EFFECTS OF ETHNIC NEIGHBORHOOD SOCIOECONOMIC-PHYSICAL CHARACTERISTICS AND INDIVIDUAL ATTRIBUTES ON IMMIGRANTS' TRAVEL MODE CHOICE IN NORTH TEXAS

by

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Abstract

Previous studies of immigrants' travel behavior have been conducted mostly in California and the United States as a whole. Even though immigrant population and the share of immigrants have rapidly increased in Texas, only limited studies have been conducted for travel behavior of Hispanic immigrants. No study has examined the effects of attributes at multiple geographic levels on travel behavior.

This study intends to fill the void. It examines the effects of ethnic neighborhoods' social, economic, and physical characteristics on residents' travel mode choice, with a focus on immigrants in North Texas using the 2017 National Household Travel Survey, the 2017 American Community Survey, and other data from various sources, The results show that consistent with the current literature, immigrants are more likely to use public transit, walk and bicycle modes than non-immigrants. There exist ethnic neighborhoods where specific ethnic groups are concentrated. The results of the multilevel multinomial logit model further indicate that controlling for other individual, household, and neighborhood characteristics, the likelihood of immigrants using public transit, walk and bicycle modes, relative to private vehicles, decreases as the year staying in the U.S. increases. In contrast to the current literature, the effect of ethnic neighborhood is negatively associated with the mode choice of public transit, walk, and bicycle compared to the use of private vehicles. Implications of the findings are discussed.

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Chapter 1

Introduction

Immigrants[1] play a significant role in U.S. population growth. The number of the immigrant population has increased rapidly since 1970 as well as their share of U.S. population (U.S. Census). According to U.S. Census, the immigrant population rose from 9.6 million in 1970 to 42.2 million in 2016. As a share of U.S. population, the immigrant population increased from 4.7 percent in 1970 to 13.2 percent in 2016 (Figure 1-1).

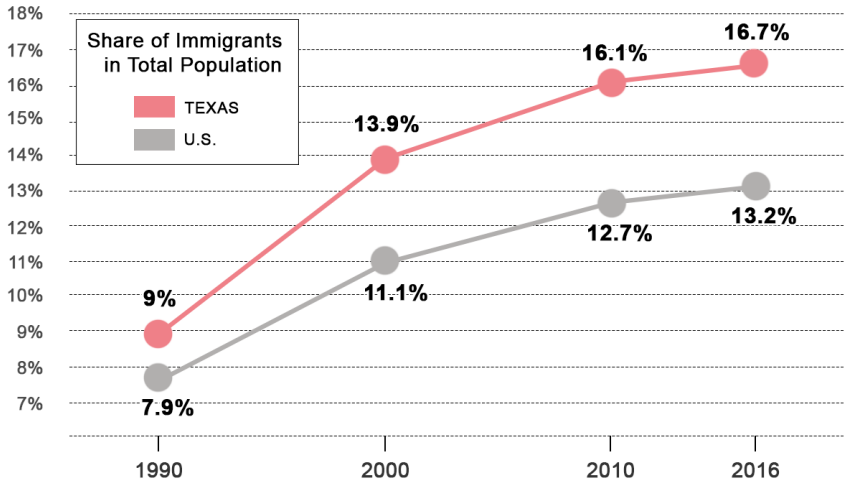


Figure 1-1. Share of Immigrants in Total Population of Texas and U.S.

[1] In this research, immigrants indicate foreign born population. U.S. Census defines nativity status in native born and foreign born. Native born population indicates who U.S. citizens are at their birth: born in the United States territory (including Puerto Rico and U.S. island areas) and born abroad of U.S. citizen parent(s). Foreign born population means who are not U.S. citizens at their birth: naturalized U.S. citizens, legal permanent residents, temporary immigrants, humanitarian migrants, and unauthorized migrants. In this research, immigrants indicate foreign born population.

Based on data from decennial U.S. census data from 1990 to 2010 and the 2016 American Community Survey (ACS), the number of immigrants has risen rapidly in Texas from 1.5 million in 1990 to 4.5 million in 2016. The share of the immigrant population in the entire population in Texas also increased sharply increased between 1990 and 2016, which was about 16.7 percent as compared to about 11 percent in the U.S. average. Hence, Texas was ranked the second populous immigrant states followed by California which had 10.4 million immigrants in 2016 (Figure 1-2).

Similarly, the travel behavior of immigrants has an effect on the transportation system in the region, state, and the United States. Immigrants have shared a decisive portion of all transit ridership, walking, biking, and carpooling in the United States. Many scholars have found that the effect of immigrants' travel behavior is far from US-born individuals. For instance, immigrants drive automobile a lot less (Asgari et al., 2017; Beckman and Goulias, 2008; Blumenberg, 2008 and 2009; Blumenberg and Shiki, 2007; Blumenberg and Evans, 2010; Chatman and Klein, 2013; Handy et al., 2009; Kim, 2009; Klein and Smart, 2015; Tal and Handy, 2010; Smart, 2014) and commute by public transit twice more than US-born individuals when they arrived in the States (Blumenberg ad Shiki, 2007). These researches primarily focus on to understand the tendency of immigrants to use environmental- friendly modes of travel (public transportation, carpooling, walking, and bicycling).

Researchers also found that travel behavior among Immigrants is far from uniform. A growing number of studies have been conducted to explain these differences among immigrants by socio-demographic, especially gender and race/ethnicity in the US. However, studies so far have hardly identified the effect of immigrant neighborhoods on individual travel behavior.

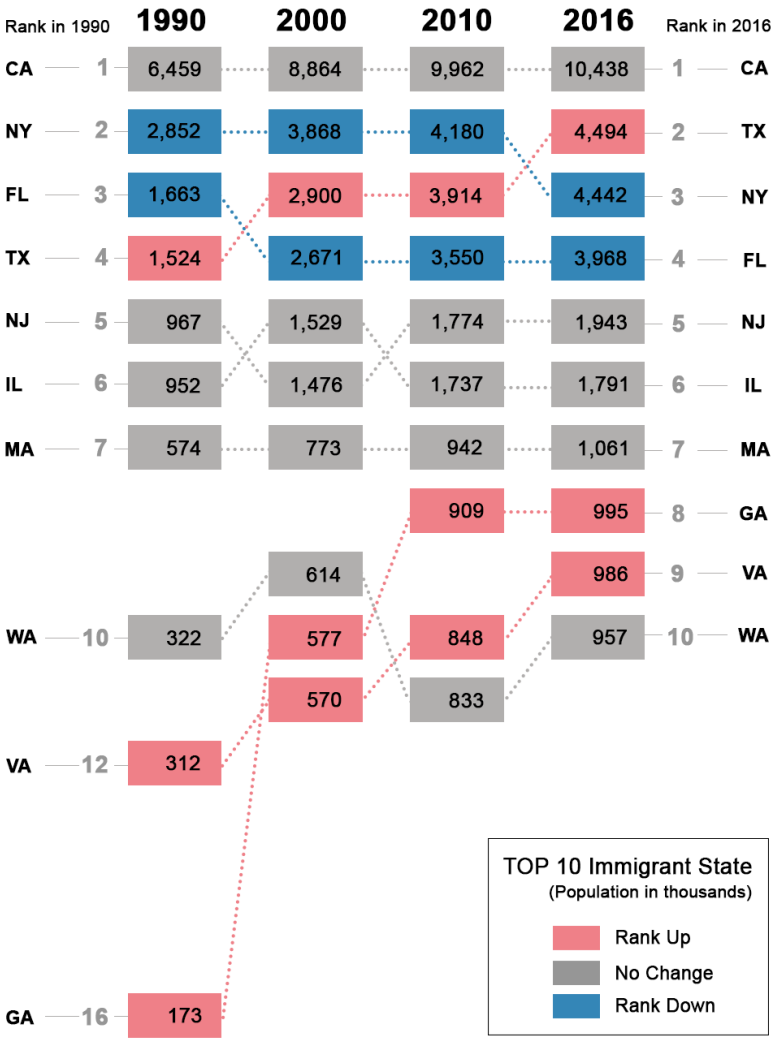


Figure 1-2. Change of top 10 immigrant population states between 1990 and 2016

1.1 Motivation and Goals

Previous researches have examined recent immigrants' travel behavior since 1990s. These studies conducted in California, Florida, Georgia, New Jersey, New Jersey, Texas, Vermont, and the United States, but nearly all of them conducted in California and the United States. Immigrant's travel behavior has been studied on travel mode choice (Beckman and Goulias, 2008; Blumenberg, 2008; Hu, 2017; Blemenberg and Smart, 2010; Kim, 2009) along with travel time (Beckman and Goulias, 2008; Hu, 2017), trip length (Blumenberg and Smart, 2010; Hu, 2017; Matsuo, 2016), trip purpose (Blumenberg and Smart, 2010; Chatman, 2013), and gender difference.

Geographic level of the Immigrants' travel behavior studies was varied, such as city, MSAs, region, state, and national wide. Most of the studies statistically approached by using National Household Travel Survey (NHTS), U.S. Census, or Integrated Public Use Microdata Series (IPUMS) dataset. However, fewer studies examine immigrants in Texas, even though that Texas has been one of the top five immigrant states. Researches on travel behaviors in Texas seem likely to lean toward high-occupancy vehicle (HOV), known as carpooling (Cline et al., 2009; Li et al., 2007; Burris et al., 2006; Giuliano et al., 1990). Only Cline et al.(2009) and Jimenez and Mattingly (2009), among these travel behavior literature, analyze travel behavior of immigrants in Texas. However, these studies discuss only in a particular ethnic group, Hispanic immigrants. And Cline et al. focus a certain mode of travel, carpooling, derived from 2006 IPUMS, while Jimenez and Mattingly (2009) study on all travel modes, vehicle, transit, walking and others, using 2001 NHTS Texas add-on data set.

The preeminent goal of the proposed dissertation is to study the effect of neighborhood social, economic, and physical (socioeconomic-physical) characteristics on immigrant's travel behavior in North Texas. The overall goal of this dissertation is to

better understand the relationship between travel behavior of immigrants in North Texas and the effect of socio-physical environment of their neighborhoods on immigrants' travel behavior. This work is significant in terms of the following:

First, this proposed dissertation will be one of the first comprehensive researches on the travel mode choice of immigrant group in North Texas. Previous travel behavior studies in North Texas have been limited in small number, in a certain ethic group with a certain travel mode, Hispanics and carpooling. This dissertation expands the scope of study object concerning all racial/ethnic groups of immigrants and all travel modes (public transit, carpooling, walking, biking, and driving alone), and comparing travel behavior of different racial/ethnic groups in the same neighborhood. Also, this dissertation will encourage to learn North Texas's transportation situation by examining comparisons among top immigrant states. Ample evidence has indicated that lack of accessibility to transport resources in the major mobility constraint confronted by ethnic minority population groups (Blumenberg and Evans, 2007; Blumenberg and Shiki, 2007; Chatman and Klein, 2009; Bose, 2014). For instance, the studies conducted in New York and California, which have distinctive ethnic claves, reveal that their immigrant population heavily depends on the informal ethnic mobile resource, such as Chinatown van, Chinese taxi, jitney and carpooling (Blumenberg and Smart, 2014; Yu, 2016). Detailed comparisons among travel behavior of immigrants in North Texas and in other top immigrant states can draw attention to specific travel demand in North Texas region. These findings help better understanding for the firm relationship between a social network of the domestic ethnic group in the region and their distinctive travel behavior. Understanding the travel behavior of immigrant population in North Texas can highlight how their daily travel activities are enhanced or hindered by regional transportation system.

Second, I use the small geographic units of analysis (census tract) to identify the location of immigrant neighborhoods in North Texas and its effects on immigrants' travel behavior with confidential 2017 NHTS add-on dataset. The most earlier studies, which used the NHTS dataset, on the relationship between residential areas and their residents, they use larger geographic unit, such as county or larger (Bhat et al.,2013; Casa et al., 2004; Chatman, 2009; Matsuo, 2008; Blumenberg and Smart, 2010; Ding et al., 2017; Hu, 2017). Unfortunately, the previous researches on immigrant or ethnic neighborhoods have been defined a "neighborhood" in inconsistent and large geographic scope, such as county or city, thus it likely leads to an ambiguous understanding of the tendency of immigrants' travel patterns. Using small enough unit of geography, like census tract, can be useful for testing neighborhood level hypothesis as well as immigrant related travel data by identifying the location of immigrant neighborhoods in North Texas and socio-physical characteristics of those neighborhoods. This dissertation, in the context of the vague definition of immigrant neighborhoods, represents a meaningful improvement on existing studies by suggesting a significant geographic level of the neighborhood that affects residents' travel mode choice. The small geographic units (census tract) of analysis can guide a further broad policy goal learning from immigrants' location choice in North Texas. If the causes of their travel behavior are the result of affable circumstances or preferences, there may be lessons to learn from immigrant neighborhoods that can be applied region-wide.

Third, this dissertation more comprehensively addresses the relationship between travel mode choice of immigrants and the socio-physical environment of their neighborhood by examining multilevel analysis. Existing researches does not provide a clear answer to the neighborhood's effect on immigrant travel behavior. Earlier researches on neighborhood's impact on immigrant travel heavily focused on the

influence of social network in immigrant/ethnic neighborhood on travel by using quantitative approach (Lovejoy and Handy, 2011; Blumenberg and Smart,2010, 2014; Carrasco et al., 2008; Wang et al., 2015; Di Ciommo et al., 2014; Yu, 2016). Researchers have examined social networks occurring in ethnic neighborhoods as a motivation for travel and its role in shaping travel behavior (Carraso et al.,2006; Petersen and Vovsha, 2006) and the role of travel in maintaining spatially dispersed social networks (Urry, 2002). However, the role of the physical environment of immigrant neighborhoods on residents' travel behavior has been neglected and examined in limited aspects in the region. I hypothesize that a combination of socioeconomic-physical factors of the neighborhood and individual immigrant characteristics will exhibit a different use of transportation modes for their daily travel. The analysis of Location Quotient (LQ) and Local Moran-I suggest immigrant neighborhoods in North Texas and multilevel multinomial logit examine the effect of the individual immigrant (Level 1) and their neighborhood (Level 2) engagement predictors on immigrants' likelihood of travel mode choice.

1.2 Dissertation Structure

This dissertation is organized as follows. First, I include literature review section (Chapter 2) immediately following this introduction chapter to cover the literature that is relevant to this dissertation. Literature review composites two sections of immigrant travel behavior and immigrant neighborhood. In immigrant travel behavior section, I review observed unique travel behaviors of immigrants by influential factors like race/ethnicity, gender, arrival cohorts, education, or household size.

The second section of literature review seeks to link together disparate works of literature on the effect of ethnic neighborhoods' socio-economic characteristics on travel choice and effect of built environment (physical factor of neighborhoods) on travel. Particularly, studies on built environment and travel have not been studied on immigrant/ethnic neighborhoods, hence I review the researches on the relationship between built environment of general neighborhoods and travel. This dissertation is the first step in filling this gap of the physical arrangement of immigrant neighborhoods and immigrant travel.

In Chapter 3, I focus on research design and hypothesis for the dissertation. This dissertation consists of three analytic components; thus, I reoccur each component's research design one by one. Then the research hypothesis is provided.

Chapter 4 presents a brief description of immigrants' travel behavior in Texas comparing other immigrant states is presented. It is preliminary study of Texas immigrants' travel behavior before examining North Texas immigrants' travel behavior with neighborhood effect on mode choice.

The next chapter (chapter 5) describes immigrant geography in North Texas. This chapter explains the dataset and techniques using for the identification of immigrant neighborhoods. And immigrant neighborhoods are categorized by the dominant race/ethnicity population (White, Black, Asian, Hispanic, and mixed-race/ethnicity). Moreover, the accessibility of foods and public transit in immigrant neighborhoods is displayed.

Chapter 6 focuses the main analysis of neighborhoods' effects on residents' mode choice with controlling individual and household characteristics. Data integration is one of the main aspects of this analysis. Data and data modification is firstly explained, then the possible methodologies and the selected methodology was introduced. The

results are presented by each level (individuals, households, and neighborhoods) with meaningful variables.

Final chapter (chapter 7) summarized the major results of this study. Then the limitation of this study and implications for policies and regulation are discussed.

Chapter 2

Literature Review

The body literature review explores unique travel behaviors of immigrants in terms of their demographic and social characteristics and the nature of immigrant neighborhoods. To measure immigrant neighborhoods in North Texas, clarifying the definition of neighborhood and guidelines for identification of geographic boundary of a neighborhood are also attended. Due to earlier studies have been limited to the effect of social networks happening in immigrant neighborhood on travel, the relationship between general built environment and travel is reviewed for this dissertation.

2.1 Immigrants and Travel Behavior

Previous research has established that the travel behavior of immigrants is different from the travel behavior of US-born residents in terms of auto use and alternative transportation use (including transit, biking, walking, and carpooling). Indeed, majority of immigrants quickly adapt to car-based transportation system in U.S. and the dominance of their travels occurred by using automobiles. However, the tendency of using alternative mode (including transit, walking, biking, and carpooling) is noticeably higher than U.S. born population (Smart, 2015; Kim, 2009; Blumenberg and Evans, 2010; Blumenberg and Smart, 2010, 2014). In the meantime, there may be some barriers on public transit such as limited service hours for commute needs, access issues in rural areas, and fear of crime and discrimination, discouraging their long-term reliance on it (Liu and Schachter, 2007; Valenzuela et al., 2005).

The study on immigrants and carpooling by Blumenberg and Smart (2010) denoted that recent immigrants (0-4 years in U.S.) made 63% of their trips by using

alternative mode, when non-immigrants made 46% of their trips by these modes based on 2001 NHTS data. In their detailed finding on trip mode between immigrants and non-immigrants, Chatman and Klein (2009) found that immigrants had 4 times higher usage on transit, 3.5 times higher on biking, 2 times higher on walking, and nearly 7% more likely on carpool than non-immigrants. Even settled immigrants who have been in the U.S. more than 21 years are more likely to commute by carpool (share of 11.9%) and transit(share of 7.4%) than U.S. born population: 9.4% on carpool and 3.2% on transit (Chatman and Klein, 2009).

These figures comprise a portfolio of travel behaviors that are likely significant less resource-intensive than U.S.-born. Thus, Immigrants are far more modest consumers of transportation services and have much less impact on the roads than do native-born commuters (Myer, 1997; Chatman, 2014; Blumenberg and Smart, 2014).

Studies on immigrants' travel patterns and behavior have remained limited. Most researches have tended to focus largely on transportation mode usage, with a particular interest in relatively frequent use of alternative modes for commute to work, or immigrants' lower average automobile ownership rates. In most part, this limitation may be due to the lack of very precious data on immigrants and their travel related attributes. Therefore, the utmost quantitative researches on immigrants' travel behavior have been examined using only few particular data sources; U.S. Census, Integrated Public Use Microdata Series (IPUMS), National Household Travel Survey (NHTS), and each regional travel survey. Furthermore, these data source has their own limitations. For example, U.S. census and IPUMS provide only aggregate data. Only 2001 and 2009 NHTS contains detailed information related to immigrants' travel, such as immigrant status, year of entry, country of origin (only in 2001 NHTS) (Blumenberg and Smart, 2010; Smart,

2015). Despite it provides elaborate information on nonwork travel by immigrants, underrepresentation of immigrants and lower representation of undocumented immigrants are considered as a deficiency of NHTS (Chatman and Klein, 2009). Most studies are on immigrants' travel behavior have conducted in nationwide, California, and New York/New Jersey. limited studies focus on immigrant travel in Texas (Table 2-1).

The other notable limitation is that while numerous researches on immigrants' travel mode choice between automobile and other transportation modes have shown the consolidate finding (Blumenberg and Smart, 2010, 2014; Kim, 2009; Asgari et al.,2017), immigrants' preference among alternative transportation (including transit, carpool, walking and biking) have remained debatable,. For example, Blumenberg and Smart (2010) report immigrants prefer to carpool over transit, however Kim (2009) find that immigrants more likely to use public transit or non-motorized transportation (NMT) than carpool when vehicles are accessible by scrutinizing the 2006 Integrated Public Use Microdata Series (IPUMS).

Table 2-1. Study Areas on Immigrant Travel

Author(s)	Study Area	Study Geographic Unit	Immigrant Status Data	Focus Immigrant Group(s)	Focus Travel Mode(s)	Methods
Asgari et al. (2017)	Florida	Census Tract	2009 NHTS	Immigrants as a whole	All transportation mode	Multinomial Logit
Beckman & Goulias (2008)	California	State	2000 PUMS	Hispanic Immigrants	All transportation mode	CHAID
Blumenberg & Shiki (2007)	California	State	2000 PUMS	Immigrants as a whole	Automobile	Logit
Blumenberg & Smart (2009)	Los Angeles CMSA	Census Tract	2000 Census	Immigrants as a whole	Carpooling, Transit	Latent Class Analysis
Blumenberg & Smart (2010)	U.S.	MSA	2001 NHTS	Immigrants as a whole	Carpooling	Multinomial Logit
Blumenberg & Smart (2014)	Southern California	Census Tract	2001 regional survey	Immigrants as a whole	Carpooling	Poisson regression
Chatman (2014)	New Jersey	Census Tract	Telephone survey	Indian, South-Asian, and Latin American immigrants	Automobile	Logit
Chatman & Klein (2013)	New Jersey	State	Telephone survey	Indian, South-Asian, and Latin American immigrants	Automobile	Qualitative analysis
Cline et al. (2009)	Texas	State	2006 ACS PUMS	Hispanic Immigrants	Carpooling	Logit
Hu (2017)	U.S.	Census Tract	2001 and 2009 NHTS	Asian Immigrants	All transportation mode	Regression
Jimenez & Mattingly (2009)	Texas	State	2001 NHTS	Hispanic Immigrants	All transportation mode	Regeression
Kim (2009)	U.S.	Region	2006 IPUMS	Immigrants as a whole	All transportation mode	Multinomial Logit
Lovejoy & Handy (2008)	California	City	Focus group discussion	Mexican Immigrants	Automobile	Qualitative analysis
Lovejoy & Handy (2011)	California	City	Focus group discussion	Mexican Immigrants	Carpooling	Qualitative analysis
Ma & Srinivasan (2010)	Miami–Fort Lauderdale CMSA, Florida	Public-Use Microdata Area	1990 and 2000 PUMS	Immigrants as a whole	Automobile	Ordered probit
Matsuo (2016)	U.S.	BEA region	2009 NHTS	Hispanic Immigrants	Automobile	Logit
Smart (2010)	U.S.	Nation	2001 NHTS	Immigrants as a whole	Bicycling	Multinomial Logit
Smart (2015)	U.S.	Census Tract	2001 NHTS	Immigrants as a whole	All transportation mode	Multinomial Logit
Tal & Handy (2010)	U.S.	Nation	2001 NHTS	Immigrants as a whole	All transportation mode	Regeression
Yu (2016)	New York City	Neighborhoood	Interview	Chinese Immigrants	Community-based transit	Qualitative analysis

2.1.1 Arrival cohort and transportation assimilation

Arrival cohort is a strong indicator of Immigrants' travel behavior. In other words, Immigrants' travel behavior tends to associate with the length of settlement in the country. For example, commuting to work on public transit is especially prevalent among recent immigrants. Newer cohorts of immigrants in U.S. and Canada have a higher propensity of using alternative mode than past arrival cohorts (Chatman and Klein, 2009; Heisz and Schellenberg, 2004; Smart, 2015), and less likely to drive alone (Smart, 2015). Their residential location choice might explain this higher dependency on alternative transportation among new and recent immigrants. New immigrants are more likely to live in more top density areas that can be served by public transportation and, not surprisingly, use public transit more than less recent immigrants (Rosenbloom, 1998).

Vehicle Miles Traveled (VMT) also differs significantly among immigrant cohort. Immigrants who have been in U.S. less than 5 years drive just 63% of the non-immigrant's average driven miles per year, while established immigrant who have resided over 20 years in the country drive similar miles to non-immigrants' (Tal and Handy, 2010).

The classification of newer, recent, and settled or established cohorts of immigrants slightly differs by the researchers based on which data they examined. Newest Immigrants (less than 1 year in U.S.) have nearly 2.5 times higher rates of public transit usage on their commute than settled or established immigrants who have been in U.S. more than 21 years (Chatman and Klein, 2009). Carpooling is also much regular mode among recent immigrants (0-4 years in U.S.) than U.S. borns and earlier cohort of immigrants (Contrino, 2006; Chatman and Klein, 2009; Smart, 2015).

As immigrants advance economically and adapt to the American life-style, it is generally observed that they also assimilate into the car culture, their tendency of driving

alone increases, and appear to abandon the public transportation and alternative transportation modes with the length of settlement years in U.S. (Myers, 1997; Liu and Painter, 2007; Chatman and Klein, 2009; Blumenberg and Shiki, 2007; Cline et al., 2009; Blumenberg and Smart, 2010, 2014; Arsgari et al., 2017). The speed of immigrants' adaptation to the U.S. transportation system, so called "transportation assimilation", is remarkable with their propensity to commute by transit. The rate of transit usage was shown dropping by as much as half in just 10 to 15 years (Blumenberg and Shiki, 2007; Blumenberg and Evans, 2010; Chatman and Klein, 2009; Smart, 2015), when the researchers examined it with a different dataset. For example, analyzing 2001 NHTS for native-born and foreign-born adults in Southern California by arrival cohort of immigrants ;0-4 years, 5-9 years, and 10 years or longer, Blumenberg and Smart (2010) find that immigrants are likely to choose carpools over transit than native-born Americans, but the effect of immigrant status on the likelihood of carpooling is weakened over length of time in the United States. 54% of recent immigrants made a trip by carpooling (household and external carpooling) while 45% of settled immigrants were using carpool for their trip (Blumenberg and Smart, 2010).

As noted in other studies about immigrant's age at arrival and transportation assimilation, Cline et al. (2009) examine 2009 Integrated Public Use Microdata Series (IPUMS) for Hispanic and Hispanic immigrants in Texas to explore the odds of carpooling on their commute. They find a strong relationship between immigrant's age at arrival and their adaptation to single-occupancy vehicle (SOV) on the journey to work. There is no significant difference between Hispanic immigrants who arrived in the U.S. as children and non-Hispanic white, but Hispanic immigrants who arrived as adults are 1.4 times more likely to carpool than non-Hispanic whites.

2.1.2 Immigrant's demographics and their travel behavior

Associated with how long have been resided in the country, immigrants gradually assume the travel patterns of non-immigrants (Blumenberg and Shiki, 2007; Myer, 1996; Kim, 2009; Tal and Handy, 2010; Blumenberg and Smart, 2010; Chatman and Klein, 2013). Besides arrival cohorts, many demographic factors, including race, ethnicity, country of origin, gender, income, and household characteristics suggest some reasons for noticeable travel patterns among immigrants.

Race/ ethnicity explains different travel pattern among immigrants. Studies on travel difference by racial groups among immigrant have had more attention on Hispanics, the major group of immigrants, than other groups. Findings from some researches on immigrants in California shows that distinct travel behaviors of Hispanic immigrants. Hispanic immigrants have remarkably high public transit and carpooling dependency upon their arrival and even after many years of residence in the U.S. than other racial immigrants (Blumenberg and Evan, 2010; Blumenberg and Shiki, 2007; Cline et al., 2009; Lovejoy and Handy, 2008; Lovejoy Handy, 2011). Then they showed the greatest decline, 74 percent decline (Blumenberg and Shiki, 2007), in transit use, after 20 years in the country. As the years of residency increase, Hispanic immigrants tend to rely on transit less than Black and Asian immigrants but still more than native-born Hispanics (Blumenberg and Evan, 2010; Blumenberg and Shiki, 2007).

Both Hispanic and Asian immigrants still relay on public transit in rates higher than White immigrants after more than 20 years in California (Blumenberg and Evans, 2010). Although little research has been explored the travel behavior of Asian Immigrants, Asian immigrants exhibit a different travel pattern with others. Recent Asian immigrants are much less likely to relay on transit than their Hispanic counterpart

(Blumenberg and Shiki, 2007) and own more cars per household drivers than other racial groups, excluding non-Hispanic Whites (Hu, 2017). Asian immigrants tend to have faster adaptation into automobile culture than Hispanic immigrants (Blumenberg and Shiki, 2007). Also, transit use among Asian immigrants decrease after a short period of living in the U.S. and remains lower than that of native-born Asians. This travel difference of Asians can be explained by their have the highest average income and education in all racial/ethnic groups. Most of them are employment-based immigrants, particularly the H1-B visa holders (Li et al., 2016). Among Asian immigrant groups, Indian immigrants tend to exhibit almost same auto use to non-immigrants, after controlling other demographic factors and residential preference (Chatman, 2014).

Gender is a significant factor affecting travel. However, overall observation on female immigrants' travel behavior tells a slightly nuanced story. Myers (1997), Kim (2009), and Blumenberg and Smart (2014) examine immigrants' likelihood of carpooling in Southern California. Blumenberg and Smart (2014) report that carpooling is significantly higher among immigrants than non-immigrants, especially female immigrants are more likely associated with carpooling by examining regional travel survey data. However, Myers (1997) and Kim (2009) find that females are less likely to carpool and also tend to have lower propensities toward public transit for their commute to work when they studied US census and IPUMS data. In terms of transportation assimilation, Myers (1997) states that the rate of drive alone increases remarkably among female immigrants after they gain an additional 10 years of residence in the United States. But, Blumenberg (2009) finds that the gender difference in drive alone increases with years in the U.S., as male immigrants more rapidly transportation assimilate compared to female immigrants.

Scholars often mention that culturally-based gender roles are the most significant aspect that may influence female immigrant travel. For instance, US-born females are slightly more likely (78.9%) to drive alone to work than US-born males (78.2%), however female immigrants tend to drive less than male immigrants, even after settled in the country (Blumenberg, 2009; Ruggles, 2007). Possible explanations for low auto ownership rates among female immigrants are varied. First, becoming a car owner is financially more difficult to female immigrants. Female less likely participate in the labor market in some countries, such as South Asia, North Africa, and the Middle East, than in the U.S. (International Labour Office, 2008). Some of these patterns may remain when women migrate to the U.S. and male immigrants are much more likely to work for wages than Female immigrants. Therefore, female immigrants may have low incomes and less likely to afford automobile ownership, both the purchase and the maintenance expenses (Handy et al., 2008; Matsuo, 2016). Second, some female immigrants might not possess driver licenses or know how to drive, because of cultural difference associated with driving. For example, females in less developed countries are more likely use public transit and carpooling and travel less frequently (Kwan and Kostev, 2015; Mastuo, 2016), and much less likely to possess driver's licenses or to know how to operate vehicles than women in the US (Pisarski, 1999). In some countries, women are officially discouraged from using automobiles. The most extreme example is that women in Saudi Arabia were legally banned from driving until June 2018.

Income significantly connects with immigrant households' travel, especially with their car ownership. Low-income households have more difficulty to access automobile than relatively affluent households (Blumenberg and Pierce, 2012). Because the costs of car ownership represent a higher share of the total household budget for low-income households than for relatively affluent households (Rice, 2014). For example, Asians

have the highest average income among all racial/ethnic groups (Calvo and Sarkisian, 2015; Hu, 2017). Thus, it is clear that Asian immigrants assimilate to the automobile culture to a great extent than other immigrant groups (Blumenberg and Shiki, 2007; Blumenberg, 2007; Chatman and Klein, 2013; Smart, 2015).

Immigrants have much poor accessibility to private vehicle due to their economic condition and the competition with household member for the use of their limited cars (Tal and Handy, 2010; Blumenberg and Smart, 2011; Chatman and Klein, 2013; Klein and Smart, 2017). For instance, Chatman and Klein (2013) did a qualitative research on why immigrant drive less by interviewing six focus groups of immigrants in New Jersey. In this research, some Philippine immigrants explained about their delay of car ownership; owning car was not their priority, because they had to save money to send it back to their relatives in Philippines. So, buying a car seems like a luxury. For immigrants and undocumented immigrants, driving is a fearful and high-risk activity (Garni and Miller, 2008; Stuesse and Coleman, 2014). In addition to their legal or illegal status, language barrier, and expenses to obtain a driver's license, they face discrimination in the purchase of cars. Most low-income immigrants have no credit history in the U.S. (Blumenberg and Smart, 2011), and this cause a serious impediment to accessing the market for auto loans (Cohen, 2006; Lovejoy and Handy, 2008) and auto insurance (Lovejoy and Handy, 2008). Therefore, they are more likely use public transit as well as find alternative ways to access automobile such as sharing or borrowing cars and carpooling (Lovejoy and Handy, 2008).

Household size is also a robust indicator of immigrant travel behavior. While immigrants tend to have larger families than nonimmigrants, their use of automobiles differs from that of nonimmigrants. Since immigrants live in large households and own fewer vehicles than nonimmigrants, they have limited access to household vehicles

(Blumenberg and Smart, 2011; Blumenberg, 2009; Lovejoy and Handy, 2008). For using the household cars, negotiations are necessary among household members and some household members need to find other ways to travel (Lovejoy and Handy, 2008). Households cannot afford a car or enough cars for their families, they more likely use public transit or alternative transportation. Particularly, carpooling is positively related to lower income (Blumenberg and Smart, 2010) and large households (Blumenberg, 2009; Tal and Handy,2010). Because immigrant households tend to live in a high-density ethnic area where can served by a good public transportation and easily coordinate rides with neighbors (Rosenbloom and Fielding, 1998; Blumenberg and Shiki, 2007; Lovejoy and Handy, 2008). Additionally, households with a vehicle can share rides to minimize one of the principal difficulties associated with carpooling; finding reliable carpool partners (Blumenberg, 2009; Tal and Handy,2010).

2.2 Built Environment and Immigrants' Travel

With little research on relationship between immigrant travel behavior and their neighborhood, in this section I first review literatures on immigrant neighborhoods and community-based transportation, namely ethnic neighborhood vans (e.g. Chinatown vans), ethnic taxi (e.g. Chinese taxi and camionetas), or employer provided transportation, I then review the definition of a neighborhood and its geographic unit by neighborhood effect on travel behavior studies. Finally, due to the lack of researches on the built environment in immigrant neighborhoods, I review that the built environment effect on inhabitants' travel behavior in general. This dissertation addresses this gap between immigrants' neighborhood and its impact on their travel behavior in the literature.

2.2.1 Immigrant's neighborhoods and community-based transportation

In the case of immigrants, the clustering of immigrants in the urban housing market and the labor market is a well-known phenomenon. Immigrants heavily concentrate in certain residential neighborhoods and certain industrial sectors of the economy, forming "ethnic enclaves" (Wilson and Portes, 1980) and "ethnic niches" (Waldinger, 1994). Repeated actions of social networks and information sharing that connecting new immigrants to housing and job opportunities close their settled co-ethnics brought the emerge of the both forms of ethnic concentration (Liu and Painter, 2012). Thus, ethnic enclaves are neighborhoods with intensive ethnic businesses, services, and institutions and a high share of the same racial/ethnic residents.

Ethnic enclaves have usually formed first in central city locations, but more suburban ethnic communities have emerged recently with the decentralization of metropolitan population and employment (Logan et al., 2002). Li (1998) termed this new ethnic suburban as "ethnoburb" and defined as recognized suburban ethnic clusters of residential areas and business districts in large metropolitan areas. Ethnoburb is not just suburban version of ethnic enclaves; Li (1998) argued that it has socially, economically, and politically developed from the traditional ethnic community with its wealthy, highly educated and skilled new immigrants, unlike their antecedents. As a result of the combination of recent international economic restructuring processes and changing geopolitical situation, this new form of ethnic community remains important sites of employment, support a more suburban type of living, and create ethnoburbs.

Living in ethnically affluent neighborhoods, so-called ethnic enclave or ethnoburb, with a high concentration of other immigrants from the same region of origin may have enhanced transportation accessibility with carpooling and community-based

transportation. (Blumenberg and Smart, 2009, 2010; Cline et al., 2009). However, urban form and so-called “neighborhood effects” among transportation scholars (Crane, 2000; Levine et al., 2005; Chatman, 2009; Crane and Crepeau, 1998; Handy, 1996), relatively little scholarly studies examined relationships between immigrant neighborhoods and transportation (Liu and Painter, 2012), despite widespread interest in immigrant communities in the social sciences. A big portion of researches on the relationship between immigrant neighborhoods and transportation is determining immigrants’ travel behavior in terms of travel time and mode choice to work with the importance of residential location. Immigrant neighborhood have a distinct characteristics; relatively high transit and population density, and dense social networks arising from the spatial proximity of the same ethnic groups. These aspects promote the use of alternative transportation and transportation sharing among residents (Blumenberg and Smart, 2009,2014). In order that, previous studies on the relationship between immigrant neighborhoods and their residents’ travel behavior have been focused on how immigrants’ social networks in their ethic neighborhood influences on their transportation mode choice. For instance, Shin (2016) demonstrate the previous studies findings that residents in ethnic neighborhoods had higher usage of household- based carpools for commuters (Liu and Painter, 2012), but higher usage of external carpools for nonwork travel by studying in California.

Travel time studies reveal that central city immigrants living in ethnic community experience longer commutes than their non-enclave counterparts (Preston et al., 1998; Liu 2009), but it is uncertain whether the higher commuting premium is a result of their public transit reliance or longer work journeys (Liu, 2009).The results indicate that living in areas with higher ethnic concentrations increases both the likelihood of carpooling and of taking public transit (Liu and Painter, 2012). An immigrant who lives in an ethnic

community with ample employment opportunities are shown in shorter work trips, and rarely expected solo driving to work. Thus, carpooling rates are higher, given fact that carpool partners may be found through ethnic network contacts. Beside social networks of neighbor interactions, immigrants easily find flexible, cheap, and ethnic friendly transportation resources in an ethnic enclave. For example, Flushing in New York City is one of fast-growing Chinese Communities in the United States. People in Flushing use Chinese vans for daily commuting, visiting friends and relatives, and attending cultural activities in other Chinese communities in New York City. Also, employers provide free commuting service to their employees and Chinese taxis are popular informal travel mode as the fare is cheaper than yellow cabs (Yu, 2016).

2.2.2 Definition of a neighborhood in neighborhood effect studies

In order to examine socio-physical characteristics of a neighborhood and their effect on immigrant travel behavior, the term and geographic unit of neighborhood must be defined. What a neighborhood is and how to define it have been debated among social scientists. At a minimum, scholars have agreed that neighborhoods are continuous areas of geographic space in which humans interact and conduct their daily life (Glaster, 2001; Kearns and Parkinson, 2001; Martin, 2003). Park (1916) defined “a neighborhood is that a subsection of a larger community which is a collection of both people and institutions occupying a spatially defined area influenced by ecological, cultural, and sometimes political forces” (as cited in Sampson et al., 2002, p.445).

A geographic definition of neighborhood is too vast. The geographers’ constant interest is identifying neighborhoods in the definition of geographic units for spatial analysis. Many scholars have equated geographic boundary of neighborhoods with social networks or communities of people living or acting in these space (Park, 1916; Wellman

and Leighton,1979; Chaskin, 1998). In the United States, neighborhood socioeconomic characteristics have most commonly been measured for census tracts or census block groups (Krieger et al., 1997) as well as United States Postal Service ZIP codes (Mobley et al., 2004). In practice, most social scientists and virtually all studies of neighborhoods I reviewed relay on geographic boundaries defined by the Census Bureau. Census tracts are mostly applied as boundaries of neighborhood area. The Census Bureau designed census tracts as a pseudo-neighborhood area that have a population size between 1,200 and 8,000 with an optimum population of 4,000 (U.S. Census Bureau, 2012).

Indeed, the geographic unit of a neighborhood is varied based on the subject and purpose of projects or researches, yet mostly in a variation of census tracts. For neighborhood planning, local officials have divided their city into small areas to provide data at that geographic level which is politically meaningful to some degree and practical for researchers. Most regular data are census tracts or similar units, and census data ones can easily identify tracts and lack of alternative geographic units make it legitimate to treat those tracts as if they were real neighborhoods (Logan et al., 2011). For instance, The Department of City Planning in New York City created Neighborhood Tabulation Areas for the long-term suitability plan. To minimize the error associated with population projection, New York City set the aggregation of census tracts as a neighborhood with population size of 15,000 (City of New York, n.d.). The City of Dallas did likewise in their citywide neighborhood revitalization plan in 2015. They identified twelve Neighborhood Plus Target Areas for housing and neighborhoods revitalization. The geographic unit of target neighborhood areas was the aggregation of census tracts (City of Dallas, 2015).

In the studies about neighborhood effects on travel behavior, the geographic unit of a neighborhood are not unified in a certain geographic level; some are at the census tract level; some are at the county level; some are at the block groups level; and others

are not defined in U.S. Census geographic unit. It seems like because of lack of comprehensive individual and household travel data including immigration status and micro-scale geographic identifier. Table2-2 lists reviewed studies about neighborhood effect. These studies have several things in common. As they analyze the effect of neighborhood on travel mode, they applied definite neighborhood geographic boundary, usually in U.S. census geography. Also, all apply a statistical test to determine the significance of the various effects of neighborhoods.

Table 2-2. Applied Geographic Unit and Variables of Neighborhoods in Relevant Studies

Author(s)	Geographic Unit of Neighborhood	Study Area	Variables for Neighborhood	Study on Immigrant Travel Mode
Asgari et al. (2017)	Census Tract	Florida	• Land use index • Immigrant concentration • Social status	All transportation mode
Blumenberg & Smart (2009)	Census Tract	Los Angeles CMSA	• Urban/Suburban • Residents + Workers Density • Distance from downtown • Median age of housing stock	Carpooling, Transit
Blumenberg & Smart (2014)	Census Tract	Southern California	• Percentage of immigrants • Country of origin • Residential density • Employment access • Centrality (Distance to city hall) • Level of transit service (bus stops density)	Carpooling
Cao et al. (2007,2009)	not clearly defined in U.S. Census geography	Nothern California	• Accessibility (to shopping mall, downtown, community center, and freeway) • Physical activity (bike route, sidewalk, parks and open space, and public transit) • Safty • Socializing • Attractiveness	None
Cervero (2002)	County	Montgomery County, Maryland	• Residents + Workers Density • Land use diversity • Ratio of sidewalk mile to road miles	None

Chatman (2009)	County	California	• Retail employee density • Resident density • Accessibility to heavy/light rail • Distance to downtown • Four-way intersection	None
Crane and Crepeau (1998)	County	San Diego County, California	• Connected street pattern •Mixed street pattern • Street network density • Residential share • Vacant share • Distance to downtown	None
Ding et al. (2017)	not clearly defined in U.S. Census geography	Baltimore Metropolitan Area, Maryland	• Population density • Employment density • Land use mixture • Street network connectivity • Accessibility to employment • Distance to transit (bus stop)	None
Kim & Ulfarsson (2004)	Block group	Washington state	• Population density • Median housing value • Median gross rent • Median income • Percentage of immigrants • Percentage of household 65 and older • percentage of single-person household • percentage of household in poverty • percentage of workers commuting in a private vehicle/a bus • percentage of open space	None

Lee et al. (2014)	County	Houston Metropolitan Area, Texas	• Population density • Employment density • Entropy index (land use) • Dissimilarity index (land use mixture) • Roadway measure • Connectivity • Number of households	None
Reilly and Landis (2003)	Not clearly defined in U.S. Census geography (A grid cell of 2.5 acres)	San Fransico Bay Area	• Population density • Share of commercial land use • Distance to commercial • Dissimilarity index • Transit access • Intersection density • Mean block size • Mean parcel size • Proportion detached • Median year built	None
Smart (2015)	Census Tract	U.S.	• Size of metro area (%) • Mean % renter • Mean residents/sq.mile • % household living in New York City	All transportation mode
Wang et al. (2015).	Not clearly defined in U.S. Census geography (Within 10km from Ohio State University)	Ohio	• Distance from residence to campus • Proximity to bicycle infrastructure • Intersection density	None

2.2.3 Built environment and travel behavior

Residential location and neighborhood characteristics have influenced residents' travel behavior. One of studies on travel behavior and neighborhood concluded that the built environment has a greater impact on trip lengths and travel mode choice (Ewing and Cervero, 2001). In general, physical neighborhood characteristic, in other words, the built environment, is expected to impact travel demand along five principal dimensions: density, diversity, design, destination accessibility, and distance to transit (Cervero and Kockleman, 1997; Ewing and Cervero, 2001, 2010). Built environment variables of interest using in initial researches are listed in Table 2-3.

Table 2-3. Built Environment Factors and Variables

		Factor	Variable	Reference
5Ds	3Ds	Density	Household or Population density	CK, EC
			Employment density	CK, EC
			Accessibility to jobs	CK
		Diversity	Dissimilarity index	CK
			Entropy index (Land use mix)	CK, EC
			Jobs-housing balance	EC
			Vertical mixture	CK
			Per developed acre intensities of land use	CK
			Activity center mixture	CK
			Commercial intensities	CK
			Proximities to commercial-retail uses	CK
		Design	Intersection or street density	CK, EC
			% 4-way intersections	CK, EC
			Pedestrian and cycling provisions	CK
			Site design	CK
		Destination accessibility	Job accessibility by auto	EC
			Job accessibility by transit	EC
		Distance to transit	Distance to downtown	EC
			Distance to nearest transit stop	EC

(Source: Cervero and Kockleman, 1997; Ewing and Cervero, 2001, 2010)

Cervero and Kockleman tested how built environment, defined as 3Ds (density, diversity, and design), affect trip rates and travel mode choice in the San Francisco Bay area. Their study came to the conclusion that compact built environment with mixed land use setting generally reduce personal VMT and encourage alternative travel mode choice of residents (Cervero and Kockleman, 1997). The influence of design factor, particularly land use, on travel mode choice behavior have found in a growing body of research. It is clear that land use mixture effects on travel behavior, but the degree of significance is different by researches. Cervero (2002) and Zhang (2004) concluded that land use plays key role and have significant effect in travel mode choice behavior, while Reilly and Landis (2003) found the effect are generally moderate.

In addition to 3Ds, Ewing and Cervero added two more built environment factors, destination accessibility and distance to transit, estimated by job within one mile and distance to nearest transit stop (Ewing and Cervero, 2010). Ewing and Cervero (2010), a meta-analysis with studies on built environment and travel behavior, concluded unexpected results that the relationship between built environment and personal VMT are inelastic. However, the relationship between built environment and walking and transit use are elastic. This unexpected result about VMT in compact neighborhoods might be due to minimum sample size and/or missing control on residential self-selection (Ewing and Cervero, 2010).

Consistent with Cervero and Kockleman (1997) and Ewing and Cervero (2001), most recent studies on built environment effect on travel, Ding et al. (2017) and Lee et al. (2014) found that the built environment have important direct effect on travel mode choice. Both studies conducted in different metropolitan areas: Ding et al. (2017) in Baltimore metropolitan area and Lee at al. (2014) in Houston-Galveston metropolitan

area. Density (population and employment density) in a compact neighborhood tent to reduce the likelihood of auto travel. Particularly, employment density and mixed land use have significantly positive direct effect on travel mode of transit, walking, and biking.

Studies demonstrate compact, mixed-use, and walk-friendly urban built environment can significantly influence to their resident travel mode choice. However, studies on immigrant neighborhood effect have failed to apply the factors of built environment thoroughly; most past studies defined immigrant neighborhood by only density and diversity factors (e.g. Smart, 2015; Shin, 2017). Considering immigrant neighborhoods usually have grown in the central parts of many metropolitan areas (Logan et al.,2002; Chriswick and Miller, 2004; Culter et al., 2008) where are compact urban built environments, all five principle factors (density, diversity, design, destination accessibility, and distance to transit) may significantly affect immigrant travel behavior. Thus, further researches are needed on the effect of physical characteristics of immigrant neighborhoods on travel behavior as well as socioeconomic characteristics.

Chapter 3

Data, Research Design, and Hypothesis

Previous research on immigrants and their travel behavior has focused on limited study areas. In particular, few studies are done in Texas. Moreover, the study of the travel behavior of individuals who live in immigrant neighborhoods has been limited by a lack of immigrant-related travel data and microdata at small enough geographic scales to be useful for testing neighborhood-level hypotheses. This chapter addresses how this dissertation overcomes these data and methodology issues.

This paper proposes three analytic components to investigate the effect that living in an immigrant neighborhood has on its immigrant residents' travel behavior. This chapter discusses each study's specific purpose and methodology within the broader research design. The specific research questions are:

1) Do immigrants in North Texas exhibit specific travel behaviors compared to their counterparts in other states?
2) Do immigrants settle in a specific area in North Texas? If so, where are these immigrant neighborhoods located and what are the prevailing socioeconomic-physical conditions in them?
3) Is there a significant relationship between Individual trip (level 1), individual immigrants (level 2), households (level 3), and immigrant neighborhoods (level 4), and if so, what effect does that relationship have on immigrants' likelihood to travel?

3.1 Data

3.1.1 Data for the first analytic component

There has been little research on immigrants and their travel behavior due to the small number of sources that measure a traveler's immigrant status as a data point. The publicly accessible sources that contain both immigrant status as well as travel information are U.S. Census Public Use Microdata Sample (PUMS), NHTS, and regional survey data. In research on this topic, scholars have collected data through surveys or combined multiple datasets to overcome the limited data on immigration status, and the research tends to focus on immigrants' relatively high rates of use of alternative modes of transportation (including public transit and carpool), relying on descriptive statistics (Casas et al., 2004; Myers, 1997; Blumenberg and smart, 2010). The main purpose of this chapter is to provide a brief overview of Texas immigrants' travel behavior by comparing their behavior with that of immigrants in other large states to examine descriptive statistics. To achieve this goal, this study applies 2017 American Community Survey (ACS) 5% PUMS data. This dataset contains individual travel information (such as travel time to work, departure time for work, and mode of travel to work) as well as personal attributes, including immigrant status. This dataset allows the researcher to understand the distinctions between the characteristics of immigrants in each state. The 2017 ACS PUMS contains sample data on 1,522,384 immigrants and 6,286,787 non-immigrants in the 10 US states with the largest immigrant populations. Table 3-1 shows the sample size of each state.

Table 3-1. Sample size of immigrants in top 10 states

States	Sample size of immigrants
California	289,880
Florida	207,851
Georgia	47,052
Illinois	76,596
Massachusetts	57,620
New Jersey	94,960
New York	1,314,511
Texas	207,873
Virginia	51,012
Washington	48,386

3.1.2 Data for the second analytic component

This study combines several datasets to determine the location of immigrant neighborhoods in North Texas and the physical conditions in those areas. The researcher aggregated the first dataset, the 2017 U.S. Census (U.S. Census, 2017), at the same (census tract) geographic level to match with 2017 NHTS data, which is geocoded in 2010 census geography. This census dataset includes demographic, social, and economic information for many neighborhoods. The North Texas region is the northern part of the central portion of Texas, which includes Dallas, Fort Worth, and surrounding areas. North Texas contains 16 counties (Collin, Dallas, Denton, Ellis, Erath, Hood, Hunt, Johnson, Kaufman, Navarro, Palo Pinto, Parker, Rockwall, Somervell, Tarrant, and Wise) which belong to the North Central Texas Council of Governments (NCTCOG). According to 2017 U.S. Census, the total number of census tracts in North Texas is 1,351 (Table 3-2).

Table 3-2. Number of census tracts in North Texas by counties

County	Number of Tracts
Collin	152
Dallas	529
Denton	137
Ellis	31
Erath	8
Hood	10
Hunt	19
Johnson	28
Kaufman	18
Navarro	10
Palo Pinto	9
Parker	19
Rockwall	11
Somervell	2
Tarrant	357
Wise	11
Total	1,351

The second dataset is based on information from referenceUSA (referenceUSA database, 2019). This dataset is comprised of business data, including company names, locations (address and geolocation coordinates), industry classifications, business sizes (measured through sales volume and number of employees), and years of establishment. This research focuses on data from grocery and supercenter stores (e.g., Walmart and Target). Grocery store categories include food market, grocery (including ethnic, health, take-out, and pick-up foods), seafood retail, frozen food retail, meat retail, fruit and vegetable retail, and farmer's market. This business data is useful to determine how accessible food and shopping is for immigrants. Most North Texas grocery stores are located in Dallas (38%) and Tarrant (30%) county, which have a combined total of 3,244 grocery stores.

The last dataset is the General Transit Feed Specification (GTFS; U.S. Department of transportation, 2019), published by the U.S. Department of Transportation. Table 3-3 shows the public transit agencies in North Texas. The GTFS dataset is useful to examine the accessibility of public transportation using corresponding geographic information from immigrant neighborhoods. By combining these datasets, one can analyze the locations, socioeconomic characteristics, and accessibility of food and public transportation in immigrant neighbourhoods.

Table 3-3. Public Transportation agencies and service areas in North Texas

Agency	Service	Service Area
STAR transit	Bus, Shuttle	Kaufman Rockwall
Dallas Area Rapid Transit (DART)	Rail, bus, paratransit	Collin Dallas Denton Ellis Rockwall Tarrant
Denton County Transportation Authority	Rail, bus	Denton
Trinity Metro	Rail, bus, paratransit	Tarrant

(Source: U.S. Department of Transportation and each agencies websites)

3.1.3 Data for the third analytic component

The hypothesis this chapter tests is whether the character of North Texas immigrant neighborhoods, identified in the previous section, influence their immigrant residents' travel behavior based on individual and household characteristics. In order to examine this hypothesis, one must modify the employed dataset to satisfy several requirements. First, the dataset must contain travel data information for individuals with immigrant status. One must be able to link the individuals' travel data with household and

neighborhood data. Each dataset includes several identifiers for trips, individuals, households, and neighborhoods (Table 3-4). A trip location ID includes the GEOID of the census tract of the traveller's household location and his or her destination. In order to connect the datasets with different geographic levels, I used several modified IDs based on original IDs.

Table 3-4. Identifiers of each dataset

Dataset	Providing Identifier
Trip	Household ID Person ID Trip location ID
Person	Household ID Person ID
Household	Household ID (equals to Census Tract ID)
Neighborhood	Census Tract ID

Second, mode of transportation is the primary element of individuals' travel behavior. The NHTS dataset includes information regarding individuals' modes of transportation for each individual trip. To run the model properly, I divided the modes of transportation into three broad categories: (1) driving a private vehicle, (2) taking public transit, and (3) walking or biking (Table 3-5). Because the data show that very few North Texans travel using carsharing or ridesharing (0.3% of non-immigrants; 0.06% of immigrants),[2] I included these modes of transportation in the private vehicle mode to ensure the model would run properly. Furthermore, I excluded data for trips with no transportation mode

[2] In dataset of the 2017 NHTS of North Texas, only 231 trips among total 64,868 trips (0.36 %) reported using carsharing or ridesharing.

and business trips to other states where the traveller used an unusual mode of transportation, such as airplane, boat, ferry, water taxi, and other methods of travel.

Table 3-5. Category of transportation mode

Category	Transportation Mode
1: Private Vehicle	Car
	SUV
	Pickup truck
	Van
	Rental car (Including Zipcar / Car2Go)
	RV (motor home, ATV, snowmobile)
	Motorcycle / Moped
	Golf cart / Segway
	Taxi / limo (including Uber / Lyft)
2: Public Transit	Public or commuter bus
	Subway / elevated / light rail / streetcar
	Private / Charter / Tour / Shuttle bus
	Amtrak / Commuter rail
	School bus
	City-to-city bus (Greyhound, Megabus)
	Paratransit / Dial-a-ride
3: Walk and Bike	Walk
	Bicycle

3.2 Research Design

3.2.1 Overview of Texas Immigrants' travel behavior

This is a preliminary study to understand Texas immigrants' travel behavior. As indicated in Chapter 2, there are few studies that examine Texas immigrants' travel behavior, and most of them focus on car-pooling patterns among Hispanic immigrants (Li et al., 2007; Cline et al., 2009; Kemper et al., 2007; Jimenez & Mattingly, 2009). Texas is

a populous state with many immigrants, with Dallas and Fort Worth being the new immigrant gate cities. Considering the effect that immigrants' population size and travel behavior has on transportation systems and infrastructure, it is useful to investigate Texas immigrants' travel behavior by comparing it with their counterparts in the other 10 states with the largest immigrant populations. The other states I use for comparison are California, New York, Florida, New Jersey, Illinois, Massachusetts, Georgia, Virginia, and Washington, which were selected based on the total number of immigrants by using 2017 American Community Survey (ACS) 5-year estimate data.

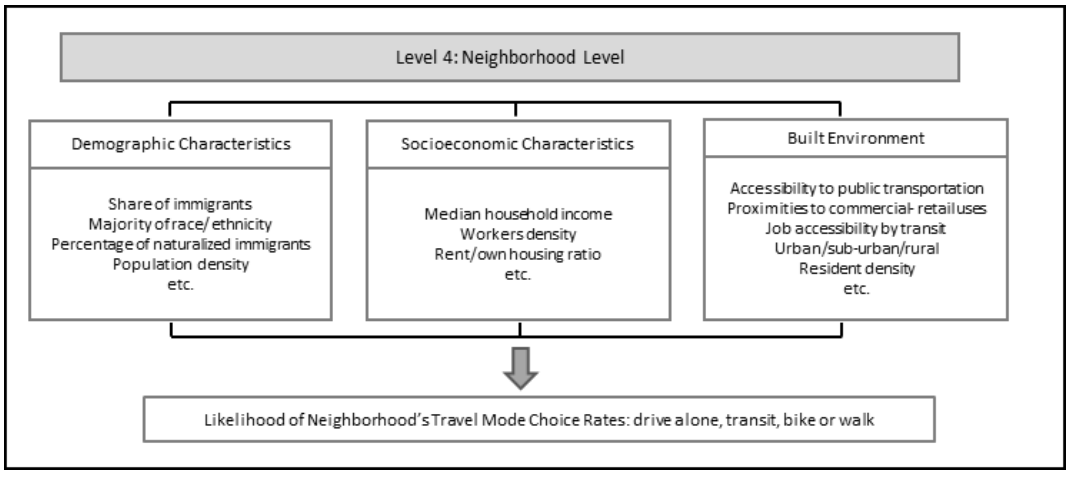
3.2.2 Analysis of Immigrant (Ethnic)Geography of North Texas

This study identifies the location of immigrant (ethnic) neighborhoods by studying the spatial arrangements of socioeconomic and physical conditions within the North Texas region. Using the 2000 U.S. Census aggregated data at tract level, which includes data about immigrants' race, ethnicity, and origins, this study contextualizes the region's immigrant neighborhoods. There are well-known methods one can use to define ethnic neighborhoods, such as the percentage of the population that are immigrants, the concentration index (in other words, the location quotient), and the spatial clustering method, including Moran's I. In this study, the researcher calculated the concentration indices of immigrant and ethnic populations in each census tract using Location Quotients (LQ). LQ measures the concentration of immigrants in a tract, thus indicating the degree of ethnicity in a location. Local Moran's I gauges a unit in terms of the characteristics of its neighbors, and thus it indicates the presence of an ethic cluster. Using both the LQ and Local Moran's I methods together, the researcher was able to capture tracts with high immigrant concentrations and tract clusters (ethnic neighborhoods).

This spatial clustering, involving spatially continuous values of concentration indices, objectively measures features of immigrant neighborhoods. Once I identified immigrant neighborhoods, I then computed and mapped each neighborhood's socioeconomic and physical characteristics.

3.2.3 Analysis of Immigrant (Ethnic) Neighborhood Effect on Travel Behavior

This comprehensive study seeks to determine the effect of the socioeconomic-physical environment of immigrant neighborhoods on the travel behavior of immigrants who reside in these neighborhoods. In terms of methodology, this study utilizes an extensive approach to investigating the effects that immigrant neighborhoods have on their residents' travel behavior by applying a multilevel multinomial logit, using 2017 NHTS data associated with neighborhood data obtained from 2017 census tract level data (Figure 3-1). Thus, this study extends prior research by examining the effect of immigrant neighborhoods on their immigrant residents' daily travel, beyond the relationship between immigrant aspects and their travel behavior.



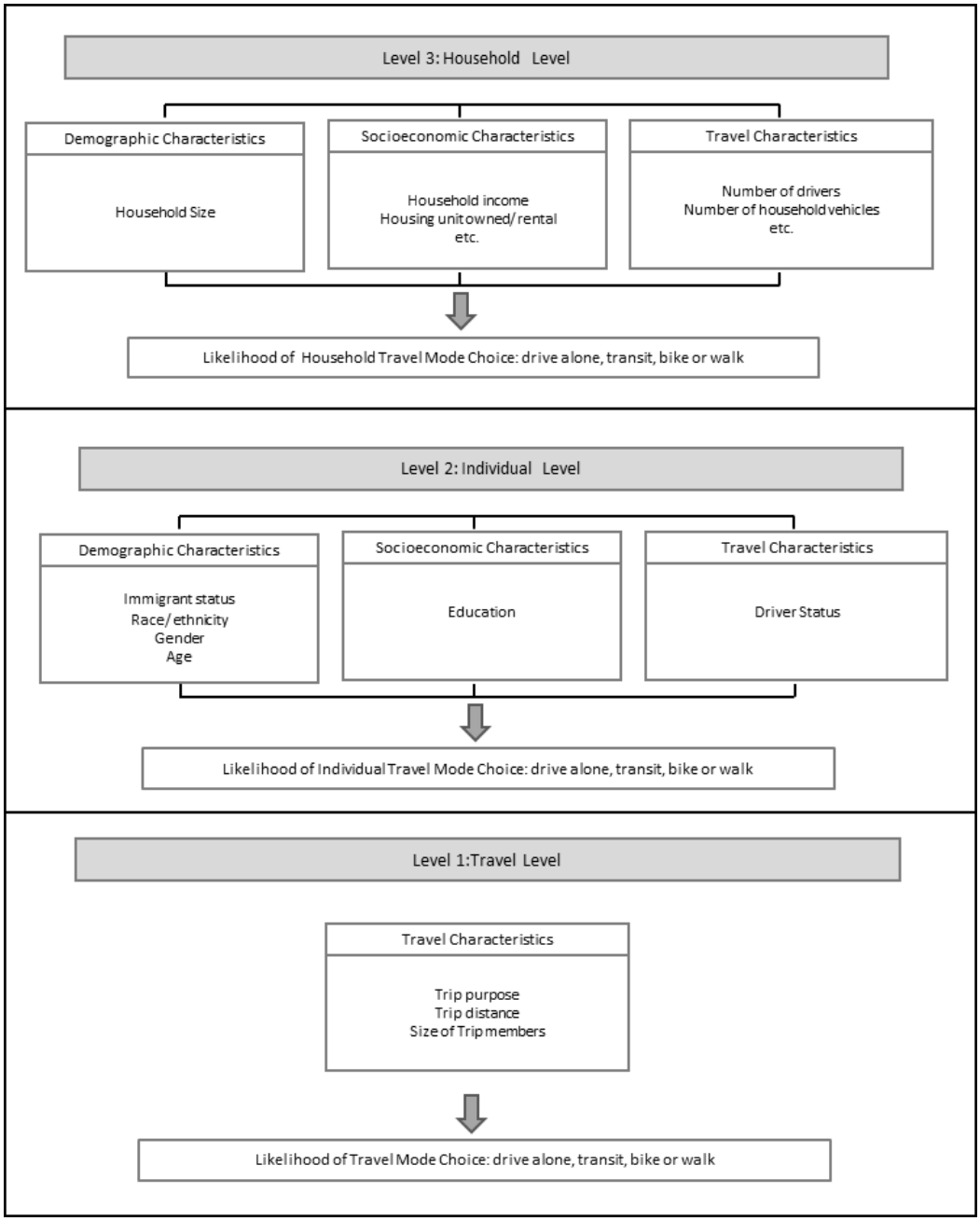


Figure 3-1. Conceptual model of travel mode choice for multilevel analysis

3.3 Hypothesis

The main research question of this dissertation is, “Is there a significant relationship between individual immigrants and their immigrant neighborhoods on likelihood to travel mode choice?” In short, I hypothesize that:

> *Hypothesis 1*: Immigrants who living in an immigrant (ethnic) neighborhood, with the same racial/ethnic group, have enhanced accessibility to alternative transportation, such as car-sharing, public transportation, biking, and walking.
>
> *Hypothesis 2*: Travel behavior of immigrants and household is different based on the location of their neighborhoods. Thus, the physical characteristics of an immigrant neighborhood, such as infrastructure, business density, and land use, influence on residents’ travel mode choice after controlling socioeconomic characteristics.

These hypothesis hinge on understanding of social network theory and discrete choice theory. As explored in literature review section, race/ethnicity explains different travel pattern among immigrants. The demographic variables of race and ethnicity represent not only cultural differences in attributes towards different types of transportation, but also strong interconnect caused by cultural similarity including language. Social network theory outlines a framework that cultural similarity encourages stronger personal influence within more cohesive social groups than less cohesive ones. Three key network concepts on network effects are centrality, cohesion, and structural equivalence. Freeman (1979) proposed three distinct measures to indicate structural centrality: degree, closeness, and betweenness. Network cohesion measures the degree of interconnections among a group of nodes, and network cohesion serves as an

important structural feature that moderates the influence of interpersonal networks (Liu et al, 2017).

Considering cultural similarity including language within a co-ethnic group, immigrants likely to get transportation information including how to get a driver license, how to use public transportation, and how to find car-sharing partner from their co-ethnic neighbors. Due to information sharing in the neighborhood, immigrant's travel behavior would be alike their co-ethnic neighbors. Previous researches on this topic has focused mostly on the Hispanic groups and the car-sharing, while this dissertation's analysis is all racial/ethnic immigrant's group and multimodal transportation.

The probability of an immigrants 'choice of transportation modes in the immigrant neighborhoods will be estimated by discrete choice model. Discrete choice models (Ben-Akiva and Lerman, 1985) consider that the environment that shapes the behavior of choice of an individual is random and specific to each situation, and can operate within a framework of rational choice when confronted with a discrete set of options, people choose the option of maximal benefit or utility. It is influenced by several factors in relation to both the socioeconomic characteristics of the individual in question and the attribute being chosen and the circumstances that characterize the environment of choice (Aloulou, 2018).

Traditional ethnic enclaves have usually formed in central city locations where a high concentration of settled co-ethnic immigrants have enhanced transportation accessibility with carpooling and community-based transportation. (Blumenberg and Smart, 2009, 2010; Cline et al., 2009). However, recent ethnic communities have emerged in suburban area with wealthy, highly educated and skilled new immigrants (Logan et al., 2002). The new form of immigrant neighborhoods has more diverse race/ethnic group and more suburban type of living, thus residents in this neighborhood

have fewer options of transportation mode for their travel due to lack of enough public transportation infrastructures. I hypothesize that immigrants who lived in recent immigrant neighborhoods more likely choose to drive their vehicle rather than using alternative transportation modes unlike immigrants in traditional immigrant neighborhoods.

Chapter 4

Immigrants' Travel Behavior in the 10 States with the Largest Immigrant Populations

The vast majority of immigrants in the US are densely populated in particular states. Based on 2017 U.S. Census data, 74% of immigrants live in the following 10 states, which have the most immigrants: California, New York, Florida, New Jersey, Illinois, Massachusetts, Georgia, Texas, Virginia, and Washington. Around half of immigrants in the US are located in California (33%) and Texas (15%). Historically, Texas has been a populous immigrant state, and North Central Texas has a significant portion of the Texas immigrant population. However, studies on immigrants' travel behavior in Texas have typically had a limited scope, examining only Hispanic immigrants and carpooling and high-occupancy vehicle (HOV) use. This chapter conducts a preliminary study of Texas immigrants, comparing Texas with the other nine US states with large immigrant populations to understand Texas immigrants' travel behavior.

4.1 Immigrants' travel behavior in Top 10 Immigrant states

Despite the dominance of car-based travel among immigrants, their propensity to use alternative modes of transportation (including carpooling, public transit, walking, and biking) is considerably higher than non-immigrants. Table 4-1 shows the mean modes of commuter transportation among immigrants in the 10 aforementioned states. Immigrants comprise nearly 20% of the total sample in these 10 states. The total sample size is 1,522,384 individuals in following categories: 111,352 immigrants who resided in the US for 0-4 years, 152,542 immigrants who resided in the US for 5-9 years, and 1,258,490 immigrants who resided in the US for 10 years or longer. The classification of US

immigrant cohorts by years slightly differs between researchers based on their research topics, but much of the research on immigrants and transportation categorizes immigrant cohorts into three categories: newer (0-4 years in US), recent (5-9 years in US), and settled (over 10 years in US; Blumenberg and Smart, 2010; Chatman and Klein, 2009; Smart, 2015).

Table 4-1. Immigrants' travel behavior in top 10 states

		Immigrant			Non-Immigrant
		Years in U.S.			
		0-4 years	5-9 years	Over 10 years	
Partial Percentage to total		7.3%	10.0%	82.7%	
Transportation to commute	Private Vehicle	60.0%	70.4%	80.3%	84.3%
	Public Transit	17.3%	16.7%	10.7%	5.9%
	Bike & Walk	10.4%	7.1%	3.4%	3.5%
	Other	7.4%	5.8%	5.6%	6.3%
Mean Commute Time (min)		10	14	17	11
Gender	Male	49.0%	47.5%	47.2%	49.1%
	Female	51.0%	52.5%	52.8%	50.9%
Race	White	43.6%	41.8%	50.0%	77.7%
	Black	7.9%	10.0%	7.4%	11.4%
	Asian	35.1%	34.4%	25.6%	3.1%
Total Observation		1,522,384			6,286,787

Immigrants use alternative transportation modes (i.e., public transportation, walking, and biking) more than non-immigrants. These alternate modes account for 15.6% of all commutes by immigrants versus 9.4% for non-immigrants. There are differences between the commuting transportation modes for different arrival cohorts of immigrants. Immigrants who resided for over 10 years in the US are more dependent on private vehicles (80.3%) than newer arrival cohorts (60% for 0-4 years and 70.4% for 5-9

years in the US). Public transit use is higher among new (17.3%) and recent immigrants (16.6%) than settled immigrants (10.7%), while only 5.9% of non-immigrants use public transit for their commutes. The longer immigrants are settled in the US, the less they tend to commute by biking and walking; in fact, settled immigrants (3.4%) bike and walk less than non-immigrants (3.5%). Immigrants' mean travel time tends to increase the longer they live in the US. Only newer immigrant cohorts have shorter commuting times (10 minutes) than non-immigrants (11 minutes). Settled immigrant cohorts travel far longer (17 minutes) than any other immigrant cohort and non-immigrants as well. One explanation for this could be spatial mismatch between immigrants' residential and employment locations. Immigrants tend to settle initially in urban ethnic communities, and then move to better suburban neighborhoods with non-immigrant majorities. Immigrants move where the jobs are and employment locations (including manufacturing, service, retail, and professional jobs) are further than ever from suburban settings due to technological innovation and the development of interstate highways (Liu & Painter, 2012b; Kneebone, 2009). Unlike the immigrant cohorts of the past, a sizable portion of current immigrants now first settle in the suburbs where their jobs are accessible.

Figure 4-1 shows all commuters' chosen modes of transportation by state. Among the 10 states with the largest immigrant populations, Texas immigrants have the greatest dependency (90.2%) on private vehicles for their commutes. Past studies show that immigrant status is one of the most significant factors influencing the use of non-single occupancy vehicle (SOV) modes of transport, specifically public transportation (Blumenberg and Shiki, 2007; Beckman and Goulias, 2008). However, public transportation is not available to commuters in most areas in Texas, and the PUMS microdata sample provides data regarding the number of commuters who use public transportation, although it does not provide information about public transportation

service availability (Cline et al., 2009). Limited accessibility of public transportation in most areas in Texas may be one of reasons behind the high rate of private vehicle usage in Texas compared to other states. Massachusetts shows the lowest rates of private vehicle usage among immigrants (70.6%) and the second highest utilization of public transportation (15.5%), followed by New jersey (17.2%). Texas also shows the lowest dependency (2.2%) on biking and walking; this rate is around four times higher in Massachusetts (8.2%). Other modes of transportation, including taxicab and ferries, as well as work-from-home arrangements, are defined in the U.S. Census PUMS data.

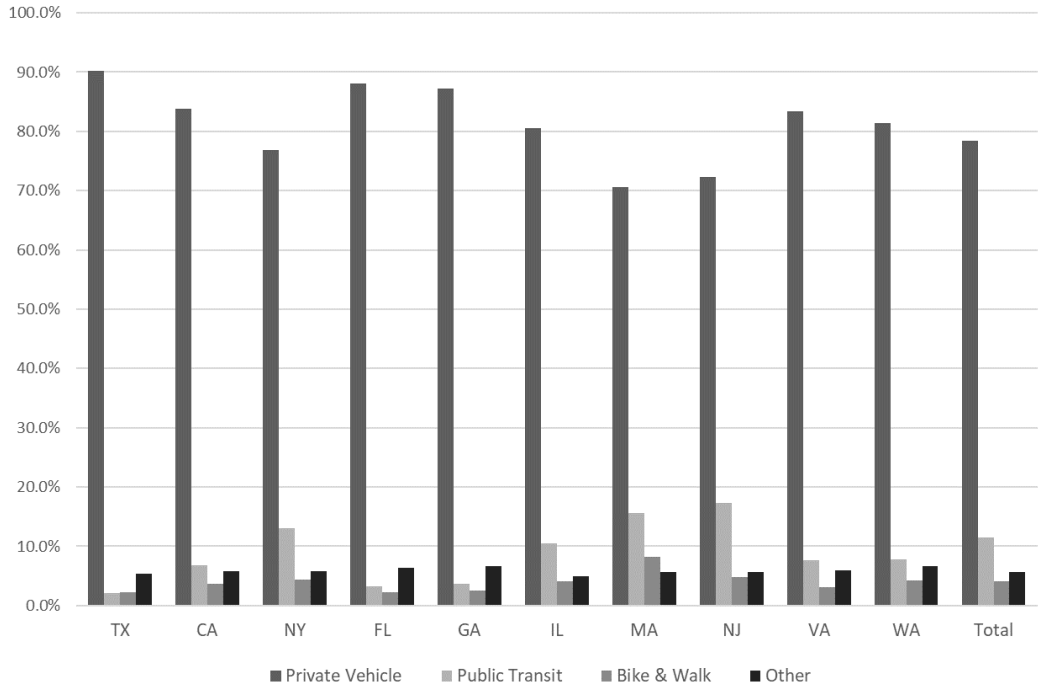


Figure 4-1. Rate of transportation mode to commute in top 10 states

According to the 2017 ACS PUMS data, commute times range from 0-160 min. This dataset shows that Texas immigrants have relatively shorter commute times (12.2 min) than those in other states, just slightly longer than Californian immigrants (11.7 min). The average commute time for all 10 states is 13.8 min, as shown in Figure 2-4. Beckman and Goulias (2008) found that two immigrant groups (one group commuted by public transportation, and the other group had the highest likelihood to take public transit) had higher average travel time than the entire population. Immigrants in states with relatively high usage of public transportation, like New Jersey, Massachusetts, and New York, have longer average trip times for their commute. For example, immigrants in New Jersey use public transportation at the highest rate (17.2%), and also have the longest average trip times (16.3 min).

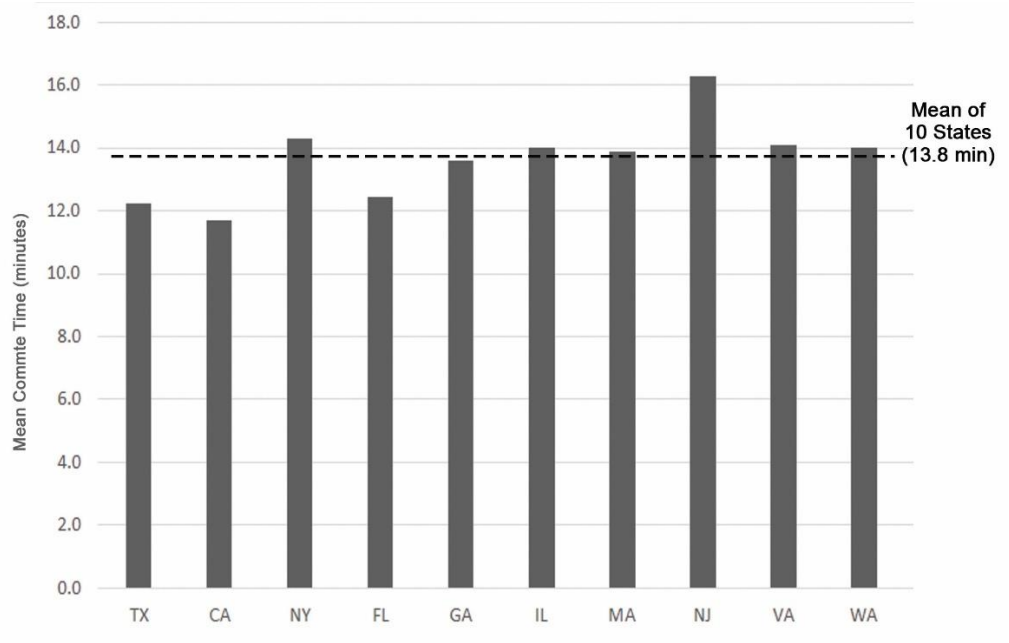


Figure 4-2. Mean commute time in top 10 states

4.2 Texas immigrants' travel behavior by individual attribute

Scholars have found that transportation assimilation decreases immigrants' propensity to use public transportation. The 2017 5% PUMS data for Texas (Table 4-2) also shows that Texas immigrants' use of public transportation declines the longer that immigrants reside in the US (5.1% of new immigrants, 3.5% of recent immigrants, and 1.7% of settled immigrants use public transportation). Simultaneously, their dependency on private vehicles increases with the time spent in the US. Although private vehicles are the dominant mode of transportation for commutes among Texas immigrants, their rate of use of public transportation is higher than that of non-immigrants (1.3%). Alternative modes of transportation (including public transportation, biking, and walking) and carpooling continue to play an important role among immigrants, especially newer immigrants. Immigrants in Texas tend to have longer commutes than non-immigrants; only newer immigrants' mean commute time (9 min) is shorter than that of non-immigrants (10 min).

Like arrival cohorts, race and gender are useful factors for explaining different travel behavior among immigrants, although previous studies show nuanced findings regarding the effects of race and gender and variability over different study regions. Gender has different effects on immigrants' travel behavior, which can be explained as a result of gender-based household responsibilities and occupational differences. Women with demanding home roles, including childcare, have shorter commutes to work. The suburbanization of employment and residence have increased gender-based differences in commuting distances. Myers (1997) states that female immigrants' transportation assimilation increases remarkably for immigrants that have resided in the US for 10

years. Excluding immigrant status, Ericksen (1977) found that black females had longer commuting distances than white females.

Table 4-2. Travel behavior of Texas immigrants by arrival cohorts

		Immigrant			Non-immigrant
		Years in U.S.			
		0-4 years	5-9 years	Over 10 years	
Partial percentage to total		8.6%	11.1%	80.3%	
Transportation to commute	Private Vehicle	77.9%	87.4%	91.3%	90.8%
	Public Transit	5.1%	3.5%	1.7%	1.3%
	Bike & Walk	6.0%	3.8%	1.7%	1.9%
	Other	5.6%	5.2%	5.3%	6.0%
Carpooling	Drive alone	75.5%	79.2%	84.6%	87.1%
	Carpool	24.4%	20.8%	15.4%	9.9%
Mean Travel Time (min)		9	12	15	10
Gender	Male	51.4%	49.4%	48.7%	49.1%
	Female	48.6%	50.6%	51.3%	50.9%
Race	White	51.9%	52.8%	63.8%	80.5%
	Black	7.6%	8.0%	3.7%	11.1%
	Asian	27.4%	26.3%	17.3%	1.5%
Total Observation			207,874		1,087,571

Likewise, gender differences, race and ethnicity explain different travel patterns among immigrants. Previous studies on travel behavior and racial groups among immigrants often focused on Hispanics, as they are the largest group of immigrants in the US. Hispanics are more likely to carpool and ride public transportation than non-Hispanics. Blumenberg and Evans (2010) found that after residing in California for more than 20 years, both Hispanic and Asian immigrants were more dependent on public

transit than white immigrants. Although there is little research into the travel behavior of Asian immigrants, they exhibit different travel patterns than other immigrant groups. However, Blumenberg and Shiki (2007) found that newer Asian immigrants were much less likely to rely on transit than their Hispanic counterparts. Furthermore, their results show that transit use among Asian immigrants decreased shortly after they moved to the US and remained lower than that of native-born Asians.

Table 4-3 details the travel behavior of Texas immigrants by gender and race using 2017 ACS PUMS data. The data show that female immigrants drive private vehicles less (89.5%) than male immigrants (91.1%), although the difference is small. Female immigrants in Texas ride public transit (2.6%) more and have commutes that are less than half as long (10 min) as their male counterparts. As Kim's (1994) research shows, relying on survey data of the Los Angeles Metropolitan Area, females were more likely to find employment in residential areas than males, and therefore their commuting times were shorter than males. Also, a greater proportion of female immigrants (4.4%) than males (3.5%) work at home in Texas. There are racial differences among the travel patterns of Texas immigrants. Black immigrants are more dependent on alternative modes of transportation (public transit, walking, and biking) than white and Asian immigrants. In Texas, 6.5% of black immigrants use alternative modes of transportation, in comparison to 3.7% of their white and 5.1% of their Asian counterparts. Notably, black immigrants have the longest average commutes (17 min) among Texas immigrants.

Table 4-3. Travel behavior of Texas immigrants by gender and race

		Gender		*Race*		
		Male	Female	White	Black	Asian
Partial percentage to total		49.0%	51.0%	61.5%	4.5%	19.2%
Transportation to commute	Private Vehicle	91.1%	89.5%	91.0%	89.3%	88.7%
	Public Transit	1.7%	2.6%	1.7%	3.9%	2.8%
	Bike & Walk	2.2%	2.2%	2.1%	2.6%	2.3%
	Other	5.1%	5.7%	5.3%	4.3%	6.1%
Mean Travel Time (min)		19	10	14	17	15
Total Observation		207,873		207,873		

4.3 Summary

This chapter shows that the travel behavior of Texas immigrants is similar to immigrants in other populous states. Overall, immigrants in the top 10 US states with the largest immigrant populations are two times more likely to use alternative modes of transportation (public transit, walk, and bike) than non-immigrants.

Texas immigrants have low usage of alternative modes of transportation – below the average in the 10 states with the largest immigrant populations – but they still use them more than non-immigrants. While California immigrants have the shortest commuting times, Texas immigrants drive shorter distances for their commutes than immigrants in most of the other states. The data also show travel assimilation in Texas as well as the other nine states. Immigrants who have resided in the US for longer show greater dependency on private vehicles than alternative modes of transportation with longer commuting times. The data show there are racial differences in travel behavior among Texas immigrants. In Texas, black immigrants have the highest usage of public

transit and non-motorized modes of transportation (walking and biking); they also have longer commutes than other immigrant groups. Asians use other modes of transportation, including carpooling, at the highest rate among immigrants. Moreover, findings of gender-based differences in travel behavior vary by study areas. For example, Texas females are less dependent on private vehicles, have higher rates of usage of public transit and other modes of transportation, and have shorter commutes than male immigrants.

The next chapter illustrates the geography of immigrant neighborhoods in North Texas, provides details for each ethnic immigrant neighborhood, and data on the accessibility of public transit and grocery stores in immigrant neighborhoods.

Chapter 5

Immigrant Geography in North Texas

As shown in the previous chapter, the travel behavior of Texas immigrants is different from other states with dense immigrant populations. Texas immigrants are highly dependent on private vehicles, less dependent on alternative modes of transportation (public transit, walking, and biking), and have relatively shorter commutes than immigrants in other states. There are many hypotheses to explain these differences, from idiosyncrasies in transportation infrastructure, to unique spatial distributions of residential locations, workplaces, and activity sites for immigrants in Texas. In this chapter, I examine the spatial distribution of immigrant neighborhoods in North Texas to determine where immigrants live and how the socioeconomic-physical conditions of those neighborhoods influence their travel decisions.

5.1 Methodology

Several scholars have examined the settlement patterns of immigrants, and the method of determining what constitutes an immigrant (ethnic) neighborhood vary between researchers. The use of absolute agglomeration levels (measuring the percentage of a population that is ethnic) is most common method, as it allows for hypothesizing or empirically deriving cutoff points of agglomeration. To avoid the arbitrary selection of cutoff points in the dataset, some researchers have determined relative cutoffs by using Location Quotients (LQ). For example, an ethnic neighborhood may be defined as those census tracts that contain ethnic agglomerations that are twice as high as the region-wide average level of agglomeration.

5.1.1 Location Quotient (LQ)

Immigrant neighborhoods are those that have a high spatial concentration of immigrant groups, measured using language, religion, class, lifestyle, and particularly race and ethnicity. To identify immigrant neighborhoods in North Texas, this dissertation employs both a structural index (LQ) and a spatial index (Local Moran's I). A researcher can use Local Moran's I (LM-I) to evaluate a census tract through comparisons of the characteristics of its neighboring census tract, while LQ treats the concentration of immigrants in each census tract independently. Thus, using both measures together captures both the concentration-evenness and clustering-exposure dimensions of segregation (Brown and Chung, 2006; Carroll at el., 2008).

LQ compares the proportion of a study group in a territory to the total population of the territory (Morrill, 1991). LQ has been used by geographers and regional labor economists for many years and is a standard tool to estimate a region's specialization in a given industry (Stimson et al. 2006). Furthermore, LQ also has been widely used in studies of clustering and segregation of racial and/or ethnic populations because of its simplicity, straightforwardness, and familiarity (Brown and Chung, 2006). This dissertation uses LQ to calculate the immigrant concentration index. I utilized the following formula to measure the LQ of immigrant populations in each census tract (immigrant concentration index):

$$\text{Immigrant Concentration Index (ICI)} = (a_i/t_i)/(A/T)$$

In the above formula, a_i and t_i are the immigrant population and total population, respectively, in the census tract i; A and T respectively refer to the immigrant population and total population in the North Texas. Hence, if the percentage of the immigrant

population in a block group matches its percentage in North Texas overall, ICI = 1. If the percentage of the immigrant population in a census tract is greater than its percentage in North Texas overall, ICI > 1. Lastly, if the percentage of the immigrant population in a census tract is less than its population in North Texas overall, ICI < 1. To gauge significance, I used an ICI of 1.5 or greater to indicate an immigrant population of significant concentration and an ICI of 0.85 or less to indicate underrepresentation of immigrants. This approach is borrowed from Brown et al.'s study on the spatial segregation of ethnic and racial groups in Ohio (1996). Table 5-1 shows the ICI in North Texas. The mean ICI is 1.01 and the maximum value is 3.33.

Table 5-1. Descriptive statistics of Immigrant Concentration Index in North Texas

	LQ
Mean	1.01
Median	0.85
Minimum	0
Maximum	3.33
Count	1351

5.2 Immigrants Neighborhoods in North Texas

Using 2017 U.S. Census tract level data for North Texas and the LQ method, this study determines locations with high immigrant concentrations. Figure 5-1 displays the location of tracts of high immigrant concentrations in North Texas using the ICI. The red colored areas are census tracts where the concentration of immigrants are more than 1.5 times the average in North Texas. The results show that 24% (325 tracts) of the tracts in North Texas are heavily immigrant concentrated, mainly in six counties: Tarrant, Dallas,

Denton, Collin, Navarro, and Rockwall. Immigrants in North Texas have an urban orientation and are highly concentrated in Dallas county (Figure 5-2). Lastly, the bright gray areas denote tracts with lower concentrations of immigrants than other North Texas tracts. In these areas, the ICI is below the median value of 0.85.

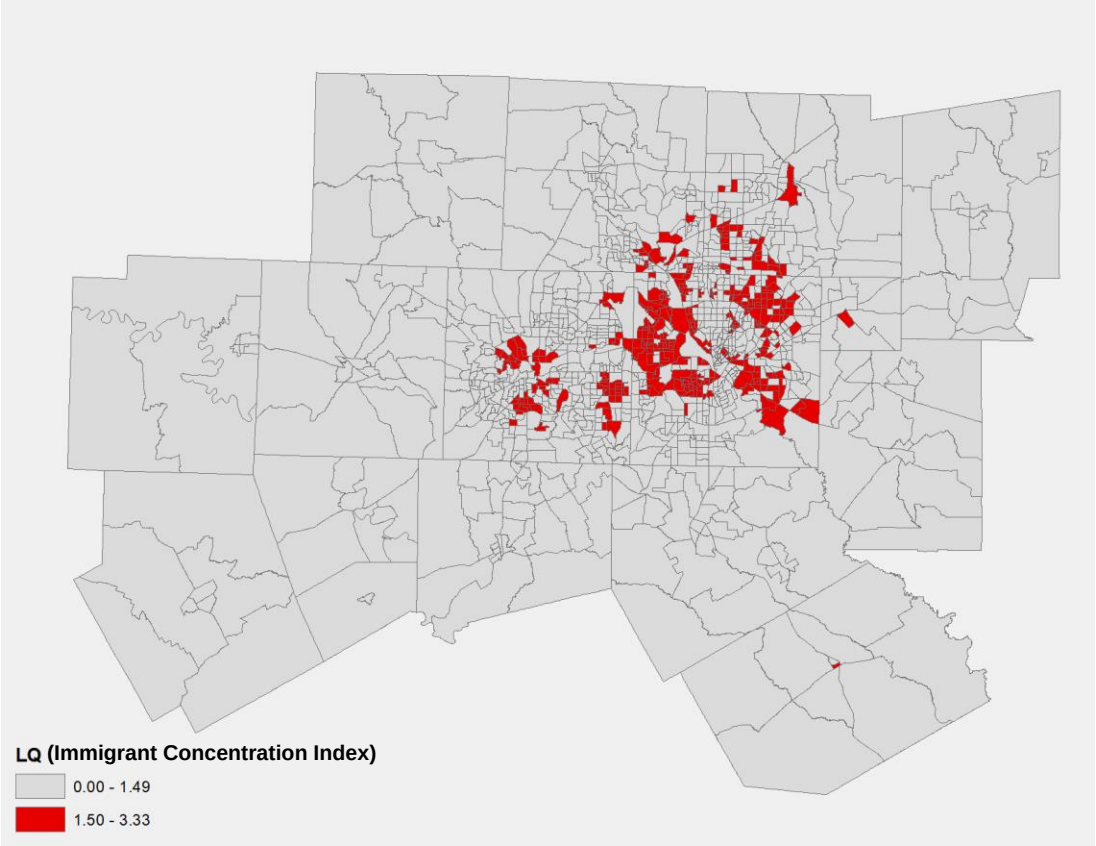


Figure 5-1. Immigrant concentrated tracts in North Texas

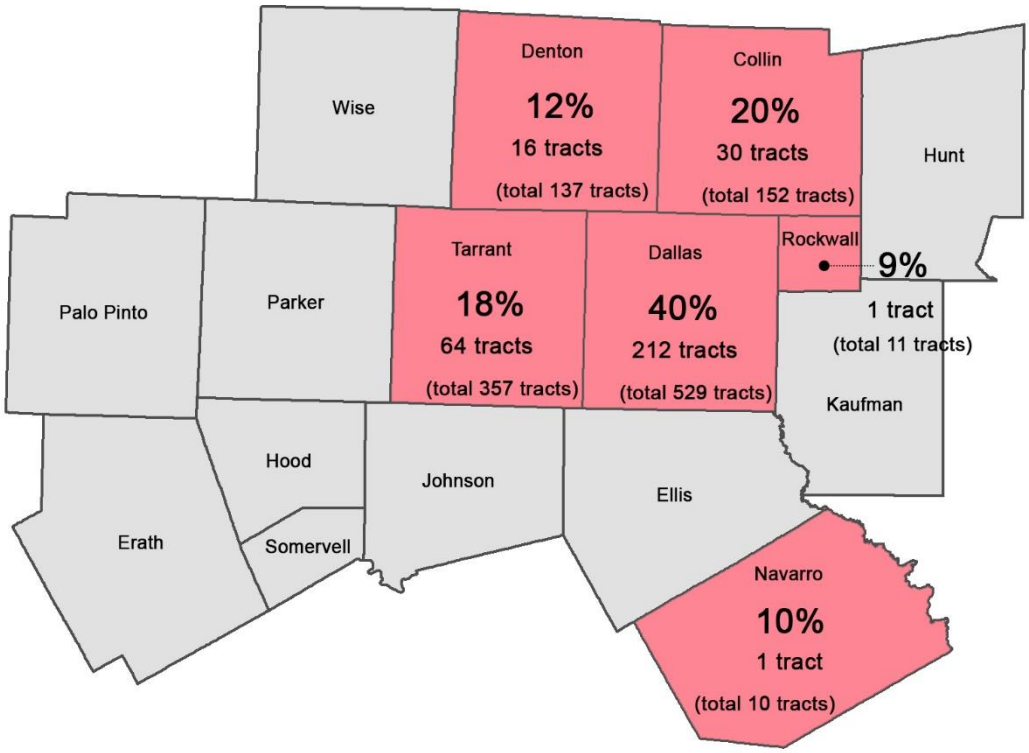


Figure 5-2. Proportion of immigrant neighborhoods in North Texas counties

5.2.1 Immigrant neighborhoods by race/ethnicity

Immigrants share information and establish social networks in their neighborhoods with other individuals of the same ethnicity. These neighborhoods have high concentrations of immigrants from the same region of origin and boast unique ethnic businesses, services, and institutions. Thus, I categorize the tracts of high immigrant concentration by the residents' race/ethnicity (white and non-Hispanic, black, Asian, and Hispanic).

Figure 5-3 shows immigrant neighborhoods and the major racial/ethnic immigrant groups of those neighborhoods. I deemed immigrant neighborhoods as those where the ICI equaled 1.5 or greater. Thus, ethnic immigrant neighborhoods are those where immigrant concentrations are 1.5 times more than North Texas overall and where the percentage of individuals who are of a related race or ethnicity is over 50% of the total population in the tract. Mixed race/ethnicity immigrant neighborhoods are those that do not have a dominant racial/ethnic group. For example, census tract 99, located between Asian and Hispanic neighborhoods in Dallas County, is categorized as a mixed race/ethnicity immigrant neighborhood. This census tract, with a total population of 3,144, is 48% Hispanic White and 43% Asian.

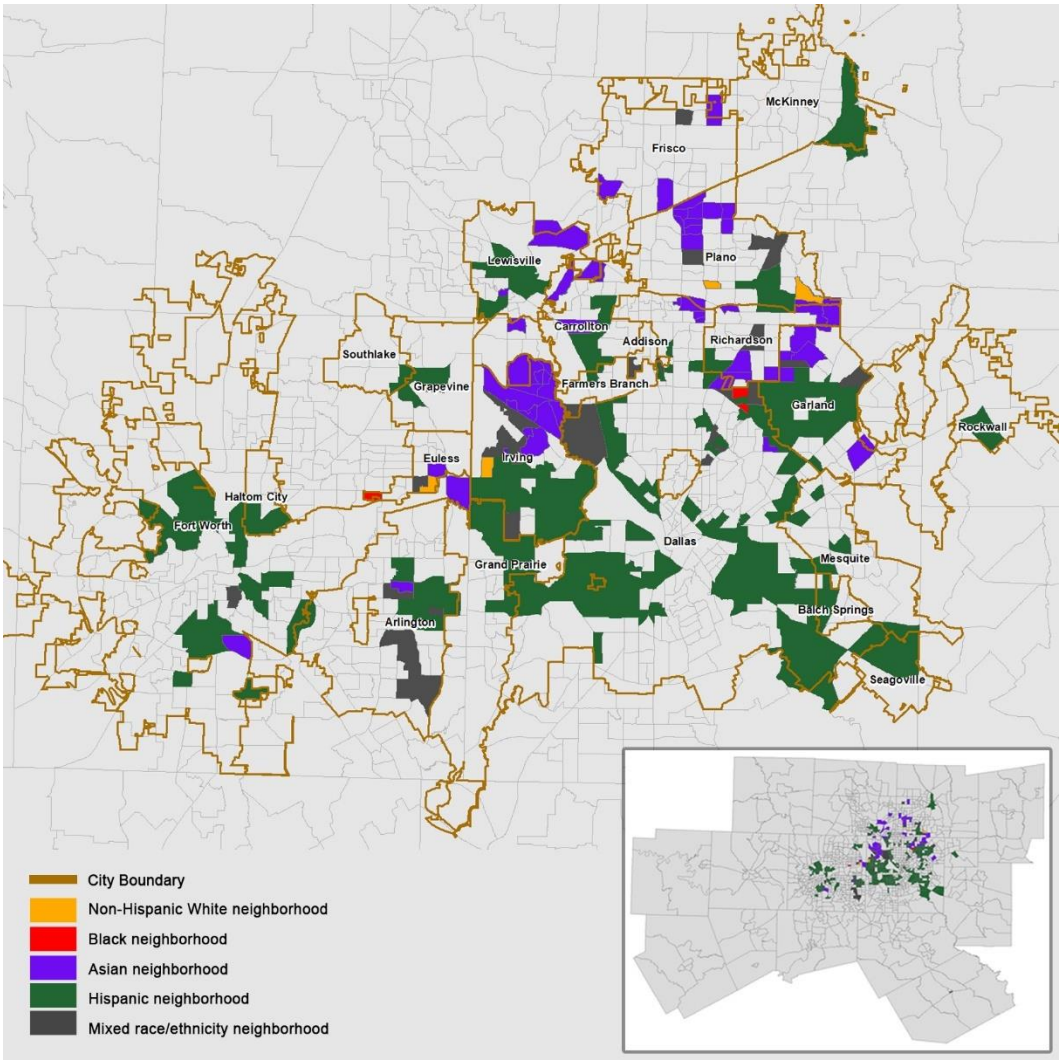


Figure 5-3. Immigrant neighborhoods by race/ethnicity

Figure 5-4 shows maps of immigrant neighborhoods by race and ethnicity, while Table 5-4 shows the mean, minimum, and maximum of each racial/ethnic neighborhood's characteristics. With only four census tracts, non-Hispanic white immigrants' neighborhoods are second smallest and are dispersed in such a way that none of them neighbor another.

The average median household income in these tracts is $52,139, and 68% of housing is renter occupied. The lowest percentage of whites (53%) in the non-white immigrant neighborhoods means that non-white immigrants are less segregated from other racial/ethnic groups. The cities where each tract is located are Euless, Irving, and Plano.

There are 234 tracts that comprise Hispanic immigrants' neighborhoods, which is the largest number of tracts of any ethnicity in the study area. Most of these tracts are adjacent to one another and cluster into groups. Most of those clusters are located in Dallas, Fort Worth, Irving, Arlington, and Garland. The percentage of Hispanic persons in Hispanic neighborhoods show the highest degrees of ethnic homogeneity (the data show a mean value of 87%, maximum of 100%, and minimum of 50%) compared with the same ethnic proportions of other ethnic immigrant neighborhoods. Thus, Hispanic individuals tend to reside with other Hispanics and not with members of other minority groups. Also, Hispanic immigrant neighborhoods have disproportionately poor economic and physical conditions. The mean of median household income is the highest ($120,568) among immigrant neighborhoods, but the gap between low and high household income values in Hispanic immigrant tracts is extensive. This indicates that the neighborhoods in which Hispanic immigrants live are, in general, disadvantaged economically. The condition of the built environment in these neighborhoods also shows

disparity (e.g., median years of development of built structures, number of grocery stores in the tract).

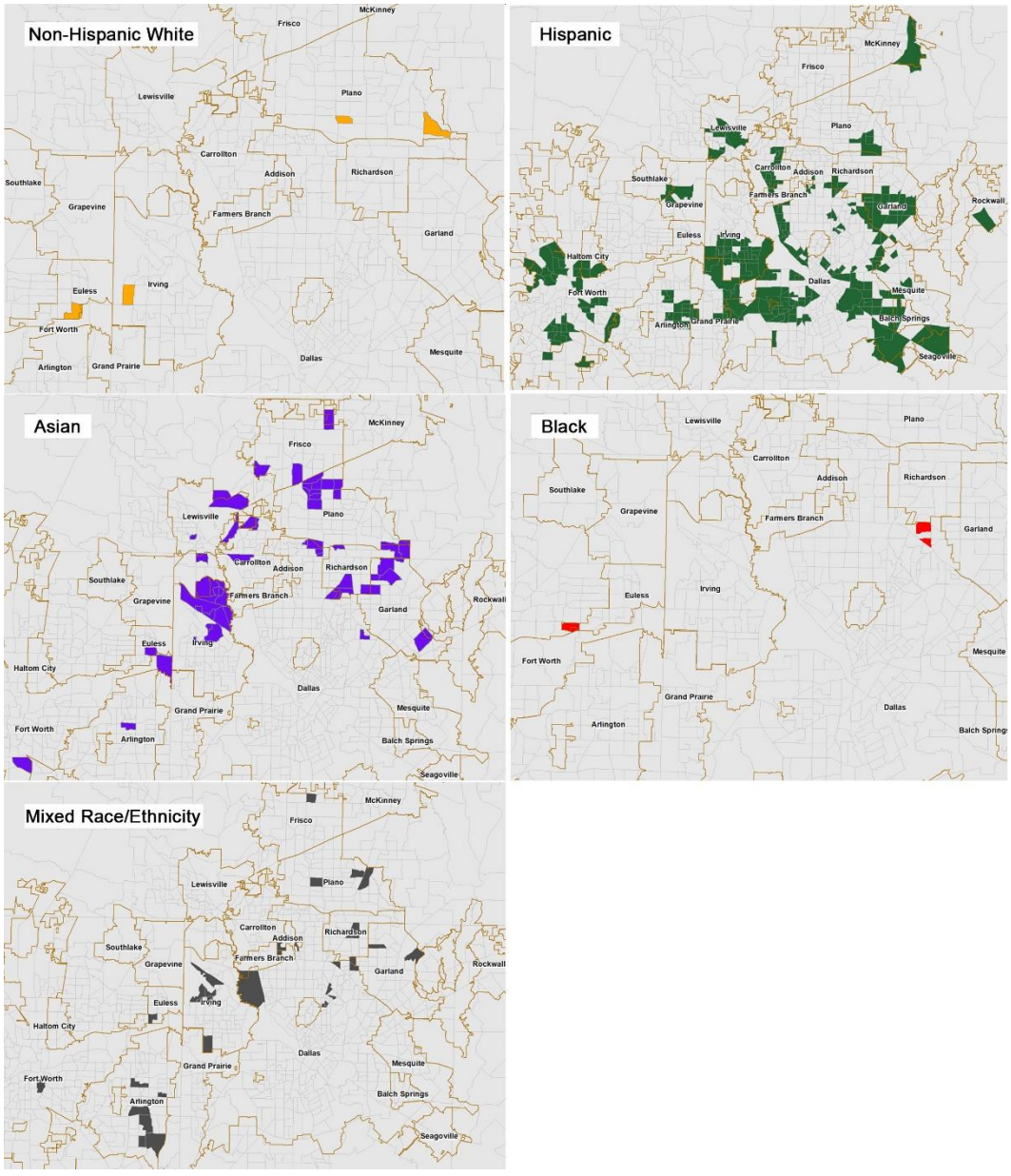


Figure 5-4. Ethnic immigrant neighborhoods in North Texas

Table 5-2. Statistical descriptive of ethnic immigrant neighborhoods (tracts)

	Non-Hispanic White			Black			Asian		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Total Population	5,349	6,398	3,970	5,541	6,065	4,677	4,947	9,734	1,595
Immigrant Concentration Index	1.36	2.00	1.15	1.15	1.15	1.15	2.07	3.33	1.54
Median Household Income	52,139	57,525	44,722	34,845	38,843	31,467	115,278	135,833	77,674
Urban Area Ratio	1	1	1	1	1	1	1	1	1
Median Year Built	1985	1987	1984	1980	1983	1975	2008	2010	1992
% of Renter Housing	63%	94%	31%	87%	97%	76%	14%	92%	8%
Number of Grocery Store	1	2	0	2	4	1	1	6	0
Number of Public Transit Stop	7	11	0	9	20	0	0	7	0
% of White	53%	59%	50%	21%	33%	13%	18%	38%	5%
% of Black	8%	21%	1%	66%	72%	61%	6%	27%	0%
% of Asian	32%	39%	27%	10%	25%	1%	70%	93%	50%
% of Hispanic	35%	43%	18%	17%	22%	12%	11%	39%	1%
Total Tracts		4			3			52	

	Hispanic			Mixed Race/Ethnicity		
	Mean	Max	Min	Mean	Max	Min
Total Population	5,010	11,920	1,102	5,354	19,354	1,039
Immigrant Concentration Index	1.96	3.32	1.50	1	2	1
Median Household Income	120,568	190,707	75,663	54,496	125,257	20,457
Urban Area Ratio	0.93	1	0	1	1	1
Median Year Built	1996	2011	1971	1985	2007	1956
% of Renter Housing	28%	59%	5%	65%	100%	17%
Number of Grocery Store	1	7	0	3	19	0
Number of Public Transit Stop	1	5	0	17	111	0
% of White	68%	99%	6%	33%	48%	17%
% of Black	3%	40%	0%	17%	42%	1%
% of Asian	7%	44%	0%	36%	49%	16%
% of Hispanic	87%	100%	50%	33%	48%	11%
Total Tracts		234			31	

Asian immigrants' neighborhoods in North Texas contain a total of 52 census tracts. There are clusters of Asian immigrant communities in Irving, Carrollton, and Plano. The economic and physical conditions in Asian immigrant neighborhoods are, in general, better than other immigrant neighborhoods. Relative to other immigrant neighborhoods, Asian immigrant neighborhoods are characterized by newer built environments. The average of the median years of built structures in Asian immigrant neighborhoods is 2008. The percentage of housing occupied by renters is the lowest among all ethnic groups (14%) and the mean of median household income ($115,278) is relatively high, followed by Hispanic immigrant neighborhoods. Asians account for 70% of the residents in these neighborhoods, which is the second highest level of homogeneity after Hispanic immigrant neighborhoods. The high percentage of Asians in these neighborhoods suggests that Asian immigrants more likely settle with others from the same racial/ethnic group.

Black immigrants' neighborhoods are comprised of three census tracts (two tracts in Dallas and one tract in Euless). These neighborhoods' economic and physical conditions are poorer than other immigrant neighborhoods. For example, black immigrant neighborhoods have the lowest average median household income ($34,845) among ethnic immigrant neighborhoods, and there is only a slight gap between the maximum ($38,843) and minimum ($31,467) incomes in these black neighborhoods. This implies that black immigrant neighborhoods in North Texas are the most disadvantaged of all immigrant neighborhoods. Furthermore, black neighborhoods tend to have older infrastructure, with the median year of built structures being 1980, and 87% of the housing in these neighborhoods is renter occupied. Many other studies corroborate this data regarding the inferior economic conditions in black neighborhoods. Osypuk et al (2009) found that racially segregated black neighborhoods consistently have greater

concentrations of poverty. Black immigrants experience poverty at a rate 2.6 times greater than whites, and extreme long-term poverty is more common among black people in these areas (Bloome, 2014).

5.2.2 Food accessibility in immigrant neighborhoods

A trip to the grocery store is one of the most important activities for immigrants. People can access to healthy food using various modes of transportation, including public transit, walking, and biking. However, some immigrants face barriers that stymie their use of public transit. For instance, limited service hours may affect the accessibility of transit, despite the fact that immigrants are major customers of public transportation. The goal of this section is to determine whether there are accessible grocery stores and public transit stops in North Texas immigrant neighborhoods.

Grocery stores generally have low thresholds and small market ranges. Researchers view grocery shopping as a local activity, and these businesses are often owned and operated by members of ethnic minority groups (Wang and Lo, 2007; Li, 1998). For immigrants, the cultural meaning behind particular shopping places might be more important than their size and location. Culture seems to play a critical role in immigrants' choice of stores and use of retail outlets. For example, immigrants who live outside of ethnic commercial enclaves have been observed traveling to more distant ethnic stores. Thus, immigrant shopping patterns are characterized by cultural and spatial complexity, and drive development of new economic and cultural geography (Li, 1998; Barnes, 2003). However, scholars have devoted little attention to the role of culture and ethnicity in spatial behavior, even though marketing scientists and geographers have studied the ethnicity of consumers extensively. Only a few studies on individuals' travel decisions and the cultural characteristics of their destinations have considered ethnicity as a possible factor in travel decisions (Cervero et al, 1999; Murdie, 1965).

This dissertation examines immigrant travel behavior and the effect that living in an immigrant neighborhood has on that behavior. Thus, the accessibility of grocery stores

for residents of immigrant neighborhoods is more relevant than travel decisions and the cultural characteristics of a person's destination. This dissertation treats accessibility as a significant factor for spatial behavior with regard to two elements of travel: spatial separation and destination attractiveness. Figure 5-5 shows the locations of grocery stores and supercenters (department stores) in North Texas to determine which immigrant neighborhoods are spatially segregated from food access. According to ReferenceUSA data regarding NAICS code 445110 (supermarkets and other grocery stores), there are a total of 3,244 shopping places in the study area (3,085 grocery stores and 159 supercenters). Here, grocery stores include ethnic retail stores, grocery stores (such as Kroger and ALDI), and convenience stores. Supercenters refer to larger-sized grocery stores and department stores (such as Walmart and Target).

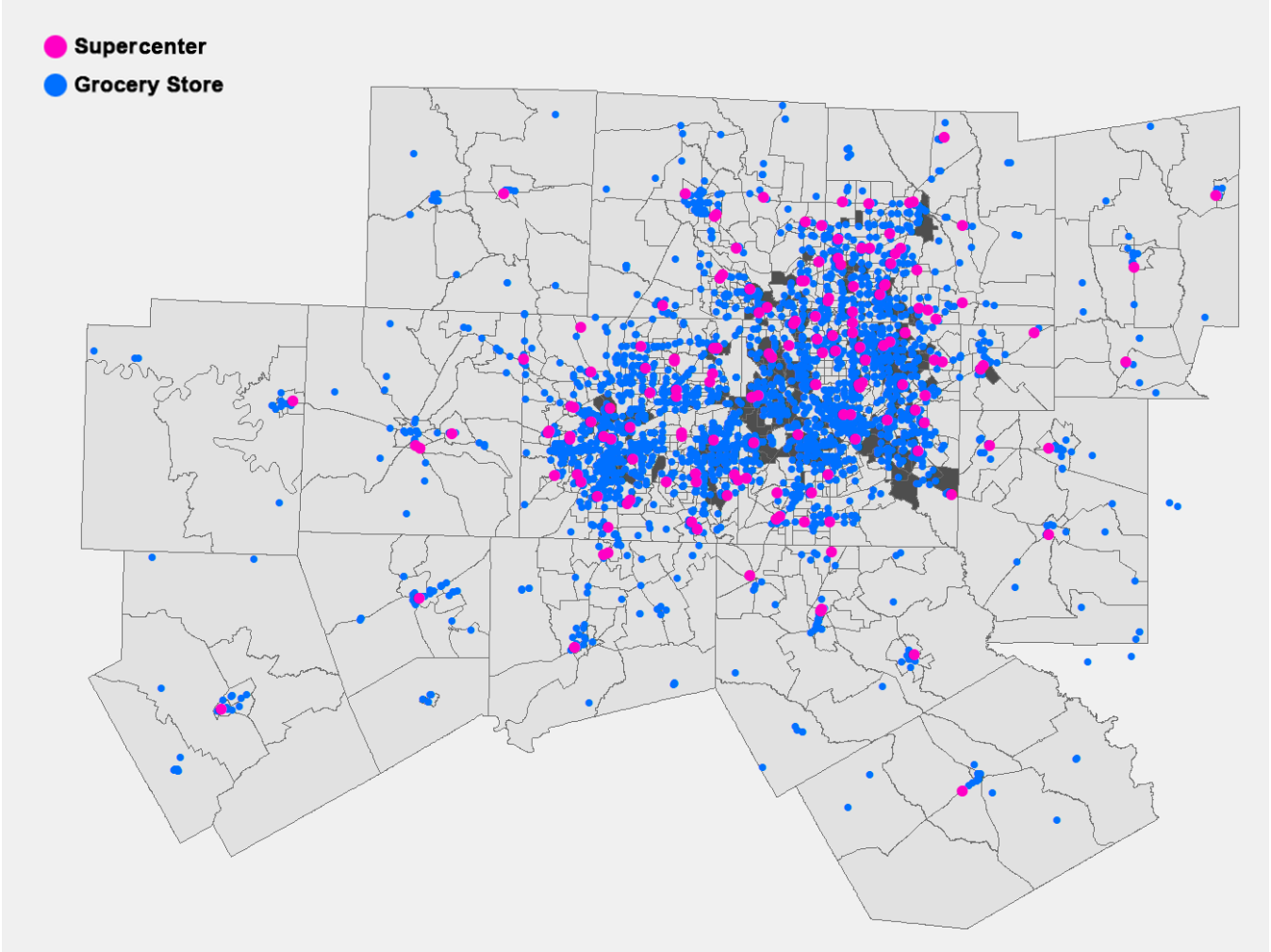


Figure 5-5. Locations of grocery stores and super centers in North Texas

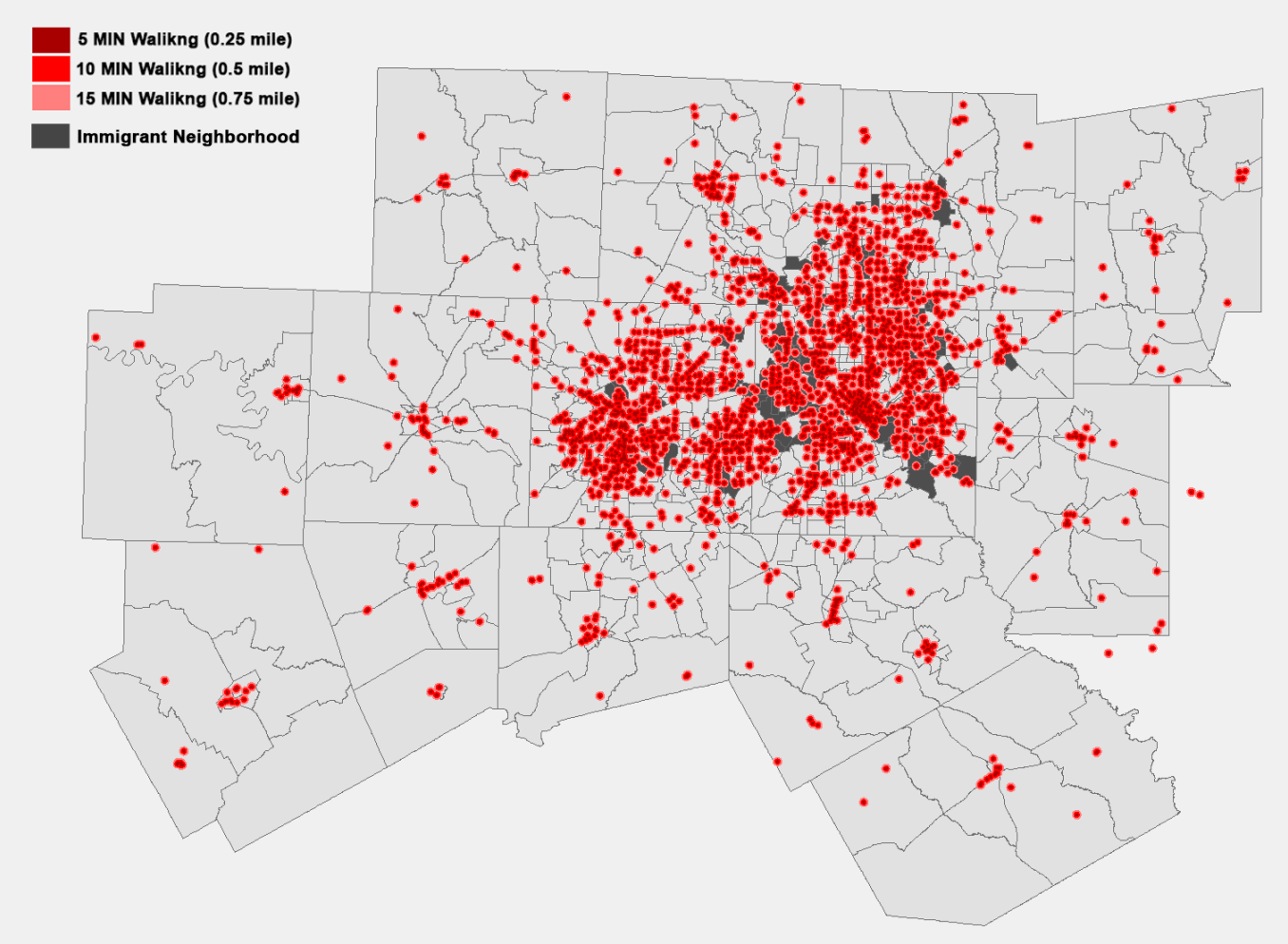


Figure 5-6. Accessibility to grocery stores by walking

Most immigrants have several grocery stores in their neighborhoods. The immigrant neighborhoods that have the most grocery stores (with a total of 19 grocery stores) in North Texas are in census tract number 99 in Dallas county. This tract includes mixed racial/ethnic immigrant neighborhoods with a high ICI of 2.24. Considering the low threshold and narrow service area of grocery stores, urban immigrants more likely to walk or bike to access local grocery stores in their neighborhoods. According to Atash (1994), a comfortable walking distance for the average American is under 0.25 miles (about a 5 min walk). Using this data, I determined the walking accessibility of grocery stores in immigrant neighborhoods. Figure 5-6 exhibits data regarding the accessibility of grocery stores which are within a 5, 10, or 15 minute walk. A small portion of immigrant neighborhoods do not have any grocery stores which are within walking distance.

Unlike local grocery stores, the service area of a supercenter is far more extensive. The U.S. Department of Agriculture reports that about 23.5 million people live further than one mile from a large grocery store or supercenter in the US (Ver Ploeg et al.,2009). Thus, access to supercenters using alternative modes of transportation seems to be limited within the study area. By considering data regarding the convenience of public transit and personal vehicles to access supercenters, one can estimate the accessibility of supercenters. Research shows that a convenient driving distance is approximately 10 miles, or a 17.9 minute drive (Colabianchi et al., 2007). Using public transit takes on average 1.4-2.6 times longer than driving a car to reach any given destination (Liao et al., 2020). As shown in Figure 5-6, residents in immigrant neighborhoods can access supercenters in 17.9 minutes by car. In most immigrant neighborhoods, except fragments of two Hispanic immigrant neighborhoods in Collin and Dallas county, residents can travel to supercenters by public transit (with the caveat that public transit must be available in the area).

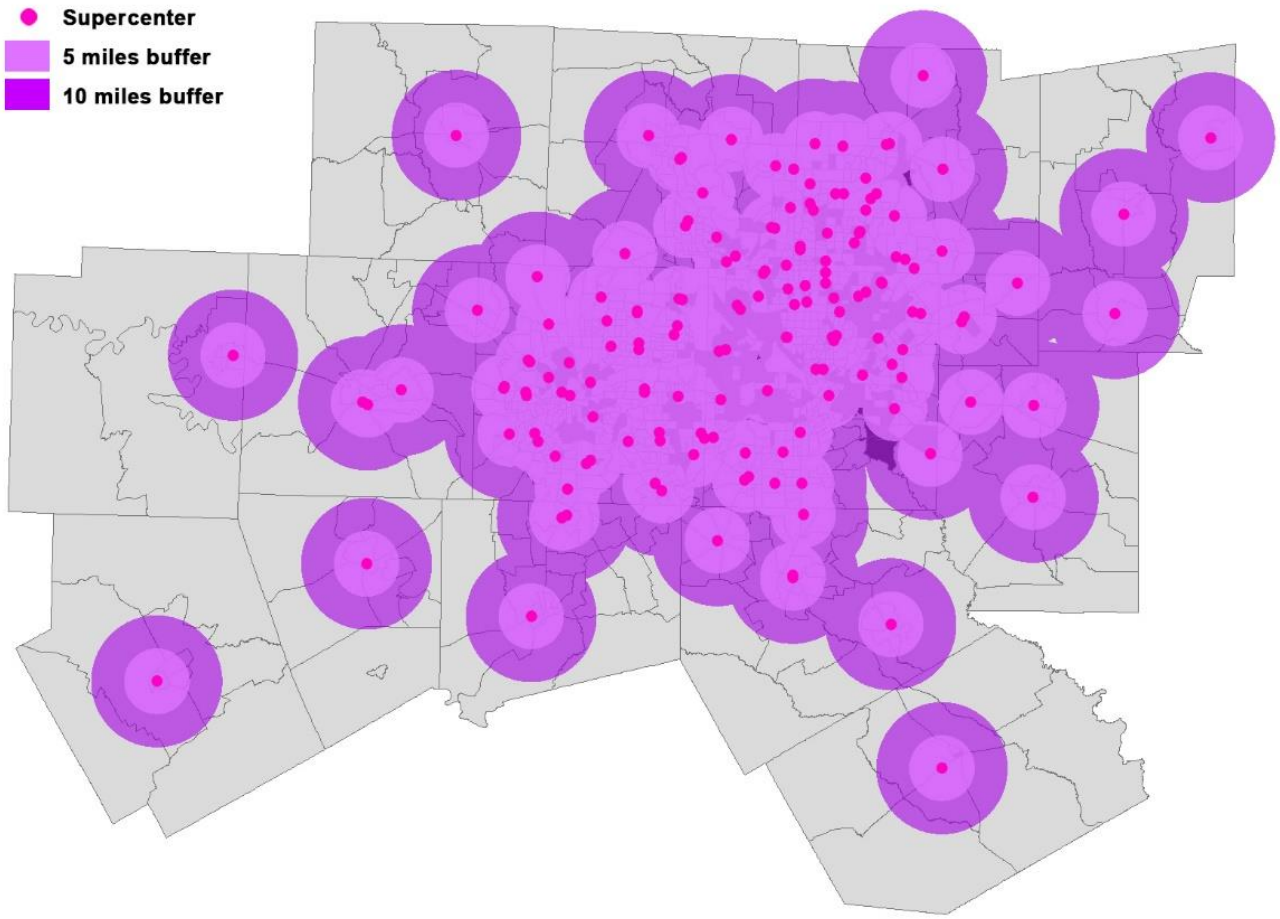


Figure 5-7. Accessibility to supercenters (department stores)

5.2.3 Accessibility of public transit in immigrant neighborhoods

Public transportation plays a critical role in ensuring the accessibility of activities and services. Immigrants have an inextricable relationship with public transit; their usage rate of public transportation is remarkably higher than that of non-immigrants (Smart, 2015; Kim, 2009; Blumenberg and Evans, 2010; Blumenberg and Smart, 2010, 2014). Moreover, from a sustainable city development perspective, mass mobility and quality of life for urban-dwelling individuals can be improved by establishing public transportation networks that are accessible to pedestrians within a reasonable walking distance. Understanding factors that influence walking distances to public transportation hubs is a key element of establishing equitable access to this service.

As seen in Figure 5-8, transit stops in the North Texas area are common in urban cores, particularly in the central regions of Dallas, Tarrant, and Denton counties. The spatial distribution of public transit stops is reflected in the access time to reach transit services on foot. Data show that the average walking distances to access rail-based transportation are typically longer than those to access buses. Generally, it is a 5 minute walk to road-based transit and a 10 minute walk to reach rail-based transportation (Daniels and Mulley, 2013; Bok and Kwon, 2016). However, it is important to understand that walking distances vary based on individual users' characteristics. For instance, pedestrians might use pedestrian-only corridors to reduce their walking distance or take a longer path due to road conditions or safety concerns. Figure 5-8 displays the geographic distribution of public transit catchment areas within 10 and 20 minute walks in North Texas immigrant neighborhoods. Most immigrant neighborhoods are within a 20 minute walk to public transit (including road- or rail-based transit or both). The majority of immigrant neighborhoods are located in Dallas county, which has a well-established

public transportation system with broad service areas. Unlike the ease of access to public transit in Dallas county, some immigrant neighborhoods in Tarrant and Collin county cannot access public transit by foot. For example, immigrant neighborhoods in Arlington do not have access to proper public transit services. According to the General Transit Feed Specification (GTFS) dataset, there is only one bus stop (at TCC southeast campus) in Southeast Arlington. Moreover, these transit services are only available on weekdays.

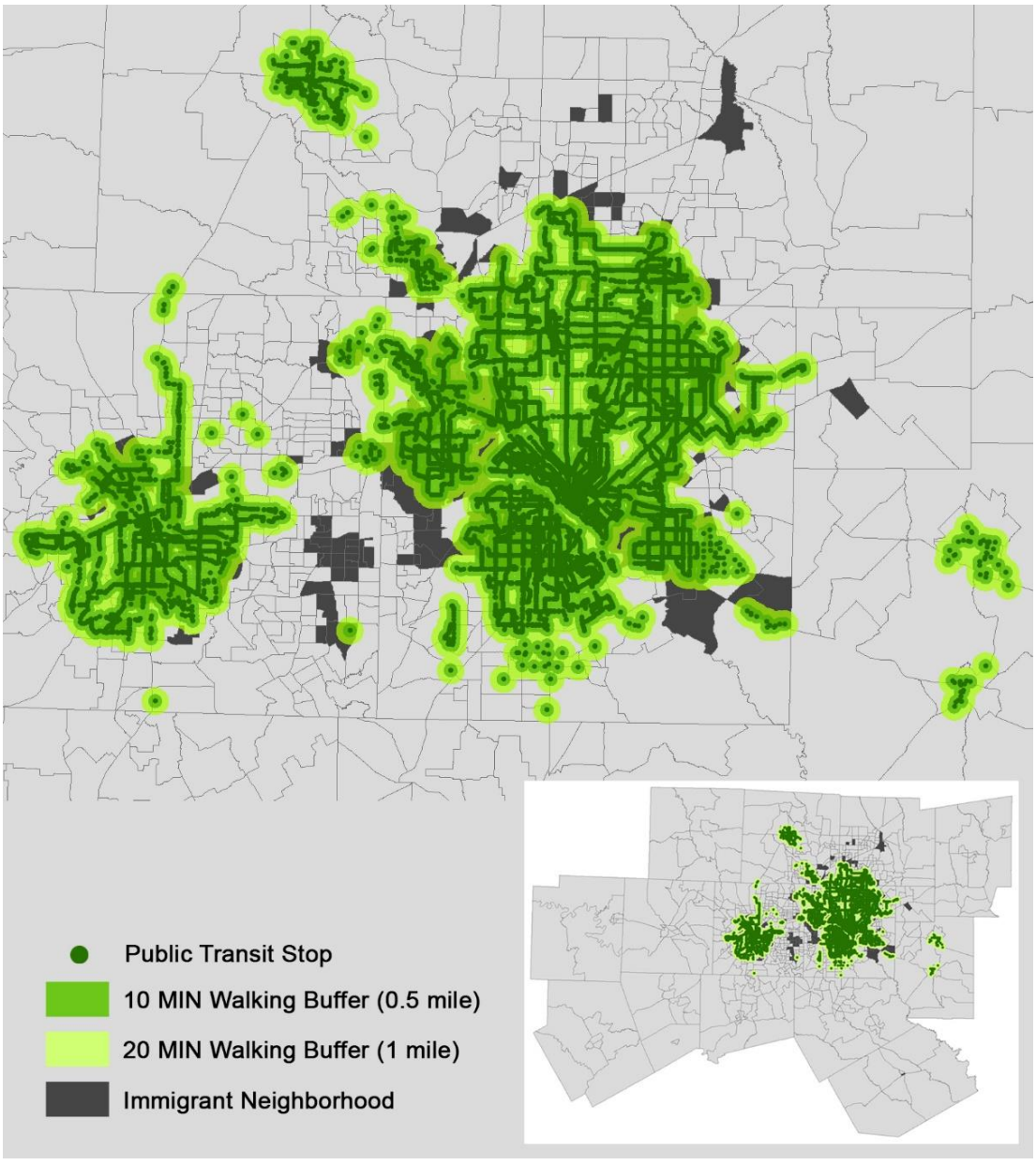


Figure 5-8. Accessibility to public transit

5.3 Summary

The neighborhood is an important element of immigrant life. Especially for immigrants who have just arrived in the US, immigrant neighborhoods allow migrants time to adapt to their new country by providing enclaves of familiar culture and language, separate from the majority population. Furthermore, immigrant neighborhoods fill recent immigrants' needs for affordable housing, ethnic foods, and job opportunities. The spatial location of immigrants from similar backgrounds also closely connects with their social, cultural, and economic integration into the host society (Anderson, 2015). Segregation is a natural part of the "spatial assimilation" process (Massey, 1985; Logan et al.,2002).

This chapter shows the geography of immigrant neighborhoods in North Texas. I identify immigrant neighborhoods using the relative immigrant concentration in a census tract with reference to data regarding North Texas immigrants as a whole. The majority of immigrant neighborhoods are in urban areas of Dallas county. As past studies demonstrate, North Texas immigrant neighborhoods are located in city centers, where immigrants have easy access to various modes of transportation, services, and foods. One can observe clear racial/ethnic segregation within immigrant neighborhoods. Most immigrant neighborhoods have a majority population from a particular race/ethnicity, except mixed race/ethnicity neighborhoods (which make up 9.6% of the total immigrant neighborhoods).

Each ethnic immigrant neighborhood has distinct socioeconomic characteristics. In North Texas, Hispanic neighborhoods and Asian neighborhoods tend to be economically affluent. Asian immigrant neighborhoods have a relatively newer built environments and the lowest percentage of renter-occupied housing (an average of 14%). Black immigrant neighborhoods are the most disadvantaged; these neighborhoods have the lowest median household income, oldest built environment, and highest

percentage of renter-occupied housing (an average of 87%). However, black immigrant neighborhoods have the best accessibility to public transit services. The results of the spatial autocorrelation test reveal that non-white immigrant neighborhoods and black immigrant neighborhoods are spatially separate from other immigrant neighborhood clusters (Figure B-6 in Appendix B).

The next chapter explains this dissertation's overall analysis of the effect a neighborhood has on immigrants' choice of transportation by applying a multilevel multinomial logit model.

Chapter 6

The Effect of Neighborhoods on Immigrant Travel Behavior

In this chapter, I test whether the immigrant neighborhoods discussed in the previous chapter influence their immigrant residents' travel behavior, while remaining cognizant of the effect of individual and household characteristics. The first section in this chapter explains the dataset at the individual, household, and neighborhood levels, and details indicators of social networks in neighborhoods. Next, this section describes the dataset process before running the model. Due to the limitations of the dataset, the carsharing and ridesharing modes of transportation were combined into the private vehicle mode. Thus, in this dissertation, the private vehicle mode does not necessarily indicate that a person drives alone. In the next section, I introduce my methodology (multinomial logit), comparing other possible methodologies that could be used to test the hypothesis. Furthermore, this section addresses the final model methodology (multilevel multinomial logit) and process. I apply the multilevel multinomial logit (MML) to examine the data by using STATA with gsem (generalized structural equation model) and mlogit syntax. The final section shows the results of this analysis at each level with significant variables on mode choice. This section comprises four separate models: the base, social network, built environment, and final models.

6.1 Dataset

6.1.1 Social networks in immigrant neighborhoods

Settling in the US involves overcoming many challenges for newly arrived immigrants, such as finding residence, getting a job, taking public transportation until they

have their own vehicles, and nationalization. Immigrant neighborhoods play an important role for newly arrived immigrants. Due to language and cultural barriers, government resources are not generally accessible to all immigrants. Most immigrants rely on themselves or their neighborhood resources; they often use informal networks for assistance and obtain information from their co-racial/ethnic neighbors. A well-established network among residents in areas with high immigrant concentrations meet the newly arrived immigrants' basic needs, such as affordable housing, work, and a familiar cultural environment. This social network is a primary resource for immigrants to obtain basic necessities and is a requirement for survival (Vega et al., 1991; Duncan and Waldorf, 2009; Logan et al., 2002). Immigrants rely on social networks most heavily during the early stages after immigration, and their legal status (US citizenship) is also proportional to the length of time they have resided in the US. By examining immigrants from the Caribbean islands in New York, Duncan and Waldorf (2009) found that social networks and immigrant neighborhood characteristics affect immigrants' propensity to obtain US citizenship. These tendencies are related to the size and maturity of the immigrant enclave in the immigrant's neighborhood. Previous studies in immigrant neighborhoods use several variables to measure social networks. For example, researchers examine contact frequency with friends and family (Vega et al., 1991), the percentage of the population in the neighborhood that is co-racial/ethnic (Shin, 2017; Abramson et al., 2006; Elliot & Sims, 2001), and the maturity of immigrant enclaves (Duncan and Waldorf, 2009) to measure social networking.

This dissertation uses ICIs, neighborhood match with individual race/ethnicity, and the maturity of immigrant enclaves as social network variables. The ICIs and

maturity of immigrant enclaves indicate the size and level of social networks in immigrant neighborhoods.

6.1.2 The dataset

This dissertation combines several datasets to test how immigrant neighborhoods affect their immigrant residents' travel behavior. The first dataset is a confidential, geocoded version of the 2017 National Household Travel Survey (NHTS) in North Texas. I applied the 2017 NHTS add-on for Texas (North Central Texas Council of Government, 2017), utilizing tract-level geographic identification rather than the newer version of 2017 NHTS in county level, to perform neighborhood level analysis in the meaningful neighborhood unit. This 2017 NHTS dataset provides detailed travel information for individual and households, including immigrant status, and is geocoded to the census tract level. Thus, the combined dataset contains the travel data information of households and individuals within households, and the socioeconomic and physical characteristics of neighborhoods that influence immigrants' daily travel behavior.

The 2017 NHTS data for North Texas includes information regarding more than 66,600 daily trips by 19,961 individuals from a total of 8,997 households. The daily trip data includes the general purpose of the trip (i.e., home- or non-home-based trip for shopping, recreation, or work), time of drop off at public transit, travel time (AM or PM), number of non-household members on the trip, public transit use as part of the trip, travel day, trip distance, and so on. Individual and household data regarding daily travel is specific to individuals within households, such as the number of drivers in the household, total number of trips, number of household members, number of vehicles in the household, trip distance, number of workers in the household, and race and ethnicity of the drivers, as well as their immigrant status, income, and so on. The trip data for individuals and households is derived from 1,055 census tracts in 12 counties located in

North Central Texas. I obtained neighborhood-related data from multiple data sources (including the 2017 American Community Survey from the U.S. Census, Reference USA, and the U.S. Department of Transportation) and computed as required.

Table 6-1 shows the definitions of the variables used in this dissertation. The dependent variable is the mode of transportation immigrants choose for their trips, which I have categorized as “1” for private vehicle, “2” for public transit, and “3” for walking and biking. Out of 64,520 trips, immigrants comprised 12% of the total number of trips. I categorized the independent dataset into three levels: individual, household, and neighborhood. The individual data contains characteristics of the immigrants and their trip information, as well as the degree to which the racial or ethnic composition of their neighborhoods matches with their race or ethnicity. I restricted the analysis to the purpose of the trip (i.e., commuting, shopping, and social or recreation activities) and individual characteristics of the person making the trip (including their age, race/ethnicity, gender, educational level, and immigrant status). Household data includes information about household size, economic status, and the number of people in a household who drive. In order to control the great number of neighborhood factors, I combined 2017 U.S. Census American Survey data at tract level, ReferenceUSA retail data and GTFS public transit data with the 2017 NHTS add-on for Texas. This allowed me to test the effect of residing in immigrant neighborhoods on immigrants’ travel behavior, controlling for a number of factors that influence individuals’ travel behavior.

The pivotal explanatory variables for immigrants’ neighborhoods are ICI, neighborhood match (Nmatch), and enclave maturity (maturity). One can use the ICI, coupled with population density data, to explain the size of immigrant neighborhoods. An enclave's maturity is a measurement of the percentage of previously naturalized immigrants who live in the same neighborhood. The maturity index refers to the level of

social networks in the neighborhood. Lastly, the neighborhood matching index can be used to determine whether an individual lives in a co-racial/ethnic group or not.

Table 6-1. Variable definitions

Variable		Description
Dependent Variable		
transmode		Transportation mode: 1= private vehicle, 2= public transit, 3= walk & bike
Independent Variable		
Trip	trpmiles	Trip distance in miles
	nonhhm_trp	number of non HHM on trip / number of people on trip including respondent
	whytrp_commu	Travel purpose_commute: 1= yes, 0= no
	whytrp_shop	Travel purpose_shopping: 1= yes, 0= no
	whytrp_social	Travel purpose_social/recreation: 1= yes, 0= no
Individual	age	Age (years)
	driver	Driver status: 1= yes, 0= no
	educ	Education status: 1= less than highshcool, 2= highschool graduate, 3= some college or associate degree, 4= Bachelor's degree, 5= Graduate dgree or professional degree
	gender	Male= 1, Feamle= 0
	borninus	Non-immigrant= 1, immigrant= 0
	yrtous	Year of entering to US: Non-immigrant=0, 2017-2013=1, 2012-2008=2, Before 2007=4
	white	White: 1= yes, 0= no
	black	Black: 1= yes, 0= no
	asian	Asian: 1= yes, 0= no
	hisp	Hispanic: 1= yes, 0= no
	Nmatch	Matching individual's race/ethnicity with ethnic neighborhood: 1= yes, 0= no

	Variable	Description
Household	homeown	Home own: 1= owner, 0= renter
	hhsize	Count of household members (range 1-15)
	hhv/hhs	number of household vehicle/ number of household member
	hhinc	household income: 1= less than $10,000, 2= $10,000 to $14,999, 3= $15,000 to $24,999, 4= $25,000 to $34,999, 5= $35,000 to $ 49,999, 6= $50,000 to $74,999, 7= $75,000 to $99,999, 8= $100,000 to $124,999, 9= $125,000 to $149,999, 10= $150,000 to $199,999, 11=$200,000 or more
	hhdriver	number of drivers in household
Neighborhood	urbrur	Are type where household located: 1= urban, 0= rural
	workdensity	Workers per square mile in the census tract
	perrenter	Percent of renter-occupied housing in the census tract
	housdensity	Housing units per square mile in the census tract
	popdensity	Population density (persons per square mile) in the census tract
	medhhinc	Median household income in the census tract
	bb1970	% of structure built before 1970
	ICI	Immigrant Concentration Index
	maturity	Enclave maturity: % of immigrants naturalized (among total immigrants)
	num_groc	number of grocery market in census tract
	num_pts	number of public transportation stops in census tract
	near_scdist	distance (mile) nearest super center from the center of the census tract
	near_ptsdist	distance (mile) nearest public transportation stop from the center of the census tract

Table 6-2. Descriptive statistics by immigrant status

	Variable	Immigrant (15% of households)	Non-immigrant (85% of household)
transmode	Private Vehicle	89.8%	91.5%
	Public Transit	2.0%	1.9%
	Walk & Bike	8.2%	6.6%
Trip	trpmiles (mean)	7.88	8.48
	nonhhm_trp (mean)	0.07	0.08
	whytrp_commu	52.4%	48.1%
	whytrp_shop	15.5%	18.3%
	whytrp_social	14.7%	17.8%
Individual	age (mean)	44.2	47.0
	driver	90.1%	86.3%
	educ	3.5	3.3
	gender (% female)	50.9%	53.7%
	yrtous (median)	1998	-
	white	45.9%	86.2%
	black	8.6%	10.4%
	asian	37.5%	2.4%
	hisp	30.9%	9.0%
	Nmatch	46.2%	45.3%
Household	homeown (% renter)	30.2%	20.4%
	hhsize (mean)	3.2	2.7
	hhv/hhs (mean)	0.77	0.94
	hhinc (mean)	6.6	7.1
	hhdriver (mean)	2.1	2.0
Neighborhood	urbrur (% urban)	95.7%	92.0%
	workdensity (mean)	2288.05	1772.97
	perrenter (mean)	37.41	31.45
	housdensity (mean)	1826.29	1423.08
	popdensity (mean)	4388.77	3400.32
	medhhinc (mean)	83587.49	83096.62
	bb1970 (mean)	0.15	0.18
	ICI (mean)	1.17	1.13
	maturity (mean)	0.46	0.47
	num_groc (mean)	2.55	2.44
	num_pts (mean)	8.09	7.21
	near_scdist (mean)	1412.23	1602.35
	near_ptsdist (mean)	2626.62	3855.97
	N trips	7,831	56,689
	N individual	1,980	13,737
	N household	1,286	7,517
	N neighborhood	706	1,260

Table 6-2 shows the descriptive statistics for individuals, households, and neighborhoods by immigrant status. The variables shown in the Table 6-2 are included in the models used this dissertation. In the 2017 NHTS add-on for Texas, 15% of the respondents are immigrants and 85% are US born. Immigrants who appeared in 2017 NHTS survey use public transit (2%) and walk and bike (8.2%) more than non-immigrant respondents. They are also less dependent on private vehicles than non-immigrants. This parallels other researchers' findings, as discussed in Chapter 2 of this dissertation; the rate of use for alternative modes of transportation (including transit, walking, biking, and carpooling) is noticeably higher among immigrants than the US-born population (Smart, 2015; Kim, 2009; Blumenberg and Evans, 2010; Blumenberg and Smart, 2010, 2014).

While both groups use public transit to a slight extent, both groups walk and bike over three times more than they take public transit. The difference in average travel miles travelled between both groups is small, but the non-immigrant group has slightly longer average trips than the immigrant group. The immigrant group also has a somewhat higher average level of educational attainment (i.e., the average is between some college or an associate and bachelor's degree), but lower household income (less than $75,000) than the non-immigrant group. The proportion of race is the most distinguishing factor between immigrants and non-immigrants. Although the immigrant group has significantly higher Asian and Hispanic ethnicities than its counterparts, the share of white individuals is roughly half. Notably, residing in areas with co-racial/ethnic populations is common in both the immigrant and non-immigrant groups.

Around half of immigrants and non-immigrants live in the same racial/ethnic neighborhoods. On average, immigrant households have worse financial conditions than non-immigrant households. Immigrant households also have a larger average household

size (3.2 persons), fewer vehicles per household member (0.77), and rent at higher rates (30.2%) than non-immigrants.

The majority of both groups live in urban areas, with 95.7% of immigrant households and 92% of non-immigrant households in urban settings. Immigrant neighborhoods are common in city centers and have high population density and transit accessibility. Moreover, immigrant residential concentrations often overlap with employment site concentrations because immigrants are likely to work in the same industry sector (Logan and Alba, 2002; Bohon, 2005). The neighborhoods in which immigrants have settled in the dataset tell a similar story. These neighborhoods have higher worker density (2,288 workers per square mile), higher percentages of renter-occupied housing (37.41%), higher housing density (1,826 housings per square mile), higher population density (4,389 persons per square mile), more grocery stores (2.55), more public transit stops (8.09), and shorter distances to supercenters than their counterparts' areas. Remarkably, there are no significant differences between the average ICIs and maturity indexes in immigrant and non-immigrant neighborhoods.

6.2 Methodology

6.2.1 Multinomial Logit (MNL)

The multinomial logit (MNL) model predicts the probability of category membership on a dependent variable based on multiple independent variables. MNL is a simple extension of the binary logit model that allows for more than two categories of the dependent or outcome variables. When the scope of application and the popularity of logit model increased, the MNL model was introduced independently by Cox (1966) and Thiel (1969). Then Daniel McFadden linked the multinomial logit to the qualitative choice theory (discrete choice theory). Transportation research was a big motivation from the beginning of the MNL model. For example, when Thiel (1969) introduced his theory on the multinomial extension of the linear logit model, he used the transportation mode choice as an example of applying the MNL model. McFadden (1973) included an empirical application section to illustrate the MNL method; he used results from shopping trip mode and destination decisions to study travel demand models.

There are pros and cons of applying the MNL model for mode choice in transportation planning. As noticed in a brief history of the MNL model, research on transportation planning, itself, is a significant purpose of the MNL model. In this context, by far, the most tractable, most accessible, and widely used of available choice models is the MNL model. The MNL model can use categorical and unordered dependent variables; so, the outcome can choose from various choice options of transportation mode (drive alone, car sharing, public transit, walk, and bike). Second, the MNL model provides probabilities for outcomes independently. The most natural interpretation of logistic regression models is in terms of odds and odds ratios. As an example, consider transportation modes for a commute. There are three possible travel modes: car, mass

transit, and bike. Choosing a car as the reference, then the odds of mass transit versus car and the odds of bike versus car are provided in MNL model results. Thus, researchers can easily get individual probabilities of selected transportation mode by comparing other transportation mode choice.

MNL model also has faults and shortcomings for transportation planning. First, the MNL model is basically nonbehavioral. It reproduces the results of conditions existing at the time of the data collected. And it provides little or no guidance to the effects on travel decisions of changes in travelers' circumstances or the terms upon which they are offered to compete for alternatives in the transportation environment. Second, the MNL model in transportation planning is not policy-oriented. There is essentially no interaction between system performance and the choices of trip frequency or trip destination. Third, the MNL model is based on data. As an example, the MNL model in the neighborhood-level would require obtaining the specific locations of origins and destinations and extensive data gathering to get an accurate and reliable estimation. However, aggregated neighborhood-level data have a limitation, such as difficult to match individual characteristics due to data limitation. This limitation in data makes the MNL model very difficult to generalize. Despite several shortcomings, the MNL model is the most widely used transportation choice mode because of its simple mathematical structure and more straightforward estimation and interpretation.

The statistical limitation of the MNL model can be avoidable by applying the multinomial probit (MNP) model, the nest logit (NL) model, or the generalized nested logit (GNL) model as an alternative. While the MNP model is rarely used in application due to complexity in computation, estimation, and difficult interpretation, the NL model introduced by Williams (1977) is the most widely known relaxation of the MNL model. The NL model includes intermediate branches that group alternatives, whereas the MNL

model treats all alternatives equally (Figure 6-1). The grouping of alternatives indicates the degree of sensitivity (cross-elasticity) among alternatives.

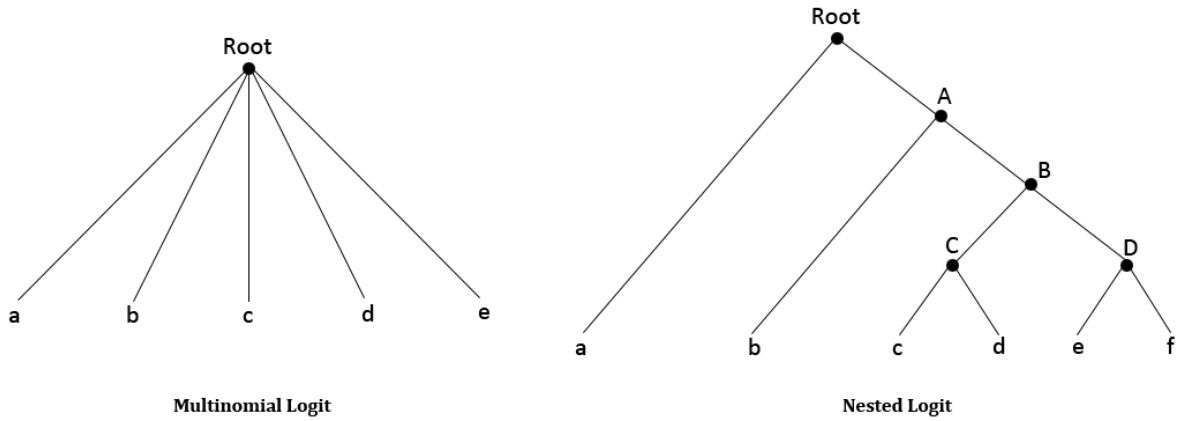


Figure 6-1. Structure of MNL model tree and NL model tree

Alternatives in a typical nest show the same degree of increased sensitivity than alternatives not in the nest. The differences in structure can result in dramatically different mode ridership projections and divisions than those obtained by the MNL model in cases where the NL logit model is significantly different from the MNL model (Forinash and Koppelman, 1993). Researchers who applied the NL model for their studies need to estimate proper structures to avoid getting inaccurate results due to model structure. For example, Forinash and Koppelman (1993) applied the NL model to estimate intercity mode choice (train, air, bus, and car) for travel in the Ontario-Quebec. There are 16 two-level and 12 three-level NL structures among four available alternatives. They considered the six two-level structures with train nested and examined all obtained structures to find the best fit structure to the data.

The NL model's limitations are rooted in that each alternative can be included in the intermediate branch; thus, there are too many structures to examine to find the best fit structure. The generalized nested logit (GNL) model addresses this problem by using allocate proportions of alternatives to different nests (Koppelman and Sethi, 2005). Thus, the GNL model can approximate any multi-level NL model by including a nest, which corresponds to each node in the nested logit (Figure 6-2).

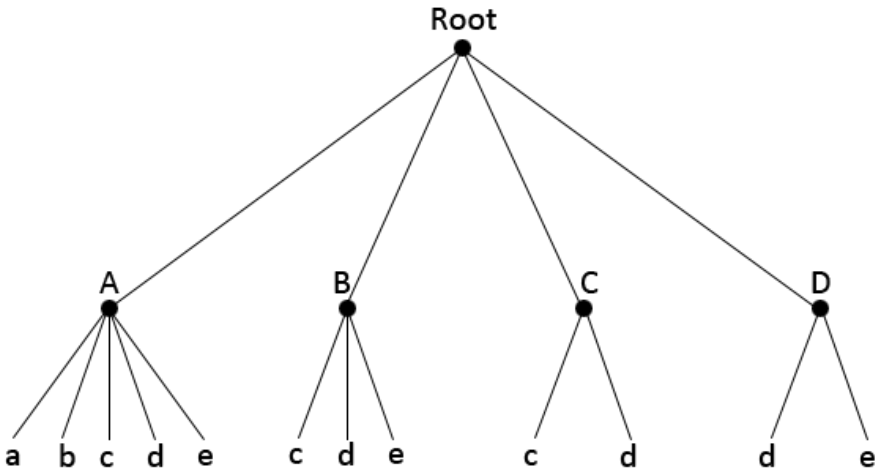


Figure 6-2. Structure of GNL model tree

The GNL model adds useful flexibility by providing a more flexible structure for estimating differential cross-elasticities among pairs of alternatives. GNL model provides a structural framework for exploring alternatives cross-elasticity structures without necessarily estimating a large number of distinct models as required in the estimation of the NL model (Wen and Koppelman, 2001).

6.2.2 The models: Multilevel Multinomial Logit (MML)

This dissertation conducts a multilevel multinomial logit model (MML) to estimate the effects of individual characteristics, household characteristics, and their neighborhoods' socioeconomic and physical characteristics for diversity on immigrant travel mode choice in North Texas. The multilevel multinomial modeling approach is appropriate for two reasons:

First, multinomial logit (MNL) analysis is better than a series of binary logit analyses in that it uses data more efficiently. Although estimates from binary logit provide consistent estimates of the multinomial logit model parameters, the former approach involves a large number of comparisons. For example, with three categories, such as the type of transit mode choice in this dissertation, four comparisons should be made in the binary logit model, whereas the multinomial logit model requires only two comparisons.

Second, multilevel models are useful when data has a nested structure in which we cannot maintain the assumption that each observation behaves independently irrespective of its upper group. If a researcher uses the traditional linear regression approach to estimating parameters, the researcher neglect the upper-level effects that differ by upper-level type on the observations subjected to the upper group. Another benefit of the multilevel model is to reduce the statistical problems associated with the traditional linear regression model (Raudenbush and Bryk, 1986; Lee and Bryk, 1989; Duncan et al., 1993). Thus, the multilevel multinomial approach is appropriate for this dissertation with the nested data with a multinomial outcome.

MML analysis requires three levels of models in this dissertation: (a) individual-level effects, (b) household-level effects, and (c) neighborhood-level effects on immigrant travel mode choice for a given trip, with the outcomes of interest being the choice to use an alternative travel mode (public transit, biking and walking) instead of driving.

This dissertation uses four MML models to test each level's characteristics (trip, individual, household, and neighborhood-level) influence on residents' travel mode choice. The first model is a base model that expresses individual immigrant status effects on travel mode choice while controlling other individual variables (such as gender, race/ethnicity, and trip miles) and household variables. The second and third models add neighborhoods' specific properties to examine whether the added attribute is primary on travel mode choice. The second model adds the social networking effect on mode choice. The third model tests the effect of built environments on residents' travel mode choice by adding the neighborhood's physical characteristics. Comparing with the full (final) model, how the added aspects (social networking in model 2 and built environment in model 3) influence the residents' mode choice. The final model, the comprehensive model, accounts for neighborhood socioeconomic and physical attributes effect on travel mode choice.

6.3 Results

As mentioned in the previous section, 6.2 Methodology, the first model employs immigrant status variable with control variables. The second model adds social networking variables in the individual and neighborhood levels to test the effect of social networks in neighborhoods. Social networks are estimated by ethnic neighborhood matching with individuals' race/ethnicity, immigrant concentration index, and enclave maturity. The third model adds built environment variables in the neighborhood level to examine how the neighborhood's physical characteristics influence residents' travel mode choice. The built environment's explanatory variables are the area type of neighborhood(urban or rural), housing unit density, percentage of structures built before 1970, number of grocery stores, number of public transit stops, distance to the nearest supercenter, and distance to the nearest public transit stop. The final model adds neighborhood socioeconomic and physical characteristics as additional control variables. These four models run separately to obtain relatively clear answers of neighborhood effects on immigrant travel behavior, where existing research does not provide.

Although the result tables do not provide R^2 or pseudo R^2, the log-likelihood can contribute as a convenient measure of goodness-of-fit of any model (Hunt, 2008)[3]. Hunt (2008) states that AIC (Akaike Information Criterion) has some concerns that may unduly favor models of high complexity, and BIC (Bayes Information Criterion) is sometimes used to avoid over-fitting. Thus, most alternatives rely on the log-likelihood as a

[3] I use a STATA 16 program for this MML analysis. And the result tables refuse to give an R^2 or pseudo R^2. The official STATA website says that it is because an R^2 or pseudo R^2 may not be the best measurement to test the goodness-of-fit of the model on some technical ground.

measurement of model fit. Comparing the log-likelihood of models can help determine an optimal model for the analysis; the higher value of log-likelihood is the better.

6.3.1 MML model fit

The results of four models (Table 6-3), overall, perform well and support the hypothesis that neighborhood socioeconomic and physical characteristics affect an individual's travel behavior. The Log-likelihood of Model 4 (-11725.169) is the biggest than other models. Thus, the comprehensive model (Model 4), including all neighborhood control variables, has better goodness-of-fit. Notably, the built environment of neighborhoods predicts better the odds of choosing travel mode than social networks in neighborhoods, according to log-likelihood values of model 2 and model 3.

Before discussing the effect of neighborhood characteristics in detail. I first focus on the overall importance of neighborhood on trip mode choice. By running the MML models using a combination of gsem (generalized structural equation model) and mlogit syntax, this syntax uses the latent variable M0, M1, M2, and M3 to define the group level variances. A random effect is included in four MML models by incorporating latent variables at the group level; these are the latent variables M1 (neighborhood level), M2 (household level), and M3 (individual level). M0 is the trip level as the reference level.

As shown in Table 6-3, the M1 variables' coefficient is estimated to be considerably smaller than the other models' coefficient. So, household-level and individual-level variables are certainly more primary than neighborhood-level in explaining individuals' trip mode choice. However, neighborhood-level variables are 1.2 times more critical than trip-level variables to explain residents' travel mode choice, as reported by the odds ratio of M1.

Table 6-3. Model goodness-of fit and level importance

Model 1 (Base)			
Log likelihood	-11990.787		
	Coeff.	OR	Std. Err.
var(M0[trip])	Reference Level		
var(M1[neighborhood])	0.244	1.276	0.094
var(M2[household])	4.201	66.777	0.270
var(M3[individual])	2.026	7.581	0.179
Model 2 (Social Networks)			
Log likelihood	-11986.964		
	Coeff.	OR	Std. Err.
var(M0[trip])	Reference Level		
var(M1[neighborhood])	0.249	1.283	0.094
var(M2[household])	4.189	65.954	0.269
var(M3[individual])	2.020	7.541	0.179
Model 3 (Built Environment)			
Log likelihood	-11741.491		
	Coeff.	OR	Std. Err.
var(M0[trip])	Reference Level		
var(M1[neighborhood])	0.202	1.224	0.09287
var(M2[household])	4.235	69.055	0.275
var(M3[individual])	2.021	7.548	0.182
Model 4 (Full)			
Log likelihood	-11725.169		
	Coeff.	OR	Std. Err.
var(M0[trip])	Reference Level		
var(M1[neighborhood])	0.167	1.181	0.09005
var(M2[household])	4.198	66.527	0.273
var(M3[individual])	2.024	7.566	0.182

Note: Coeff. = Coefficient; OR = Odds Ratio; Std. Err. = Standardized Error

Table 6-4 through 6-7 present the result of four multilevel multinomial logit models of the travel mode choice categorized three modes: private vehicle, public transit, and walk and bike. The reference mode is a private vehicle.

6.3.2 Trip level effect on travel mode choice

All trip-level variables are potent predictors of non-motorized mode (walk & bike) choice with statistically significant. In contrast, only trip purpose variables are essential in public transportation choice over private vehicles.

As shown Table 6-4, public transportation choice is negatively associated with trip purposes. The odds ratios of all trip purpose variables are statistically significant at the 0.01 level but are smaller than 1. It implies that people with some trip purposes, such as commuting, shopping, and recreational and social gathering, less likely to choose public transportation over private vehicles.

Walk and bike mode choice, however, is positively associated with commute purpose and social/recreation purpose (Table 6-6). While the odds ratios of other trip-level variables (trip distance in miles, the ratio of non-household members per people on the trip, and shopping purposes) are smaller than 1, the two trip purpose variables' odds ratios are bigger than 2. According to this result, people want to commute 2.3 times more, and people have social and recreational purposes 3.2 times more likely to use non-motorized mode than private vehicle mode. However, the odds ratio of shopping purposes (0.39) says that people travel for shopping have 61% decrease in the odds of using public transit for their travel rather than private vehicles. Moreover, people who travel long distances and travel with more non-household members, are less likely to choose public transportation over private vehicles.

6.3.3 Individual level effect on travel mode choice

The influence of individual characteristics is shown in some variables with statistically significant. Without neighborhood related effect, the key individual predictors of mode choice of public transit are shown in model 1 (Table 6-4). Statistically significant variables are shown below.

- Age
- Driver status (driver=1)
- Gender (female=1)
- Immigrant status (immigrant=1)
- Arrival year to United States
- White (white=1)

Specifically, aged residents, residents who have a driver's license, non-immigrants, and recent immigrants are less likely to choose public transportation than private vehicles. Likewise, Myers (1997) and Kim's (2009) findings of that females are less likely toward public transit or carpooling for travel, North Texas female residents (odds ratio of 0.71) also have 29% less likely to use public transit than private vehicles. Individuals' immigrant status also positively influences on choice of alternative mode (public transit, walking, and biking) in North Texas. Immigrants in North Texas 2.3 times more likely to use public transit and 4.1 times more likely to use non-motorized mode over private vehicles.

Race/ ethnicity is one of the influential factors to explain different travel behavior. However, one variable among Individual race/ethnicity variables is worth mentioning in this model: the dummy variable of the white. The white race shows significance at 0.01 level in public transit mode choice. Its odd ratio (0.45) says that white residents have 55%

decrease in the odds of using public transit for their travel rather than private vehicles. In other words, other racial residents, who are not whites, use public transportation roughly 2 times higher than private vehicles.

Findings from California immigrants indicate that public transit dependence is most visible among Hispanic immigrants (Blumenberg and Shiki, 2007; Blumenberg and Evan, 2010; Cline et al., 2009; Lovejoy and Handy, 2008). However, this dissertation results reveal that Hispanic ethnicity is not a significant predictor in explaining public transit choice in North Texas: the Hispanic variable is not statistically significant, and the odds ratio is less than 1 (Table 6-4).

Regarding choice of non-motorized mode (walk & bike) than private vehicle, different variables are observed comparing choice of public transit (Table 6-6). Influential predictors are:

- Driver status (driver=1)
- Education level
- Gender (female=1)
- Immigrant status (immigrant=1)
- Arrival year to United States

These variables are statistically significant in 0.01 level, except arrival years to US (significant at 0.5 level), to explain individuals' choice of walk & bike over private vehicles. Driver's license holders, females, immigrants who arrived in the US earlier, and non-immigrant are less likely to choose a non-motorized mode than a private vehicle. Immigrant status is notably significant in the choice of non-motorized mode. North Texas immigrants are 3.7 times more likely to use walking and biking for their trip than private vehicle modes.

Surprisingly, education status has a positive influence on the choice of walk & bike mode. More educated persons are 1.3 times more likely to use walking & biking than private vehicles. It might be explained by the relationship between walking and biking and concerns on health and the environment. A higher education level predicts better physical and mental health (Vable et al., 2020) and is positively related to eco-friendly attitude (Bopp et al., 2011). Thus, the relationship between non-motorized mode, health, and attitude on the environment can explain the non-motorized mode choice of higher educated people; walking and biking make them increase physical activity and have a less environmental impact.

6.3.3 Household level effect on travel mode choice

Regarding the influence of household characteristics, three variables are powerful predictors of travel mode choice with statistically significant. The pivot household variables are:

- Home owned household (owner=1)
- Household size
- Ratio of household vehicles per household members

Based on Model 1 (Table 6-6), these three variables exceed a significant level of 0.01. As expected, home owned households, larger sized households, and households with more household vehicles per household members are less likely to choose public transit for their travels over private vehicles. In particular, the odds ratio of the household vehicles per household member variable (0.315) is the smallest among the three variables. It means an increase in one unit of the household vehicles per household members variable significantly reduces the likelihood of using public transportation than the impact of a one-unit increase of the other two variables (home owned household and

household size). For example, households having more household vehicles per household members are 68% less likely toward public transit, while larger sized households are 32% decrease the likelihood of using public transit than private vehicles. Moreover, home owned households are 43% less likely to use public transportation than a private vehicle, while renter households 1.77 times more likely to choose public transit for their travels. Two significant variables show that households are how economically affluent to buy a house and enough vehicles per household member. However, surprisingly, the direct indicator of buying ability (household income) is not a significant variable to explain public transit versus car choice.

The result (Table 6-6) shows influential variables of household on the choice of walk & bike mode are the same as that on the choice of public transit, under controlling neighborhood-related variables. For non-motorized mode, however, the variable with the smallest odds ratio is home owned households, in contrast to the household vehicles variable on the choice of public transportation. That is, renter households show a better likelihood of using non-motorized modes than households with fewer household vehicles per household member. Furthermore, the least likely to choose walking and biking is shown in larger sized households: households with more household members are 23% less likely to choose walking and biking than private vehicle mode for their travel.

6.3.4 Neighborhood level effect on travel mode choice

Even though neighborhoods' overall importance is less than a households' and individuals' characteristics to explain residents' mode choice, some neighborhood-level's variables are shown in statistically significant on travel mode choice.

First, social networks influence only the choice of public transportation observed in Model 2 (Table 6-4 and Table 6-6). The critical variables to explain social networks in

neighborhoods is immigrant concentration index (ICI). As mentioned in descriptive statistics by immigrant status in this chapter (section 6.1.2.), public transit users take a small proportion among all immigrants. However, public transit is still an essential transportation mode for immigrants until they are eligible to own their private vehicles. Extant researches also find that residents in immigrant concentrated neighborhoods are more likely to carpool and to use public transit (Smart, 2015; Liu and Painter, 2008)

The result shows that social networks in immigrant neighborhoods influence residents' mode choice between public transit and private vehicles by contacting co-racial/ethnic groups; however, its effects are unexpected. Among three social networking indicators, only one variables of immigrant concentration index (ICI) show statistically significant at 0.10 level, but its odds ratio values are less than 1. The odds ratio of ICI is 0.62. The result implies that North Texas residents, who live in neighborhoods with higher immigrant concentration are 38% less likely to choose public transit than private vehicles. This unexpected effect of social networks may have come from the transportation mode category in this dissertation. As shown in Table 3-5, private vehicle mode includes rental cars and taxi (including Uber or Lyft), due to a lack of sufficient carsharing and ridesharing mode data. Thus, I predict that residents in those neighborhoods share the process of ridesharing (e.g., Uber, Lyft) or carsharing (e.g., rental car such as Zipcar), rather than the information of public transits.

Second, the neighborhood's physical condition also encourages to use alternative modes of transportation than cars, and influential variables are more observed in the choice of public transit than walk & bike. Meaningful variables of built environment clarifying public transit usage are:

- Percentage of structure built before 1970
- Number of public transits stops in a neighborhood

- Density of housing units in a neighborhood[4]

Past studies find that living in dense urban environments with proximity to public transit infrastructure positively impacts transit use (Shen, 2000; Giuliano, 2003). Easy access to public transit service, defined by the number of transits' stops in this analysis, enhances the transit use among residents. Also, more dense neighborhoods may provide more transit ridership options and competitive transportation by transportation system improvement.

The result of model 3 (Table 6-5) shows similar findings with past studies. However, the result shows that estimated impacts are not sizable magnitude; the odds ratio of two variables, density of housing units and percentage of structures built before 1970, are marginally larger than 1. North Texas residents who live in neighborhoods with a higher density of housing units and a higher number of public transit stops are more likely to use public transit than private vehicles. However, the model predicts residents living in neighborhoods with aged built environments have 37% decrease in the odds of using public transit.

Regarding walking and biking mode choice, only the density of housing units is statistically significant at the 0.01 level. The benefits of a dense residential area can predict it in terms of transportation mode choice. Dense residential areas provide more destinations, such as K-12 schools, restaurants, and grocery stores. Furthermore, retail

[4] U.S. census defines the housing unit as a house, an apartment, a group of rooms, or a single room as a separate living quarter. Thus, the density of housing units means the density of residents. For example, residents may take a small proportion of the neighborhoods' population, with a higher density of mixed-use building units.

destinations (e.g., cafes, dry cleaners, convenience stores) in these areas are located within a shorter distance of residences (Kackar & Preuss, 2013). With destinations close by, residents in dense neighborhoods can walk and bike at least some of their daily travel (especially commuting and grocery shopping) due to fewer travel miles and better street and road conditions.

Third, model 4 shows the impact of entire neighborhood characteristics on travel mode choice (Table 6-5 and 6-7). Prominent neighborhood variables impacting on public transit mode choice are:

- Workers density in a neighborhood
- Density of housing units in a neighborhood
- Median household income in a neighborhood
- Percentage of structure built before 1970
- Immigrant concentration index
- Number of public transits stops in a neighborhood

These six variables are statistically significant, have slightly unexpected direction, and most are of a small sizable magnitude.

Considering having better access to a private vehicle (including ridesharing and carsharing in this analysis) reduces the odds of using public transit, the estimated effect of workers' density is predicted to decrease public transit usage. Residents in worker-intensive neighborhoods can easily find multiple commuters sharing the proximate trip origin and destination. It influences the increased likelihood of ridesharing or carsharing than public transit. For instance, Choldin (1972) finds that 25% of workers in ethnically affluent neighborhoods get the help of transportation needs from friends, co-workers, and neighbors by examining Chicago data. Moreover, Yu (2016) reports that some employers provide free commuting services to their employees in the labor-intensive ethnic

neighborhoods, and cheaper chinses taxis are popular informal travel mode in New York City.

As expected, the impact of workers density in the neighborhood is negative on public transit usage, and residential density is associated with the likelihood of public transit choice. Two variables, the immigrant concentration index and the percentage of structure built before 1970, show the meaningful magnitude and statistically significant. North Texas residents in neighborhoods with higher immigrant concentration are 45% less likely to choose public transit relative to a private vehicle, when residents in neighborhoods with older built structures are 38% less likely to walk and bike than private vehicles.

Important neighborhood variables having impacts on walk and bike mode are:

- Density of housing units in a neighborhood
- Percentage of renter-occupied housing in a neighborhood
- Median household income in a neighborhood

The results (Table 6-7) indicate that the odds ratio in the non-powered mode is almost 1.0 and no increase in odd numbers. Despite the small effect of neighborhoods, variables of the percentage of rental houses (OR= 1.008), housing density (OR= 1.0003), and household median income (OR= 1.000007) in neighborhoods are positively associated with pedestrian and bicycle modes than private vehicles. For example, an increase of one unit in the density of housing units variable results in a 0.8% increase in walk and bike mode choice than a private vehicle.

The effect of median household income in the neighborhoods shows the most unexpected result. Previous studies find that people living in lower-income households must use other forms of transportation (such as public transit, walk, and bike) and get help from others, including friends, co-workers, and neighbors, to work. However, this

analysis result shows that people living in higher-income areas are more likely to use walk and bike mode. The unexpected effect of the high-income neighborhoods on mode selection can be inferred that better road conditions (including well-paved bike paths) and transportation infrastructures (e.g., road signs, traffic lights, streetlights) in the high-income areas might encourage residents to ride a bicycle or walk more.

The finding suggests that residents in dense residential, higher percentage renter-occupied, and higher median household income neighborhoods are more likely to use walk and bike mode for their daily travel, but the effect is not visibly sizable.

Table 6-4. Determinants of Mode Choice: Private Vehicle (reference) vs. Public Transit: Model 1 vs. Model 2

		Model 1				Model 2			
		Base				Social Networks			
		Coeff.	Sig.	Z	Odd Ratio	Coeff.	Sig.	Z	Odd Ratio
Trip	trpmiles	-0.003		-1.25	0.997	-0.003		-1.23	0.997
	nonhhm_trp	0.094		0.45	1.099	0.096		0.46	1.101
	whytrp_commu	-0.337	***	-3.86	0.714	-0.337	***	-3.87	0.714
	whytrp_shop	-1.714	***	-9.74	0.180	-1.719	***	-9.76	0.179
	whytrp_social	-1.347	***	-8.63	0.260	-1.347	***	-8.63	0.260
Individual	age	-0.018	***	-4.91	0.982	-0.018	***	-4.91	0.982
	driver	-3.635	***	-20.1	0.026	-3.626	***	-20.06	0.027
	educ	0.045		0.79	1.046	0.043		0.75	1.044
	gender	-0.344	***	-3.75	0.709	-0.344	***	-3.75	0.709
	borninus	0.767	*	1.75	2.154	0.778	*	1.77	2.177
	yrtous	-0.310	*	-1.82	0.734	-0.307	*	-1.81	0.736
	white	-0.810	***	-3.9	0.445	-0.807	***	-3.83	0.446
	black	0.205		0.87	1.227	0.185		0.78	1.203
	asian	-0.147		-0.57	0.864	-0.119		-0.46	0.887
	hisp	-0.070		-0.43	0.932	-0.088		-0.53	0.915
	Nmatch					-0.035		-0.28	0.965
Household	homeown	-0.571	***	-4.05	0.565	-0.550	***	-3.86	0.577
	hhsize	-0.387	***	-5.75	0.679	-0.385	***	-5.72	0.681
	hhv/hhs	-1.154	***	-6.55	0.315	-1.164	***	-6.58	0.312
	hhinc	0.005		0.18	1.005	0.015		0.57	1.015
	hhdriver	0.140		1.35	1.150	0.137		1.32	1.147

	urbrur							
	workdensity							
	perrenter							
	housdensity							
	popdensity							
	medhhinc							
Neighborhood	bb1970							
	ICI				-0.479	*	-1.66	0.620
	maturity				-0.501		-1.58	0.606
	num_groc							
	num_pts							
	near_scdist							
	near_ptsdist							
Constant		0.578		1.59	1.783	1.286	**	2.51	3.618
var(M1[neighborhood])		0.244		0.114	1.276	0.249		0.119	1.283
var(M2[household])		4.201	***	3.704	66.777	4.189	***	3.693	65.954
var(M3[individual])		2.026	*	1.703	7.581	2.020	*	1.698	7.541
Log likelihood				-11990.787				-11986.964	

Note: Coeff. = Coefficient; OR = Odds Ratio

*The asterisks identify significance; *p<0.10; ** p< 0.05; *** p<0.01*

The number of observations is (n= 61,413)

Table 6-5. Determinants of Mode Choice: Private Vehicle (reference) vs. Public Transit: Model 3 vs. Model 4

		Model 3				Model 4			
		Built Environment				Full			
		Coeff.	Sig.	Z	Odd Ratio	Coeff.	Sig.	Z	Odd Ratio
Trip	trpmiles	-0.003		-1.22	0.997	-0.003		-1.21	0.997
	nonhhm_trp	0.171		0.81	1.187	0.187		0.89	1.206
	whytrp_commu	-0.334	***	-3.78	0.716	-0.334	***	-3.79	0.716
	whytrp_shop	-1.714	***	-9.63	0.180	-1.727	***	-9.68	0.178
	whytrp_social	-1.377	***	-8.72	0.252	-1.382	***	-8.74	0.251
Individual	age	-0.014	***	-3.91	0.986	-0.014	***	-3.84	0.986
	driver	-3.605	***	-19.79	0.027	-3.569	***	-19.6	0.028
	educ	-0.010		-0.18	0.990	-0.022		-0.37	0.978
	gender	-0.346	***	-3.73	0.708	-0.345	***	-3.72	0.708
	borninus	0.720		1.63	2.054	0.742	*	1.68	2.100
	yrtous	-0.321	*	-1.88	0.726	-0.323	*	-1.88	0.724
	white	-0.807	***	-3.83	0.446	-0.814	***	-3.82	0.443
	black	0.153		0.64	1.165	0.134		0.55	1.143
	asian	-0.117		-0.45	0.890	-0.098		-0.37	0.907
	hisp	-0.106		-0.64	0.899	-0.087		-0.52	0.917
	Nmatch					-0.021		-0.17	0.979
Household	homeown	-0.319	**	-2.14	0.727	-0.294	*	-1.89	0.745
	hhsize	-0.328	***	-4.81	0.720	-0.318	***	-4.64	0.727
	hhv/hhs	-1.143	***	-6.4	0.319	-1.139	***	-6.35	0.320
	hhinc	-0.007		-0.26	0.993	-0.019		-0.68	0.981
	hhdriver	0.131		1.25	1.140	0.127		1.21	1.135

	urbrur	-0.142		-0.54	0.868	-0.100		-0.37	0.905
	workdensity					-0.0003	*	-1.88	0.9997
	perrenter					0.001		0.28	1.001
	housdensity	0.000	***	4.39	1.000	0.0005	***	3.45	1.001
	popdensity					0.000		-0.59	1.000
	medhhinc					0.000	**	1.97	1.000
Neighborhood	bb1970	-0.469	*	-1.81	0.626	-0.479	*	-1.69	0.620
	ICI					-0.604	**	-2.05	0.547
	maturity					-0.561		-1.43	0.571
	num_groc	0.021		0.87	1.021	0.021		0.89	1.021
	num_pts	0.013	***	3.65	1.013	0.011	***	3.28	1.012
	near_scdist	0.000		1.28	1.000	0.000		1.4	1.000
	near_ptsdist	0.000		-0.43	1.000	0.000		-1.09	1.000
Constant		0.092		0.19	1.096	0.774		1.12	2.169
var(M1[neighborhood])		0.202		0.082	1.224	0.167		0.058	1.181
var(M2[household])		4.235	***	3.729	69.055	4.198	***	3.695	66.527
var(M3[individual])		2.021	*	1.695	7.548	2.024	*	1.696	7.566
Log likelihood		-11741.491				-11725.169			

Note: Coeff. = Coefficient; OR = Odds Ratio

*The asterisks identify significance; *p<0.10; ** p< 0.05; *** p<0.01*

The number of observations is (n= 61,413)

Table 6-6. Determinants of Mode Choice: Private Vehicle (reference) vs. Walk & Bike: Model 1 vs. Model 2

		Model 1				Model 2			
		Base				Social Networks			
		Coeff.	Sig.	Z	Odd Ratio	Coeff.	Sig.	Z	Odd Ratio
Trip	trpmiles	-1.282	***	-47.55	0.278	-1.282	***	-47.54	0.277
	nonhhm_trp	-0.416	**	-2.51	0.659	-0.416	**	-2.5	0.660
	whytrp_commu	0.833	***	10.14	2.301	0.833	***	10.13	2.300
	whytrp_shop	-0.953	***	-8.37	0.386	-0.952	***	-8.35	0.386
	whytrp_social	1.172	***	12.45	3.228	1.173	***	12.46	3.232
Individual	age	-0.003		-1.17	0.997	-0.003		-1.11	0.997
	driver	-2.167	***	-14.73	0.114	-2.171	***	-14.74	0.114
	educ	0.262	***	6.48	1.300	0.263	***	6.48	1.300
	gender	-0.237	***	-3.39	0.789	-0.235	***	-3.35	0.791
	borninus	1.316	***	3.31	3.728	1.296	***	3.26	3.655
	yrtous	-0.320	**	-2.22	0.726	-0.316	**	-2.19	0.729
	white	-0.128		-0.67	0.880	-0.088		-0.45	0.916
	black	-0.026		-0.12	0.975	-0.053		-0.24	0.948
	asian	-0.071		-0.3	0.931	-0.019		-0.08	0.981
	hisp	-0.194		-1.34	0.823	-0.174		-1.19	0.840
	Nmatch					-0.118		-1.18	0.889
Household	homeown	-0.545	***	-4.62	0.580	-0.529	***	-4.45	0.589
	hhsize	-0.263	***	-4.53	0.769	-0.264	***	-4.55	0.768
	hhv/hhs	-0.442	***	-3.65	0.643	-0.436	***	-3.6	0.647
	hhinc	-0.002		-0.08	0.998	-0.001		-0.05	0.999
	hhdriver	0.036		0.4	1.036	0.043		0.49	1.044

	urbrur								
	workdensity								
	perrenter								
	housdensity								
	popdensity								
	medhhinc								
Neighborhood	bb1970								
	ICI					-0.068		-0.28	0.934
	maturity					-0.252		-0.98	0.778
	num_groc								
	num_pts								
	near_scdist								
	near_ptsdist								
Constant		0.455		1.43	1.576	0.628		1.42	1.874
var(M1[neighborhood])		0.244		0.114	1.276	0.249		0.119	1.283
var(M2[household])		4.201	***	3.704	66.777	4.189	***	3.693	65.954
var(M3[individual])		2.026	*	1.703	7.581	2.020	*	1.698	7.541
Log likelihood				-11990.787				-11986.964	

Note: Coeff. = Coefficient; OR = Odds Ratio

*The asterisks identify significance; *p<0.10; ** p< 0.05; *** p<0.01*

The number of observations is (n= 61,413)

Table 6-7. Determinants of Mode Choice: Private Vehicle (reference) vs. Walk & Bike: Model 3 vs. Model 4

		Model 3				Model 4			
		Built Environment				Full			
		Coeff.	Sig.	Z	Odd Ratio	Coeff.	Sig.	Z	Odd Ratio
Trip	trpmiles	-1.264	***	-46.83	0.282	-1.264	***	-46.78	0.283
	nonhhm_trp	-0.371	**	-2.21	0.690	-0.372	**	-2.22	0.689
	whytrp_commu	0.846	***	10.15	2.331	0.847	***	10.16	2.333
	whytrp_shop	-0.939	***	-8.12	0.391	-0.935	***	-8.09	0.392
	whytrp_social	1.185	***	12.43	3.272	1.186	***	12.44	3.275
Individual	age	-0.002		-0.66	0.998	-0.001		-0.52	0.999
	driver	-2.135	***	-14.34	0.118	-2.119	***	-14.22	0.120
	educ	0.239	***	5.82	1.270	0.228	***	5.54	1.256
	gender	-0.240	***	-3.39	0.787	-0.241	***	-3.41	0.786
	borninus	1.263	***	3.15	3.536	1.240	***	3.09	3.456
	yrtous	-0.314	**	-2.16	0.730	-0.308	**	-2.12	0.735
	white	-0.077		-0.4	0.926	-0.032		-0.16	0.969
	black	0.005		0.02	1.005	0.033		0.15	1.034
	asian	0.004		0.02	1.004	0.025		0.1	1.025
	hisp	-0.185		-1.25	0.831	-0.134		-0.9	0.875
	Nmatch					-0.096		-0.92	0.909
Household	homeown	-0.446	***	-3.6	0.640	-0.347	***	-2.69	0.707
	hhsize	-0.221	***	-3.73	0.802	-0.206	***	-3.47	0.814
	hhv/hhs	-0.422	***	-3.43	0.656	-0.392	***	-3.19	0.676
	hhinc	-0.005		-0.23	0.995	-0.032		-1.37	0.969
	hhdriver	0.014		0.16	1.014	0.021		0.24	1.021

	urbrur	-0.219		-0.98	0.804	-0.230		-1.02	0.794
	workdensity					-0.0002		-1.42	0.9998
	perrenter					0.008	**	2.37	1.008
	housdensity	0.000	***	3.12	1.000	0.0003	**	2.41	1.0003
	popdensity					0.000		-0.51	1.000
	medhhinc					0.000	***	3.74	1.000
Neighborhood	bb1970	-0.099		-0.47	0.906	0.061		0.27	1.063
	ICI					-0.204		-0.82	0.815
	maturity					-0.277		-0.87	0.758
	num_groc	-0.004		-0.21	0.996	-0.009		-0.42	0.991
	num_pts	0.002		0.6	1.002	0.000		0.04	1.000
	near_scdist	0.000		0.45	1.000	0.000		0.68	1.000
	near_ptsdist	0.000		-0.96	1.000	0.000		-1	1.000
Constant		0.292		0.7	1.340	-0.078		-0.14	0.925
var(M1[neighborhood])		0.202		0.082	1.224	0.167		0.058	1.181
var(M2[household])		4.235	***	3.729	69.055	4.198	***	3.695	66.527
var(M3[individual])		2.021	*	1.695	7.548	2.024	*	1.696	7.566
Log likelihood		-11741.491				-11725.169			

Note: Coeff. = Coefficient; OR = Odds Ratio

*The asterisks identify significance; *p<0.10; ** p< 0.05; *** p<0.01*

The number of observations is (n= 61,413)

6.4 Summary

The analysis results presented this chapter indicates the neighborhood effects for mode choice, particularly public transit and non-motorized mode than private vehicle mode. Overall model fit shows the best fit in the final model (Model 4), including all neighborhood variables. However, the random effect of neighborhood-level (M1) is shown best result in Model 2 (including social networks).

In the final model, these neighborhood characteristics explain none of the immigrant neighborhood effects on non-motorized mode choice essentially, while showing meaningful negative effects of immigrant neighborhood effect on public transit mode (Model 4 in Table 6-5 and Table 6-7). This unexpected immigrant neighborhood effect on public transit mode choice might come from the dataset process: private vehicle mode means not only driving alone but carsharing and ridesharing in this dissertation.

Individual immigrant status shows the most substantial effect on alternative mode choice than private vehicles. Immigrant individuals 2.2 times more likely to choose public transit and 3.7 times more likely to use walk and bike mode over private vehicles than non-immigrants. However, the individual's race/ethnicity does not significantly affect mode choice, except the negative effect of the white on public transit mode.

Moreover, ethnic enclaves' effects on residents' travel mode choice, measured by ethnic neighborhood match (Nmatch), do not show any meaningful results, unlike immigrant neighborhood effects. Immigrant neighborhoods, measured by immigrant concentration index (ICI), show a significant adverse effect on public transit than private vehicle mode. Residents who live in immigrants' concentrated neighborhoods have a 48% decrease in the odds of using public transit for their travel. This estimated result can interpret with active social networks in immigrant neighborhoods; people in immigrant

neighborhoods can easily find carsharing partners or transportation help from their neighbors.

Chapter 7

Conclusion

This dissertation consists of three analytic components; 1) Texas immigrants' travel behavior comparing other immigrant populous states; 2) immigrant neighborhoods by dominant race/ethnicity groups in North Texas; 3) neighborhood effects on residents' mode choice in North Texas.

Texas shows the highest private vehicle usage rate than the other nine states with a large immigrant population. This highest private vehicle rate shows among recent immigrants (less than 5 years in the U.S.), who usually shows the lowest dependency on car among the immigrant group. 78% of recent immigrants in Texas use private vehicles for their daily commute when the average recent immigrants' private vehicle usage is 63% in the other nine states. Moreover, the usage rate of public transit shows the lowest value in Texas immigrants than immigrants in other states. Settled immigrants (over 10 years in the U.S.) use public transit less than non-immigrants in Texas. Thus, the prevailing trend of high propensity of using environmentally friendly travel (using public transit, walk, and bike) among immigrants is inappreciable in Texas. Public transportation service is limited to commute in most areas in Texas. Therefore, automobiles may be more critical in Texas to access employment, and carpooling more frequently happens among immigrants without private vehicles. This finding has implications for immigrant car ownership, traffic congestion, and better opportunities for transit ridership needs among immigrants in Texas.

In North Texas, immigrant neighborhoods are located in large urban areas, and these neighborhoods are clustered by the dominant population's race/ethnicity. Spatial segregation is observed among immigrant ethnic neighborhoods. Results from the spatial

autocorrelation test, Asian and Hispanic immigrant neighborhoods in Dallas county's urban areas are significantly clustered; however, non-Hispanic white and black immigrant neighborhoods are separated from other immigrant neighborhoods. Notably, black immigrant neighborhoods are segregated not only spatially but also socioeconomically from other immigrant neighborhoods. Black immigrants are settled in disadvantaged neighborhoods with low median household income, high rate of renter-occupied housing, and old built environments.

One of the potential positive influences of living in immigrant neighborhoods in North Texas is that residents have better access to public transit services. Most of the immigrant neighborhoods are placed within the service areas of North Texas public transits. Immigrants undergo driver licensing restrictions, discrimination in lending practices, and restricted mainstream labor and housing markets. Thus, immigrants, who usually live in vehicle-shortage households, are likely to choose to live in locations closer to the workplace and neighborhoods where they quickly get public transportation service or transportation help (Bohon et al., 2008; Blumenberg and Smart, 2009). Additionally, they may find easily informal transportation services in the immigrant neighborhoods to meet their transportation needs, including Chinese van, jitney van, Chinese taxi, or camionetas, which passengers pay drivers a flat fee to access their destinations (Kemper et al., 2007; Valenzuela et al., 2005; Yu, 2016).

Despite North Texas immigrant neighborhoods not considered as food deserts, it does not mean that every neighborhood is within easy access to affordable healthy and nutritious food. Some immigrant neighborhoods are excluded from public transportation service areas and 5 miles buffer (approximately 9 min drive by car) of supercenters. Moreover, considering that immigrants tend to remain distinct in their ethnic identity and

show their shopping behavior on ethnic foods (Wang and Lo, 2007), access to ethnic shopping places using alternative mode is not simple.

The multilevel multinomial logit results estimate that household and individual effects are more important than neighborhood effects on residents' mode choice. Social networks in neighborhoods are considered to affect mode choice between public transit and private vehicles negatively. Social networks by contacting co-racial/ethnic groups in immigrant neighborhoods influence residents to choose private vehicle mode rather than public transit. However, it is not clear that residents who choose a private vehicle prefer to driving alone, carpooling, carsharing, or ridesharing. Neighborhood variables that are showing a meaningful size of the impact on mode choice are varied. For instance, residential density and accessibility to public transits positively influence the choice of public transits. Simultaneously, the percentage of renter-occupied housing positively affects walking and biking rather than private vehicles.

Regarding household and individual factors, the results show that households with a higher household income, bigger household size, or more household vehicles per household member increase the odds of choosing private vehicles over alternative transportation mode. Only individuals' immigrant status shows a positive effect on public transit usage in north Texas; North Texas immigrants are 2.2 times more likely to choose public transit relative to private vehicles. For non-motorized mode choice, individuals' commute purpose, social and recreational purpose, education level, and immigrant status show a positive impact. Persons who are immigrants, get a higher education, or travel to commute or socialize more likely to walk and bike than cars. The influence of the significant variables is more pronounced in residents' bicycle and walking choices in North Texas, while these variables of odds ratios in public transit choice do not reach a noticeable level.

7.1 Implications

This study has some implications for policies. Results from three analytics components reveal the needs of policies and support related to community development, investments in the transportation system and networks, investment in public transit, and social network investments. The existing socioeconomic gaps among immigrant ethnic neighborhoods may be opportunities to establish diversity goals for diverse neighborhoods and support mixed-income development programs. Mixed-income development has gained increased attention since the mid-1990s, as a solution for failed public housing developments and racial and socioeconomic segregation in urban areas. Policymakers and local developers, who support mixed-income developments, think that mix-income development strategy will alleviate highly concentrated inner-city poverty and promote upward mobility among low-income families (Joseph, 2006; Joseph et al., 2007; Joseph and Chaskin, 2009).

Learning from immigrants' shopping behavior using alternative mode (public transit and informal transportation) suggests the needs of broader public transit networks and developing methods to help informal transportation operators increase drivers' and passengers' safety. Lack of connectivity is a major barrier to choosing public transit in North Texas, as well as limited service areas. Hadas and Ceder (2010) state that connectivity is the primary element of transit networks; thus, transfer comfort occurring in multilegged trips is a major contributor to the transit system's reliability issues. Thus, improving public transit connectivity is one of the most vital tasks for transportation planners and public transit operators.

It is unclear who use informal transportation and when they choose that mode in this study due to data limitation. Recent literature finds that immigrants (documented and

undocumented) are the primary customers on informal transportation. Considering the high proportion of Hispanic and Asian immigrants in North Texas, and these racial groups mostly mentioned in the studies on informal transportation (Valenzuela et al., 2005; Kemper et al., 2007; Yu, 2016), informal transportation should be considered as a significant transportation mode for Asian and Hispanic groups' trips.

The main disadvantage of informal transportation is the lack of insurance (Valenzuela et al., 2005). The insurance issue of informal transportation is associated with legality but also the safety of drivers and patrons. It is the right time to consider the support programs that help informal transportation providers obtain proper training for getting commercial driver license (CDL) and adequate insurance for drivers and patrons' safety.

Learning from neighborhoods' effect on residents' mode choice implicate are twofold. First, considering the pronounced likelihood of non-motorized mode, it may be an opportunity to identify current road networks and transportation systems that need improvements for future walkers and bicyclists. Increases in biking and walking may be associated with road safety; in general, bicyclists experience a much higher fatality rate (11 times higher) per kilometer traveled than do drivers in the US (Mapes, 2009). In contrast, Marshall and Garrick (2011) find that cities with high bicycling rates have better road safety record. Their finding implicates that large numbers of bicyclists tend to lower vehicle speeds and increase driver awareness; moreover, a bike-friendly road system makes toward a safer and more sustainable transportation system for all road users.

Second, intra-neighborhood social networks need to broaden via online platforms for quickly getting transportation help and information; this study considers only face-to-face social networks in neighborhoods. The neighborhood-centered social networks provide social identity and a sense of belonging, as well as support and information.

Moreover, online social networks are not limited by time and place, unlike face-to-face social networks; residents do not need to wander a local cafe or local commercial mall or set up appointments to meet friends and neighbors who can help them. Also, people can have more prompt help through online communication with simultaneously connected neighbors.

Developing an online platform or apps for a neighborhood's residents will enhance their social networks by providing a firm sense of belonging. For example, one of the famous online platforms of free community-building service is the 'Front Porch Forum (FPF)' in Vermont state. Around ninety Vermont towns covering about half of the state have been using FPF, and nearly 60,000 households participate. People only can access their neighborhood forum by providing their housing location information with the exact address. Vermont state is empowering the FPF by including FPF in the package of 'eVermont,' Vermont community broadband project, an initiative from the Vermont Council on Rural Development (Vermont council on Rural Development, n.d.). This online-based neighborhood social networks might help shift residents' mode choice by providing better information and rapid transportation help.

Appendix A: Travel Behavior of Immigrants in 10 States

This appendix provides the immigrants' travel behavior in other 9 immigrant populous states except Texas: California, New York, Florida, New Jersey, Illinois, Massachusetts, Georgia, Virginia, and Washington, using 2017 American Community Survey (ACS), 5% Public Use Microdata Sample (PUMS) data.

Table A-1. Travel behavior of California immigrants by arrival cohorts

		Immigrant			Non-immigrant
		Years in U.S.			
		0-4 years	5-9 years	Over 10 years	
Partial percentage to total		3.3%	8.3%	88.4%	
Transportation to commute	Private Vehicle	66.1%	73.9%	84.9%	33.1%
	Public Transit	13.2%	11.4%	6.3%	1.8%
	Bike & Walk	12.5%	7.6%	3.2%	1.6%
	Other	8.1%	7.1%	5.6%	2.8%
Carpooling	Drive alone	74.9%	78.6%	83.2%	89.3%
	Carpool	25.1%	21.4%	16.8%	10.7%
Mean Travel Time (min)		8	11	16	10
Gender	Male	48.5%	47.4%	47.5%	50.0%
	Female	51.5%	52.6%	52.5%	50.0%
Race	White	37.5%	35.7%	43.3%	70.5%
	Black	1.8%	2.2%	1.4%	6.7%
	Asian	47.3%	47.5%	33.6%	7.1%
Total Observation			289,880		758,693

Table A-2. Travel behavior of New York immigrants by arrival cohorts

		Immigrant			Non-immigrant
		Years in U.S.			
		0-4 years	5-9 years	Over 10 years	
Partial percentage to total		7.1%	9.8%	83.0%	
Transportation to commute	Private Vehicle	61.2%	67.3%	78.6%	84.1%
	Public Transit	19.7%	19.1%	12.1%	4.6%
	Bike & Walk	11.2%	7.7%	3.7%	4.1%
	Other	7.8%	5.8%	5.7%	7.3%
Carpooling	Drive alone	76.2%	79.1%	84.2%	89.3%
	Carpool	23.8%	20.9%	15.8%	10.7%
Mean Travel Time (min)		10	14	18	11
Gender	Male	48.5%	47.2%	47.0%	50.0%
	Female	51.5%	52.8%	53.0%	50.0%
Race	White	42.0%	39.8%	47.9%	70.0%
	Black	7.9%	10.3%	8.0%	6.5%
	Asian	36.5%	35.9%	26.9%	9.0%
Total Observation			1,314,511		1,354,364

Table A-3. Travel behavior of Florida immigrants by arrival cohorts

		Immigrant			Non-immigrant
		Years in U.S.			
		0-4 years	5-9 years	Over 10 years	
Partial percentage to total		8.8%	10.5%	80.6%	
Transportation to commute	Private Vehicle	79.5%	85.3%	89.1%	89.0%
	Public Transit	6.8%	5.1%	2.8%	1.4%
	Bike & Walk	5.5%	3.7%	1.9%	2.2%
	Other	8.3%	5.9%	6.2%	7.5%
Carpooling	Drive alone	79.1%	81.8%	86.6%	90.7%
	Carpool	20.9%	18.2%	13.4%	9.3%
Mean Travel Time (min)		10	13	15	10
Gender	Male	48.6%	46.4%	46.1%	48.9%
	Female	51.4%	53.6%	53.9%	51.1%
Race	White	69.5%	65.5%	69.0%	81.8%
	Black	10.8%	15.7%	13.8%	13.6%
	Asian	10.5%	10.7%	8.9%	0.9%
Total Observation			207,851		766,876

Table A-4. Travel behavior of New Jersey immigrants by arrival cohorts

		Immigrant			Non-immigrant
		Years in U.S.			
		0-4 years	5-9 years	Over 10 years	
Partial percentage to total		7.5%	10.9%	81.7%	
Transportation to commute	Private Vehicle	54.6%	61.1%	74.7%	83.1%
	Public Transit	28.3%	25.0%	15.7%	8.8%
	Bike & Walk	9.6%	7.7%	4.2%	2.6%
	Other	7.5%	6.2%	5.5%	5.5%
Carpooling	Drive alone	71.6%	76.2%	85.0%	92.4%
	Carpool	28.4%	23.8%	15.0%	7.6%
Mean Travel Time (min)		13	16	20	13
Gender	Male	47.8%	47.9%	47.5%	48.5%
	Female	52.2%	52.1%	52.5%	51.5%
Race	White	34.3%	37.2%	47.7%	79.5%
	Black	8.7%	10.8%	9.1%	11.9%
	Asian	42.6%	36.5%	28.5%	3.5%
Total Observation			94,960		344,910

Table A-5. Travel behavior of Illinois immigrants by arrival cohorts

		Immigrant			Non-immigrant
		Years in U.S.			
		0-4 years	5-9 years	Over 10 years	
Partial percentage to total		6.9%	9.0%	84.1%	
Transportation to commute	Private Vehicle	58.8%	71.2%	82.5%	82.8%
	Public Transit	19.9%	16.0%	9.5%	8.2%
	Bike & Walk	13.9%	7.5%	3.3%	3.5%
	Other	7.4%	5.3%	4.7%	5.5%
Carpooling	Drive alone	78.1%	81.3%	84.5%	91.4%
	Carpool	21.9%	18.7%	15.5%	8.6%
Mean Travel Time (min)		10	14	18	12
Gender	Male	49.9%	48.9%	48.7%	48.8%
	Female	50.1%	51.1%	51.3%	51.2%
Race	White	36.8%	39.6%	55.5%	81.5%
	Black	6.4%	7.0%	3.1%	12.1%
	Asian	45.0%	41.4%	22.9%	2.6%
Total Observation			76,596		557,582

Table A-6. Travel behavior of Massachusetts immigrants by arrival cohorts

		Immigrant			Non-immigrant
		Years in U.S.			
		0-4 years	5-9 years	Over 10 years	
Partial percentage to total		10.8%	13.3%	75.9%	
Transportation to commute	Private Vehicle	49.0%	56.8%	74.7%	79.1%
	Public Transit	21.8%	23.2%	13.8%	8.6%
	Bike & Walk	21.9%	14.8%	5.9%	6.2%
	Other	7.4%	5.2%	5.6%	6.2%
Carpooling	Drive alone	72.1%	78.7%	85.7%	91.7%
	Carpool	27.9%	21.3%	14.3%	8.3%
Mean Travel Time (min)		10	14	17	13
Gender	Male	48.9%	47.3%	46.9%	48.2%
	Female	51.1%	52.7%	53.1%	51.8%
Race	White	38.3%	36.7%	51.0%	88.7%
	Black	11.9%	16.5%	12.4%	4.7%
	Asian	35.2%	31.1%	22.2%	3.4%
Total Observation			57,620		287,195

Table A-7. Travel behavior of Georgia immigrants by arrival cohorts

		Immigrant			Non-immigrant
		Years in U.S.			
		0-4 years	5-9 years	Over 10 years	
Partial percentage to total		9.0%	11.7%	79.3%	
Transportation to commute	Private Vehicle	72.9%	83.3%	88.7%	89.5%
	Public Transit	12.2%	5.7%	2.8%	1.9%
	Bike & Walk	7.4%	5.2%	1.8%	2.0%
	Other	7.5%	5.8%	6.7%	6.6%
Carpooling	Drive alone	71.9%	74.1%	82.0%	90.3%
	Carpool	28.1%	25.9%	18.0%	9.7%
Mean Travel Time (min)		10	13	18	11
Gender	Male	50.0%	49.5%	49.0%	48.3%
	Female	50.0%	50.5%	51.0%	51.7%
Race	White	34.9%	34.0%	46.2%	67.6%
	Black	15.2%	18.3%	15.6%	27.8%
	Asian	37.1%	36.7%	24.2%	1.2%
Total Observation			47,052		442,752

Table A-8. Travel behavior of Virginia immigrants by arrival cohorts

		Immigrant			Non-immigrant
		Years in U.S.			
		0-4 years	5-9 years	Over 10 years	
Partial percentage to total		8.7%	12.2%	79.1%	
Transportation to commute	Private Vehicle	66.7%	78.1%	85.0%	87.0%
	Public Transit	14.9%	11.3%	6.8%	3.9%
	Bike & Walk	9.5%	5.8%	2.5%	3.1%
	Other	8.9%	4.8%	5.8%	6.0%
Carpooling	Drive alone	73.6%	79.2%	85.3%	90.5%
	Carpool	26.4%	20.8%	14.7%	9.5%
Mean Travel Time (min)		10	13	20	12
Gender	Male	47.2%	45.3%	46.6%	49.0%
	Female	52.8%	54.7%	53.4%	51.0%
Race	White	40.0%	37.7%	44.7%	76.6%
	Black	9.4%	14.0%	9.0%	17.0%
	Asian	36.7%	37.5%	34.9%	2.1%
Total Observation			51,012		366,865

Table A-9. Travel behavior of Washington immigrants by arrival cohorts

		Immigrant			Non-immigrant
		Years in U.S.			
		0-4 years	5-9 years	Over 10 years	
Partial percentage to total		8.7%	11.2%	80.1%	
Transportation to commute	Private Vehicle	60.7%	74.0%	83.6%	83.2%
	Public Transit	17.1%	13.5%	6.5%	5.4%
	Bike & Walk	12.4%	6.2%	3.4%	4.4%
	Other	9.8%	6.3%	6.5%	7.1%
Carpooling	Drive alone	71.6%	77.2%	83.0%	89.2%
	Carpool	28.4%	22.8%	17.0%	10.8%
Mean Travel Time (min)		10	13	16	11
Gender	Male	48.3%	47.1%	46.6%	49.7%
	Female	51.7%	52.9%	53.4%	50.3%
Race	White	30.8%	32.1%	46.0%	84.8%
	Black	6.2%	8.0%	3.6%	2.5%
	Asian	50.3%	48.7%	35.8%	2.9%
Total Observation			48,386		310,689

Appendix B: Immigrant Neighborhoods' Maps

Figure B-1. Non-Hispanic White immigrant neighborhoods

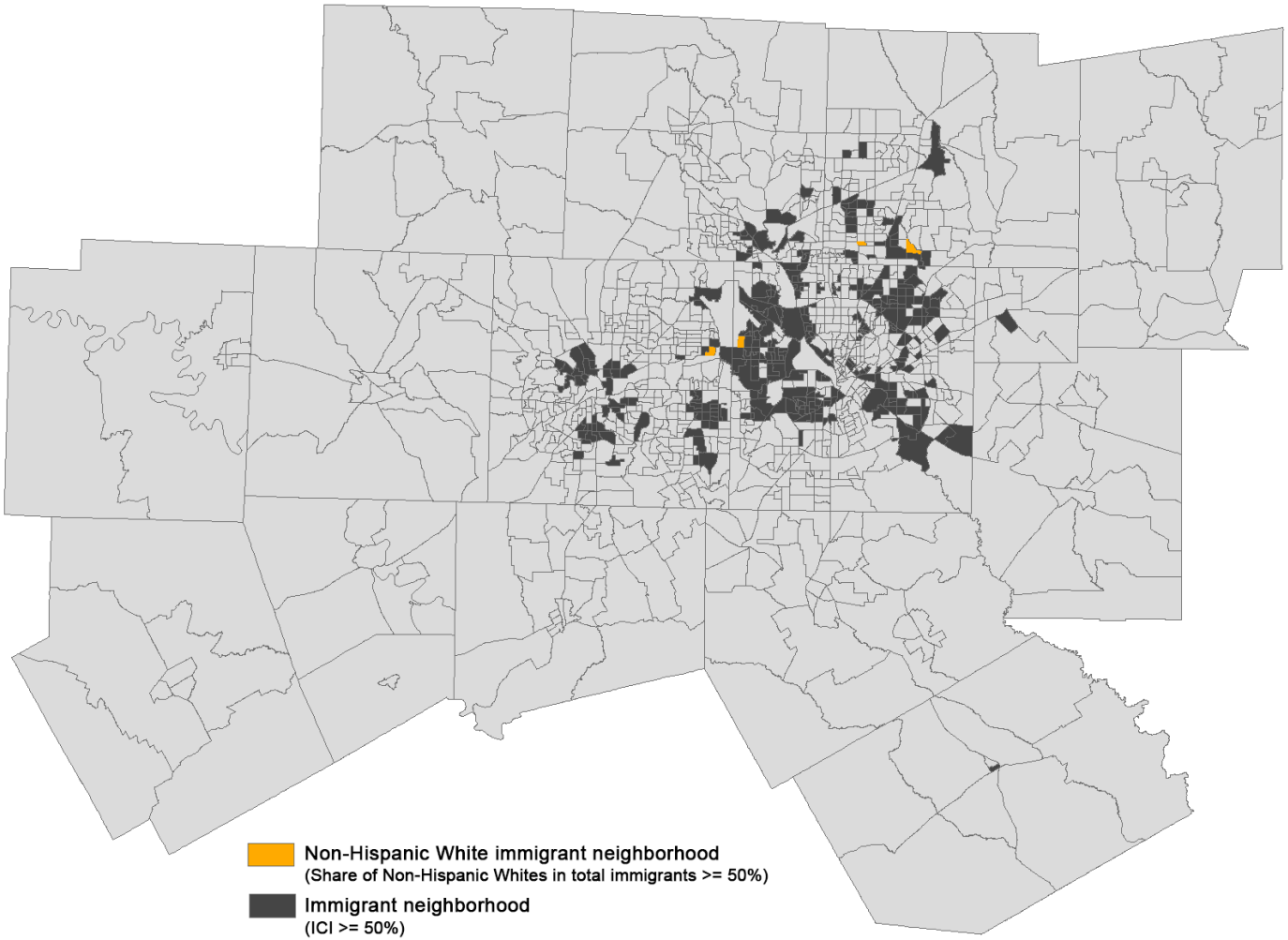


Figure B-2. Black immigrant neighborhoods

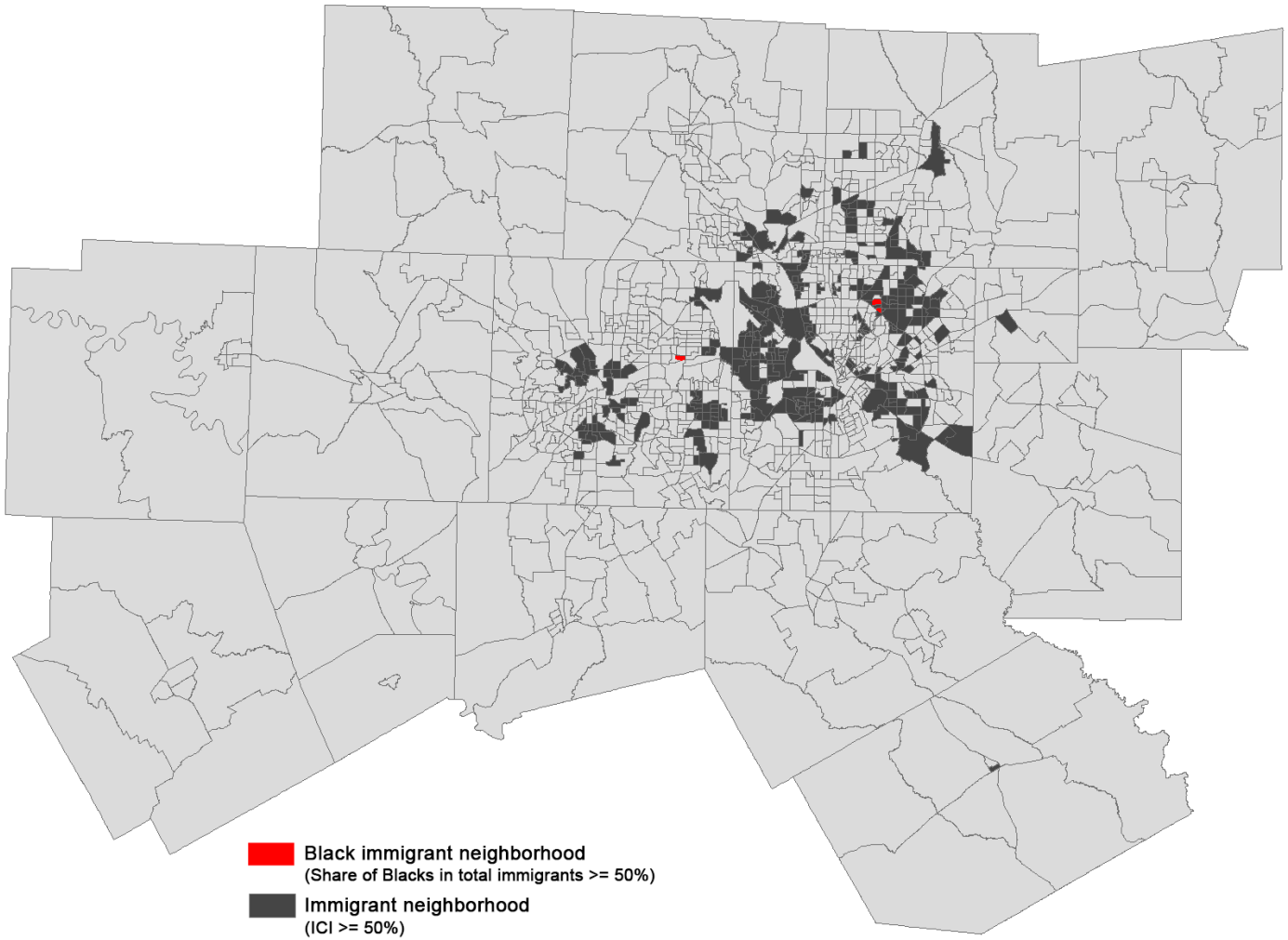


Figure B-3. Asian immigrant neighborhoods

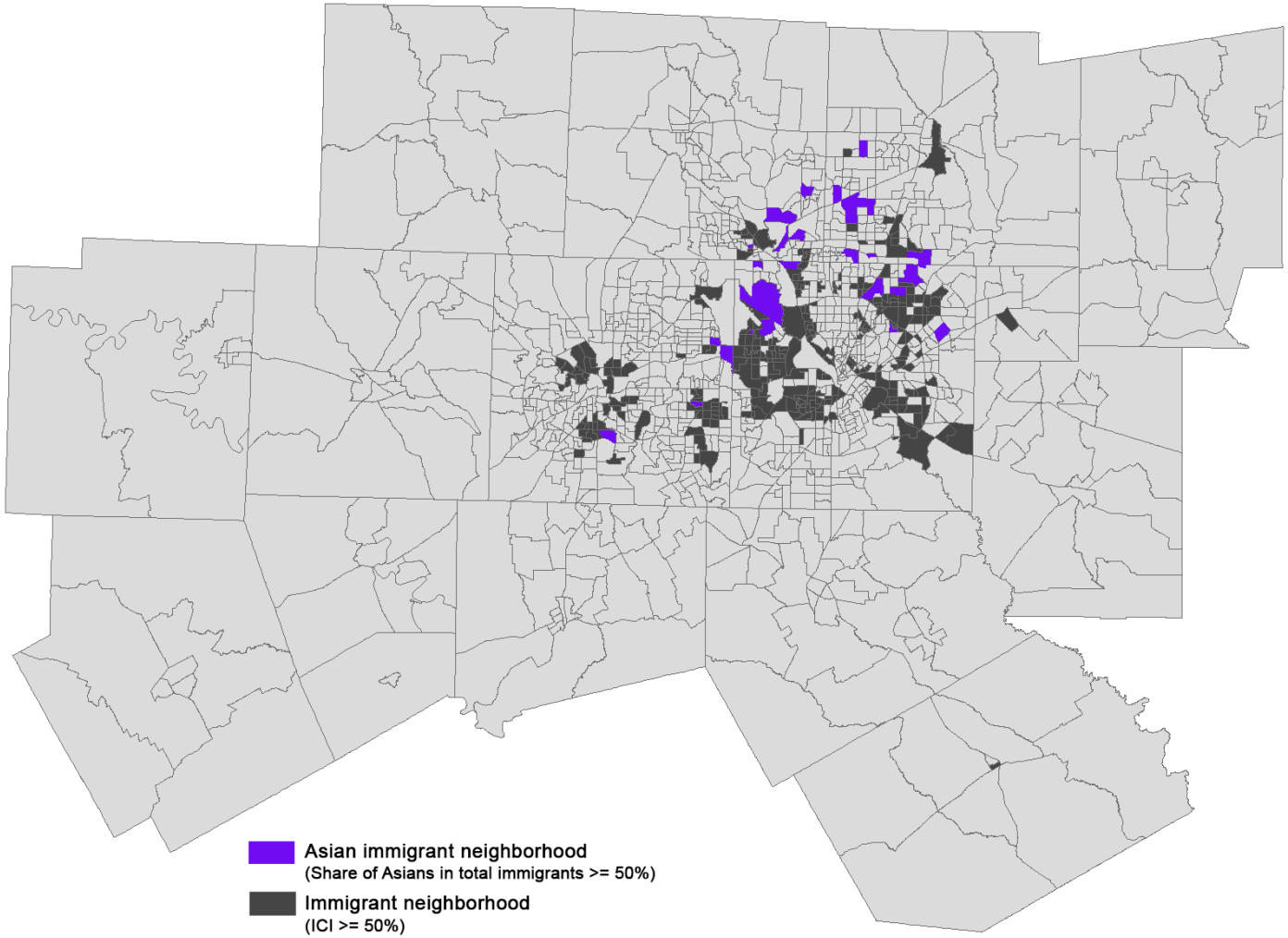


Figure B-4. Hispanic immigrant neighborhoods

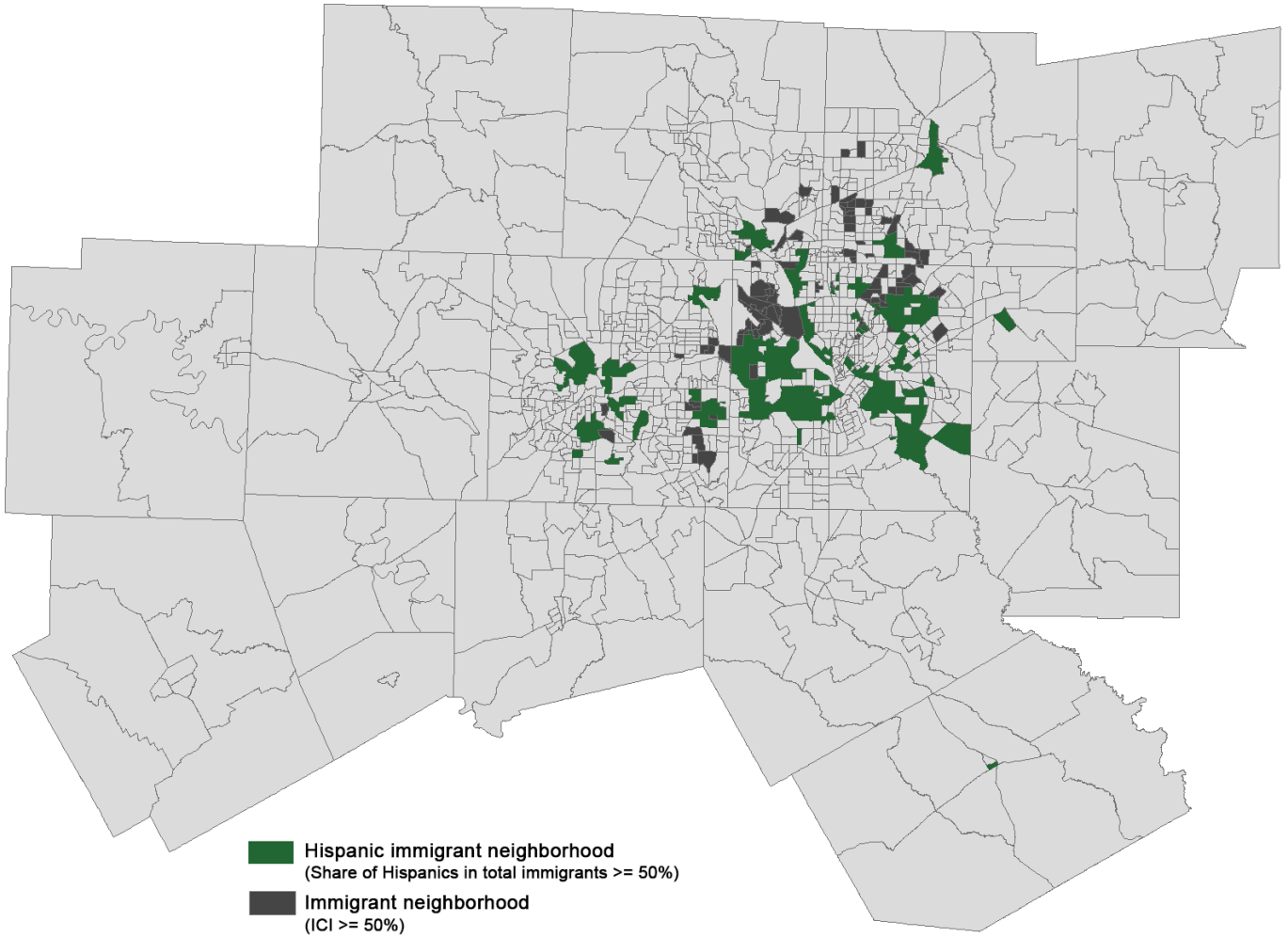


Figure B-5. Mixed race/ethnicity immigrant neighborhoods

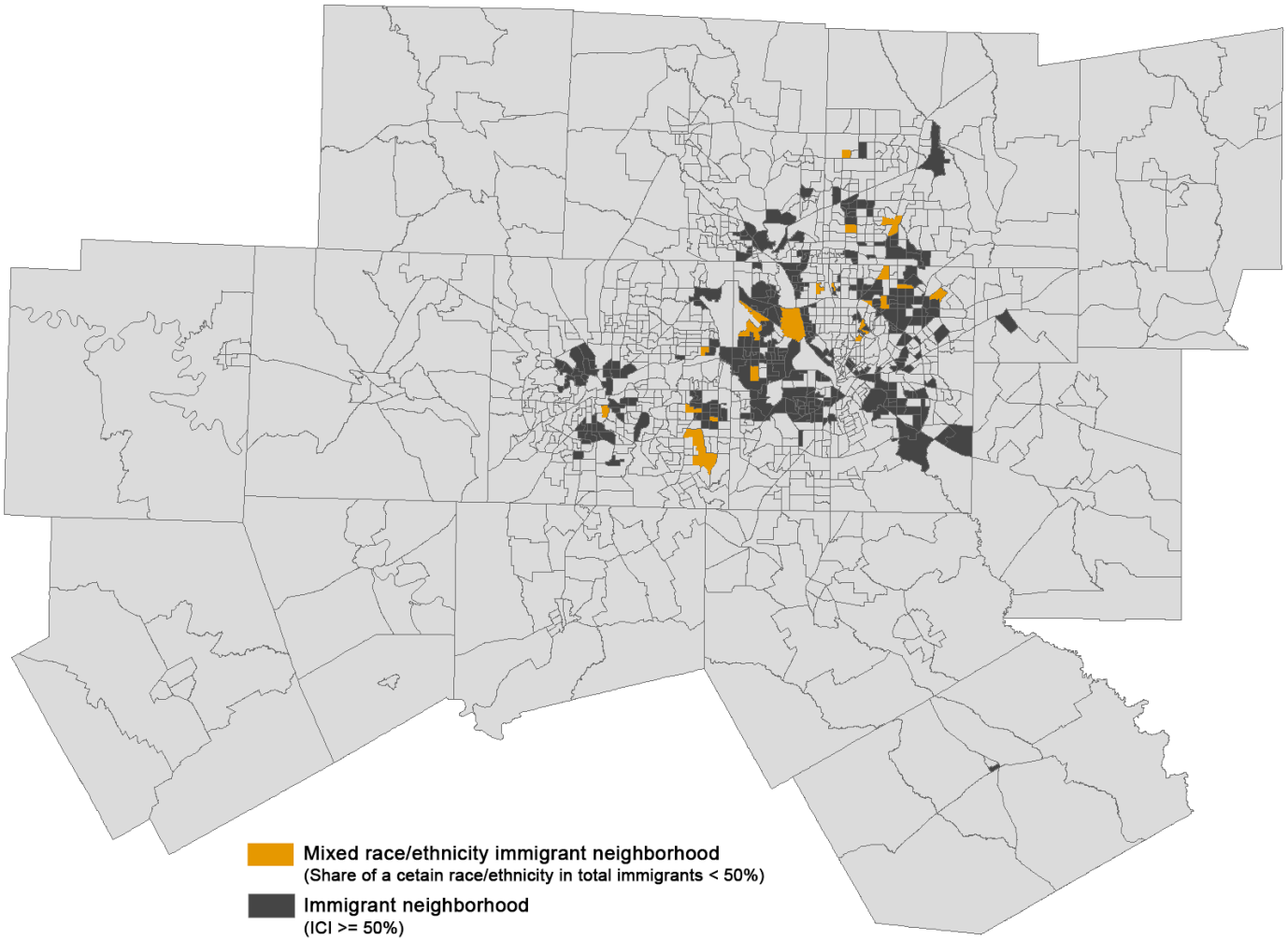
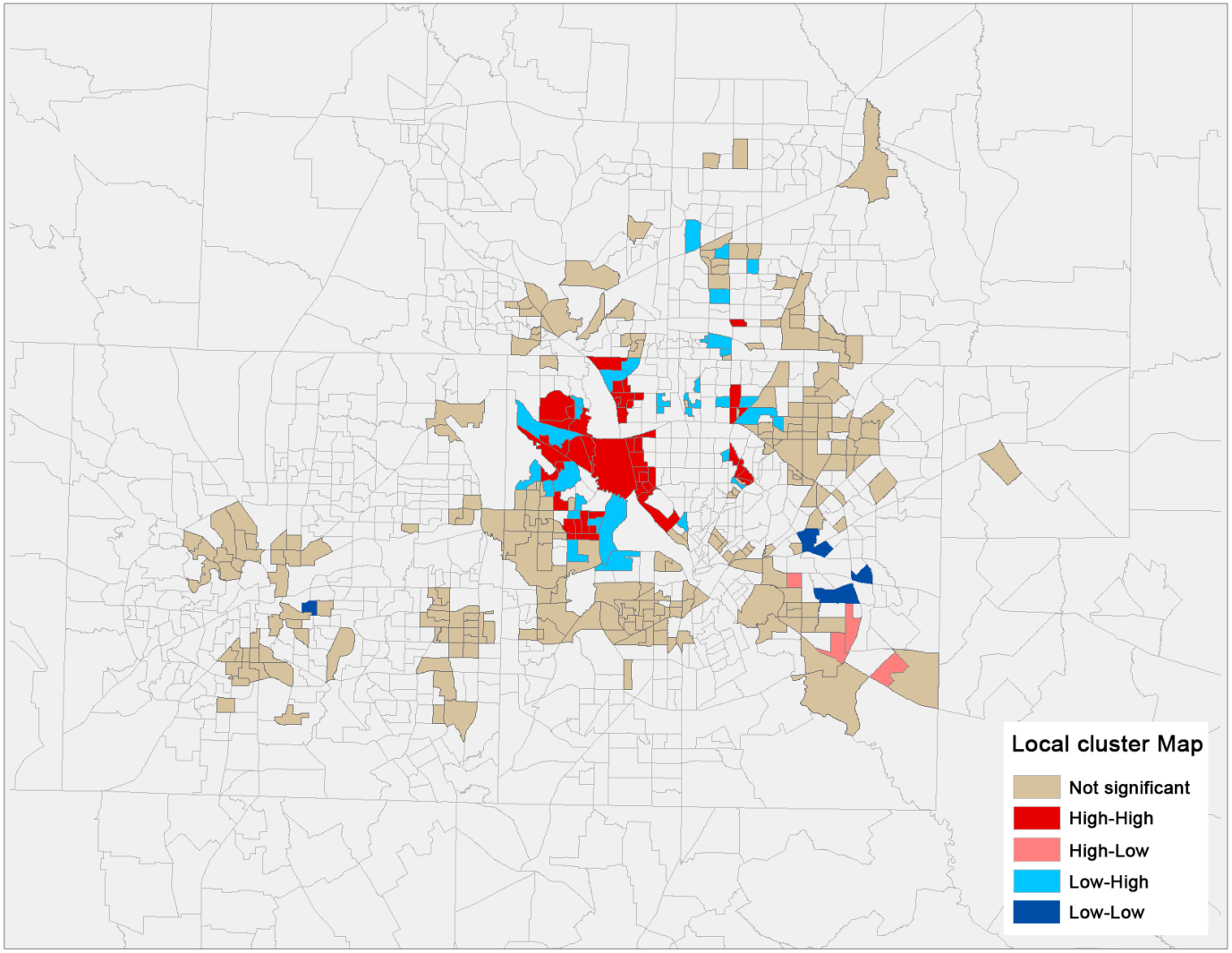


Figure B-6. Local cluster map of immigrant neighborhoods



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