the second function, while sense of fear from crime during the night (-0.761) exhibits the greatest magnitude to the function, traffic-related fear variables show substantially strong correlation coefficients (0.762 for night time and 0.376 for day time). Thus, the first function was labeled as 'fear from crime,' and the second function was labeled as 'fear from traffic.'

Table 36 Standardized coefficients and correlations of predictor variables with the two discriminant functions by social environment

	Correlation coefficients with discriminant functions		Standardized Coefficients for discriminant functions	
	Function 1	Function 2	Function 1	Function 2
Discriminant analysis III: Social environment grouping				
Sense of fear from crime[1], day	.827	.118	.502	.306
Sense of fear from crime, night	.910	-.216	.618	-.761
Sense of fear from traffic[2], day	.379	.376	-.160	-.345
Sense of fear from traffic, night	.468	.762	.176	.220

Dependent Variable (categories): urban density neighborhood groups (Urban Detroit neighborhoods, Higher density suburban neighborhoods, and Lower density suburban neighborhoods)

1. Sense of fear from crime on Likert scale, 1=none, 2=low, 3=moderate, and 4=high;
2. Sense of fear from traffic on Likert scale, 1=none, 2=low, 3=moderate, and 4=high.

Canonical scores of group means (centroids, from figure 37) show that the urban Detroit neighborhood group (coded as 1) was separated by function 1 for the greater canonical score of ‘fear from crime’ compared to its suburban counterparts. In contrast, the lower density suburban neighborhood group (coded as 2) was separated by function 2 for the greater canonical score of ‘fear from traffic’ compared to the other high density neighborhoods, both urban and suburban. The discriminant functions predicted 94% (n=1077) of the variance between neighborhood groups among the total survey sample for fear from crime and traffic as a differing environmental characteristic that influences individual pedestrian travel.

Table 37 Group statistics by sense of fear variables

	Urban Detroit		Higher density suburban		Lower density suburban	
	Mean (Std.Dv)	N	Mean (Std.Dv)	N	Mean (Std.Dv)	N
Sense of fear from crime, day	2.29 (.951)	233	1.23 (.483)	454	1.26 (.473)	390
Sense of fear from crime, night	3.18 (.909)	233	1.84 (.698)	454	1.75 (.655)	390
Sense of fear from traffic, day	2.20 (.971)	233	1.53 (.670)	454	1.67 (.738)	390
Sense of fear from traffic, night	2.72 (1.002)	233	1.75 (.714)	454	2.07 (.897)	390

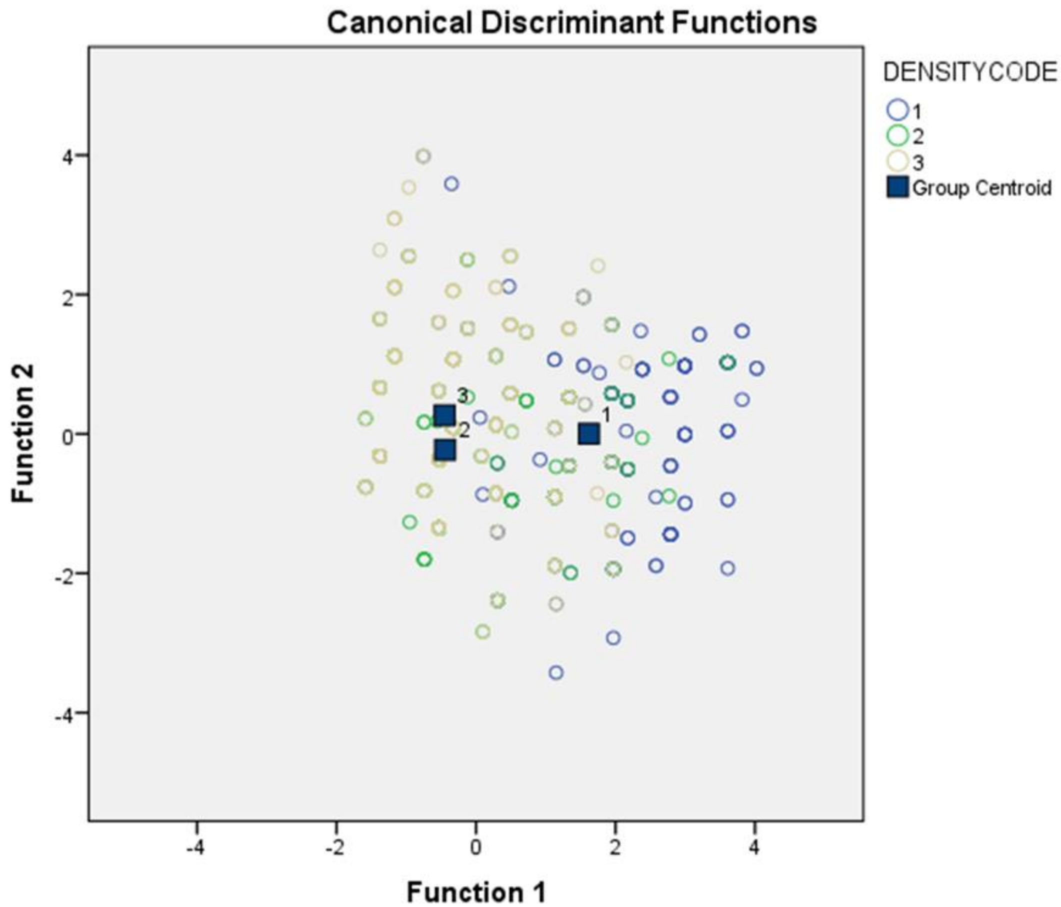


Figure 37 Separation of groups on discriminant functions by sense of fear variables

Table 38 Canonical scores of group means with the two discriminant functions

	Function 1	Function 2
Discriminant analysis I: Socio-economic and demographic profile grouping		
Urban Detroit	-1.588	.028
Higher density suburban	.364	-.177
Lower density suburban	.540	.187
Discriminant analysis II: Travel pattern grouping		
Urban Detroit	-.200	.397
Higher density suburban	-.211	-.118
Lower density suburban	.675	-.004
Discriminant analysis III: Social environment grouping		
Urban Detroit	1.619	.002
Higher density suburban	-.443	-.229
Lower density suburban	-.451	.266

Based on the three discriminant analyses results, distinctive characteristics of each urban density neighborhood group were revealed (table 38). The urban Detroit neighborhood grouping was characterized as a low income population sub-group with pedestrian-dominant travel patterns and a greater fear from crime associated with walking in the neighborhood. The higher density suburban neighborhood group was characterized as a high income population sub-group at an earlier life cycle stage with walking-dominant travel patterns, but a lesser fear from crime and traffic associated with walking in the neighborhood. Lastly, for the lower density suburban neighborhood group, the neighborhood was characterized as a high income population sub-group with driving-dominant travel patterns, but a greater sense of fear from traffic walking in the neighborhood.

4.5. Travel behavior characteristics in three neighborhood typologies in the Detroit region

In order to understand the effects of individual socio-economic and demographic characteristics on trips, controlling the urban built environment is crucial to accurately understand the effects of individual socio-economic and demographic characteristics on trip making (Handy, 1993). Travel costs and patterns vary by neighborhood built environments, since urban form provides different sets of potential destinations for daily activities within the neighborhood.

First, before looking at the disaggregate individual travel behavior analysis results from the disaggregate regression analysis and analysis of covariance in the following chapter, it is noteworthy to examine the mean differences in travel activities between the three neighborhood typologies. By comparing travel patterns—total trip frequency and cumulative trip distance—for all travel activities, a clear distinction was revealed between the three urban neighborhood density groups (table 39). On average, the respondents in the lower density suburban neighborhoods made the least number of trips, but they traveled the greatest trip miles by all modes for all activities. Meanwhile, the respondents in the higher density neighborhoods, both urban and suburban, made more trips, supporting the argument that shorter neighborhood travel distances in high density neighborhoods may spur trip generation and thereby overall travel (Crane, 1996; Crane and Crepeau, 1998).

However, despite the similar urban densities between the higher density urban and higher density suburban neighborhoods, the respondents in the urban Detroit neighborhoods traveled longer distances by all modes for all activities, providing the critical cue to explore the differing effects of neighborhood amenity characteristics on individuals' trip making. Moreover, a pattern of greater miles traveled by all modes in the lower density suburban neighborhood, both in terms of average miles traveled and sum of miles traveled, offers empirical evidence of the extreme automobile-dependence in urban environments characterized by low densities.

Differing travel behaviors by neighborhood type become more obvious when trip frequencies and distances are explored separately by each travel mode (pedestrian, public transit, and driving, see table 39). In the lower density suburban neighborhoods, there were almost no public transit trip and the respondents in these neighborhoods made the least number of trips on average by walking. The respondents in the lower density suburban neighborhoods also traveled the most—both in terms of trip frequency and distance—by driving for all activities.

In the urban Detroit neighborhoods, the respondents traveled not only more frequently, but also over greater miles, by pedestrian and public transit modes compared to respondents in similar higher density suburban neighborhoods (figure 38 and 39). In particular, the public transit trip distance for the urban Detroit neighborhoods was substantially greater than that of the respondents in the higher density suburban neighborhoods. In terms of driving trips and distances traveled to reach their destinations, respondents in the urban Detroit neighborhoods also traveled more frequently and greater miles on average compared to those of the higher density suburban neighborhoods (figure 40). These descriptive results suggest the greater travel burdens of the urban Detroit neighborhoods.

Table 39 Descriptive analysis results of travel patterns for all activities in three neighborhood typologies

	All modes		Pedestrian		Public transit		Driving	
	Freq.	Dist.	Freq.	Dist.	Freq.	Dist.	Freq.	Dist.
Urban Detroit neighborhood								
Mean	12.44	41.08	5.96	10.63	4.43	24.41	9.94	37.56
Std. Dv.	12.303	58.261	7.191	20.853	4.685	31.949	10.131	53.993
Sum	2911	9202	673	1020	297	1318	1939	7061
Minimum	1	0	1	0	0	1	1	0
Maximum	76	337	54	146	25	191	76	333
N	234	224	113	96	67	54	195	188
Higher density suburban neighborhood								
Mean	12.31	35.88	4.78	5.20	3.42	6.67	9.78	34.43
Std. Dv.	7.023	43.209	4.417	9.362	4.681	12.403	6.386	44.468
Sum	5699	16467	1276	1164	164	307	4440	15459
Minimum	1	0	0	0	0	0	0	0
Maximum	36	277	24	88	32	82	52	277
N	463	459	267	224	48	46	454	449
Lower density suburban neighborhood								
Mean	11.75	59.04	3.22	7.79	1.67	15.20	10.83	56.55
Std. Dv.	7.931	53.887	3.310	11.164	0.816	20.572	7.548	52.622
Sum	4584	22731	373	740	10	76	4202	21660
Minimum	1	1	0	0	1	1	1	1
Maximum	61	349	21	54	3	51	61	349
N	390	385	116	95	6	5	388	383

For trips to work, people in the urban Detroit neighborhoods consistently made more trips and traveled more miles as pedestrians and by public transit than those in both the high and lower density suburban neighborhoods (table 40). The urban respondents traveled on average 16 miles by walking, and 26 miles by public transit to work, which is a substantially longer distance compared to 6 and 8 miles by pedestrian and public transit modes, respectively, in the similar built form higher density suburban neighborhoods. This may imply the pattern of the reverse commute (Kain, 1968; Johnston-Anumonu, 1992, 1997; McLafferty and Preston, 1992, 1996a, b, c, 1997; Vojnovic and Darden, 2013b; Wyly, 1998). Among all three neighborhood density groups, the lower density suburban neighborhood residents traveled the greatest miles to work by driving, which reflects the great dependence on driving trips of the lower density suburban neighborhood residents.

Table 40 Descriptive analysis results of travel patterns for *work* trips in three neighborhood typologies

	Frequency			Distance		
	Pedestrian	Public transit	Driving	Pedestrian	Public transit	Driving
Urban Detroit neighborhood						
Mean	3.86	3.52	5.03	15.77	26.29	46.43
Std. Dv.	1.859	2.108	3.139	14.202	31.34	49.593
Sum	85	81	357	205	368	2507
Minimum	1	0	1	0	1	0
Maximum	7	8	18	49	126	220
N	22	23	71	13	14	54
Higher density suburban neighborhood						
Mean	3.18	2.99	4.45	6.1	7.81	43.57
Std. Dv.	2.078	1.975	1.391	9.762	14.451	51.646
Sum	258	102	1197	433	242	10763
Minimum	1	1	1	0	1	0
Maximum	10	7	8	69	82	284
N	81	34	269	71	31	247
Lower density suburban neighborhood						
Mean	2.92	3.00	4.81	13.95	17.5	63.75
Std. Dv.	1.978	2.828	2.135	10.352	9.192	79.326
Sum	76	6	1053	265	35	12240
Minimum	1	1	1	2	11	1
Maximum	7	5	20	36	24	965
N	26	2	219	19	2	192

For other daily activities, such as shopping, going to restaurants, accessing personal service, and leisure activities, trip patterns were consistent to work trips and aggregate trips (for all activities) (table 41, 42, 43, and 44). That is, respondents in the lower density suburban neighborhoods were involved in the least pedestrian trips, regardless of travel activity. Subsequently, the lower density suburban respondents traveled more frequently and traveled more miles by driving than those in the higher density suburban neighborhoods for each activity. However, the fact that the urban Detroit respondents traveled more miles for shopping than both the suburban neighborhood types (lower or higher density) shows that urban minorities face greater travel burdens from traveling between scarce destinations in the urban neighborhoods.

The greater travel burden of urban minorities in the Detroit neighborhoods is also evident from the greater frequency and distance that these population sub-groups travel as pedestrians and by public transit for their daily activities. For shopping, restaurant, and service trip activities, the Detroit urban respondents made the most pedestrian trips and traveled the longest distances when compared to all other neighborhood groupings. The Detroit urban respondents also traveled the most miles by public transit for shopping, restaurant, service, and leisure compared to those respondents in the similar higher density suburban neighborhoods. Higher density suburban respondents, in fact, made the least frequent trips as pedestrians and by driving, and traveled the least miles by any travel modes for their daily activities (except for leisure). For leisure trips, the higher density suburban respondents made more pedestrian trips, but they traveled fewer miles than the Detroit urban respondents. This might be attributed to after-dinner walks or walking the dog within their neighborhood.

We can conclude from this analysis, therefore, that individual travel behaviors are a set of choices that result from differing socio-economic and demographic characteristics, the nature of available travel modes, and urban built environments in which an individual lives. It is clear that lower income Detroit residents traveled more frequently as pedestrians and by public transit, while the lower density suburban residents traveled more frequently by car. Furthermore, longer trip distances were evident for the lower density suburban respondents in their daily travel activities. However, lower income Detroit residents traveled longer distances for daily activities when compared to the higher density suburban residents.

Table 41 Descriptive analysis results of travel patterns for *shopping* trips in the three neighborhood typologies

	Frequency			Distance		
	Pedestrian	Public transit	Driving	Pedestrian	Public transit	Driving
Urban Detroit neighborhood						
Mean	3.77	3.97	3.47	7.70	15.00	14.36
Std. Dv.	3.954	5.242	3.567	18.888	27.563	19.950
Sum	283	119	586	547	450	2369
Minimum	0	1	0	0	1	0
Maximum	23	21	30	146	150	186
N	75	30	169	71	30	165
Higher density suburban neighborhood						
Mean	2.15	1.69	3.26	2.22	2.46	6.90
Std. Dv.	1.672	1.974	2.300	3.507	2.665	6.186
Sum	215	22	1371	213	32	2886
Minimum	0	0	0	0	0	0
Maximum	12	8	16	29	9	55
N	100	13	421	96	13	418
Lower density suburban neighborhood						
Mean	2.21	0.50	3.55	5.79	2.00	11.81
Std. Dv.	1.855	0.707	2.805	9.834	0.000	14.151
Sum	75	1	1287	197	4	4251
Minimum	0	0	0	0	2	0
Maximum	8	1	30	54	2	168
N	34	2	363	34	2	360

Table 42 Descriptive analysis results of travel patterns for *restaurant* trips in the three neighborhood typologies

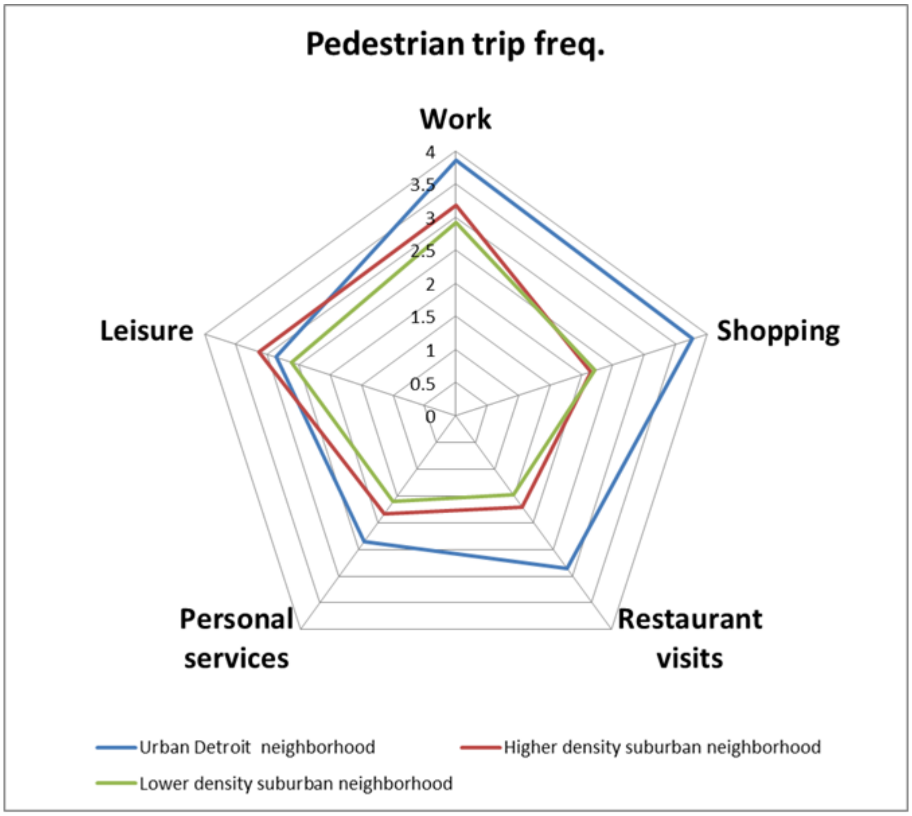
	Frequency			Distance		
	Pedestrian	Public transit	Driving	Pedestrian	Public transit	Driving
Urban Detroit neighborhood						
Mean	2.86	1.88	2.83	3.33	6.69	8.12
Std. Dv.	3.942	1.054	2.639	4.503	7.525	13.914
Sum	120	32	320	130	107	893
Minimum	1	1	0	0	1	0
Maximum	25	5	16	20	30	101
N	42	17	113	39	16	110
Higher density suburban neighborhood						
Mean	1.71	2.50	1.93	2.52	2.33	5.44
Std. Dv.	1.390	1.732	1.495	9.414	1.528	7.384
Sum	162	10	516	209	7	1332
Minimum	0	1	0	0	1	0
Maximum	10	4	8	86	4	61
N	95	4	268	83	3	245
Lower density suburban neighborhood						
Mean	1.48	2.00	2.19	6.45	5.50	9.63
Std. Dv.	1.238	0.000	1.961	9.364	6.364	11.663
Sum	34	4	558	142	11	2244
Minimum	0	2	0	0	1	0
Maximum	5	2	12	43	10	72
N	23	2	255	22	2	233

Table 43 Descriptive analysis results of travel patterns for *personal service* trips in the three neighborhood typologies

	Frequency			Distance		
	Pedestrian	Public transit	Driving	Pedestrian	Public transit	Driving
Urban Detroit neighborhood						
Mean	2.36	1.76	3.10	3.93	9.58	10.54
Std. Dv.	1.973	1.091	3.017	6.434	11.217	13.247
Sum	99	51	418	110	182	1054
Minimum	1	1	1	0	0	0
Maximum	10	5	18	33	37	67
N	42	29	135	28	19	100
Higher density suburban neighborhood						
Mean	1.83	2.38	2.46	1.58	2.63	5.24
Std. Dv.	1.365	2.774	1.988	1.975	2.446	6.118
Sum	187	19	796	120	21	1304
Minimum	0	1	0	0	1	0
Maximum	7	9	14	14	8	43
N	102	8	324	76	8	249
Lower density suburban neighborhood						
Mean	1.61	1.00	2.96	2.79	5	10.53
Std. Dv.	1.202	.	2.599	3.919	.	22.339
Sum	50	1	936	78	5	3032
Minimum	0	1	0	0	5	0
Maximum	6	1	30	18	5	332
N	31	1	316	28	1	288

Table 44 Descriptive analysis results of travel patterns for *leisure* trips in the three neighborhood typologies

	Frequency			Distance		
	Pedestrian	Public transit	Driving	Pedestrian	Public transit	Driving
Urban Detroit neighborhood						
Mean	2.86	2.46	3.23	3.63	12.53	20.4
Std. Dv.	2.333	1.769	3.655	5.304	11.838	28.208
Sum	120	59	349	69	213	1469
Minimum	0	0	1	0	1	0
Maximum	10	7	21	21	42	164
N	42	24	108	19	17	72
Higher density suburban neighborhood						
Mean	3.13	1.63	2.95	2.49	3.25	10.44
Std. Dv.	2.780	1.408	2.665	4.136	3.304	19.849
Sum	523	13	913	237	13	2318
Minimum	0	1	0	0	1	0
Maximum	15	5	28	36	8	206
N	167	8	310	95	4	222
Lower density suburban neighborhood						
Mean	2.62	2.00	2.99	2.81	10.00	19.78
Std. Dv.	2.407	1.000	3.497	3.257	1.414	25.574
Sum	144	6	844	90	20	4491
Minimum	0	1	0	0	9	0
Maximum	14	3	40	10	11	229
N	55	3	282	32	2	227



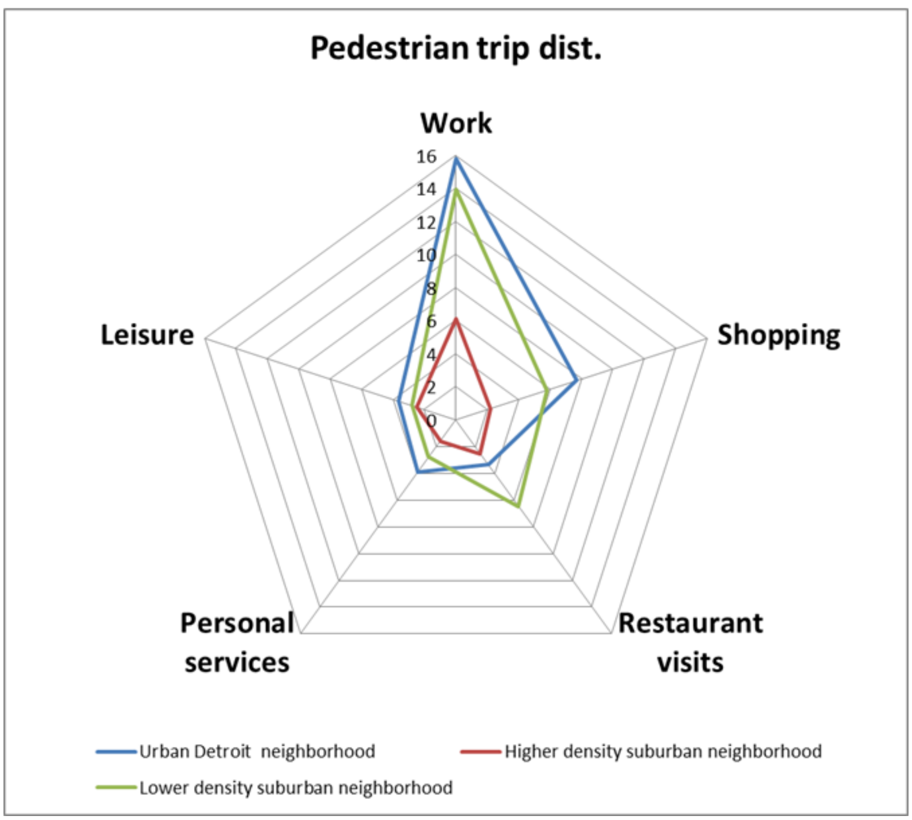
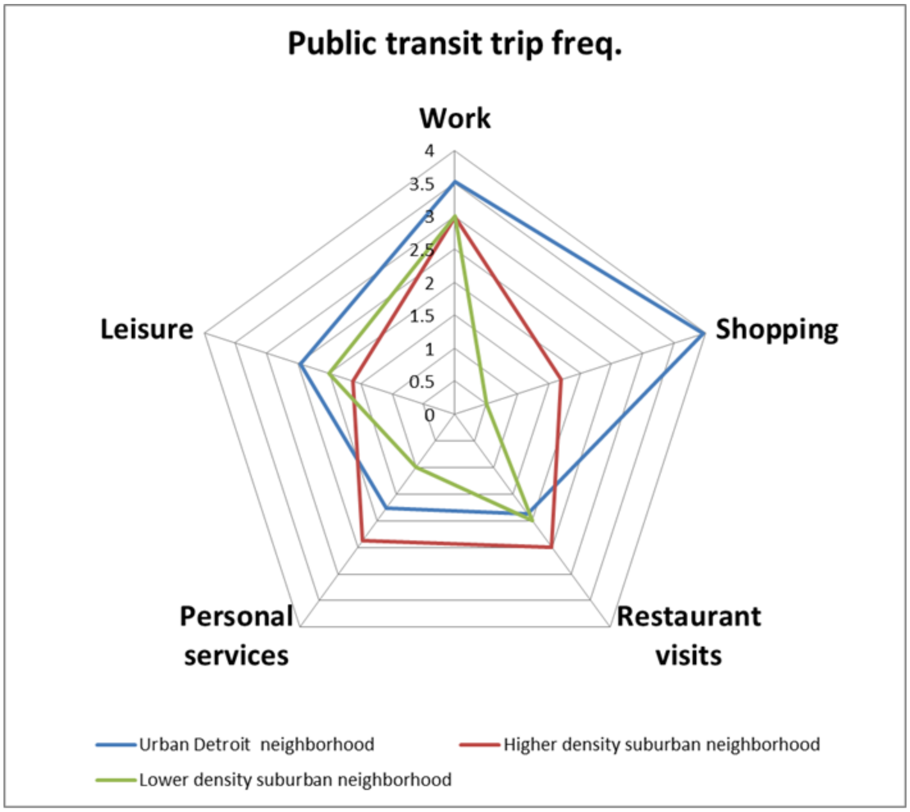


Figure 38 Pedestrian trips for each travel activity by neighborhood groups



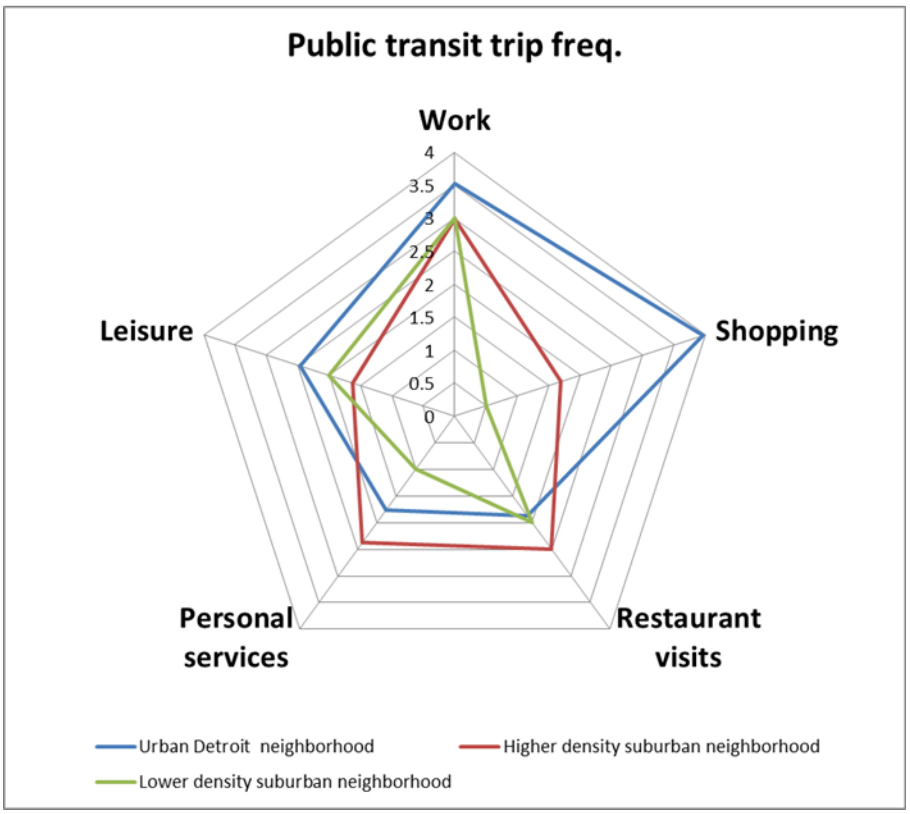
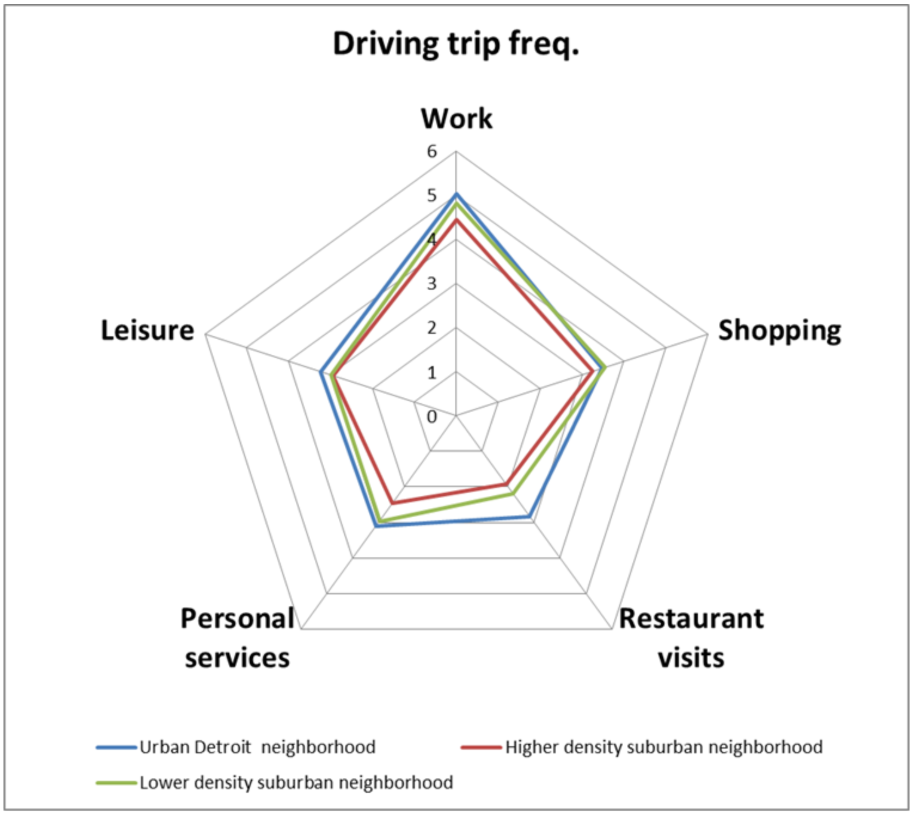


Figure 39 Public transit trips for each travel activity by neighborhood groups



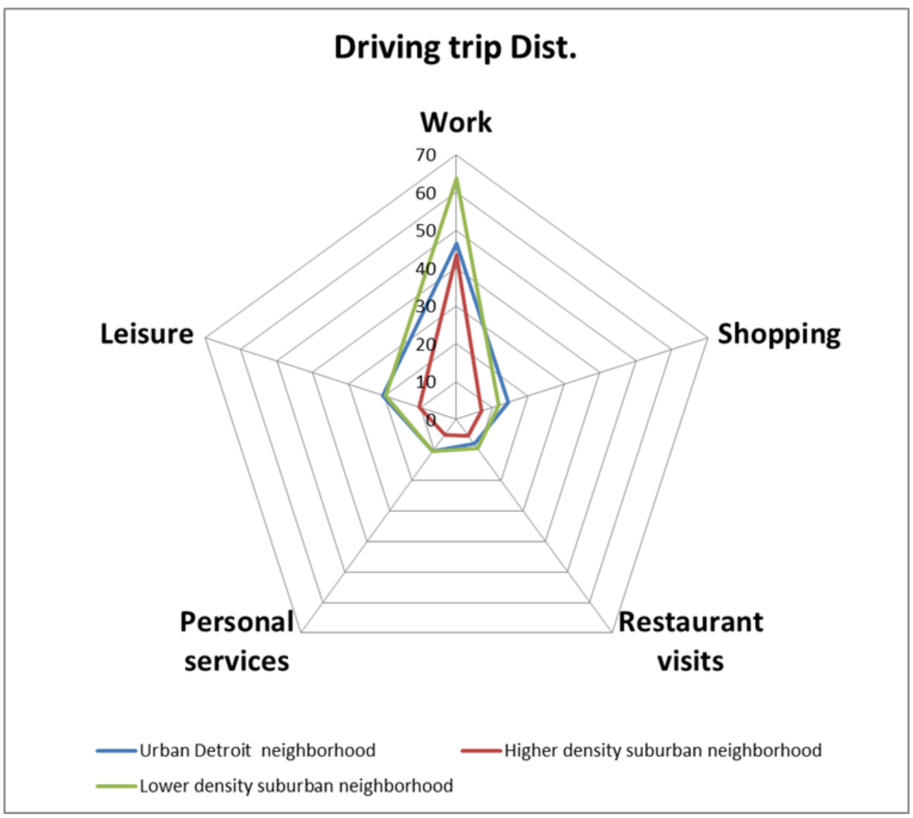


Figure 40 Driving trips for each travel activity by neighborhood groups

4.6. Conclusion and Discussion

First, the findings from the aggregate travel pattern analyses in the Detroit region (n=1,148) demonstrates the significant effects of socio-economic and demographic factors (income, age, personal automobile access, and the number of dependent children) on individual trip making. Before separating travel modes, income and personal vehicle access had a positive effect on trip generation (total trip frequencies and distance) for all activities, work and nonwork travel, while age and the number of dependent children had a negative effect. Thus, a person's travel patterns—in terms of both trip frequency and distance—are influenced substantially by travel modes, including whether one does, or does not have access to a personal vehicle.

In addition, individuals make different choices regarding travel options in the context of personal inter-relationships, whether one is married, whether one is a parent with dependent children, or whether one is a single-parent. This, in turn, implies that women in a multi-person household form their daily travel patterns according to their specialized gender roles as paid laborer, housewife, and mother (Jones, 1990; Hanson and Hanson, 1980a, 1980b, 1981; and Pickup, 1985; 1990). Therefore, women's travels, when compared to men's travel behavior, are affected by life cycles and household organization, and limited by spatial and temporal constraints (Hagerstrand, 1970; Hamilton and Jenkins, 1990; Jones, 1990; Kwan, 1999a, 1999b, 2000; and Pickup, 1990). The details of these relationships will be discussed further in chapter 5.

Second, discriminant analyses were applied to confirm differing characteristics between neighborhood groups in the Detroit region before analyzing disaggregate individual travel behavior. By incorporating socio-economic and demographic factors (income, age, personal vehicle access, and the number of dependent children), the discriminant analysis results differentiated urban Detroit neighborhoods by their lower socio-economic characteristics (income and personal vehicle access) and higher density suburban neighborhoods by their younger life cycle stage characteristics (age and the number of dependent children). By incorporating travel pattern variables (total trip frequencies and cumulative trip distances by travel mode), the analysis discriminated the lower density suburban neighborhoods against the other higher density neighborhood groupings by the lower density neighborhoods' driving dominant travel patterns. In addition, urban Detroit neighborhoods were separated by pedestrian dominant travel patterns against the suburban neighborhood typologies. Given the differences in income levels between suburban neighborhoods and urban Detroit neighborhoods, these results were expected.

Moreover, using the degree of fear from crime and traffic as a proxy for different neighborhood environment quality for pedestrian travel, the analysis results clearly discerned urban Detroit neighborhoods with the fear from *crime* against both the higher density suburban and the lower density suburban neighborhoods. This, again, can be expected given the level of disinvestment, decline, and abandonment in the Detroit urban neighborhoods. With regard to fear from *traffic*, the lower density suburban neighborhoods were differentiated against both the urban Detroit and the higher density suburban neighborhoods. Residents in the lower density suburban neighborhoods faced considerable fear from walking within and between their automobile oriented neighborhoods, where particularly the connecting arterials are characterized by high speeds and a large volume of traffic. Therefore, the discriminant analysis results confirm the importance of structuring a typological analysis—three differing neighborhoods, higher density urban Detroit, higher density suburban, and lower density suburban neighborhood typologies—in order to understand the social dynamics of urban travel.

Lastly, the descriptive analysis results illustrated substantial differences in average trip frequency and trip distance between the three neighborhood typologies. As argued in the literature, populations in the lower density suburban neighborhoods made fewer trips by all modes than in the higher density—urban or suburban—neighborhoods. Respondents in the lower density suburban neighborhoods, however, traveled longer distances by all modes when compared to the higher density neighborhoods, which is consistent with previous studies (Crane, 1996; and Crane and Crepeau, 1998). Nevertheless, the fact that respondents in the urban Detroit neighborhoods traveled longer distances than the respondents in the higher density suburban respondents supports the importance of this neighborhood typology, and its disinvestment and decline, in understanding the travel burdens of lower-income urban minorities.

By disaggregating travel activities by travel type, the travel burdens faced by urban minorities in the Detroit region become even clearer. Regardless of travel activities—whether they were commutes to work, trips to shopping, restaurant visits, personal services, or leisure destinations—the respondents in urban Detroit neighborhoods traveled longer distances not only as pedestrians, but also by public transit, when compared to respondents who lived in the higher density suburban neighborhoods. However, the results are still limited in depicting the full understanding of individual travels since there were too few respondents after disaggregating by travel activities. By driving, on average, respondents in urban Detroit neighborhoods also traveled longer distances for their daily activities than the respondents in the higher density suburban neighborhoods. Furthermore, to access their shopping, personal services, and leisure destinations, Detroit urban minorities even drove longer distances than respondents in the lower density suburban neighborhoods. Consequently, these descriptive results may offer the initial evidence of the differing effects of neighborhood typologies on individual travel patterns, and in particularly within the context of a region where low-income, minority sub-groups live in neighborhoods experiencing disinvestment and decline. This analysis also offers the potential insight and importance of further disaggregation of the data, and specifically reflecting on the type of differences in travel that might be apparent by gender.

CHAPTER 5: Gender difference in travel behavior in Detroit region

In Chapter 5, I will examine the differences in trip making between women and men living in differing urban built environments—specifically the higher density urban, higher density suburban and lower density suburban neighborhood typologies—and how these differences vary by socio-economic and demographic characteristics. For this analysis, six neighborhoods in the Detroit region were selected in the counties of Wayne (two urban Detroit neighborhoods situated on the east side of the city), Washtenaw (one Ann Arbor neighborhood), and Oakland (three neighborhoods, one each in Birmingham, Bloomfield Hills, and West Bloomfield). Among these neighborhoods, the two urban Detroit neighborhoods and the Ann Arbor and Birmingham neighborhoods were characterized as higher density urban built environments, in contrast to the two suburban lower density neighborhoods located in Bloomfield Hills and West Bloomfield.

By socio-economic and demographic characteristics, urban Detroit neighborhoods were described as low income, predominantly non-white with low access to a private automobile. In contrast, the two suburban neighborhood groups, the higher density suburban and lower density suburban groups, were characterized by higher incomes, predominantly white, with greater access to a car. In the urban Detroit neighborhoods, 91.9% of the respondents were non-white, and the average personal income was $23,600, while the suburban neighborhood groups were predominantly white (94.7% for the higher density suburban neighborhood group and 88.6% for the lower density suburban neighborhood group) and higher income ($58,100 in the higher density suburban neighborhood group and $63,900 in the lower density suburban neighborhood group).

Another stark difference between the urban Detroit and the suburban neighborhoods was the percentage of population that was married. The majority of urban Detroit respondents were not married (76.2%) while more than 70% of the suburban respondents from both neighborhood groups were married (71.3% for the higher density suburban neighborhood group and 76.0% for the lower density suburban neighborhood group). Subsequently, in reflecting on socio-economic differences from being married or living with a partner (Light, 2004; U.S. Census Bureau, 2010), it is assumed that minority women who were not married in urban Detroit neighborhoods were at the lowest income categories among gender and marital status groups in the survey sample. Lastly, the lower income status of the urban Detroit neighborhood group was also reflected in the average automobile access per capita. Average automobile access per capita was less than one car (0.8) in urban Detroit, whereas each suburbanite had access to more than one car (1.3 for the higher density suburban neighborhood group and 1.4 for the lower density suburban neighborhood group). Table 3 in chapter 2 provides a more detailed break-down.

By disaggregating daily trips into trips to work, shopping, restaurants, personal services and leisure, and exploring these differences by gender, this chapter will provide a more systematic review of travel—including trip frequencies, trip distances, and travel modes—within different neighborhood typologies in the Detroit region. The disaggregation of travel into a comprehensive array of diverse travel activities can offer considerable insight into understanding the complexity of women's daily travel based on their socio-economic status and multiple roles within the household (Freedman and Kern, 1997; Hamilton and Jenkins, 1990; Hanson 1995; Hanson and Hanson, 1980a, 1980b; Hanson and Johnston, 1985; Hanson and Giuliano, 2004; Hu and Young, 1999; Jones 1990; Johnston-Anumonwo, 1992; Kwan, 1999a, 1999b, 2000; McFadden and Reid, 1975; Schintler et al., 2000; Santos et al., 2011; and Pickup, 1985, 1990).

In addition, the effects of socio-economic and demographic characteristics on travel among women will be more clearly evident when factors that influence their travels, such as differing built environments, are controlled for in the statistical models. Disaggregate travel behavior analysis offers appropriate explanations on the complexity of women's daily travels that are highly influenced by their household structure, the nature of travel modes (whether they have access to a car), and the immediate neighborhood environment (Freedman and Kern, 1997; Handy, 1993, 1996; Hanson and Hanson, 1980a, 1980b; Hanson, 1982; and Srinivasan and Bhat, 2005). Hence, measuring the easiness of reaching various destinations within the neighborhood is crucial to identify the travel burdens of women as they accomplish their daily responsibilities. Within this context, disaggregated travel behavioral models at a neighborhood level will help to explain the differences in trip making between women and men, and also among women with different socio-economic and demographic profiles.

5.1. Research Objectives, Questions and Hypotheses

The goal of this chapter is to examine gendered travel patterns and their relationship with urban built environment characteristics after controlling for socio-economic and demographic factors. Accordingly, it is hypothesized that women's travels are more related to household responsibilities within the urban built environment. It is also hypothesized that lower-income, urban minority women tend to rely on walking and public transit in accessing daily destinations more than other women's groups, such as wealthier women in suburban neighborhoods, due to lower access to a car among the lower-income Detroit women. Subsequent research questions are how women travel differently from men within similar urban built environments for daily activities and how lower-income urban minority women's travels are more disadvantaged than other women's groups living in the suburban Detroit neighborhoods.

5.2. Disaggregate Travel Behavior Research Data and Method

In order to address the social dynamics of an individuals' travel behavior, particularly between women and men, I performed two sets of disaggregated analyses: (1) OLS regression; and (2) Analysis of Covariance (see table 45). Gender differences in travel behavior will be examined after controlling for different urban built environments at a neighborhoods scale.

Ordinary Least Squares (OLS) regression was used to assess how women's travel behavior differed from those of men utilizing various travel modes—including pedestrian, public transit, and driving—after controlling for other socio-economic and demographic characteristics that were selected from the general trip generation models. It becomes particularly important to understand the different utilization of travel modes by women in the context of their travel constraints that result from differing degrees of access to a private vehicle in the household.

Women's travel patterns should also be understood with consideration to gender roles and to the multifaceted household responsibilities of women. Hence, the complexity of women's daily travels were explored by disaggregating their travel patterns into various daily activities, such as trips for work, shopping, restaurant visits, leisure and personal services. ANCOVA (Analysis of Covariance) was also used to assess the mean differences between women and men by marital status and types of activity-based travel behavior. With this method significant mean differences between women and men were reported, taking into account whether they were not-married or married, controlling for age and household structure and adjusted family income (herein referred to as income). A fuller explanation of the application of these two methods in this research follows.

Table 45 Variables for disaggregate travel behavior models

Models	Dependent Variables	Independent Variables (Predictors)
Gender differences in individual travel behavior		
OLS regression (*Within* neighborhoods)	Total trip frequency[1] Cumulative trip distance[2] • Work trip • Shopping trip • Restaurant trip • Service trip • Leisure trip	Gender (Women)[3] Income[4] Age[5] # of personal vehicles available # of dependent children[6]
Gender and marital status differences in individual travel behavior		
ANCOVA (*Within* neighborhoods)	Total trip frequency[1] Cumulative trip distance[2] • Work trip • Shopping trip • Restaurant trip • Service trip • Leisure trip	Gender (Women)[3] Marital status[7] Covariates • Income[4] • Age[5]

1. Weekly total trip frequency by each mode (walking and cycling, public transit, and driving)
2. Weekly cumulative trip distance by each mode (walking and cycling, public transit, and driving)
3. Women = 1 and men = 0
4. Household structure adjusted family income
5. Adults who are 18 years old and older
6. Children who are younger than 18 years old
7. And Married = 1 and not-married = 0

In order to explain the travel demand generated by individuals or households, researchers have used disaggregated regression analyses as a function of the characteristics of these decision-makers (White and Senior, 1983). Due to the relatively large variation in trip generations of individuals and households between analysis groups, sometimes the coefficients of correlation and determination are low, but this does not mean that disaggregate regressions provide inferior fits to reality compared to other studies using regression analyses (Manheim, 1979; Martin, Memmot, and Bone, 1967; and Meyer and Miller, 1984). Moreover, as an indicator of actual trip making responses, disaggregate regression coefficients can aid in more fully understanding changes in explanatory (independent) variables (White and Senior, 1983). In summary, disaggregate methods, compared to aggregated zonal regression methods, have captured the true behavioral variation in trip making by individuals and households more accurately and have used survey data more efficiently. Equation 6 is an example of a disaggregate travel behavior regression model.

(Equation 6)

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \cdots\cdots + b_iX_i + e$$

Where Y = travel behavior response (dependent) variable

a = the intercept term

b = the regression coefficient (slope term) for variable X

X = socio-demographic characteristic predictors (independent variable)

i = the number of predictors (independent variables)

e = an error (disturbance) term

Since individual travel behavior are closely related to the role of individuals in the household—e.g. married versus not married, households with or without dependent children, or two income-earner households versus single income earner households—it is important to discern the differences in trip making by household characteristics. Particularly in exploring gender differences in individual travel behavior, the incorporation of marital status is crucial in examining the variations in travel behavior that are differentiated by the diverse travel activities between women and men (Hamilton and Jenkins, 1990; Hanson and Hanson, 1980a; Jones, 1990; Pickup, 1985). Here, I use the analysis of covariance (ANCOVA) to detect the mean differences between women and men while also considering their marital status.

The ANCOVA is a statistical method that utilizes the benefits of both analysis of variance (ANOVA) and linear regression analysis (Silk, 1979). It is also concerned with a response or dependent variable, measured on an interval or ratio scale, and a set of predictors (independent variables) that are measured on a nominal or ordinal scale. In addition to categorical predictors, the ANCOVA introduces a covariate, an additional explanatory variable, measured on a ratio or interval scale, to adjust mean values already estimated according to the analysis of variance model on the categorical variables. The ANCOVA adjusts the mean for each categorical group on the basis of the mean deviation for the covariate. The adjustment of dependent variables can be found by subtracting the group deviation on the covariate that is weighted by the regression coefficient from the unadjusted deviation. Such adjustments are particularly important to disentangle the confounding effects between the categorical predictors and covariates.

In this study, the ANCOVA allows for greater test sensitivity in examining the effects of gender and marital status on determining trip characteristics of each daily activity, including shopping, restaurant, and leisure trips. From household or individual travel surveys, disaggregating individual travel behavior into a variety of daily travel activities only enables limited observations (N) for each category—such as married women versus married men from the interaction between gender and marital status categories. Thus, the ANCOVA can offer mean differences as the effects of groups, while the inclusion of such categorical variables into OLS regressions empirically results in challenges on detecting differences on individual travel behavior at such disaggregated levels of travel activity. Equation 7 is an example of the ANCOVA model of travel behavior that is used in this research.

(Equation 7)

$$\overline{Y}_{j(adj.)} = \overline{Y}_j - b(\overline{X}_j - \overline{X})$$

Where Y = travel behavior response (dependent) variable

$\overline{Y}_j$ = deviation of dependent variable for categorical group j

b = the regression coefficient (slope term) for covariate X

X = covariate variable (income and age)

$\overline{X}_j$ = deviation of covariate variable for categorical group j

j = the number of categorical group of predictors (independent variables)

5.3. Results

5.3.1. Urban Detroit (Lower East Side Detroit Neighborhoods): Disaggregate analyses on individual travel behavior in the higher density urban neighborhoods

In this section, the effects of gender, socio-economic and demographic characteristics on individual travel behavior were analyzed for disaggregate travel activities in the higher density urban Detroit neighborhoods. First, the OLS regression was used to estimate the causal relationships between gender and trip frequency (model 1) and distance (model 2), after adjusting for differences in socio-economic and demographic characteristics (age, income, number of dependent children and the number of personal vehicles available) for each of the travel activities. Both dependent variables were transformed using square-root and logarithm respectively. The results showing the effects of gender on trip frequency (table 46) and distance (table 47) for daily activities are provided, for the travel activities going to work, shopping, restaurant visits, personal service, and leisure. Travel frequency and distance were also explored by three travel modes: pedestrian (also referred to as walking or biking), public transit and driving. While gender (women = 1) was primarily used to understand individual travel behavior, other independent variables (age, income, number of dependent children and personal vehicle availability) were also employed in the models when the sample size allowed.

Table 46 OLS regression results of gender differences in disaggregate analyses on individual travel behavior in the urban Detroit neighborhoods: *trip frequency*

		Total trip frequency[1]				
		N[2]	β	S.E.	df	P-value
WORK						
Pedestrian	Women[3]	21	.642	.188	3	.006
Public transit	Women[4]	22	-.093	.399	3	.819
Driving	Women[5]	67	-.167	.224	3	.458
SHOPPING						
Pedestrian	Women[6]	70	.115	.254	3	.651
Public transit	Women[7]	27	.081	.565	3	.887
Driving	Women[8]	155	.221	.154	3	.155
RESTAURANT VISITS						
Pedestrian	Women[9]	41	-.266	.284	3	.356
Public transit	Women[10]	15	-.069	.197	3	.734
Driving	Women[11]	95	-.042	.136	4	.760
SERVICE						
Pedestrian	Women[12]	40	-.028	.270	3	.918
Public transit	Women[13]	26	-.408	.194	3	.051
Driving	Women[14]	122	.110	.161	3	.496
LEISURE						
Pedestrian	Women[15]	35	.059	.264	4	.826
Public transit	Women[16]	20	-.926	.188	4	.000
Driving	Women[17]	101	-.052	.181	3	.777

1. Total trip frequency per person on a weekly basis (trip count, square root transformed);
2. N = number of resident men and women;
3. Gender dummy: women = 1, and men = 0, and controlled for constant, age and income (**);
4. Controlled for constant (***), age and income (**);
5. Controlled for constant, age and income;
6. Controlled for constant (*),age (**) and income;
7. Controlled for constant, age and income;
8. Controlled for constant, age and income;
9. Controlled for constant (*), age (***) and income;
10. Controlled for constant, age and income;
11. Controlled for constant (*), age (**), income and personal vehicle available (**);
12. Controlled for constant, age (***) and income;
13. Controlled for constant (***), age and income (**);
14. Controlled for constant, age (*), and income (*);
15. Controlled for constant, age, income and the number of dependent children (**);
16. Controlled for constant, age, income and the number of dependent children (**);
17. Controlled for constant, age (**) and income.

For all models, the tolerance values were above 0.600 for all predictors.
Statistical significance at the 90% (*), 95% (**), and 99% (***) level, respectively.

Table 47 OLS regression results of gender differences in disaggregate analyses on individual travel behavior in the urban Detroit neighborhoods: *trip distance*

		Cumulative trip distance[1]				
		N[2]	β	S.E.	df	P-value
WORK						
Pedestrian	Women[3]	12	.576	1.982	3	.786
Public transit	Women[4]	14	-.734	.905	3	.441
Driving	Women[5]	49	-1.144	.489	3	.025
SHOPPING						
Pedestrian	Women[6]	60	-.047	.386	3	.904
Public transit	Women[7]	23	-1.350	.714	4	.077
Driving	Women[8]	146	-.181	.228	3	.429
RESTAURANT VISITS						
Pedestrian	Women[9]	32	-.459	.428	3	.294
Public transit	Women[10]	14	-1.476	.965	3	.165
Driving	Women[11]	96	-.229	.300	3	.448
SERVICE						
Pedestrian	Women[12]	18	.856	.732	4	.267
Public transit	Women[13]	17	-2.018	.711	3	.018
Driving	Women[14]	90	-.358	.298	3	.233
LEISURE						
Pedestrian	Women[15]	16	1.018	.540	3	.086
Public transit	Women[16]	15	.017	.598	3	.978
Driving	Women[17]	62	-.589	.283	4	.043

1. Cumulative trip distance to destinations per person on a weekly basis (mile, logarithm transformed);
2. N = number of resident men and women;
3. Gender dummy: women = 1, and men = 0, and controlled for constant, age and income, the tolerance values were above 0.500 for all predictors;
4. Controlled for constant, age and income;
5. Controlled for constant (**), age, and income;
6. Controlled for constant, age, and income;
7. Controlled for constant, age, income and personal vehicle available (**);
8. Controlled for constant, age and income (*);
9. Controlled for constant, age and income (*);
10. Controlled for constant, age and income (*);
11. Controlled for constant, age and income (*);
12. Controlled for constant, age (**), income and personal vehicle available (**), the tolerance values were above 0.500 for all predictors;
13. Controlled for constant (**), age and income (*);
14. Controlled for constant, age and income (*);
15. Controlled for constant, age and income;
16. Controlled for constant (*), age and income (**), the tolerance values were above 0.500 for all predictors;
17. Controlled for constant (**), age (**), income and the number of dependent children (**).

For all other models, the tolerance values were above 0.600 for all predictors.
Statistical significance at the 90% (*), 95% (**), and 99% (***) level, respectively.

5.3.1.1. Gender Difference in Travel Behavior: Trips to Work

In the Detroit urban neighborhoods, women had significantly more trips to work via walking or biking than men (*B*= 0.642, p-value = 0.005) controlling for differences in age and income. Of those women and men who drove to work (n=49), women's trips were significantly shorter than men's trips (*B* = -1.144, p-value = 0.025) controlling for differences in age and income.

5.3.1.2. Gender Difference in Travel Behavior: Trips to Shops, Restaurants, Personal Services, and Leisure

5.3.1.2.1. Trips to shopping

In the Detroit urban neighborhoods women overall made more frequent shopping trips than men using all modes of transportation, however, the differences in frequency by modes were not significant. Of women and men who traveled to shop by public transit (n=23) women traveled shorter distances than men (*B* = -1.350, p-value = 0.077) controlling for age, income and number of personal vehicles available. Men overall made longer trips to shopping than women using all modes of transportation; however these differences in distance were not significant.

5.3.1.2.2. Trips to restaurants

In the Detroit urban neighborhoods, women traveled less frequently and shorter distances than men to restaurants by all modes of transportation, however these differences were not significant controlling for age and income.

5.3.1.2.3. Trips to personal services

In the Detroit urban neighborhoods, women traveled significantly less frequently than men by public transit to reach personal services (*B* = -0.408, p-value = 0.051) controlling for differences in age and income. Women also traveled significantly shorter distances to personal services than men using public transit (*B* = -2.018, p-value = 0.018) controlling for differences in age and income. In general women drove more frequently than men to personal services (*B* = 0.110), but their travel distance was shorter than that of men (*B* = -0.358). These differences in driving and travel distances were not significant.

5.3.1.2.4. Trips for leisure

In the Detroit urban neighborhoods, women traveled significantly fewer trips than men by public transit for leisure activities (*B* = -0.926, p-value = 0.000), controlling for age, income and number of dependent children. Women also drove significantly shorter distances than men in their trips to leisure destinations (*B* = -0.589, p-value = 0.043) controlling for age and income. In general women walked or biked longer distances than men for leisure activities, however, the differences were marginally significant (B = 1.018, p-value = 0.086). In the high density urban Detroit neighborhoods, differences in individual travel behavior between women and men were also observed within the context of marital status (table 48). Particularly, from the ANCOVA results, there were clearly observed divergences in travel patterns for disaggregated travel activities for married and non-married women and men (tables 49-53).

Table 48 Average weekly total trip frequency and cumulative distance (mile)* by gender and marriage in the urban Detroit neighborhoods

			Men		Women	
			Not-married	Married	Not-married	Married
Work	Trip Frequency	Pedestrian	2.65	3.02	4.62	4.72
		Public transit	4.63	2.37	3.43	2.59
		Driving	5.20	5.26	4.76	5.97
	Trip Distance	Pedestrian	4.43	n/a	22.43	11.57
		Public transit	25.19	16.98	32.23	-7.60
		Driving	61.97	96.69	36.74	53.66
Shopping	Trip Frequency	Pedestrian	3.27	4.73	3.55	5.95
		Public transit	0.79	3.89	2.87	11.55
		Driving	2.94	3.49	3.86	3.83
	Trip Distance	Pedestrian	6.24	2.79	6.30	17.81
		Public transit	22.98	26.65	4.62	55.01
		Driving	13.02	17.32	14.80	18.14
Restaurant visit	Trip Frequency	Pedestrian	2.42	9.17	2.42	1.26
		Public transit	2.00	2.17	1.78	2.22
		Driving	2.86	4.31	2.90	2.31
	Trip Distance	Pedestrian	1.32	10.43	3.36	1.28
		Public transit	4.96	30.02	4.68	8.63
		Driving	8.51	25.82	6.90	5.70
Service	Trip Frequency	Pedestrian	2.52	2.59	2.32	2.15
		Public transit	2.14	0.76	1.72	1.76
		Driving	3.55	3.38	3.04	3.38
	Trip Distance	Pedestrian	1.11	12.60	3.14	6.39
		Public transit	24.19	n/a	6.66	3.16
		Driving	14.91	16.60	9.14	8.46
Leisure	Trip Frequency	Pedestrian	2.28	1.72	2.74	4.64
		Public transit	4.25	5.19	1.84	2.40
		Driving	3.54	3.04	3.35	3.03
	Trip Distance	Pedestrian	1.21	1.68	4.41	5.58
		Public transit	13.47	17.28	11.83	16.35
		Driving	27.23	22.36	16.84	20.25

*Calculated with original weekly total trip frequency and cumulative trip distance data.

Table 49 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in urban Detroit neighborhoods—*work*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.540	1.666	2.114	2.168	21
		(S.E.)	(.179)	(.449)	(.143)	(.201)	
	Public transit[4]	Mean	2.073	1.387	1.813	1.297	22
		(S.E.)	(.264)	(.428)	(.185)	(.314)	
	Driving[5]	Mean	2.224	2.146	2.081	2.320	67
		(S.E.)	(.187)	(.339)	(.115)	(.181)	
Trip dist.[2]	Pedestrian[6]	Mean	1.938	n/a	2.799	1.966	12
		(S.E.)	(.785)		(.426)	(.653)	
	Public transit[7]	Mean	3.012	3.139	2.646	1.953	14
		(S.E.)	(.635)	(1.354)	(.458)	(1.530)	
	Driving[8]	Mean	3.736	4.433	3.089	3.527	49
		(S.E.)	(.412)	(.662)	(.215)	(.353)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.937931, AGE = 43.62.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.839309, AGE = 43.45.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.148370, AGE = 45.69
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.050115, AGE = 42.75.
7. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.879326, AGE = 41.71
8. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.199968, AGE = 44.04.

Mean difference between gender groups was only significant for pedestrian trip frequency (p-value = .066).

Mean difference between marital status groups was only significant for public transit trip frequency (p-value = .085).

Table 50 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in urban Detroit neighborhoods—*shopping*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.732	1.509	1.762	2.138	69
		(S.E.)	(.218)	(.415)	(.133)	(.244)	
	Public transit[4]	Mean	1.213	1.894	1.537	2.969	27
		(S.E.)	(.690)	(.668)	(.220)	(.495)	
	Driving[5]	Mean	1.577	1.662	1.792	1.818	154
		(S.E.)	(.140)	(.216)	(.087)	(.149)	
Trip dist.[2]	Pedestrian[6]	Mean	1.639	0.902	1.263	1.55	59
		(S.E.)	(.348)	(.678)	(.201)	(.375)	
	Public transit[7]	Mean	3.157	3.224	1.274*	3.364	27
		(S.E.)	(.682)	(.660)	(.217)	(.490)	
	Driving[8]	Mean	2.260	2.473	2.059	2.402	145
		(S.E.)	(.205)	(.325)	(.123)	(.206)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.690909, AGE = 47.43.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.654437, AGE = 45.89.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.925840, AGE = 51.05.
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.687254, AGE = 46.49.
7. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.654437, AGE = 45.89.
8. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.923101, AGE = 50.66.

Mean difference between gender groups was only significant for pedestrian trip frequency (p-value = .066).

Mean difference between marital status groups was only significant for public transit trip frequency (p-value = .073), and public transit trip distance (p-value = .064).

Mean difference between gender and marital status groups was only significant for public transit trip distance (p-value = .074).

Table 51 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in urban Detroit neighborhoods—*restaurant visit*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.383	2.448***	1.517	1.213	41
		(S.E.)	(.221)	(.329)	(.136)	(.224)	
	Public transit[4]	Mean	1.367	1.416	1.297	1.438	15
		(S.E.)	(.332)	(.210)	(.104)	(.180)	
	Driving[5]	Mean	1.555	1.823	1.596	1.408	104
		(S.E.)	(.147)	(.229)	(.087)	(.153)	
Trip dist.[2]	Pedestrian[6]	Mean	.677	1.801**	.903	.371	32
		(S.E.)	(.417)	(.447)	(.192)	(.384)	
	Public transit[7]	Mean	1.255	3.243	1.116	2.254	14
		(S.E.)	(1.077)	(.993)	(.336)	(.588)	
	Driving[8]	Mean	1.257	2.296***	1.420	1.416	95
		(S.E.)	(.267)	(.404)	(.165)	(.278)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.614206, AGE = 46.71.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.242150, AGE = 50.47.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.907100, AGE = 48.91.
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.626288, AGE = 45.63.
7. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.301572, AGE = 49.57.
8. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.932552, AGE = 48.53.

Mean difference between gender groups was only significant for pedestrian trip frequency (p-value = .035).

Mean difference between marital status groups was only significant for public transit trip distance (p-value = .071), and driving trip distance (p-value = .079).

Mean difference between gender and marital status groups was only significant for pedestrian trip frequency (p-value = .007), pedestrian trip distance (p-value = .041), and driving trip distance (p-value = .074).

Table 52 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in urban Detroit neighborhoods—*personal services*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.439	1.549	1.419	1.419	40
		(S.E.)	(.233)	(.382)	(.104)	(.184)	
	Public transit[4]	Mean	1.403	0.905	1.255	1.288	26
		(S.E.)	(.203)	(.433)	(.110)	(.218)	
	Driving[5]	Mean	1.708	1.66	1.602	1.742	122
		(S.E.)	(.149)	(.235)	(.086)	(.156)	
Trip dist.[2]	Pedestrian[6]	Mean	0.330	2.347*	1.193	1.180	22
		(S.E.)	(.453)	(.792)	(.231)	(.292)	
	Public transit[7]	Mean	2.728	n/a	1.742	1.031	17
		(S.E.)	(.613)		(.411)	(.655)	
	Driving[8]	Mean	2.235	2.405	1.668	1.819	90
		(S.E.)	(.255)	(.440)	(.158)	(.266)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.661107, AGE = 44.20.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.437054, AGE = 46.65.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.928739, AGE = 51.41.
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.787968, AGE = 44.41.
7. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.474528, AGE = 46.12.
8. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.012668, AGE = 51.60.

Mean difference between gender groups was only significant for driving trip distance (p-value = .063).
Mean difference between marital status groups was only significant for pedestrian trip distance (p-value = .051).
Mean difference between gender and marital status groups was only significant for pedestrian trip distance (p-value = .054).

Table 53 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in urban Detroit neighborhoods—*leisure*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.409	1.056	1.576	1.971	39
		(S.E.)	(.229)	(.351)	(.155)	(.271)	
	Public transit[4]	Mean	1.979	2.277	1.341	1.485	20
		(S.E.)	(.224)	(.532)	(.168)	(.221)	
	Driving[5]	Mean	1.730	1.587	1.623	1.635	101
		(S.E.)	(.169)	(.274)	(.103)	(.181)	
Trip dist.[2]	Pedestrian[6]	Mean	0.417	0.059	1.295	1.020	16
		(S.E.)	(.625)	(1.005)	(.370)	(.669)	
	Public transit[7]	Mean	2.370	2.814	2.155	1.982	15
		(S.E.)	(.484)	(1.117)	(.393)	(.533)	
	Driving[8]	Mean	2.958	2.760	2.104	2.685	70
		(S.E.)	(.256)	(.379)	(.164)	(.272)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.604177, AGE = 47.46.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.423945, AGE = 38.15.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.914638, AGE = 48.69.
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.847110, AGE = 44.38.
7. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.608436, AGE = 39.67.
8. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.985673, AGE = 48.69.

Mean difference between gender groups was only significant for pedestrian trip frequency (p-value = .055), public transit trip frequency (p-value = .060), and driving trip distance (p-value = .096).

5.3.1.3. Distinctions by Gender and Marital Status in Travel Behavior: Trips to Work

More women walked or biked to work than men and this finding did not vary by marital status (table 48). For work trips, both married and not-married women walked significantly more than men (p-value = 0.066, table 49). Non-married women and men were more likely to take public transit to work than married women and men; however, non-married women traveled less frequently to work via public transit than non-married men (3.43 vs. 4.63 times per week). Both married men and married women took public transit less frequently to work than both not-married men and not-married women, and at a significant level (p-value = 0.085). Married women engaged in the most frequent driving trips to work (5.97 times a week), while not-married women engaged in the least frequent driving trips to work (4.76 times a week) when compared to men (5.26 and 5.20).

In terms of work trip distance (Tables 48 and 49), not-married women walked the longest distance to work (22.43 miles per week). This is almost twice as far as both married women (11.57 miles). There was no married man in the sample who walked to work. In addition, not-married women traveled the longest distance to work by public transit (32.23 miles per week). In fact, married women engaged in the shortest travel by public transit to reach their work destinations. Lastly, with regard to driving by car, married men (96.69 miles per week) and not-married men (61.97 miles) drove longer distances to employment compared to women, both married (53.66 miles) and not-married (36.74 miles). In summary, not-married women in the urban Detroit neighborhoods had the least access to a car and traveled least frequently and the shortest distances to work by driving.

5.3.1.4. Distinctions by Gender and Marital Status in Travel Behavior: Trips to Shops, Restaurants, Personal Services, and Leisure

5.3.1.4.1. Trips to shopping

Shopping trips were a primarily women's travel responsibility in the urban Detroit neighborhoods. Regardless of travel modes, women made more frequent shopping trips in urban Detroit (table 48). Married women, in particular, traveled the most frequently for shopping activities among gender and marital status groups, and by all modes of travel. On a weekly basis, married women walked 5.95 times for shopping, while not-married men walked least frequently (3.27 times). The gender difference in pedestrian shopping trip frequency was statistically significant (p-value = 0.066, table 50).

Married women also traveled for shopping most frequently by public transit (11.55 times a week), more than twice compared to married men who traveled to shopping by public transit (3.89 times a week). However, both married women and married men traveled more frequently by public transit to reach shopping destinations when compared to not-married men and not-married women, and at a significant level (p-value = 0.073, table 50). Married women also traveled more frequently for shopping on a weekly basis by car (3.83 times per week) than married men.

In terms of trip distance, married women traveled further distances for shopping only by public transit. With statistically significant marital status differences in public transit distance (p-value = 0.064), married women took public transit for the longest miles to shop (55.01 miles). In addition, the public transit distance for shopping by not-married women (less than 5 miles) significantly differs from those of other gender and marital status groups, who traveled distances at least more than 20 miles (p-value = 0.074, table 48 and 50) to reach shopping destinations by public transit.

In terms of walking, married women traveled the greatest miles for shopping (17.81 miles per week, from table 48). By driving, while both married men and married women traveled the longest distances for shopping, married women traveled more miles to shop compared to married men (18.14 miles per week by married women versus 17.32 miles per week by married men). Not-married women traveled the shortest distance by car (14.80 miles) to reach shopping. In fact, not-married women engaged in the shortest distances to their shopping destinations by all modes of travel except walking, implying their limited accessibility and mobility for shopping opportunities in the inner-city Detroit neighborhoods (table 48).

5.3.1.4.2. Trips to restaurants

Trips to restaurants, however, reveal very different patterns from shopping trips, and it is evident in gender and marital status distinctions (table 48). Married men traveled the most frequently—9.17 times a week—to visit restaurants by walking. Compared to other gender and marital status groups, married men also traveled significantly more times to access restaurants (p-value = 0.035, table 51). In addition, both married and not-married men walked more times on a weekly basis to access restaurants compared to married and not-married women.

By public transit, married men and married women traveled about 2.2 times a week to access restaurants, which was more frequent when compared to both not-married men and not-married women. Married men also traveled most frequently by driving to reach restaurant destinations, 4.31 times a week, while married women drove the least frequently to restaurants.

In terms of trip distance to access restaurants, married men traveled the farthest, and this is the case for all modes of travel.

As pedestrians, married men traveled 10.43 miles per week to restaurants, while married women engaged in the shortest pedestrian trip distances to restaurants (1.28 miles). In fact, the average pedestrian trip distance by married men to a restaurant was significantly longer than the trip distance to access restaurants by any other gender and marital status groups (p-value = 0.041, table 51). Married men also traveled the longest distances (30.02 miles) by public transit to reach a restaurant. Both married men and married women traveled significantly longer distances to restaurants when compared to not-married men and not-married women (p-value = 0.071, table 51). Lastly, married men drove 25.82 miles on average to a restaurant, which significantly differs from driving trip distances by other gender and marital status groups (p-value = 0.074, table 51). Both married men and married women traveled significantly longer distances by a car to visit restaurants when compared to not-married men and not-married women (p-value = 0.079).

5.3.1.4.3. Trips to personal services

For personal service trips, married men dominated pedestrian trips, in both trip frequency and distance. Married men traveled 2.59 times a week to reach personal service destinations, while married women and not-married women traveled twice a week (table 48). However, married men traveled the least frequently for personal services by public transit (0.76 time a week), whereas not-married men made the most frequent transit trips to service destination (2.14 times a week). By driving, not-married men drove the most times (3.55 times a week) for personal services compared to other gender and marital status groups. However, none of the gender and marital status distinctions in personal service trip frequencies was statistically significant. In terms of trip distances, married men walked significantly longer distances (10.43 miles per week, table 48) than not-married men, married women, and not-married women (p-value = 0.054, table 52). In fact, both married men and married women walked significantly longer distances for personal service than not-married men and not-married women (p-value = 0.051, table 52).

With regard to public transit use to access personal services, not-married men traveled further distances (24.19 miles per week) than married women (3.16 miles per week) and not-married women (6.66 miles per week) (table 48). There were no married men respondents using public transit to access personal services. By driving, married men, again, traveled the greatest miles (16.60 miles per week) to reach personal service destinations, while married women traveled the fewest miles (8.46 miles per week) (table 48). Both married men and not-married men in the urban Detroit neighborhoods traveled significantly longer distances by driving than women, married and not-married (p-value = 0.063, table 52).

5.3.1.4.4. Trips for leisure

Finally, with regard to leisure destinations, married women walked the most frequently (4.64 times a week) while married men walked the least frequently (1.72 times a week) to access leisure activities (table 48). Both married women and not-married women walked more frequently for leisure than both married men and not-married men, and at a significant level (p-value = 0.055, table 53). In contrast, both married men and not-married men took public transit significantly more times to leisure destinations when compared to married women and not-married women (p-value = 0.060, table 53).

By public transit, married men traveled most frequently (5.19 times a week) to access leisure activities, while not-married women traveled least frequently among all gender and marital status groups, less than twice a week (table 48). By driving, not-married men traveled most frequently (3.54 times a week) to access leisure activities (table 48).

For leisure activities, married women walked the greatest miles (5.58 miles per week), while not-married men walked the shortest distance (1.21 miles per week) (table 48). However, married men traveled the longest distances by public transit (17.28 miles per week) to reach leisure destinations. Not-married women traveled the shortest distances by public transit, among all the groups, to reach leisure activities (11.83 miles per week). When it came to driving by car to access leisure destinations, not-married men traveled the greatest miles (27.23 miles per week), while the shortest driving trip distances to reach leisure destinations was by not-married women (16.84 miles). This implies that not-married women were spatially constrained for their leisure activities due to limited access to a car and personal time. In urban Detroit neighborhoods, women, regardless of marital status, traveled longer distance as pedestrians for leisure activities whereas men traveled longer distances by public transit and driving. The only gender difference that was statistically significant in driving distances was for leisure activities (p-value = 0.096, table 53).

5.3.1.5. Discussion

In the urban Detroit neighborhoods, the OLS regression results illustrated that women traveled more frequently and greater miles as pedestrians to work compared to men. However, women traveled less frequently and fewer miles than men by motorized travel modes, both taking public transit and driving to work. In contrast, for non-work trips related to household responsibilities—such as shopping and personal services—women traveled more frequently by car. This is consistent with findings among some of the leading gender travel studies (Hamilton and Jenkins, 1990; Hanson and Hanson, 1980a, 1980b; Hanson and Johnston, 1985; Hanson and Giuliano, 2004; Jones, 1990; and Pickup, 1985). Consequently, the fact that women drove more frequently only for shopping and personal services confirms women had less access to a private automobile for daily activities, except for household-related activities. In other words, in urban Detroit, women suffer from greater travel burdens due to their more limited access to a car regardless of age or income. Therefore, Detroit urban women appear to have prioritized household affairs, given their gender role, whenever the private automobile was made available.

In addition, given the fact that women traveled shorter distances in general compared to men reveals that women's spatial extent is more confined compared to that of men, due to their obligation in meeting their daily responsibilities at home and at work. This is again consistent with prior research on the topic on gendered travel behavior (Kwan, 1999a, 1999b, 2000). Furthermore, as shown in previous studies, women in the Detroit urban neighborhoods traveled fewer miles due to their more limited access to a car. Detroit women's shorter trip distances also reveal their more limited accessibility to urban opportunities, a particularly troubling factor given that these neighborhoods are experiencing urban decline. Notice, however, that the Detroit urban neighborhoods—due to their built environment characteristics, the higher densities, mixed land uses, and street connectivity—should, in fact, have higher level of accessibility to urban amenities.

With decentralizing urban opportunities, such as employment, retail and personal services, populations in the lower income neighborhoods face greater travel burdens in the form of longer trip distances to suburban destinations in order to meet their daily needs. There is an added burden for women compared to men within this context. Lower-income women in Detroit's east side neighborhoods are further constrained in their travel as a result of their greater dependence on walking, biking and public transit regardless of their age or income status.

Furthermore, the fact that women do not travel in public transit as much as men—in terms of trip frequency (except shopping) and distance (except leisure)—and in part likely a result of safety related concerns, implies an added layer of burdens placed on women in their daily travel patterns. Consequently, exploring lower-income women's travel behavior at the disaggregate neighborhood level contributes to understanding more accurately socially marginalized groups' travel constraints in a declining urban area such as Detroit. However, in spite of these relationships between gender and individual travel behavior, there were only a few variables, specifically age and income, which significantly explained these travel differences. Additionally, it is possible that the results for pedestrian and public transit work trips might be skewed due to limited Ns from a high unemployment rate and scarce employment opportunities within the city of Detroit. Due to a lower return rate from Detroit urban neighborhoods, the smaller numbers of respondents might have also influenced the regression results for pedestrian and public transit trips for non-work trips.

From the ANCOVA results, more specific mean differences between gender and marital status groups were identified for various travel activities at a disaggregate level. Overall, women made more pedestrian trips compared to men, while men traveled more in public transit and cars. For work, in particular, women traveled fewer miles than men even though married women traveled most frequently as pedestrians and by driving. Therefore, married women's work travels were much more geographically confined, being closer to home, which is a finding consistent with the existing literature (Kwan, 1999a, 1999b, 2000). Women's travel for household responsibilities can be also examined based on their trips for household duties. Married women in the urban Detroit neighborhoods traveled most frequently and the farthest distances for their shopping trips regardless of travel mode. Married men, in contrast, traveled most frequently and the farthest distance in accessing restaurants. In addition, between the married and not-married respondents, ones in marriage made more frequent trips for shopping, but less for leisure.

Another important finding was that not-married women traveled by public transit across the greatest distances in reaching work, personal services, and leisure destinations, but fewer miles for shopping and restaurant visits when compared to married women. When it came to driving, however, not-married women traveled fewer miles when compared to married women for all activities except restaurant visits. Since not-married women tended to have a lower income when compared to married women, married men and not-married men (Light, 2004; and U.S. Census Bureau 2010[5]), their greater use of public transit is likely a result of lower personal automobile access due to the more limited incomes.

5.3.2. Higher Density Suburban (Ann Arbor and Birmingham Neighborhoods): Disaggregate analyses on individual travel behavior in the high density suburban neighborhoods in the Detroit region

In this section, I will explore the differences in travel patterns between women and men in robust and dynamic higher density suburban neighborhoods. These neighborhoods—in Ann Arbor and Birmingham—are characterized by higher densities, mixed land uses and connected street networks, a similar built environment to the Detroit urban neighborhoods, but unlike the city of Detroit neighborhoods, they are not experiencing disinvestment and decline. The OLS

[5] U.S. Census Bureau, *Income, Poverty, and Health Insurance Coverage In the United States: 2009*, Current Population Report, September, 2010.

regression analyses will examine the relationships between gender and individual travel behavior for an array of daily activities (such as work, shopping, restaurants, personal services, and leisure) after controlling for socio-economic and demographic factors (income, the number of personal vehicles available, age, and the number of dependent children). In turn, the ANCOVA will reveal the differences between gender and marital status groups in travel behavior for disaggregate travel activities. Again, for both models, I used trip frequency and distance as dependent variables that are transformed using square-root and logarithm respectively.

Table 54 OLS regression results of gender differences in disaggregate analyses on individual travel behavior in the higher density suburban neighborhoods: *travel frequency*

		Total trip frequency[1]				
		N[2]	β	S.E.	Df	P-value
WORK						
Pedestrian	Women[3]	75	-.339	.139	3	.018
Public transit	Women[4]	32	-.230	.201	3	.264
Driving	Women[5]	243	-.048	.057	3	.400
SHOPPING						
Pedestrian	Women[6]	89	-.376	.129	3	.005
Public transit	Women[7]	13	-.264	.336	3	.459
Driving	Women[8]	349	.108	.068	4	.113
RESTAURANT VISITS						
Pedestrian	Women[9]	85	.000	.124	3	.999
Public transit	Women[10]			n/a		
Driving	Women[11]	233	-.063	.079	3	.422
SERVICE						
Pedestrian	Women[12]	91	.028	.129	3	.829
Public transit	Women[13]	8	-2.045	.249	3	.004
Driving	Women[14]	287	.059	.079	3	.455
LEISURE						
Pedestrian	Women[15]	154	.068	.139	3	.626
Public transit	Women[16]	8	-.389	.610	3	.558
Driving	Women[17]	258	-.131	.095	4	.170

1. Total trip frequency per person on a weekly basis (trip count, square root transformed);
2. N = number of resident men and women;
3. Gender dummy: women = 1, and men = 0, and controlled for constant (*), income, and age (*);
4. Controlled for constant (**), age and income (*);
5. Controlled for constant, age (*) and income (***);
6. Controlled for constant (**), age and income;
7. Controlled for constant (**), age and income (**);
8. Controlled for constant (***), age (*), income, and personal vehicle access (**);
9. Controlled for constant (**),age and income;
10. Not available;
11. Controlled for constant, age and income;
12. Controlled for constant (***),age and income (*);
13. Controlled for constant (***),age (**) and income, the tolerance values were above 0.300 for all predictors (n=8);
14. Controlled for constant, age (***) and income;
15. Controlled for constant (***), age and income (*);
16. Controlled for constant, age and income, the tolerance values were above 0.200 for all predictors (n=8);
17. Controlled for constant, age, income and personal vehicle access (**).

For all other models, the tolerance values were above 0.600 for all predictors.
Statistical significance at the 90% (*), 95% (**), and 99% (***) level, respectively.

Table 55 OLS regression results of gender differences in disaggregate analyses on individual travel behavior in the higher density suburban neighborhoods: *travel distance*

		Cumulative trip distance[1]				
		N[2]	β	S.E.	Df	P-value
WORK						
Pedestrian	Women[3]	65	-.115	.256	3	.656
Public transit	Women[4]	28	-.285	.363	4	.440
Driving	Women[5]	223	-.312	.189	3	.102
SHOPPING						
Pedestrian	Women[6]	70	-.327	.200	3	.107
Public transit	Women[7]	12	-.048	.501	3	.927
Driving	Women[8]	371	.135	.097	3	.165
RESTAURANT VISITS						
Pedestrian	Women[9]	57	.074	.268	3	.785
Public transit	Women[10]			n/a		
Driving	Women[11]	205	-.143	.143	3	.316
SERVICE						
Pedestrian	Women[12]	53	.001	.181	3	.994
Public transit	Women[13]	8	-1.730	1.683	3	.380
Driving	Women[14]	216	-.157	.144	3	.276
LEISURE						
Pedestrian	Women[15]	75	-.371	.197	3	.065
Public transit	Women[16]			n/a		
Driving	Women[17]	168	-.299	.179	5	.096

1. Cumulative trip distance to destinations per person on a weekly basis (mile, logarithm transformed);
2. N = number of resident men and women;
3. Gender dummy: women = 1, and men = 0, and controlled for constant, income, and age (*);
4. Controlled for constant (**), age, income (*), and personal vehicle access (**);
5. Controlled for constant, age and income (**);
6. Controlled for constant, age and income;
7. Controlled for constant, age (*) and income;
8. Controlled for constant (***), age and income;
9. Controlled for constant, age and income;
10. Not available;
11. Controlled for constant, age (***) and income;
12. Controlled for constant, age and income;
13. Controlled for constant, age and income, the tolerance values were above 0.300 for all predictors (n=8);
14. Controlled for constant, age (**) and income;
15. Controlled for constant, age (**) and income;
16. Not available;
17. Controlled for constant, age, income, personal vehicle access (**), and the number of dependent children (**).

For all other models, the tolerance values were above 0.600 for all predictors.
Statistical significance at the 90% (*), 95% (**), and 99% (***) level, respectively.

5.3.2.1. Gender Difference in Travel Behavior: Trips to Work

In table 54 and 55, OLS regression results demonstrate that in the higher density suburban neighborhoods, women made less frequent trips to work and traveled shorter distances when compared to men, regardless of travel modes. Travelling to work, women walked significantly fewer times than men (B = -0.339, p-value = 0.018) after controlling for socio-economic and demographic factors, such as personal income, age, personal vehicle access, and the number of dependent children (table 54). Women in the higher density suburban neighborhoods also walked fewer miles to work than men. In exploring travel to work by public transit, women respondents in the higher density suburbs traveled less frequently and shorter distances to work compared to men. In addition, within these higher density suburban neighborhoods, women were also less likely to travel by car to work and they also traveled fewer miles than men by car to reach work.

These patterns can be expected, as the existing gender and transportation literature has shown comparable outcomes, with women travelling less frequently and shorter distances to work, and by all modes of travel (Hanson and Hanson, 1980a, 1980b; Hanson and Pratt, 1991; Hanson and Giuliano, 2004; and Rosenbloom, 2005). The fact that women in higher density suburbs drove fewer times and shorter distances supports a traditional pattern in gendered travel, with work trips dominated by men. This is an important pattern to recognize since the women in the higher density suburbs maintained higher incomes—and had greater access to a car—compared to lower income women in urban Detroit. Despite the higher personal incomes and the greater car access, women in the higher density suburban neighborhoods still traveled to work less frequently and shorter distances by driving compared to women in urban Detroit.

5.3.2.2. Gender Differences in Travel Behavior: Trips to Shops, Restaurants, Personal Services and Leisure

5.3.2.2.1. Trips to shopping

Table 54 and 55 illustrates how women travel differently to meet their daily needs, including household responsibilities, compared to men. The OLS regression results demonstrate that in the higher density suburban neighborhoods, women in general, made less frequent trips and traveled shorter distances for daily activities when compared to men. For shopping, women in the higher density suburbs traveled significantly fewer times (B = -0.376, p-value = 0.005, table 54) and shorter distances as pedestrians than men. Women were also less likely to travel by public transit for shopping compared to men, both in terms of frequency and distance. However, by driving, women in the higher density suburban neighborhoods traveled more frequently and greater miles than men for shopping.

5.3.2.2.2. Trips to restaurants

For restaurant visits, there was no difference between men and women in trip frequency (table 54). While women were more likely to walk to a restaurant than men, the difference was minor (table 55). Gender differences in trips by public transit were not available since there were no respondents who took public transit to restaurants in the higher density suburban neighborhoods. By driving, however, women traveled less frequently and shorter distances than men for restaurant visits, which parallels the outcomes in urban Detroit. In other words, men in both the higher density urban and the higher density suburban neighborhoods drove more frequently and longer distances to access restaurants.

5.3.2.2.3. Trips to personal services

For travel to access personal services, women in the higher density suburbs walked more times and longer distances, but the differences were not all that significant. In contrast, women in the higher density suburbs took significantly fewer public transit trips to access personal services compared to men (*B* = -2.045, p-value = 0.004, table 54). Women also traveled shorter distances than men by public transit to reach personal services. However, there were only a few respondents that utilized public transit for travel to access personal services (n=8, table 54 and 55). With regard to driving, women in the higher density suburban neighborhoods traveled more frequently than men for personal services (table 54), however, women traveled shorter distances by driving when compared to men (table 55).

5.3.2.2.4. Trips for leisure

With regard to leisure destinations, women in the higher density suburban neighborhoods traveled more frequently as pedestrians than men (table 54). However, the women respondents living in the higher density suburban neighborhoods walked significantly shorter distances for leisure activities (*B* = -0.371, p-value = 0.065, table 55). By public transit, women traveled fewer times for their leisure activities compared to men, but as with all cases of public transit use in the suburbs, there is a limited sample size (n=8, table 54). By driving, women made fewer trips (table 54) and traveled significantly shorter distances (*B* = -0.299, p-value = 0.096) compared to men to reach leisure destinations. Another important factor in determining driving leisure trips was personal vehicle access (for both trip frequency and distance, table 54 and 55) and the number of dependent children (for trip distance, table 55). Thus, in the higher density suburban neighborhoods, a woman's leisure opportunity was limited if she did not have personal access to a car or if she had more dependent children. In the higher density suburban neighborhoods, differences in individual travel behavior between women and men were also observed within the context of marital status (table 56). Particularly, from the ANCOVA results, there were clearly observed divergences in travel patterns for disaggregated travel activities for married and non-married women and men (tables 57-61). The mean differences between gender and marital status groups were adjusted with two covariates, income and age.

Table 56 Average weekly total trip frequency and cumulative distance (mile)* by gender and marriage in the higher density suburban neighborhoods

			Men		Women	
			Not-married	Married	Not-married	Married
Work	Trip Frequency	Pedestrian	3.80	3.90	3.40	2.41
		Public transit	4.10	3.06	2.37	2.85
		Driving	4.27	4.62	4.36	4.24
	Trip Distance	Pedestrian	3.34	6.54	4.78	6.65
		Public transit	28.27	5.14	3.04	5.44
		Driving	56.01	45.07	32.35	38.40
Shopping	Trip Frequency	Pedestrian	2.54	2.81	2.02	1.92
		Public transit	7.71	0.99	1.22	1.40
		Driving	2.49	3.31	2.99	3.57
	Trip Distance	Pedestrian	1.43	3.35	2.30	1.88
		Public transit	5.13	2.15	2.82	1.38
		Driving	5.19	7.06	6.35	7.76
Restaurant visit	Trip Frequency	Pedestrian	2.20	1.92	1.48	1.70
		Public transit	n/a	n/a	n/a	n/a
		Driving	1.99	1.96	1.68	2.01
	Trip Distance	Pedestrian	1.94	1.26	1.77	3.84
		Public transit	n/a	n/a	n/a	n/a
		Driving	5.77	6.02	4.74	4.88
Service	Trip Frequency	Pedestrian	2.47	1.76	1.87	1.75
		Public transit	9.53	n/a	1.78	1.28
		Driving	2.40	2.40	2.54	2.45
	Trip Distance	Pedestrian	3.70	1.27	1.61	1.34
		Public transit	7.47	n/a	3.25	1.71
		Driving	5.12	5.78	4.57	5.53
Leisure	Trip Frequency	Pedestrian	3.07	2.74	3.86	3.03
		Public transit	3.31	1.73	0.69	1.96
		Driving	3.57	3.10	3.61	2.62
	Trip Distance	Pedestrian	1.63	2.98	5.03	1.48
		Public transit	n/a	n/a	n/a	n/a
		Driving	18.47	11.71	17.24	6.45

*Calculated with original weekly total trip frequency and cumulative trip distance data.

Table 57 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in the higher density suburban neighborhoods—*work*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.869	1.866	1.761	1.482	75
		(S.E.)	(.214)	(.110)	(.204)	(.098)	
	Public transit[4]	Mean	2.008	1.612	1.468	1.581	32
		(S.E.)	(.269)	(.223)	(.219)	(.158)	
	Driving[5]	Mean	2.020	2.122	2.053	2.018	243
		(S.E.)	(.075)	(.048)	(.059)	(.038)	
Trip dist.[2]	Pedestrian[6]	Mean	1.181	1.394	1.164	1.356	65
		(S.E.)	(.485)	(.198)	(.345)	(.172)	
	Public transit[7]	Mean	2.797**	0.957	1.207	1.396	30
		(S.E.)	(.450)	(.351)	(.379)	(.247)	
	Driving[8]	Mean	3.318	3.208	2.853	2.902	223
		(S.E.)	(.252)	(.170)	(.204)	(.128)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.898593, AGE = 46.39.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.764266, AGE = 47.53.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.862601, AGE = 45.92.
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.943127, AGE = 45.97.
7. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.821237, AGE = 46.90.
8. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.868839, AGE = 45.29.

Mean difference between gender groups was only significant for driving trip distance (p-value = .048).
Mean difference between marital status groups was only significant for public transit trip distance (p-value = .037).
Mean difference between gender and marital status groups was only significant for public transit trip distance (p-value = .010).

Table 58 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in the higher density suburban neighborhoods—*shopping*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.563	1.582	1.305	1.270	89
		(S.E.)	(.171)	(.115)	(.149)	(.084)	
	Public transit[4]	Mean	2.532*	1.024	1.001	1.145	13
		(S.E.)	(.486)	(.202)	(.178)	(.238)	
	Driving[5]	Mean	1.510	1.700	1.673	1.787	374
		(S.E.)	(.100)	(.059)	(.067)	(.045)	
Trip dist.[2]	Pedestrian[6]	Mean	0.606	0.869	0.742	0.516	70
		(S.E.)	(.303)	(.177)	(.238)	(.130)	
	Public transit[7]	Mean	1.549	0.585	0.688	0.322	12
		(S.E.)	(1.030)	(.436)	(.405)	(.490)	
	Driving[8]	Mean	1.362	1.603	1.624	1.697	371
		(S.E.)	(.146)	(.086)	(.098)	(.066)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.868290, AGE = 51.61.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.701677, AGE = 55.77.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.856635, AGE = 50.62.
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.870293, AGE = 52.23.
7. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.622427, AGE = 56.83.
8. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.854712, AGE = 50.54.

Mean difference between gender groups was only significant for pedestrian trip frequency (p-value = .038), public transit trip frequency (p-value = .038), driving trip frequency (p-value = .079), and driving trip distance (p-value = .085).
Mean difference between marital status groups was only significant for public transit trip frequency (p-value = .045), and driving trip frequency (p-value = .031).
Mean difference between gender and marital status groups was only significant for public transit trip frequency (p-value = .055).

Table 59 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in the higher density suburban neighborhoods—*restaurant visits*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.399	1.249	1.126	1.211	85
		(S.E.)	(.237)	(.110)	(.142)	(.082)	
	Public transit[4]	Mean	n/a	n/a	n/a	n/a	(3)
		(S.E.)					
	Driving[5]	Mean	1.331	1.316	1.171	1.295	233
		(S.E.)	(.115)	(.065)	(.082)	(.055)	
Trip dist.[2]	Pedestrian[6]	Mean	0.401	0.528	0.178	0.571	57
		(S.E.)	(.422)	(.205)	(.335)	(.159)	
	Public transit[7]	Mean	n/a	n/a	n/a	n/a	(2)
		(S.E.)					
	Driving[8]	Mean	1.107	1.329	1.140	1.127	205
		(S.E.)	(.205)	(.123)	(.157)	(.101)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.849140, AGE = 47.41.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.581218, AGE = 57.00.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.861317, AGE = 51.71.
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.751607, AGE = 47.00.
7. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 9.819338, AGE = 58.00.
8. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.865119, AGE = 51.80.

Table 60 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in the higher density suburban neighborhoods—*personal services*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.525	1.214	1.222	1.214	91
		(S.E.)	(.195)	(.116)	(.136)	(.081)	
	Public transit[4]	Mean	3.162	n/a	1.283	1.117	8
		(S.E.)	(.213)		(.164)	(.070)	
	Driving[5]	Mean	1.381	1.433	1.472	1.469	287
		(S.E.)	(.131)	(.067)	(.077)	(.051)	
Trip dist.[2]	Pedestrian[6]	Mean	1.571***	0.373	0.347	0.379	53
		(S.E.)	(.367)	(.167)	(.169)	(.114)	
	Public transit[7]	Mean	2.169	n/a	0.453	0.439	8
		(S.E.)	(1.443)		(1.111)	(.471)	
	Driving[8]	Mean	1.304	1.394	1.147	1.231	216
		(S.E.)	(.249)	(.129)	(.135)	(.093)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.825470, AGE = 48.93.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.414687, AGE = 47.63.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.842210, AGE = 52.07.
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.793998, AGE = 47.04.
7. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.414687, AGE = 47.63.
8. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.831961, AGE = 51.14.

Mean difference between gender groups was only significant for public transit trip frequency (p-value = .004), and pedestrian trip distance (p-value = .011).

Mean difference between marital status groups was only significant for pedestrian trip distance (p-value = .013).

Mean difference between gender and marital status groups was only significant for pedestrian trip distance (p-value = .009).

Table 61 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in the higher density suburban neighborhoods—*leisure*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.648	1.492	1.725	1.606	154
		(S.E.)	(.233)	(.116)	(.149)	(.085)	
	Public transit[4]	Mean	1.535	1.303	0.873*	1.398	8
		(S.E.)	(.254)	(.092)	(.043)	(.094)	
	Driving[5]	Mean	1.787	1.579	1.783	1.507	273
		(S.E.)	(.144)	(.080)	(.091)	(.058)	
Trip dist.[2]	Pedestrian[6]	Mean	0.764	0.812	0.845	0.513	75
		(S.E.)	(.441)	(.166)	(.226)	(.122)	
	Public transit[7]	Mean	n/a	n/a	n/a	n/a	(4)
		(S.E.)					
	Driving[8]	Mean	2.180	1.730	2.159	1.444	187
		(S.E.)	(.256)	(.148)	(.174)	(.117)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.843167, AGE = 48.05.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.728356, AGE = 55.25.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.873971, AGE = 50.16.
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.775058, AGE = 48.28.
7. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.217641, AGE = 51.00.
8. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.890388, AGE = 50.55.

Mean difference between gender groups was only significant for public transit trip frequency (p-value = .004).

Mean difference between marital status groups was only significant for driving trip distance (p-value = .001).

Mean difference between gender and marital status groups was only significant for public transit trip frequency (p-value = .053).

5.3.2.3. Gender and Marital Status Distinctions in Travel Behavior: Trips to Work

For their work trips, as shown in the OLS regression results, the ANCOVA results demonstrate that women make fewer trips and travel shorter distances to work even after taking account marital status. Incorporating marital status, however, revealed more nuanced variations in commutes to work between men and women. First, married women traveled to work least frequently (2.41 times a week) as pedestrians. On the other end of the spectrum, both married and not-married men traveled to work most frequently (3.90 and 3.80 times a week) as pedestrians (table 56). Married women preferred not to walk to work, likely due to the inconvenience and less efficient time allocation given their household responsibilities (Rosenbloom, 2005).

In terms of distance to work, not-married men walked the shortest distances (3.34 miles per week) among all gender and marital status groups. Both married men and married women walked longer distances to work than not-married men and not-married women. As pedestrians, both married and not-married women traveled fewer times and shorter distances than both married and not-married men, but the differences were not statistically significant.

With respect to travel to work by public transit, not-married men traveled to work most frequently (4.10 times a week) by transit, while not-married women traveled least frequently (2.37 times a week) by this mode of travel. Both married men and not-married men used public transit more frequently to go to work when compared to both married women and not-married women. When compared to all gender and marital status groups, not-married men traveled the longest distances to get to work by public transit and at a significant level (28.27 miles per week, p-value = 0.010 from table 57). Not-married women, in contrast, traveled the shortest distance to work by public transit (3.04 miles per week). Due to the significantly longer trip distances to work by not-married men, marital status differences in public transit trip distance was significant; not-married men and not-married women traveled longer distances by public transit to work than married men and married women (p-value = 0.037) (table 57).

Lastly, married men drove to work most frequently (4.62 times a week), while married women drove to work least frequently (4.24 times a week). The gender and marital status group who drove the greatest miles to work were the not-married men (56.01 miles per week). In contrast, not-married women drove the shortest distances to work (32.35 miles per week) (table 56). Married and not-married men traveled significantly longer distances by driving to work when compared to married and not-married women (p-value = 0.048) (table 57).

5.3.2.4. Gender and Marital Status Distinctions in Travel Behavior: Trips to Shops, Restaurants, Personal Services, and Leisure

5.3.2.4.1. Trips to shopping

In addition to significant gender differences in shopping trips, as illustrated in the OLS regression results, the ANCOVA results also reveal significant differences between gender and marital status groups in non-work activities in the higher density suburban neighborhoods. For shopping trips, married men walked most frequently (2.81 times a week), while married women walked the fewest times (1.92 times a week) (table 56). In fact, both married and not-married women walked fewer times to shopping when compared to married and not-married men, and at a significant level (p-value = 0.038, table 58). This is a different pattern when compared to the urban Detroit neighborhoods, where women walked more frequently to shop than men. This is likely due to the fact that women in the higher density suburban neighborhoods, with a higher personal income and greater access to a car, prefer driving to shopping destinations and their greater access to resources allows them to do so. As pedestrians, married men walked the longest distance to shop (3.35 miles per week) when married women walked shorter distance (1.88 miles per week) than married men. Again, compared to women in urban Detroit, who walked 4.7 miles per week for shopping, women in the higher density suburban neighborhoods had the resources, and the choice, not to walk for their shopping trips.

By public transit, not-married men traveled the most frequently for shopping (7.71 times a week), while married men traveled the fewest times (once a week) (table 56). Not-married men, in fact, traveled significantly more times by public transit for shopping than any other group (p-value = 0.055) (table 58). Therefore, both gender differences (men traveled more frequently than women) and marital status differences (the not-married traveled more frequently than the married) are apparent with the use of public transit to shop, with public transit shopping trip frequencies being statistically significant (p-value = 0.038, and 0.045 respectively) (table 58).

Similar to walking trip distances for shopping, married women in the higher density suburban neighborhoods traveled the shortest distances by public transit (1.38 miles per week). This is significantly different from the urban Detroit neighborhoods, where married women traveled the longest distances to shop (some 55 miles per week) by public transit. Both married and not-married women traveled shorter distances by public transit to shop when compared to married and not-married men. In addition, both married men and married women traveled shorter distances by public transit to shop when compared to not-married men and not-married women.

By driving, however, married women traveled most frequently (3.57 times a week) and over the longest distances (7.76 miles per week) for shopping. Again, this particular gender and marital status group traveled the fewest miles by walking or public transit. Therefore, it confirms that married women select to drive when shopping—when resources allow them to do so—for convenience and efficient time allocation, and this is because of their multiple household responsibilities (Hanson and Hanson, 1980a, 1980b; Jones, 1990; Kwan, 1999a, 1999b; 2000; and Hanson and Giuliano, 2004). Both married and not-married women drove significantly longer distances when compared to married and not-married men for shopping (p-value = 0.085).

Between ones who are married and not-married, both married men and married women drove longer distances to shop than not-married men and not-married women. Not-married men traveled by driving to shop the least frequently and the shortest distances. The married preferred driving a car for their shopping trips due to the convenience and being able to purchase and transport more shopping goods given the greater number of members in their household, and it was accommodated by their greater personal income. The results, therefore, confirm differentiated trip allocations between travel modes for shopping purposes by gender and marital status.

5.3.2.4.2. Trips to restaurants

In contrast to shopping, men traveled more frequently than women for restaurant trips in the higher density suburban neighborhoods (table 56). As pedestrians, not-married men traveled most frequently (2.20 times a week) to visit a restaurant while not-married women traveled least frequently (1.48 times a week). Both married and not-married men also walked more frequently to restaurants when compared to married and not-married women. However, married women walked the longest distance to go to a restaurant (3.84 miles).

By driving, not-married men, again, traveled most frequently, 1.96 times a week (table 56), to a restaurant. Both married and not-married men traveled more frequently by car for restaurant visits when compared to married and not-married women. Similar to the urban Detroit neighborhoods, married men drove the longest distances for restaurant visits (6.02 miles per week). However, there was no mean difference between gender and marital status groups that was significant when it came to travel to restaurants (table 59). In addition, there were very few respondents that travelled to restaurants by public transit—unlike in the case of the urban Detroit neighborhoods—which meant that no actual trip patterns between the groups was evident for this particular travel mode.

5.3.2.4.3. Trips to personal services

It was also difficult to find significant mean differences in personal service trips (table 56 and 60). For personal services, not-married men traveled the most frequently (2.47 times a week) and for the longest distance (3.70 miles per week) as pedestrians (table 56). Both married men and married women walked less frequently for personal services than not-married men and not-married women. Due to not-married men's more frequent and farther (p-value = 0.009) walking trips for personal services, men, regardless of marital status, walked significantly further distances than women for personal services (p-value = 0.011) (table 60). Subsequently, among marital status groups, not married groups walked significantly further distances than married groups (p-value = 0.013) (table 60) to access personal services.

With regard to public transit trips to personal services, not-married men also traveled most frequently (9.53 times a week) and the greatest miles (7.47 miles per week) to access personal services. None of the married men traveled by public transit for personal services. However, women, both married and not-married, made more frequent personal service trips (2.45 and 2.54 times a week) by driving than men in the higher density suburban neighborhoods (table 56). Despite the more frequent trips, both married and not-married women drove shorter distances for personal services than married and not-married men. By driving, married men drove the longest distance (5.78 miles per week) to reach their personal service destinations (table 56).

5.3.2.4.4. Trips for leisure

In the higher density suburbs, there were clear differences in leisure trips between married and not-married respondents. As pedestrians, not-married women traveled the most frequently (3.86 times a week) for leisure activities, while married men traveled the least frequently (2.74 times a week). For leisure, both married and not-married women in the higher density suburban neighborhoods walked more frequently than married and not-married men. Not-married women also walked longer distance (5.03 miles per week) for leisure than any other gender and marital status group. Married women, however, walked the shortest distance for leisure (1.48 miles per week) (table 56).

By public transit, while not-married men traveled most frequently to reach their leisure activity destinations (3.31 times a week, table 56), not-married women utilized public transit the least, and significantly so (.69 time per week) among all gender and marital status groups (p-value = 0.053, table 61). Accordingly, women's groups in the higher density suburbs traveled significantly fewer times by public transit than men to reach their leisure destinations (p-value = 0.004) by public transit (table 61). There were too few respondents to identify a gender and marital status variation in public transit trip distances for leisure activities (table 61).

By driving, married women in the higher density suburban neighborhoods made the least frequent trips to access leisure activities and traveled the shortest distance to leisure destinations (table 56). Both not-married men and not-married women drove more than married men and married women to reach their leisure destinations. Respondents that are married also drove shorter distances to reach their leisure destinations when compared to respondents that are not married. While not-married men and not-married women traveled by car 18.47 and 17.24 miles to reach their leisure destinations, married men and married women traveled in a car 11.71 and 6.45 miles respectively. The mean difference between the married and the not-married groups was also statistically significant (p-value = 0.001, table 61). In terms of gender differences evident in travel for leisure, both married men and not-married men drove more frequently and greater distances when compared to married women and not-married women. However, the gender differences were not statistically significant.

5.3.2.5. Discussion

First, the OLS regression results revealed that after controlling for socio-economic and demographic factors, women traveled less frequently than men to work regardless of travel modes in the higher density suburban neighborhoods. The OLS regression results also demonstrated women's shorter work trip distances compared to men. This is a consistent finding with the existing literature on commuting (Hanson and Hanson, 1980a, 1980b, 1981; Hanson and Pratt, 1991; Hanson and Johnston, 1985; Hanson and Giuliano, 2004: and Rosenbloom, 2005). Thus, in spite of women's increased participation in paid labor (Hanson and Giuliano, 2004; Rosenbloom, 2005), work trips are still dominated by men.

It is important to note that, however, that unlike women respondents in urban Detroit, women in higher density suburban neighborhoods did not walk more frequently to go to work than men. With statistical significance, women's less frequent pedestrian work trips can be interpreted as the effects of greater access to a private automobile, a function of higher personal incomes in the higher density suburban neighborhoods, when compared to urban Detroit.

Furthermore, even for shopping, women in the high density suburban neighborhoods were less likely to walk (p-value = 0.005) or to take public transit, unlike the women in Detroit who traveled more frequently as pedestrians and by public transit. Women in the higher density suburban neighborhoods drove more frequently for shopping. Women also traveled longer distances than men by driving to their shopping destinations, but shorter distances by walking and public transit. Therefore, whether a woman does, or does not, have access to a car is an important factor in understanding a women's daily travel pattern, and particularly for shopping.

For trips to restaurants and personal services, there was no significant gender effect. However, women drove fewer times for shorter distances for restaurant visits, similar to the case in the Detroit urban neighborhoods. For personal services, women walked and drove more frequently than men, but the differences were rather insignificant. The only statistically significant gender difference was the less frequent public transit use by women to access personal services. In their personal service travel, women in the higher density suburbs also traveled shorter distances by public transit. Survey responses, however, were limited because so few residents in the higher density suburban neighborhoods actually traveled by public transit for their daily activities.

For leisure activities, women in the higher density suburban neighborhoods only traveled more frequently than men as pedestrians. Yet they did not walk any further distance for leisure activities than men, and at a significant level. The women in the higher density suburban neighborhoods also drove less frequently than men in reaching their leisure destinations. They also drove significantly shorter distances for leisure activities when compared to men.

In conclusion, the higher incomes among the suburban respondents and the more robust nature of the outer suburban communities—and particularly when compared to the urban Detroit neighborhoods, which are experiencing disinvestment and decline—likely played an important role in the shorter distances and fewer frequencies traveled by public transit in the higher density suburban neighborhoods. The effect of differing incomes on women's travel behavior was also evident in pedestrian trips. Whereas women in urban Detroit traveled more frequently as pedestrians for work, shopping, and leisure, women in the higher density suburban neighborhoods did not walk more frequently than men for these same activities.

In fact, the gender differences in pedestrian work trip frequencies in both Detroit urban and higher suburban neighborhoods were statistically significant, but in opposing directions. In the higher density suburban neighborhoods, both married and not-married women walked to work less frequently than both married and not-married men whereas both married and not-married women in urban Detroit neighborhoods walked more frequently to work than married and not-married men. Therefore, gender differences in individual travel behavior should be understood more precisely in regards to differing effects of socio-economic and demographic characteristics, such as personal income and access to a car of particular population sub-groups.

With respect to driving, women in both urban Detroit and the higher density suburban neighborhoods drove shorter distances than men. Despite the greater income levels and greater automobile access when compared to the Detroit urban respondents, suburban women still drove fewer miles than men—in all cases except shopping—after controlling for socio-economic and demographic factors. This gendered travel pattern is consistent with the findings in existing studies on gendered differences in travel (Kwan, 1999a, 1999b, 2000; Hanson and Hanson, 1980a, 1980b, 1981; Hanson, 1995; Hanson and Giuliano, 2004; Mclafferty and Preston, 1996 a, b, c; Preston and Mclafferty, 1992, 1999; Rosenbloom, 2005; and Wyly, 1996, 1998). Therefore, women, in comparison to men, still travel shorter distances for daily activities, and this is evident across diverse income groups and neighborhood structures.

From the ANCOVA results, more specific mean differences between gender and marital status groups were examined for the various travel activities, which were disaggregated by travel type. Even in the dynamic and robust high density suburban neighborhoods, with a rich bundle of travel destinations, women traveled less frequently and fewer miles in a private automobile to work, but drove more frequently and more miles for shopping. Married women in the higher density suburban neighborhoods drove least frequently to work while married men drove most frequently in their commutes to work. However, married women drove most frequently and the longest distance for shopping.

Married women, however, preferred not to walk or take public transit, and they, in fact, maintained the least frequency and the shortest distances in accessing shopping and personal services by these travel modes. The results, thus, imply that married women in the higher density suburban neighborhoods drove predominantly for household related activities in order to maximize the efficiency of their trips. The car allows women to travel at greater speeds, and gives them greater flexibility, which is important given their more constrained time frame in their multiple roles as both a worker and household maker (Hanson and Hanson, 1980a; Kwan, 1999a, 1999b, 2000; and Pickup, 1985, 1990).

Another distinctive gender and marital status difference in individual travel behavior was found in leisure trips. Both married men and married women in the higher density suburban neighborhoods traveled less frequently as pedestrians and by driving for leisure than not-married men and not-married women. Higher density suburban residents that are married also traveled shorter distances to reach their leisure destinations. In fact, married women traveled the shortest distances regardless of travel modes (no response for public transit, however) of all groups. Thus, married women allocated their time and resources—for example, ensuring access to a personal automobile—in order to travel and fulfill household responsibilities, such as shopping and personal services, instead of their own leisure activities.

5.3.3. Lower Density Suburban (Bloomfield Hills and West Bloomfield Neighborhoods): Disaggregate analyses on individual travel behavior in the lower density suburban neighborhoods in the Detroit region

In order to identify how a differing urban built environment would affect individual travel behavior—while still continuing to explore gender differences—two lower density suburban neighborhoods, in Bloomfield Hills and West Bloomfield, were selected for the analyses. Due to characteristics of the low density development patterns, and subsequently, the limited cases (Ns) for public transit, travel by transit was omitted from this individual travel behavior analyses. The OLS regression results were used to analyze the relationship between gender and disaggregated individual travel behavior (all activities including trips to work, shopping, restaurants, personal services, and leisure) after controlling for socio-economic and demographic factors. In addition, the ANCOVA results demonstrated significant mean differences between gender and marital status groups in the individual travel behavior for disaggregate travel activities, when adjusting for socio-economic and demographic factors. The dependent variables—trip frequencies and distance—were, once again, transformed using square-root and logarithm, respectively.

Table 62 OLS regression results of gender differences in disaggregate analyses on individual travel behavior in the lower density suburban neighborhoods: *travel frequency*

		Total trip frequency[1]				
		N[2]	B	S.E.	df	P-value
WORK						
Pedestrian	Women[3]	25	-.098	.253	3	.702
Public transit	Women[4]			n/a		
Driving	Women[5]	200	-.096	.076	3	.206
SHOPPING						
Pedestrian	Women[6]	30	.018	.209	3	.932
Public transit	Women[7]			n/a		
Driving	Women[8]	311	.211	.078	3	.007
RESTAURANT VISITS						
Pedestrian	Women[9]	20	-.252	.270	3	.365
Public transit	Women[10]			n/a		
Driving	Women[11]	225	-.107	.092	3	.245
SERVICE						
Pedestrian	Women[12]	28	-.078	.163	3	.637
Public transit	Women[13]			n/a		
Driving	Women[14]	271	.069	.078	3	.375
LEISURE						
Pedestrian	Women[15]	48	.097	.191	3	.614
Public transit	Women[16]			n/a		
Driving	Women[17]	248	.204	.109	3	.062

1. Total trip frequency per person on a weekly basis (trip count, square root transformed);
2. N = number of resident men and women;
3. Gender dummy: women = 1, and men = 0, and controlled for constant, income, and age;
4. Not available;
5. Controlled for constant, age and income;
6. Controlled for constant, age and income;
7. Not available;
8. Controlled for constant, age and income;
9. Controlled for constant, age and income;
10. Not available;
11. Controlled for constant, age and income;
12. Controlled for constant, age and income;
13. Not available;
14. Controlled for constant (***),age and income;
15. Controlled for constant (**), age and income (*);
16. Not available;
17. Controlled for constant, age and income.

For all other models, the tolerance values were above 0.600 for all predictors.
Statistical significance at the 90% (*), 95% (**), and 99% (***) level, respectively.

Table 63 OLS regression results of gender differences in disaggregate analyses on individual travel behavior in the lower density suburban neighborhoods: *travel distance*

		Cumulative trip distance[1]				
		N[2]	β	S.E.	df	P-value
WORK						
Pedestrian	Women[3]	19	-.806	.496	4	.130
Public transit	Women[4]			n/a		
Driving	Women[5]	176	-.389	.173	3	.026
SHOPPING						
Pedestrian	Women[6]	22	-.080	.400	3	.844
Public transit	Women[7]			n/a		
Driving	Women[8]	291	.391	.101	4	.000
RESTAURANT VISITS						
Pedestrian	Women[9]	16	-.136	.547	3	.808
Public transit	Women[10]			n/a		
Driving	Women[11]	201	-.095	.147	3	.522
SERVICE						
Pedestrian	Women[12]	20	.473	.506	3	.366
Public transit	Women[13]			n/a		
Driving	Women[14]	246	-.081	.141	3	.567
LEISURE						
Pedestrian	Women[15]	22	-.087	.414	3	.836
Public transit	Women[16]			n/a		
Driving	Women[17]	201	.354	.178	3	.048

1. Cumulative trip distance to destinations per person on a weekly basis (mile, logarithm transformed);
2. N = number of resident men and women;
3. Gender dummy: women = 1, and men = 0, and controlled for constant, income, age, and personal vehicle access (**);
4. Not available;
5. Controlled for constant, age (***) and income (*);
6. Controlled for constant, age and income;
7. Not available;
8. Controlled for constant, age, income (**) and the number of dependent children (**);
9. Controlled for constant, age and income;
10. Not available;
11. Controlled for constant, age and income;
12. Controlled for constant, age and income;
13. Not available;
14. Controlled for constant, age and income;
15. Controlled for constant, age and income;
16. Not available;
17. Controlled for constant, income, and age.

For all other models, the tolerance values were above 0.600 for all predictors.
Statistical significance at the 90% (*), 95% (**), and 99% (***) level, respectively.

5.3.3.1. Gender Differences in Travel Behavior: Trips to Work

In table 62, it is shown that, after controlling for socio-economic and demographic factors (income, age, personal automobile access and the number of dependent children in the household), women in the lower density suburban neighborhoods were less likely to travel to work. Women not only walked less frequently to work when compared to men, but they also drove fewer times. Similar to trip frequency, women in the lower density suburban neighborhoods traveled shorter distances to work than men, regardless of travel modes (table 63). In addition, women in the lower density suburban neighborhoods drove significantly shorter distances to reach their place of employment compared to men (B= -0.389, p-value = 0.026). Therefore, the pattern of women's less frequent and shorter trip distance to work was consistently evident across the neighborhood groups in the Detroit region, regardless of urban density and land use characteristics.

5.3.3.2. Gender Differences in Travel Behavior: Trips to Shops, Restaurants, Personal Services and Leisure

5.3.3.2.1. Trips to shopping

In the lower density suburban neighborhoods, women also traveled more frequently for activities that are related to household responsibilities, such as shopping and personal services. The OLS regression results showed that women traveled more frequently as pedestrians for shopping. Women in the lower density suburban neighborhoods, however, traveled shorter distances as pedestrians for shopping. Both differences in shopping trip frequency and distance were minor and statistically insignificant.

Women also drove significantly more times for shopping when compared to men in the lower density suburban neighborhoods, after adjusting for socio-economic and demographic factors (*B*= 0.211, p-value = 0.007) (table 62). In addition, women drove significantly longer distances to reach their shopping destinations than men (*B*= 0.391, p-value = 0.000) (table 63). This specific characteristic in shopping patterns, with women travelling longer distances to access shops, becomes better understood with the added variable of dependent children.

The number of dependent children significantly contributes to increased shopping trip distance, with women in the lower density suburban neighborhoods travelling further distances when more dependent children were present in the household. Subsequently, women in such households were more likely to travel longer distances by driving to shop for the family's daily needs. This is consistent with previous research on gendered travel behavior (Hanson, 1995; Hanson and Hanson, 1980a; Hanson and Pratt, 1991; Hanson and Giuliano, 2004; Jones, 1990; Pickup, 1990; and Rosenbloom, 2005).

In fact, the burden of women's trips associated with shopping becomes clearer in the context of dispersing destinations in the lower density suburbs. In particular, while women in both the higher density and the lower density suburban neighborhoods drove more times and for longer distances to shop when compared to men, the gender difference was only statistically significant for the lower density suburbs.

When comparing the lower density suburban and the urban Detroit neighborhoods, the lower-income urban minority women also drove more frequently for shopping than men, again, similar to women in the lower density suburban neighborhoods. However, unlike the suburban residents, the lower-income minority women in Detroit did not travel longer distances by driving than men for their shopping activities. Thus, there were observable and clear distinctions by neighborhood types and differing income levels in women's shopping trips.

5.3.3.2.2. Trips to restaurants

Women in lower density suburban neighborhoods were less likely to travel to visit a restaurant as pedestrians and by driving (table 62). As pedestrians, women in the neighborhoods traveled fewer times and shorter distances to access restaurants when compared to men. Women in the lower density neighborhoods also travelled less frequently and shorter distances to get to restaurants by driving (tables 62 and 63). Therefore, across all six Detroit region neighborhoods, women traveled less frequently and shorter distances than men to access restaurants.

5.3.3.2.3. Trips to personal services

In accessing personal services, women in the lower density suburban neighborhoods walked less frequently, but traveled longer distances than men. However, women in these neighborhoods drove more frequently but shorter distances then men to reach their personal service destinations (tables 62 and 63). Thus, in the lower density suburban neighborhoods, women chose to drive more frequently for personal services, but they travelled shorter distances to reach these destinations by driving when compared to men.

5.3.3.2.4. Trips for leisure

With respect to travel for leisure, women in the lower density suburban neighborhoods walked more frequently, but shorter distances when compared to men. However, women traveled significantly more times by driving to reach their leisure destinations than men (B= 0.204, p-value = 0.062) (table 62). In order to reach their leisure destination, women also drove longer distances than men and at a significant level (B= 0.354, p-value = 0.048) (table 63). This is a different outcome when compared to the Detroit urban neighborhoods and the higher density suburban neighborhoods.

This is a unique travel pattern in the lower density suburban neighborhoods, facilitated by higher incomes, greater access to a car and longer distances between leisure destinations. Women in the lower density suburban neighborhoods traveled more frequently and longer distances for leisure since they had greater access to a personal automobile when compared to lower-income urban Detroit women respondents. In addition, unlike the higher density suburban residents, women in the lower density suburban neighborhoods drove more frequently than men for their leisure activities and traveled longer distances to reach leisure destinations. This could be expected given the lower density development patterns of these neighborhoods, and the dispersed nature of destinations across this landscape. The ANCOVA results for disaggregate travel activities examined the mean differences in individual travel behavior between gender and marital status groupings (table 64). The detailed breakdowns of these results by trip destination are provided below.

Table 64 Average weekly total trip frequency and cumulative distance (mile)* by gender and marriage in the lower density suburban neighborhoods

			Men		Women	
			Not-married	Married	Not-married	Married
Work	Trip Frequency	Pedestrian	n/a	2.94	1.90	2.81
		Public transit	n/a	n/a	n/a	n/a
		Driving	4.73	5.11	4.67	4.56
	Trip Distance	Pedestrian	n/a	14.98	10.16	13.13
		Public transit	n/a	n/a	n/a	n/a
		Driving	54.95	82.02	45.43	57.90
Shopping	Trip Frequency	Pedestrian	2.96	1.69	1.96	1.34
		Public transit	n/a	n/a	n/a	n/a
		Driving	3.02	3.37	3.78	3.93
	Trip Distance	Pedestrian	6.61	4.01	4.14	2.12
		Public transit	n/a	n/a	n/a	n/a
		Driving	9.98	11.08	16.29	12.47
Restaurant visit	Trip Frequency	Pedestrian	2.47	1.68	2.14	0.93
		Public transit	n/a	n/a	n/a	n/a
		Driving	2.23	2.44	1.91	2.11
	Trip Distance	Pedestrian	1.22	6.49	18.08	4.74
		Public transit	n/a	n/a	n/a	n/a
		Driving	10.96	10.72	9.60	9.41
Service	Trip Frequency	Pedestrian	2.42	1.13	1.47	1.20
		Public transit	n/a	n/a	n/a	n/a
		Driving	3.31	2.71	3.20	2.94
	Trip Distance	Pedestrian	1.71	2.35	3.15	3.68
		Public transit	n/a	n/a	n/a	n/a
		Driving	15.66	8.58	9.40	9.04
Leisure	Trip Frequency	Pedestrian	2.87	2.42	2.53	2.77
		Public transit	n/a	n/a	n/a	n/a
		Driving	2.74	2.70	3.19	3.34
	Trip Distance	Pedestrian	2.96	4.91	4.16	2.33
		Public transit	n/a	n/a	n/a	n/a
		Driving	28.20	17.83	21.44	19.68

*Calculated with original weekly total trip frequency and cumulative trip distance data.

Table 65 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in the lower density suburban neighborhoods—*work*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	n/a	1.604	1.283	1.608	24
		(S.E.)		(.183)	(.457)	(.193)	
	Public transit	Mean	n/a	n/a	n/a	n/a	n/a
		(S.E.)					
	Driving[4]	Mean	2.118	2.201	2.1	2.087	195
		(S.E.)	(.128)	(.057)	(.098)	(.056)	
Trip dist.[2]	Pedestrian[5]	Mean	n/a	2.478	2.29	2.102	19
		(S.E.)		(.311)	(1.009)	(.357)	
	Public transit	Mean	n/a	n/a	n/a	n/a	n/a
		(S.E.)					
	Driving[6]	Mean	3.808	3.94	3.415	3.536	173
		(S.E.)	(.297)	(.134)	(.236)	(.129)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.992268, AGE = 55.25.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 11.011105, AGE = 51.48.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 11.062639, AGE = 55.58.
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 11.041770, AGE = 51.03.

Mean difference between gender groups was only significant for driving trip distance (p-value = .066).

Table 66 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in the lower density suburban neighborhoods—*shopping*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.676	1.142	1.356	1.155	30
		(S.E.)	(.273)	(.132)	(.231)	(.227)	
	Public transit	Mean	n/a	n/a	n/a	n/a	n/a
		(S.E.)					
	Driving[4]	Mean	1.655	1.697	1.824	1.898	305
		(S.E.)	(.122)	(.065)	(.092)	(.056)	
Trip dist.[2]	Pedestrian[5]	Mean	1.388	1.405	1.291	1.389	22
		(S.E.)	(.484)	(.291)	(.410)	(.584)	
	Public transit	Mean	n/a	n/a	n/a	n/a	n/a
		(S.E.)					
	Driving[6]	Mean	1.906	1.952	2.432	2.276	299
		(S.E.)	(.162)	(.085)	(.122)	(.072)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.920003, AGE = 52.53.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.901893, AGE = 56.23.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.876764, AGE = 56.36
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.908568, AGE = 55.75.

Mean difference between gender groups was only significant for driving trip frequency (p-value = .037), and driving trip distance (p-value = .000).

Table 67 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in the lower density suburban neighborhoods—*restaurant visits*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.498	1.190	1.452	0.724	20
		(S.E.)	(.420)	(.188)	(.330)	(.239)	
	Public transit	Mean	n/a	n/a	n/a	n/a	n/a
		(S.E.)					
	Driving[4]	Mean	1.380	1.417	1.271	1.302	220
		(S.E.)	(.167)	(.073)	(.111)	(.068)	
Trip dist.[2]	Pedestrian[5]	Mean	1.357	1.827	2.318	1.198	16
		(S.E.)	(1.936)	(.410)	(.642)	(.559)	
	Public transit	Mean	n/a	n/a	n/a	n/a	n/a
		(S.E.)					
	Driving[6]	Mean	1.924	1.906	1.940	1.775	197
		(S.E.)	(.276)	(.120)	(.180)	(.110)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 11.000764, AGE = 54.20.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.941513, AGE = 56.17.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.990896, AGE = 55.13.
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.939777, AGE = 56.60.

Table 68 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in the lower density suburban neighborhoods—*personal services*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.513	1.051	1.182	0.998	28
		(S.E.)	(.192)	(.122)	(.138)	(.142)	
	Public transit	Mean (S.E.)	n/a	n/a	n/a	n/a	n/a
	Driving[4]	Mean	1.652	1.548	1.671	1.637	267
		(S.E.)	(.122)	(.065)	(.091)	(.054)	
Trip dist.[2]	Pedestrian[5]	Mean	0.647	0.620	1.283	0.711	20
		(S.E.)	(.599)	(.355)	(.519)	(.511)	
	Public transit	Mean (S.E.)	n/a	n/a	n/a	n/a	n/a
	Driving[6]	Mean	1.873	1.839	1.833	1.754	242
		(S.E.)	(.212)	(.120)	(.165)	(.094)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.919367, AGE = 53.39.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.895376, AGE = 56.28.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 11.023041, AGE = 48.75.
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.902581, AGE = 55.83.

Mean difference between gender groups was only significant for pedestrian trip frequency (p-value = .053).

Table 69 ANCOVA results: average total trip frequency and cumulative distance by gender and marriage in the lower density suburban neighborhoods—*leisure*

			Men		Women		N
			Not-Married	Married	Not-Married	Married	
Trip freq.[1]	Pedestrian[3]	Mean	1.563	1.474	1.478	1.507	47
		(S.E.)	(.291)	(.190)	(.251)	(.144)	
	Public transit	Mean	n/a	n/a	n/a	n/a	n/a
		(S.E.)					
	Driving[4]	Mean	1.554	1.459	1.654	1.657	243
		(S.E.)	(.181)	(.090)	(.118)	(.072)	
Trip dist.[2]	Pedestrian[5]	Mean	0.828	1.387	1.210	0.964	21
		(S.E.)	(.491)	(.538)	(.350)	(.345)	
	Public transit	Mean	n/a	n/a	n/a	n/a	n/a
		(S.E.)					
	Driving[6]	Mean	2.704	2.143	2.587	2.556	196
		(S.E.)	(.276)	(.152)	(.172)	(.115)	

1. Dependent variable was transformed with square-root.
2. Dependent variable was transformed with natural logarithm.
3. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.952798, AGE = 51.26.
4. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.912629, AGE = 56.16.
5. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 11.061906, AGE = 49.76.
6. Covariates appearing in the model are evaluated at the following values: LNMADJFINCOME = 10.927554, AGE = 55.78.

5.3.3.3. Gender and Marital Status Distinctions in Travel Behavior: Trips to work

With respect to work commutes, married men walked to work in the lower density suburban neighborhoods most frequently (2.94 times a week) and the longest distance (14.98 miles per week) when compared to married men and not-married women (table 64).

By driving, it was married men again that traveled most frequently (5.11 times a week) and the greatest distance (82.02 miles) to reach their place of employment. Married women, in contrast, drove least frequently (4.56 times a week) to work, while not-married women drove the shortest distance (45.43 miles per week). Accordingly, both married and not-married men made more frequent driving trips to work, and they also traveled longer distances than both married and not-married women. This is a consistent finding evident in previous studies (Hanson and Giuliano, 2004; Rosenbloom, 2005), In the lower density suburban neighborhoods, the gender difference in average driving trip distance—about 15 miles on average—was also statistically significant (p-value = 0.066) (tables 64 and 65).

5.3.3.4. Gender and Marital Status Distinctions in Travel Behavior: Trips to Shops, Restaurants, Personal Services, and Leisure

5.3.3.4.1. Trips to shopping

As consistently evident in the other neighborhood groups, both in urban Detroit and in the higher density suburbs, married women in the lower density suburban neighborhoods also traveled most frequently to shop. For shopping trips, not-married men in the lower density suburban neighborhoods walked most frequently (2.96 times a week), while married women walked least frequently (1.34 times a week). In fact, both married men and married women preferred not to walk for their shopping trips when compared to not-married men and not-married women.

Not-married men also traveled as pedestrians the longest distances (6.61 miles per week) among all gender and marital status groups, while married women walked the shortest distances (2.12 miles per week), see table 64. However, none of the mean differences by gender or marital status was statistically significant. The significant difference in shopping trips was evident with driving. To reach their shopping destinations, married women in the lower density suburban neighborhoods drove most frequently (3.93 times a week) while not-married women drove the longest distances (16.29 miles per week). Not-married men, in contrast, traveled least frequently (3.02 times a week), and the shortest distances (9.98 miles) to shop. Both of the women's groups, married and not-married, traveled significantly more times (p-value = 0.037) and longer distances (p-value = 0.000) by driving to shop when compared to both married and not-married men (table 66).

5.3.3.4.2. Trips to restaurants

One of the destinations for which married women made the least visits was restaurants. Married women traveled least frequently (less than once a week) as pedestrians. Both not-married men and not-married women walked more frequently for restaurant visits when compared to married men and married women. By driving, married men traveled most frequently to access restaurants (2.44 times a week), while not-married women made the least frequent trips (1.91 times a week). Therefore, both married and not-married men made more frequent trips to restaurants by driving than both married and not-married women.

As for the driving trip distance, married women traveled the shortest distances to restaurants (9.41 miles per week) when compared to the other gender and marital status groups (table 64). Similar to the frequency of pedestrian trips to restaurants, not-married men traveled the longest distances by driving (10.96 miles per week). Thus, both not-married men and not-married women drove further distances to access restaurants when compared to married men and married women, even though they made fewer driving trips. None of the mean differences in restaurant trips, however, was statistically significant.

5.3.3.4.3. Trips to personal services

Both men and women who were not married dominated personal service trips in the lower density suburban neighborhoods (table 64 and 68). In fact, the not-married respondents traveled more miles for service trips, regardless of travel mode. Married men walked least frequently (1.13 times a week) to reach their personal service destinations while not-married men traveled most frequently (2.42 times a week) (table 64). To access personal service destinations, however, not-married men walked the shortest distances (1.71 miles per week) while married women walked the longest distances (3.68 miles per week) (table 64). As for the gender differences, both married and not-married men walked more frequently for personal services, while they walked shorter distances compared to both married and not-married women. However, the gender difference was only statistically significant for the pedestrian trip frequency (p-value = 0.053) (table 68).

Between the marital status groups, both not-married men and not-married women traveled more frequently but shorter miles as pedestrians to reach personal service destinations. By car, not-married men traveled most frequently for personal services (3.31 times a week) while married men traveled the least frequently (2.71 times a week). Again, not-married men and not-married women drove more frequently than those married to access personal service destinations. Respondents that are not married also traveled longer distances by car for personal services than married respondents. Married women, in fact, drove the shortest distances (9.04 miles per week) for personal services, while not-married men traveled the longest distances (15.66 miles per week). However, in the lower density suburban neighborhoods, there was no significant mean difference by gender and marital status in personal service travel, except for pedestrian trip frequency.

5.3.3.4.4. Trips for leisure

For leisure trips, there was no observed significant mean difference between the gender and the marital status groups in the lower density suburban neighborhoods. However, not-married men and not-married women were participating in leisure activities more frequently than married men and married women. For example, not-married men traveled most frequently (2.87 times a week) as pedestrians to reach leisure destinations, whereas married men traveled least frequently (2.42 times a week). Despite their low frequency count for this travel activity, married men walked the greatest distances (4.91 miles per week) for leisure.

Married women traveled more frequently as pedestrians (2.77 times a week) and by driving (3.34 times a week) for leisure than not-married women. However, not-married women traveled longer distances as pedestrians (4.16 miles a week) and by driving (21.44 miles a week) for leisure when compared to married women. Thus, it is rather unique that for leisure trips, married women in the lower density suburbs traveled most frequently by car, while married women in the higher density suburbs drove least frequently to access leisure. In addition, married women in the lower density suburbs drove more frequently than they walked to leisure destinations, whereas married women's groups in both urban Detroit and the higher density suburban neighborhoods walked more frequently than they drove.

Another important insight into travel within the lower density suburbs was associated with married men's leisure trips. In the lower density suburban neighborhoods, married men drove least frequently (2.70 times a week) to reach their leisure destinations. They also drove the shortest distances (17.83 miles per week) for leisure, while not-married men made the most frequent leisure trips by driving. Thus, in the lower density suburban neighborhoods, married men and women prioritized commutes to work and shopping trips in their daily trip allocations. This is due to the longer trip distances between destinations in the lower density suburbs. Married men and women spent more time traveling longer distances to work and to shop in the lower density built environments. In turn, both men and women in marriage considered leisure or restaurant trips less important compared to commutes to work or shopping trips.

5.3.3.5. Discussion

In the lower density suburban neighborhoods in Bloomfield Hills and West Bloomfield, there were explicit gender differences in individual travel behavior. From the OLS regression results, women, in comparison to men, traveled more frequently and greater miles for household related activities, but less frequently and fewer miles for work. By driving, as a single dominant travel mode in the lower density suburban neighborhoods, women were likely to travel significantly more times and longer distances for non-work trips, such as shopping and leisure. Specifically for shopping trips, the number of dependent children was a significant factor in increasing shopping trip distance. Thus, women with dependent children were more likely to drive a longer distance to shop.

This confirms the nature of gendered travel behavior. Women's daily trips are mainly for household duties, a pattern that has been recognized in the existing gender and transportation literature (Hanson, 1995; Hanson and Hanson, 1980a, 1980b; Hanson and Pratt, 1991; Hanson and Giuliano, 2004; Jones, 1990; Pickup, 1990; and Rosenbloom, 2005). As pedestrians, women also traveled more frequently for shopping and leisure, and greater miles for personal services. However, the results were rather biased since the portion of pedestrian trips to total trips was a minor component in the lower density suburban neighborhoods.

Unlike in both the higher density Detroit urban and suburban neighborhoods, women in the lower density suburbs traveled by driving significantly more times and longer distances than men to reach their leisure destinations. It is a rather unique condition found only in the lower density suburban neighborhoods, and likely tied to the greater personal automobile access among women living in these extreme built environments. As a function of higher income levels and the decentralized built environment, women in the dispersed suburban neighborhoods had greater access to an automobile. In addition, they had to travel farther to reach dispersed destinations in the lower density suburban neighborhoods, a complete contrast to the condition of women living in the higher density suburban neighborhoods.

The role of women in fulfilling non-work trips was effectively established from the ANCOVA results that explored disaggregated travel behavior. Among all gender and marital status groups, married women drove least frequently to work, but most frequently for shopping, after adjusting for income and age covariates. As commonly evident across both the higher density Detroit urban and suburban neighborhoods, married women drove predominantly for household errands and chores, while married men traveled predominantly for work. These findings support the results of existing travel behavior literature (Hamilton and Jenkins, 1990; Hanson and Hanson, 1980a; Hanson and Pratt, 1991; Hanson and Giuliano, 2004; Jones, 1990; Pickup, 1990; and Rosenbloom, 2005).

Married women in the lower density suburban neighborhoods traveled shorter distances to work by walking and by driving, when compared to married men. Married women, however, traveled most frequently and the longest distances by car to reach shopping destinations. In addition, for restaurant visits, married women traveled least frequently and the shortest distances as pedestrians and by driving compared to other marital and gender groups in the lower density suburban neighborhoods. For leisure activities, however, married women drove more frequently and longer distances than married men, who traveled least frequently and the shortest distances by car. Not-married men and not-married women, in fact, drove farther to access their leisure destinations than married men and married women in the lower density suburban neighborhoods.

It is also important to note that compared to other women's groups in both urban Detroit and the higher density suburban neighborhoods, married women in the lower density suburbs walked less frequently for daily activities. This is to be expected given the dispersed urban built environments of these communities; the low density, single use and disconnected neighborhoods that literature has shown increase distances between destinations. Within these urban built environments, there are few—if any—potential destinations that are accessibly by walking or biking from the isolated and lower density residential neighborhoods. Moreover, longer distances to travel deter married women from walking or biking to meet daily needs due to increased travel cost, given the limited time as a result of their multiple roles at home and in the workplace.

Finally, married women in the lower density suburban neighborhoods prefer driving a personal vehicle due to the greater availability of automobiles in these higher income households. Married women in the lower density suburban neighborhoods also prefer to drive as a result of its greater convenience in comparison to walking. Nevertheless, even in these extreme built environments, women—regardless of marital status—still drove shorter distances to work, while they drove longer distances to shop, in comparison to men.

5.4. Conclusion and discussion

While the existing literature addresses general gender differences in trip generation across urban space, more nuanced analyses of socio-economic and demographic dynamics on individual trip activities is necessary in order to understand the more specific effects of population characteristics (e.g. gender and marital status). The analyses presented in this chapter also explore an extensive array of disaggregated travel patterns, including trips to work, restaurant visits, shopping, personal services, and leisure destinations. In particular, women's travels are often derived from their multiple responsibilities between paid employment and household duties (Hanson and Hanson, 1980a, 1980b 1981; Hanson and Pratt, 1991; Jones, 1990; and Pickup, 1985, 1990). Accordingly, a disaggregate analysis of individual travel behavior needs to include gender and marital status to examine women's daily trips for various travel activities, both work and non-work (Hanson, 1995; Hanson and Hanson, 1980a; Hanson and Pratt, 1991; Hanson and Giuliano, 2004; Hamilton and Jenkins, 1990; Jones, 1990; Pickup, 1985, 1990; and Rosenbloom, 2005).

In addition to the analyses in previous studies focusing on built environment characteristics in shaping individuals' travel behavior, it is also important to identify differing urban environment characteristics on individuals' daily trips—and particularly within the context of this research—of the socio-economically disadvantaged living in neighborhoods experiencing disinvestment and decline. In the lower east side urban Detroit neighborhoods, racial and ethnic minorities, and single-parent households, face greater travel burdens due to severe disinvestment and decline within these neighborhoods, which have shifted many of the urban amenities—the necessary daily destinations—from the immediate neighborhoods to suburban locations.

Due to the region's deep history of racial segregation, Detroit's black population is isolated largely in the city and spatially separated from the white population in the suburbs (Darden et al., 1987). The decentralization of Detroit has resulted from racial discrimination in the housing market that was controlled by apartment managers, real estate brokers, and builders (Darden et al., 1987, 2009; Sugrue, 1996; Thomas, 1997; and Vojnovic and Darden, 2013a). Accordingly, the decentralization of its population and tax base led to a polarized fiscal capacity between the city and the wealthy suburbs, and severely impacted opportunities for social mobility, and particularly among the city's minority population. As a result, the city of Detroit has been described as the most distressed urban core with an increasing concentration of unemployment, poverty, and racial and ethnic minorities due to outmigration of middle- and upper-income Whites to the suburbs.

Disinvestment and decline places severe burdens on lower income populations, as they increasingly have to travel to distant suburban locations to access basic daily necessities, including fresh fruits and vegetables, healthy restaurant options, personal services, and leisure destinations. In addition, with limited access to a private automobile, and greater reliance on public transit and walking to reach daily destinations, this places an added layer of burdens on lower income urban Detroit residents. Thus, in spite of similar built environments to the higher density suburban neighborhoods—that is, despite having an urban form characterized by higher density, mixed land use, with connected road networks—travel patterns among urban Detroit respondents were vastly different from those of the wealthier higher density suburban respondents, who had access to a rich variety of urban opportunities as potential destinations.

In order to identify how women and men travel differently in the Detroit region, disaggregate individual travel activity analyses were used. Disaggregated analyses were performed with three typologies of differing urban neighborhoods—higher density urban Detroit neighborhoods, higher density suburban neighborhoods, and lower density suburban neighborhoods. Disaggregated travel activity analyses—including OLS regression and Analysis of Covariance—examined gender differences, and also the gender division of intra-household responsibilities, in individuals' trip making for various daily activities. The OLS regression results suggested a relationship between gender and individual travel behavior (such as trips to work, shopping, restaurant visits, service and leisure) after controlling for socio-economic and demographic factors (income, age, personal vehicle access and the number of dependent children). In turn, the ANCOVA results demonstrated the mean differences in disaggregate travel activities in light of gender and marital status, after adjusting for income and age.

Regardless of the neighborhood typology, men traveled more frequently and over longer distances to reach their place of employment. Women's shorter driving trip distance to work was consistent across all three neighborhood types, urban Detroit (at a significant level), the higher density suburban neighborhoods (not at a significant level) and the lower density suburban neighborhoods (at a significant level). Women, however, traveled more frequently and longer distances for nonwork trips and particularly for trips related to household responsibilities, such as shopping and personal services. In the multi-person household, married women tend to shop for daily goods in the family. Subsequently married women traveled to shop more frequently than married men and traveled longer distances, and this was consistent across all the neighborhood typologies. However, married men consistently traveled more frequently and longer distances to restaurant when compared to married women, and in all three neighborhood typologies.

Therefore, it is expected that access to a private automobile will critically impact a married woman's ability to complete her multiple responsibilities, as both homemaker and paid laborer, by maximizing trip efficiency in terms of travel speed and flexibility, and also maximizing the spatial extent of 'reachable' destinations. The limited access to a private automobile will decrease a woman's mobility and particularly if destinations are dispersed and/or alternative modes of travels are scarce or poorly serve particular areas. This was evident among married women and their extensive public transit trip distances to shopping in the urban Detroit neighborhoods, where distances between destinations were increased by the disinvestment and disappearance of necessary urban amenities within the city.

In addition, decentralizing employment resulted in extreme trip distances to work for residents living in the Detroit urban neighborhoods. For work trips, married men in the urban Detroit neighborhoods drove more than 80 miles per week and married women drove more than 30 miles per week to their work destinations, distances that were similar or more to that of the lower density Detroit suburban residents. These longer commute distance patterns for urban Detroit residents have been extensively discussed in the spatial mismatch and racial justice literature (Kain, 1968; Vojnovic and Darden, 2013b).

While significant, the results have limitations with respect to their refinement and initial sample groups. First, limitations were related to individual characteristics of the sample population. The effect of increasing age in individuals' pedestrian trip making should be carefully treated since the observations included all adults with an age of 18 years and older. The physical ability to walk or bike as a mode of travel, therefore, changed nonlinearly with increasing age. For the same reason, the relationship between individuals' trip-to-work and socio-economic and demographic factors, such as age and income, need to be interpreted carefully due to the fact that the sample included retirees.

Another limitation to the research was the 'race' variable, which was not included as a separate independent variable in the models. The ideal model should incorporate a racial breakdown between African Americans and the Whites in the neighborhoods so that white women and men in the urban Detroit would be compared with white women and men in the suburban neighborhoods. However, due to the scarcity of white population in the urban Detroit neighborhoods, models were not able to capture a meaningful gender comparison between racial groups. Thus, income and racial characteristics of each neighborhood group (urban Detroit as predominantly lower income and African Americans, and two suburban neighborhood groups as predominantly higher income and white) permitted to identify gender and racial differences in individual travel behavior.

Marital status, either married or not married, might mislead the interpretation of the results, and specifically the not-married classification, since it included both people who were never married and people who were not currently in a marriage, including the divorced, separated, and widowed. Therefore, in this study, there was no differentiation within the models between never-married single-parent households and those who are not currently in a marriage. Lastly, the differences between married men and married women did not represent exactly the intra-household variation. Since the data did not have exact 'paired-sets' of husbands and wives for each household, the inter-dependence between husband and wife, and subsequent travel constraints, were not fully captured.

In addition, in spite of a large sample size in the region (n=1148), disaggregation of individual travel behavior into various travel activities substantially limited the number of observations (Ns) in each OLS regression analysis and ANCOVA—for example, public transit trips for restaurant visits, $N_{\text{Detroit urban}}$ = 17 (frequency) and 16 (distance), and $N_{\text{high density suburban}}$ =

4 (frequency) and 3 (distance). Thus, results for certain daily activities by certain travel modes were potentially skewed.

For example, the standard errors varied with relatively large extents due to limited sample sizes. It is because the means become more sensitive to influences of individual cases in the distribution of observed values after subgrouping the sample by gender and marital status. While I successfully obtained interesting results for each subgroup for the travel behavior, both trip frequency and trip distance for each travel activity, the limitations with small Ns and subsequent large variations of S.E. are unavoidable. Also, the reality of high unemployment rates in the urban Detroit neighborhoods limited the ability to analyze work trip behavior with meaningful differences between groups.

Also, since the data did not capture trip chaining in daily travel activities, trip variables—both trip frequency and distance—were assumed as single trips between home addresses and various destinations. With potential trip chaining missing, women's more frequent and segmented trips between their multiple responsibilities between paid employment and household duties could not be captured. Lastly, with respect to driving trips, the difference between a person traveling as the driver and a passenger was not considered. As a result, a person's driving trips were included in the analyses even though the person might not have access to a personal automobile.

Thus, further research using similar methods can systematically test and calibrate these results against a more comprehensive set of data, including trip chaining components, intra-household variation between men and women in union, and types of vehicle travels. Also, it will be useful to analyze the data with alternative methods, for example logistic regression, that may reveal the meaningful differences between populations and allow tests with more rigorous grouping schemes. Lastly, a longitudinal analysis will help to fully understand the changes in urban built environments and the effects on individual travel behavior.

CHAPTER 6: CONCLUSION

6.1. Summary and Conclusion

Urban transportation researchers have established strong theoretical support and have demonstrated empirically that encouraging regular participation in moderate physical activity can encourage healthier life-styles (Frank, 2000, 2004; Frank et al., 2006; Handy, 1996, 2005a; Hanson et al. 2002; Saelens et al., 2003a; Sallis et al., 2004, Vojnovic et al., 2006). The studies have consistently shown that a compact community—a neighborhoods that is characterized by higher density, mixed land uses, and high connectivity—is more likely to encourage the use of more sustainable modes of transport, such as walking, cycling and public transit, when compared to a low-density suburban neighborhood promoting a singular vehicle travel mode, private automobile use.

Transportation researchers have also increasingly recognized the differences in travel behavior based on gender and different socio-economic and ethnic/racial composition (Johnston-Anumonwo, 1992, 1997; McLafferty and Preston, 1997; and Wyly, 1996, 1998). In addition to automobile dependent urban transportation systems, the unequal distribution of urban amenities across U.S. metropolitan areas has resulted in differential travel costs for different income, race and ethnicity, age and gender population subgroups that face more limited sets of choices for their travel destinations (Handy et al., 2005; Hanson and Hanson, 1981; Hanson and Johnston, 1985, Hanson, 1986, Johnston-Anumonwo, 1989, 1997; MacDonald, 1999; McLafferty and Preston, 1997; Rosenbloom, 1989, 2005; Rosenbloom and Raux, 1985; Vojnovic et al., 2013; LeDoux and Vojnovic, 2013; and Wyly, 1996, 1998, 1999).

While studies have found links between residents living in compact, mixed land-use, and connected neighborhoods and increased walking frequency and shorter walking distances, urban transportation research has mainly focused on major service based cities with robust urban cores; cities such as Chicago, Seattle, Boston and San Francisco. As a result, very little research has focused on travel patterns in traditional industrial cities in the Midwest and the Rustbelt, cities like Detroit. The urban minorities concentrated in such cities not only find few employment opportunities in the urban core, but also confront great distances to reach potential employment in the suburbs. This geographical separation between the central city and the suburbs in the Detroit region has also been facilitated through class and racial segregation, and a politically fragmented regional jurisdictional structure, with little inter-municipal cooperation.

This dissertation fills the gap in the literature on gender differences in travel behavior while taking into account socio-economic and racial variables. Longer distances between spreading destinations—such as jobs, stores and public services in most U.S. urban areas—aggravate travel burdens of the disadvantaged, including women, minorities and lower-income populations. Specifically women in the household with one or no car, in many cases likely due to their lower incomes, have struggled with their multiple household responsibilities as a result of their constrained mobility (Hanson, 1986; Hanson, 2010; and Turner and Neimeier, 1997). Despite the significant implications of these urban and transportation stresses, women's travel and their access to urban opportunities have been marginalized in urban transportation research.

In addition, there is little that is understood in how these variations in travel behavior by gender might be affected by income, ethnicity, age, household types, and neighborhood structure. Moreover, nonwork trips have not been examined in detail, even though non-work trips tend to be more dynamic and associated with people's social roles and responsibilities.

The limitations in the existing research are also found in the scale of study. Most travel behavior studies have attempted to understand travel demand and patterns with aggregate data at conventional TAZs (traffic analysis zones), counties, or MSAs. The focus of studies on these large geographic areas averages out differences in travel that can be recognized at the micro-scale, the neighborhood or block level. Within this context, it is important to understand the full range of transportation demands, and specifically taking into account the realities confronted by lower income populations, urban minorities and women within the neighborhood, and in robust neighborhoods as well as neighborhoods experiencing disinvestment and decline.

One objective of this dissertation was to identify the effects of the built environment on promoting non-motorized travel. A second objective was focused on women's accessibility and mobility in urban space within the context of differing urban built environment characteristics in the Detroit region. First, in chapter 3, the relationship between urban density, land use mix, street connectivity, bus stops and individual travel behavior was explored. This particular analysis aimed to understand the causal relationships of the urban built environment in promoting pedestrian trips and reducing automobile use. Accordingly, two main research questions were involved: (1) do people utilize non-motorized travel modes such as walking and biking more in urban neighborhoods characterized by higher-densities, mixed land uses, and high connectivity? and (2) people reduce automobile travel in urban neighborhoods characterized by higher-densities, mixed land uses, and high connectivity? In this component of the research, the hypothesis was that urban neighborhoods with higher density, mixed land uses, and high connectivity would increase the likelihood of utilizing non-motorized travel modes.

Spatial data of urban built environment elements, including land use density and types, 4-way intersection density, and the number of bus stops, were collected for six 3 by 3 mile neighborhoods, about 9 sq. miles each, in the Detroit region. The additional process of boundary data collection (an area covering half a mile distance from each neighborhood boundary) enabled the study to capture the built environment characteristics with a walking distance of half a mile from each respondent's address.

Neighborhood comparative analysis results showed that there were clear distinctions between the three neighborhood groups. Four higher density urban and suburban neighborhoods were characterized with a greater land use density and mix, and more 4-way intersections and bus stops than the lower density suburban neighborhoods. The two higher density urban neighborhoods, however, differed from the two higher density suburban neighborhoods in that there were a greater variety of both residential and nonresidential land uses in the higher density suburban neighborhoods, due to the scale of decline and disinvestment in urban Detroit.

For the multivariate regression analysis, 1,106 road network buffers (RNBs) were created from residential addresses of survey respondents located using the ESRI ArcGIS Network Analyst. RNB is a service area of a half a mile distance, running in different in-network directions of a half a mile from a residential location using the actual road network. The dependent variables were three trip measures, including mode split, trip frequency and trip distance (length of trip), for work and nonwork trips. As independent variables, the densities of residential and non-residential structures, land use mix measures (entropy measures ranging from 3 to 8 land use types), the density of 4-way intersections and bus stop densities within the RNB were determined. In addition to the urban form indicators, personal income and age were added to the modes as controlling factors.

The analysis results showed the significant associations between built environment elements and individual travel behavior. First, pedestrian travel was likely to increase in RNBs with a greater density, diverse land uses, highly connected road networks, and more bus stops. In addition, motorized travel for daily activities was substantially reduced in the densely developed RNBs with a greater land use mix, more intersections and bus stops. People also tend to utilize non-motorized travel modes more and drive less if the immediate built environment has a better balance of land uses, and particularly a mix of residential, commercial (retail and personal services) and public institution. Finally, I used the stepwise regression analysis to test the relative strength of each of the urban form factors in influencing individual travel behavior. Among the built environment factors, the number of bus stops and 4-way intersections were the most strongly associated with individual travel behavior.

This particular analysis is important because the results not only confirm the previously addressed relationships between urban form and individual travel behavior, but also offer the broadened understanding of urban travel with more elaborate dimensions in neighborhood characteristics. Unlike the existing studies, the results explored the relationship between built environment and travel behavior in a region characterized by a rapidly declining urban core, the Detroit region, which is experiencing extreme urban decentralization coupled with disinvestment in the central city. The results, therefore, were able to reveal how individual's travel was actually affected in neighborhoods experiencing extreme disinvestment and decline.

Another important aspect of the analysis comes from the reaffirmed significance of the land use mix in promoting pedestrian travel and reducing automobile use. The strongest influence of commercial land uses was in increasing pedestrian trips and in decreasing automobile trips, stressing the importance of a balance between residential, commercial, and public institutional land uses (i.e. LUM3). This analysis also supports the importance of utilizing a disaggregate analysis at a fine urban scale, the neighborhood level or lower. These relationships between urban form factors and individual pedestrian travel were more accurately understood from the finer scale analysis of road network buffers (RNBs), after controlling for socio-economic and demographic characteristics. Utilizing RNBs is in itself a seldom utilized approach to travel behavior analysis.

In chapter 4, three neighborhood typologies were defined in the exploration into trip generation, residents' socio-economic profile and the quality of neighborhood environments. This chapter was to identify the neighborhood typology that helps explain differences in travel behavior between urban and suburban neighborhoods. Subsequently, two main research questions were involved: (1) which socio-economic and demographic factors significantly influence total trip generation? and (2) which neighborhood group, among urban Detroit, higher-density suburban, and lower-density suburban neighborhoods, is differentiated against others in terms of socio-economic and demographic characteristics, travel patterns, and neighborhood quality for pedestrians? The hypothesis was that residents in the higher income neighborhoods, with greater automobile access, tend to travel more frequently and longer distances by motorized travel modes. Also, residents in the neighborhoods with more diverse urban opportunities and higher quality pedestrian environments (e.g. neighborhoods with a reduced fear of walking) would have improved accessibility for daily activities when compared to neighborhoods with similar urban density and connectivity.

First, the entire sample of travel survey data (n=1,148) was used to model trip generation among the general population in the Detroit region. Findings from the OLS regression indicated that income and personal vehicle access had a positive effect on trip generation (total trip frequencies and distance) for all activities, work and non-work travel, while age and the number of dependent children had a negative effect. Thus, the significant effect of personal vehicle access to a person's travel patterns was confirmed.

Second, discriminant analyses were applied to confirm differing characteristics between neighborhood groups in the Detroit region before analyzing disaggregate individual travel behavior. By incorporating socio-economic and demographic factors (income, age, personal vehicle access and the number of dependent children), the discriminant analysis results differentiated urban Detroit neighborhoods by their lower socio-economic characteristics (i.e. lower income and personal vehicle access) and higher density suburban neighborhoods by their younger life cycle stage characteristics (i.e. age and the fewer dependent children).

By incorporating travel pattern variables (total trip frequencies and cumulative trip distances by travel mode), the analysis differentiated the lower density suburban neighborhoods against the other higher density neighborhoods (both urban and suburban) by the driving dominant travel patterns in the lower density neighborhoods. Urban Detroit neighborhoods were also separated against the suburban neighborhoods (both higher and lower density) by their pedestrian dominant travel patterns.

Lastly, the descriptive analysis results illustrated substantial differences in mean trip frequency and trip distance between the three neighborhood typologies. Residents in the lower density suburban neighborhoods traveled longer distances by all modes when compared to the higher density neighborhoods, which is consistent with previous studies (Crane, 1996; Crane and Crepeau, 1998). Nevertheless, the pattern of longer trip distances by the urban Detroit neighborhood residents when compared to their higher density suburban counterparts reconfirmed the importance of this neighborhood typology in understanding the unique travel burdens of lower-income urban minorities.

Defining the neighborhood typology is particularly important in order to understand the travel burden of individuals in neighborhoods experiencing disinvestment and decline. In addition to the unequal distribution of travel opportunities, such as reaching employment, retail, or personal services, income disparities across the neighborhoods result in a greater burden placed on lower-income urban minorities with limited personal automobile access.

The neighborhood typologies also enabled the close examination of travel burdens faced by urban minorities in the Detroit region. The fact that urban Detroit residents traveled longer distances as pedestrians and by public transit clearly revealed their burdens in accessing urban amenities when compared to residents in the higher density suburbs. In addition, urban Detroit residents, for certain activities, also drove longer distances when compared to the lower density suburban residents. Therefore, defining these neighborhood typologies provided a better understanding of travel constraints of the socially marginalized populations, and particularly lower-income women in the declining urban neighborhoods, one of the principal areas of this dissertation's research interest.

In the last analysis chapter (chapter 5), the differences in travel behavior between women and men were examined within the full array of daily travel activities. This particular analysis sought to examine gendered travel patterns and their relationship with urban built environment characteristics and socio-economic and demographic factors. Two main research questions were: (1) how women travel differently from men within similar urban built environments? and (2) how lower-income urban minority women's travels were more disadvantaged than other women's groups living in the suburban Detroit neighborhoods? The central hypothesis was that women would travel more for household responsibilities regardless of neighborhood built environment characteristics. Also, it was assumed that lower-income urban minority women would walk more and use public transit more than women in the suburban neighborhoods, due to lower incomes and lower automobile access.

In this chapter, the entire sample of travel surveys was divided into three neighborhood groups, the urban Detroit neighborhoods, the higher density suburban neighborhoods and the lower density suburban neighborhoods, in order to control the effects of the built environment and the unique conditions of urban Detroit. Daily trips were also disaggregated into trips to work, shopping, restaurants, personal services and leisure. In this way, the complexity of individual travel behavior would be better understood in the context of gender effects. In the first part of the analysis, I used OLS regression to address how women's travel behavior would be different from that of men in utilizing various travel modes—including pedestrian, public transit, and driving—and after controlling for socio-economic and demographic factors (including income and age). The socio-economic and demographic factors were selected from the general trip generation models (chapter 4). The 'race' variable was excluded in this analysis since the main focus of the research centered on gender effects of individual travel behavior.

The results showed that men traveled more frequently and over longer distances to reach their place of employment regardless of the neighborhood typology. The gender difference in commutes to work was also confirmed in terms of women's shorter driving trip distance in all three neighborhood typologies. Women, however, traveled more frequently and longer distances for trips related to household responsibilities, such as shopping and personal services. Thus, the results confirmed that the traditional gender role was still reflected in women's daily travel in the Detroit region.

I also used the ANCOVA (Analysis of Covariance) to detect the mean differences between women and men while taking into account their marital status, and after controlling for income and age. The findings revealed that married women traveled to shop more frequently than married men and traveled longer distances across all three neighborhood typologies. However, married men consistently traveled more frequently and longer distances to restaurants when compared to married women, and in all three neighborhood typologies.

The results, therefore, illustrate the importance of access to a private automobile, particularly in the context of a married woman's ability to complete her multiple responsibilities as a homemaker and as a workforce participant. Private automobile access critically impacts woman's ability to enhance trip efficiency in terms of travel speed and flexibility, and also maximizes the spatial extent of 'reachable' destinations. Thus, more limited access to a private automobile decreased a woman's mobility in an urban area where destinations are dispersed and/or alternative modes of travel are scarce or poorly serve particular areas.

Another important aspect of the analysis centered on the disappearing urban amenities within declining urban neighborhoods and the associated outcomes in the accessibility of daily destinations among urban minority populations. For instance, married women in the urban Detroit neighborhoods traveled extensive distances by public transit for shopping due to the increased distances between destinations, resulting from disinvestment and the disappearance of necessary urban amenities within the city. The extreme commute distances confronted by urban

Detroit residents also supports the argument of decentralizing employment, spatial mismatch and racial injustice.

6.2. Theoretical contributions and policy implications

There are several theoretical contributions advanced by this dissertation. The first comes from the benefits of micro-scale urban travel behavior analysis where we can focus on unique built environment characteristics that are normally just averaged out at the traditional county–scale levels of analysis (Vojnovic, 2006; Vojnovic et al., 2008, 2013, forthcoming; Griffith, Vojnovic, and Messina, 2012; and LeDoux and Vojnovic, 2013). While the analyses at the county scale were able to provide significant evidence that greater urban density and diverse land uses increased automobile travel, the traditional method was unable to capture variations of such factors within the zone (e.g. within the county). In other words, differences in urban density or land use mix between smaller geographical scales (e.g. a neighborhood or even smaller scale such as a walkable area) were discarded.

For example, in this study, in the Birmingham neighborhood (a higher density suburban neighborhood) and the two other lower density suburban neighborhoods are all located in Oakland County, however their urban forms vary vastly as do their individual travel behavioral characteristics. Hence, county scale analyses are unable to assess accurately different effects of urban built environment characteristics on subpopulations' travel behavior between neighborhoods that are located in the same city or county. This is also particularly important to understand how an urban neighborhood and its provision of amenities affect individual daily travel. Despite the similar higher density urban forms, the two urban Detroit neighborhoods were characterized with less diverse land uses, specifically, more limited nonresidential land uses when compared to the two higher density suburban neighborhoods. As a result, urban Detroit respondents traveled longer distances to meet the basic daily needs, such as shopping for food. In addition, it is possible to evaluate the effects of urban form factors on diverse travel activities such as trips for shopping, restaurants and personal services rather than just focusing on commutes to work.

In addition, road network buffers (RNBs) on the existing road system permit the analysis into the effects of the immediate built environment (within half a mile of one's home), enabling the exploration into the relative strength of certain urban form factors on promoting pedestrian travel and reducing automobile travel. Measuring the relevance of each urban form factor—that is the RNBs—becomes particularly significant since pedestrian travel, in comparison to automobile travel, is affected to a greater extent by the immediate urban form within a walking distance of one's residence.

For example, the analysis results from this dissertation show the importance of the availability of retail and personal services within walking distance of one's home in promoting non-motorized travel. The results also illustrate that the diversity in residential land uses and industrial land use within walking distance of one's residence had no significant effects on promoting pedestrian travel. In sum, the results at a micro-scale analysis offer much greater sensitivity to model the effects of urban built environment characteristics on individual travel behavior.

This study also reconfirms gender differences in travel behavior, and particularly in the higher density neighborhoods. On a weekly basis, men travel longer distances and women make more trips for the full array of daily activities in both the higher density suburbs and higher density urban neighborhoods. For example, by driving, women in both higher density urban and suburban neighborhoods traveled more frequently for shopping and personal services. These are findings that are consistent with the existing travel behavior literature (Hanson and Hanson, 1981; Hanson, 1986; Kwan, 1999b; and Wyly, 1998). The results also show that men in both higher density urban and suburban neighborhoods traveled longer distances in their commute to work. These findings, once again, are consistent with previous studies on gender and urban transportation (Hanson and Johnston, 1985; Johnston-Anumonwo, 1992; and Wyly, 1998).

The analysis results, however, contributed to understanding another important aspect, that is, women in the urban Detroit neighborhoods utilized pedestrian modes and public transit significantly more to reach their daily destinations when compared to women living in the higher density suburban neighborhoods. Not only traveling more frequently by pedestrian and public transit modes, Detroit urban minority women also had to travel longer distances by all modes to meet their daily needs. Accordingly, the travel patterns confirm the greater travel burdens confronted by urban minority women in the neighborhoods experiencing extreme disinvestment and decline.

This study, however, shows that gender differences in travel behavior in extremely low density neighborhoods are not maintained. In the lower density suburbs, women make more frequent trips and also travel longer distances than men. On a weekly basis, women make more trips and travel longer distances when exploring the full array of daily activities in the lower density suburbs (Hanson and Hanson, 1981; Hanson, 1986; Kwan, 1999b; and Wyly, 1998). The extreme characteristics of this urban form—the low densities, the single zoned uses and the disconnected road network—not only make everyone more automobile dependent, but they also encourage extensive driving distances by car to reach even the basic daily necessary destinations.

This not only reveals the inefficiencies of these urban/suburban spaces, but speaks to the demand for ensuring highly isolated enclaves by the wealthy as an urban design strategy to keep out the "unwanted" (Vojnovic, 2006; Vojnovic, 2009; Vojnovic et al., 2013; and Vojnovic and Darden, 2013b).

In terms of its relevance to policymakers, this study contributes insights to urban development and design strategies that improve walking environments and access, and in the process, provide a greater understanding of how healthy communities can be promoted, and especially for women, racial/ethnic minorities, and low income groups. Even though the urban Detroit neighborhoods and the higher density suburban neighborhoods were similarly characterized by higher densities, diverse land uses, and connected street networks, urban Detroit respondents traveled longer distances by driving to reach daily destinations when compared to the higher density suburban residents.

Furthermore, the respondents in the urban Detroit neighborhoods were hindered from walking or bicycling due to greater perception of fear in the neighborhoods. However, the implications of higher densities, mixed land-uses, and connected street networks on travel behavior and physical activity in such deteriorated inner-city neighborhoods have not been fully tested. The research thus also shows that while urban design is important in promoting non-motorized travel, wider socio-economic conditions—urban disinvestment, decline, and poverty—are even more important that design is shaping travel behavior.

This study also contributes to insights on transportation planning strategies that offer alternative transportation options to meet our populations' diverse travel demands. Urban Detroit neighborhoods used public transit significantly more frequently than suburban neighborhood residents, identifying the importance of the provision of appropriate public transit services in the region. Specifically when considering the location of employment and major retail outlets in the region, understanding the travel demand of inner-city urban residents, and the need for providing appropriate public services, becomes extremely critical to improve not only conditions of equity, but also basic mobility.

Lastly, this study contributes to insights on community development and planning that, in the wider context, could potentially foster more equitable opportunities through socio-spatial integration and economic development. The analysis results illustrate the importance of having access to diverse nonresidential locations—such as retail and personal services—in the immediate neighborhoods in order to encourage pedestrian travel as a part of daily physical activity. However, longer driving distances by urban Detroit neighborhood residents also reveals the unequal access that urban minorities face in reaching basic opportunities such as jobs, shopping, personal services and leisure destinations. Therefore, offering a rich bundle of urban amenities to lower-income urban minorities, as well as diverse housing options, is crucial in order to ensure the equitable access to urban opportunities.

6.3. Future research

As for my next steps in my research endeavors, in order to reveal more precisely the effects of the urban built environment on individual travel behavior, work trips and nonwork trips can be explored in separate models with further separation of nonwork trips into specific trip purposes (travel for shopping, personal services, leisure, and restaurants). Furthermore, in addition to income and age, other individual characteristics, such as gender and car ownership, or household characteristics such as marital status, can be adopted as controlling factors in the model and might help to further explain individual travel behavior choices and travel demands.

Additional information on travel destinations can also be added in the model. For instance, a dummy variable distinguishing between a central city or a suburban location will allow the model to examine not only the travel flows within the metropolitan region, but also exhibit the travel burdens of racial or ethnic minorities in declining urban cores. This will improve the understanding of urban travel, specifically reverse commutes and longer shopping trip distances to suburban retail locations.

The effects of pedestrian-friendly built environment factors on BMI (body mass index) will also be explored. The models should be developed separately at a finer scale (e.g. road network buffer for the entire sample population), and also at the neighborhood level (e.g. three neighborhood typologies). This is particularly important since there have been unsynchronized relationships between a higher level of BMI and densely developed urban neighborhoods with connected road networks. Therefore, the models will examine thoroughly the effects of neighborhood quality, such as the diversity of commercial destinations and leisure and recreational sites, on BMI in consideration of promoting physical activity and maintaining healthy lifestyles.

In addition, further research on gender dynamics and the complexity in individual travel should systematically test and calibrate the previous results against a more comprehensive set of data, including trip chaining components, intra-household variation between men and women in union and types of vehicle travel. Since, in this study, there was no differentiation between never-married single-parent households and those who are not currently in a marriage within the models, the results may mislead the interpretation of the effects of marital status (as either married or not married) on individual travel. Furthermore, the differences between married men and married women did not represent exactly the intra-household variation since the data did not specify exact 'paired-sets' of husbands and wives for each household. Therefore, the inter-dependence between husband and wife, and subsequent travel constraints, were not fully captured.

In addition, women's more frequent and segmented trips in their multiple responsibilities between paid employment and household duties could not be explored since the data did not capture trip chaining in daily travel activities. All trips were assumed as single trips between home addresses and the various destinations. Lastly, the differentiation between a person traveling as the driver and a passenger was not considered. As a result, driving trips of passengers were included equally across the analyses as driving trips, even though the person might not have access to a personal automobile.

Finally, alternative multivariate statistical procedures will be useful to analyze the data. For example, logistic regressions may reveal the meaningful differences between populations and allow tests with more rigorous grouping schemes. A longitudinal analysis will also enable a better understand of changes in the urban built environment and the effects on individual travel behavior through time.

APPENDIX

APPENDIX:

Data histograms: built environment and individual travel behavior

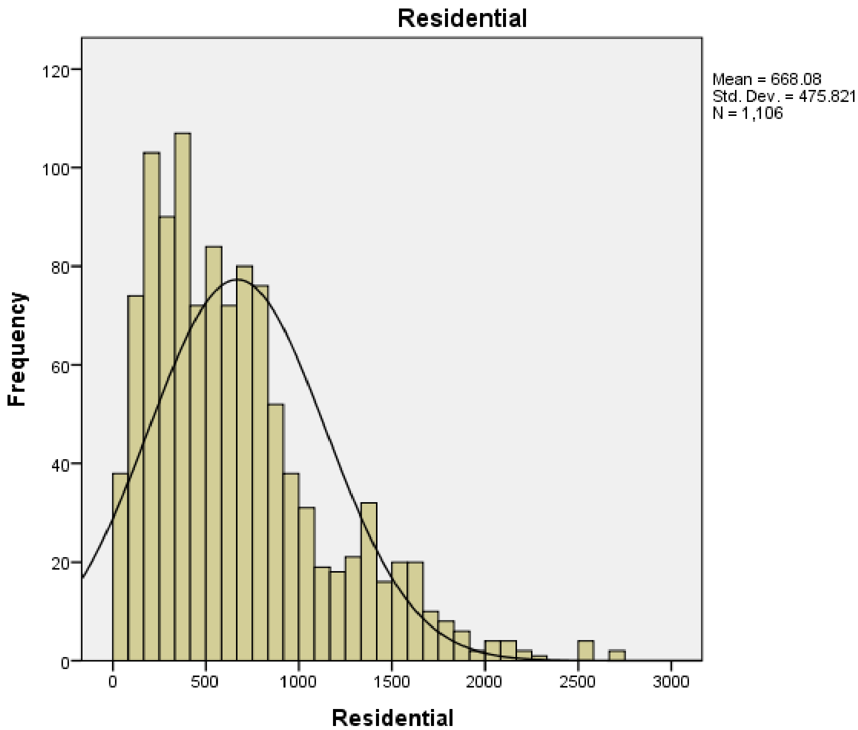


Figure 41 Built environment factor: residential land use density

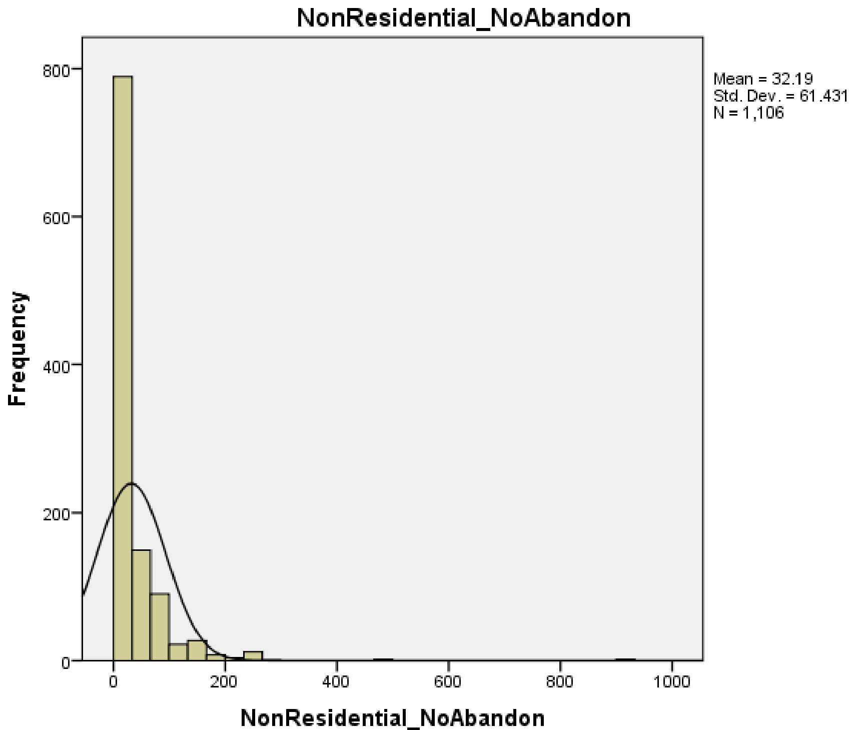


Figure 42 Built environment factor: non-residential land use density

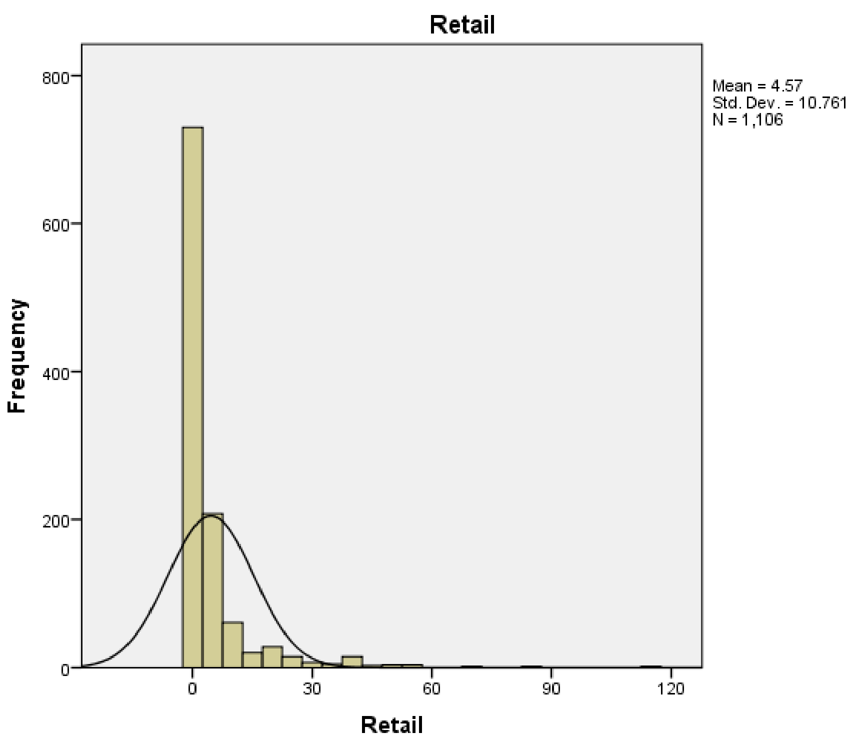


Figure 43 Built environment factor: retail land use density

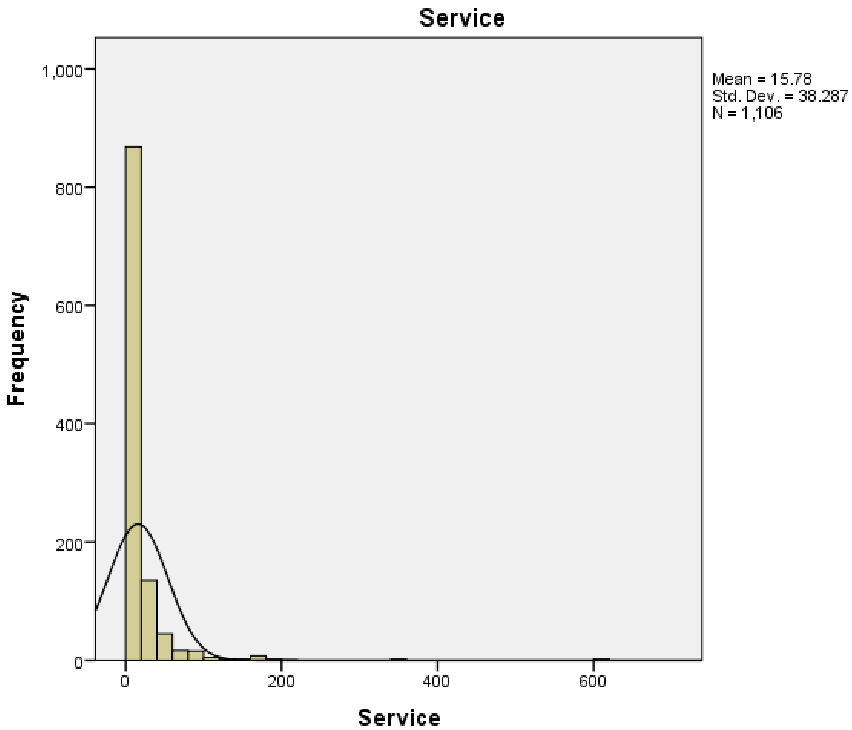


Figure 44 Built environment factor: personal services land use density

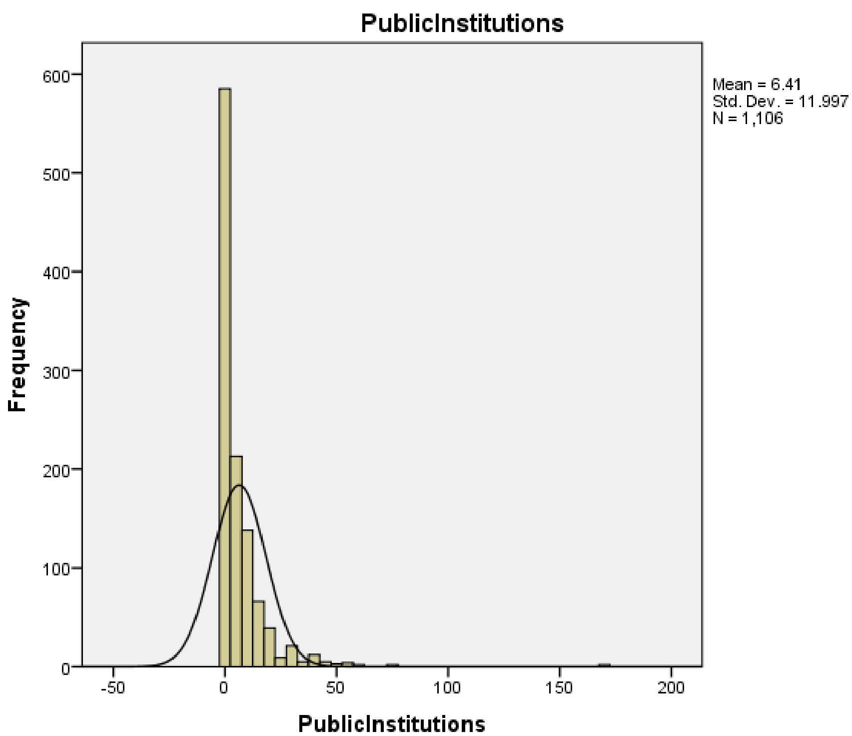


Figure 45 Built environment factor: public institutions services land use density

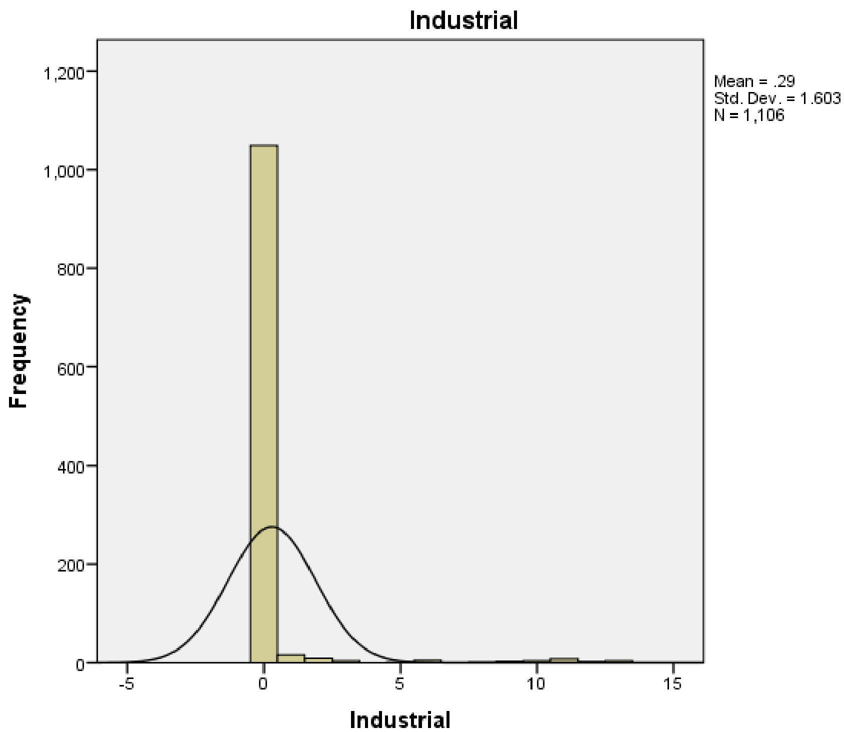


Figure 46 Built environment factor: industrial land use density

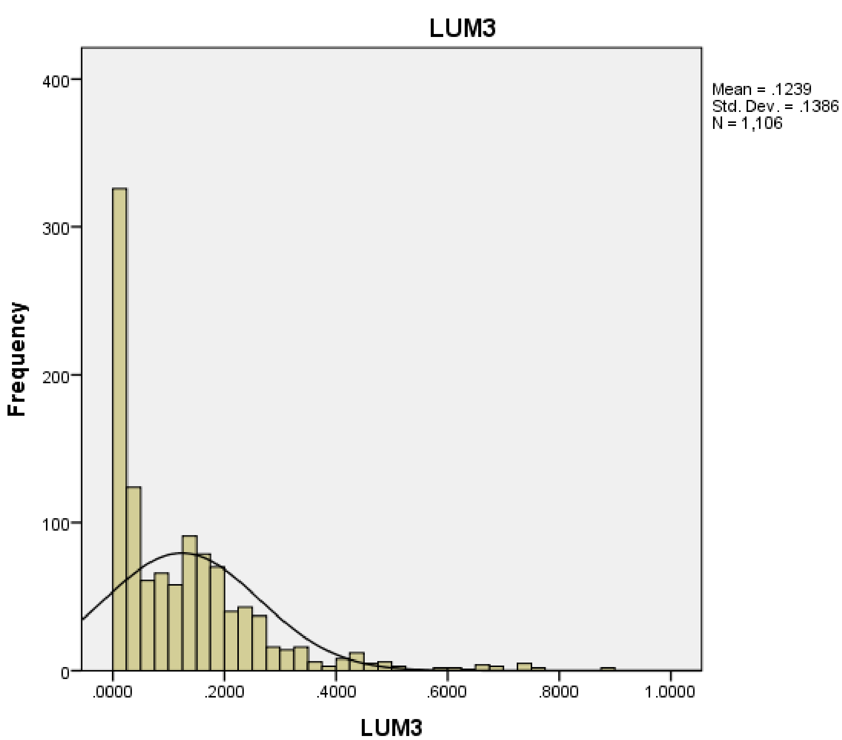


Figure 47 Built environment factor: land use mix index with 3 categories (LUM3)

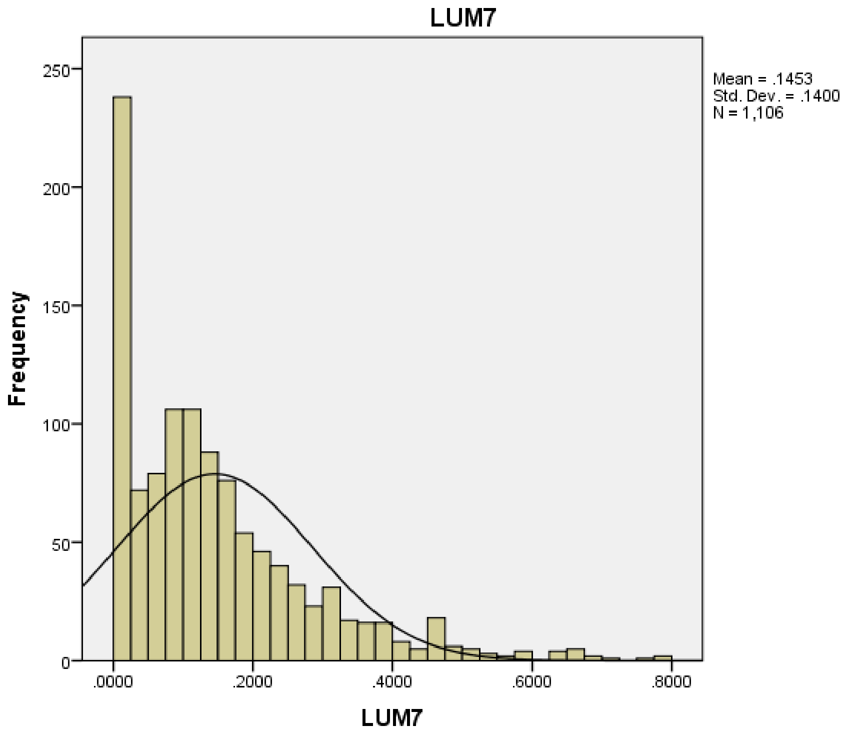


Figure 48 Built environment factor: land use mix index with 7 categories (LUM7)

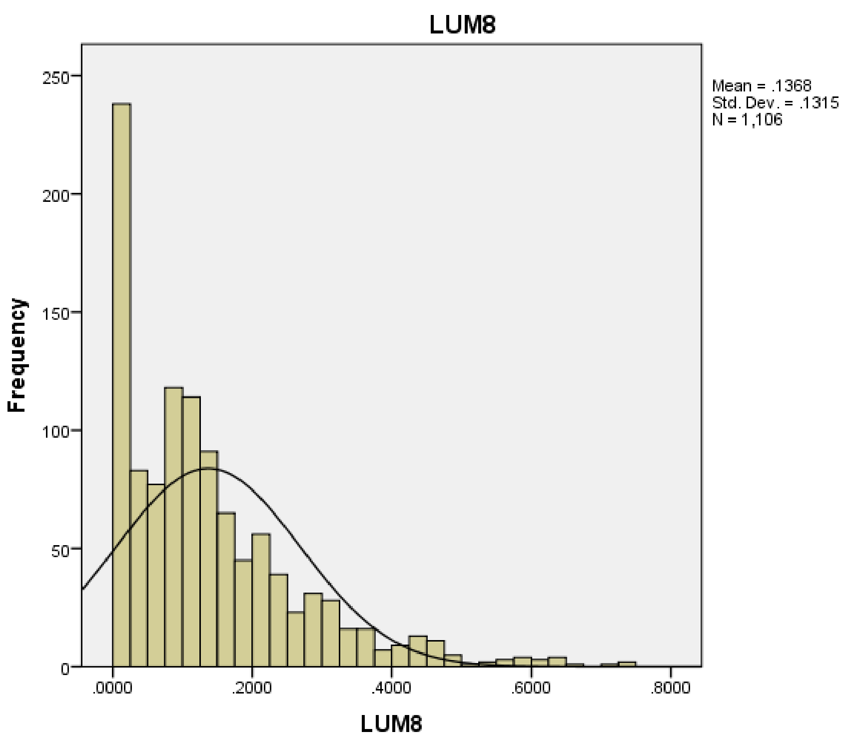


Figure 49 Built environment factor: land use mix index with 8 categories (LUM8)

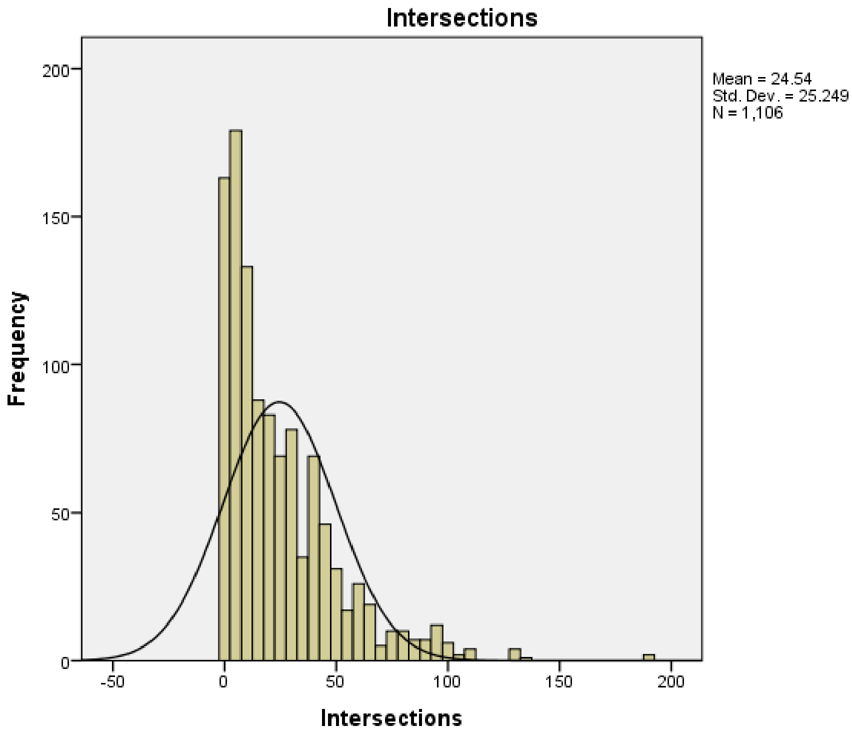


Figure 50 Built environment factor: 4-way intersection density

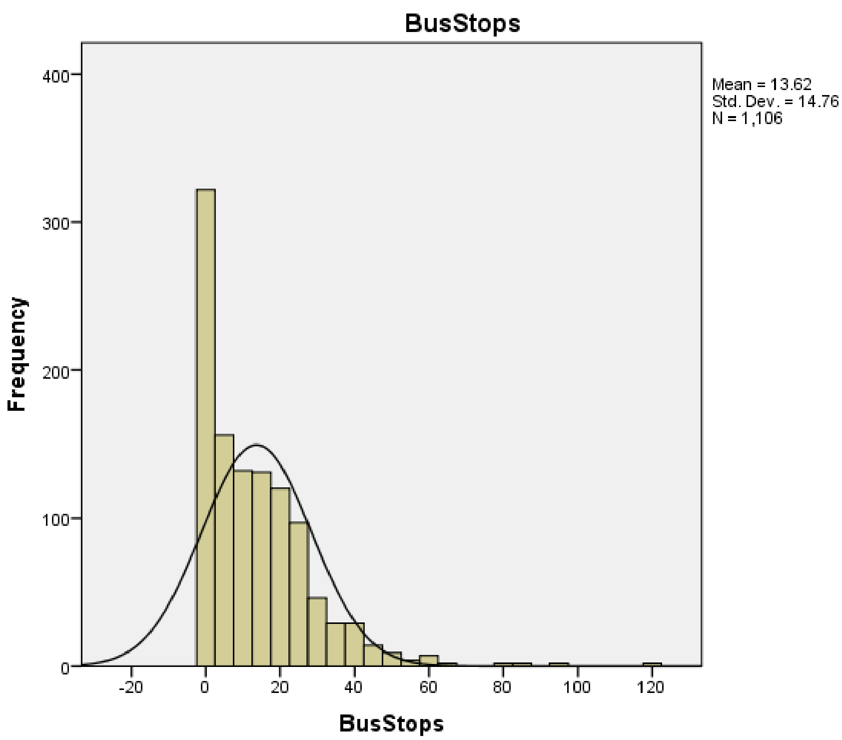


Figure 51 Built environment factor: bus stop density

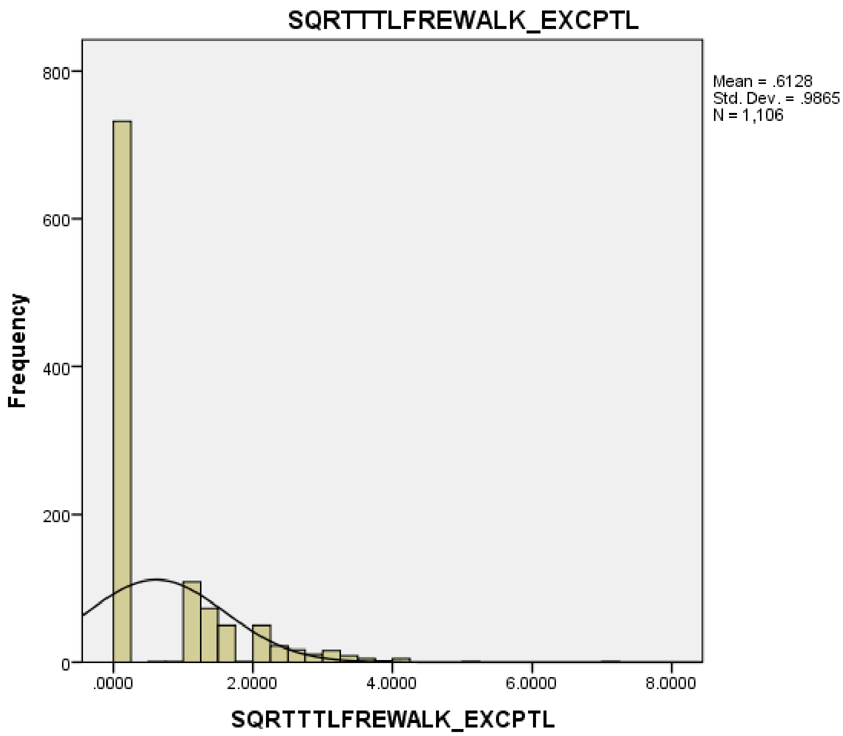


Figure 52 Individual travel behavior variables: total pedestrian trip frequency for all activities

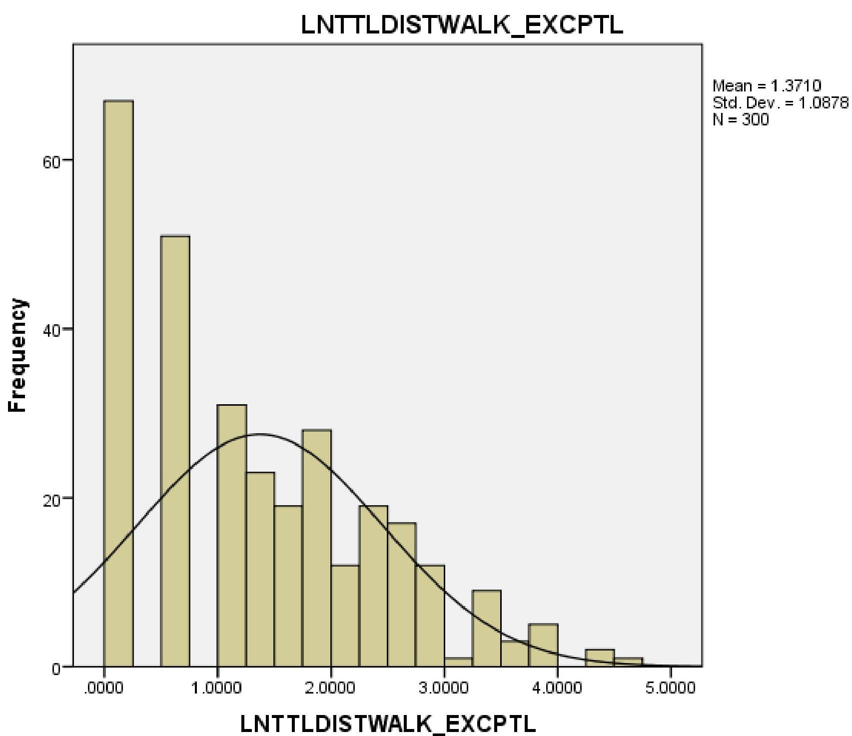


Figure 53 Individual travel behavior variables: total pedestrian trip distance for all activities

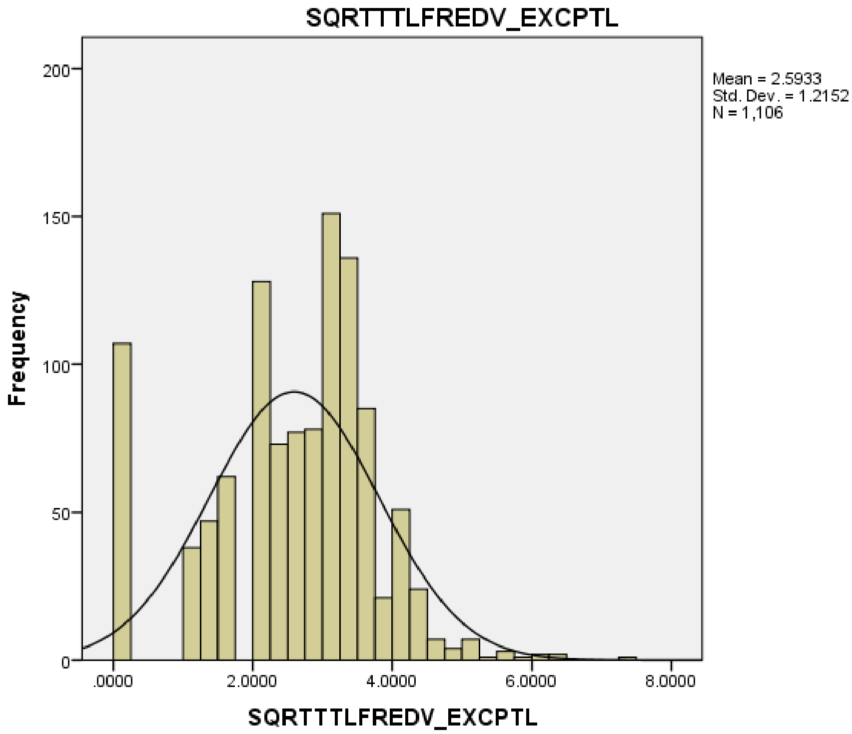


Figure 54 Individual travel behavior variables: total driving trip frequency for all activities

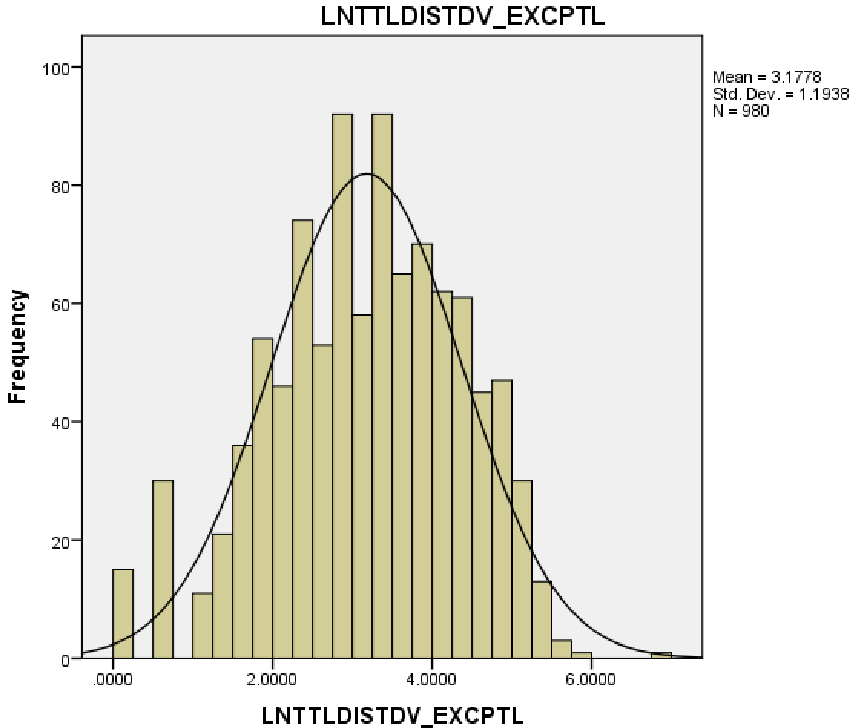


Figure 55 Individual travel behavior variables: total driving trip distance for all activities

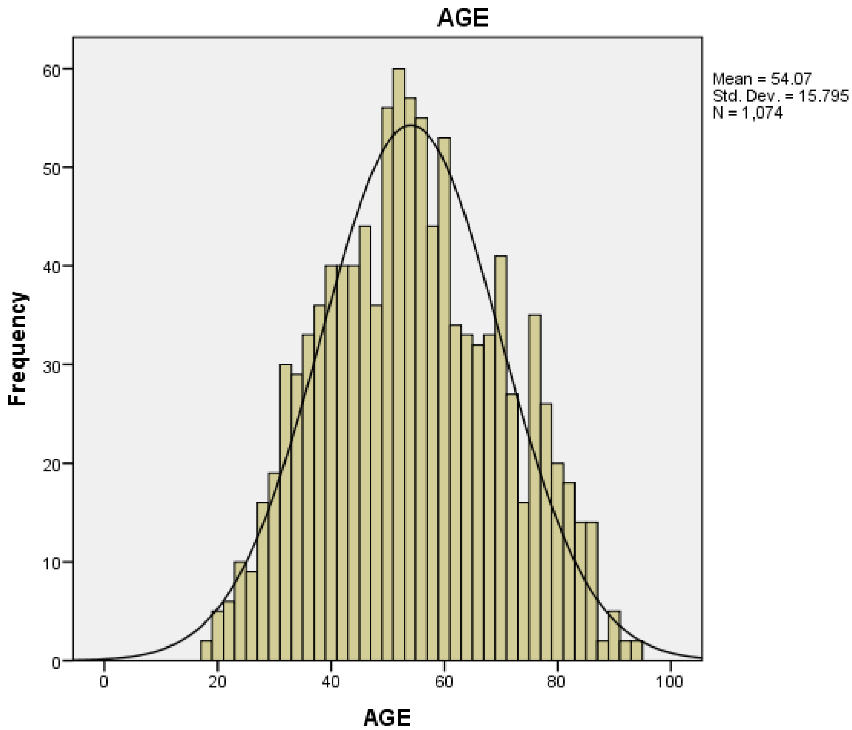


Figure 56 Socio-economic and demographic factors: age

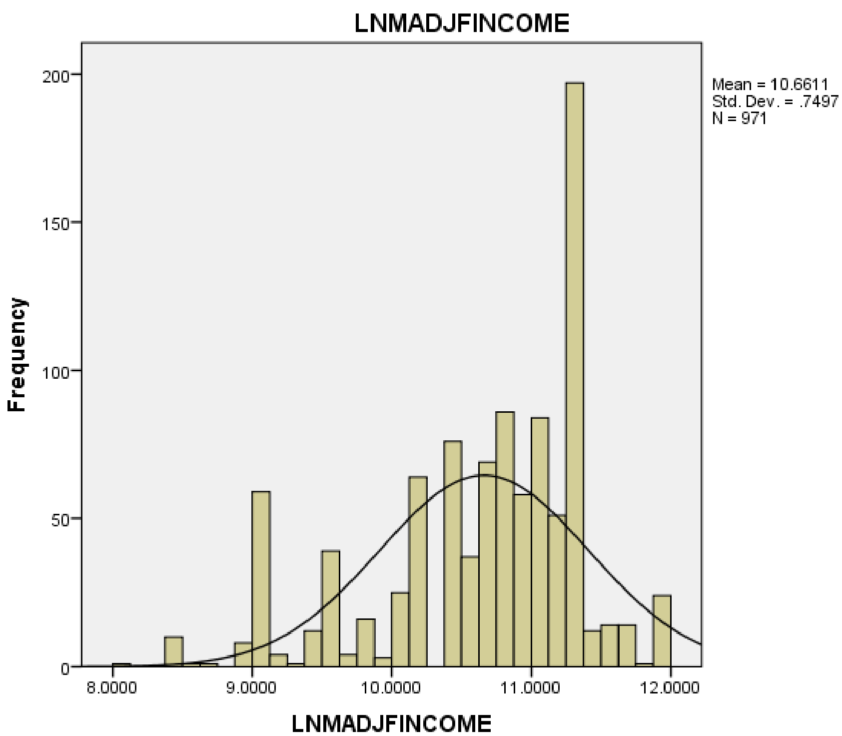


Figure 57 Socio-economic and demographic factors: income

REFERENCES

REFERENCES

Administration on Aging. 1998. *Mobility and independence: Changes and challenges for older drivers.* Washington, DC: Author.

Alsnih, R. and D.A. Hensher. 2003. "The mobility and accessibility expectations of seniors in an aging population." *Transportation Research A* 37 (10):903–916.

Barla, P., L. F. Miranda-Moreno, N. Savard-Duquet, M. Theriault, and M. Lee-Gosselin. 2010. "Diaggregated Empirical Analysis of Determinant of Urban Travel Greenhouse Gas Emissions." *Transportation Research Record* (2156):160-169.

Biles, J.J., and B.W. Pigozzi, 2000. "The Interaction of Economic Reforms, Socio-economic Structure and Agriculture in Mexico." *Growth and Change*31 (1):3-22.

Blumenberg, E. 2004. "En-gendering effective planning: spatial mismatch, low income women, and transportation policy." *Journal of the American Planning Association*70 (3):269–281.

Boarnet, M.and R.Crane. 2001a. *Travel by Design: The influence of urban form on travel* New York, NY: Oxford University Press.

Boarnet, M., and R. Crane. 2001b. "The influence of land use on travel behavior: specification and estimation strategies." *Transportation Research Part a-Policy and Practice* 35 (9):823-845.

Boarnet, M. G., and S. Sarmiento. 1998. "Can land-use policy really affect travel behaviour? A study of the link between non-work travel and land-use characteristics." *Urban Studies* 35 (7):1155-1169.

Burns, R., and R. Burns. 2008. *Business Research Methods and Statistics using SPSS*S. Sage publication LTD., London: UK.

Cao, X., P.L. Makhtarian and S. L. Handy. 2007. "Do changes in neighborhood characteristics lead to changes in travel behavior? A structural equations modeling approach." *Transportation* 34:535-556.

Cao, X., P.L. Makhtarian and S. L. Handy. 2008. "Neighborhood design and aging: an empirical analysis in Northern California." In Transportation Research Board 87th Annual Meeting, Washington, DC.

Carter, M. 2005. "Gender differences in experience with and fear of crime in relation to public transport." In *Research on women's issues in transportation* Vol. 2, Conference proceedings 35, 100. Washington, DC: Transportation Research Board.

Centers for Disease Control and Prevention. 1996. *Physical Activity and Health: A Report of the Surgeon General.* U.S. Department of Health and Human Services, Atlanta, GA.

Centers for Disease Control and Prevention. 2008. *Behavioral Risk Factor Surveillance System: 2007 Codebook Report.* U.S. Department of Health and Human Services, Atlanta, GA.

Centers for Disease Control and Prevention. 2009. NCHS Health E-Stat, Prevalence of overweight, obesity and extreme obesity among adults: United States, trends 1960-62 through 2005-2006. http://www.cdc.gov/nchs/data/hestat/overweight/overweight_adult.htm. Last accessed August 2nd, 2010.

Centers for Disease Control and Prevention. Date last reviewed: January 8, 2010. U.S. Physical Activity Statistics. http://www.cdc.gov/nccdphp/dnpa/physical/stats/index.htm. Last accessed August 1st, 2010.

Centers for Disease Control and Prevention. Overweight and Obesity. http://www.cdc.gov/nccphp/dnpa/obesity. Last accessed July 1st, 2010.

Cervero, R. 1996. "Mixed land uses and commuting: evidence from the American housing survey." *Transportation Research* 30A (5):361–377.

Cervero, R. 2002. "Built Environment and Mode Choice: Toward a Normative Framework." *Transportation Research Part D* 7:265-284.

Cervero, R., and R. Gorham. 1995. "Commuting in transit versus automobile neighborhoods." *Journal of the American Planning Association* 61 (2):210-225.

Cervero, R., and K. Kockelman. 1997. "Travel Demand and the 3Ds: Density, Diversity and Design." *Transportation Research D* (3):199-219.

Collia,D., J. Sharp and L. Giesbrecht. 2003. "The 2001 National Household Travel Survey: a look into the travel patterns of older Americans." *Journal of Safety Research* 34:461–470.

King, L. J. 1970. "Discrimnant analysis – review of recent theoretical contributions and applications." *Economic Geography* 46 (2):367-378. doi: 10.2307/143150.

Crane, R. 1996. "Cars and drivers in the new suburbs: Linking access to travel in neotraditional planning." *Journal of the American Planning Association* 62:51-65.

Crane, R. 2000. "The influence of urban form on travel: An interpretative review." *Journal of Planning Literature* 15 (1):3-23.

Crane, R. and R. Crepeau. 1998. "Does neighborhood design influence travel?: A behavioral analysis of travel diary and GIS data." *Transportation Research Part D: Transport and Environmen* 3 (4):225-238.

Cutts, B. B., K. L. Darby, C. G. Boone, and A. Brewis. 2009. "City structure, obesity, and environmental justice: An integrated analysis of physical and social barriers to walkable streets and park access." *Social Science and Medicine* 69 (9):1314-1322.

Darden, J. T. 1987. “Choosing neighbors and neighborhoods: The role of race in housing preference.” In *Divided Neighborhoods: Changing Patterns of Racial Segregation*, ed. G. A. Tobin, p. 15-42. Beverly Hills, CA: Sage Publications.

Darden, J. T. 1989. “Blacks and other racial minorities: The significance of color in inequality.” *Urban Geography* 10:562-77.

Darden, J. T., R. Hill, J. Thomas and R. Thomas. 1987. *Detroit: Race and Uneven Development.* Philadelphia: Temple University Press.

Darden, J. T., and S. Kamel. 2000. “Black residential segregation in suburban Detroit: Empirical testing of the ecological theory.” *The Review of Black Political Economy* 27:103-23.

Darden, J. T., and S. Kamel. 2000. “Black residential segregation in the city and suburbs of Detroit: Does socioeconomic status matter?” *Journal of Urban Affairs* 22:1-13.

Darden, J. T., R. W. Thomas and C. Stokes. 2007. *The State of Black Michigan: 1967-2007.* Michigan State Press: East Lansing, MI.

Darden, J., R.J. Schaetzl, and D. Brandt. D. (eds). 2009. *Michigan Geography and Geology*. Pearson Custom Publishers, Boston, MA.

Darden, J. T., and R. W. Thomas. 2013. *Detroit: race riots, racial conflicts, and efforts to bridge the racial divide.* East Lansing: Michigan State University Press.

Dill, J., and K. Voros. 2007. "Factors affecting bicycling demand - Initial survey findings from the Portland, Oregon, Region." *Transportation Research Record* (2031):9-17. doi: 10.3141/2031-02.

Domencich, T. and D. L. McFadden. 1996. *Urban Travel Demand: A Behavioral Analysis.* North-Holland Publishing Co.

Edwards, P. and A.Tsouros. 2006. *The Solid Facts: Promoting physical activity and active living in urban environments.* WHO Europe: Copenhagen, Denmark.

Elliott, J.R. and M.S. Joyce. 2004. “The effects of Race and Family Structure on Women’s Spatial Relationship to the Labor Market.” *Sociological Inquiry* 74(3):411-435.

Ewing, R. 1997a. *Transportation and Land Use Innovations.* Chicago: American Planners Association.

Ewing, R. 1997b. “Is Los Angeles style sprawl desirable?” *Journal of the American Planning Association* 63: 107–126.

Ewing, R. 1998. “Pedestrian and Transit-Friendly Design.” In *Third National Conference on Access Management.* Fort Lauderdale, FL: U.S. Department of Transportation Federal Highway Administration.

Ewing, R. 2000. “Pedestrian- and Transit-Friendly Design: A Primer for Smart Growth.” EPA *Smart Growth Network. P.*1-22.

Ewing R. and R. Cervero. 2001. “Travel and the Built Environment: A synthesis.” *Transportation research Record: Journal of the Transportation Research Board* 1870:87-113.

Ewing, R., and R. Cervero. 2010. “Travel and the Built Environment.” *Journal of the American Planning Association* 76 (3):265-294.

Farley, S. Danziger and H.J. Holzer, 2000. *Detroit Divided.* Russell Sage Foundation, New York.

Hu, P. S., and T. R. Reuscher. 2004. *Summary of Travel Trends: 2001 National Household Travel Survey.* Washington, DC: Federal HighwayAdministration, U.S. Department ofTransportation.

Flegal, K.M., Carroll, M.D., Ogden, C.L., Curtin, L.R. 2010. “Prevalence and Trends in Obesity Among US Adults, 1999-2008.” *Journal of the American Medical Association* 303(3): 235-241.

Forsyth A., and Southworth, M. 2008. “Cities afoot—pedestrians, walkability, and urban design.” *Journal of Urban Design* 13(1):1–3.

Frank, L. 2000. “Land Use and Transportation Interaction: Implications on Public Health and Quality of Life.” *Journal of Planning, Education, and Research* 20 (1): 6-22.

Frank, L. D. 2004. “Public Health and the Built Environment, Emerging Evidence and Complexity.” Insert to *Canadian Journal of Dietetic Practice and Research* 65 (2).

Frank, L. D. and G. Pivo, G.1995. “Impacts of Mixed Use and Density on Utilization of Three Modes of Travel: SOV, Transit and Walking.” *Transportation Research Record* 1466:44-55.

Frank, L. D., B. Stone, and W. Bachman. 2000. “Linking land use with household vehicle emissions in the central Puget Sound: methodological framework and findings.” *Transportation Research Part D: Transport and Environment* 5(3):173–196.

Frank, L. D., and P. Engelke. 2001. “The built environment and human activity patterns: exploring the impacts of urban form on public health.” *Journal of Planning Literature* 16 (2):202–218.

Frank, L. D., M. Andresen, and T. Schmid. 2004. “Obesity Relationships with Community Design, Physical Activity, and Time Spent in Cars.” *American Journal of Preventive Medicine* 27 (2):87-96.

Frank, L. D., and P. Engelke. 2005. “Multiple impacts of the built environment on public health: walkable places and the exposure to air pollution.” *International Regional Science Review* 28 (2):193–216.

Frank, L.D., T. L. Schmid, J. F. Sallis, J. Chapman, and B. E. Saelens. 2005. “Linking objectively measured physical activity with objec-tively measured urban form.” *American Journal of Preventive* Medicine 28(2):117–125.

Frank, L.D., J. F. Sallis, T. L. Conway, J.E. Chapman, B.E. Saelens and W. Bachman. 2006. “Many Pathways from Land Use to Health: Associations between Neighborhood Walkability and Active Transportation, Body Mass Index, and Air Quality.” *Journal of the American Planning Association* 72 (1):75-87.

Frank, L. D., B. E. Saelens, K. E. Powell, and J. E. Chapman. 2007. “Stepping towards causation: do built environments or neighborhood and travel preferences explain physical activity, driving, and obesity?” *Social Science and Medicine* 65(9):1898–1914.

Frank, L. D., J. F. Sallis, B.E. Saelens, L. Leary, K. Cain, T. Conway, and P. Hess. 2009. “The development of a walkability index: application to the Neighborhood Quality of Life Study.” *British Journal of Sports Medicine* doi:10.1136/bjsm.2009.058701

Freedman, O., and C.R.Kern. 1997. “A Model of Workplace and Residence Choice in Two-worker Households.” *Regional Science and Urban Economics* 27:241-260.

Friedman, B., S.P. Gordon., and J. B. Peers. 1994. “Effect of neotraditional neighborhood design on travel characteristics.” *Transportation Research Record* (1466):63-70.

Frumkin, H., L. D. Frank, and R. Jackson. 2004. *Urban sprawl and public health: designing, planning, and building for healthy communities.* Washington, DC: Island Press.

Frye, A. 2005. ‘Keynote Address.’ Conference Proceedings 35: *Research on Women’s Issues in Transportation: Volume 1*. 2004 Nov. in Chicago, IL. Washington DC.: Transportation Research Board.

Gallagher, J. 2010. *Reimagining Detroit: opportunities for redefining an American city*. Detroit, Michigan: Wayne State University Press.

Gallagher, J. 2013. *Revolution Detroit: strategies for urban reinvention.* Detroit, Michigan: Wayne State University Press.

Gibson, K. J., W. A. Darity, and S. L. Myers. 1998. "Revisiting occupational crowding in the United States: A preliminary study." *Feminist Economics* 4 (3):73-95.

Giles-Corti, B., G. Wood, T. Pikora, V. Learnihan, M. Bulsara, K. Van Niel, A. Timperio, G. McCormack, and K. Villanueva. 2011. “School site and the potential to walk to school: The impact of street connectivity and traffic exposure in school neighborhoods.” *Health & Place* 17 (2):545-550.

Giuliano, G., and D. Narayan. 2003. “Another look at travel patterns and urban form: The US and Great Britain.” *Urban Studies* 40 (11):2295-2312.

Giuliano, G., and J. Dargay. 2005. “Car ownership, travel and land use: A comparison of the US and Great Britain.” *Transportation Research Part A* 40:106-24.

Golob, T. F., and M. G. McNally. 1997. “A model of activity participation and travel interactions between household heads." *Transportation Research B* 31:177-194.

Grady, S. C. 2006. “Racial disparities in low birthweight and the contribution of residential segregation: A multilevel analysis.” *Social Science and Medicine* 63:3013-29.

Grady, S.C. and S. McLafferty. 2007. “Segregation, nativity, and health: reproductive health inequalities for immigrant and native-born black women in New York City.” *Urban Geography* (Special Issue: New Directions in Segregation Research) 2S (4):377-397.

Grengs, J. 2010. “Job accessibility and the modal mismatch in Detroit.” *Journal of Transport Geography* 18:42-54.

Hagerstrand, T. 1970, “What about people in regional science?” *Papers of the Regional Science Association* 24: 7-21.

Hamilton, K., and L. Jenkins. 1990. “Why Women and Travel” in *Gender, Transport, and Employment: the Impact of Travel Constraints* edited by Grieco, M., L.Pickup, and R.Whipp, Oxford Transport Studies, Gower Publishing Company Limited. Hants, England, p.17-45.

Handy, S. 1993. “Regional versus local accessibility: neo-traditional development and its implications for non-work travel.” *Built Environment*. 18 (4):256–267.

Handy, S. 1996. “Methodologies for Exploring the Link between Urban Form and Travel Behavior.” *Transportation Research D* 1 (2):155-165.

Handy, S. 2005a. “Smart Growth and the Transportation-Land use Connection.” *International Regional Science Review* 28(2):146-167.

Handy, S. 2005b. “Critical Assessment of the Literature on the Relationships Among Transportation, Land Use, and Physical Activity.” Resource paper for *Special Report 282: Does the Built Environment Influence Physical Activity? Examining the Evidence.* TRB; Committee on Physical Activity, Health, Transportation, and Land Use, Institute of Medicine, National Academies, Washington, D.C.http://trb.org/downloads/sr282papers/sr282Handy.pdf.

Handy, S. 2006a. “Questioning Assumptions 1: Do New Urbanists Walk More?” *Planning* 72 (1):36-38.

Handy, S. 2006b. “The Road Less Driven.” *Journal of the American Planning Association* 72 (3):274- 278.

Handy, S. M. G. Boarnet, R. Ewing, and R. E. Killingsworth. 2002. “How the built environment affects physical activity: views from urban planning.” *American Journal of Preventive Medicine* 23 (2S):64–73.

Handy, S., X. Cao, and P. Mokhtarian. 2005. "Correlation or Causality Between the Built Environment and Travel Behavior? Evidence from Northern California." *Transportation Research* 10:427–444.

Handy, S., X. Cao, and P. L. Mokhtarian. 2006. "Self-Selection in the Relationship between the Built Environment and Walking." *Journal of the American Planning Association* 72 (1):55-74.

Hansen, W. G., 1959. "How accessibility shapes land use." *Journal of the American Institute of Planners* 12 (2):73–76.

Hanson, S. 1982. "The determinants of daily travel-activity patterns: Relative location and socio-demographic factors." *Urban Geography* 3:179–202.

Hanson. S. 1986. *The Geography of urban Transportation*. New York, NY, USA: Guilford.

Hanson, S.(ed.), 1995. *The Geography of Urban Transportation* 2nd Edition. New York: Guilford Press.

Hanson, S. 2010. "Gender and mobility: new approaches for informing sustainability." *Gender, Place and Culture* 17 (1):5–23.

Hanson, S. and P. Hanson. 1980a. "Gender and Urban Activity Patterns in Uppsala, Sweden." *Geographical Review* 70 (3):291-299.

Hanson, S. and P. Hanson. 1980b. "The Impact of Women's Employment on Household Travel Patterns: A Swedish Example." In *Women's Travel Issues: Research Needs and Priorities: Conference Proceedings and Papers* (S Rosenbloom, ed.), U.S. Department of Transportation, U.S. Government Printing Office, Washington, D.C., 1980

Hanson, S. and P. Hanson. 1981. "The Impact of Married Women's Employment on Household Travel Patterns." *Transportation* 10:165 183.

Hanson, S. and I. Johnston. 1985. "Gender Differences in Work-trip Lengths: Explanations and Implications." *Urban Geography* 6 (3):193-219.

Hanson, S. and G. Pratt. 1991. "Job Search and the Occupational Segregation of Women." *Annals of the Association of American Geographers* 81:229-253.

Hanson, S. and G. Giuliano. 2004. *The Geography of Urban Transportation* 3rd Edition. New York: The Guilford Press.

Harvey, D. 1985. *The Urbanization of Capital*. Basil Blackwell (Oxford) and Johns Hopkins University Press.

Holtzclaw, J. 1994. *Residential Patterns and Transit, Auto Dependence, and Costs*. Resources Defense Council, San Francisco.

Hu, P.S., J. Young. 1999. *Summary of Travel Trends: 1995 Nationwide Personal Transportation Survey.* Federal Highway Administration, U.S. Department of Transportation. Washington, D.C.

Ingalls, G., D. Hartgen, and T. Owens. 1994. "Public fear of crime and its role in bus transit use." *Transportation Research Record* 1433:201-11.

Jargowsky, P.A. 1997. *Poverty and place: ghettos, barrios, and the American city*. Russell Sage Foundation, New York.

Johnston-Anumonwo, I. 1989. "Journey to Work: A Comparison of Characteristics of Single and Married Parents." *Journal of Specialized Transportation Planning and Practice* 3 (3):219-246.

Johnston-Anumonwo, I. 1992. "The influence of household type on gender differences in work trip distance."*Professional Geographer* 44: 161-169.

Johnston-Anumonwo, I. 1997. "Race, Gender, and Constrained Work Trips in Buffalo, NY, 1990." *The Professional Geographer* 49:306–317.

Jones, P. 1990. "Household organization and travel behavior"In *Gender, Transport, and Employment: the Impact of Travel Constraints* edited by Grieco, M., L.Pickup, and R.Whipp, Oxford Transport Studies, Gower Publishing Company Limited. Hants, England, p. 17-45.

Kain, J. F. 1968. "Housing segregation, negro employment, and metropolitan decentralization." *Quarterly Journal of Economics* 82 (2):175-197.

Kain, J. and R. Fauth. 1977. "The Effect of Urban Structure on Auto Ownership and Journey to Work Modes." *Transportation Research Record* 658:9-17.

Kawabata, M and Q. Shen, 2007. "Commuting inequality between cars and public transit: the case of the San Francisco Bay Area, 1990–2000." *Urban Studies* 44 (9):1759–1780.

King, L.J. 1970. "Discriminant Analysis: A Review of Recent Theoretical Contributions andApplications." Supplement: Proceedings. International Geographical Union, *Economic Geography* 46:367-378.

Kitamura, R., P. Mokhtarian, and L. Laidet. 1994. *A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay area*. University of California at Davis report prepared for the California Air Resources Board.

Kockelman, K. M., 1999. "Application of a Utility-Theory-Consistent System-of-Demand-Equations Approach to Household Travel Choice." *Transportation Research Record* 1676:20-29.

Koskela, H., and R. Pain. 2000. "Revisiting fear and place:Women's fear of attack and the built environment." *Geoforum* 31:269-80.

Krizek, K. J. 2003. "Residential relocation and changes in urban travel - Does neighborhood-scale urban form matter?" *Journal of the American Planning Association* 69 (3):265-281.

Kwan, M. P. 1999a. “Gender and Individual Access to Urban Opportunities: A Study Using Space-Time Measures.” *The Professional Geographer* 51 (2):210-227.

Kwan, M. P. 1999b. “Gender, the Home-work Link, and Space-time Patterns of Non-employment Activities.” *Economic Geography* 75 (4):370-394.

Kwan, M. P. 2000. *Evaluating Gender Differences in Individual Accessibility: A Study Using Trip Data Collected by the Global Positioning System*. Final Report to the Federal Highway Administration.

Lawrence Frank & Company (LFC) Inc, Mark Bradley and Keith Lawton Associates. 2005. *Travel Behavior, Emissions, & Land Use Correlation Analysis in the Central Puget Sound*. Prepared for the Washington State Department of Transportation, Olympia WA. Report no. WA-RD 625.1

LeDoux, T. F., and I. Vojnovic. 2013. “Going outside the neighborhood: The shopping patterns and adaptations of disadvantaged consumers living in the lower eastside neighborhoods of Detroit, Michigan.” *Health & Place* 19:1-14.

Lee, C. and A. V. Moudon. 2004. “Physical Activity and Environment Research in the Health Field: Implication for Urban and Transportation Planning Practice and Research.” *Journal of Planning Literature* 19 (2):147-181.

Leslie E., N. Coffee, L. Frank, N. Owen, A. Bauman and G. Hugo. 2007. “Walkability of local communities: using geographic infor-mation systems to objectively assess relevant environ-mental attributes.” *Health & Place* 13 (1):111–122.

Levinson, D. M., and A. Kumar. 1997. “Density and the journey to work.” *Growth and Change* 28 (2):147-172.

Light, A. 2004. “Gender Differences in the Marriage and Cohabitation Income Premium.” *Demography*41 (2):263-284.

Litman, T. 2003. “Economic Value of Walkability.” *Transportation Research Record* 1828:3-11.

Lopez, R. P. and H. P. Hynes. 2006. "Obesity, physical activity, and the urban environment: public health research needs." *Environmental Health: A Global Access Science Source*. doi:10.1186/1476-069X-5-25.

Loukaitou-Sideris, A. and C. Flink. 2009. “Settings: a survey of U.S. transit agencies addressing women’s fear of victimization in transportation.” *Urban Affairs Review* 44 (4):554–588.

MacDonald, H. I. 1999. “Women’s Employment and Commuting: Explaining the Links.” *Journal of Urban Planning Literature* 13 (3):267-283.

Manheim, M. L. 1979. *Fundamentals of Transportation Systems Analysis.* The Massachusetts Institute of Technology Press, Cambridge, Massachusetts and London, England.

Marshall, J.D., M. Brauer, and L.D. Frank. 2009. “Healthy Neighborhoods: Walkability and Air Pollution.” *Environmental Health Perspectives* 117 (11):1752–1759.

Martelle, S. 2012. *Detroit: a biography.* Chicago, Ill: Chicago Review Press.

Martin, B. V., F. W. Memmott, III and A.J. Bone. 1967. *Principles and techniques of predicting future demand for urban area transportation: MIT report No.3.* The Massachusetts Institute of Technology Press, Cambridge, Massachusettsand London, England.

Martin, W.A. and N.A. McGuckin. 1998. *Travel Estimation Techniques for Urban Planning, NCHRT Report 365.* Transportation Research Board, Washington D.C.

Massey, D.S. and N. A. Denton. 1993. *American apartheid: Segregation and the making of the underclass.* Harvard University Press, Cambridge, Mass.

McConnell, J.E., 1979. “The Export Decision: An Empirical Study of Firm Behavior.” *Economic Geography* 55 (3):171-183.

McFadden, D.L. 1974. "The Measurement of Urban Travel Demand." *Journal of Public Economics* 3 (4):303-328.

McFadden, D. and F. Reid. 1975. “Aggregate Travel Demand Forecasting from Disaggregated Behavioral Models." *Transportation Research Record: Travel Behavior and Values* 534:24-37.

McFadden, D.L. 2001. “Disaggregate Behavioral Travel Demand's RUM Side: A 30-Year Retrospective.” *The Leading Edge of Travel Behavior Research* by David Heshner (ed.) Pergamon Press: Oxford.

McLafferty, S. and V., Preston. 1992. “Spatial mismatch and labor market segmentation for African-American and Latina women.” *Economic Geography* 68:406-431.

McLafferty, S. and V., Preston. 1996a. “Gender, race and the determinants of commuting: New York in 1990.” *Urban Geography* 18 (3):192-212.

McLafferty, S. and V., Preston. 1996b. “Transportation and minority women's employment: insights from New York.” Paper presented at the Second National Conference on Women's Travel Issues, Baltimore, MD, 1996 October.

McLafferty, S. and V., Preston. 1996c. “Spatial mismatch and employment in a decade of restructuring.” *The Professional Geographer* 48:420-431.

McNally, M.G., 2000. “The Four Step Model.” In: *Handbook of Transport Modelling,* ed. Hensher, D.A., and K.J.Button, p. 35-69.

Messenger, T. and Ewing, R. 1996. “Transit-orienteddevelopment in the Sun Belt.” *Transportation Research Record* 1552:145-153.

Meyer, J.R. and J.A. Gómez-Ibañez, 1981. *Autos, Transit and Cities.* Harvard University Press, Cambridge, MA.

Meyer, M.D. and E. J. Miller. 1984. *Urban Transportation Planning: a decision oriented approach.* McGraw-Hill Book Company.

Mingione, E. (ed.). 1996. *Urban Poverty and the Underclass.* Oxford: Basil Blackwell.

Moudon, A. V., C. Lee, A. D. Cheadle, C. Garvin, D. Johnson, and T. L. Schmid. 2006. "Operational definitions of walkable neighborhood: theoretical and empirical insights." *Journal of physical activity & health* 3 (1):S99–S117.

Naess, P. 2006. "Accessibility, activity participation and location of activities: exploring the links between residential location and travel behaviour." *Urban Studies* 43:627–652.

Newman, P.W. G. and Kenworthy, J. R. 1989. "Gasoline consumption and cities: a comparison of U.S. cities with a global survey." *Journal of the American Planning Association* 55 (1):24–37.

Nobis, C. and L. Barbara. 2005. "Gender Differences in Travel Patterns: Role of employment status and household structure." In *Conference Proceedings 35: Research on Women's Issues in Transportation: Volume 2.* 2004 Nov. in Chicago, IL. Washington DC.: Transportation Research Board.

O'Sullivan, S. and J. Morrall. 1996. "Walking Distance to and from Light-Rail Transit Stations." *Transportation Research Record* 1538:19-22.

Owen, N., N, Humpel, E. Leslie, A. Bauman, and J. F. Sallis. 2004. "Understanding environmental influences on walking: review and research agenda." *American Journal of Preventive Medicine* 27 (1):67–76.

Paaswell, R.E., W.W. Recker and V. Milione. 1976. "Profile of a carless population." *Transportation Research Record* 578:16-28.

Parks, V. 2004. "Access to Work: the Effect of Spatial and Social Accessibility on Unemployment for Native-Born Black and Immigrant Women in Los Angeles." *Economic Geography* 80 (2):141-172.

Pickup, L. 1985, "Women's gender role and its influence on travel behavior." *Built Environment* 10 (1):61-69.

Pickup, L., 1990, "Women's travel requirements: employment, with domestic constraints." In *Gender, Transport, and Employment: the Impact of Travel Constraints* edited by Grieco, M., L.Pickup, and R.Whipp, Oxford Transport Studies, Gower Publishing Company Limited. Hants, England, p. 17-45.

Preston, V. and S. McLafferty. 1992. "Income disparities and employment and occupational changes in New York." *Regional Studies* 27:223-235.

Preston, V. and S. McLafferty. 1993. “Gender differences in commuting at suburban and central locations.” *Canadian Journal of Regional Science* 16:237-259.

Preston, V. and S. McLafferty. 1999. “Spatial mismatch research in the 1990s: progress and potential.” *Papers in Regional Science* 78:387-402.

Pucher, J. and J. L. Renne, 2003. “Socioeconomics of urban travel: evidence from the 2001 NHTS.” *Transportation Quarterly* 57(3):49-77.

Rosenbloom, S. 1989. “The Transportation Needs of Single Salaried Mothers; A Critical Analysis.” *Journal of Specialized Transportation Planning and Practice* 3 (3):295-310.

Rosenbloom, S. 2005. “Understanding Women’s and Men’s Travel Patterns: The research challenge.”In *Conference Proceedings 35: Research on Women’s Issues in Transportation: Volume 1*2004 Nov. in Chicago, IL. Washington DC.: Transportation Research Board.

Rosenbloom, S. and C. Raux. 1985. “Employment, Childcare and Travel Behavior: France, The Netherlands, and the United States.” In *Behavioral Research for Transport Policy,* VNU Science Press, Utrecht, The Netherlands. p. 365-381.

Rutherford, B. and G. R. Wekerle. 1989. “Single Parents in the Suburbs: Journey-to-work and Access to Transportation.” *Journal of Specialized Transportation Planning and Practice* III (3):277-294.

Rutherford, B.and G. R. Wekerle .1988. “Captive Rider, Captive labor: Spatial Constraints and Women’s Employment.” *Urban Geography* 9 (2):116-137.

Saelens, B. E., J. F. Sallis, and L.D. Frank. 2003a. “Environmental Correlates of Walking and Cycling: Findings from the Transportation, Urban Design, and Planning literatures.” *Annals of Behavioral Medicine* 25 (2): 80-91.

Saelens, B.E., J. F. Sallis, J. B. Black, and D. Chen. 2003b. “Neighborhood-based differences in physical activity: An environment scale evaluation.” *American Journal of Public Health* 93:1552-1558.

Sallis, J. F., L. D. Frank, B. E. Saelens, and M. K. Kraft. 2004. “Active transportation and physical activity: Opportunities for collaboration on transportation and public health research.” *Transportation Research Part A: Policy and Practice* 38:249-268.

Sanchez, T.W., W. Shen, and Z.R. Peng. 2004. “Transit mobility, jobs access and low-income labour participation in US metropolitan areas.” *Urban Studies* 41 (7):1313–1331.

Santos, A., N. McGucking, H.Y. Nakamoto, D. Gray, and S. Liss. 2011. *Summary of Travel Trends: 2009 National Household Travel Survey.* Federal Highway Administration, U.S. Department of Transportation. Washington, D.C.

Sassen, S. 2001. original in 1991. *The global city: New York, London, Tokyo.* 2nd Ed. Princeton: Princeton University Press.

Schintler, L., A. Root, K. Button, and T. R. B. 2000. "Women's travel patterns and the environment - An agenda for research." In *Public and Nonmotorized Transportation in Other Nations; Women's Issues in Transportation: Safety and Human Performance* 1726: 33-40.

Schulz, D., and S. Gilbert. 1996. "Women and transit security: A new look at old issues." In *Women's Travel Issues Second National Conference*. Washington, DC: Federal Highway Administration.

Schwanen, T., M. Dijst, and F.M. Dieleman. 2002. "A microlevel analysis of residential context and travel time." *Environment and Planning A* 34(8):1487–1507.

Schwanen, T., M.P. Kwan and F. Ren, 2008. "How fixed is fixed? Gendered rigidity of space-time constraints and geographies of everyday activities." *Geoforum* 39 (6):2109–2121.

[SEMCOG] Southeast Michigan Council of Governments. 2003. *Land use change in southeast Michigan: Causes and consequences*.

Silk, J. 1979. *Analysis of covariance and comparison of regression lines* (Concepts and techniques in modern geography; no. 20). Geo Abstracts, University of East Anglia.Downloaded from http://www.qmrg.org.uk/files/2008/11/20-analysis-of-covariance.pdf.

Sommer, B. B. and R. Sommer. 1997. *A Practical Guide to Behavioral Research: Tools and Techniques.* New York: Oxford University Press.

Srinivasan, S., and C. R. Bhat. 2005. "Modeling household interactions in daily in-home and out-of-home maintenance activity participation." *Transportation* 32 (5):523-544. doi: 10.1007/s11116-005-5329-z.

Sugrue, T. J. 1996. *The Origins of the Urban Crisis: Race and Inequality in Postwar Detroit*. Princeton: Princeton University Press.

Surface Transportation Policy Project. 1999. High mileage moms. http://www.transact.org/

Thomas, J. M. 1997. *Redevelopment and Race: Planning a Finer City in Postwar Detroit*. Baltimore: Johns Hopkins University Press.

Littman, T. 2003. "Economic Value of Walkability." *Transportation Research Record* 1828:3-11.

Transportation Research Board (TRB). 2005a. *Research on women's issues in transportation, Vol. 1, Conference overview and plenary papers, Conference Proceedings 35*. Washington, DC: Author.

Transportation Research Board (TRB). 2005b. *Research on women's issues in transportation, Vol. 2, Technical papers, Conference Proceedings 35*. Washington, DC: Author.

Turner, S. C. 1997. "Barriers to a better break: employer discrimination and spatial mismatch in metropolitan Detroit." *Journal of Urban Affairs* 19 (2):123–141.

Turner, T., and D. Niemeier. 1997. “Travel to work and household responsibility: new evidence.” *Transportation* 24:397–419.

US Census Bureau. 2002. Demographic Trends in the 20th Century. http://www.census.gov/prod/2002pubs/censr-4.pdf

U.S. Census Bureau. 2010. *Income, Poverty, and Health Insurance Coverage In the United States: 2009, Current Population Report.* U.S. Government Printing Office, Washington, DC.

Untermann, R. 1984. *Accommodating the Pedestrian: Adapting Towns and Neighborhoods for Walking and Bicycling.* Van Nostrand Reinhold, New York.

Vojnovic, I. 1999. “The environmental costs of modernism: an assessment of Canadian cities.” *Cities: The International Journal of Urban Policy and Planning* 16 (5):301-313.

Vojnovic, I. 2000a. “Municipal restructuring, regional planning, and fiscal accountability: designing municipal tax zones in two Maritime regions.” *Canadian Journal of Regional Science* 23 (1):49-72.

Vojnovic, I. 2000b. “Shaping Metropolitan Toronto: A study of linear infrastructure subsidies.” *Environment and Planning B: Planning and Design* 27:197–230.

Vojnovic, I. 2000c. “The transitional impact of municipal consolidations.” *Journal of Urban Affairs* 22:385–417.

Vojnovic, I. 2003a. “Governance in Houston: Growth theories and urban pressures.” *Journal of Urban Affairs* 25:589–624.

Vojnovic, I. 2003b. “Laissez-faire governance and the archetype laissez-faire city in the USA: Exploring Houston.” *Geografiska Annaler* B (85):19–38.

Vojnovic, I. 2006. “Building Communities to promote physical activity: A Multiscale Analysis.” *Swedish Society for Anthropology and Geography* 88 B (1):67-90.

Vojnovic, I. 2009. “Urban Settlements: Suburbanization and the Future” In Schaetzl, R., Darden, J., and Brandt, D. (eds.) *Geography and Geology of Michigan*. Boston: Pearson Custom Publishers. p.487-507.

Vojnovic, I. C. Jackson-Elmoore, J. Holtrop, and S. Bruch. 2006. “The renewed interest in urban form and public health: Promoting increased physical activity in Michigan.” *Cities* 23 (1):1-17.

Vojnovic, I., Smith S., Kotval, Z., and Lee, J. 2008. “Built Environments: Planning Cities to Encourage Physical Activity” In Dele Davies (Ed.) *Obesity in Childhood and Adolescence: Medical, Biological, and Social Issues* (Vol. 1). Westport: Praeger Press. p. 93-129.

Vojnovic, I., and J. T. Darden. 2013a. “Racial Conflict, Intolerance, and Distortions in Urban Form: Lessons for Sustainability from the Detroit Region.” *Ecological Economics* 96:88-98.

Vojnovic, I., and J. T. Darden. 2013b. The Colors That Shaped a City: The Role of Racial and Class Tensions in Inhibiting Urban Sustainability, the Detroit Context In *Urban Sustainability: A Global Perspective* edited by Vojnovic, I. Michigan State University Press, East Lansing, USA. p. 435-474.

Vojnovic, I., J. Lee, Z. Kotval-K, A. Podagrosi, P. Varnakovida. T. LeDoux, and J. Messina. *2013*. "The Burdens of Place: A Socio-economic and Ethnic/Racial Exploration into Urban Form, Accessibility, and Travel Behavior in the Lansing Capital Region, Michigan." *Journal of Urban Design* 18 (1):1-35.

Vojnovic, I., Z. Kotval-K, J. Lee, M. Ye, T. LeDoux, P. Varnakovida, and J. Messina. *Forthcoming*. "Urban Built Environments, Accessibility, and Travel Behavior in a Declining Urban Core: An Exploration into the Detroit Region." *Journal of Urban Affairs*.

Wekerle, G.R. 1981. "Women in the Urban Environment." In C.R. Stimpson et al. (eds.), *Women and the American City*. Chicago: University of Chicago Press.

Wekerle, G. R. 2005. "Gender and the Global City: Urban Restructuring, Social Exclusion and Claims for Justice" in H. Hiller (ed) *Urban Sociology in Canada.* Toronto: Oxford University Press

Wekerle, G. R., R. Peterson, and D. Morley (eds). 1980. *New Space for Women.* Boulder, CO: Westview Press.

Wekerle, G. R. and B. Rutherford. 2004. "The Mobility of Capital and the Immobility of Female Labor: Responses to Economic Restructuring." in L. Servon and S. Fainstein (eds) *Gender Planning and Policy.* New Brunswick NJ: Rutgers University Press.

White, H.P., and M. L. Senior. 1983. *Transport Geography.* Longman Inc.: New York, USA.

Wilson, W. J. 1987. *The declining significance of race: The truly disadvantaged—the inner city, the underclass, and public policy.* Chicago: University of Chicago Press.

Wilson, W. J. 2009. *More than Just Race: Being Black and Poor in the Inner Cit*y. 1st Edition. W. W. Norton & Company.

Wyly, E. K. 1996. "Race, Gender, and Spatial Segmentation in the Twin Cities." *The Professional Geographer* 48 (4):431-444.

Wyly, E. K. 1998. "Containment and Mismatch: Gender Differences in Commuting in Metropolitan Labor Markets." *Urban Geography* 19 (5):395-430.

Wyly, E. K. 1999. "Occupational Sex Segregation and Local Labor Markets in an American Metropolis." *Journal of Urban Affairs* 21 (1):1-33.