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The Capitalization Effects of Work and Nonwork Accessibilities in Southeast Michigan

By

Guangyu Li

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy

in

City and Regional Planning

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Professor Robert Cervero, Chair
Professor Paul Waddell
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Abstract

The Capitalization Effects of Work and Nonwork Accessibilities
in Southeast Michigan

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Doctor of Philosophy in City and Regional Planning

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Is accessibility, the key to connect land use and transportation, still important in modern metropolitan areas? Some say no, arguing that well-established transportation network has weakened its influences. Others have found that accessibility is still critical in affecting households and business's location choices. Yet few studies have examined how accessibility is evaluated in housing transactions and how this relationship interacts with different local context, information that is needed for planners to make informed land use decisions.

This dissertation examines accessibility's capitalization effects using data from the Southeast Michigan region. In particular, it compares the impacts of work accessibility with the impacts of three major nonwork accessibilities, that is, shopping accessibility, school accessibility and recreational accessibility. The results from multilevel modeling show that work accessibility is still important in affecting property values, but the effects vary by local housing markets and development context. For example, the impact of work accessibility in Ann Arbor is very different from that in Detroit. The study also confirms the significant capitalization effects from the three nonwork accessibilities, especially when the local context has been accommodating.

By comparing model results across different accessibility measurements, this dissertation also echoes what previous studies have found, that is, the impacts of accessibility tend to be more localized in modern urban areas. Thus, good accessibility measurement should capture local variations by incorporating disaggregated information with refined methodology that is both theoretically sound and appropriate for the study context.

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Chapter I. Introduction

One of the most important issues in modern planning is the land use and transportation connection. Although the history of urban development has demonstrated a strong influence of transportation investment on urban development pattern, empirical studies in recent year have found less significant impact and sometimes even mixed results. Some scholars (Giuliano, 1995) have argued that transportation-land use connection is weakening over time and transportation may not be an effective tool to influence land development. This argument is a serious challenge to policymakers who seek to integrate transportation and land use planning. Development strategies such as smart growth rely on the interaction of land use and transportation. If the link between land use and transportation is insignificant, advocating smart growth planning may not be justified and planning practices such as integration of land use and transportation modeling are also questionable.

There is abundant literature that seeks to explain the relationship between transportation and land uses. Some examines how transportation investment might lead to land use changes (Handy, 2002), while others focus on analyzing how land use pattern might induce travel demand (Crane, 2000; Cervero, 2003). It is not difficult to understand why these studies have not reached consensus on those subjects. First, the research context varies a lot. Each study has its own study area that differs in geographic setting, market conditions, policy environment, which may affect research results. Second, studies also differ from each other in their research design such as modeling technique and variable measurement.

Despite the differences in research findings, several reviewers have tried to sort out some general consensus (Huang, 1994; Boarnet & Chalermpong, 2000; Crane, 2000; Ewing & Cervero, 2001; Handy, 2002). On the transportation side, it can be concluded that highway investment does influence urban development patterns, but at a finer scale than what was previously expected (Boarnet & Haughwout, 2000). Instead of increasing growth, highway' contribution is more to influence where development occurs and the characteristics of the development (Handy, 2002). Moreover, it was also found that transit investment could produce significant impact on nearby residential and commercial land uses when and only when it was combined with other favorable conditions (Cervero & Landis, 1995). The magnitude of the influence depends on the nature of the transit system and the degree to which it enhances accessibility in the region (Handy, 2002).

On the land use side, the built environment seems to have more complicated influence on travel demand. A review by Ewing & Cervero (2001) shows that trip length is more related to the built environment than trip frequency and mode choice. Moreover, households' overall social and economic characteristics seem to weigh more than environmental elements. Yet, as Handy (2002) pointed out, studies on this subject often did not pay much attention to the causality or self-selection issue. For example, do people living in high-

density areas take fewer trips or people who want to take fewer trips choose the high-density neighborhood?

Other than the generalization from above, it is hard to reach any further agreement from these existing studies. As those reviewers have pointed out, to truly identify the transportation and land use connection, not only do researchers need to improve their methodology, they also need to have a thorough understanding of local socioeconomic environment and development contexts. It is these arguments that motivate my dissertation research.

More specifically, my dissertation will examine three questions. First, do today's households still value the accessibility to work and if so, how is this accessibility captured in residential property value? Second, how do local and regional scales of accessibility differ in affecting residential property value? Third, has the non-work accessibility also become important in affecting residential property values, or do households only care about the accessibility to employment? I raise these questions in view of the changes that have occurred in household travel behaviors. In the United States, decades of suburbanization and auto-dependency have greatly shaped household travel behaviors and even their life styles (Nelson & Niles, 2000). Today, more than 80 percent of the total household travels are nonwork related (Hu & Reuscher, 2004). Given those changes, one would wonder how the different types of accessibilities are valued on real estate market, in particular, whether the nonwork accessibilities have become more important than work accessibility. Understanding these issues can inform planners' efforts on promoting smart growth or other sustainable development strategies.

To answer these questions, I will measure both the work and nonwork accessibilities in various methodologies and will examine how these accessibilities are capitalized into local property values. In particular, by conducting the study in Southeast Michigan, I will examine how these effects have differed in different metropolitan contexts. This is because the Southeast Michigan contains two metropolitan areas, Metro Detroit and Metro Ann Arbor, which differ significantly in both their employment structure and the attractiveness of their core cities. The City of Detroit, for example, has long suffered from deindustrialization and population loss. As a result, its influences as a major job center have declined over the years. City of Ann Arbor, on the other hand, has maintained both a stable employment base and a pleasant living environment. As a result, it not only functions as a local job center, but is also a highly attractive place to live. As my work will show, all these have important implications on how different types of accessibilities are capitalized into residential property values.

In addressing these questions, I will make several improvements in research methodology over the existing studies. First, I will measure accessibilities at both regional and local levels. Although studies of household location choices have confirmed the importance of both regional and local accessibilities (Waddell & Nourzad, 2002; Waddell, Ulfarsson, Franklin & Lobb, 2007), most of the existing studies examining the capitalization

effects from transportation investment have measured accessibility based on the accesses to local transportation facilities with only a few exceptions such as Voith (1993), Cervero & Duncan (2001) and Franklin & Waddell(2003). As Huang (1994, p.21) pointed out, "according to classical models of the relationship between land rent and land use, the key factor is whether the metropolitan accessibility of a parcel can support high-intensity land uses". Without regional accessibility information, it is hard to judge where the land value premium came from. Neither can the impacts of local accessibility be separated from those at the regional level.

Second, I will distinguish work accessibility according to the matches between employment and residents in different occupational categories. As discovered by Cervero, Rood and Appleyard (1999), compared to aggregated measurements such as the total number of jobs, distinguishing the different types of occupations would provide more meaningful measurements and also have stronger explanatory power. This improvement is especially important for my study in Southeast Michigan, where studies have identified serious spatial mismatch between jobs and residences in this area (Kain, 1968).

Third, I will apply different measurement methodologies to construct the accessibility indicators, which include cumulative opportunities, gravity models, and utility-based measures. As the following literature review will show, each of the measurement has its own strengths and weaknesses. It will be interesting to see how the capitalization effects vary by the different measurement methods and which might fit better in my study context.

Fourth, I will carefully examine and compare the impacts of the different types of nonwork accessibilities. Recently nonwork related accessibilities have attracted scholars' attention. For example, the study conducted by Lee, Waddell, Wang & Pendyala (2010) has confirmed the importance of good access to nonwork activities such as shopping in household location preferences. However, knowledge on how nonwork accessibilities contribute to housing values is still limited. Given the significant share of nonwork trips in today's travel behaviors, more systematic evaluation and comparison are needed to improve our understanding of how nonwork accessibilities affect housing markets. In this study, I will measure and assess the impacts of the different types of nonwork accessibilities using a unique housing transaction dataset.

Finally, in evaluating the capitalization effects of the different types of accessibilities, I will apply multilevel regression modeling instead of the traditional hedonic price modeling approach. Studies have shown that single-level hedonic price modeling often fails to account for the localized structure of housing markets and their disequilibrium nature (Orford, 2000). As a result, it may generate results that are biased or inefficient (Anselin, 1988; Maclennan & Tu, 1996; Orford, 2000). Multilevel modeling, on the other side, can address those issues by simultaneously modeling the compositional effects of housing stock and the contextual effects of submarkets (Orford, 2000).

Chapter II. Literature Review

2.1 Accessibility as the Link between Transportation and Land Uses

"The basic concept underlying the relationship between land use and transportation is accessibility" (Giuliano, 2004, p.240). Accessibility refers to the easiness to reach desired opportunities. On one side, it considers the quantity and quality of opportunities and therefore, is strongly tied to land use patterns. On the other side, it counts in people's travel behavior, which largely reflects the flexibility and efficiency of urban transportation system. The role of accessibility as the central piece to connect land use and transportation is well explained in classic urban economic theories and location choice theories.

Classic urban economic theories often start with the monocentric model, which assumes that major business activities are concentrated in city centers due to numerous agglomeration benefits. Various land uses, such as industrial, commercial and residential land uses, are organized through competition on the land market and the level of bid rent decides the ownership of land parcels (Alonso, 1964; Mills, 1972; Muth, 1969). In this way, land is always assigned to the highest bidder and is thus used most efficiently. How much bid rent each household or business can offer is subject to their budget constraints. Therefore, households or businesses have to make their location choices based on the trade-off between land costs and transportation savings. When transportation cost is high, either households or businesses have to be located to where land price is low. Since transportation cost increases as one moves away from the CBD, land rent will be higher in places near CBD than the less accessible areas such as city edges.

Location choice theories further predict that the spatial differential impacts vary by the type of industries. In traditional manufacturing industry, a significant proportion of its production cost comes from material and product shipping. Thus savings on transportation costs has a high priority in its location choices. Manufacturing firms often prefer places with good accessibility to transportation facilities such as locations near railways or harbors (Weber, 1928; Hoover, 1948). For market oriented industries such as retail and service firms, market proximity is valued more than the access to transportation facilities. Central place theory developed by Christaller (1966) and Losch (1954) describes the geographic organization for such firms as a hierarchical structure of market centers at different levels. Centers at the same level are evenly distributed with each center having its own hexagon service area. This spatial pattern minimizes "consumer range", i.e., consumers' travel distance, to market centers and thus provides the best accessibility for all consumers.

Both urban economic theories and location choice theories have provided good explanations for the spatial patterns of firms and households and through them, we can see how accessibility binds land use and transportation together. Historical urban development patterns were generally consistent with what were described by these theories (Adams, 1970). However, with modern transportation technology and highly-connected highway

system, urban development patterns in many places have evolved from monocentric to polycentric or even non-centric forms (Gordon & Richardson, 1994). Such evolution has challenged the basic assumptions in these traditional theories such as the concentration of employment in CBD areas and the trade-off between transportation cost and land cost (Giuliano, 2004). Given these changes, a series of studies examining the phenomenon of "wasteful commuting", such as Hamilton (1982), White (1988), Small and Song (1992), Cropper and Patrice (1991), and Giuliano and Small (1993), have rejected the assumption that minimizing commuting cost is always the highest priority in household location decisions. These studies argue that, depending on household characteristics, other factors such as the need to balance commuting in two-worker households, the desire to live in a better school district or safer neighborhood may have higher priorities. In addition, constraints such as housing shortage near work places may also limit household location choice (Cevero, 1989).

In view of past studies, Giuliano (1995) argued that in the current transportation network and urban form setting, the relationship between transportation and land use is weakening. Due to the high connectivity of modern urban transportation system, accessibility has become relatively pervasive and transportation cost has fallen to such a low level that marginal improvement of the transportation system has little impacts on development patterns or travel patterns. Yet, other scholars have challenged Giuliano's argument. For example, while acknowledging the declining transportation cost and increased accessibility, Cervero and Landis (1995, 1996) argued that transportation investment, when combined with other policies, can strongly affect land use patterns. Planning strategies relying on the transportation-land use connection are still important tools to promote better environment and manage transportation demand.

Given the importance of this subject, more studies have been conducted to examine the relationship between land use and transportation in polycentric urban areas. For example, recent studies of residential location choices have proved that accessibility to both work and nonwork activities are important factors and their significance can be identified at both regional and local level (Lee et al., 2010; Waddell et al., 2010, Waddell & Nourzad, 2002). In an analysis of residential lifestyle choices, that is, the joint decisions on household activity participation, travel patterns and residential locations, the overall accessibility was ranked as No.1 in the factor matrix (Krizek & Waddell, 2002). Thus, a majority of the population still prefer better overall accessibility in contemporary urban settings. Moreover, land use modeling including the latest development of UrbanSim has used accessibility as one of their key model components to simulate future land use and transportation interactions due to its proved importance in model estimations (Waddell , 2002; Waddell et al., 2007). In particular, these efforts to integrate land use and transportation modeling have shown that, with activity based modeling, disaggregated household data and spatial details, accessibilities to various activities are not only effective but also very important factors in both employment and residential location choices (Waddell, Wang, Charlton & Olsen, 2010; Waddell et al., 2007; Wang, Waddell, Outwater, 2011) . However, how the preferences of

different types of accessibilities are reflected in residential property value has not yet been fully examined.

As Handy (2002) pointed out in an excellent review, it is understandable that findings from different studies are not always consistent due to the variations in study context. However, most of them have shown that accessibility still matters, but land use and transportation are now interacting in more complicated and dedicated ways (Handy, 2002). Therefore, studies with more refined methodology and broadened context are needed to understand the evolving role of accessibility in modern urban environment. One particular challenge faced by those studies is on how to measure accessibility, an issue that will discussed in the next section.

2.2 Defining and Measuring Accessibility

2.2.1 Accessibility Definitions

The literature on accessibility has developed various definitions for this concept. Most of them contain two essential elements: spatial attraction and resistance (Hansen, 1959; Ingram, 1971; Ryan & McNally, 1995; Schoon, MacDonald and Lee, 1999). A typical definition, for example, is offered by Litman (2003, p. 5): "Accessibility (or just Access) is the ability to reach desired goods, services, activities and destinations (together called opportunities)". From this definition, a conceptual framework about how to measure accessibility can be constructed, that is, accessibility assessments should include the measurements for both the desired opportunities and the ability to reach them.

However, as discovered in empirical studies, the measurements of accessibility components are quite complicated by nature. For example, opportunities could differ by quantities as well as quality and in many cases, such as jobs in different occupations or professions and thus may not be directly comparable. Moreover, the ability to reach opportunities, also referred as the impedance to destination, could be evaluated in multiple terms including monetary values, time duration, travel comfort, risk etc. In addition, some aspects of accessibility may not be fully understood or are hard to capture. For example, built environment has significant influence on people's choices of local travel mode and route, but such factors are seldom considered in accessibility measurement (Crane, 2000).

Above all, the key to accessibility concept is to understand the underlying behavioral dimensions of accessibility evaluation (Kwan, Murray, O'Kelly & Tiefelsdorf, 2003). Theories about spatial interaction from geography, physics, and economics, have been introduced to build accessibility measurements. With an improved understanding of human behavior in space, accessibility measurements have become more and more sophisticated and have ranged from Euclidian distance, which presents simple spatial relationship, to utility based measurement, which is capable of evaluating individual response to opportunities by considering both choices and personal attributes (Handy & Niemeier, 1997).

However, modern transportation technology such as ITS (Intelligent Transportation System) and information technology are quickly changing ways of interaction between person, place, space and activity (Miller, 2005). Thus, along with these increasingly complicated interactions, the concept and measurement of accessibility will continue to evolve.

2.2.2 Measurements of Accessibility

Based on the evaluation methods, Handy and Niemeier (1997) grouped accessibility measurements into three big categories: cumulative opportunity, gravity-based and utility-based measures. These measures are widely implemented in many accessibility impact studies as well as in planning practice. In recent years, the availability of more detailed data and more advanced analysis tools such as GIS allow the indicators to be more disaggregated as well as more inclusive. However, Miller (2005) believes that these traditional evaluations of accessibility are still incomplete since they are functions of places, not people who evaluate accessibility with significant different personal characteristics. Therefore, person-based accessibility measure should be used to complement the traditional place-based technique. In the following sections, I will first review accessibility measurements by three evaluation frameworks as summarized by Handy and Niemeier (1997) and then discuss some recent improvements such as the person-based measurements.

Accessibility measurements by three evaluation methods

Measurement of Cumulative opportunity:

This type of measures is also called "isochrone measures" and can often be seen in early studies including the works of Wachs and Kumagai (1973) and Vickerman(1974). The basic idea is to count the total opportunities within a designated distance or time range. The more opportunities there are, the higher the accessibility is. This evaluation method is regarded as an extension of the simple distance-based indicator (Miller, 2005), which use Euclidian distance or network travel time to measure accessibility. The advantages of cumulative opportunity include the consideration of the quantity of opportunities and its easiness to interpretation. But its weaknesses are also obvious (Handy & Niemeier,1997; Makrí & Folkesson, 1999). First, the measurement is sensitive to the distance or time cut-off. For example, with a threshold of thirty-minute travel time, a destination at thirty minute is considered accessible while one at thirty-one minute is not. This is counter intuitive since in reality those two destinations will be considered similar or the same to many people. Second, for a long time there is a lack of consensus on the best standards on the selection of time or distance thresholds. Different time or distance choices are presented in studies without clear theoretical guidance (Makrí & Folkesson, 1999). Only in recent studies (Cevero & Duncan, 2006) has the theoretical reasoning of some distance threshold been discussed and suggested; Third, all opportunities within the same ranges are weighted equally without consideration of the impact of travel endurance (Handy & Niemeier, 1997). This could lead to serious measurement bias when the specified time or distance thresholds are large.

Gravity-based measurement:

This measurement was described by Hansen (1959) and later widely adopted in many accessibility studies (Handy, 1992; Geertman and van Eck, 1995; Kwan, 1998; Cervero et al., 1999). The indicator follows the interaction rules of masses, in which the strength of interaction is directly proportional to the masses, but inversely proportional to the square of distance. In actual accessibility calculation, the impedance factor often takes more complicated function forms such as inversed power function, in which parameters are usually derived from real travel data.

The strength of the gravity-based measure is its emphasis on the influence of impedance. The adjustable functional forms and parameters allow impedance evaluation to be finely adjusted so that travel model results could match real traffic data. When this strength is combined with reasonable measurement of opportunities, gravity-based measurement is theoretically sounding and has thus become quite popular in many studies since its introduction. Even today, gravity-based measurement and its improved variants are still regarded as good choices for spatial interactions when detailed data are not available. However, some of its limitations are also pointed out by scholars (Handy & Niemeier,1997; Makrí & Folkesson, 1999; Miller, 2005). One frequently discussed problem is that the measurement, which often uses aggregated data in practice, ignores differences among individuals or opportunities. Or in other words, this indicator considers differences across space but not within space. Yet, the neglect of individuals' preference could have significant meaning to accessibility results (Ben-Akiva and Lerman, 1979). Another problem in gravity-based accessibility is on the issue of spatial scales (Kwan et al., 2003). Due to data availability, early studies used large areas such as cities or districts as analysis zones. Since accessibility can vary greatly across small distances, large analysis zones may not provide accurate estimation of accessibility. Recent studies have reduced the geographic level to census tracts, TAZs(traffic analysis zones), or even more detailed level.

Utility-based measurement:

This type of measurement is based upon random utility theory with the assumption that all individuals are trying to maximize personal utility in their travel decision making (Ben-Akiva & Lerman, 1979; Handy & Niemeier, 1997; Kwan, 1998). Here, the utility concept is linked to consumer welfare, which represents the overall benefits provided by transportation choices. For each trip, a set of travel choices is developed and the utilities for each choice are compared. The one with maximum utility is assumed to be chosen. In such equation, overall benefits provided by all transportation choices can be measured by the logarithm form of the sum of logit model's denominator, also known as logsum(Ben-Akiva & Lerman, 1979). The measurement of accessibility could use the logsum from the mode choice model in combination with the evaluation of opportunities or use the logsum directly from the destination choice model.

Another advantage of the utility-based measurement is that it allows for alternative functions that could be derived and tested to best match travel behavior (Makrí & Folkesson, 1999). For example, it can include variables capturing the observable factors in personal travel decisions such as opportunities and personable attributes as well as unknown elements

like personal preferences (Handy & Niemeier, 1997). Therefore, it is often regarded as the most theoretically sounding measurement. However, its weaknesses are also obvious (Handy & Niemeier, 1997): First, utility is treated as a random variable since it is not known to the analyst. Second, this method has a high demand for detailed data, such as personal or household attributes, which may not be available in many cases. Finally, this measurement is also limited by the specification of travel models (Waddell et al., 2007).

Accessibility with advanced improvements

Accessibility by demographic attributes or activity types

As discussed before, one major issue with traditional accessibility measurements such as gravity model is the lack of sensitivity to individual differences (Handy & Niemeier 1997). Population or households' characteristics could greatly affect activity decisions and travel behaviors. It is also reasonable to assume that the same opportunities may be valued differently by individuals with different social economic status and lifecycles. Therefore, researchers have extended their accessibility measurements by breaking down population characteristics (Wachs & Kumagai,1973; Niemeier, 1997) and found that refined assessments have indeed increased the overall accuracy of accessibility measurement. As to the opportunity measurement, different types of activities may also have different values. Thus, a logical improvement is to categorize opportunities, for example, distinguishing employment opportunities by occupation (Cervero et al., 1999) or industry (Franklin & Waddell, 2003, Giuliano, Gordon, Pan & Park, 2010) and evaluating them accordingly. Cervero et al. (1999) matched job occupations with residential workers' occupations and created composite employment index for their study zones. The new indicator added significant explanatory power to the model results. This type of measurement is especially important in places where residence and employment patterns differ significantly among occupations, for example, places where spatial mismatch is evident. In terms of capitalization effects, Franklin and Waddell (2003) found that different destination types could have opposite impacts on property values, which was also confirmed by Giuliano et al. (2010).

Market competition and constraints:

Another important improvement to accessibility evaluation is to include spatial constraints. Population and opportunities in urban areas are unevenly distributed, meaning demand for accessibility may be subject to the limitation of supply. For example, a job seeker might not have good work accessibility if nearby job center has few positions or the competition is very strong. Therefore, work accessibility has to be balanced with their spatial demand to get appropriate assessment. Shen (1998) proposed a method to discount job accessibility by taking into account its spatial demand. His study on low-income workers' job accessibility found this new method improved the estimation for location advantages of central city workers and distinguished the auto ownership as an important factor in their access to work. Another method is to use the so-called inverse balancing factors as Wilson(1971) discussed in his spatial interaction models. This method is computation

intensive since it requires iterative calculation of trips flows to ensure the numbers of trips to and from each zone equal to opportunities (Geurs & Ritsema van Eck, 2003). The effectiveness of this measure is confirmed by Geurs and Ritsema van Eck (2003) in their case study of accessibility impacts on land use in Netherland.

Space-time framework

When narrowing down to individuals, personal accessibility is limited by time budget as well. Subject to all sorts of constraints such as capability constraints, coupling constraints, authority constraints (Hagerstrand, 1970), each individual can only have limited time to travel to desired locations and participate in activities. This so-called space-time prism defines the individual's activity boundaries in both space and temporal dimensions (Hagerstrand, 1970). We can regard this concept of space-time prism as a measurement of a person's specific accessibility since it essentially describes the possible opportunities available on his/her individual activity map(Djist & Vidakovic, 2000; Kwan, 1999; Weber & Kwan, 2002). When evaluated with sufficient travel data such as distance and speed, this measurement demonstrated its advantages on delimiting individual accessibility (Miller, 1999; Kim & Kwan, 2003; Miller & Wu, 2000). The method, however, is also subject to the limitation on data availability and computation complexity. Lee et al. (2010) has innovatively operationalized the time space prism measurement and successfully applied it in shopping accessibility evaluation. Their findings confirmed that both work and nonwork are important factors in residential choices.

Activity-based accessibility measurement:

Most recent development on accessibility concept has been focused on analyzing individuals' activity patterns, instead of single trips in traditional travel models. By using all activity patterns available to individuals as travel choices, the maximum utility derived from the choice set can then be seen as a measure for accessibility (Dong, Ben-Akiva, Bowman and Walker, 2006). This measurement captures all activities an individual engages as well as incorporating travel characteristics such as trip chaining and scheduling. Franklin and Waddell (2003) applied this measurement in their study for housing capitalization effects of different types of employment accessibilities and found that depending on the specific activity types, the identified effects could be either positive or negative. The potential of this measurement is to describe activity patterns by specific population groups and to evaluate the policy impacts or travel behavior in a more precise way. However, one prerequisite for this accessibility indicator is the availability of activity-based travel survey data or model results.

2.2.3 Choosing the Best Measurement

From simple distance or cumulative measures to advanced activity-based measures, accessibility assessment becomes more and more sophisticated. The methodology improvements reflect a better understanding of people's "behavioral responses to the spatial separation of locations of supply to the locations of demand" (Kwan et al. 2003, p. 130). The introduction of disaggregated information such as demographic attributes, market conditions,

and individual travel patterns clearly overcomes some evaluation flaws and leads to more theoretically sounding indicators. However, even with most advanced measurement, there are still gaps between actual and predicted activity patterns as some qualitative aspects of accessibility measurement are still missing in the evaluations. Therefore, qualitative analysis also needs to be seriously considered to further improve the accuracy of accessibility measures (Handy & Niemeier, 1997).

In addition, depending on the study purpose, it is not necessary to always use more complicated measures as they may not be more effective than simple ones (Handy and Niemeier,1997). The more complex the measure is, the more difficult the interpretation might be, and, sometimes the policy implications may also become obscured (Handy and Niemeier, 1997). On the other hand, simple measurements still have advantages as they are easy to understand and rely less on large amount of data. And more importantly, the results of simple indicator may not be inferior to those resulting from complicated methods. A study from Srour, Kockelman and Dunn (2002) on land value and household location choice demonstrates that simple accessibility measurement such as cumulative jobs performed better than utility-based measurement in their models. Therefore, "no one best approach to measuring accessibility exists", the choice of a good approach will largely depend on "different situations and purposes" (Handy and Niemeier, 1997, p.1182). Thus, some studies (Srour et al,. 2002) have developed more than one indicators and compared their performance. In that way, not only can we find out which accessibility measurement excels in the specific study context but we can also advance our understanding on how to improve our accessibility measurement in the future. This is also the approach I will apply in this dissertation.

2.3 Empirical Studies about the Capitalization Effects of Accessibilities

2.3.1 Theory and Evaluation on the Capitalization Effects of Accessibility

The popular cliché "location, location, location" in real estate market highlights the importance of spatial location as the source of land values. The meanings of good location are usually multi-folded, including better accessibilities to jobs, shopping centers, recreation and other desired opportunities as well as better living conditions such as safer neighborhood, good environment, walkable streets, etc. On urban land market, location premiums are capitalized into land values but the capitalization effects are never simple and could vary significantly with property's regional and local context. First, the value of good accessibility is more likely determined by its relative advantages than its absolute level. For places with prevailing good transportation access, the benefits from shorter commute tend to be small (Giuliano, 2004). Second, the value of time saving may be affected by other factors such as personal income (Gwilliam, 1997). In general, the higher the income is, the more valuable time is. Third, since the accessibility premium is assessed through land market, its market value is subject to the interaction between market demand and supply (Voith, 1993). Forth, benefits from accessibility improvement might be nonlinear to actual time or distance

savings as empirical studies showed (Vesalli, 1996). Economic theories tell us that, all else being equal, the marginal return from a continuous input will be diminishing when it goes beyond a certain point.

The theory behind location capitalization is the economic utility enjoyed by residents (Lancaster, 1966; Malpezzi, 2002). A traditional way to find out people's willingness to pay for their current locations is to use hedonic regression model to break down housing units into individual components such as floor space, number of rooms, distance to work and estimate the implicit market prices for each component. This method assumes that housing components are traded without constraints on an equilibrium housing market, where people evaluate any component exactly the same way. However, this is not the case in ordinary housing market (Rosen, 1974; Malpezzi, 2002). Housing products have to be sold as bundles and both supply and demand for desired attributes such as good locations are unlikely to reach market clearance. Therefore, housing market is actually segmented (Goodman and Thibodeau, 1998) and the implicit prices of housing attributes could vary in different submarket (Orford, 2000). Traditional single-level regression model can be described as a reduced form (Malpezzi, 2002) with the potential to generate biased or misleading estimation. Several modeling techniques were introduced to improve hedonic model estimation. Among them, multilevel modeling technique is promising since it can more effectively connect the model specification to housing market dynamics, e.g. it can simultaneously capture the housing attribute composition and the contextual effects of housing sub-markets (Orford, 2000).

The impacts of accessibility are better assessed with proper evaluation of regional accessibility improvement versus local accessibility changes. As Huang (1994) pointed out, without distinguishing the two type of effects (regional versus local), the impacts of transportation improvement could be hardly generalized due to the varying local context for each individual project. However, most empirical accessibility impact studies are focused on specific transportation projects rather than general transportation accessibility (Franklin and Waddell, 2003). A practical reason behind this phenomenon is that specific projects are often the central concerns of transportation authorities and local communities. In addition, impacts are usually most observable or assessable in a project's surrounding areas. However, studies limited to project areas do not provide much insight into the effects of general accessibility to activities across the metropolitan region (Franklin & Waddell, 2003). Therefore, to understand the fundamental link between land use and transportation, it is important to evaluate the impact of general accessibility with the control of local transportation factors. As the majority of household travels are non-work related and the share of nonwork trips keeps increasing (Deakin, 2003), it is also increasingly important to include nonwork accessibilities in impact studies in order to have the full picture of how accessibility is evaluated by contemporary population. Although some studies have examined a certain type of nonwork accessibilities, there is still a lack of systematic analysis on this topic.

In the following sections, I will first review the capitalization effects of regional accessibility and then discuss the impacts from the access to particular transportation facilities. I will also review studies that examine the effects from nonwork accessibilities.

2.3.2 The Capitalization Effects of Regional Transportation Accessibility

Guided by the traditional urban economic theories (von Thünen, 1826; Alonso, 1964), researchers examined the bid rent curves against the access to major CBD and reveal interesting patterns in various study contexts. An earlier study by Rachlis and Yezer (1985) tested CBD distance and housing prices in five metro areas and found inconsistent capitalization effects. Some are positive, as what the theories predict, and others are not. Rachlis and Yezer suspected the assumption of monocentric employment no longer held in certain metro areas as jobs have spread out to the suburbs instead of being concentrated in CBD. In response to the concerns of accessibility values in decentralized urban form, Voith (1993) studied the housing value changes in Philadelphia area between 1970 and 1988. He found solid evidence that access to Philadelphia CBD, measured by commuting time, was capitalized into housing values and, contrary to many people's belief, the values of highway access did not decline but increased in his study period. This strengthened effect between accessibility and housing values was attributed to the improving economic health of the city. Thus Voith concluded that a growing CBD could benefit suburban communities substantially. Archer, Gatzlaff and Ling (1996) examined housing data in Dade County, Florida and found that distance to CBD was indeed inversely related to housing values. But the housing value appreciation varied significantly by each city.

Considering the reality of job suburbanization and polycentric urban form, more and more studies applied accessibility measurement to multiple employment sub-centers. Heikkila et al. (1989) incorporated distances to multiple job centers in their study in Los Angeles. Their hedonic price model indicated insignificant housing price gradients from CBDs. Waddell, Berry and Hoch(1993) used Dallas County data with more refined measurement than Heikkila's and their finding showed significant price gradients to both primary CBD and sub-centers. But capitalization effects appeared to be rather localized, within a distance of not more than 10-15 miles. They also observed sharp decline of housing prices within half miles from south side of CBD, which had a much higher crime rate and worse living conditions than the north side. Kockelman's (1997) study on housing prices and rents in the Bay Area identified significant impacts of major downtowns. However, the relationship went opposite for San Francisco and Oakland. For San Francisco, shorter distance to CBD had strong and positive impacts on housing values. While in Oakland, locations closer to downtown area saw value losses. Kockelman believed the reason for the reverse value curve for Oakland CBD was associated with its negative environment such as high crime rates, lack of attractiveness and abundant supply of land. This observation is consistent with Waddell et al.(1993).

At more disaggregated level, capitalization studies also examined the effects of general accessibility to employment at TAZs. Srour et al. (2002) developed cumulative accessibility indicators for employment, retail activity and parks using zonal job information. Their land value models for Dallas and Tarrant counties in Texas identified job accessibility as the most important and positive contributor to property values. Compared to utility-based accessibilities derived from designation choice models, they found simple cumulative measures had better explanatory power on household location choices. Franklin and Waddell (2003) studied single-family housing price in King County between 1995 and 1998. They evaluated access to different type of jobs and found different accessibility had different impacts on housing values. For example, access to commercial areas and universities had positive effects while industrial and educational land uses were negative. Giuliano et al.(2010) also used TAZ-based travel time to develop gravity accessibility indicators for jobs. They found aggregated job accessibility contributed less than expected to the model but are still qualified as reasonable. When breaking down total job accessibility into four job sectors, they saw significant coefficients but the directions of accessibility impacts were not all positive. Access to industrial, public administration and professional services jobs had negative effects. The result is somewhat puzzling. They believe, in this case, sector based accessibility indicator is more a proxy indicator to other activities than to expected jobs. Job accessibility still matters but less important and in a more complex way, they concluded.

2.3.3 The Capitalization Effects of Accessibility to Transportation Facilities

Accessibility to Highway:

Starting from the highway-building boom in the 1950s and 1960s, numerous studies were conducted to examine highway's impacts on economic development and land use. A rich literature was developed to examine the capitalization effects of improved highway accessibility. In a comprehensive review, Huang (1994) examined the most important studies from the1950s to early 1990's. According to his observations, the first wave of studies reported large land value increase near highway construction, but the capitalization effects were much less from the1970s to the 1980s. In addition, some negative effects have been identified in those studies. For example, Buffington and Meuth (1964) found huge increases in land values (2,562%) over time in the study area of Temple, Texas. But Palmquist's study (1982) on single family housing prices in Washington State showed only 12%-15% appreciation. Tomasik (1987) in Phoenix found positive capitalization effects of proximity to highway if the distance was 0.5 mile or further. Within 0.5-mile highway corridor, property values had no correlation with distance and he believed this was due to the depreciation effects from nuisances that offset the proximity premium of the highway accessibility. Langley (1981) used 17 years of home sale records in North Springfield, Virginia and found houses near I-495 were sold for approximately $3,000-$3,500 less than comparable but more distant properties. He blamed the noises from the highway as the reason for the price difference.

Studies after 1990 were mostly carried out in response to the increased public concerns about urban problems such as sprawl, traffic congestion and central city decline. Research methodology continues to improve during this period. More and more studies applied GIS techniques and utility-based accessibility measurements, which allowed more fine-grained studies than what was possible before. Giuliano (2004) reviewed some important studies during this period. She compared the findings of Harder and Miller (2000), Boarnet and Chalermpong (2001) and Voith (1993) and concluded that highway impacts on land uses were place-specific. For example, in Harder and Miller's study of 1995 Toronto Metro area, residential property values were negatively associated with nearby highway existence, although the proximity to city CBD remained as a positive source of house prices. Boarnet and Chalermpong(2001) did a time series study in Orange county. Their regression results indicated that new toll road changed the accessibility and the accessibility premium was reflected in home prices. However, as Giuliano noted in her review, their findings were achieved under the context that the development and the highways were tied together (Giuliano, 2004).

Based on the reviews (Huang, 1994; Handy, 2002; Giuliano, 2004), some consensus can be reached. First, housing prices change when there are significant accessibility improvements resulted from highway construction. The accessibility premiums were strong in the early years when highway supply was limited. New highway investments tend to have smaller impacts and at a smaller geographic scale than in the past since the new links to highway system can bring limited or marginal time savings. Second, highway impacts are "place-specific" (Giuliano, 2004, p.261). The types of impacts and their magnitude are subject to other conditions such as market demand, land supply and supportive development regulations. The highway itself is not sufficient to promote land use changes. Third, if property values are regarded as part of the economic growth, the increase usually happens at the cost of adjacent areas. So highway impacts on economic activity may not be a net gain.

Accessibility to Transit:

Transit is another major urban transportation system. Unlike highway, transit service impacts are often limited to transit corridors, especially station areas. Hence, the examinations of transit impacts have been mainly focused on properties within station areas. According to Huang's (1994) review of transit capitalization studies, "virtually all found that proximity to stations had positive property value effects" (p. 9). But the magnitude of proximity varied a lot from study to study. He used two studies to illustrate the difference. One is Gatzlaff and Smith's study (1993) in Miami. The announcement of the Metrorail system had very weak residential value effects. The other study was done by Al-Mosaind, Dueker, and Strathman (1993), who detected a very large premium of rail stations in Portland. The houses within 500 meters of stations were sold for $4,324 (about 10% of average housing prices in that area) higher than other houses. The reasons for this big difference can be explained by the attributes of the transit project as well as different land use policies. Housing price premiums estimated in other early studies such as Boyce et.al. (1972) and Dewees (1976) were within the ranges of the above two studies. More recent

transit accessibility studies continued to find evidence of positive capitalization effects. Two examples are Benjamin and Sirmans (1996)'s finding of 2.4% to 2.6% decrease for each one-tenth mile increase of distance from Metro stations in Washington and Lewis-Workman and Brod (1997)'s estimation of $1,578 increase for every 100 feet closer to BART Pleasant Hill station.

Interestingly, some transit projects continue to attract researchers' interests and were repeatedly studied by different researchers. For example, a series of studies were conducted from 1993 to 1999 in Portland area and all studies concerned residential land uses. Al-Mosaind, Dueker and Strathman (1993) analyzed the home sale values within 0.25 mile of the MAX stations. Their study found a $663 increase for each 100 feet nearer the transit for the east side rail line. Knaap, Hopkins and Pant (1996) studied the west side rail and used 0.5-mile rings from the station to measure accessibility. They found that property prices increased with distance to the station within the first ring and fell with distance beyond that. The 1997 study by Lewis-Workman and Brod was focused on the area beyond half mile from the MAX stations and a $75 premium was observed for each 100 feet closer to stations. Chen, Rufulo and Dueker (1998) used a similar method, but chose the study ring from 100 meters to 1000 meters from stations and their finding revealed a $32.2 housing price reduction for each meter. The most recent study (Dueker & Bianco, 1999) used a test and control group method and the researchers found the biggest housing price difference of $2,300 occurs at 200 feet away from stations.

Instead of focusing on single projects, some studies compared the transit projects in different areas and gave more in-depth observations on its land use impacts. One example is a study in California by Landis et al. (1995), which examined the land use effects of five rail lines. Comparing the two commuter heavy rail lines, BART generated a premium for places nearby its stations while Caltrain did not. This appears to be the result of the differences in the level of service and the availability of parking spaces. Even more interestingly, light rail systems in three different regions also showed mixed or even opposite results. In San Diego, a value-adding effect was detected; in Sacramento, no effects were observed on housing prices near transit stations; in San Jose, the existence of transit facilities actually reduced housing values. Further analysis identified three factors for this regional variation, the performance of transit system, competition from highway, and the nuisance of being near stations. This pattern confirms that transit itself is not a sufficient condition to bring land value or land pattern changes (Landis et al., 1995). In summary, according to Giuliano (2004), three observations could be made on transit's capitalization effects. First, transit "impacts are highly localized" (p. 268) and tend to occur at urban core areas. Second, transit is a necessary but not sufficient condition for land use impacts. Third, the impacts of transit system "depend on complementary zoning, parking and traffic policy, and especially on development subsidies" (p. 268).

2.3.4 The Capitalization Effects of Nonwork Accessibilities

The evaluation of nonwork accessibility is more complicated than work accessibility. Besides quantity, the quality aspect of nonwork activities often plays an important role in determining its attractiveness. In addition, nonwork activities are often not comparable or substitutable, meaning their opportunity indicators should not be combined. It is generally recognized that good access to shopping, school, parks are important factors benefiting daily lives and can be important source of housing values. However, as many studies have shown, the actual impacts of such nonwork accessibilities vary case by case and are sensitive to study context and model specification (Boarnet & Greenwald 2000; Rajamani et al.,2004) .

Shopping accessibility

Shopping accessibility, similar to work accessibility, could be measured at different geographic scales. At regional level, shopping opportunities could be represented by either TAZ employment or number/scale of regional shopping centers (Guy, 1983; Srour et al., 2002; Lee et al., 2010). And shopping accessibility indices could be derived by coupling opportunity patterns with transportation impedance in either traditional gravity formula (Guy, 1983) or more advanced time-space-prism calculation (Lee et al., 2010) . At local level, researchers have focused more on the influences of shopping centers, which could be single or multiple, on proximate property values. A typical accessibility measurement is the Euclidian distance to shopping centers (Colwell, Gujral and Coley, 1985). Moreover, with the availability of detailed spatial data, analysis could be done to examine opportunities proximate at a land gridcell or parcel level (Waddell & Nourzad, 2002; Waddell et al., 2007). Between regional and local scales exists measurements at middle geographic level. Des Rosiers et al. (1996), for example, used 20 minutes travel time as service areas to study big shopping centers' impacts on housing values. Shopping accessibility measured at different geographic scales could be very meaningful according to Handy's (1992) study on local versus regional accessibility. She found households with scarce local accessibility to shopping had to compensate with regional trips. In another study of shopping accessibility, Handy and Clifton (2001) found distance is by far not the deterministic factor when comparing with many other obvious and less obvious factors. But local shopping with the option of less driving is clearly valued by residents. A study by Waddell and Nourzad (2002) in Wasatch Front region applied local shopping distance of 600 meters and found positive location preferences from households. Moreover, its importance was stronger for those with less driving opportunities, e.g. households having fewer cars than the number of workers. Therefore, depending on specific urban setting, both regional and local shopping accessibilities could be valuable and important to households.

Regardless of spatial scales, most of the studies identified significant capitalization effects of shopping accessibility with some negative influence detected with close adjacency. For example, Colwell et al.'s study (1985) saw both positive and negative capitalization of shopping centers. Their model indicate dominant diseconomies within 1500 feet to a shopping center, while beyond this distance, properties gained values. Waddell et al. (1993)

's findings are consistent with Colwell's on both the positive capitalization and negative externalities within the proximity of shopping center. But their findings indicated a much larger range of value adding effects for properties located up to10 miles away. Their negative impact range is one and half miles to shopping malls. Sirpal (1994) further extended the evaluation of distance measurement by including the size of shopping centers in consideration and found both had significant impacts. Des Rosiers, et al. (1996) used travel time by minutes as accessibility indicator instead of Euclidean distance from shopping centers. Their model shows that households within 3-20 minutes travel time indeed put positive values to their houses. Srour et al.(2002) modeled cumulative shopping jobs in their land value study and found at parcel level, shopping detracted housing values but at census tract level, the capitalization effect was positive.

Besides distance and size, retail type as another aspect of shopping accessibility has also caught researchers' attention. In the study to explore neighborhood accessibilities, Handy and Clifton (2000) compared seven neighborhoods in Austin. Beside the intensity and diversity of retail activities by distance buffers, they also illustrated the importance to evaluate access by specific retail types. Good retail access in general may not guarantee access to all important destinations. For example, in the case of Cesar Chavez, although it ranks high in both retail intensity and diversity, it is the lowest in grocery shopping. Also, their location quotient analysis indicated quite different location patterns between retail types. For example, some neighborhoods concentrate many more liquor stores than average. Therefore, considering retail types in accessibility studies is necessary, although availability of local data is often a challenge.

School accessibility

Access to quality school is always regarded as the one of the most important factors to property values (Rosen & Fullerton,1977; Goodman & Thibodeau, 1998). In the U.S., public school attendance is essentially determined by property locations, which are assigned to certain school districts and attendance areas. Households, especially those with school-age children, are bidding up housing prices in good districts or attendance areas to gain access to better education opportunities. As a result, properties near better schools enjoy additional premiums even though they are often taxed more heavily than others. This positive relationship between housing prices and school quality has been confirmed through numerous studies (for example, Haurin & Brasington, 1996; Bogart & Cromwell, 1997; Goodman & Thibodeau; 1998), although the best indicator to represent school quality and the true magnitude of the capitalization effects are still under debate.

In 1999, David Brasington reviewed measurements on school quality from many studies. According to him, earlier school capitalization studies tend to use input factors for school quality such as school expenditures (Oates,1969; Gustely,1976) or student-teacher ratios (Grether & Mieszkowski, 1974). However, this method was criticized by scholars (for example, Rosen & Fullerton, 1977) as school spending is only one of the many inputs to school education and more importantly, it is not outcome-oriented. Therefore, performance

related indicators such as proficiency test scores were recommended and have been used as the major indicator in many hedonic studies (Walden, 1990; Haurin & Brasington, 1996; Goodman & Thibodeau, 1998). Regardless of the exact formula of performance indicators, most of the studies successfully indentified academic scores as a significant positive factor to housing values. This result is consistent with Tiebout (1956)'s household sorting theory. Some scholars also evaluated school quality with other indicators such as value added from school education process. Instead of final testing scores, scholars like Hayes and Taylor(1996) focused on the improvement to the students' academic performance brought by school system. The hypothesis is that potential improvement from a school matters more than its existing status. However, Brasington's study (1999) shows that as property owners, parents actually value the outcomes, e.g. proficiency test results, rather than the value added from the school education. Brasington speculated that what parents are investing is the socio-economic status of school districts, not their capability to improve students' performance. He also concluded that in property value study, performance indicator is more appropriate than value-adding approach.

Also as some studies have shown, controlling for neighborhood social-economic characteristics is important for the correct estimation of school quality impacts since quality schools tend to be co-located with good neighborhoods(Chiodo, Hernández-Murillo & Owyang, 2010). To minimize the impacts caused by neighborhood differences, some researchers (Black,1999; Imbens and Lemieux,2008) advanced their hedonic model with "boundary discontinuity regression". They restricted their samples to houses near the boundaries between school attendance areas or districts and control for neighborhood characteristics with boundary fixed effects. However, this approach is still challenged as it may still fail to control for omitted neighborhood characteristics (Cheshire & Sheppard, 2004; Bayer, Ferreira, and McMillan, 2007; Chiodo et al., 2010). In a recent study, Chiodo et al. (2010) responded to this concern by introducing additional demographic characteristics as controlling variables and applied spatial auto-regression. And their finding showed school performance was statistically significant, but the relationship with property values might not be linear.

Recreation accessibilities

Parks, open space, water bodies and other recreational opportunities are generally accepted as neighborhood amenities. Their impacts on proximate residential properties are widely studied (Weicher & Robert, 1973; Kimmel,1985; Waddell et al., 1993; Bolitzer and Netusil, 2000; Crompton, 2000). The evidence from these studies supports the positive influences of recreation opportunities on nearby neighborhoods and properties. Depending on the locations, the scales, activity types, and competitions from other similar opportunities, the capitalization effects from nearby parks can be as far as 2000 feet away and increase property values as large as 20-30% of the total housing prices (Crompton, 2005).

Crompton (2005) reviewed studies in the past two decades on park and open space impacts on property values. In addition to the solid evidence of positive capitalization, he

also made several observations: first, as presented in studies, the relationship between increased property values and proximity to parks could vary from negative linear (Sielski, 2002) to negative exponential (Miller, 2001) or even irregular patterns (Lutzenhiser and Netusil, 2001). Second, the scale of the parks also matters (Miller, 2001). Larger parks seem to have larger effects than small ones on property values. However, when compared to proximity, the impact of park size is relatively small. Third, subject to local environment, the premium from parks or open spaces is not guaranteed. On one hand, when access to parks or similar amenities is abundant, the capitalization effect is small or even non-existent (Nicholls, 2002). On the other hand, adverse impacts are possible if the residents suffer from traffic congestion, noise, vandalism and other nuisance from the visitors of parks (Cromton, 2005).

Other studies (Brown & Pollakowski, 1977; Lansford & Jones, 1995; Loomis & Feldman, 2003; Muller, 2007) have specifically examined the impacts of water bodies, which are also regarded as potential value-adding sources to nearby properties. Similar to parks and open space, distance is usually the primary concern to households and studies often confirmed the positive impacts from the proximity to water bodies. One thing worth noting is that, the location along a waterfront or whether having an open view of water is often preferred by residents and could add additional price premiums than just the proximity effects. As Muller (2007) argued in his study, it is necessary to separate the water-front, water-view and distance effects in a hedonic price model and use all three variables for correct specification.

2.4 Thoughts on Future Research

In reviewing the literature, scholars (Huang 1994; Vesalli, 1996; Boarnet & Haughwout, 2000; Giuliano, 2004) have often discussed in great details the strengths and weakness of existing work and pointed out directions for future research. For example, despite the constraints of data availability, it is often argued that future research needs to pay more attention to model specification and interpretation. This section will discuss several issues that are related to my dissertation research.

The Importance of Nonwork Accessibility

In many accessibility studies, accessibility destinations are often evaluated by major activity centers, which mostly represent job clusters. It is true that job location has been one primary concern in household residential location decision. However, highly accessible highway network and faster commuting speed allow people to live much farther away from work than before. Therefore, commuting has become less deterministic than it was in the past. As discovered in the series of studies on "wasteful" commuting, other factors such as school quality or neighborhood safety may have become more important. Meanwhile, given the fundamental changes in suburban lifestyle (Nelson & Niles, 2000), the growing nonwork travels also represent different dynamics in activity patterns (Deakin, 2003). The trend of rising nonwork travels is likely to continue in the future and has become part of the more

complex interactions between people and space. For example, recent analysis by Lee et al., (2010) showed that shopping access is preferred by households. Therefore, it is worth examining the impacts of nonwork accessibility on property values as it could add important insights on the subject of transportation and land use connection and related policy design. Some previous studies have included nonwork accessibility measurements or specifically focused on one type of nonwork accessibility. But there is still a lack of systematic analysis on the roles of nonwork accessibilities in comparison to work accessibilities.

The Need to Focus on General Accessibilities

As discussed before, many studies of accessibility's capitalization effects were focused on the access to particular transportation facilities. By not including travel destinations in accessibility measurement, the observed transportation impacts are vague as their sources could be either regional accessibility improvement or local land use changes (Huang, 1994). Thus, to understand the importance of accessibility, it is necessary to focus on the improvement of general accessibility rather than specific transportation projects. By differentiating general accessibility from local transportation proximity and examining the benefits from general accessibility improvement, the results would be a lot more meaningful. One good example is Voith's study (1993) on highway travel time saving to the Philadelphia CBD. The study found that both the savings on rail and highway travel time to CBD had significant capitalization effects. He also related the capitalization effects to the economic health of the CBD and concluded that the central city economy is important to the wealth of suburban communities. Another example is the study by Waddell and Nourzad (2002), who differentiated regional and local accessibility and found both have contributed to household location choices.

The Advantages of Multilevel Modeling

Traditional hedonic price modeling has been widely used in existing studies. However, as scholars (Maclennean and Tu, 1996) have pointed out, its assumption about unitary housing market and instantaneous equilibrium is too simple. The existence of housing submarket, inseparable housing attributes, and inelastic demand for locations could easily violate the core assumptions of the single-level hedonic price model (Orford, 2000). As a result, the estimation of implicit prices for housing components may become biased or misleading. While some methods could be introduced to provide technical fix, they don't "reflect the processes and structures implicit in local housing market dynamics" (Orford, 2000, p. 1643). Multilevel modeling, by contrast, can successfully capture the hierarchical nature of the housing market and incorporate compositional effects of housing stock in the modeling process. It is also proved to be able to effectively handle two major challenges often encountered in traditional hedonic price models: heteroscedasticity and spatial auto-correlation. Some recent studies such as Cervero and Kang (2009) have applied this modeling technique and found significant improvement in modeling results.

In this dissertation, I will conduct a comprehensive study of the capitalization effects from the different types of accessibilities in the Southeast Michigan region. In addition to methodological improvement, such as using small geographic units, applying GIS

techniques, and a matched-pair accessibility index, I will also address the three critical issues discussed above, that is, the distinction between local and regional accessibility, the incorporation of nonwork accessibility, and the use of multilevel modeling to capture the capitalization effects.

Chapter III. Background of Case-Study Region

3.1 Regional Basics

Southeast Michigan region contains seven counties, i.e. Livingston, Oakland, Macomb, Monroe, St. Clair, Washtenaw and Wayne County. In 2010, about 1.9 million households and 4.8 million people lived in this area. Detroit MSA and Ann Arbor MSA are the two major metropolitan areas in this region. The city of Detroit, with a population of 713,000 in 2010, is the largest urban core in the region and is ranked as the 18th largest city nationwide (U.S. Census Bureau, 2010).

In 2010, there were close to 2.5 million jobs in Southeast Michigan region. Professional services, health care and retail services are the major industries and together they provided more than 40% of the total employment. In the past, Southeast Michigan was the biggest auto research and manufacturing base in the nation, with the "Big Three" auto makers leading the regional economy. Yet, in recent years, the continuous declining market share of domestic cars has led to significant job losses in both auto manufacturing and its related industries. Since 2000, manufacturing jobs has already declined by about 50 percent. During the 2008-2009 financial crisis, the entire region lost about 200,000 jobs (Southeast Michigan Council of Governments, 2012). Recent economic statistics has shown some encouraging sign of recovery but the process is slow. Today, this region is looking forward to rebuilding its economy by investing in knowledge-based sectors and diversifying its industry structure with new energy technology, movie making and entertainment services.

3.2 Development History

From 1900 to 1970s, Southeast Michigan experienced a long and rapid growth driven by its booming automobile industry. Regional population increased more than eight times to 4.7 million. Starting in the 1970s, however, growth has slowed down. The area's total population declined to less than 4.5 million over the next two decades. The decline was somewhat reversed in the 1990s when the region has resumed its growth, albeit very slowly. The revival of auto industry restored many jobs and bumped the population to over 4.8 million (SEMCOG, 2002).

As the region's largest population center, the city of Detroit's development history is typical to many American central cities that have suffered from population loss and job decentralization. However, the Detroit story is more dramatic. During the early years before World War II, the city was the absolute job and population center and attracted a lot of migration. From the 1950s to the 1960s, newly built interstate highway and ample job opportunities in this area made suburban life so attractive that employers and workers started moving out from inner Detroit to its suburbs. This movement was further aggravated by

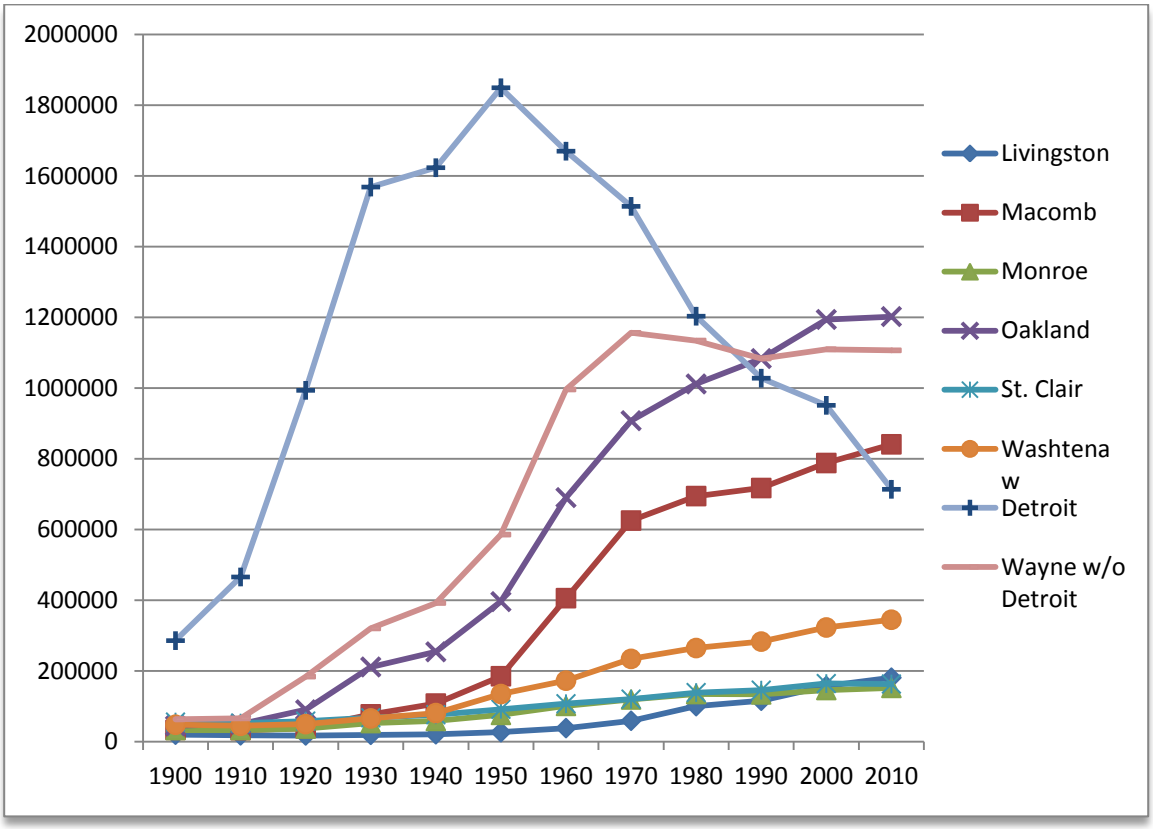
events like Detroit Race Riots in 1967 and the energy crisis in the 1970s, which further pushed people out of the central city. Heavy population loss eroded city tax base and led to serious public service cuts. High crime rates, drug abuse, along with concentrated poverty and neighborhood decline, not only worsened the living environment but also damaged the city's image. Today, Detroit has less than 40 percent of its peek population achieved in the 1950s. According to census statistics, city employment declined by more than 50% between 1970 and 2000. Yet, at the same time, suburban communities in Oakland, Macomb counties and Out-Wayne (Wayne County outside Detroit) area have seen steady job and population growth (Figure 3.1 and 3.2). In 2000, Oakland county population was three times of what it was in the 1950s and its per capita income was ranked 26th in the nation (U.S. Census Bureau, 2000).

Ann Arbor metropolitan area covers Washtenaw County. As the largest sub-center in the region, it is functioning relatively independently from the Detroit metropolitan area. Its economy depends much less on the auto industry and is mainly focused on activities like education, health care, professional and scientific service, and retail trade. As shown in Figure 3.1 and 3.2, population and job growth in Washtenaw County was quite stable throughout the 20th century. The metro's core city, city of Ann Arbor, is home to the University of Michigan and holds many high-tech and professional companies such as Google, Arbortext, A123Systems. As of today, the city of Ann Arbor is leading the job and population growth in its metropolitan area. More than 124,000 jobs, about half of the metro's total, are concentrated within the city limit.

3.3 Transportation Infrastructure and Travel Patterns

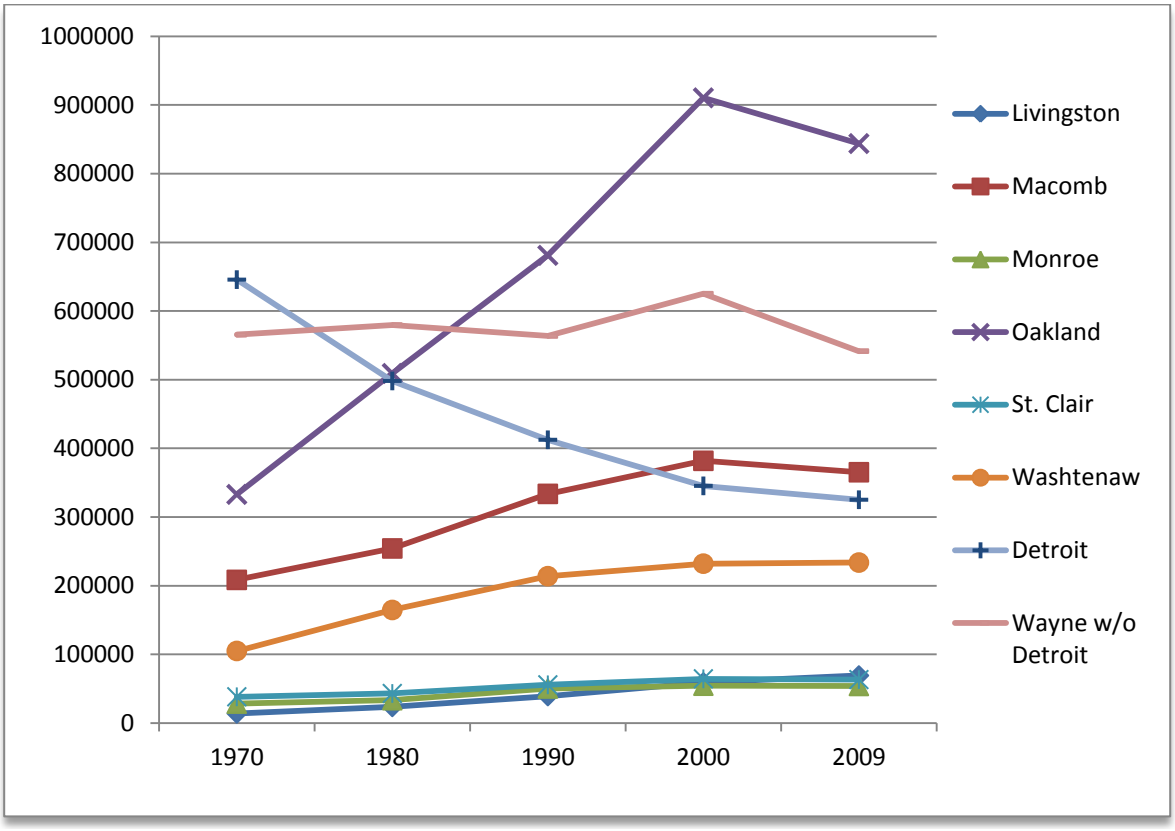
Since the completion of the interstate highway in the 1960s, there have not been any major changes to the highway system in Southeast Michigan. Highway 75, 94, 96 and 696 form a radial road network with Detroit city as the central hub. This structural pattern was developed in response to the commuting demand in the 1950s and 1960s when Detroit was the single largest job center in the region. The system is still functioning well today to serve international cargo and passenger transportation between the US and Canada. However, as map 3.1 shows, as centers of job distribution are now shifted to the Detroit suburbs, the region has seen a significant change in commuting pattern. For many commuters, Detroit is no longer their ultimate destinations. A significant portion of Detroit residents now travel to the suburbs for work, a reverse commuting pattern as a result of the spatial mismatch between jobs and residential locations. Besides the city of Detroit, the other transportation hub in this region is the city of Ann Arbor that connects highway 94, 23 and 14. While Ann Arbor is much smaller than Detroit in terms of city scale and traffic volume, its steady job and population growth have increased its roles in regional economy and transportation systems.

Figure 3.1 Population Changes by County and Detroit from 1900 to 2010 in Southeast Michigan



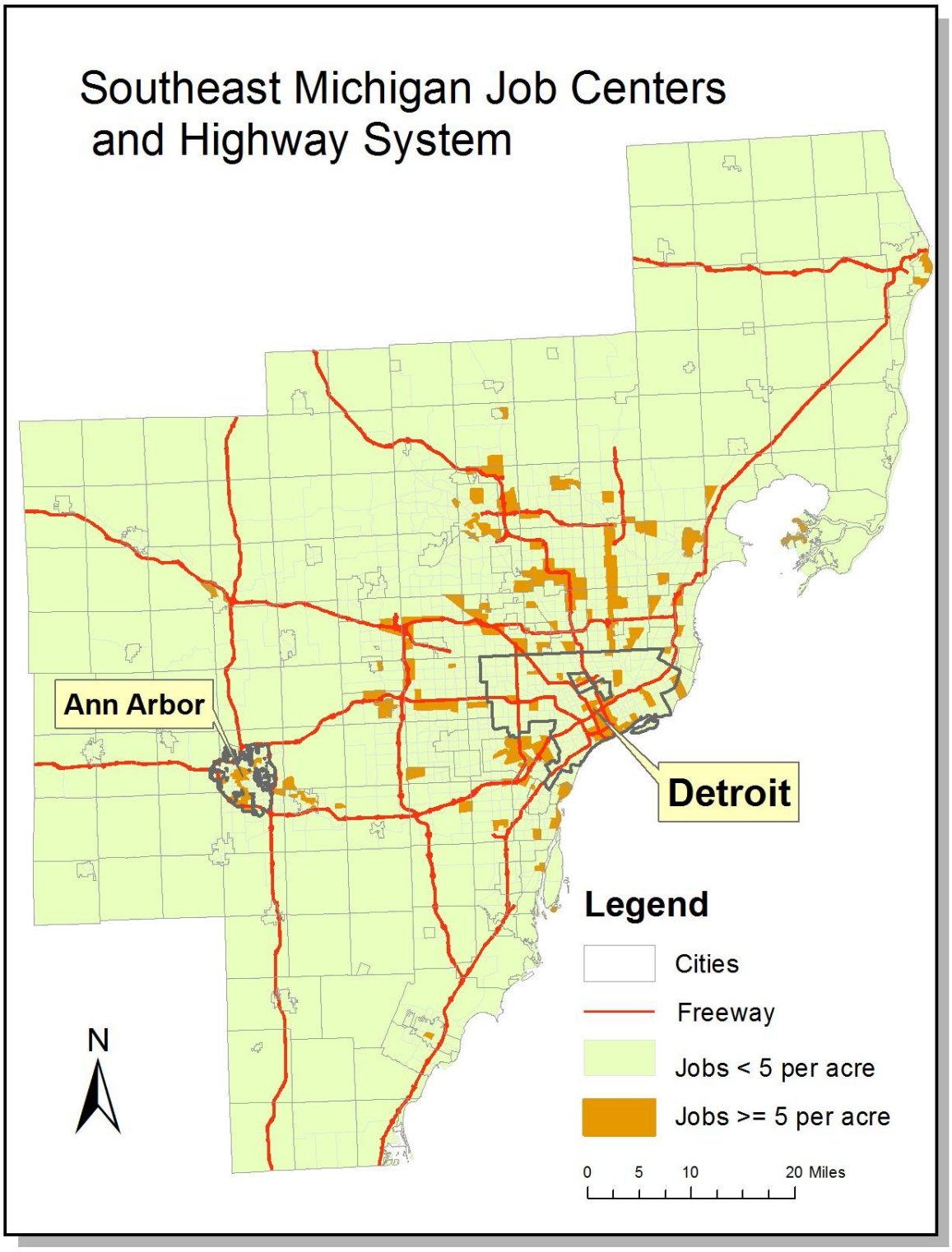
Source: Historical Population and Employment by Minor Civil Division, SEMCOG 2002 & U.S. Census 2010

Figure 3.2 Employments by County and Detroit from 1990 to 2009 in Southeast Michigan



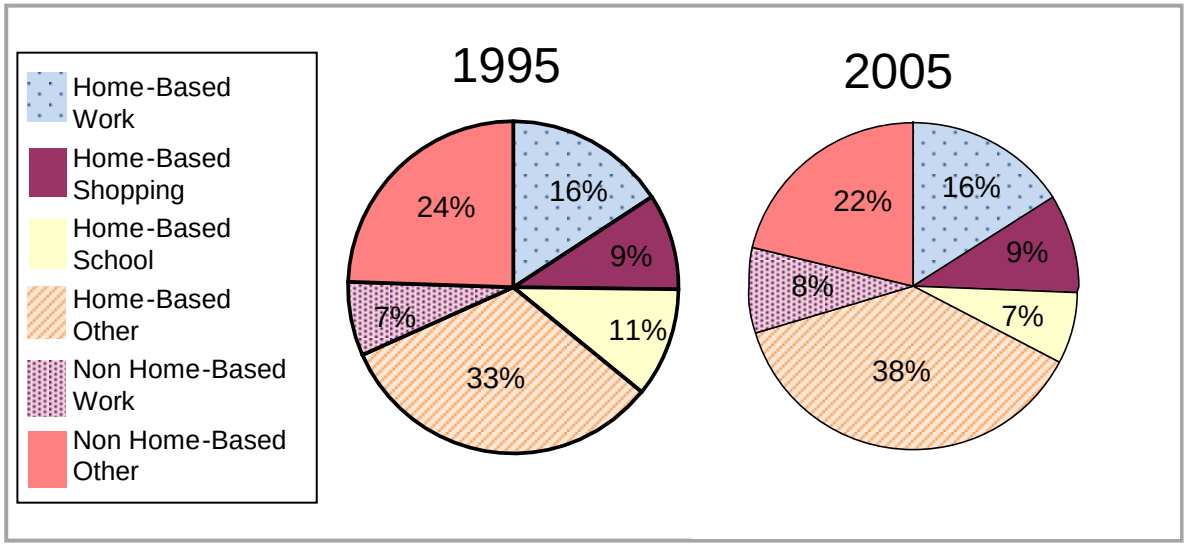
Source: Historical Population and Employment by Minor Civil Division, SEMCOG 2002 & SEMCOG estimates for Detroit 2009 data

Map 3.1 Job Centers and Highway System in Southeast Michigan in Year 2000



As 2005 SEMCOG travel survey shows, there were about 18.5 million trips for each weekday. A majority of the travels were car driving. Public transit only took a very small share, about 1.2 percent. Figure 3.3 shows the trip distribution by purposes. In terms of trip purpose, home based commuting trip is about 16%. Non-home based trip is 8.4 percent. Other trips, including shopping, school, recreation and others, account for 75.6% of the totals. Between 2005 travel survey and 1995 travel survey, the total number of trips in the region increased by 18.1 percent over the ten years. But the share of total work and nonwork related trips remained roughly the same, about 23% for work trips and 77% for nonwork trips.

Figure 3.3 1995 and 2005 Trip Distribution by Purpose



Source: SEMCOG 1995 and 2005 Travel Survey

Chapter IV. Research Methodology

This dissertation examines the impacts of the different types of accessibilities on property values and how the impacts vary by local contexts. These different types of accessibilities include work accessibility, shopping accessibility, accessibility to quality school, accessibility to recreational opportunities. This chapter will discuss how these accessibilities will be measured and the multilevel regression modeling that will be used to evaluate these impacts.

One critical task for this study is to establish the proper measurements for the different types of accessibilities. As the accessibility literature shows, there are many different way to measure the easiness for people to reach their desired destinations. Base on the existing studies and data availability, I selected five zone-based accessibility measurements and applied them to Southeast Michigan region. These included one measurement based on cumulated opportunities, two gravity-based measurements, and two utility-based measurements. Moreover, in developing these accessibility measurements, I also consider occupational matches between jobs and residents. As research has shown, matched indicators have much stronger explanatory power than aggregated measures (Cervero et al., 1999).

4.1 Work Accessibilities

4.1.1 Work Accessibility Measured by Cumulated Opportunities

$$A_i = \sum_j \sum_n (P_{in} O_{jn}) ; \; T_{ij} \leq V \qquad (4.1)$$

Where:

A_i is the accessibility index for residential zone *i*.
P_{jn} is the proportion of employed residents in zone i with occupation *n*
O_{jn} is the number of jobs by occupation n for zone j
T_{ij} is the travel time or distance
V is a specific time or distance threshold

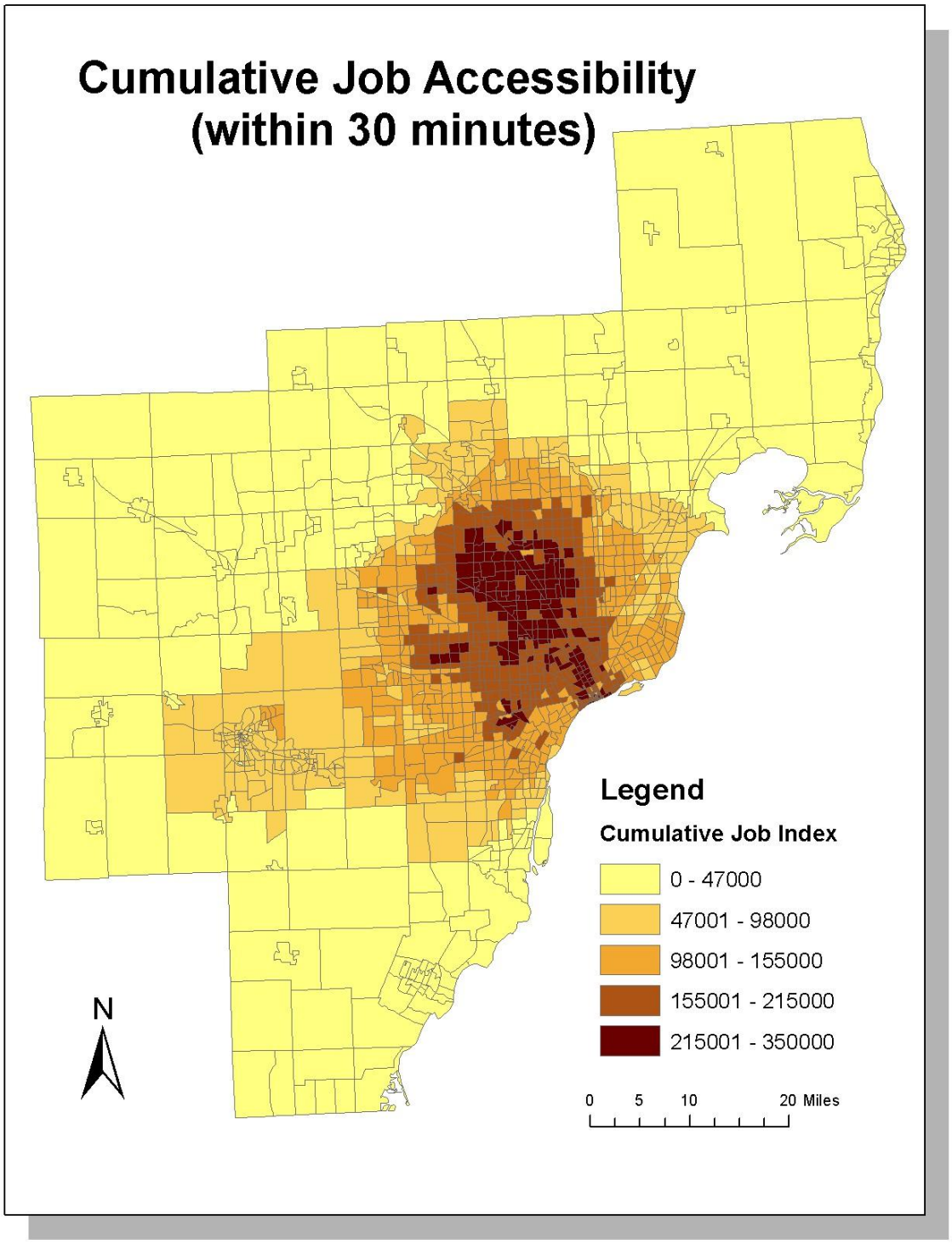
This equation is modified from Cevero et al. 's (1999) gravity model index with the friction factor removed to be consistent with the notion of cumulative opportunities. One important task is to select a good threshold value for travel time or distance. In past practice, researchers usually made their own judgments based on their study purposes and data availability. More recently, Cervero and Duncan (2006) suggested using the distance from accessibility metric that is most strongly associated with housing values. In this study, I adopted this method by examining the performance of statistical models on property values against cumulative indicators by travel time. I tested time values between 5 minutes to 45 minutes by 2.5-minute interval for time range less than 20 minutes and by 5-minute interval

for time range between 20-45 minutes. My tests showed that the highest model significance was reached when the travel time was 30 minutes. Therefore, I applied 30 minutes as the cutoff for my cumulative indicator. When compared to 2005 SEMCOG travel survey, this value is actually close to the average commuting time of 26 minutes in this region.

As past studies show, using total employment as attractive mass might be misleading since workers are not seeking all jobs in general, but looking for specific jobs matching their skill set and experience. Therefore, matching employment and residential workers by occupation categories is very important and can add strong explanatory power to the model (Cervero et al., 1999). This is especially true for Southeast Michigan area, where there has been a severe spatial mismatch problem between the city of Detroit and its suburbs, as identified by scholars such as John Kain (1968). Thus, to address this issue, this study has broken down both the zonal employments and residents into five big occupation groups based on BLS standards. These five groups include, 1) management professional, and related occupations; 2) service occupations; 3) sales and office occupations; 4) natural resources, construction, and maintenance occupations; 5) production, transportation, and material moving occupations. For detailed description of these categories, please see table 5.2 in the data input section (Chapter V).

Even with occupation matching, however, the cumulative measurement is still subject to one key problem, that is, all jobs have equal weights regardless their travel distance. As a result, the spatial pattern of the cumulative work accessibility indicator is heavily shaped by job locations and road network connections. Map 4.1 presents the spatial pattern of the cumulative work accessibility in Southeast Michigan. As this map shows, the accessibility surface is rather smooth. The area between north Detroit and the border of Oakland and Macomb is the single major center for job accessibility. Some little variations can be seen in nearby zones. But it is hard to tell whether places like Ann Arbor are job centers or not. This pattern is not consistent with the general knowledge that Ann Arbor area has concentrated a large number of jobs and is identified as an independent MSA from Detroit MSA by the Census Bureau. Clearly, this accessibility pattern is still over-aggregated and does not reveal the local context effectively.

Map 4.1 Work Accessibility Based on Cumulative Opportunities



4.1.2 Work Accessibility Measured by Gravity model

There are two types of job accessibility measurements in the gravity model.

a) Work accessibility by traditional gravity model

$$A_i = \sum_n [P_{in} \sum_j \frac{k_{ij} O_{jn}}{f(c_{ij})}] \quad (4.2)$$

Where:

A_i is the accessibility index for zone *i*

P_{in} is the proportion of employed residents with occupation *n* in zone *i*

O_{jn} is the number of job in occupation group n in destination zone j

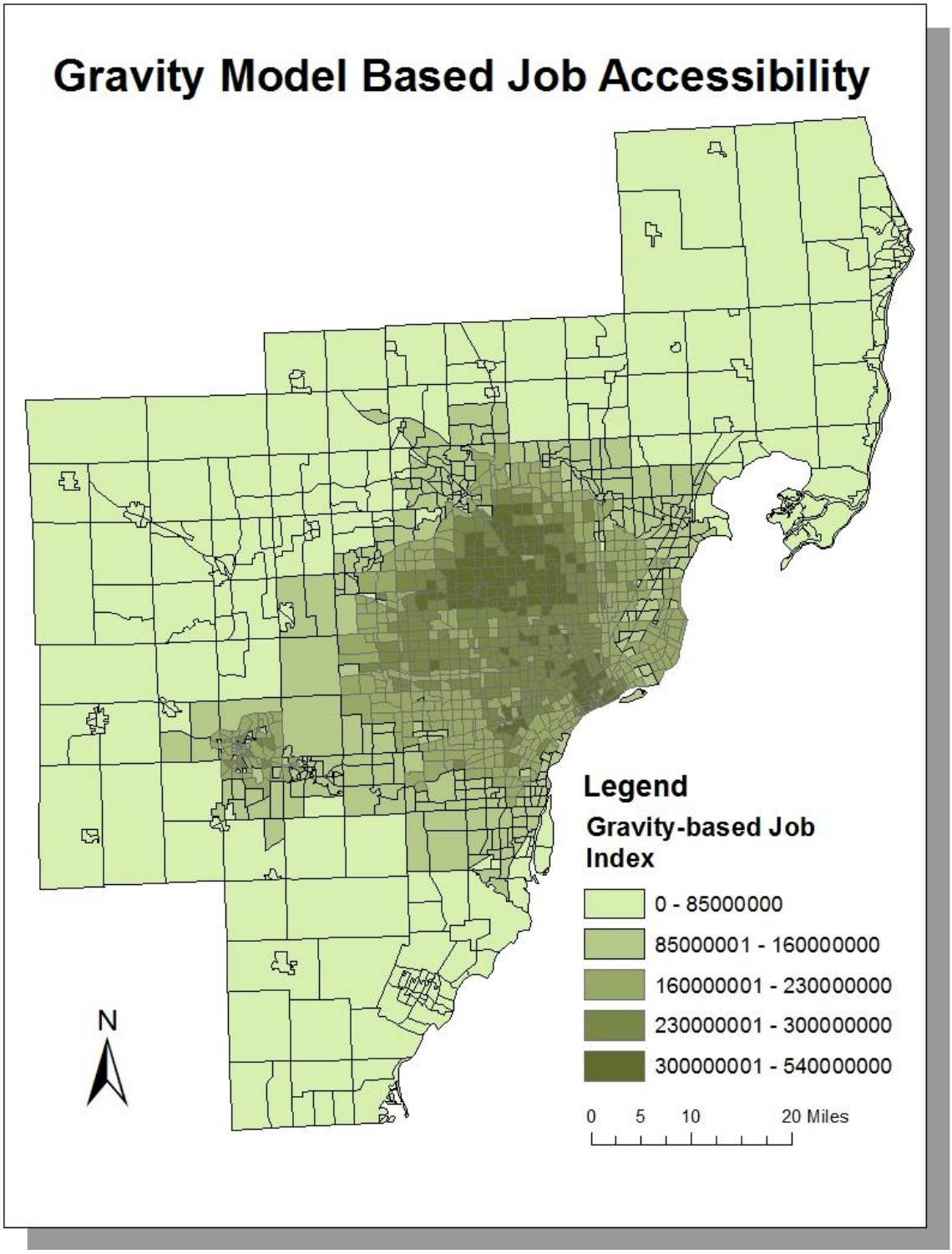
k_{ij} is an adjustment factor between zone i and j

$f(c_{ij})$ is a general friction factor between zone i and j, together with k to formulate the correct frictions between zones

SEMCOG travel model used the standard gravity model for trip distribution. The k and f factors in gravity function were first estimated using travel survey data. In order to produce trip distributions that are consistent with observed travel patterns, those k and f factors were further adjusted to the traffic count data. The final product is a compiled friction-adjustment lookup table by travel time, which has become the key input to my calculation of the accessibility indicator using the gravity model. Moreover, as discussed before, the calculation of the accessibility indicator incorporated occupation group information. In particular, I first calculate the accessibility indicator for each occupation group, and then compile a weighted composite index, with the weight assigned by the share of residents in different occupation group in each zone.

Map 4.2 presents the spatial distribution of the work accessibility indicator measured by the traditional gravity model. As the map shows, the gravity-based indicator clearly created more disaggregated patterns for zonal accessibility than cumulative measurement. The area around the borders of Oakland, Macomb and Wayne counties is the major center of the region. The city of Detroit and Ann Arbor are also distinguishable sub-centers. However, beyond the three centers, there are hardly any identifiable high job accessibility clusters.

Map 4.2 Work Accessibility Based on Gravity Model



b) Work accessibility by gravity model with competing factors

$$A_i = \sum_n (P_{in} \sum_j \frac{O_{jn} F_{ij}}{\sum_l P_{ln} F_{lj}}) \quad (4.3)$$

Where:

A_i is the accessibility index for zone *i*

P_{in} and P_{ln} are the proportion of employed residents with occupation *n* in zone *i* or *j*

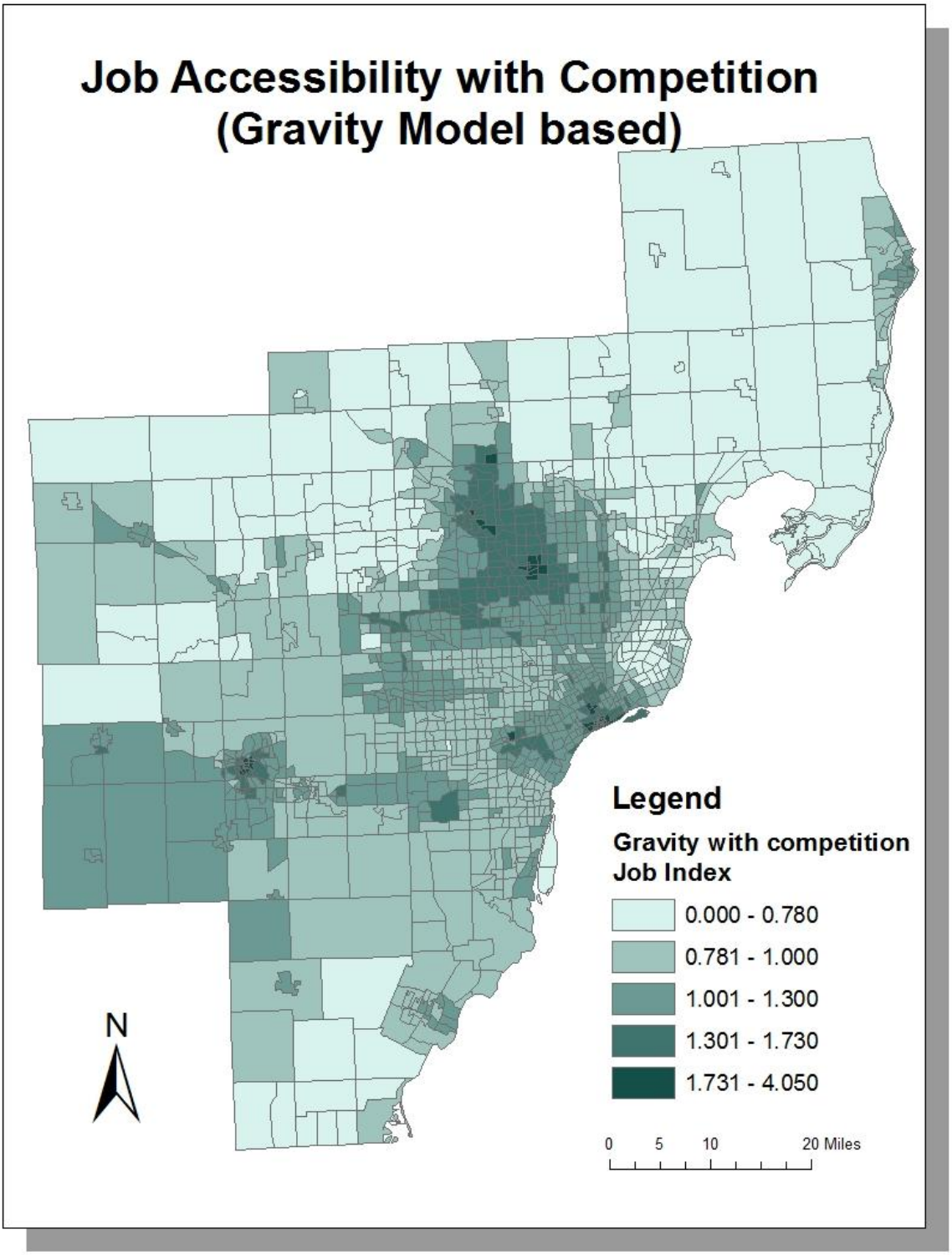
O_{jn} is the number of job of occupation group n in destination zone j

F_{ij} and F_{lj} are impedance between zone i, j or zone l, j. They are the combinations of adjustment factor k and friction factor f from the first gravity equation.

As many researchers pointed out, a simple gravity model only considers job supply but not spatial demand. However, job competition is common in the real world and strong competition could put significant constraints on job seekers. In other words, high job concentration might not guarantee good work accessibility if there are a lot of people competing for them. Therefore, work accessibility has to be balanced with spatial demand so as to get more appropriate assessment of the accessibility level. This study applies the constraint method developed by Shen (1998) to adjust the job accessibility by counting uneven spatial distribution of workers. In particular, for each occupation group, I first calculate the spatial demand for jobs using the gravity model. I then calculate work accessibility based on traditional gravity model but discount it according to the distribution of spatial demand. Finally, I combine the competition indicators for these different occupations into one composite indicator.

Map 4.3 presents the spatial distribution of the work accessibility indicator measured by the gravity model with competing factors. As this map shows, this method produces more disaggregated accessibility pattern than traditional gravity model. The big accessibility cluster in north metro Detroit is now broken down into three to four accessibility centers. All counties, including the remote counties like St. Clair and Monroe that have significant fewer jobs than Oakland and Wayne counties, now have their own accessibility centers.

Map 4.3 Work Accessibility Based on Gravity Model and Job Competition



4.1.3 Work Accessibility Measured by Utilities

According to the utility theory, consumer surplus can be measured through logsum of the discrete choice model. In travel model, logsums from mode choice model represent the level of mobility. This measure, when combined with job data, can serve as accessibility indicators. The major advantages of this type of measurement include: 1) it incorporates non-time factors 2) it represents the influence of multiple travel modes; 3) it reflects the distribution of the jobs (Waddell et al., 2007). There are two different measurement forms in this category:

a) Work accessibility by logsum and jobs

$$A_i = \sum_n (P_{in} \sum_j O_{jn} e^{Logsum_{ij}}) \quad (4.4)$$

Where:

A_i is the accessibility index for zone *i*

P_{in} is the proportion of employed residents with occupation *n* in zone *i*

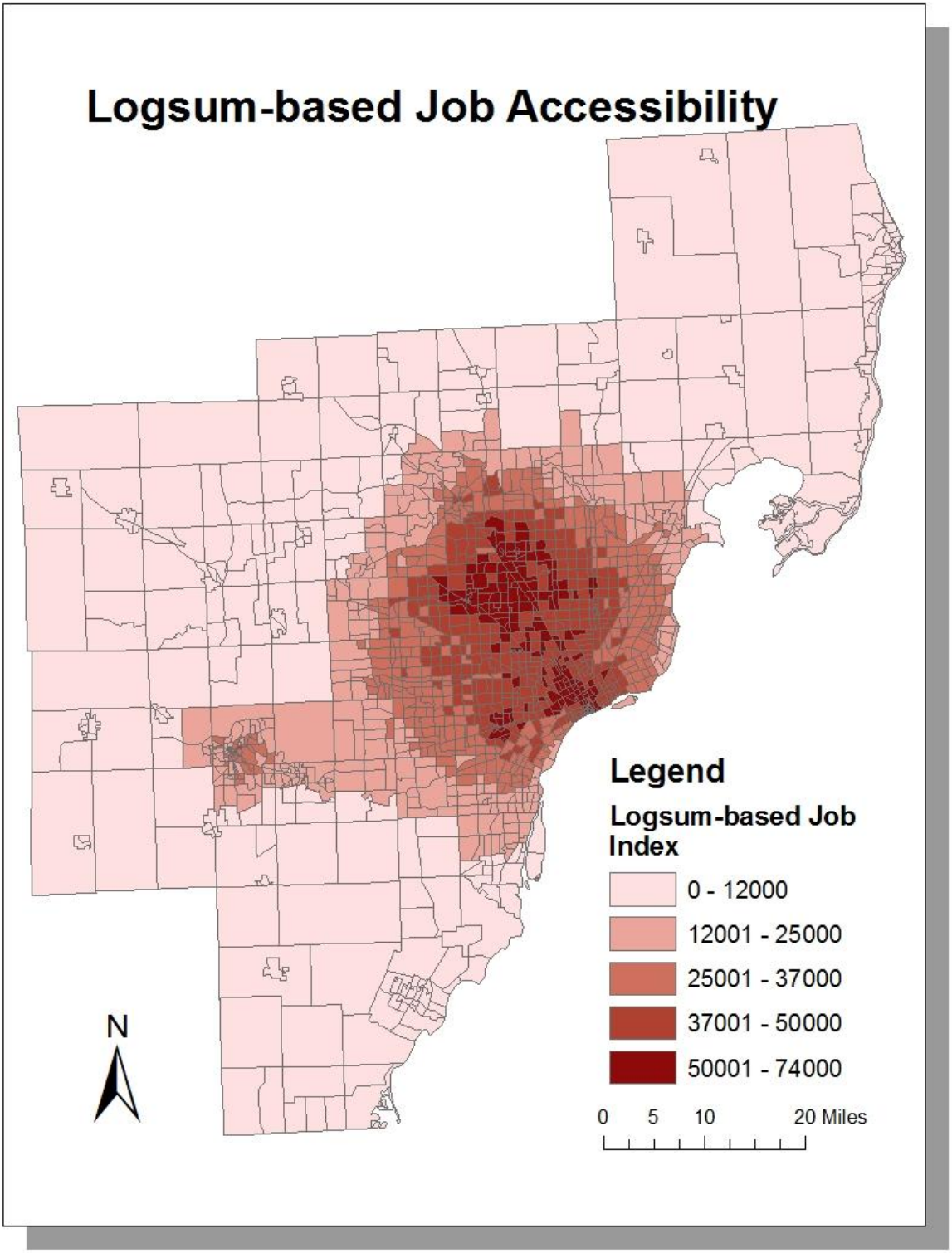
O_{jn} is the number of job of occupation group n in destination zone *j*

$Logsum_{ij}$ is the log form of the denominator of a mode choice model. For any zone i and j, the probability of travel choice m can be expressed as: $Pr_m = \frac{e^{V_m}}{\sum_k e^{V_k}}$, the natural logarithm of denominator's sum is called logsum: $logsum = log(\sum_k e^{V_k})$. It represents the expected utility across all available alternatives.

The above equation is modified from Waddell et al.(2007). This method has similar functional form as gravity model but uses exponential of logsum from mode choice model to represent the spatial connections between zones. The major advantage of this method is that logsums evaluate the overall utility for all available transportation modes between the original and destination zones, while the gravity fraction only captures the access of one travel mode.

Map 4.4 presents the spatial distribution of the work accessibility indicator measured by the logsum with jobs approach in Southeast Michigan. The accessibility pattern is similar to what was observed in traditional gravity measurement, with two high-level accessibility centers concentrated in metro Detroit and Ann Arbor. This result is not surprising. First, the mode choices of SEMCOG travel model considered only auto and transit and the share of transit users in this region is very small, only about 1.2% (SEMCOG 2005 Travel Survey). Second, public transit service covers only a very limited area in this region, mainly Detroit city plus some nearby suburbs as well as the city of Ann Arbor. As a result, while the utility-based measurement is able to capture the impacts of multiple travel modes, its pattern is not that much different from what the traditional gravity indicator has shown in which only the auto driving mode is considered.

Map 4.4 Work Accessibility Based on Logsum and Jobs



b) Work accessibility by logsum and trip distribution

$$A_i = \frac{\sum_j (T_{ij} Logsum_{ij})}{\sum_j T_{ij}} \quad (4.5)$$

Where:

A_i is the accessibility index for zone *i*

T_{ij} are number of trips from zone i to zone j based on trip distribution

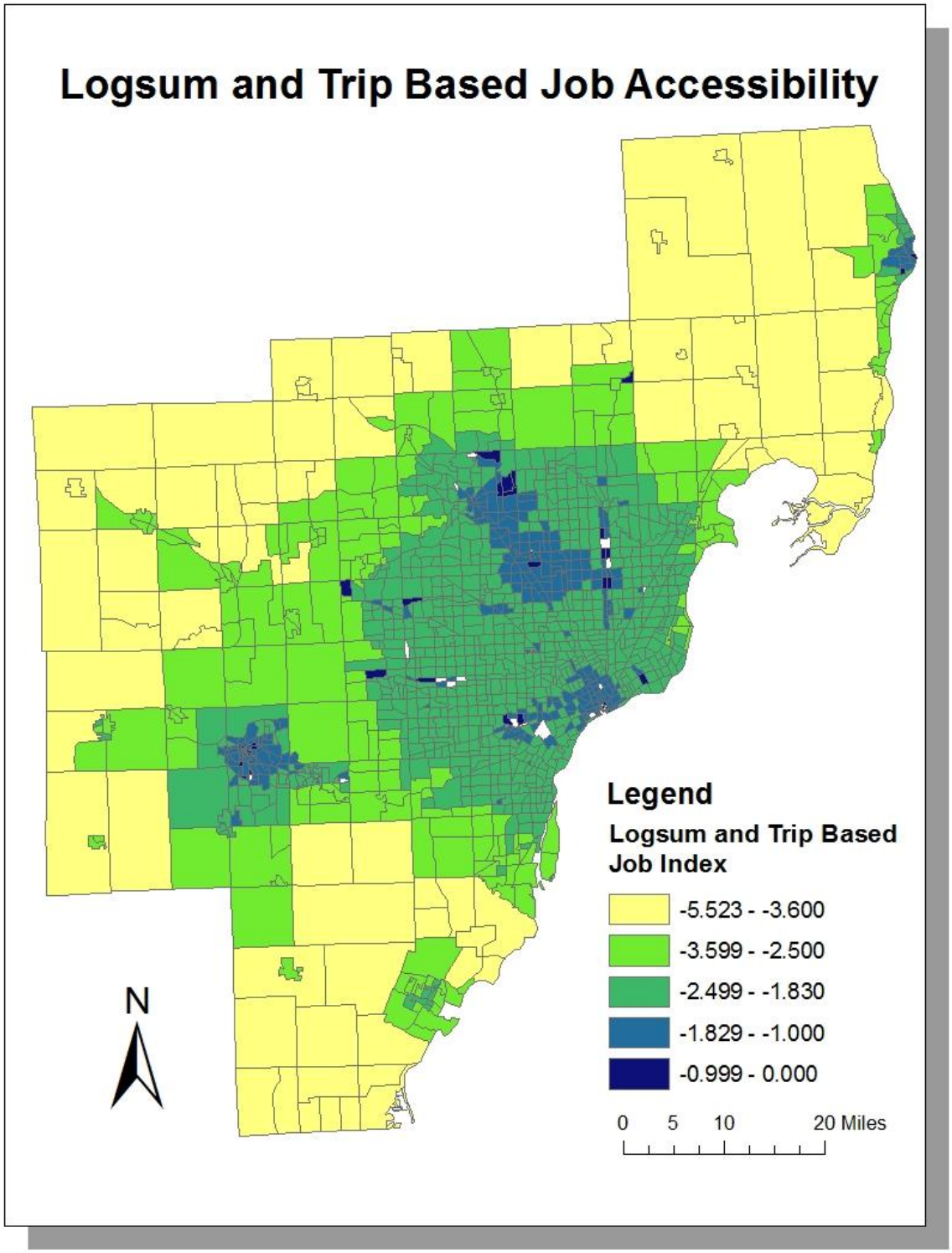
$Logsum_{ij}$ is the same as what was presented in function 4.4, which indicates the overall utility for all mode choices between zone i and j .

Instead of using total jobs, this method uses trips to destination zones to evaluate attractiveness. In this way, some unobserved factors in accessibility measurement can be captured such as the difference of employment sectors in destination zones, preference and demographic differences among residential zones, etc. Therefore, this method can better reflect the connections between OD zones than pure jobs based measurement. The results usually show stronger spatial variations across zones.

The key feature in this measurement is to use the number of trips to destination zones, instead of jobs, to measure the scale of opportunities. The destination trips could be extracted from either travel model distribution result such as the SEMCOG trip distribution used in this study or CTPP (Census Transportation Planning Products) journey-to-work flow table. The advantage of this measurement is that it could provide a theoretically more accurate evaluation of the interaction between OD zones. The problem, however, is that the current definition for home based work trips does not consider trip chaining. A complete work tour in daily life could be split into several separate trips, such as home to school, school to work, work to shopping, etc. Therefore, home based work trips from either SEMCOG travel model or CTPP journey-to-work flow tend to under count the work trips, which may lead to biased estimation (McGuckin and Srinivasan, 2005). So far, there is no easy fix to this issue without introducing activity-based travel model.

Map 4.5 presents the spatial distribution of the work accessibility indicator measured by logsum with trip distribution in Southeast Michigan. The map has shown the most disaggregated pattern among all the accessibility measurements discussed so far. Moreover, the map also reveals some high accessibility islands, which have much higher accessibility level than adjacent zones.

Map 4.5 Work Accessibility Measured as Logsum and Trip Distribution



4.2 Measuring Nonwork Accessibility

The evaluation of nonwork accessibility is more complicated than work accessibility. The nature of nonwork activities shows that their attractiveness has to be assessed by different standards. It is generally recognized that good access to shopping, school, parks and other opportunities benefit people's daily life and will thus be capitalized into housing values. However, as many studies have shown, the impacts of nonwork accessibilities vary case by case and are sensitive to study context and model specifications (Boarnet & Greenwald 1999; Rajamani et al., 2004; Nelson & Niles 2002). Furthermore, many studies focus on only one or two selected accessibilities but did not give a full picture of major nonwork accessibilities and their impacts on housing values. Therefore, for this study, besides work accessibility, I select three important types of nonwork accessibilities, shopping, school and recreation and try to detect their impacts on property values.

4.2.1 Shopping Accessibility

Depending on the travel distances, shopping trips can be differentiated at both the regional and local level. As past studies show, shopping accessibility can significantly affect property values (Colwell et al., 1985; Waddell et al., 1993; Srour et al., 2002). However, since shopping travels are usually not mandatory and have more flexible schedule than work commutes or school trips, the impacts of shopping accessibility are usually not as strong as work accessibility. Recent analysis also shows that not all shopping opportunities have the same benefits to neighborhoods (Handy and Clifton, 2001). In addition, side effects from traffic, noise, or even safety concern from nearby retail activities may reduce the location premium or even generate negative impacts on residential properties (Colwell et al.,1985).

One difficulty in measuring shopping accessibility is the availability of data, especially the data for retail intensity. Retail employment and the size of retail stores are commonly used indicators, but they both come with strengths and shortcomings. Number of retail jobs is generally a good indicator for retail supply. However, job data are usually aggregated at TAZ level and there is no detailed sub-categorical information from CTPP. Therefore, the number of retail jobs by TAZ zones is good for evaluating shopping accessibility over a large geographic area, for example, region-wide shopping accessibility. The floor space of retail store, on the other side, may not be as a good indicator of retail intensity as employment data. For example, with similar footprint, car dealers usually have much less customers than grocery stores. However, store size information is often available at parcel level from assessors' records, which may also contain detailed information on retail types. Consequently the retail footage would provide a good measurement of the variations in local accessibility and produce meaningful results for planners or researchers (Handy and Clifton, 2001).

Based on the review of past shopping accessibility, in this study I have modeled shopping accessibilities at three scales, regional level, community level and local level.

a) Regional shopping accessibility.

Regional shopping accessibility is calculated based on zonal retail jobs from CTPP. The calculations follow the same methodology as work accessibilities. Therefore, each work accessibility indicator measured by the different methodology has its counter-part in regional shopping accessibility. And they pair together as regional work and shopping accessibilities in the multilevel regression models. The only exception is the accessibility measured by the gravity model. For work accessibility, I have used both the traditional gravity model and gravity-based with job competition model. But for shopping accessibility, I only use the traditional gravity model. The reason is that unlike job accessibility that could be constrained by the level of competition among potential job seekers, there is seldom such constraint on retail shoppers, given that most retail stores would have sufficient capacity to accommodate their customers. As a result, I only use the gravity-model without weighing by spatial demand to calculate the shopping accessibility. Together I have calculated four types of shopping accessibilities, including one cumulated opportunity index, one gravity-based index, and two logsum-based indices. Since both the work accessibility and regional shopping accessibility measurements have used the number of jobs as opportunity assessment, I expect them to be somewhat correlated. Such correlations will be discussed in my modeling analysis. Maps of regional shopping accessibility measured by these different approaches are included as appendix at the end of this document.

b) Community-level shopping accessibility

Community-level shopping accessibility is to measure the convenience for daily shopping, which has been categorized in SEMCOG travel survey. Depending on how to define the geographic boundaries, there are several ways to measure this community-level shopping accessibility. The simplest measurement is to use a housing property's city or township boundaries to see how many shopping opportunities are available within the city/township limits. The problem with this approach, however, is how to handle the situations where properties are located close to jurisdiction boundaries. A second method is to identify a fixed-distance buffer zone. But this method would ignore road network and traffic conditions, thus may not be able to capture the real variations in accessibility level. A third method is to use TAZ areas within a specified travel time, say, 15 minutes. But this also has its own problem in the sense that large variation in TAZ size will generate significant measurement biases and make the accessibility comparison questionable.

With the availability of road network from travel models and ArcGIS network analyst, my final solution to this accessibility measurement is to develop a shopping shed for each individual property using the road network and then measure how much shopping opportunities exist within this specific area. Map 4.7 presents an example of a 15-minute travel shed for a given property.

Finally, considering that residents' accessibility preference may differ for different types of shopping activities, I also distinguish four types of retail stores using the SEMCOG parcel data, with each type of store has its own community level shopping indicator.

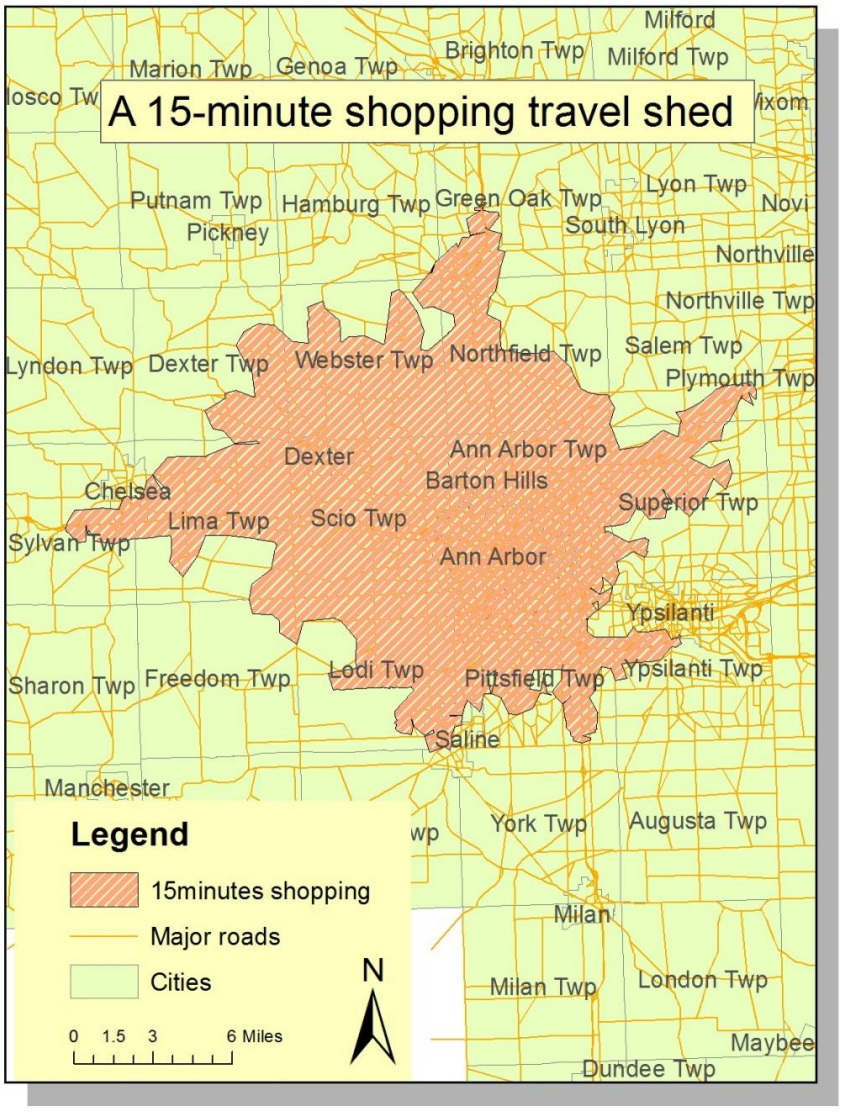
1) Small and convenience stores: stores are either small in size or identified in the convenient category;

2) Regular retail stores: including independent stores and stores located in strip malls;

3) Regional shopping center: typically large shopping mall with major department stores;

4) Restaurants and bars.

Map 4.7. An Example of 15-Minute Travel Shed from a Given Property in Ann Arbor



c) Local shopping accessibility

This type of local shopping accessibility indicators is to measure the possible shopping opportunities by the walking mode. This is important for people who prefer walking or those having severe constraints on using private vehicles. Based on SEMCOG travel survey, I used the 1 mile distance as the cutoff since the survey shows that the average shopping trip by walking is usually between 15 to 20 minutes. This would translate into a 1-mile distance given an average walking speed of 3 to 4 miles per hour. Moreover, one mile is also the distance standard used in "walkable score" research. I measure the one-mile walking distance based on actual network of walkable roads, not straight distance. Map 4.8 shows the 1-mile walking area for a chosen property. Finally, just like the community-level shopping accessibility measurement, I also distinguish the local shopping accessibility indicators by the four different types of retail stores as discussed before.

4.2.2 Accessibility to Quality Schools

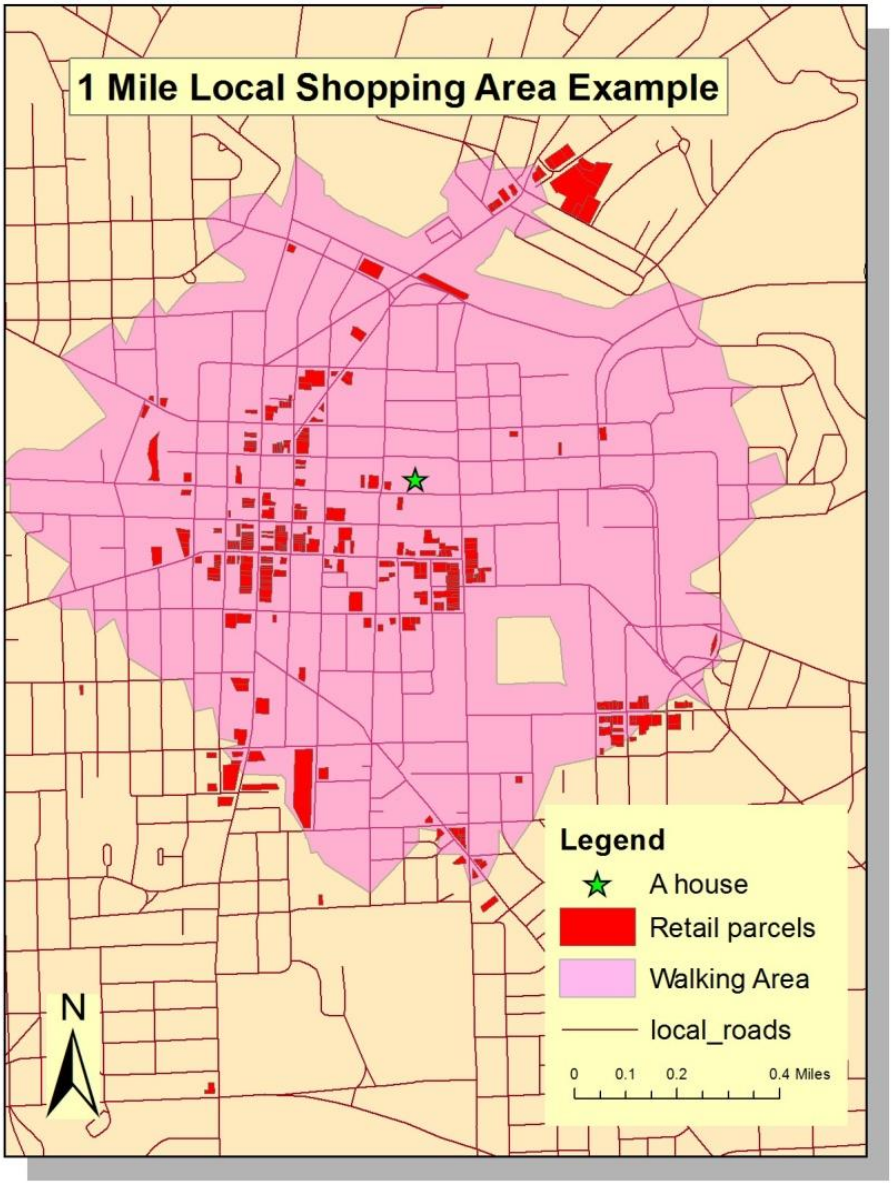
Households, especially those with school-age children, would often value properties located in good school district. Numerous studies have shown a strong relationship between school quality and housing prices (Walden, 1990; Haurin & Brasington, 1996; Goodman & Thibodeau, 1998). There are many ways to evaluate school quality such as class size, curriculum, special programs. Yet, academic excellence is always preferred by parents regardless their other differences (Brasington, 1999; Kleitz et al, 2000). In Michigan, all public elementary and middle schools are required to participate in Michigan Educational Assessment Program (MEAP) test. This test covers topics such as math, reading, writing and science etc. For each topic, it reports the percentage of students meeting or passing the state standards.

Since school attendance areas would determine a child's chance to go to a good school, it is one of the most important factors in affecting residents' willingness-to-pay for a given property. Unfortunately, in Southeast Michigan, I have not been able to find any attendance maps in GIS format that could be used to identify the attending school for each property in my housing transaction dataset. As a result, I tried two methods to deal with this problem.

The first method is to use Thiessen polygons to simulate school attendance areas. Thiessen polygons are polygons used to decompose a specific space based on some discrete points (schools in this case) within that space. Those polygons cover the whole space and are mutually exclusive. Any place within each polygon has the shortest distance to its center (discrete point). With this method, all properties were assigned to its closest school. This simulation approach can easily produce school attendance areas for all the properties across the entire region. However, when compared to the real attendance map, I found a significant portion of property samples are assigned to wrong home schools. Statistic models based on

this school indicator also yield unsatisfactory results. School performance didn't show up as a significant variable in my analysis.

Map 4.8 An Example of 1 Mile Walking Area from a Given Property in Ann Arbor



My second method is to pursue the real attendance boundaries. I have found some attendance maps in various graphic or PDF formats on k12 school district websites. I managed to collect attendance maps for 16 school districts in the study region and digitized them into GIS maps. Those 16 school districts covered the major cities in this region, including the city of Detroit, city of Ann Arbor, as well as some major cities in Detroit suburbs, such as Dearborn, Farmington, Troy, Novi, Livonia, etc. Together, about 11,500 sampled housing properties are located in these 16 school districts and its 2.0 million residents represent 41% of the total population in Southeast Michigan region. Map 4.9 shows the coverage of the school attendance areas I have collected. Corresponding MEAP test scores collected from Michigan Department of Education are joined to each individual attendance area and then assigned to properties within.

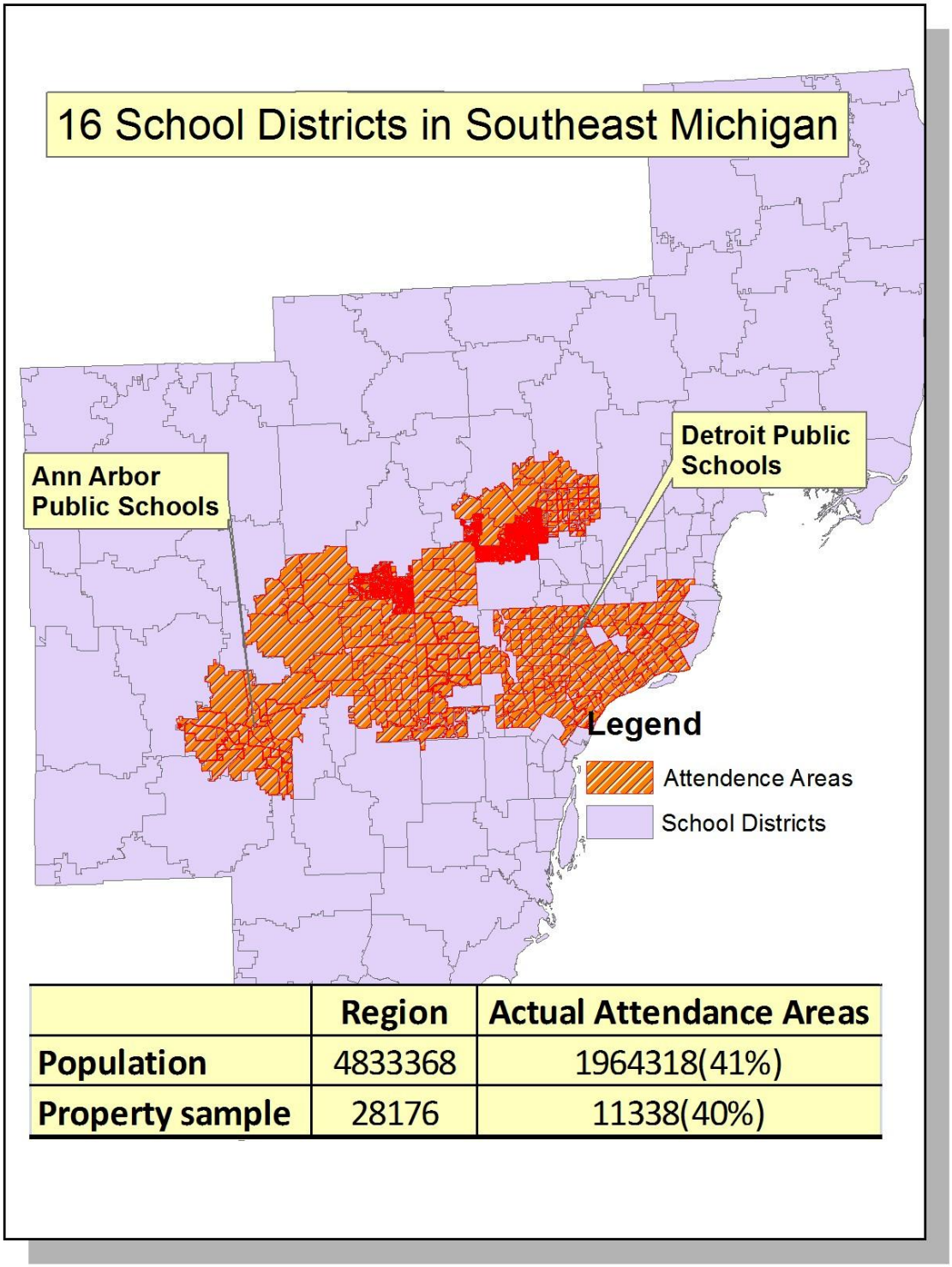
4.2.3 Accessibility to Recreational Opportunities

To measure the accessibility to recreational opportunities, I have identified two types of natural features – parks and water bodies. First is the accessibility to parks. Parks and open space are well known for increasing the amenities of the surrounding environments. There is a rich literature about how parks contribute to the values of adjacent properties (John Crompton, 2005). But the impacts may vary by different dimensions, for example, distance, park size, shape, and design features. The consensus is that significant capitalization effects could be expected within 500-600 feet from parks and in some cases, the impacts can be as far as 1500-2000 feet. In addition, negative impacts could be identified for properties very close to parks. Base on the review of past studies, I have developed the following different measures to examine the impacts of parks on nearby property values:

1) Distance to nearest parks: Logarithm of the straight line distance from a housing property to the nearest park;
2) Park size within specified distance: Total size of the parks within 1200 feet of a property;
3) Total park area from multiple parks weighted by distance: Park sizes are weighted by their distances to a given property and then all parks within 1200 feet of a property were combined into a single indicator for this property's park accessibility;
4) Buffered ring to parks: Various distance buffers from parks to identify close-by properties.

Based on the model test results, the first indicator, natural logarithm of park distance shows up more significantly than the other two and its coefficients had expected signs. Therefore, in the final model specification, I used distance as the park accessibility indicator. For proximate buffer rings, 50-feet dummy variable had better fit than others in the model. Therefore, this variable is included in model discussion.

Map 4.9 16 School Districts with Real Attendance Areas



	Region	Actual Attendance Areas
Population	4833368	1964318(41%)
Property sample	28176	11338(40%)

The second type of indicators measuring recreational opportunities is the accessibility to water bodies. Besides the big lakes surrounding Michigan, there are many water bodies located through the inner land of the state. Those water bodies provide good view and also recreation opportunities such as fishing or boating. So the access to water body could also generate location premiums. However, water also has some potential negative effects such as flooding or basement damage. So being close to water bodies is not always desirable. Overall researchers (Brown & Pollakowski, 1977; Lansford & Jones, 1995; Loomis & Feldman, 2003; Muller, 2007) did seem to agree that proximity to water body can add values to nearby properties. But Muller (2007) has argued that the distance-only accessibility measurement could overstate the importance of this amenity. Thus the impacts of water bodies should be distinguished between water front and water view locations. Therefore, following his arguments, I developed three measures of water body amenities:

1) Lake front: if a property is within 500 feet of a water body;
2) Lake view: if a property is within 1000 feet of a water body;
3) Distance to Lake: natural logarithm of straight-line distance to water bodies.

4.3 Methodology to Measure the Impacts of Accessibilities

Beyond all accessibility measurements, one remaining task in this study is to apply a sound methodology to measure the property value impacts from the different types of accessibilities. A widely used statistical model for this type of analysis is the hedonic regression approach, which has a long history and is still very popular today (Sirman, Macpherson & Zietz, 2005). The key idea of hedonic regression model is to treat housing as a bundle of different characteristics, then break them down and evaluate each component individually (Fisher & Shell, 1971). However, according to Rosen (1974), housing is unique in the sense that its attributes cannot be traded separately on the market. Thus, the ordinary least-squares (OLS) regression model has severe constraints when dealing with housing submarkets and its dynamic nature (Orford, 2000). Therefore, more advanced modeling technique such as multilevel analysis is needed to address those fundamental issues.

4.3.1 Traditional Single-level Housing Price Model

The emergence of hedonic regression modeling can be traced back to the early 1920s and 1930s when studies were conducted to disentangle the factors affecting automobile prices or farm land values (Sirman et al., 2005). The idea behind the hedonic price modeling is simple. Similar to a bundle of groceries whose price is the sum of the price for each particular produce, housing can also be seen as a bundle of different housing attributes such as size, rooms, and other amenities, and thus its price should also reflect the prices for all individual attributes (Fisher & Shell, 1971). This utility meaning of housing characteristics was also established by Lancaster (1966) from a microeconomic perspective and, as reviewed by Malpezzi (2002), it has become the source of regular ordinary least-squares model or

single-stage models. The formula of such hedonic regression model takes the following form (Malpezzi, 2002):

$$R = f(S, N, L, C, T) + \varepsilon \quad (4.6)$$

Where, R is the market rents or value of sampled units; S is the structural characteristics; N is the neighborhood attributes; L is the unit locations; C represents the specific contract conditions; T is the time period when the rental or sale transaction happen.

This form of hedonic price modeling has been widely used in empirical research. In doing so, researchers have often adopted a single-stage specification, which treats all individual attributes equally and neglects the structure of the attributes or context of the market (Sirman et al., 2005). It also assumes that housing market is always at equilibrium and the implicit prices for housing components are invariant across the market (Maclennearn and Tu, 1996).

However, as Rosen and other scholars have argued (Rosen, 1974; Malpezzi, 2002), housing market dynamics, in particular, the interaction between supply and demand, is far more complicated than what the hedonic price modeling could describe. On the demand side, depending on income level and life cycles, households may have different preferences about structural and location characteristics. On the supply side, the availability of desirable locations is often limited and housing supply usually lags behind demand due to the lengthy and costly construction or redevelopment process. Housing units have to be sold as attribute bundles and each attribute cannot be traded separately. Therefore, unlike other retail markets, housing markets are often in disequilibrium, and the tension between heterogeneous demand and inelastic supply leads to market segmentation (Goodman and Thibodeau, 1998). Market segmentation can be further enforced by other contextual factors such as public services or tax liabilities. As a result, households sort themselves into different housing sub-markets (Ross and Yinger, 1999).

The bidding dynamics and the existence of sub-markets clearly change the way how each individual housing attributes should be evaluated at particular locations. Ignoring this will cause serious problems such as heteroscedasticity and spatial autocorrelation, which violates the basic assumption of OLS model and lead to unreliable or biased estimations (Orford, 2000). As discussed by Orford (2000), some "technical fixes" to model specification could be applied to improve estimation results, yet they didn't address the fundamental issue on how to connect model specification directly with market dynamics. Thus, different model specification is needed to simultaneously model the compositional effects of housing stock and the contextual effects of submarket (Orford, 2000). A multilevel modeling approach offers such advantages.

4.3.2 Advantages of Multilevel Model

In a multilevel modeling, samples are no longer a group of independent data but rather a reflection of the multilevel or hierarchical structure of population (Hox, 1995). Therefore, individual samples are organized through higher-level groups and they share certain characteristics within groups. In such relationship, correlations between individuals are expected and are explicitly expressed in the model structure (Orford, 2000). Moreover, variables do not have to be defined at the same level, being either aggregated or disaggregated, but can be specified at any hierarchical level (Hox, 1995). Different from single-level analysis where all variables are treated equally, in multilevel modeling, group-level variables have different roles than individual variables in model specification. They could shift the global intercept by each specific group, thus highlighting the group differences, and/or by interacting with individual variables, they could profoundly change their slopes. Following the definition by Hox (1995), in multilevel modeling, the regression equation could be defined as:

$$P_{ij} = \beta_{0j} + \beta_{1j}X_{ij} + e_{ij} \quad (4.7)$$

Where, i is the subscript for samples, j is the subscript for groups. β_{0j} is the intercept and $\beta_{1j}$is the slope.

The above equation shows that in multilevel model, intercepts β_{0j} actually vary by groups. Since the between-group variation is influenced by group attributes, the term can be further described as:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}Z_j + \mu_{0j} \quad (4.8)$$

Where $\gamma_{00}$is the intercept for the whole population; γ_{01} represents the slopes for group variable, vectors Z; μ_{0j} is the error term. This equation is called random intercept model since the intercepts are no longer fixed.

β_{1j} in equation 1 also vary by groups and can be expanded in a similar vein:

$$\beta_{1j} = \gamma_{10} + \gamma_{11}Z_j + \mu_{1j} \quad (4.9)$$

This equation means the estimates for individual variables depend on group characteristics. Therefore, the coefficients for individual variables are no longer fixed as well. This model is called random slope model.

Housing transactions can be seen having the same hierarchical structure as described above, where submarkets represent sample groups. The constant terms of housing values and the estimates for each housing attribute could change by submarkets. Thus the multilevel modeling approach could effectively address the problem of spatial autocorrelation since the source of the problem, similarity of property values within the same submarket, has already been captured in the modeling structure (Goldstein, 1987).

Moreover, since the variations between submarkets are also modeled and non-constant variance of factor can be captured, multilevel modeling is also an effective technique to deal with heteroscedasticity (Orford, 2000). Multilevel modeling technique is not only theoretically sound, empirical work has also proved that submarket indeed matters in housing research given the importance of location in housing transactions (Bourassa, Hoesli, & Peng, 2003). As a result, the spatial disaggregation offered by multilevel modeling has generated significant gains in model prediction (Goodman & Thibodeau, 2003).

As Gelman and Hill (2007) discussed in their book, multilevel analysis works naturally with structured data where traditional analyses with either "complete pooling" or "no pooling" strategies could fail. Parameters for both individual and group-level indicators could be estimated more accurately and standard errors will be more efficient by accounting for uncertainty. Several other benefits can also be expected such as extending our understanding of factor influence from universal level to group-specific; overcoming the estimation difficulty for groups with very small sample size by "borrowing the strength" from all samples; enabling the prediction of new sample values for new groups using information from both group and individual indicators.

This study collects housing transaction data throughout Southeast Michigan, which covers both Detroit and Ann Arbor metropolitan area. Given the size of the study area and the significant variation of socioeconomic characteristics within the area, the segmentation of housing submarkets can be expected. As the above discussion shows, multilevel modeling offers many advantages by accounting specifically for submarket segmentation. As a result, this study will apply this approach to examine how the different types of accessibilities have been capitalized into local property values.

Chapter V. Data Input

This section discusses the various datasets that have been used in this study. Major datasets include housing transaction dataset from the county assessors' records, parcel-level GIS data, SEMCOG transportation model inputs and outputs, employment data from CTPP 2000 (Census Transportation Planning Products, 2000), Michigan Educational Assessment Program (MEAP) scores from State education department, GIS layers for recreational areas etc.

5.1 Housing Transaction Dataset

Housing transaction datasets include all property transaction records in year 2000 in Southeast Michigan collected from county assessors' offices. The dataset also include detailed information on property attributes, such as residential square footage, lot size, building age, building types and building quality. Records with missing sale prices, land area, residential square footage and other important building attributes were removed. I also validated the values for some critical housing variables and ensured that all data values are within reasonable ranges. For example, some outlier samples with extremely large parcel areas or incorrect sale prices were identified and deleted. I then join the cleaned property data to parcel polygons in ArcGIS to allow further spatial analysis. Table 5.1 presents the numbers of sample records by each county.

Table 5.1 Southeast Michigan Housing Transaction Data

county	Property samples in the whole region	Samples with true attendance areas
Livingston	1149	0
Macomb	7098	623
Monroe	116	0
Oakland	4251	1908
St. Clair	881	0
Washtenaw	2412	1135
Wayne without Detroit	7306	2709
Detroit City	4963	4963
Total	28176(*100%)*	11338(*40%*)

5.2 Transportation and Employment Data

SEMCOG travel model outputs and CTPP employment data are the two main data sources for calculating regional work and shopping accessibilities. Travel model provides zone-to-zone travel time, gravity impendence, and mode choice utility matrices to measure

the difficulty/ easiness of work and nonwork trips, while the CTPP employment data would provide us information about the scale of attractiveness at destination zones.

Transportation data

SEMCOG travel model for year 2000 was a typical zone-based four-step travel demand forecast model. However, the TAZ (traffic analysis zone) system used in SEMCOG travel model was very unique and not matching the TAZ zones in Census CTPP 2000. So it is impossible to directly use SEMCOG travel model with CTPP employment data for accessibility calculation. On the other side, the confidentiality agreement with state prohibited me from using SEMCOG zonal job data. Therefore, some conversion and imputation work is needed to address this incompatibility issue between the CTPP and SEMCOG data. One common practice in this situation is to proportionally redistribute CTPP zonal data by intersection areas to SEMCOG TAZs. Although this method is technically viable, the sacrifice on data accuracy due to the highly incompatible zone structure may have large impacts on accessibility assessment.

Fortunately, starting year 2002, SEMCOG travel model adopted a new model zone system, which increased the number of TAZs from 1470 to 2899. In doing so, most of the new TAZs are well nested within CTPP 2000 zones. Therefore, it is possible to convert the SEMCOG travel model outputs to CTPP 2000 zones with good accuracy. Depending on the specific type of travel model outputs, I have set up a series of conversion rules to average, aggregate and weight the travel matrices from SEMCOG post-2002 zones to CTPP 2000 zones. A set of python programs were developed to complete the task.

Employment data

As discussed before, this study has conducted occupational matching for all the work accessibility calculations except utility-trip based measurement. The matching process utilized the 25 occupations from CTPP 2000 dataset. To facilitate the analysis, the 25 occupations are further grouped into 5 occupational groups according to the standards from Bureau of Labor Statistics. Table 5.2 lists the detailed compositions for the five occupational groups. In calculating the work accessibility, I first distinguish the employment in destination zones by the five occupation groups and then match them to the occupational composition in residential zones.

Table 5.2 Occupational Groups and Descriptions

BLS groups	Description
1	Management, Professional, and Related Occupations
2	Service Occupations
3	Sales and Office Occupations
4	Natural Resources, Construction, and Maintenance Occupations
5	Production, Transportation, and Material Moving Occupations

Table 5.3 Occupational Groups and Corresponding CTPP Occupations

Occupational group number	CTPP occupations
1	All Workers; Having Management Occupations;
4	All Workers; Having Occupation As Farmers Or Farm Managers;
1	All Workers; Having Business And Financial Operations Specialists;
1	All Workers; Having Computer And Mathematical Occupations;
1	All Workers; Having Architecture And Engineering Occupations;
1	All Workers; Having Life, Physical, And Social Science Occupations;
1	All Workers; Having Community And Social Service Occupations;
1	All Workers; Having Legal Occupations;
1	All Workers; Having Education, Training, And Library Occupations;
1	All Workers; Having Arts, Design, Entertainment, Sports, And Media Occupations
1	All Workers; Having Healthcare Practitioners And Technicians Occupations;
2	All Workers; Having Healthcare Support Occupations;
2	All Workers; Having Protective Service Occupations;
2	All Workers; Having Food Preparation And Serving Related Occupations;
2	All Workers; Having Building And Grounds Cleaning And Maintenance Occupations;
2	All Workers; Having Personal Care And Service Occupations;
3	All Workers; Having Sales And Related Occupations;
3	All Workers; Having Office And Administrative Support Occupations;
4	All Workers; Having Farming, Fishing, And Forestry Occupations;
4	All Workers; Having Construction And Excavation Occupations;
4	All Workers; Having Installation, Maintenance, And Repair Occupations;
5	All Workers; Having Production Occupations;
5	All Workers; Having Transportation And Material Moving Occupations;

5.3 Parcel-level GIS Data

Parcel-level GIS data is also available from SEMCOG. I have used the parcel-level data to extract information about the square footage of commercial buildings in my

calculation of community-level and local shopping accessibilities. Moreover, for each individual commercial parcel, I calculated its land area to validate the lot size information from the assessors' records. This procedure allowed me to detect incorrectly recorded store footage. For example, some retail stores' floor area ratios in Detroit area were exceptionally high and the derived numbers of floors were much higher than the reality when checking against parcel aerial photos. In those cases, I had to use parcel sizes and the average floor-area-ratio for this specific type of retail stores to impute the size of the retail space. The SEMCOG parcel-level data also include information about parks and water bodies that were used to calculate recreational accessibilities.

5.4 School Performance Data

This study used the MEAP scores for elementary school as the indicator of school performance. For year 2000, the state of Michigan published MEAP test results for grade 4 to7 but only the grade 4 scores are relatively complete. I thus developed the school performance indicator based on grade 4 test scores. Grade-4 school scores were then joined to geocoded school locations in ArcGIS.

Table 5.4 Definitions of All Input Variables in the Multilevel Model

Input Variables	Definitions
Work Accessibility	
Cumulative work accessibility	Regional work accessibilities measured as cumulative opportunities
Gravity based work accessibility	Regional work accessibilities measured by gravity model.
Gravity and job competition based work accessibility	Regional work accessibility measured by gravity model with job competition
Logsum-job based work accessibility	Regional work accessibility measured by logsum and zonal jobs
Logsum-trip based work accessibility	Regional work accessibilities measured by logsum and trip distribution
Shopping accessibility	
Regional Shopping Accessibility	
Cumulative shopping accessibility	Regional shopping accessibilities measured as cumulative opportunities
Gravity based shopping accessibility	Regional shopping accessibilities measured by gravity model
Logsum-job based shopping accessibility	Regional shopping accessibilities measured by logsum and retail jobs
Logsum-trip based shopping accessibility	Regional work accessibilities measured by logsum and shopping trip distribution
Community Shopping Accessibility	

Input Variables	Definitions
Small/convenience store in 15-min drive	Total square footage of small and convenient stores within 15-minute driving to a house
Regular retail in 15-min drive	Total square footage of regular retail stores within 15 minute driving to a house
Shopping mall in 15-min drive	Total square footage of regional shopping mall within 15-minute driving to a house
Restaurant/bar in 15-min drive	Total square footage of restaurant and bars within 15 minute driving to a house
Local Shopping Accessibility	
Small/convenience store in 1 mile walk	Total square footage of small and convenient store within 1 mile walking to a house
Regular retail in 1 mile walk	Total square footage of regular retail stores within 1 mile walking to a house
Shopping mall in 1 mile walk	Total square footage of regional shopping mall within 1 mile walking to a house
Restaurant/bar in 1 mile walk	Total square footage of restaurant and bars within 1 mile walking to a house
School Performance	
School MEAP score	School MEAP test score
Recreational Accessibility	
Lake front	Property is within 500 feet to nearest lake
Lake view	Property is within 1000 feet to nearest lake
Distance to lakes	Natural Log of distance to nearest lakes
Distance to parks	Natural Log of straight-line distance to nearest parks
Within 50 feet to parks	Property is within 50 feet to a park
Building Attributes	
Building class A	Building class A (highest quality)
Building class B	Building class B
Building class C	Building class C
Building class D	Building class D
Building class E	Building class E (lowest quality)
Building duplex	Building type duplex
Building mobile home	Building type mobile home
Building single family	Building type single family
Building town house	Building type town house
Ln floor area	Natural log of (residential floor area)
Ln garage area	Natural log of (garage area)
Ln building age	Natural log of (building age)
Ln lot size	Natural log of (lot size in acres)
Proximity to Transportation Facility	

Input Variables	Definitions
<= x00 feet to highway	Property is within x00 feet to nearest highway
x00-y00 feet to highway	Property is between x00 to y00 feet to
<=x00 feet to major local road	Property is within x00 feet to major local road
x00-y00 feet to major local road	Property is between x00 to y00 feet to major local road
<= x00 feet to railway	Property is within x00 feet to railroad
x00-y00 feet to railway	Property is between x00 to y00 feet to railroad
Census Tract (neighborhood) Variables	
Ln median household income	Natural log of the median household income in census tract
Vacancy	Vacancy rate by census tract
Percentage of houses occupied by owners	Percentage of houses occupied by owners
Percentage of White	Percentage of White by census tract
Percentage of Black	Percentage of Black by census tract
Percentage of Hispanic	Percentage of Hispanic by census tract
Percentage of Asian	Percentage of Asian by census tract
Percentage of other races	Percentage of other races by census tract
Population density	Population density by census tract
Others	
Sold in winter	Property sold in winter
Sold in spring	Property sold in spring
Sold in summer	Property sold in summer

Chapter VI. Multilevel Regression Models and results

6.1 Model Developments

In this study I have specified the multilevel-modeling as a two-level random intercept regression model. The first level factors are individual property attributes, proximity measurement, work and non-work accessibilities. The second level factors are the statistics at census tract level such as median household income, percentage of black population, housing vacancy rates, etc. Ideally, the higher-level spatial units in multilevel modeling should represent the structure of housing submarkets. Yet, there is no consensus on how to define housing sub-markets. The Census Bureau has defined census tracts as areas that are "homogeneous with respect to population characteristics, economic status, and living conditions"(Census Geographic Areas Reference Manual, 2000). Thus housing units in the same census tract are more likely to share similar attributes such as the access to work and shopping opportunities, neighborhood quality, and even some physical features. I thus choose census tracts to represent housing submarkets. Some past studies also confirmed that using tract could improve model performance and factor interpretation (Goodman and Thibodeau, 2002). In addition to the random intercept model, I have also tested random slope model with selected housing attributes. However, the model only gained limited performance improvement. Moreover, varying slopes (coefficients) made the interpretation of the model rather difficult considering the number of census tracts in the models. Therefore, at the end, I chose the random intercept model for the clarity of interpretation.

Before presenting the specific models, one key issue that needs to be addressed in this study is the potential collinearity among the various accessibility measurements, especially the collinearity between regional work and shopping accessibilities. This is because commercial centers often tend to be co-located with employment centers. Moreover, since the number of retail jobs used in the calculation of regional shopping accessibilities is also counted towards the total employment in the calculation of work accessibility, some degree of correlation is expected, given the similar functional forms that have been used to calculate these accessibilities. While such correlation is understandable, it does pose a problem in the model estimation in the sense that the coefficients being estimated may not be efficient. As a result, interpretation of these coefficients may be difficult. To address this issue, I will conduct tests of the collinearity among these input variables and if the collinearity is significant, I will conduct additional estimation by alternatively removing some of the highly correlated variables. For example, I will only include work accessibilities in the model (or only shopping accessibilities) to see whether the model results might differ significantly from those where both types of variables are present.

Moreover, for each dataset, besides running a regional model, I also run separate models for Ann Arbor area and Detroit area given the significant differences between the

two areas. As discussed before, due to continuous population loss and industrial decline, spatial mismatch has been a major problem in the Detroit area. Retail opportunities are also severely constrained in city of Detroit. At least by 2004, the city of Detroit, with a population of over 800,000, did not have one single regional shopping mall within its city limit. City of Ann Arbor, on the other hand, has enjoyed steady population and job growth. Thanks to its economic prosperity, the city is also well served by a variety of retailers. Given such dramatic differences, it would be important to see whether residents in the two areas have valued work and nonwork accessibilities differently.

6.2 Model Results

As noted before, this study will only present model results using housing transaction data from actual school attendance areas, given that such models have better explanatory power than those using simulated school attendance areas. To highlight the differences in local context, I ran three sets of models. The first set used samples from all 16 school districts with true attendance areas, which I identified as the regional model. The other two sets are models using data from the Ann Arbor area and Detroit area respectively. I then compared the results among the three sets of models. Note that for each dataset in a particular geographic area, I ran five models that include work and nonwork accessibilities measured by the five different types of methodologies, that is, cumulative opportunities, traditional gravity model, gravity model with job competition, logsum with jobs, logsum with trip distribution.

6.2.1 Results of Regional Models

Before presenting the results of the multilevel regression models for all 16 school districts, I should note that I first ran a grand mean model to test the necessity of the multilevel model. The grand mean model is an "empty" model with only intercepts at individual property and census tract levels. Table 6.1 and 6.2 shows the results of the grand mean model. The estimate for the mean value of regional housing price is exp(11.56), about $104,378. One important output for this model is the intraclass correlation. It measures variation in the dependent variable attributable to the group-level factors versus the total variance. The higher the value, given it is significant, the more variation would be attributed to the group level rather than the individual level. (Albright and Marinova, 2010).

The formula for interclass correlation:

$$\text{ICC (interclass correlation)} = \frac{\tau_{00}}{\tau_{00} + \sigma^2}$$

Where: τ_{00} is the variance of group coefficient
σ^2 is the variance of individual error term

The interclass correlation value calculated from table 6.2 is:

ICC=0.58/(0.1+0.58)=85.3%

It shows that a large proportion of the total variance, about 85%, is due to the variance between census Tracts. This indicates that it is necessary to use the multilevel regression model in the study.

Table 6.1 Estimates of Fixed Effects for Grand Mean Model

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	11.555	0.035	489.038	334.000	0.000	11.4878	11.624

Note, Dependent Variable: lnprice.

Table 6.2 Estimates of Covariance Parameters for Grand Mean Model

Parameter		Estimate	Std. Error
Residual		.1019824	.0014232
Intercept [subject = tract]	Variance	.5787325	.0379894

Note, Dependent Variable: lnprice.

As Table 6.3 shows, with multilevel modeling, the likelihood for all five models with different accessibility measurements dropped significantly relative to the grand mean model. This shows that the null model should be rejected. Moreover, the distribution of the likelihood values also suggests that all five models' perform not very differently, with the cumulative and logsum-trip based models fit better. In a single-level OLS regression, an intuitive way to examine model performance is to use the R square, which indicates the proportion of variation in dependent variable that can be explained by independent variables. However, in a multilevel model, because the total outcome variations are partitioned into several components of variances, there is no consensus on what should be the proper statistics to measure model fitness (Singer and Willett, 2003). With such caveat in mind, I calculated an overall Pseudo R^2 as proposed by Singer and Willett (2003) for each model to proximately measure the model performance. Table 6.3 lists the values of Pseudo R^2 for each regional model. The results show that the overall model fitness is quite good for all regional models. Independent variables at all levels explained about 88% of the total housing price variation.

Table 6.3 Goodness of Fit for the Null model and Five Regional Models with Different Accessibility Measurements

Information Criteria	Null Model	Cumulative	Gravity -model	Gravity-model with competition	Logsum-job based	Logsum-trip based
-2 Restricted Log Likelihood	8128.6	807.3	915.7	875.8	894.1	818.5
Akaike's Information Criterion (AIC)	8132.6	811.3	919.7	879.8	898.1	822.5
Hurvich and Tsai's Criterion (AICC)	8132.6	811.3	919.7	879.8	898.1	822.5
Bozdogan's Criterion (CAIC)	8149.1	827.8	936.2	896.4	914.6	839.1
Schwarz's Bayesian Criterion (BIC)	8147.1	825.8	934.2	894.4	912.6	837.1
Pseudo R^2	NA	0.884	0.879	0.880	0.878	0.882

Table 6.4 presents the results of the five multilevel models with different accessibility measurements for all 16 school districts. Due to the large number of variables in the model, table 6.4 is presented on four consecutive pages. The dependent variable is the natural logarithm of housing transaction price in year 2000. Most of the independent variables are statistically significant at 10% level. Thus variables that are statistically significant are shaded in the table. For each independent variable, table 6.4 presents both values of the coefficients (the B values in the table) and the standardized coefficients (the Beta values in the table).

Let us first take a look at the control variables. All variables describing building characteristics have expected signs, with floor area having the largest contribution toward housing price. Variables describing building classes from A to E, which represent building quality from the highest to the lowest, also have price premiums that are statistically significant and in the right order. In terms of building type, single-family properties enjoy some price premium over duplex or multifamily buildings (MF building was the reference category, not shown in results). Both lot size and garage area also contribute positively to housing prices, while the building age variable, as expected, has negative coefficient. Interestingly, variables describing the proximity to highways, major local roads, and railways all have negative coefficients that are statistically significant, which may reflect the undesirable disamenities from these facilities such as noise, pollution and other nuisance.

Five variables describing neighborhood characteristics at the census tract level are all statistically significant. Both median household income and population density in the census

tract contribute positively to property values. Housing vacancy rate, on the other hand, dragged down neighborhood property value, which is not surprising. Variables describing the share of minority population such as the percentage of black population, or population that was identified as other races, have negative coefficients that are also statistically significant, which shows that neighborhood racial composition is still a very significant factor affecting property value in this region.

Now we can compare the impacts of different types of accessibilities and how the impacts may vary by measurement methodologies. As table 6.4 shows, across the five models, variables measuring regional work accessibility have mostly positive coefficients that are statistically significant. Four out of the five models predict significant price premiums for good work accessibility. In particular, work accessibility measured as cumulative opportunities has the largest standardized coefficient. The only exception is the accessibility measured by logsum and jobs, which is not statistically significant in the model. Taken together, these models have provided strong evidence for the importance of work accessibility in affecting households' willingness-to-pay for good locations.

By contrast, the results for regional shopping accessibilities are more mixed. In the model where the regional shopping accessibility is measured as cumulative opportunities, the coefficient for this variable is negative and statistically significant, which is interesting given that the regional work accessibility measured in the same method has the most positive impacts on housing values. Moreover, in the model where the shopping accessibility is measured as logsum and retail jobs, the coefficient for this variable is positive, but not significant. In the three other models, the coefficients for regional shopping accessibility are positive and statistically significant, just like what we observed for regional work accessibilities in these models.

As discussed before, one issue we must consider in examining the impacts of regional work and shopping accessibilities is the potential correlation among them. If the correlation is very strong, it may affect the signs and significance levels of their coefficients. Table 6.5 reports the correlation coefficient between the two types of accessibilities by the different types of measurements. As table 6.5 shows, in some models the correlations are very strong, with correlation coefficients as high as 0.92 if measured as cumulative opportunities, or 0.82 if measured with logsum and jobs. To address this issue, I estimated alternative models by only including either work or shopping accessibility, not both, in the models. The results are also summarized in table 6.5. As table 6.5 shows, there have been some changes in the model where both the work and shopping accessibilities are measured as cumulative opportunities. Recall from table 6.4 that when both variables, measured as cumulative opportunities, are present, work accessibility has strong positive impact, but shopping accessibility has strong negative impact. However, after excluding the shopping accessibility, work accessibility became insignificant; after excluding the work accessibility, shopping accessibility still retain its negative coefficient that is statistically significant. It is not clear why there are persistently negative impacts from regional shopping accessibility. But it does show that the positive impacts of work accessibility could not be revealed without

controlling for shopping accessibility. However, table 6.5 also shows that for the other four models where the accessibilities are measured in different methodologies, the changes are relatively minor. Coefficients in all the other models have retained the same sign and significance level as what were reported in table 6.4, even though their values may have somewhat changed. For example, in the model where the accessibilities are measured by logsum and jobs, both work and shopping accessibilities remain insignificant as what were reported before. Moreover, when accessibilities are measured in three other forms, gravity model, gravity with competition, and logsum with trips, both work and shopping accessibilities are positive and statistically significant in both table 6.4 and 6.5.

Perhaps an examination of the spatial distribution of the accessibility pattern in the region can help us understand why the results from the models where the accessibilities are measured as cumulative opportunities or logsum differ from those of the three other models. As shown in the work accessibility maps presented in the chapter 4, both cumulative opportunities and logsum methods have produced a cluster of high accessibility zones in Metro Detroit, especially in the north side of Detroit and CBD area. Beyond these locations the accessibility surfaces are relatively smooth with little zone-to-zone variation. This pattern is clearly dictated by the area's transportation network where Detroit is the focal point of the highway system. Yet, while they have highlighted the big employment center and its nearby area, the two methods could not provide sufficient details about the local variations in accessibility for the rest of the region. As a result, even after controlling for various housing and neighborhood variables, the accessibility measurements based on the two methods are not statistically significant or even with negative coefficient. By contrast, the other three measurement methods, gravity model, gravity with competition, and logsum with trip distribution, have identified distinct accessibility centers and sub-centers in both Metro Detroit and Metro Ann Arbor. They are thus able to reveal more local variations in accessibility level throughout the region. As table 6.4 and 6.5 have shown, both regional work and shopping accessibilities as measured by the three methods have positive impacts on property values that are statistically significant.

As discussed before, scholars like Handy (1993,2002) have argued that shopping accessibilities should be examined at different levels. Table 6.4 also reports the impacts of shopping accessibilities measured at community level and local level. In this study, the community-level shopping accessibility is measured as the total floor area for different types of retail stores within 15-minute driving. Table 6.4 shows that the results for community-level shopping accessibilities are quite similar across the five models. In all five models, the supply of small and convenient stores within a 15-minute driving area has negative impacts on property value that are statistically significant. This is a little surprising. Since those small retail stores are often located along commercial strip, it may reflect the fact that higher-value properties tend to be away from these commercial strips. The supply of regular retail stores and restaurants within 15-minute driving, on the other hand, does not have any significant impacts. Yet, the existence of big shopping malls in this driving range has positive impacts on property values that are statistically significant. This shows that in terms of shopping by driving, residents would value the access to big shopping malls that could

provide a variety of merchandise selection and comparison shopping rather than the small and convenient stores.

Table 6.4 reveals some interesting patterns for local shopping opportunities within the walking distances. In this case, close-by convenient stores and big shopping malls do not have significant impacts on nearby property values, possibly because the benefits from the proximity to those stores are cancelled out by the disamenities such as noises, local traffic congestions and privacy concerns. However, access to regular or mid-sized retail stores within the walking distance has small negative impacts that are statistically significant. Restaurants, on the other hand, have positive impacts that are statistically significant, showing that property owners value the opportunity to be able to walk to a nearby restaurant.

Finally, table 6.4 also reports the impacts of school accessibilities and recreation accessibilities. As past studies have shown, school quality is an important factor affecting households' residential location choices, especially for families with children. All five models reported in table 6.4 confirm this. The better score the assigned school has in the state MEAP test, the higher value the property would have. All school performance indicators are actually significant at 5% level. Accessibility to recreation opportunities also has positive impacts on nearby property value. In all five models, property value would decline if the property is located away from parks. Being close to lakes also has positive impacts on property value, but this relationship is only significant in three out of five models. Unlike some earlier studies, variables describing lake front or lake view do not add to property value in this study. This may be because the benefits of being adjacent to lakes could be compromised by potential flooding risks given the area's frequent precipitation and short summer.

Comparing across the different types of accessibilities, table 6.4 shows that work accessibilities are likely to have larger standardized coefficients (Beta values) than regional shopping accessibility. This shows that at the regional level, households in Southeast Michigan still prefer to living within the reasonable driving range of job opportunities. Yet, when nonwork accessibilities are calculated at smaller geographic areas, for example, shopping accessibilities at community or local level, their standardized coefficients have often exceeded those of work accessibilities. Moreover, the combined effects from all the nonwork accessibilities, including shopping, recreation, or education, have clearly outperformed those of work accessibilities. Thus, taken together, the study shows that work accessibility is still important in affecting household location choices, but only at the regional level. On the other hand, the well-developed transportation network in Southeast Michigan has offered greater flexibility in households' micro-location preference, as reflected by the significant capitalization effects from a variety of nonwork accessibility measurements.

Table 6.4 Results of Multilevel Modeling by Different Accessibility Measurements for all 16 School Districts(Regional Models)

Variables that are statistically significant at 10% level are shaded in the table

16 school districts	Variables	Cumulative		Gravity-model		Gravity-model with competition		Logsum-job based		Logsum-trip based	
		B	beta	B	beta	B	beta	B	beta	B	beta
	Intercept	5.212		4.165		3.883		3.791		4.589	
Control Variables	Building class A	0.931	0.093	0.936	0.093	0.936	0.093	0.934	0.093	0.937	0.093
	Building class B	0.432	0.174	0.434	0.175	0.436	0.176	0.435	0.175	0.436	0.176
	Building class C	0.337	0.095	0.341	0.096	0.342	0.096	0.343	0.096	0.340	0.095
	Building class D	0.252	0.133	0.255	0.134	0.255	0.134	0.257	0.135	0.255	0.134
	Building class E	0.162	0.035	0.160	0.034	0.158	0.034	0.160	0.034	0.159	0.034
	Building duplex	-0.050	-0.004	-0.043	-0.004	-0.042	-0.004	-0.041	-0.004	-0.044	-0.004
	Building single family	0.266	0.069	0.266	0.069	0.266	0.069	0.266	0.069	0.265	0.069
	Ln floor area	0.533	0.327	0.534	0.328	0.535	0.329	0.538	0.331	0.536	0.329
	Ln garage area	0.097	0.047	0.097	0.047	0.097	0.047	0.096	0.047	0.097	0.047
	Ln building age	-0.082	-0.100	-0.083	-0.101	-0.082	-0.100	-0.081	-0.099	-0.082	-0.101
	Ln lot size	0.077	0.070	0.079	0.072	0.078	0.071	0.078	0.070	0.080	0.072
	Sold in winter	-0.063	-0.032	-0.062	-0.031	-0.062	-0.031	-0.062	-0.031	-0.062	-0.031
	Sold in spring	-0.012	-0.007	-0.011	-0.007	-0.011	-0.007	-0.011	-0.007	-0.011	-0.007
	Sold in summer	-0.002	-0.001	-0.002	-0.001	-0.002	-0.001	-0.002	-0.001	-0.002	-0.001
Transportation Proximity variables	<= 300 feet to highway	-0.056	-0.008	-0.055	-0.008	-0.055	-0.008	-0.055	-0.008	-0.052	-0.007
	<=200 feet to major local road	-0.126	-0.014	-0.124	-0.014	-0.123	-0.014	-0.124	-0.014	-0.125	-0.014
	<= 200 feet to railway	-0.092	-0.006	-0.103	-0.006	-0.103	-0.006	-0.100	-0.006	-0.109	-0.007

16 school districts	Variables	Cumulative		Gravity-model		Gravity-model with competition		Logsum-job based		Logsum-trip based	
		B	beta	B	beta	B	beta	B	beta	B	beta
	200-500 feet to railway	-0.115	-0.016	-0.119	-0.017	-0.122	-0.017	-0.122	-0.017	-0.124	-0.017
Census Tract Variables	Ln median household income	0.202	0.127	0.327	0.206	0.336	0.212	0.352	0.222	0.320	0.202
	Percentage of black by tract	-0.004	-0.214	-0.005	-0.235	-0.004	-0.216	-0.005	-0.232	-0.004	-0.199
	Percentage of other races by tract	-0.018	-0.108	-0.022	-0.133	-0.022	-0.131	-0.022	-0.133	-0.021	-0.127
	Population density by tract	0.009	0.064	0.009	0.061	0.009	0.064	0.008	0.057	0.008	0.056
	Vacancy rate in tract	-2.579	-0.125	-3.056	-0.148	-2.981	-0.144	-3.060	-0.148	-2.785	-0.135
School Variable	School MEAP score	3.9E-04	0.019	4.5E-04	0.022	4.4E-04	0.021	4.6E-04	0.022	4.1E-04	0.020
Access to Recreational Opportunities	Lake front	0.061	0.005	0.058	0.005	0.058	0.005	0.058	0.005	0.053	0.005
	Lake view	-0.007	-0.001	-0.009	-0.001	-0.007	-0.001	-0.010	-0.001	-0.005	-0.001
	Ln distance to lake	-4.1E-07	-0.006	-2.3E-06	-0.033	-1.8E-06	-0.027	-2.0E-06	-0.030	-1.2E-06	-0.017
	Ln distance to park	-0.009	-0.013	-0.008	-0.013	-0.008	-0.013	-0.009	-0.013	-0.008	-0.012
	Within 50 feet to parks	0.034	0.005	0.039	0.005	0.039	0.005	0.035	0.005	0.044	0.006
Community-level Shopping Accessibility	Small/convenience sqft within 15-minutes drive	-0.090	-0.073	-0.104	-0.085	-0.105	-0.086	-0.117	-0.095	-0.117	-0.095
	Retail sqft within 15-minutes driving	0.017	0.017	-0.025	-0.025	-0.017	-0.017	-0.008	-0.008	-0.024	-0.024

16 school districts	Variables	Cumulative		Gravity-model		Gravity-model with competition		Logsum-job based		Logsum-trip based	
		B	beta	B	beta	B	beta	B	beta	B	beta
	Shopping mall sqft within 15-minutes drive	0.119	0.078	0.055	0.036	0.061	0.039	0.058	0.038	0.070	0.046
	Restaurant/bar sqft within 15-minutes drive	-0.102	-0.087	-0.001	-0.001	-0.008	-0.007	0.002	0.002	-0.005	-0.004
Local Shopping Accessibility	Small/convenience sqft within 1 mile walk	8.2E-05	0.003	1.0E-04	0.004	1.0E-04	0.004	8.8E-05	0.004	6.9E-05	0.003
	Retail store sqft within 1 mile walk	-4.8E-05	-0.014	-5.2E-05	-0.015	-5.5E-05	-0.016	-5.2E-05	-0.015	-6.3E-05	-0.019
	Shopping mall store sqft within 1 mile walk	-1.0E-05	-0.002	-2.3E-05	-0.005	-2.9E-05	-0.006	-1.6E-05	-0.003	-2.2E-05	-0.005
	Restaurant/bar store sqft within 1 mile walk	0.001	0.036	0.001	0.038	0.001	0.037	0.001	0.040	0.001	0.036
Regional work and shopping accessibility	Cumulative work accessibility	3.4E-06	0.237								
	Cumulative shopping accessibility	-9.3E-06	-0.289								
	Gravity based work accessibility			4.5E-10	0.033						
	Gravity based shopping accessibility			9.7E-11	0.019						

16 school districts	Variables	Cumulative		Gravity-model		Gravity-model with competition		Logsum-job based		Logsum-trip based	
		B	beta	B	beta	B	beta	B	beta	B	beta
	Gravity based work accessibility with competition					0.108	0.030				
	Gravity based shopping accessibility					1.4E-10	0.028				
	Logsum-job based work accessibility							-2.0E-07	-0.003		
	Logsum-job based shopping accessibility							7.4E-06	0.020		
	Logsum-trip based work accessibility									0.083	0.028
	Logsum-trip based shopping accessibility									0.133	0.048

Table 6.5 Alternative Models with Only Regional Work or Shopping Accessibilities

Variables that are statistically significant at 10% level are shaded in the table.

16 school district model	Estimates for work accessibility without shopping	Estimates for shopping accessibility without work	Correlations between work and shopping accessibilities
Measured by Cumulative Opportunities	0.018	-0.055	0.92
Measured by Gravity Model	0.044	0.032	0.39
Measured by Gravity Model with Competition	0.035	0.032	0.14
Measured by Logsum and Jobs	0.010	0.018	0.82
Measured by Logsum and Trip Distribution	0.054	0.068	0.42

6.2.2 Results of Ann Arbor Area Models

As noted before, besides running the regional models for all the 16 school districts for which I have collected the school attendance maps, I also run separate models for the Ann Arbor area and Detroit area to see whether there might be any significant differences between them. More specifically, given the availability of school attendance maps, I use Ann Arbor School District to represent the Ann Arbor area, and Detroit school district to represent the Detroit area. The Ann Arbor school district includes the city of Ann Arbor and parts of eight surrounding townships, while the Detroit school district mainly covers the city of Detroit. This section presents the results for the Ann Arbor area.

Table 6.6 Goodness of Fit for the Five Ann Arbor Area Models

Information Criteria	Cumulative	Gravity-model	Gravity-model with competition	logsum-job based	logsum-trip based
-2 Restricted Log Likelihood	-484.9	-454.4	-512.3	-483.4	-558.3
Akaike's Information Criterion (AIC)	-480.9	-450.4	-508.3	-479.4	-554.3
Hurvich and Tsai's Criterion (AICC)	-480.8	-450.4	-508.3	-479.4	-554.3
Bozdogan's Criterion (CAIC)	-468.9	-438.4	-496.3	-467.4	-542.3
Schwarz's Bayesian Criterion (BIC)	-470.9	-440.4	-498.3	-469.4	-544.3
Pseudo R^2	0.803	0.82	0.818	0.818	0.836

Table 6.6 shows the goodness of fit results for the Ann Arbor area models. As we can see, AIC and BIC indicators shows logsum trips based measurement gives the best overall goodness-of-fit. Gravity model with job competition indicator ranks the second. The overall model explanation power, as indicated by the pseudo R square, are strong. All five models have more than 80 percent of the property values predicted by independent variables.

Table 6.7 presents the results of multilevel modeling by five different accessibility measurements for the Ann Arbor Area. The Ann Arbor models have the very similar dependent and independent variables as the region-wide models, but are only run for properties located within the Ann Arbor school district.

As Table 6.7 shows, just as the regional model, all the control variables have expected signs. The differences between building class are less important; only the highest two

categories have significant price premium. Town houses are valued less than single-family buildings, but both enjoy some premium over duplex. Residential floor area is still significant but garage area is not. At the census tract level, all three variables measuring median household income, percentage of Asian population, and population density have positive coefficients that are statistically significant.

As to the accessibility variables, work accessibility variables in all 5 Ann Arbor models have positive coefficients that are statistically significant. The impacts of regional shopping accessibilities, on the other hand, are quite mixed. Two out of five are negative and the remaining three are positive but only two are significant. Again, given the strong correlations between work and regional shopping accessibilities, I also run alternative models by only including one type of the accessibility in the models. Table 6.8 presents the results from these alternative models. As Table 6.8 shows, by only including one of them, both work and shopping accessibilities have significantly positive impacts on property values in four out of five models. The exception is again the models where accessibilities are measured as cumulative opportunities. In these cases the work accessibility is not significant, while the shopping accessibility is negative but statistically significant, which are quite similar to what we observed for the regional models.

It would be useful to examine the accessibility maps to see why the results are different in models that measure accessibilities as cumulative opportunities. As the accessibility maps presented in the last section have shown, all the accessibility measurements except the one based on cumulative opportunities have highlighted the city of Ann Arbor as an important regional job center and the zones with good accessibility level in Ann Arbor district are centered around the city of Ann Arbor. These maps have captured well the actual distribution of economic activities in Ann Arbor area. By contrast, if we examine the accessibility map based on cumulative opportunities, zones with high accessibility levels do not overlay with city of Ann Arbor, but are instead located on the east side of Ann Arbor. This may be because the east side of Ann Arbor falls within the commuting shed of several Detroit suburbs that are located further on the east. Without considering the commuting cost, the accessibility measurement based on cumulative opportunities has overweighed the job opportunities in those suburbs rather than the more close-by opportunities in city of Ann Arbor. Despite this exception, overall all the model exercises for the Ann Arbor area have confirmed the importance of work and shopping accessibilities in the sense that both are found to have significantly positive impacts on property value. Moreover, a comparison of the beta values (standard coefficients) for these variables shows that generally work accessibility is more important than regional shopping accessibilities. In fact, the beta values of the work accessibility variables in several Ann Arbor Models are also much larger than what we observed in the regional models. This shows that households in Ann Arbor school district value more about job accessibility, which may reflect the fact that the area's job center is also a very lively city. As a result, living close to the job center has become more attractive.

Unlike the regional model, Table 6.7 shows that variables describing community-level shopping accessibilities are not significant across all models. This is not surprising given that the Ann Arbor area is well-served by a wide range of retailers. A15-minutes driving range, which is used to calculate the community-level shopping accessibilities, can essentially cover all the retail concentration in the area. As a result, there is not much variation in community-level shopping accessibility for this area.

The results for local shopping accessibilities, on the other hand, are similar to what we observed for the region-wide models. Regular retail opportunities within the walking distance reduce nearby property values. But proximity to restaurant and bars increase property value. However, what is interesting is that the standard coefficients for local shopping accessibilities in Ann Arbor models are much stronger than those of the regional models. This may reflect the unique context in Ann Arbor area, which contains a lively downtown and many walkable neighborhoods. As the 2005 SEMCOG travel survey data shows, residents in Ann Arbor area also have a much higher share of commuting or shopping trips by walking (15.8%) than the regional average (1.9%). As a result, residents in Ann Arbor area have valued more about the shopping opportunities that are available within the walking distance, as indicated by their larger capitalization effects in this area.

As the home of the University of Michigan, Ann Arbor has a highly educated population who values public education. This is strongly supported by the Ann Arbor models, where the standardized coefficients for school performance scores are four to five times as much as those in the regional models. This shows that households in Ann Arbor area prefer strongly to living close to a good school. However, unlike the regional model, parks matter not as much in Ann Arbor. Distance to parks is not statistically significant in three out of five Ann Arbor models, which may reflect the easy access to many local parks throughout the area. But distance to lakes is statistically significant and has expected negative sign, showing that property owners in Ann Arbor still values the proximity to water.

Table 6.7 Results of Multilevel Modeling by Different Accessibility Measurements in Ann Arbor Area

(Variables that are statistically significant at 10% level are shaded in the table)

Ann Arbor Area	Variables	Cumulative		Gravity-model		Gravity-model with competition		Logsum-job based		Logsum-trip based	
		B	beta	B	beta	B	beta	B	beta	B	beta
	Intercept	6.165		5.621		4.520		5.412		5.950	
Control Variables	Building class A	0.676	0.186	0.690	0.190	0.665	0.183	0.687	0.189	0.662	0.182
	Building class B	0.314	0.253	0.296	0.239	0.291	0.235	0.302	0.243	0.295	0.238
	Building class C	0.144	0.122	0.121	0.102	0.128	0.108	0.129	0.109	0.121	0.103
	Building class D	0.028	0.030	0.004	0.004	0.018	0.019	0.015	0.016	0.006	0.006
	Building class E	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Building duplex	-0.161	-0.040	-0.173	-0.043	-0.179	-0.045	-0.175	-0.044	-0.169	-0.042
	Building single family	0.043	0.015	0.035	0.012	0.028	0.010	0.030	0.010	0.044	0.015
	Ln floor area	0.548	0.486	0.543	0.481	0.541	0.479	0.547	0.484	0.531	0.471
	Ln garage area	0.027	0.021	0.032	0.025	0.026	0.020	0.026	0.021	0.033	0.026
	Ln building age	-0.039	-0.109	-0.043	-0.119	-0.048	-0.132	-0.044	-0.121	-0.049	-0.135
	Ln lot size	0.071	0.162	0.074	0.169	0.080	0.183	0.073	0.167	0.071	0.162
	Sold in winter	-0.083	-0.072	-0.083	-0.072	-0.079	-0.068	-0.083	-0.072	-0.078	-0.068
	Sold in spring	-0.018	-0.019	-0.016	-0.017	-0.016	-0.017	-0.017	-0.018	-0.015	-0.016
	Sold in summer	0.003	0.003	0.002	0.003	0.005	0.005	0.004	0.004	0.003	0.003
Transportation Proximity Variable	<= 300 feet to highway	-0.099	-0.027	-0.104	-0.029	-0.103	-0.028	-0.102	-0.028	-0.102	-0.028
	300-600 feet to highway	-0.080	-0.033	-0.082	-0.034	-0.083	-0.035	-0.081	-0.034	-0.082	-0.034
	<= 200 feet to local roads	-0.103	-0.022	-0.103	-0.022	-0.084	-0.018	-0.089	-0.019	-0.136	-0.029

Ann Arbor Area	Variables	Cumulative		Gravity-model		Gravity-model with competition		Logsum-job based		Logsum-trip based	
		B	beta	B	beta	B	beta	B	beta	B	beta
Census Tract Variable	Median household income by tract	0.103	0.090	0.128	0.113	0.196	0.173	0.152	0.134	0.172	0.151
	Percentage of Asian by tract	0.005	0.089	0.003	0.056	0.006	0.107	0.006	0.093	0.005	0.087
	Population density by tract	0.019	0.181	0.017	0.159	0.005	0.044	0.016	0.153	0.014	0.128
School Variable	School MEAP score	0.003	0.107	0.003	0.118	0.003	0.129	0.003	0.107	0.003	0.110
Access to Recreational Opportunities	Lake front	0.102	0.017	0.126	0.021	0.133	0.022	0.128	0.021	0.125	0.021
	Lake view	-0.058	-0.018	-0.068	-0.021	-0.075	-0.023	-0.070	-0.021	-0.074	-0.023
	Ln distance to lake	-7.9E-06	-0.108	-6.0E-06	-0.082	-9.3E-06	-0.128	-7.3E-06	-0.100	-5.0E-06	-0.069
	Ln distance to park	0.008	0.022	0.009	0.028	0.010	0.029	0.009	0.027	0.011	0.032
	Within 50 feet to parks	0.045	0.016	0.059	0.021	0.060	0.022	0.052	0.019	0.071	0.026
Community-level Shopping Accessibility	Small/convenience sqft within 15-minutes drive	0.032	0.015	0.026	0.012	0.039	0.018	0.038	0.018	0.016	0.008
	Retail sqft within 15-minutes driving	0.060	0.038	0.108	0.069	0.098	0.062	0.102	0.065	0.142	0.090
	Shopping mall sqft within 15-minutes drive	0.020	0.011	-0.001	-0.001	-0.014	-0.008	-0.011	-0.006	-0.012	-0.007
	Restaurant/bar sqft within 15-minutes drive	-0.138	-0.078	-0.177	-0.101	-0.163	-0.093	-0.165	-0.094	-0.180	-0.103
Local Shopping Accessiblity	Small/convenience sqft within 1 mile walk	-1.8E-04	-0.012	-3.0E-04	-0.020	-1.9E-04	-0.012	-2.2E-04	-0.014	-3.5E-04	-0.022
	Retail store sqft within 1 mile walk	-1.2E-04	-0.076	-1.2E-04	-0.077	-1.4E-04	-0.089	-1.3E-04	-0.085	-8.4E-05	-0.053

Ann Arbor Area	Variables	Cumulative		Gravity-model		Gravity-model with competition		Logsum-job based		Logsum-trip based	
		B	beta	B	beta	B	beta	B	beta	B	beta
	Shopping mall store sqft within 1 mile walk	-5.3E-05	-0.012	-6.7E-05	-0.015	-7.9E-05	-0.018	-6.7E-05	-0.015	-5.2E-05	-0.012
	Restaurant/bar store sqft within 1 mile walk	0.001	0.104	0.001	0.093	0.001	0.101	0.001	0.102	0.001	0.076
Regional Work and Shopping Accessiblity	Cumulative job accessibility	4.5E-06	0.118								
	Cumulative shopping accessibility	-1.7E-05	-0.200								
	Gravity based work accessibility			1.7E-09	0.151						
	Gravity based shopping accessibility			7.4E-11	0.035						
	Gravity based work accessibility with competition					0.513	0.239				
	Gravity based shopping accessibility					2.6E-10	0.124				
	Logsum-job based work accessibility							5.9E-06	0.075		
	Logsum-job based shopping accessibility							3.0E-05	0.083		
	Logsum-trip based work accessibility									0.516	0.483
	Logsum-trip based shopping accessibility									-0.364	-0.326

Table 6.8 Alternative Ann Arbor Models with Only Regional Work or Shopping Accessibilities

(Variables that are statistically significant at 10% level are shaded in the table).

Ann Arbor model	Estimates for work accessibility without shopping	Estimates for shopping accessibility without work	Correlations between work and shopping accessibilities
Measured by Accumulative Opportunities	0.008	-0.131	0.60
Measured by Gravity Model	0.172	0.150	0.55
Measured by Gravity Model with Competition	0.245	0.150	0.27
Measured by Logsum and Jobs	0.100	0.131	0.69
Measured by Logsum and Trips	0.254	0.090	0.88

6.2.3 Results of Detroit Area Models

This section discusses the results of multilevel modeling for the Detroit area. As mentioned before, I run the models only for properties located in Detroit school district, which serves the city of Detroit.

Table 6.9 Goodness of Fit for the Five Detroit Models

Information Criteria	Cumulative	Gravity-model	Gravity-model with competition	logsum-job based	logsum-trip based
-2 Restricted Log Likelihood	2,999.0	3,045.4	3,007.9	3,010.3	2,963.0
Akaike's Information Criterion (AIC)	3,003.0	3,049.4	3,011.9	3,014.3	2,967.0
Hurvich and Tsai's Criterion (AICC)	3,003.0	3,049.4	3,011.9	3,014.3	2,967.0
Bozdogan's Criterion (CAIC)	3,017.7	3,064.1	3,026.6	3,029.0	2,981.7
Schwarz's Bayesian Criterion (BIC)	3,015.7	3,062.1	3,024.6	3,027.0	2,979.7
Pseudo R^2	0.478	0.474	0.474	0.474	0.475

As table 6.9 shows, the model fitness in Detroit is relatively weak when compared to regional and Ann Arbor models. As the pseudo R square shows, similar independent variables only explained about 48% of the property values. Thus about half of the property value variations in Detroit cannot be explained by these models. This shows that the housing market dynamics in Detroit is quite different from those in Ann Arbor or the entire Southeast Michigan region. This may not be surprising considering the severity of the socioeconomic problems that have plagued Detroit. These problems are so entrenched and complicated that straightforward modeling cannot fully capture them. Still, according to the statistics presented in the table, logsum-trip based model and model with cumulative measurement have slightly better performance than the other three models.

Table 6.10 presents the estimation results by the five different types of accessibility measurements in Detroit area. Unlike the regional or Ann Arbor models, it seems that there is no clear relationship between work accessibility and property value in Detroit. Work accessibility measured as cumulative opportunities has significantly positive impacts on property value, while work accessibility measured as logsum and trip distribution has significantly negative impacts. Work accessibilities measured by three other approaches, such as two gravity-based measurement and one logsum job based measurement, have no significant impacts. Regional shopping accessibilities, on the other hand, have shown consistently positive impacts in four out of the five models. The only regional shopping accessibility that has negative coefficient is the one measured as cumulative opportunities.

Again, to address the potential correlation between work and regional shopping accessibilities, I also run alternative models by only including one of them in the models.

Table 6.11 presents the results from these alternative models. As table 6.11 shows, after excluding regional shopping accessibility, the impacts of work-accessibility remain weak. Only gravity-based work accessibility has significantly positive impacts on property value. In all the other four models the work accessibility variable is not significant. Meanwhile, after excluding work accessibility, the impacts of regional shopping accessibility are positive and statistically significant in three models, but insignificant in the other two models.

That work accessibility does not have clear positive impacts on property value in Detroit shows the complexity of measuring work accessibility. As the biggest hub of ground transportation and international port in Michigan, Detroit's well-developed transportation infrastructure gives its residents an advantage in mobility. However, with the deindustrialization and continuous population and job losses, the city of Detroit is no longer the dominant center for business and employment. As many scholars (Kain, 1968; Brueckner & Zenou 2003) have pointed out, the out-migration of jobs to the suburbs and the racial discrimination on suburban housing markets have caused serious spatial mismatch problem. With the diminishing job prospect for central city residents, the link between employment opportunities and residential locations is largely broken, which may explain why work accessibility has not been a significantly positive factor in affecting property values in most of the Detroit models. Perhaps in comparison to the other social problems the city has faced, such as neighborhood deterioration, public services cut, and rising crime, work accessibility may not be a significant concern of local residents in Detroit, especially since many of the job opportunities are not accessible to them anyway. Regional shopping opportunities, on the other hand, are more likely to show positive impacts, which is similar to what we observed in both the regional and Ann Arbor models.

The impacts of community-level shopping accessibilities in Detroit are similar to what we observed in the regional model. As all five Detroit models show, Detroit residents do value the accessibility to regional shopping malls within 15-minute driving, which is different from Ann Arbor models, where none of the community-level shopping accessibility variables are significant. This may reflect the retail constraints Detroit residents face since the city did not have one regional shopping mall within the city limit. Thus properties that are located within a convenient driving range of a regional shopping mall would enjoy some price premium. On the other hand, none of the variables describing local shopping accessibility within walking distance are statistically significant in Detroit models. This may seem to be puzzling considering the large number of poor people in the city who should value the shopping opportunities nearby. However, this study only examines the housing preferences of property owners, who are more likely to own their private vehicles. Since driving is a viable option for those people, they may not value so much about the shopping opportunities nearby, especially given the concern about public safety in a city that is plagued with disinvestment and abandonment. Besides regional shopping accessibility, the distance to park variable has a negative coefficient that is statistically significant in three

out of five models, showing that households in Detroit likely do value the recreational opportunities offered by parks. At the same time, being very close to park is a negative factor, which might be caused by nuisance such as safety concern. But the variable describing lake view is negative, which is somewhat surprising.

Perhaps the most surprising finding in Detroit is that the variable describing school performance is not significant in all five models, which is quite different from what we observed in both the regional models and Ann Arbor models. This again may reflect the difficult struggles the city faces. According to MEAP data, Detroit school district has lower average test scores than most of the 16 school districts examined in this study. According to a former CEO of Detroit Public Schools (Burnley,2009), in the period of 1994 to 1999, Detroit school district suffers from series of problems such as no strategic development plan, budget problem, broken payroll system, disrepair or nonfunctioning school facility, unsafe school buses, etc. As a result, Detroit public schools have lost more and more students to charter schools. Moreover, given the myriad of social problems Detroit public schools have to address, a single test score may not be able to capture the quality differences among these schools.

Table 6.10 Results of Multilevel Modeling by Different Accessibility Measurements in Detroit Area

(*Variables that are statistically significant at 10% level are shaded in the table).*

Detroit Area	Variables	Cumulative		Gravity-model		Gravity-model with competition		Logsum-job based		Logsum-trip based	
		B	beta	B	beta	B	beta	B	beta	B	beta
	Intercept	4.899		4.379		3.625		3.476		2.645	
Control Variables	Building class A	1.070	0.070	1.137	0.075	1.162	0.076	1.140	0.075	1.161	0.076
	Building class B	0.953	0.292	0.960	0.294	0.967	0.297	0.964	0.296	0.969	0.297
	Building class C	0.711	0.000	0.706	0.000	0.708	0.000	0.707	0.000	0.709	0.000
	Building class D	0.573	0.191	0.579	0.193	0.580	0.193	0.576	0.192	0.580	0.193
	Building duplex	-0.239	-0.033	-0.230	-0.032	-0.224	-0.031	-0.223	-0.031	-0.224	-0.031
	Buiilding single family	0.280	0.177	0.280	0.177	0.281	0.177	0.281	0.177	0.284	0.179
	Ln floor area	0.572	0.446	0.583	0.454	0.587	0.458	0.586	0.457	0.587	0.458
	Ln garage area	0.103	0.052	0.099	0.050	0.098	0.050	0.097	0.049	0.096	0.048
	Ln building age	-0.229	-0.114	-0.232	-0.116	-0.228	-0.114	-0.229	-0.114	-0.228	-0.114
	Ln lot size	0.102	0.064	0.103	0.064	0.102	0.064	0.103	0.064	0.099	0.062
	Sold in winter	-0.077	-0.067	-0.076	-0.066	-0.076	-0.066	-0.076	-0.066	-0.077	-0.067
	Sold in spring	-0.004	-0.004	-0.003	-0.003	-0.004	-0.004	-0.004	-0.004	-0.005	-0.005
	Sold in summer	-0.018	-0.017	-0.017	-0.016	-0.018	-0.017	-0.018	-0.017	-0.019	-0.018
Transportation Proximity Variable	<= 200 feet to local roads	-0.132	-0.028	-0.130	-0.028	-0.131	-0.028	-0.133	-0.028	-0.137	-0.029
	<=200 feet to rail roads	-0.235	-0.024	-0.247	-0.026	-0.244	-0.025	-0.244	-0.025	-0.243	-0.025
	200-500 feet to rail roads	-0.166	-0.049	-0.166	-0.049	-0.168	-0.049	-0.169	-0.050	-0.168	-0.049
Census Tract Variables	Ln median household income	0.338	0.195	0.416	0.240	0.427	0.247	0.435	0.251	0.416	0.241

Detroit Area	Variables	Cumulative		Gravity-model		Gravity-model with competition		Logsum-job based		Logsum-trip based	
		B	beta	B	beta	B	beta	B	beta	B	beta
	Percentage of black by tract	-0.003	-0.219	-0.003	-0.207	-0.003	-0.205	-0.003	-0.201	-0.003	-0.209
	Population density by tract	0.006	0.052	0.006	0.055	0.005	0.048	0.006	0.050	0.005	0.043
	Percentage of other races by tract	-0.012	-0.182	-0.013	-0.204	-0.013	-0.203	-0.013	-0.203	-0.014	-0.216
	Vacancy rate in tract	-1.255	-0.118	-1.282	-0.120	-1.245	-0.117	-1.259	-0.118	-1.266	-0.119
School Variable	School MEAP score	2.2E-04	0.019	3.0E-04	0.027	3.3E-04	0.029	3.0E-04	0.027	2.9E-04	0.026
Access to Recreational Opportunities	Lake front	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Lake view	-0.282	-0.026	-0.263	-0.024	-0.258	-0.024	-0.270	-0.025	-0.261	-0.024
	Ln distance to lake	2.1E-06	0.053	-1.5E-07	-0.004	1.9E-07	0.005	9.2E-07	0.023	9.4E-07	0.024
	Ln distance to park	-0.013	-0.023	-0.012	-0.022	-0.013	-0.024	-0.013	-0.022	-0.013	-0.023
	Within 50 feet to parks	-0.242	-0.022	-0.210	-0.019	-0.213	-0.020	-0.215	-0.020	-0.220	-0.020
Community-level Shopping Accessibility	Small/convenience sqft within 15-minutes drive	0.055	0.034	0.027	0.017	-0.024	-0.014	-0.029	-0.018	-0.111	-0.068
	Retail sqft within 15-minutes driving	-0.339	-0.165	-0.395	-0.193	-0.298	-0.145	-0.284	-0.138	-0.189	-0.092
	Shopping mall sqft within 15-minutes drive	0.069	0.054	0.079	0.061	0.075	0.058	0.077	0.059	0.079	0.061
	Restaurant/bar sqft within 15-minutes drive	0.086	0.047	0.131	0.072	0.122	0.066	0.118	0.064	0.154	0.084
Local Shopping Accessibility	Small/convenience sqft within 1 mile walk	1.4E-05	0.001	-3.3E-05	-0.002	-2.8E-05	-0.002	-1.3E-06	-7.7E-05	-1.4E-05	-0.001

Detroit Area	Variables	Cumulative		Gravity-model		Gravity-model with competition		Logsum-job based		Logsum-trip based	
		B	beta	B	beta	B	beta	B	beta	B	beta
	Retail store sqft within 1 mile walk	-3.5E-05	-0.014	-3.4E-05	-0.013	-4.4E-05	-0.017	-3.7E-05	-0.014	-4.2E-05	-0.016
	Shopping mall store sqft within 1 mile walk	5.6E-05	0.020	3.0E-05	0.011	3.3E-05	0.012	3.6E-05	0.013	3.7E-05	0.013
	Restaurant/bar store sqft within 1 mile walk	1.4E-04	0.009	1.4E-04	0.009	2.2E-04	0.013	2.3E-04	0.014	2.0E-04	0.012
Regional Work and Shopping Accessibility	Cumulative work accessibility	2.8E-06	0.282								
	Cumulative shopping accessibility	-6.6E-06	-0.268								
	Gravity based work accessibility			4.0E-10	0.042						
	Gravity based shopping accessibility			1.5E-10	0.032						
	Gravity based work accessibility with competition					-0.042	-0.014				
	Gravity based shopping accessibility					1.9E-10	0.041				
	Logsum-job based work accessibility							-4.5E-07	-0.008		
	Logsum-job based shopping accessibility							5.1E-07	0.002		
	Logsum-trip based work accessibility									-0.209	-0.060
	Logsum-trip based shopping accessibility									0.238	0.076

Table 6.11 Alternative Models with Only Regional Work or Shopping Accessibilities

(Variables that are statistically significant at 10% level are shaded in the table).

Detroit Model	Estimates for work accessibility without shopping	Estimates for shopping accessibility without work	Correlations between work and shopping accessibilities
Measured by Cumulative Opportunities	0.063	-0.045	0.93
Measured by Gravity Model	0.063	0.045	0.47
Measured by Gravity Model with Competition	-0.033	0.045	-0.28
Measured by Logsum and Jobs	-0.007	-0.003	0.69
Measured by Logsum and Trips	-0.019	0.048	0.12

Chapter VII. Discussion and Conclusion

In summary, with occupational matches between jobs and residents, my study shows that work accessibility in general has been a significantly positive factor in affecting property values in both the regional models and Ann Arbor models. This is consistent with traditional urban economics theories that predict better accessibility to workplaces leads to higher housing values. However, in examining the significance and magnitude of the results, I also find that the impacts of work accessibility vary by local housing markets and development context. In Ann Arbor area, where a thriving central city also happens to be a dominant job center, work accessibility has significant and much stronger impacts on property values than what were observed in the regional models. By contrast, in Detroit, a city that has suffered from serious population and employment loss, the value of work accessibility is not capitalized into local property value, which provides further evidence on the spatial mismatch hypothesis that John Kain proposed in 1968.

Moreover, by developing the different types of work accessibility measurements, this study also allows me to compare the performance of the different measurement methodologies. Across all the models I have examined, the gravity model with job competition and logsum model with trip distribution have provided the most consistent coefficient estimates and also have better explanatory power. This is in contrast to some scholars' work, for example, Srour, Kockelman and Dunn (2002), which finds that simple accessibility measurement based on cumulative opportunities has worked better in their studies. The different finding in my study may be due to the extensive suburbanization in Southeast Michigan. While the transportation network in this region still places Detroit and Ann Arbor as the central and sub-hubs, the distribution of population and jobs in this region have become extremely decentralized, more so than many other metropolitan areas. Given the universally low-density environment, a simple measure based on cumulative opportunities may not be able to capture the local variations. Instead, indicators capable of producing more localized accessibility patterns can better explain the variations within local housing markets. This finding is also in line with what other scholars such as Guliano (2004), who argued that the connection between transportation and land use still matters, but at a localized scale.

As to non-work accessibilities, my study shows that their effects also vary widely by local demographic and built environment. For example, both the school quality and shopping opportunities within walking distance have much stronger positive impacts in Ann Arbor areas than other places in the region. Moreover, the study also confirms that different types of shopping accessibilities should be examined at different geographic scales. The access to large shopping malls, for example, matters at the community level, within 15-minute driving range. But restaurants and bars would be valued if they are located within walking distance. General retail stores somehow are not welcomed by their neighbors,

which is puzzling and might need some further research. Finally, my study also shows that the combined effects of shopping, education and recreation opportunities are stronger than the impacts of work accessibility. Given the mature transportation network and reduced commuting costs, today's households have become less attached to job locations and have more flexibility in their residential location choices. In other word, work accessibility is still an important factor affecting household location choice at the regional level, but nonwork accessibilities have become dominant at the local level.

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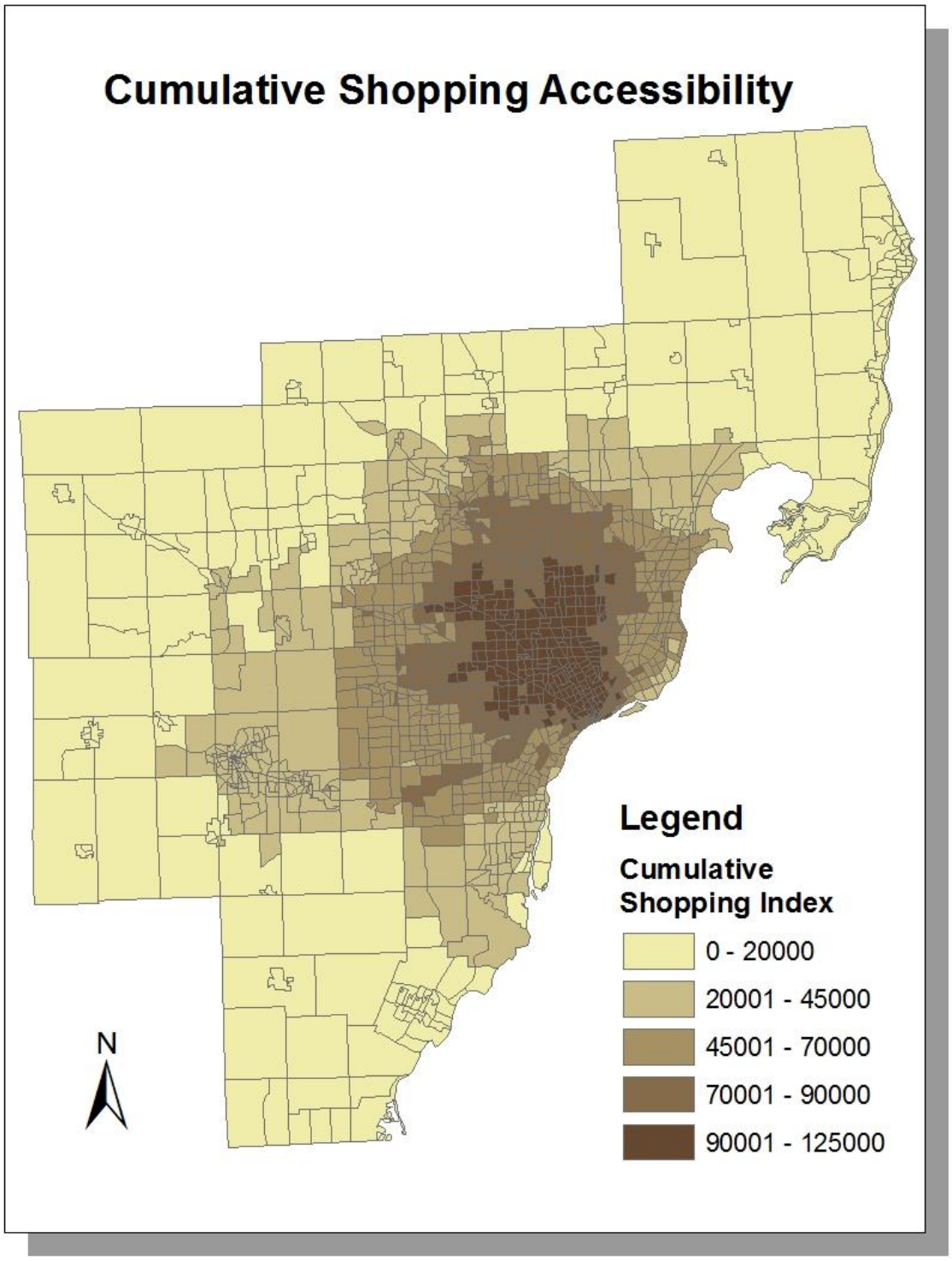
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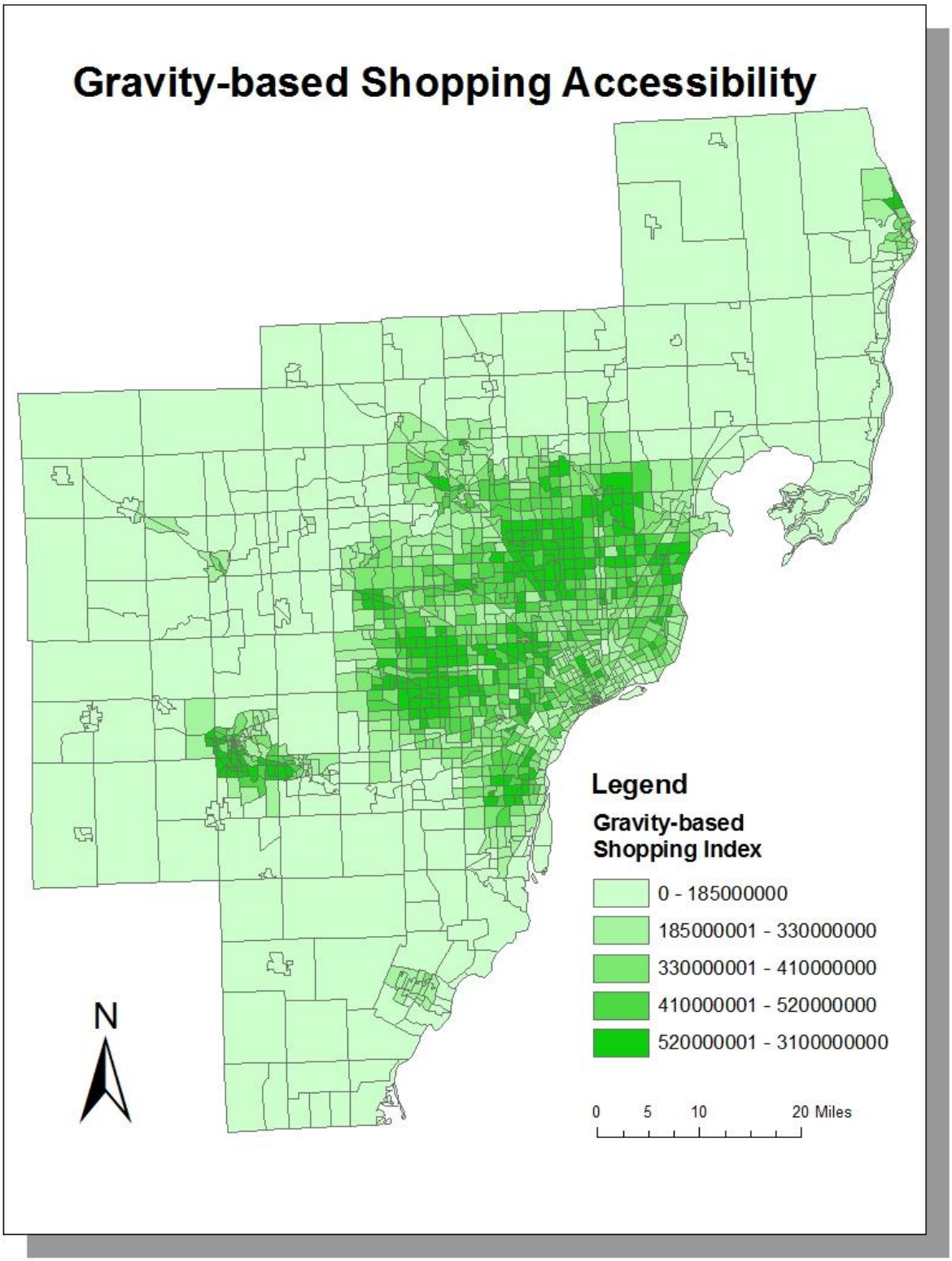
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Appendix. Maps for Regional Shopping Accessibility

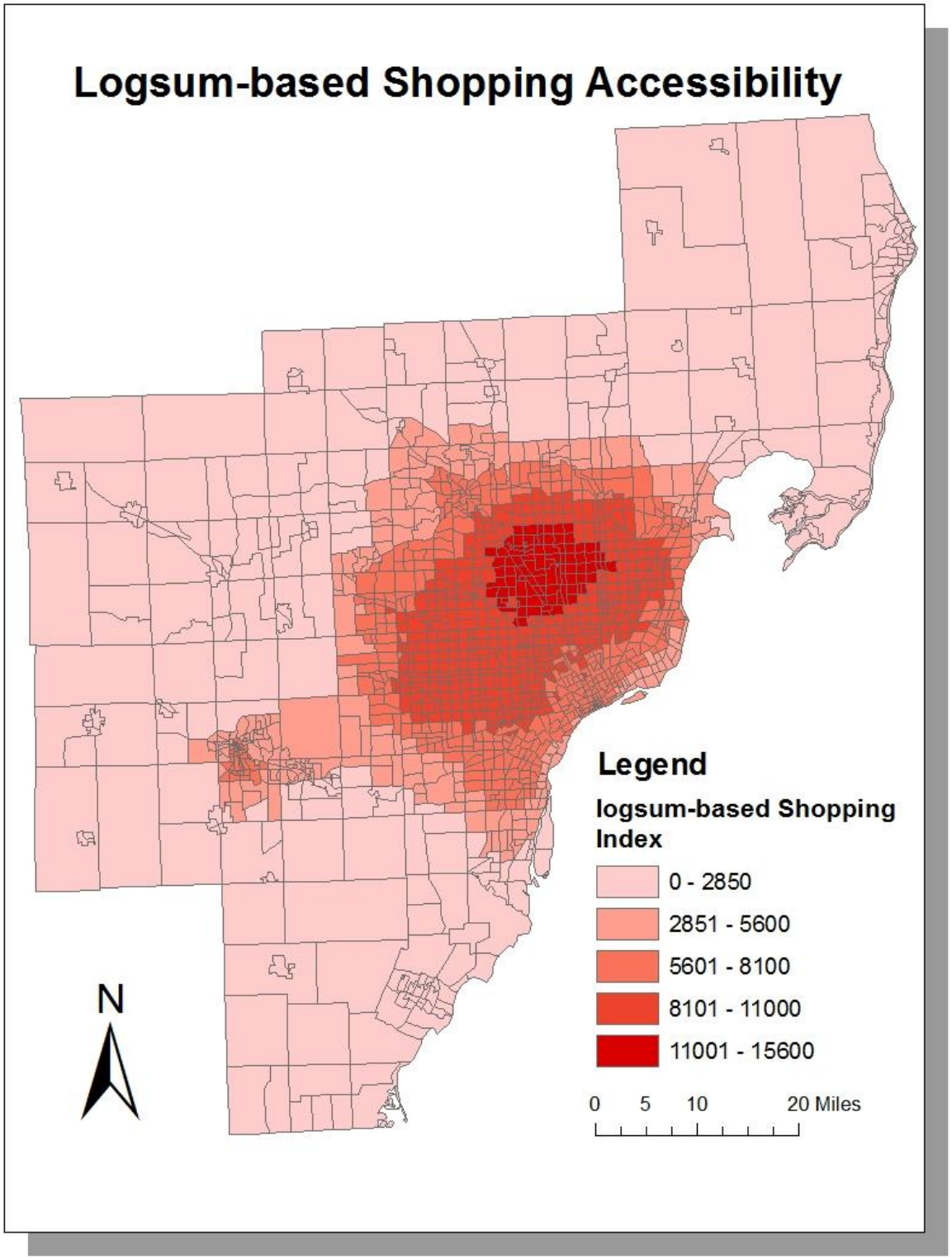
Map 1. Regional Shopping Accessibility Measured as Cumulative Opportunities



Map 2. Regional Shopping Accessibility Measured as Traditional Gravity Model



Map 3. Regional Shopping Accessibility Measured as Logsum and Retail Jobs



Map 4. Regional Shopping Accessibility Measured as Logsum with Retail Trips

