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Crime and Supermarket Locations: Implications for Food Access

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Food access in the United States has become a major policy issue that has received increased attention due to concerns of equality, health, and economic development. Since the initial academic research began to call attention to this issue a variety of tools have been developed to help identify geographic areas that have limited access to food. Supermarkets have taken the main focus as they provide for opportunities for fresh foods, greater variety, and lower prices.

While the existing research has looked to describe factors that explain the characteristics of communities with reduced supermarket access, crime has often been ignored or misclassified as only a firm cost component. Furthermore, the relationship between crime and supermarkets is one that has not been adequately discussed in the food access literature. Thus I focus in this research on the endogenous relationship between crime and supermarket access, hypothesizing that not only does crime impact where supermarkets exist but also that supermarkets impact criminal activities as either an attractor for crime or a contribution to a healthy community that deters crime.

Using Geographical Information Systems I calculate multiple measures of supermarket access throughout Connecticut. I then use a spatial econometric model that controls for the hypothesized endogenous relationship as well as the geographic relationship of neighboring areas. Findings indicate that increases in specific types of crime result in better supermarket access but that increased supermarket access also attracts more criminal behavior. These results have great implications for future policies related to economic development and the continuation of incentives for addressing concerns about limited access to supermarkets.

Crime and Supermarket Locations: Implications for Food Access

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Crime and Supermarket Locations: Implications for Food Access

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Chapter 1

Introduction

Food accessibility issues in urban areas have become a well documented problem in the United States (US) (for example: Cotterill and Franklin 1995, Alwitt and Donley 1997, Chung and Myers 1999, Gibson 1999, Kaufman 1999, Morland, Wing, Roux, and Poole 2002, Gallagher 2005, and Hartford Food System 2006) and in the United Kingdom (UK) (e.g. Beaumont, Lang, Leather, and Mucklow 1995, Cummings and Macintyre 1999, Wrigley 2002, and Clarke, Eyre, and Guy 2002). This issue is directly related to numerous health concerns, such as hunger, obesity, diabetes, and heart disease (Karpyn and Axler undated) as well as reducing employment and entrepreneurial opportunities (Pothukuchi 2005). In fact, the First Lady of the United States, Michelle Obama has spearheaded the Let's Move! program and Healthy Food Financing Initiative that aims to improve access to healthy foods in underserved areas.

The USDA has classified accessibility as a function of food security which is defined as, "access by all people at all times to enough food for an active, healthy life" (Nord, Andrews, and Carlson 2006). Supermarkets (including supercenters) are the primary retailer where researchers have focused their attention to determine if adequate food access is present. These retailers, defined by the industry as a grocery store with annual sales of $2 million or more (Trade Dimensions 2006), are larger food outlets that generally provide greater variety and lower prices than smaller superettes, convenience stores, or other food retailers. Limited access to supermarkets in certain geographic areas has led to phrases in the literature like the "urban grocery gap" (US) and "food

deserts" (UK). Many of these gaps or deserts have been the result of urban flight during the 1960s and 1970s, coupled with an evolving supermarket industry that expanded in suburbia rather than in central cities. Some of the need for expansion in suburbia is the necessity and availability of greater land areas to accommodate the innovation of superstores. In its wake, this has left a major policy issue in urban cities with regard to access to the amenities that supermarkets can provide. Furthermore, much of the limited access has been documented to greatly affect lower-income and minority households that are typical of central cities.

In response to limited food access, local communities, central cities, states, and even the federal government have developed policies to encourage urban supermarket development. One key element to determining where to channel programs and funding is the identification of food deserts or underserved locations. The USDA has developed a Food Desert Locator, more recently renamed the Food Access Research Atlas due to a changing atmosphere of political correctness that is moving away from the food desert term. This tool presents a spatial overview of access to supermarkets for low-income and low access census tracts throughout the country. Similarly, The Centers for Disease Control and Prevention and The Reinvestment Fund have also developed measures that identify limited supermarket access based on somewhat different criteria (The Reinvestment Fund 2013; Liese et. al, 2014). These different tools that identify underserved geographic areas throughout the country are excellent examples of a first step analysis but also oversimplify the identification and offer conflicting information for some communities.

Understanding where supermarkets are not locating is just one issue, but more fundamentally we need to understand why supermarkets are choosing not to locate in certain areas. Policy makers are often focused on the lack of supermarkets in a location and then trying to figure out various policy incentives or funding mechanisms to encourage supermarket development. Unfortunately this assumes a mindset of, "if you build it they will come" with little regard for understanding why a supermarket has failed to build in a location. Besharov, Bitler, and Haider (2011) introduce the economics of food deserts in the U.S. focusing on defining the relevant products, supply side factors, consumer demand issues, and market forces. Their research is motivated by the idea that it is difficult to formulate policy that is well supported by research if we do not understand the economic reasons why there exists limited access to food. One of the potential economic reasons is the impact of crime. Crime can be considered a supply side factor that affects the firm's decision to locate in an area as a cost of doing business or a demand side factor that affects the consumer's likelihood of patronizing the business.

Crime has received very little attention when studying retail activities, although the negative externalities of crime are at the very least perceived to have significant economic impacts (Fisher 1991). Such anecdotal evidence is presented such that crime is a deterrent to economic activity and hence urban areas that have high levels of crime are expected to have reduced access to retail opportunities, including supermarkets. Only two known empirical studies exist that indirectly consider crime as a determinant of supermarket access. Gibson (1999) uses crime as a proxy for costs since areas with higher crime rates are assumed to have higher costs related to safety

and theft prevention activities. Her findings indicate that crime does not have an effect on distance to supermarkets. Donohue (1997) also finds insignificant results as well as mixed coefficient signs when considering the impact of crime on grocery service levels. A more recent study by Bowes (2007) gives some insight to these results. This study focuses on the relationship between crime and retail development. The author presents evidence that an endogenous relationship exists between the two, which gives reason to the unexpected and contradictory findings by Donohue and Gibson. When estimating a two-stage simultaneous equation model, Bowes finds that crime is a deterrent to retail development. Therefore, crime may be a deterrent for supermarkets to locate in an area, or alternatively supermarkets may present either an opportunity for criminal behavior or a promotion of healthy lifestyle and thus deterrent for crime.

In this research, I use a similar approach to Bowes (2007) that controls for an endogenous relationship between crime and supermarket access, however, I expand his methodology by considering the spatial components of the data while focusing strictly on the impact of supermarket access. This method of studying the impact of crime on supermarket access significantly adds to the existing literature that is lacking in this area. Using supermarket location data from 2009, I present an analysis of supermarket access throughout the 169 towns in the state of Connecticut. With the addition of these components to the literature policymakers can be better informed on how to address concerns of limited access to food given other important community characteristics.

1.1. Research Objectives

I use Geographic Information Systems and advanced spatial econometric techniques to improve our understanding of the relationship between supermarket access and crime. While the most straightforward impact related to crime is that it affects economic business activities and would thus discourage supermarkets locating in an area, an alternative view has developed that a simultaneous relationship exists between retail development and crime. Therefore, to study the relationship between supermarket access and crime, I develop a model that accounts for the endogenous nature of these two variables. It is hypothesized that:

(1) crime reduces access to a supermarket because of the costs associated with the loss of customers and quality employees – a result of the fear of being victimized and the loss of merchandise from theft, and;

(2) access to supermarkets has an ambiguous effect on crime, where access has an increasing effect on crime because of the greater criminal opportunities available but also a decreasing effect on crime because of the neighborhood amenity that supermarkets provide in promoting a healthy lifestyle.

In addition to my focus on these two research questions I also revisit previous literature in examining whether minority and low-income neighborhoods have reduced access to supermarkets, relative to other populations.

This dissertation continues with a review of the literature relevant to supermarket access, followed by a section on crime and the theory related to crime and supermarket access. I then present a discussion of the spatial issues that need to be considered and identify an econometric model. The next section focuses on testing the empirical model

and discussion of results. The final section of this research includes a discussion of policies designed to alleviate supermarket access and how this work adds to considerations for future policy development.

Chapter 2

Supermarket Access

Supermarket access in urban areas is of great interest because of issues of nutrition and equality. Many of the concerns about supermarket access originated from the urban flight of supermarkets to suburban areas (Becker 1992, Gottlieb 1996, Donohue 1997, Ferguson and Abell 1998, Kolodinsky and Cranwell 2000, Pothukuchi 2005). Reasons for supermarket flight include economic, industry, spatial, and social variables. Economic reasons focus on income and decreased buying power as well as the increased cost of doing business through land values, utility, and labor costs. The nature of the supermarket industry has also changed over the years with greater emphasis on larger stores with more service options and various other formats. Much of this has been a result of industry concentration and mergers. The spatial factors include neighborhood demographics, zoning and other regulatory issues along with land availability to accommodate larger store formats. Crime and racism are social issues that have also been linked with supermarkets abandoning urban areas.

While these reasons are informative with regard to potential policy changes, where to focus those policy efforts is largely dependent upon understanding where supermarket access is limited, and the explicit factors from the previous list that explain such access.

2.1. Literature Review of Supermarket Access

Much of the literature in the US that addresses supermarket access in urban cities has documented that urban residents, particularly the poor, black, and less mobile

(i.e. lack of vehicle) are suffering from a lack of supermarkets in their area. Many of these studies, some of which are outlined below, focus on one or a few geographic areas and a limited definition of access. The only known study that exists to date that has looked at this issue across metropolitan areas in America is from The Food Marketing Policy Center at the University of Connecticut (Cotterill and Franklin 1995). This work uses a zip code analysis of 21 metropolitan areas throughout the US, defining access as the number of stores per capita or the number of square feet per capita, both within a given zip code. They find that access is limited to lower income communities, particularly those without vehicles, a common result throughout the US.

Alwitt and Donley (1997) study access to various types of retail establishments in the City of Chicago. Using a definition of access as the number of stores in the zip code and the number of stores per dollar of purchasing power, they find that residents of poor zip codes have reduced access to supermarkets and increased access to small grocery stores, small drug stores, and liquor stores. Chung and Myers (1999) find similar results in the Twin Cities of Minnesota, also noting that prices in the inner city are higher because small grocery stores, as opposed to large chains, are more likely to locate there. Similarly, low-income households lack access to supermarkets and lower costs foods in rural areas of the lower Mississippi Delta along the Mississippi River (Kaufman 1999).

In a study that overlaps some of these areas, Morland, Wing, Roux, and Poole (2002) define a model to test whether fewer supermarkets and more corner markets are located in lower income neighborhoods and black neighborhoods. Using census tract data in Mississippi, North Carolina, Maryland, and Minnesota, the authors find three

times as many supermarkets in higher income neighborhoods compared to lower income neighborhoods. White neighborhoods also had four times as many supermarkets as black neighborhoods.

A study by the Hartford Food System (2006) addressed supermarket access throughout Connecticut. Looking at every supermarket in the state, they find a nonlinear relationship between supermarket space (square feet per resident) and median family income. As median income rises to $60,000, there exists a greater number of square feet of supermarket space per person. Above $60,000 the square footage per person declines as median income rises. This indicates that middle-income families in Connecticut have the best access to supermarkets.

The concern of limited access to food is not just within the US as similar studies have also been undertaken in the UK. One such study found the atypical result that chain stores were locating in poor areas, reasoning that stores are returning to areas previously believed to be unprofitable (Cummings and Macintyre 1999). In another study, Clarke, Eyre, and Guy (2002) focus on access in the urban cities of Leeds/Bradford and Cardiff. Recognizing the spatial element of measuring access, the authors compute an index of the level of provisions in an area. This index is weighted based on the size of local and neighboring supermarkets as well as the number of households in the area. Areas are then identified where supermarket access is limited and comparisons are made by social class. While most of the areas with poor access to groceries are where lower income households are located, there are also high-income households that are not readily served. Prior to classifying these areas as food deserts, the authors consider if residents of these areas own a car. In areas with a high

percentage of vehicles and limited local access to groceries, households are more likely to be able to travel for their purchases, and the classification as a food dessert may be unnecessary. Many of the areas where high-income households do not have local grocery access are also areas where more households have cars, suggesting that food deserts in these urban cities are only where lower income households reside.

The issue of supermarket access in Canada has also been studied (Smoyer-Tomic, Spence, and Amrhein 2006 and Apparicio, Cloutier, and Shearmur 2007). These studies focus on supermarket access in Edmonton and Montreal. Interestingly, both studies find relatively no evidence of food desserts in these areas. In Edmonton, accessibility is greater in the inner-city and higher-need neighborhoods. In Montreal, only isolated gaps exist and no specific neighborhood characteristics are identified that represent a widespread issue. Suggestions are offered as to why these results differ from some of the previous research in the US, such as no loss in population during urban flight and trends toward increased economic development.

One of the major issues with many of these studies is with regard to spatial and statistical considerations. Analysis has been based on area averages and descriptive statistics along with choropleth mapping. While these methods do present a quick overview of the issue, they can often be interpreted to have more significant meaning that just a single variable presentation of data. One study on Detroit communities begins to address these concerns (Zenk 2004).

Focusing on supermarket access in Detroit neighborhoods with a greater proportion of African Americans, Zenk (2004) develops a Geographic Information Systems (GIS) based spatial analysis considering three methods of accessibility. Using

data from the 2000 census and defining neighborhood boundaries as census tracts she adjusts for spatial dependence with a moving average spatial regression. The choice of a moving average model is explained by the suspected spatial dependence from the distance based accessibility measures, omitted variables, and arbitrary neighborhood designations from the use of census tracts. Findings for predominantly higher African American neighborhoods include an increased distance to the nearest supermarket, fewer stores within a three mile radius, and roughly 60-70% less accessibility to all supermarkets in Detroit. Although the author attempts to account for spatial effects, she does recognize that some spatial dependence is present and unaccounted for in the residuals. I intend to expand on this literature by using spatial modeling techniques to account for spatial dependence in the residuals as well as incorporating crime into the access analysis.

2.2. Price and variety at supermarkets

One of the concerns with limited supermarket access is with respect to the prices paid and the variety of items available, particularly fresh healthy perishable products. Grocery stores, smaller than supermarkets, are believed to be higher priced stores while supermarkets are expected to be lower priced stores due to economies of scale (Hall 1983, MacDonald and Nelson 1991, Morris, Neuhauser, and Campbell 1992, Mantovani and Daft 1996, Finke, Chern, and Fox 1997, Kaufman, MacDonald, Lutz, and Smallwood 1997). If in fact supermarket access is limited then the price of groceries is presumed to be higher. This raises important questions about whether the poor or other demographic groups of individuals pay more for food.

A number of research studies have addressed this issue (Hall 1983, MacDonald and Nelson 1991, Morris, Neuhauser, and Campbell 1992, Ashman, de la Vega, Dohan, Fisher, Hippler, and Romain 1993, Hoats 1993, Mantovani and Daft 1996, Finke, Chern, and Fox 1997, Kaufman, MacDonald, Lutz, and Smallwood 1997, Chung and Myers 1999, Cummins and Macintyre 2002). Findings have largely indicated that lower income households pay more for food and urban area prices are greater than suburban area prices. There is also evidence that prices are in fact lower in larger sized store formats, including in New Haven, Connecticut where prices are 51 percent higher in small neighborhood stores than in supermarkets (Andreyeva et al. 2008).

While it is informative to understand the correlation between supermarket prices and geographic areas, one of the necessary distinctions when measuring the price of groceries is the link between supermarket prices and the prices specific households actually pay. Shelf prices and scanner data provide information on the available options, but it is unknown which specific demographic groups are actually purchasing these items. Finke, Chern and Fox (1997) attempt to address this problem by comparing average prices paid by various groups of individuals using survey data and a relatively homogenous basket of goods. They find that in urban areas black households pay higher prices than white households and low-income households pay more than higher-income households. These findings correlate nicely with much of the supermarket access literature, thus reinforcing the notion that increased supermarket access is correlated with lower prices.

In addition to larger supermarkets offering lower prices these store formats also offer a greater variety of items. In 2013 the average number of items carried in a

supermarket was 43,844.[1] Of those offerings, one of the key advantages is the presence of fresh fruits and vegetables, meats, and other healthier foods. One study has surveyed local supermarkets, grocery stores, convenience stores, mass merchandisers, and dollar stores in an attempt to quantify the differences in offerings of these healthier products. Throughout 44 stores in Texas, Bustillos et .al. (2009) find that supermarkets consistently carry full selections of fruit, vegetables, meats, dairy, eggs, healthier cereals, and bread. Alternatively, smaller grocery stores did not all of the same products, with differing selections at different locations. The other three types of store types carried an even smaller selection.[2]

2.3. Policy Focus in the United States

With the focus on food access looking at supermarket locations a variety of local, state, and national policies have been developed in an attempt to bring supermarkets into underserved areas. One example of a local city policy is the New Orleans Fresh Food Retailer Initiative. The City of New Orleans began this program by providing low-interest and forgivable loans to food retailers that located in underserved communities (Ulmer et. al 2012). This policy, while also focused on providing support for fresh food in smaller food stores and farmers markets was largely based upon the nation's first state policy developed in Pennsylvania. The Pennsylvania Fresh Food Financing Initiative (PAFFI) was developed to provide financing to increase supermarket development in underserved areas. The PAFFI, run by The Food Trust and The Reinvestment Fund, initially concentrated in the Philadelphia area but quickly gained

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[1] Food Marketing Institute, Supermarket Facts, Industry Overview 2013 (http://www.fmi.org/research-resources/supermarket-facts).

[2] It is worth noting that mass merchandisers, grocery stores, and dollar stores have started to increase their selection of these items in the past few years through grants to provide equipment and a changing focus to offer more one stop shopping.

statewide support and ultimately state funding in 2004. The program resulted in opening of 32 new stores through PA in the first four years by providing a combination of financing along with tax credits (Giang et al. 2008).

The popularity at the local and state level, coupled with the implication that increasing supermarket access can address issues of obesity and other health related disease has also led to policy development at a national level. First Lady, Michelle Obama pioneered the Let's Move! initiative that ultimately resulted in the Healthy Food Financing Initiative in 2010.[3] This nationwide initiative was designed to, "eliminate food deserts across the country within seven years" as well as "create jobs and economic development, and establish market opportunities for farmers and ranchers."

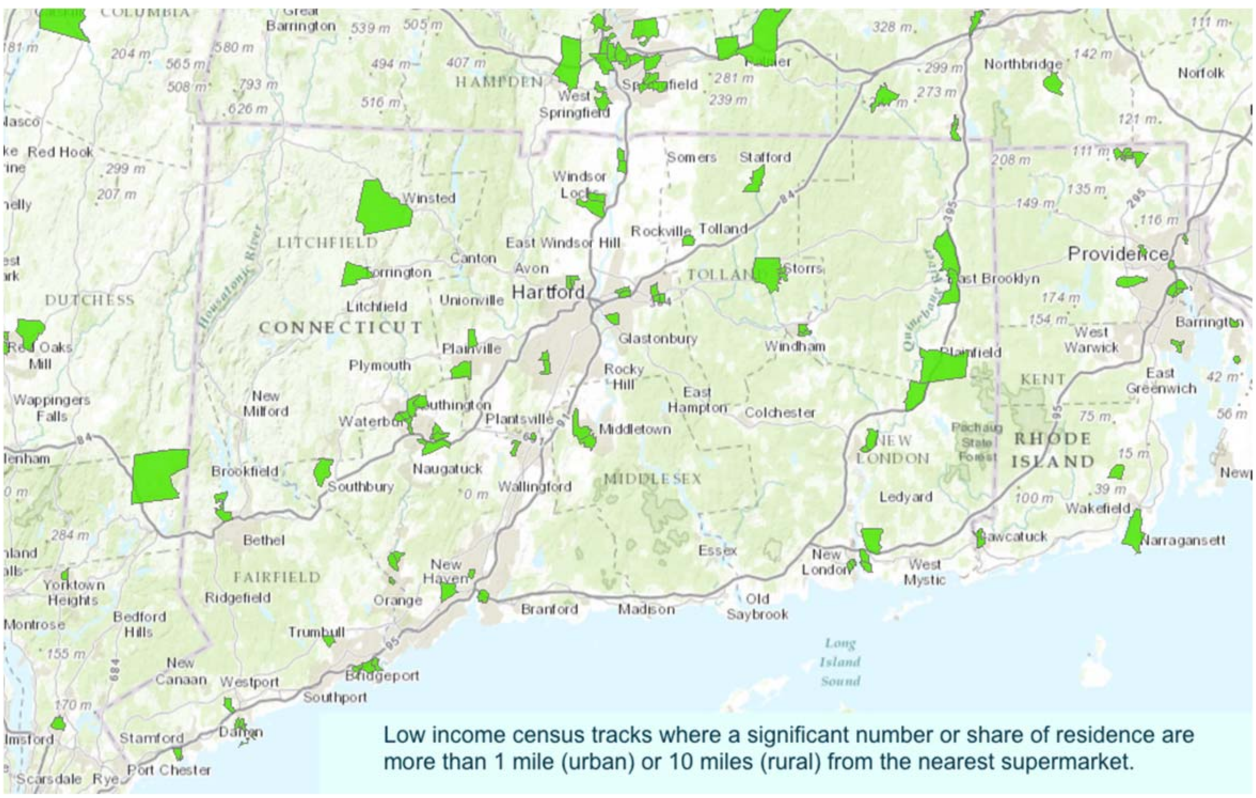
2.4. Tools and Measures of Supermarket Access

Multiple online tools have been developed to allow policy makers and other stakeholders to easily identify areas that are underserved by supermarket access. The first of such tools was developed by the Economic Research Service of the USDA and was called the Food Desert Locator. In an effort to broaden the scope of the tool and reduce the stigma associated with the term "food desert", the second version of the tool has recently been named the Food Access Research Atlas. This atlas identifies census tracts throughout the US that are considered to be underserved when they have both limited income and low access to supermarkets. The identification of limited income is based on a census tract's poverty rate being 20 percent or greater; or the census tract's median family income being less than or equal to 80 percent of the state-wide median family income; or when the census tract is in a metropolitan area it has a median family

[3]http://www.usda.gov/wps/portal/usda/usdamediafb?contentid=2010/02/0077.xml&printable=true&contentidonly=true

income less than or equal to 80 percent of the metropolitan area's median family income. The distance to the closest supermarket is then calculated to determine if the census tract has low access, with a defined threshold of 1 mile in urban areas and 10 miles in rural areas. Alternative variations of low access include the determination of supermarkets within 0.5 miles in urban areas and 10 miles in rural areas or 1 mile / 20 miles in urban and rural, respectively. An additional criterion looks at households without vehicle access that live more than ½ mile from the nearest supermarket.

Map 1. USDA – Food Access Research Atlas: Areas of Limited Food Access in Connecticut



Source: USDA Food Access Research Atlas available at: http://www.ers.usda.gov/data-products/food-access-research-atlas.aspx#.

Map 1 shows areas within Connecticut that are shaded in green that are determined to have low income and low access with the 1 mile in urban and 10 miles in

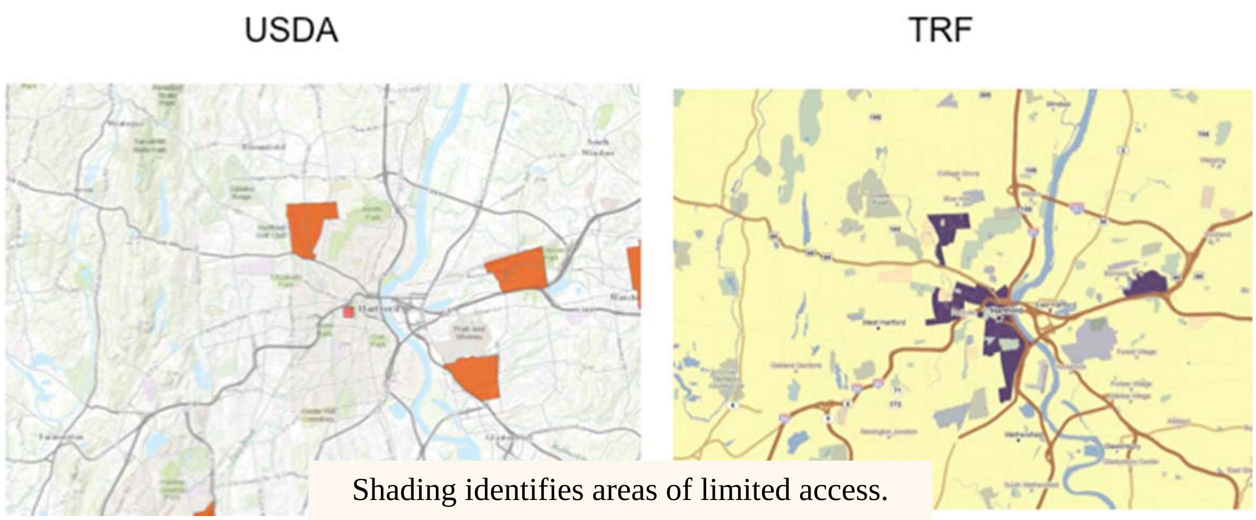
rural areas definition. One can see that these areas include portions of major cities in Bridgeport, Hartford, New Haven, and Waterbury as well as very rural areas such as Brooklyn, Plainfield, Storrs, and Winsted. With the online tool one can zoom into each area for a finer level of detail to identify specific census tracts that have been identified as underserved by the USDA.

Another online tool to identified underserved areas was developed by The Reinvestment Fund, a financing group that focuses on neighborhood revitalization and has been directly involved in the Pennsylvania Fresh Food Financing Initiative. This tool focuses on measures of limited supermarket access throughout the nation by identifying census block groups where a resident must travel significantly farther to the nearest supermarket than residents of areas showing similar population density and car-ownership characteristics as well as median household incomes greater than 120% of the area median. Using this criteria, Connecticut ranks 4th in the nation with regards to the scale of the problem and burden on low income residents. Furthermore, New Haven and Hartford rank 5th and 8th, respectively, relative to cities of similar size, thus identifying these areas as in need for policy implementation to address problems of limited supermarket access (The Reinvestment Fund, 2013).

Looking closer at the City of Hartford, Map 2 on the left shows the USDA identified low income/limited access areas (shaded in orange) while on the right is The Reinvestment Fund limited supermarket access areas (shaded in purple). One can easily see how these two mapping tools end with different results even though they have similar objectives of identifying areas that are underserved by supermarkets. The USDA map shows an area in orange, north of US-44 near the Hartford Golf Club that is

actually mostly within the University of Hartford campus. The Reinvestment Fund map includes that similar area to the east of the University of Hartford campus but also a large number of other areas in Hartford to the south of US-44. This of course presents policy makers and other stakeholders with conflicting information – which designation is accurate?

Map 2. Comparison of USDA and TRF Mapping Areas in Hartford, Connecticut



Shading identifies areas of limited access.

Source: USDA Food Access Research Atlas available at:
http://www.ers.usda.gov/data-products/food-access-research-atlas.aspx#.
The Reinvestment Fund map available at:
http://www.trfund.com/limited-supermarket-access-lsa-analysis-mapping-tool/.

Further complicating the discussion of limited supermarket access is that both of these tools, as well as others not discussed here, focus on where supermarkets are already located and policy then attempts to mitigate existing gaps. This implies that "if you build it they will come", i.e. if one can identify areas where there are a lack of supermarkets and build in those areas this will solve the problems of hunger and related health issues including the obesity epidemic. Unfortunately, what this approach does not do is consider the reasons why supermarkets have chosen not to locate in that community. Rather than a simple mapping project, a more comprehensive economic

analysis can help provide a better understanding of the type of communities that would be underserved holding other economic variables constant.[4]

2.5. The Economics of Supermarket Access

Most of the existing literature has focused on supply side variables of the whether or not supermarkets exist in certain areas with little regard for the economics behind the question of access. Besharov, Bitler and Haider (2011) present the first theoretical view of the economics of food deserts in the US outlining four basic components. The first component is defining the relevant products. This can include defining whether the interest is on healthy and nutritious food, just fresh fruits and vegetables, or multiple food groups. Additionally, the relevant product market involves characterizing the proximity to that food category which can be affected by transportation availability and travel patterns. In particular, travel patterns are often overlooked as studies focus on proximity relative to home or population centroids giving no consideration to a person's ability to access food while traveling to and from work.

The second component that Besharov, et. al. identify are determinants of demand. This can include income, prices, and preferences. One should also consider the impact of social safety nets such as the Supplemental Nutrition Assistance Program (SNAP), Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), and other direct provision programs that have similar effects as income. With regard to preferences, one of the key issues with a focus only on supermarkets is the

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[4] The Reinvestment Fund does recognize that their identification is a first step. In a summary publication they outline a framework for evaluation that helps provide guidance as to whether an area can "potentially" support a farmers' market, small store, full-service store, or multiple full-service stores. This framework, however, is based on the existence of small stores and the amount of unmet demand that they calculate from estimated expenditures on food and annual sales of existing stores. The greater the amount of unmet demand the greater the potential for supporting a full-service store. Even with this consideration there are still factors missing from the decision process that affect firms decisions to locate and whether building a new store can be sustainable.

lack of consideration of local preferences of minority populations for specific ethic food types. This is one reason why research on food access would be more comprehensive if it considered smaller grocers/bodegas that are more common in urban areas where there are clusters of populations of specific ethnicity.

Having defined the market and considered consumer factors, one must also consider the firm or supply side of food access. The basic determinants of supply include input costs, labor, land, equipment, transportation, stocking, inventory, and wholesale product costs. In particular it is an open question as to why larger outlets like supermarkets that should have more readily available capital and advantages of economies of scale do not locate in certain areas. These supply factors should be considered to the extent that they can explain why food outlets do not locate in particular communities.

The fourth component of the economics of food deserts is the market, i.e. where consumers and firms exchange goods for money. Where this interaction occurs is the market and consumers typically have little market power. The market for food is often where there are few firms serving a community and there is generally increased prices and restricted quantity relative to the competitive price and quantity levels. The question really becomes why such market power exists and that is related to the supply side factors previously discussed, including fixed costs and economies of scale.

Given these four economic components one can undertake a more comprehensive view of food deserts. This view can begin to address issues beyond the supply side to include demand side and market variables as well as a more properly defined market. One of the areas that has been misclassified within the access

literature has been the impact of crime. Crime has only been considered a supply side factor that increases the cost of doing business for the firm that must deal with increased need for security or the costs involved with theft. Additional reasons for the supply side of crime include the difficulty of attracting adequate labor given the risks involved with working in a high crime location, or the possibility of having to pay that labor higher wages. Alternatively, one may also consider crime a demand side factor where consumers choose not to visit a supermarket location because of preferences for shopping in areas with less crime. Thus without fully considering the impact of crime and supermarket access one may not fully understand why a supermarket chooses not to locate in certain communities. My research fills this gap and provides for this better understanding.

Chapter 3

Crime

3.1. Literature Review of Crime

Anecdotal evidence exists that crime is a deterrent to economic activity and hence urban areas that have high levels of crime are expected to have reduced access to retail opportunities, including supermarkets (Giang, et al., 2008). Crime becomes one of many measures of a grocers cost because when crime increases, costs of safety and theft prevention activities increase as well. This increased cost of doing business is believed to be a deterrent to supermarkets from locating in high crime areas, thus potentially presenting problems of access to affordable and nutritious food in high crime communities.

When studying supermarket access in urban cities, previous research has primarily focused on race, income, and vehicle ownership as neighborhood characteristics that indicate reduced supermarket availability. Few studies have considered crime as a possible deterrent to supermarket access, however, those that have included crime do so as an exogenous explanatory variable and find insignificant and contradictory results, especially when compared to more general literature on crime and retail development (Fisher, 1991; Donohue, 1997; Gibson, 1999). One reason for these mixed results is the potential for an endogenous relationship between crime and store locations (Bowes, 2007). In fact, Steenbeek, et al. (2012) consider the opposite relationship and find that supermarkets are attractors of physical and social disorder,

thus adding further evidence to the idea that the relationship between supermarkets and crime may in fact be a result of an endogenous relationship.

Considering an alternative method of evaluating the impact of crime, Bowes (2007) investigates whether crime deters retail development and whether retail development attracts crime. Hypothesizing that a larger number of businesses create greater opportunities for crime in urban areas, he focuses on the Atlanta, Georgia metropolitan area and estimates the impact of retail development on the density of crimes and the density of crimes on retail development. His findings indicate that an increase in criminal activities deters retail development while an increase in the density of retail employment leads to an increase in crime. The presence of this endogeneity presents for an interesting empirical question when studying the effects of crime on supermarket access.

It is logical to say that the endogeniety of crime and supermarket access is one where supermarkets provide opportunities for criminal activities and thus attract crime and crime is considered a cost of doing business and consumer deterrent thus crime deters supermarkets. However, supermarkets have an ability to promote a healthy lifestyle. In fact, the health literature, while still not decisive on the point has identified various health benefits with adequate supermarket access (Laraia et. al. 2004; Morland et. al. 2006; Holsten 2009; Gibson 2011). Thus one might consider the healthy effects associated with supermarket access and how that can impact crime levels. The presence of a supermarket can lead to less crime because supermarkets promote a healthy neighborhood environment and the lack of criminal behavior is a byproduct of a healthy environment. The effect of neighborhood environment on crime has rarely been

empirically explored, but those studies that have addressed the issue suggest that a neighborhood plays an important role in reducing crime (Ellen and Turner, 1997). Therefore, knowledge of the relationship between crime and supermarket access can influence future policy initiatives that are geared toward improving supermarket access in underserved areas.

3.2. Theory of Crime

While little empirical evidence exists on the impact of crime on economic development/supermarket access, there is long standing theory that supports attention in this area. This includes works in economics by Becker (1968) and in sociology by Shaw and McKay (1942) and Cohen and Felson (1979). Focusing on these two disciplines gives a solid foundation for why some ambiguity may exist on the hypothesized relationship between crime and supermarket access.

Becker (1968) published the seminal piece on the economics of crime where he outlines the rational behavior of criminals who weight the benefits of committing the crime with the costs of associated with the probability of getting caught and the associated punishment. Given the existence of criminal behavior, policy must decide how to address this either through the allocation of public resources (e.g. a police force) or private resources (e.g. store security or adequate presence of employees). One of the more controversial outcomes of Becker's work is the acknowledgement that an optimal level of crime would then exist given a specific allocation of resources. Applied to supermarkets, this would mean that supermarkets are willing to accept a certain level of crime (e.g. shoplifting) because the cost of completely eliminating all crime would be too great. Thus crime would have some cost effect on supermarkets in the form of

shoplifting but also in the form of the employment levels that are necessary to achieve some optimal allocation of resources to prevent criminal activities.

The relationship of crime impacting supermarket access is often with a focus on the costs associated with crime and the economics of crime; however, there are other theories that also support this relationship that are drawn from the sociology literature. Shaw and McKay (1942) explain social disorganization theory as how characteristics of communities are associated with criminal outcomes. This disorganization component comes from the lack of cohesiveness of communities, which results in a diminished guardianship (public or private crime reduction) capability. When looking at characteristics Shaw and McKay focus on the heterogeneity and residential instability that creates disorganization. Communities that exist with a very diverse income or racial mixture, as well as a lack of stability and thus transient population, have an element of social disorganization that reduces the ability for communities to adequately regulate behavior. This lack of social control or disorganization results in an increase of crime. Thus one could focus on community characteristics as an indicator of the likelihood of criminal activity. Additionally, research that does not control for crime and finds that supermarkets do not locate in specific communities might be capturing the effects of crime through the heterogeneous communities where supermarkets choose not to locate as a result of the social disorganization and increased likelihood of crime.

The relationship between crime and supermarket access may also be reversed, where supermarket access impacts crime. The sociology literature once again can be used to inform this relationship. Cohen and Felson (1979) discuss the routine activity approach where they outline three elements that must converge for a crime to occur.

First, there must be a motivated offender with criminal intentions, second, there needs to be a suitable victim or target, and third, there needs to be the absence of a capable guardian. Supermarkets (or other routine activities) thus become a target where a suitable victim may be found. Furthermore, given the heterogeneity of people that patronize routine activity locations, the social disorganization may result in the absence of the capable guardian. Thus the presence of supermarkets and the routine activity approach can explain how increased access to supermarkets may increase criminal activity.

Focusing on the routine activity approach one can see how supermarkets may provide opportunities for increased levels of crime. Alternatively, the presence of specific types of routine activities, such as gathering places like supermarkets, might regulate behavior to the extent that supermarkets provide a mechanism to decrease criminal activity. Oldenburg (1999) discusses the formation of public gathering places that provide for the establishment of a community social network that can resolve problems of crime through community building, i.e. a reverse effect of the social disorganization theory. Papachristos et al. (2011) provides empirical support for this idea finding that coffee shops can result in reduced homicide rates. Supermarkets, with amenities such as banks, prepared foods, and welcoming seating have become a place where people gather for more than just a large weekly grocery shopping (Peirce 2010; Turner 2011). This positive influence on the community, in addition to a supermarkets variety of foods to support healthy lifestyles, leads one to hypothesize that supermarkets can have a crime reducing effect in local communities. Therefore, the

relationship between crime and supermarket access is ambiguous and in fact supported by theory to be endogenous.

Chapter 4

Spatial Econometrics

The study of supermarket access involves analysis of communities in some geographic space. Implicitly these data have a spatial nature and so one needs to consider the statistical properties of these spatial data. In particular, these data are typically riddled with problems such as spatial dependence or autocorrelation (Anselin 1988). It is through specialized spatial econometric techniques that these issues are resolved and statistical analysis yields reliable results. In this section I discuss various issues with spatial data and suggest using some of these methods in the study of supermarket access.

Geographical areas in space can be defined in many different ways, including addresses, neighborhoods, cities, counties, districts, tracts and blocks. Addresses, unlike the other geographical areas listed, are locations represented by a single point. Alternatively, other areas are defined by boundaries consisting of multiple contiguous points in space. Often, these boundaries are determined for political or administrative reasons and are not uniform in size or identifiable with any specific statistical purpose. The U.S. Census creates census blocks and census tracts which are small areas of a particular county defined for the presentation of data and designed to be relatively homogenous (Census Bureau 2006). However, research has found that census tracts are not actually as homogenous as other defined geographic areas, suggesting that census blocks are the best area for study when using census data (Myers 1954 and Goodman 1977).

Another spatially defined area commonly used in statistical analysis is zip codes. Zip codes are created by the United States Postal Service for the sole purpose of delivering mail. As a result of this administrative purpose of defining these areas, zip codes are irregular in size and shape and data do not correspond easily for comparison with other zip code areas or other geographic areas such as census tracts or blocks. Moreover, zip code territories change frequently to accommodate mail delivery routes and because spatially aggregated data is dependent upon the boundaries chosen, zip code data are prone to errors when similar zip codes are compared over time.

Political boundaries are yet another geographic area used in statistical analysis. These areas are made up of towns, counties, states, and countries. Within the U.S. these areas are irregular in size and shape but are stable in their designation over time. One distinct advantage to analysis using a political boundary is that public policy is often targeted to these areas because elected officials serve these geographic areas. In Connecticut there is not any county governance and so even though eight counties exist, the level of government below the state resides at the town level. With 169 towns in the state there is a very diverse population that can be examined with a policy relevant focus. U.S. Census data is also readily available by political boundaries including the towns in Connecticut.

Even when data are calculated on different geographic scales, sometimes the combination of data can present a problem or the scale itself is not useful in a real world setting. While the most ideal situation is to always use data at the finest level of detail, it is not always practical or available. With the implementation of Geographical Information Systems (GIS), new empirical techniques are being employed to allow

variations in defining spatial boundaries and aggregation of data (Xie 1995, Clapp, Rodriquez, and Thrall 1997 and Clapp and Wang, 2006). This aggregation of data often assumes uniform distribution through an area, although more complex dasymetric[5] mapping techniques (Xie 1995, Mennis 2002, Mennis 2003, Reibel and Bufalino 2005, Langford and Higgs 2006, and Mennis and Hultgren 2006) use secondary spatial information to improve the method of interpolating data. A further improvement, although more difficult to complete, involves the use of land use or satellite maps to classify areas as residential, commercial/industrial, open space, etc. One could then make the more restrictive assumption that data is uniformly distributed among all residential and/or commercial areas, depending upon ones data needs.

A number of other, more complex, methods exist for areal interpolation such as those developed by Goodchild, Anselin, and Deichmann (1993) and Flowerdew and Green (1994). One of the biggest issues with areal interpolation is that of accuracy. Studies have shown that accurate interpolation of data depends on the variable being interpolated, the ancillary data used in interpolation, and the shape and size of source and target zones (Gregory and Ell 2006). Even with complex measures of data aggregation, the overall benefits of being able to scale down the geographic size have not been established in the literature. Furthermore, the policy relevance of small, non-descriptive geographic areas is questionable. Thus a focus on policy relevant areas is a reasonable level of aggregation for analysis. It is important, however, to recognize that interpretation is then relevant to the geographic scale.

[5] Dasymetric is a Russian word meaning density measuring. It is a method of creating new areas that have a greater homogeneity in the density of the measured variable (Langford 2006).

One of the interpretation issues is the ecological fallacy which is defined as making an inference about an individual based on aggregate data for a group. Care must be taken when discussing aggregate data and making assumptions about individual behavior or characteristics from these data. When studying supermarket access it is proper to discuss the results as they relate to the neighborhoods specified in the model. For example, it would be accurate for one to say a town with lower income has less access to supermarkets. Discussing access of individuals, however, such as low-income individuals have less access to supermarkets, would be creating an ecological fallacy since the unit of measurement was not at the individual level.

The modifiable areal units problem (MAUP) is an issue where different statistics are calculated for different sets of areal units covering the same population (Haining 2003). MAUP is then broken down into two effects, one of aggregation and the other of identification or scale. The aggregation effect is the variability in data from the specification of different areas, thus statistical results are dependent on a given spatial specification. The identification or scale effect occurs when an area is aggregated or disaggregated into different levels of space. In the proposed study, the MAUP is a potential issue because of how certain data are organized.

Given some of the data considerations the econometric modeling also needs special spatial attention. With a simple linear regression one assumes that the effects of the explanatory variables on the dependent variable are independent at any given observation. In spatial models, however, this is not the case. The dependent variable may be explained by an explanatory variable at a given i as well as the value of that variable at a given $i+1$ and beyond, where $i+1$ is a spatially lagged variable (i.e. a spatial

neighbor) to *i*. Furthermore, neighboring dependent variables may provide explanatory power on a given dependent variable *i* or error terms at *i* and *i+1* can be correlated. It is because of these relationships that we must consider the impact of spatial dependence.

Spatial dependence relates to Tobler's first law on geography - "Everything is related to everything else, but near things are more related than distant things." (Tobler 1970). The issue with spatial data is where observations at one point are related to observations at neighboring points. Neighboring points are generally defined as those with common borders or within a specified distance to one another. Two types of dependence exist with spatial data – global and local (Anselin 1988, Anselin 2003). Global dependence considers the interaction of all neighboring points within the entire geographic space under consideration. This process uses a distance decay function to represent the spatial structure of the data. Local dependence is a more indirect approach that uses spatial weights to identify the impact of neighboring locations.

Regardless of the type of dependence, neighbors can be of various degrees, such as first order neighbors, those with common borders, or second order neighbors, those with a common border of a first order neighbor that are also not a common border with the originating point.[6] Data of first order neighbors are thus more directly related than that of second order neighbors, although higher order dependence is possible. Furthermore, spatial dependence is often attributed to the arbitrarily defined areas such as zip code areas or census tract areas, which are then compounded by aggregated data issues. When using spatial data it is important to consider this dependence in empirical modeling.

[6] Neighbors can be specified to the n-th order.

When specifying an empirical model, the focus can be either on a simultaneous or conditional specification. The idea of explaining the interaction among all locations simultaneously is called the complete spatial pattern, where an endogenous effect is specified. The endogeneity of the dependent variable implies that every location in space is a neighbor for its neighbors. This means that the dependent variable doesn't just depend on the dependent variable of the neighbors, but actually the spatial correlation of the explanatory variables and the error terms. Alternatively, the conditional approach assumes a variable at one location is conditioned on the values of that variable at neighboring locations, thus all are treated exogenously (Anselin 2003). This approach is more local, whereas the simultaneous approach is more global.

When modeling these spatial effects, one must consider the correlation of the explanatory variables and/or the error terms, i.e. the relationship between what is happening at one point in space to what is happening at neighboring points in space (Anselin 1988). Controlling for the correlation of the explanatory variables is called the modeled effect, whereas controlling for the correlation of the error terms is the unmodeled effect. With supermarket access there is no a priori reason to limit the effects to one or the other. When this is the case, the best approach is to include them both (Anselin 2003). Additionally, exploratory spatial data analysis can be used to measure the spatial correlation in the system and help guide empirical modeling (Florax and Vlist 2003).

To determine the exact spatial modeling technique used to study spatial effects it is best to first perform exploratory spatial data analysis. These techniques are useful because often no strong a priori reasons exist how to on model spatial correlation.

Ignoring a particular spatial effect can cause biased and inconsistent estimators as well as problems with efficiency (Anselin 2006). Various techniques for this type of analysis exists, including descriptive statistics, box plots, charts, histograms, choropleth mapping, and computation of spatial statistics. In particular, the Moran's *I* test statistic (Cliff and Ord 1972, 1973, and 1981) is commonly used (Florax and Vlist 2003 and Anselin 2006).

The Moran's *I* test statistic (Moran 1948) provides an estimate of the spatial autocorrelation that is present in a given variable. The statistic is given by:

$$I = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\frac{1}{N}\sum_{i=1}^{N}(y_i - \bar{y})^2 \sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}} \text{ and } w_{ii} = 0, \quad (1)$$

where N is the total number of spatial units, w_{ij} is the weight for neighbors *i* and *j*, y_i and y_j are the observed values of *i* and *j*, and $\bar{y}$ is the overall mean. When *I* > 0 positive spatial autocorrelation exists, or alternatively when *I* < 0 negative spatial autocorrelation exists. Significance of the Moran's *I* test statistic can be determined based on a random permutation procedure which recalculates the statistics and creates a reference distribution that is compared to the calculated Moran's *I*.

In addition to calculating the Moran's *I* test statistic, a Moran scatter plot can be presented to graphical depict the variable of interest on the x-axis and the spatial lag of that variable on the y-axis. This scatter plot, as shown in Figure 1, indicates the type of spatial autocorrelation in one of four quadrants.

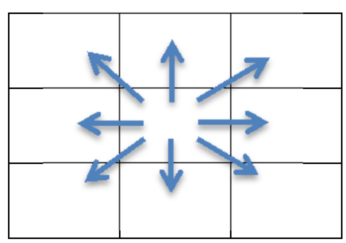
Figure 1: Moran Scatter Plot Quadrants Indicating Spatial Autocorrelation

Low-High	High-High
Low-Low	High-Low

Note that High-High and Low-Low are positive spatial autocorrelation, whereas Low-High and High-Low depict negative spatial autocorrelation. I present both Moran's *I* test statistics and scatter plots in the data and descriptive analysis section to justify the use of spatial modeling.

Once it has been established that spatial dependence exists it becomes necessary to determine a method for correcting for this problem. When modeling supermarket access, the effects are expected to be local rather than global. That is, the more immediate neighboring characteristics (explanatory variables) are expected to contain all of the effects on access to a given geographic area. Thus a queen contiguity matrix that identifies immediate neighbors with common borders would be appropriate. A queen contiguity matrix can be illustrated with the following relationship shown in Figure 2:

Figure 2: Queen Contiguity Matrix Identifying Immediate Neighbors with Common Borders



Mathematically, it is represented by an N x N matrix called a spatial weights matrix that is denoted by W. Each element (I,j) of W (denoted as wij) represents the degree of spatial proximity between the pair of towns I and j. The queen contiguity weights matrix is determined by:

$$w_{ij} = \begin{cases} 1, bnd(i) \cap bnd(j) \neq \varnothing \\ 0, bnd(i) \cap bnd(j) = \varnothing \end{cases} . \qquad (2)$$

Given that each town is defined by a different number of neighboring towns, we also row-standardize the matrix as follows:

$$w_{ij}^{std} = \frac{w_{ij}}{\sum_{j=1}^{N} w_{ij}}, \tag{3}$$

Alternatively one could consider the more complex distance decay model that gives at least some weight to areas far away, however, supermarket trade areas are typically a small radius in space, much smaller than a metropolitan area or state. Therefore, only the effects of immediate neighbors, or the local effects, are expected to impact access. Areas that are greater than the immediate surrounding neighbors have no direct effects. Given this queen contiguity matrix, I specify in the next section a spatial model and define boundaries as the political town boundaries in the state of Connecticut while accounting for spatial dependence and spatial errors when analyzing access to supermarket locations.

Chapter *5*

Econometric Model

5.1. Modeling Supermarket Access and Crime

I specify a two equation spatial econometric model to investigate the relationship between supermarket access and crime. The model, developed by Kelejian and Prucha (2004) is derived from a system of interrelated cross sectional linear equations corresponding to *n* cross sectional observations as follows:

$$Y_n = X_n \mathrm{B} + Y_n \Lambda + U_n \,, \tag{4}$$

with:

$Y_n = y_{jn} = (y_{1n}, y_{2n})$,

$X_n = x_{\ln} = (x_{1n}, ..., x_{kn})$,

$U_n = u_{jn} = (u_{1n}, u_{2n})$,

$j = 1,2$ and $l = 1,...,k$,

where y_{jn} is an *n* x 1 vector of cross sectional observations on the dependent variable in the *j*th equation which also corresponds to the endogenous variable such that y_{1n} is an endogenous variable when *j* = 2 and y_{2n} is an endogenous variable when *j* = 1, $x_{\ln}$ is an *n* x 1 vector of cross sectional observations on the *l*th exogenous variable in the *j*th equation, u_{jn} is an *n* x 1 disturbance vector in the *j*th equation, and B and Λ are parameter matrices of dimension *k* x 2 and 2x2, respectively. This is then expanded to include a spatial spillover of dependent variables of the form:

$$\overline{Y}_n = \overline{y}_{jn} = W_n y_{jn} , \tag{5}$$

such that W_n is an *n* x *n* weights matrix of known constants and equation (4) becomes:

$$Y_n = X_n \mathrm{B} + Y_n \Lambda + \overline{Y}_n \Omega + U_n , \tag{6}$$

with a 2 x 2 parameter matrix Ω.

The vector $\overline{y}_{jn}$ is referred to as a spatial lag of y_{jn} based on the relationship of neighboring units. In fact the i^{th} element of $\overline{y}_{jn}$ in equation (5) is given by:

$$\overline{y}_{ijn} = \sum_{r=1}^{n} w_{irn} y_{rjn} , \tag{7}$$

where w_{irn} is a positive and nonzero when unit *i* relates to unit *r* in some specified method that determines *i* and *r* to have a neighboring relationship and thus spatially correlated.

I continue to build upon this model by allowing for spatial autocorrelation in the disturbances. In doing so I assume that disturbances are determined by a first-order spatially autoregressive process such that:

$$U_n = \overline{U}_n R + E_n , \tag{8}$$

where:

$E_n = (\varepsilon_{1n},.\varepsilon_{2n})$,

$R = diag_{j=1}^{2}(\rho_j)$,

$\overline{U}_n = \overline{u}_{jn} = (\overline{u}_{1n}, \overline{u}_{2n})$,

$\overline{U}_{jn} = W_n u_{jn}$,

$j = 1,2$,

and ε_{jn} is an *n* x 1 vector of error terms with a unique spatial autoregressive parameter of ρ_j in the *j*th equation. Equation (8) is then combined with equation (6) to obtain a system of interrelated spatial cross sectional equations with a spatial autoregressive process for the error term.

More specifically, I estimate the following system of equations:

$$\begin{aligned}&A = \alpha_1 + \beta_{1l} X_{1l} + \lambda_1 C + \omega_{1A} WA + \omega_{1C} WC + u_1\\&\textit{where}\\&u_1 = \rho_1 \sum_{j=1}^{2} Wu_j + \varepsilon_1\\&\textit{and}\\&C = \alpha_2 + \beta_{2l} X_{2l} + \lambda_2 A + \omega_{2A} WA + \omega_{2C} WC + u_2\\&\textit{where}\\&u_2 = \rho_2 \sum_{j=1}^{2} Wu_j + \varepsilon_2\end{aligned}, \qquad (9)$$

and:

A is the dependent and endogenous variable Access

C is the dependent and endogenous variable Crime

α_1 and α_2 are the constants

β_{1l} and β_{2l} are the parameters for the *l*th exogenous variable

X_{1l} and X_{2l} are the *l*th exogenous variable

λ_1 and λ_2 are the parameters for the endogenous variables Crime and Access

ω_{jA} and ω_{jC} are the parameters for the spatial lag variables Access and Crime

W is the weights matrix for the spatial lag and error terms

ε_j is the error term that is i.i.d with mean zero and variance of σ^2.

Following the estimate approach of Kelejian and Prucha (2004) I first estimate the model parameters via two-staged least squares. Using these parameters I then

compute the estimates for the disturbance terms. With the generalized methods of moments procedure (Kelejian and Prucha 1999) I then use the estimated disturbance term from the first step to estimate the autoregressive parameter. Two-staged least squares is then used again to obtain the generalized spatial two-staged least squares estimate for the parameters in the transformed regression model that contains the autoregressive parameter from step 2. Using these parameters I compute the estimates for the disturbance terms. The last step is to use the estimated disturbances to correct the cross equation correlation and then estimate the generalized spatial three-staged least squares full information estimator. All econometrics are estimated using Stata.

5.2. Computing Measures of Supermarket Access

Part of the empirical modeling also involves defining measures of supermarket access. One such measure of access is the distance to the closest supermarket, thus providing the best opportunity for shopping from a given geographic location. Various studies support the idea that people shop at the closest store to their home (Holton 1958 and Hazel 1988). However, we also know that people do not always shop at their closest supermarket to the home, so we also find it useful to also examine the total number of stores within an area.

It has been found that 84% of survey respondents visited more than one supermarket location in a given month choosing a variety of supermarkets as well as quality of products instead of distance (Handy and Niemeier 1997 and Handy and Clifton 2001). Thus another measure of access is computing the cumulative opportunities, i.e. the number of opportunities within a given distance or travel time

(Handy and Niemeir 1997 and Zenk 2004). This measure has widely been used in looking at the number of stores available to a given location by defining a distance or travel time from a specific location and then counting the number of stores within that area. It is, therefore, important to consider the robustness of supermarket access by specifying these different measures. The distance to the closest supermarket and the total number of opportunities are reasonable alternatives that satisfy different sets of preferences and thus provide greater insight into supermarket access.

The actual measurements of each accessibility factor are typically computed from the centroid of each geographic area because data are aggregates of multiple points within spatial boundaries. In determining accessibility there are also questions of spatial disaggregation (Handy and Niemeir 1997). One method of spatial disaggregation occurs as the spatial area becomes smaller in size. For example, a census block would be a spatially disaggregated area of a census tract, while zip codes are spatially disaggregated areas of a city. Smaller areas result in more accurate measures of accessibility for the individuals or households in that area (Handy and Niemeir 1997). This is because accessibility research is generally not performed at the individual or household level due to the lack of available data. By defining smaller areas in space we can attempt to understand more local aspects of supermarket accessibility.

One major advantage of disaggregating spatial areas is that we can utilize the assistance of GIS mapping to easily exclude nonresidential areas, such as parks, airports, and bodies of water, which are of little interest when measuring food access. It is also possible to exclude commercial and other nonresidential areas, although this

requires substantially more information than is readily available and an alternative method to control for this is to consider population based centroids.

When measuring accessibility various travel modes and their related congestion are other issues that must be considered (Handy and Niemeir 1997). Additionally, travel time can be used to measure accessibility but one must use caution as results vary due to assumptions in the model. One must consider the differences between rush hour or peak hours of travel as well as travel by foot, private vehicle, and public transportation. Furthermore, one might improve the accuracy of a distance measurement by utilizing roadway or network paths rather than a straight-line distance that often yields improbable routes. Roadway networks also allow one to exclude areas that contain barriers to travel.

Walking distance to supermarkets has also become an important consideration in the food access literature and by policymakers. In the 1990s, a large majority of the MSAs in the United States experienced a growth in population (Bartlett 2003). During this period, planners, politicians, and other parties have attempted to shape how this growth of urban areas would proceed. One of the major components of this is the "pedestrian-friendly" or "walkable" areas, including walking access to essential shopping and other neighborhood services (Bartlett 2003 and Talen 2003). In 1999, as part of the Clinton-Gore Livability Agenda, Vice-President Al Gore claimed that, "Too frequently, a gallon of gas is used up just purchasing a gallon of milk" (Gore 1999). Furthermore, lower income households are less likely to own automobiles and are more likely to walk or use public transportation for shopping activities. This requires either multiple trips due to limited carrying abilities and/or substantial costs (monetary or opportunity) for

taxis or time. This lack of transportation access limits the households' ability to acquire healthy and affordable groceries (Clifton 2004). Thus it is quite apparent that supermarket access within walking distance is also an important issue of study.

Defining walking distance has been relatively consistent in previous research with specifications of roughly one-quarter of a mile, 3 blocks, 400-500 meters and 1,500 feet (City of Vancouver 1998, Donkin, Dowler, Stevenson, and Turner 1999, Clarke, et al. 2002, Wrigley 2002, Bartlett 2003, Leinberger 2005). Precise walking distance, however, can be complicated by considerations of elderly, disabled, shopping purpose, and weather. This is an issue that is difficult to account for, thus it is often assumed that many of those that find it difficult to walk this distance employ the assistance of friends, relatives, or hired help to handle these activities.

Utilizing distance along transportation networks, I study access with respect to the distance to the nearest supermarket and the cumulative supermarket opportunities within Connecticut. Calculations of walking distance are defined as in the previous literature as 3 square blocks or 3/10 of a mile and 1 mile. While this might be difficult for certain individuals, it is a reasonable estimate of walking distance for grocery shopping. With regard to driving distances, shopping for grocery items is known to be a local activity (Cotterill 2006). I consider both a 5-minute and separately a 10-minute drive time distance. Studying both of these measures allows for a comparison of the typical distance traveled for weekly shopping to a more easily accessed area.

Given an empirical specification and method for calculating supermarket access we can specify both the supermarket access and crime equations using Equation (6). The data used for this estimation is described in the next section.

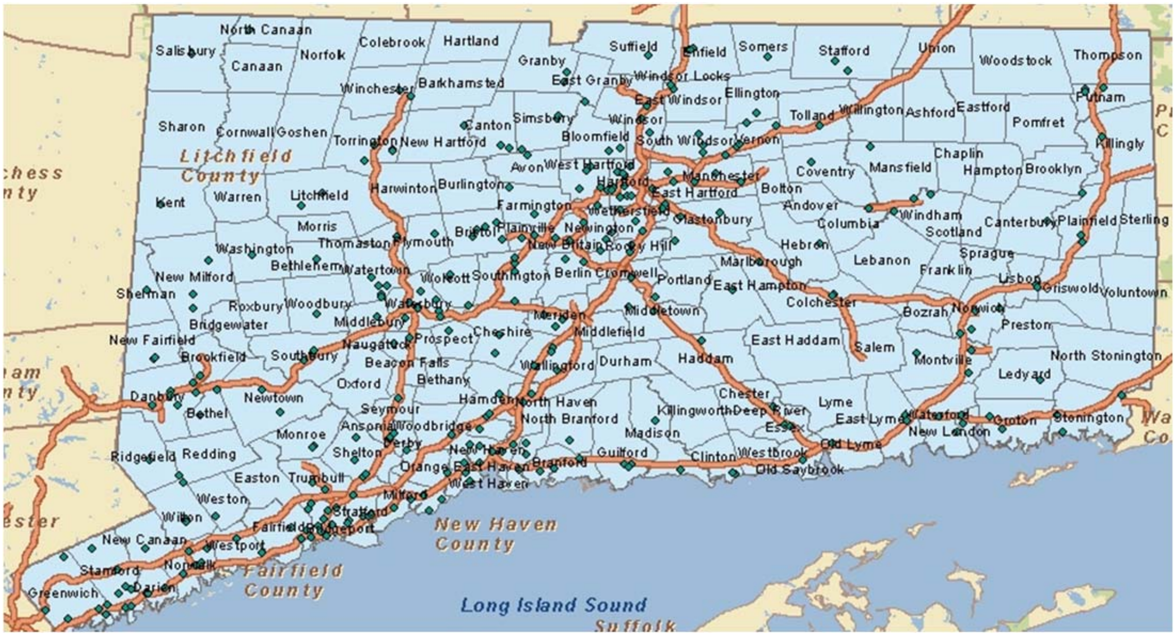
Chapter 6

Data and Descriptive Analysis

6.1. Supermarket Equation Variables

Supermarket access within a geographic area is a function of neighborhood characteristics and, for our simultaneous model, crime. The data used for this study are from 2009 in the State of Connecticut. Exact supermarket locations are obtained from Trade*Dimensions*, including both supermarkets and supercenters with greater than $2 million dollars in annual sales. There are 310 supermarket locations in the state that are geocoded using ArcGIS and shown on Map 3.

Map 3: Supermarket, Towns, and Interstate Highways in Connecticut



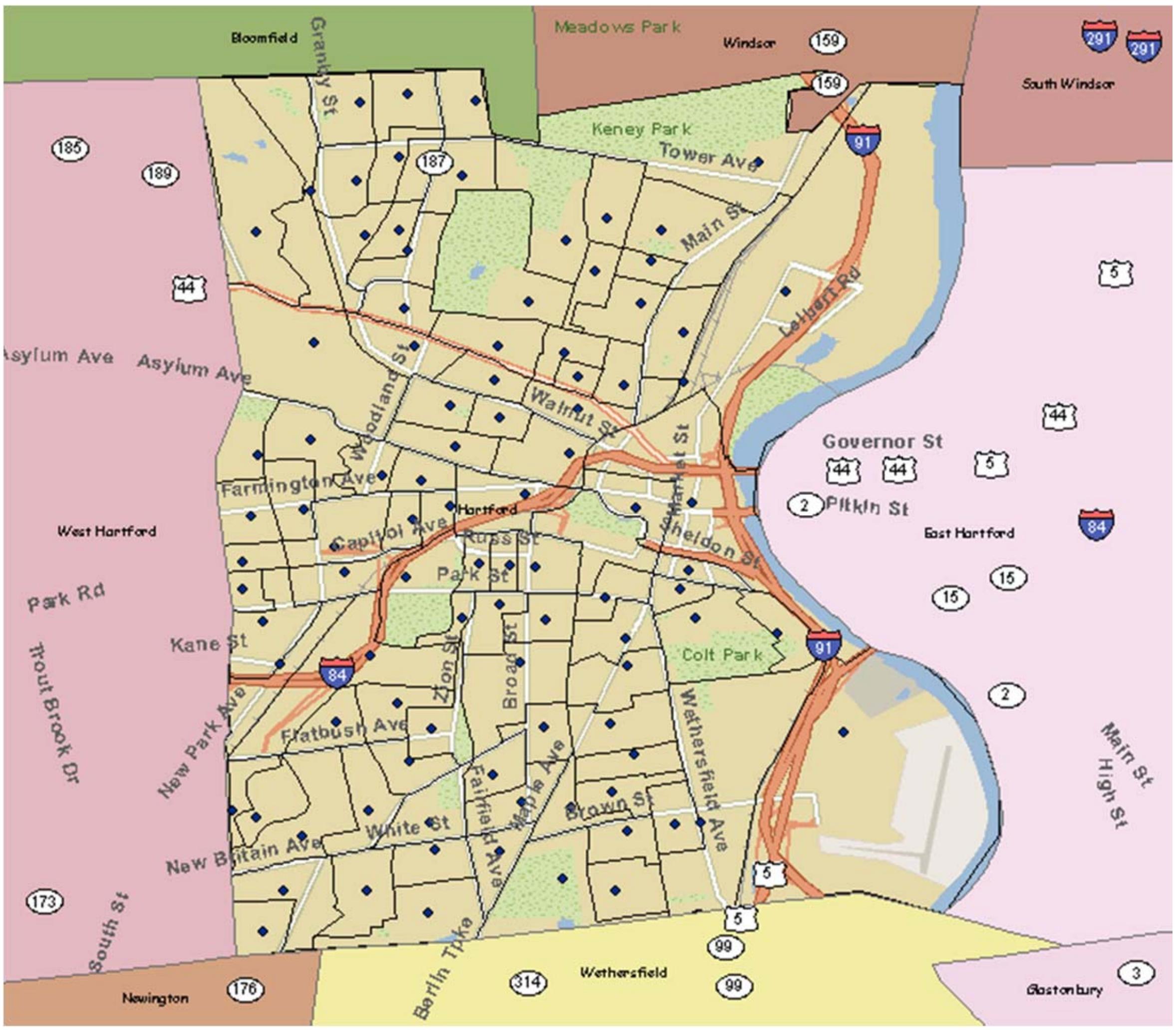
LEGEND

◆ Supermarket Location

Source: ArcGIS mapping and Trade*Dimensions* supermarket locations.

One immediately notes the distribution of supermarkets in Connecticut is concentrated along the major Interstate highways throughout the state.

Map 4: Hartford Connecticut Census Block Groups and Population Weighted Centroids



LEGEND

◆ Supermarket Location

Source: ArcGIS mapping.

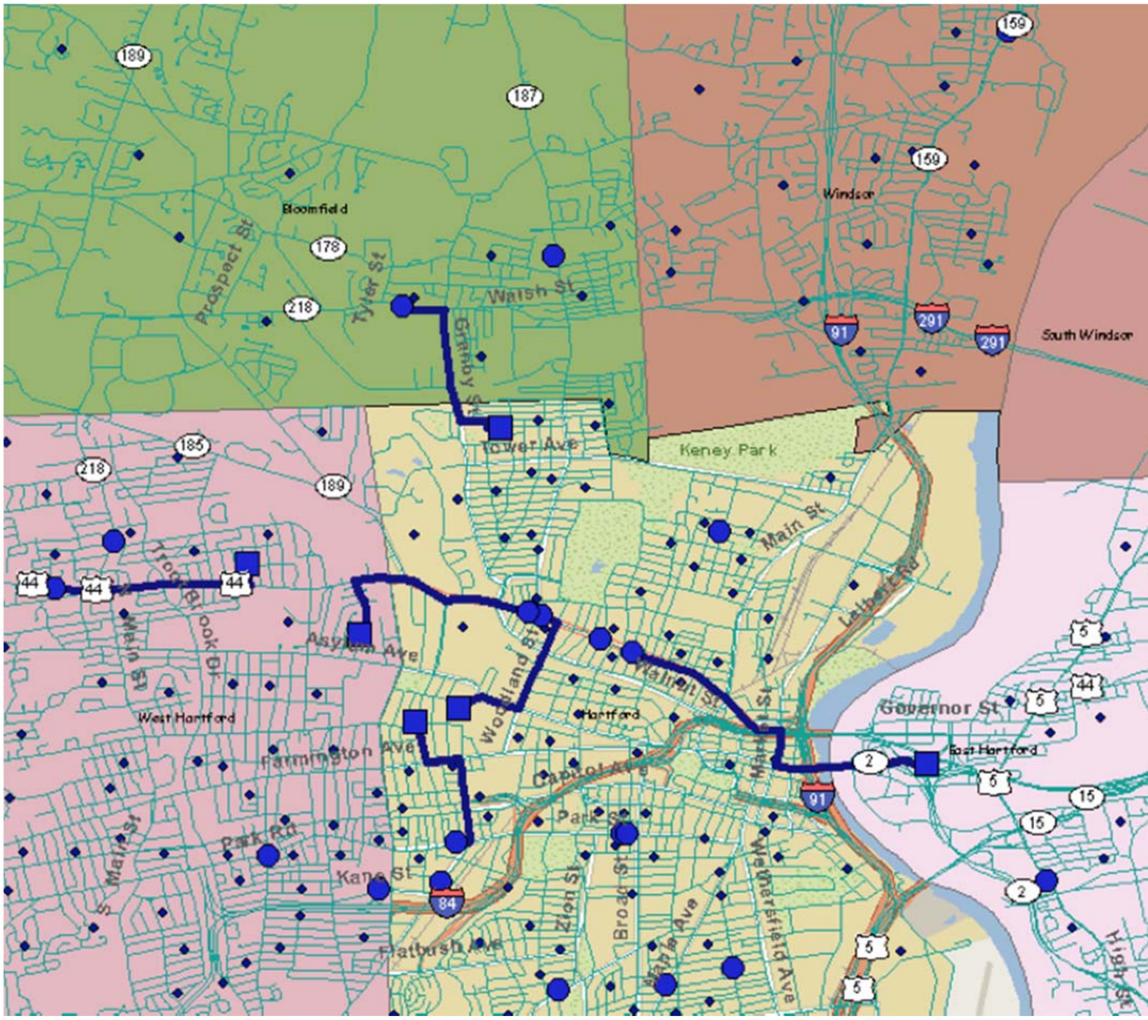
To calculate the various access measures, one also needs points of populations. For this I use census block group population centroids, i.e., a point within each block group that is determined based on where the population exists in that block group. Map

4 shows the census block groups in the city of Hartford with each population-based centroid. One can see how using the population based centroid results in the point not being in the exact middle of the geographic area, in particular within block groups where parks or highways exist. With the block group centroids and the supermarket locations I then use ArcGIS Network Analyst to calculate the distance to the closest supermarket for each centroid.

Map 5 shows an example of route calculations from select block group centroids to the closest supermarket location. Note in some cases the closest supermarket is across town boundaries, e.g. a block group centroid in northern Hartford is more easily reachable to a supermarket in southeast West Hartford. Similarly, a block group in East Harford is closer to a supermarket in Hartford even when one considers the need to cross the Connecticut River and use highways for access. This calculation is done for each of the 2,605 census block group centroids throughout the state of Connecticut.The next calculation of access is to determine the number of total supermarkets within a specific area.

Map 6 shows the 0.3 and 1 mile as well as 5-minute and 10-minute drive time catchment areas for a single block group centroid in Hartford. Using roadways these catchment areas are not uniform and faster traveling roadways allow for a greater physical distance given an equal amount of time. This is easily seen in the upper part of the 10-minute drive time area where branches extend outwards along major roadways. Within each of these catchment areas I compute the total number of supermarkets and assign that value to the relevant block group centroid.

Map 5: Hartford Connecticut Calculation of Access to Closest Supermarket



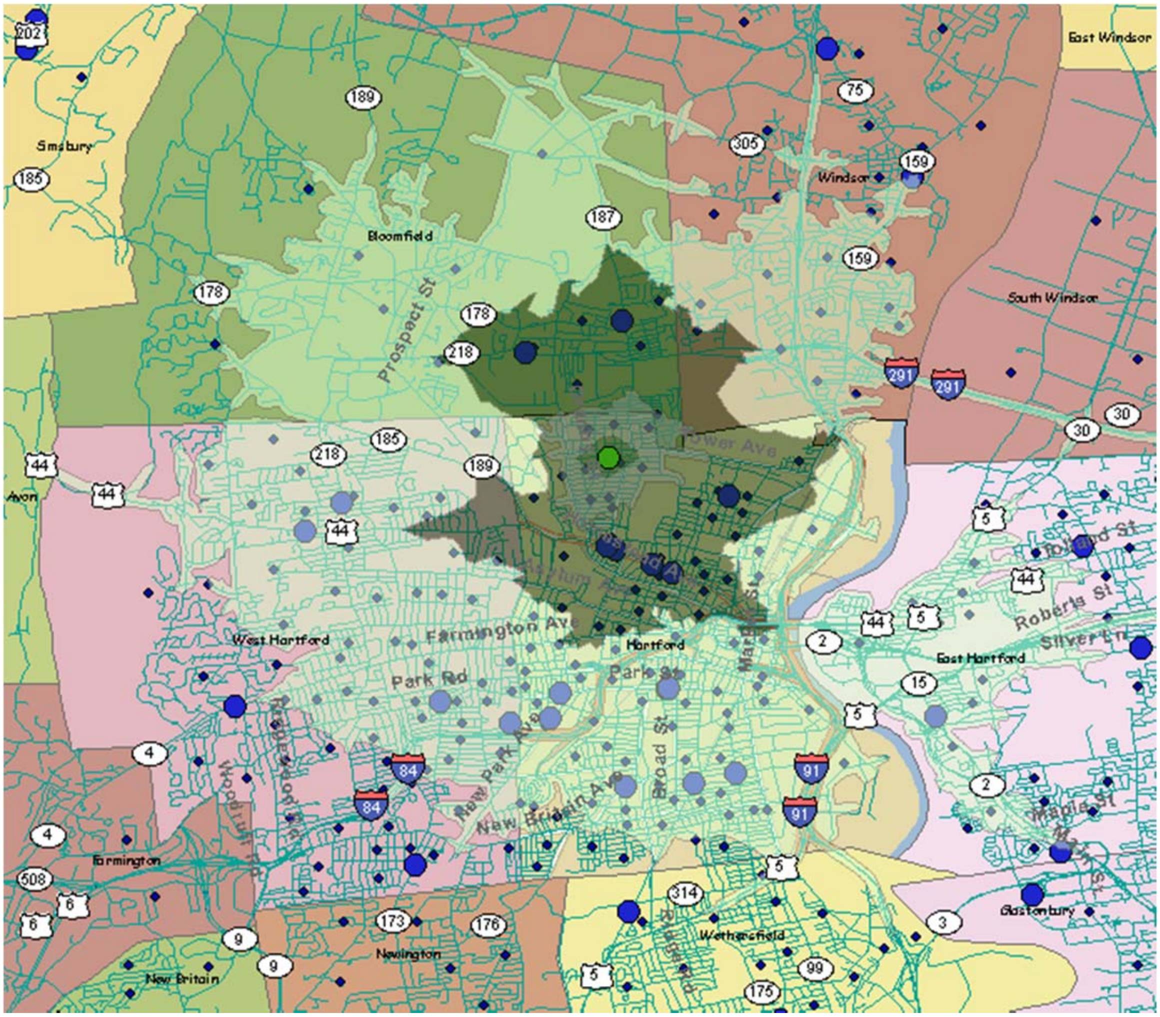
a

LEGEND

- Supermarket Location
- Census Block Group Centroid
- Routes

Source: ArcGIS mapping and calculations using Network Analyst.

Map 6: Hartford Connecticut Calculation of Access to Various Distances



LEGEND

● Supermarket Location

● Census Block Group Centroid

Source: ArcGIS mapping and calculations using Network Analyst.

While the computation of access with ArcGIS Network Analyst is done with census block group centroids, the geographic area for this study is at the town level. Thus it becomes necessary to aggregate these data to obtain a single value for each access measure in each town. Given the concern for a measure of access to

population centers, I compute a population weighted average for each access measure as follows:

$$TownAccess_i = \frac{\sum_{j=1}^{m} Population_{ij} * Access_{ij}}{\sum_{j=1}^{m} Population_{ij}}$$
$$where$$
$$\text{Town } i = 1,...,169 \qquad . \qquad (10)$$
$$and$$
$$\text{Block Group } j = 1,...,m$$

Therefore, each town has one value for each of the five different measures of supermarket access. This value then represents access for that town's population.

Table 1: Supermarket Model Variables, Descriptions, and Expected Signs

Variable	Description	Expected Sign	
Supermarket Models		Time	Number
Dependent Variables			
SuperTime	Time to closest supermarket in minutes		
Super5Min	Number of supermarkets within 5 minutes drive time		
Super10Min	Number of supermarkets within 10 minutes drive time		
Super.3Mil	Number of supermarkets within 0.3 miles		
Super1Mil	Number of supermarkets within 1 mile		
Independent Variables			
PctAfAm	Percent of population African American	+	-
PctAsn	Percent of population Asian	+	-
PctHisp	Percent of population Hispanic	+	-
PctVacant	Percent housing vacant	+	-
PctGrp	Percent of population in group quarters	+	-
MedInc	Median Income	-	+
PctUnEmp	Percent unemployed	+	-
Hwy	=1 if highway in town	-	+
Mill	Mill rate	+	-
TvlLt15min	Percent of population traveling less than 15 minutes to work	-	+
PctNoVeh	Percent households with no vehicle	+	-
PctBlwPov	Percent of population below the poverty level	+	-
PopDen	Population per square mile	-	+
MjrCrime	Number of Murder, Rape, Aggravated Assault, and Robbery per 1,000 people	+	-
MnrCrime	Number of Burglary, Larceny, and Motor Vehicle Theft per 1,000 people	+	-

Table 1 shows a list of the other variables used for the supermarket equations. Variables on race and ethnicity include the percent of African American population (PctAfAm), Asian population (PctAsn), and Hispanic population (PctHisp). These data are obtained from the U.S. Census Bureau American Community Survey (ACS) 5-year estimates from 2011. The 2011 ACS covers the year 2007 – 2011, thus centered on 2009, which corresponds to the supermarket location data. The race and ethnicity variables along with median income (MedInc) and the percent of households without a vehicle (PctNoVeh) are controls for town characteristics that previous studies have found to have limited access. In addition, I also include other variables from the ACS, such as the percent of vacant housing units (PctVacant) as a proxy for urban blight as well as a demand variable. The percent of population in group quarters (PctGrp) represents institutional living where proximity to a supermarket may not be of concern as this population is often provided food through their institution. This would also be a demand variable where larger populations living in-group quarters would have less need for food from supermarkets. Other demand variables with income effects include PctUnEmp (the percent of the population that is unemployed) and PctBlwPov (the percent of the population below the poverty level). To control for the wide population diversity amongst towns in Connecticut I also include the population per square mile (PopDen), thus controlling for differences between urban and rural populations. It is also necessary to control for the existence of a highway within the town given the distribution of supermarkets previously seen on Map 3.

One variable not found in prior literature that I include from the ACS is the percent of the population that travels less than 15 minutes to work (TvlLt15min). This

variable is an attempt to control for populations that work close to home, thus exhibiting greater travel patterns within a closer proximity to the population centroid measure. In other words, populations that do not travel very far for work would not easily obtain access to supermarkets in other regularly traveled areas and would require access closer to home since that is also close to work. In addition, the Mill rate is included as a proxy for land costs within a town. The crime variables (MjrCrime and MnrCrime) are discussed in the crime equation section below but are also included here are explanatory variables depending on the specific model estimated.

Expected signs are noted in Table 1. Note that expected signs reverse for the two different types of access variables. A smaller SuperTime variable indicates greater access, i.e. the time to the closest supermarket is less; whereas a greater Super5Min, Super10Min, Super.3Mil, and Super1Mil would indicate greater access, i.e. a larger number of supermarkets within the specified area.

6.2. Crime Equation Variables

Crime within a geographic area is a function of neighborhood characteristics and, for our simultaneous model, supermarket access. There are two categories of crime that I focus on in this study. Data are obtained from the Connecticut Uniform Crime Reporting (UCR) program for each town in 2009. The UCR releases the number of crimes in each town in each of seven disaggregate categories including murder, rape, aggravated assault, robbery, burglary, larceny, and motor vehicle theft. For this study I aggregate these seven categories into the two variables and then compute a crime rate per 1,000 people. The first crime variable, major crimes (MjrCrime), is an aggregate of murders, rape, aggravated assault, and robbery. These crimes all involve crimes

against a person where the victim is present, thus they are the harshest of criminal activity, also referred to as violent crimes. The second crime variable, minor crimes (MnrCrime), is an aggregate of burglary, larceny, and motor vehicle theft. These are crimes are also commonly referred to as property crimes.[7]

Following some of the previous literature (Greenbaum and Tita 2004 and Bowes 2007), neighborhood characteristics related to crime are defined in various subgroups, listed in Table 2. The first are attributes, which offer a higher reward or increased opportunity for crime, such as MedInc, Hwy, and Train access. The second is a characteristic that makes crime unattractive because it increases the likelihood of being caught, such as a measure of police presence in the area (PolDen). PolDen is computed from local police employee data obtained from the Federal Bureau of Investigation Policy Employee Data report from 2009. The third category of variables is demographics, which relate to the opportunity cost of crime. Variables that are included in this category include PctAfAm, PctAsn, PctHisp, PctUnEmp, the percentage of the population receiving public assistance (PctPA), and the percentage of population with a Bachelor's Degree or greater (PctBHgrt). Additional explanatory variables include housing attributes such as the existence of vacant housing (PctVacant) and a proxy for transient populations using the percent of rental housing (PctRent). The access variables (SuperTime, Super5Min, Super10Min, Super.3Mil, and Super1Mil) are previously discussed in the supermarket equation section but are also included here are

[7] Cherry and List (2002) discuss potential problems with aggregation of crime data and show that it can cause inconsistent and biased parameters. I have chosen to focus in the text on the two aggregate categories for ease in general interpretation; however, I did run disaggregate models that show the main findings presented here are robust. Results for disaggregate models are available upon request.

as explanatory variables depending on the specific model estimated. Expected signs are noted in Table 2.

Table 2: Crime Model Variables, Descriptions, and Expected Signs

Crime Models		All
Dependent Variables		
MjrCrime	Number of Murder, Rape, Aggravated Assault, and Robbery per 1,000 people	
MnrCrime	Number of Burglary, Larceny, and Motor Vehicle Theft per 1,000 people	
Independent Variables		
PctAfAm	Percent of population African American	+
PctAsn	Percent of population Asian	+
PctHisp	Percent of population Hispanic	+
PctVacant	Percent housing vacant	+
PctRent	Percent housing rented	+
PctUnEmp	Percent unemployed	+
Train	=1 if train station in town	+
Hwy	=1 if highway in town boundaries	+
MedInc	Median Income	+
PctPA	Percent of population receiving public assistance	+
PctBHgrt	Percent of population with a Bachelor's Degree or greater	-
PolDen	Number of local police officers per square mile	-
SuperTime	Time to closest supermarket in minutes	?
Super5Min	Number of supermarkets within 5 minutes drive time	?
Super10Min	Number of supermarkets within 10 minutes drive time	?
Super.3Mil	Number within 0.3 miles	?
Super1Mil	Number within 1 mile	?

Table 3 displays the overall descriptive statistics for the 169 towns in CT. Focusing first on the access measures, one can see the town with the shortest population weighted average distance to the closest supermarket is 1.21 minutes, which happens to be in East Hartford, CT. The average time in CT is 5.74 minutes with the maximum occurring at 21.26 minutes in Union, CT.

Table 3: Overall Descriptive Statistics for All Connecticut Towns

Variable	Obs	Mean	Std. Dev.	Min	Max
SuperTime	169	5.74	3.72	1.21	21.26
Super5Min	169	1.36	1.59	0.00	9.76
Super10Min	169	5.13	4.92	0.00	26.25
Super.3Mil	169	0.02	0.04	0.00	0.24
Super1Mil	169	0.22	0.30	0.00	2.02
MjrCrime	169	1.17	2.11	0.00	17.20
MnrCrime	169	14.64	10.53	1.80	58.64
PctGrp	169	2.37	4.39	0.00	42.07
PctNoVeh	169	4.65	4.65	0.00	35.19
MedInc	169	83,490	26,417	29,107	205,563
PctVacant	169	9.02	6.82	0.28	35.63
PctAfAm	169	3.87	7.61	0.00	55.77
PctAsn	169	2.69	2.44	0.00	13.27
TvlLt15min	169	0.27	0.09	0.08	0.56
PctHisp	169	6.15	7.36	0.00	42.40
Mill	169	24.41	7.09	8.44	68.34
Hwy	169	0.61	0.49	0.00	1.00
PctUnEmp	169	7.04	2.40	2.13	17.73
PopDen	169	945.04	1,343.64	31.93	8,963.25
PctBlwPov	169	5.98	4.99	0.22	32.87
Train	169	0.21	0.41	0.00	1.00
PctPA	169	5.28	5.34	0.00	37.68
PctBHgrt	169	38.27	14.66	12.00	80.80
polsqden	169	1.71	3.65	0.00	27.08

Looking at the cumulative measures of access, the average number of supermarkets within 5 minutes is 1.36. This increases to 5.13 when the distance is doubled to 10 minutes. The minimum number of supermarkets within a 5 or 10 minute drive time is zero, indicating that there are some towns within CT that no access at all when examined using this metric. In fact there are 34 such towns that have no supermarkets within 5 minutes and 15 towns that have no supermarkets within 10 minutes. The greatest number of supermarkets within a single town in CT is 9.76 and

26.25 for 5 and 10-minute drive times, respectively. Both of those observations occur within East Hartford.

Focusing on walking distance measures, the average number of supermarkets within 0.3 miles of a CT town is 0.2 while within 1 mile is 0.22. Once again there are a number of towns that do not have any such access within either of these metrics, thus the minimum is zero. The maximum number of supermarkets within 0.3 miles is 0.24 while there are 2.02 supermarkets within 1 mile. Once again, the maximum within 1 mile occurs in East Hartford, although now the maximum within 0.3 miles is in Manchester, the town immediately neighboring East Hartford to the east.

Now looking at the time crime variables, the average number of major crimes per 1,000 people is 1.17 with a minimum of zero and maximum of 17.20. Minor crimes average 14.64 per 1,000 people with a minimum of only 1.8 and maximum of 58.64. One can also see the descriptive statistics of the exogenous explanatory variables listed. Of interest is the MedInc variable that depicts the great diversity of towns in CT with median income ranging from $29,107 to $205,563 with an average of $83,490.

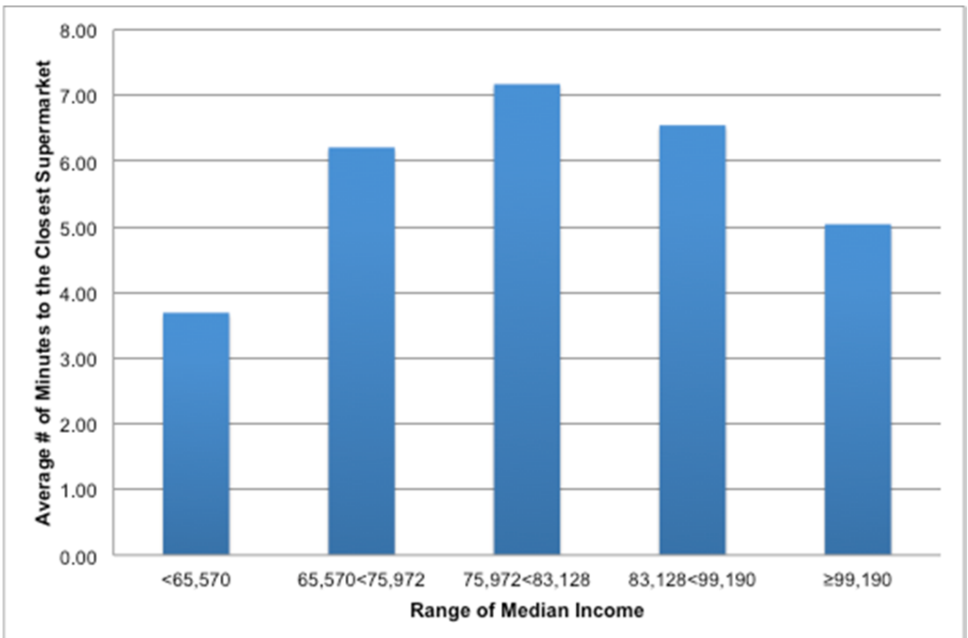
6.3. Selected Crosstabs

In addition to standard descriptive statistics of the entire sample it is interesting to group these data by selected variables. Appendix 1 displays the means of other selected variables by median income, percentage of households without a vehicle, population density, and the two categories of crime. Here I discuss specific figures of interest from these crosstabs of data.

Figure 3 shows the average number of minutes to the closest supermarket by median income groups. The median income range with the least number of minutes to

the closest supermarket, thus the best access, is for income less than $65,570. Access then decreases as median income increases, but then improves again for the higher income quintiles. This, by itself, would indicate that lower income towns have better access to supermarkets. The relationship also holds true when considering the other measures of access, shown in Appendix Table A1.

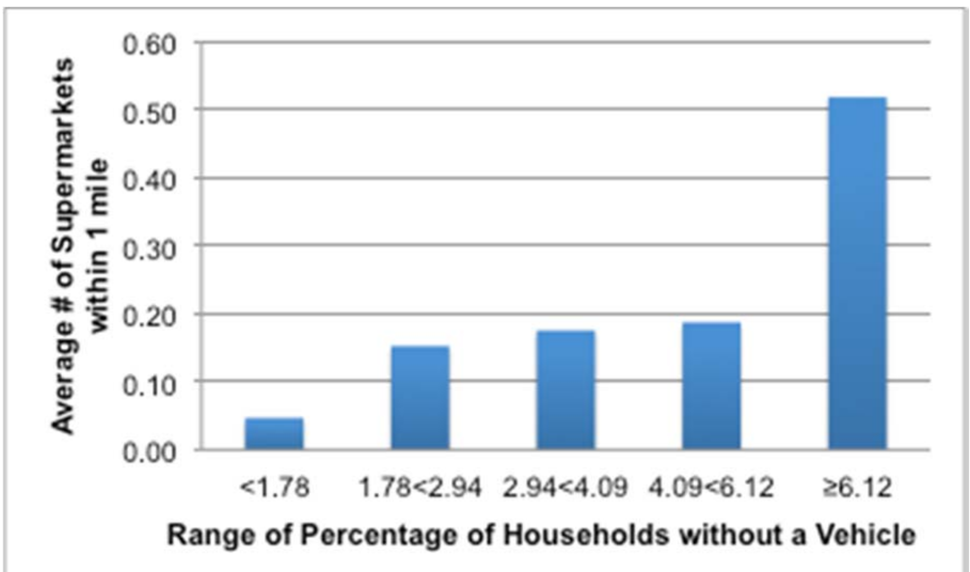
Figure 3: Average Number of Minutes to the Closest Supermarket by Median Income



There is also interest in looking closer at households without vehicles given their difficulty in reaching supermarkets at great distances. Figure 4 shows the average number of supermarkets within 1 mile by quintile groupings of the percentage of households without a vehicle. Contrary to previous research in other geographic areas, the towns in CT with a higher percentage of households without a vehicle have a greater average number of supermarkets within 1 mile. This relationship, also shown with the other measures of access in Appendix Table A2, suggests that even towns with limited personal transportation may not be underserved.

Focusing now on a breakdown by population density, one would expect that the more urban towns would have the greatest population without vehicles. In fact this relationship is seen in Figure 5 where the towns with the highest population density also have the highest average percentage of households without a vehicle. This would raise concerns if urban areas have limited access to supermarkets. Table A1 shows the opposite to be the case, that is, urban towns in CT have better access and more options than rural areas.

Figure 4: Average Number of Supermarkets within 1 mile by Households without a Vehicle



Given the focus on crime in this research I present the average number of minutes to the closest supermarket for both major and minor crimes in Figures 6, and 7, respectively. In both cases one can see that as the number of crimes per 1,000 people increases the average number of minutes decreases, thus access is better in areas where there is more crime. This relationship holds for each of the different measures of access as shown in Appendix Tables A3 and A4.

Figure 5: Average Percentage of Households without a Vehicle by Population Density

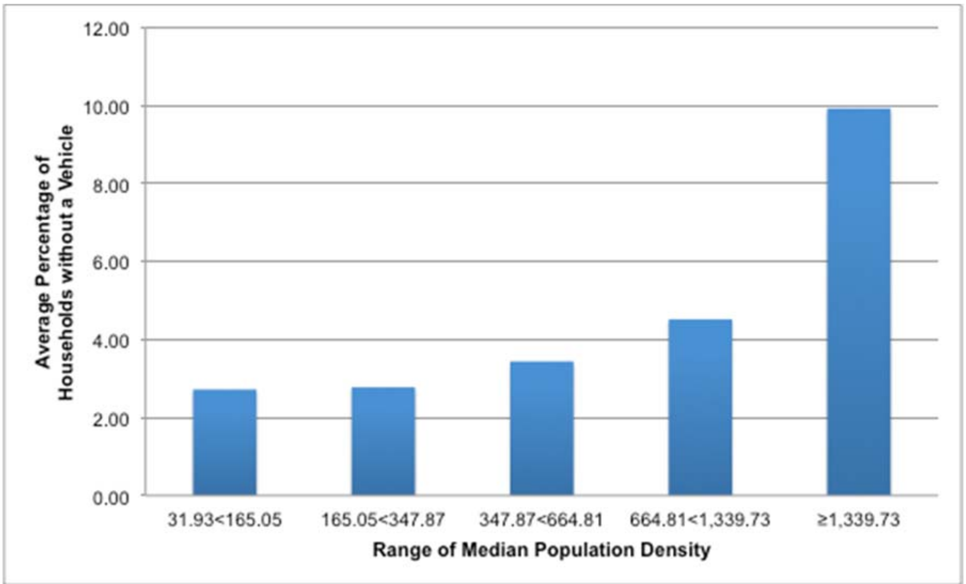


Figure 6: Average Number of Minutes to the Closest Supermarket by Major Crimes

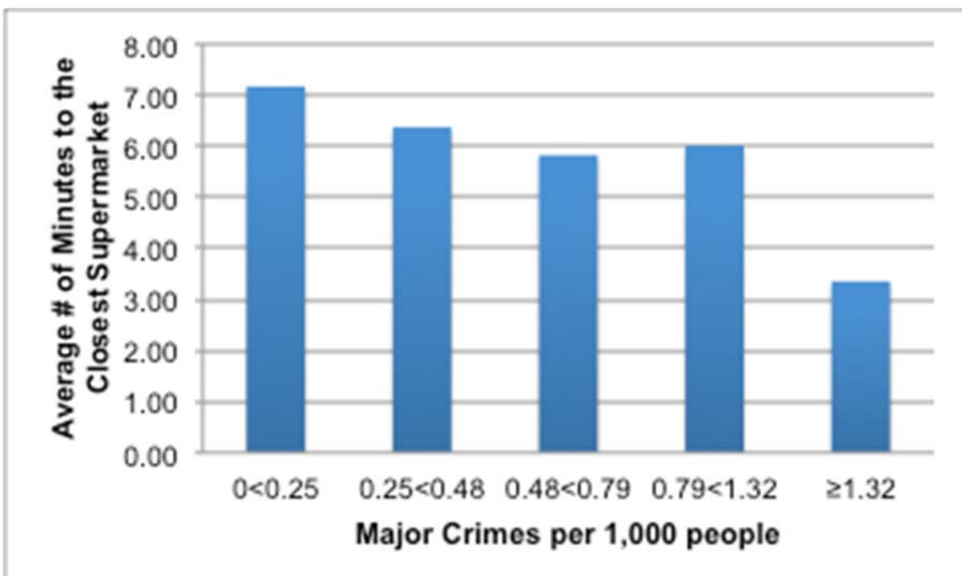
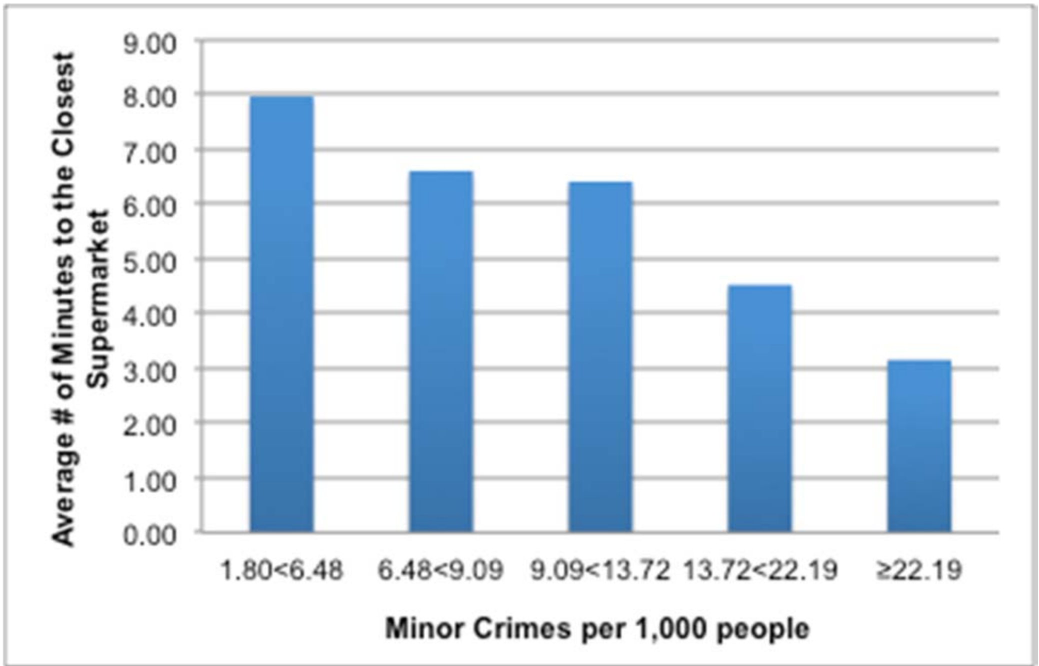


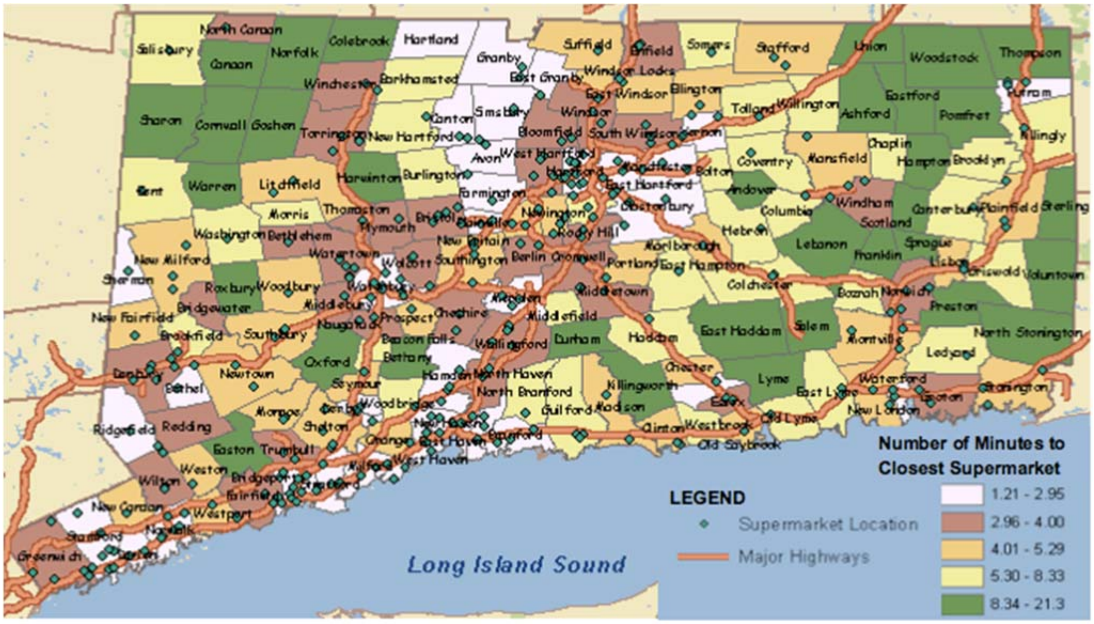
Figure 7: Average Number of Minutes to the Closest Supermarket by Minor Crimes



6.4. Choropleth Mapping

Given that the data we are using is positioned in geographic space we can also use maps to visualize how these variables vary over such space. In particular, choropleth maps can be used to display the values taken by a variable of interest with shading based on some scale and given criteria. For the following maps I choose a quintile breakdown, thus shading each town in CT one of five different colors as shown in the legend of each map. Viewing the data in this fashion can give one a better understanding of the spatial relationship of each variable and help identify clustering in space.

Map 7: Map of Time to Closest Supermarket with Quintile Shading



Source: Authors mapping using ArcGIS.

Map 7 shows the quintile shading of the number of minutes to the closest supermarket. One can quickly see the clustering that occurs in the northwest and northeast sections of the state where there are large areas of green, representing the quintile with the greatest number of minutes to the closest supermarket. These areas of the state are in fact quite rural so one would expect to have to travel greater distances. Within the central part of the state one can see clustering of a group of towns with the least number of minutes to the closest supermarket shaded in white, with neighboring towns shaded in red. These towns have some of the greatest access.

Given some of the literatures focus on urban areas being underserved, it is of interest to look at some of the larger population towns in CT. These towns are Bridgeport, New Haven, Hartford, Stamford, and Waterbury. Looking at Map 7 we see that each of these towns are shaded in white, thus indicating they are in the top quintile of towns (1.21 to 2.95 minutes) with the best access throughout the state. Therefore, a

visual analysis of the data would not indicate problems of supermarket access in urban areas in CT.[8]

Map 8: Map of Number of Supermarkets within a 5-minute Drive Time with Quintile Shading

Source: Authors mapping using ArcGIS.

Now looking at the number of supermarkets within a 5 minute and 10 minute drive time, Maps 8 and 9, one needs to first recall that the measure of access is reversed when viewed in this fashion. Here a larger number is indicative of better access, thus areas shaded in green are better served than areas shaded in white. In both of these maps one can again see clusters that exist throughout the state. On Map 8, the towns shaded in white have no supermarkets within a 5-minute drive time, most of which exist in areas that are not served by Interstate highways. Of particular concern would be the cluster of towns in the northwest and northeast sections that have no supermarkets within 5 minutes. Comparing that to Map 9, one can see that these same

[8] It is worth reminding the reader that the geographic area of focus for this study is at the town level. The author recognizes that pockets of more limited access may exist in isolated areas within these towns but that analysis is outside the scope of this particular project.

towns also have quite limited access within 10 minutes. This is somewhat consistent with the observations from examining Map 7 that showed the number of minutes to the closest supermarket. Thus towns in the northwest and northeast not only have to travel a greater amount of time to the closest supermarket but there are also fewer options available, a result not overly surprising given then rural nature of these areas.

Map 9: Map of Number of Supermarkets within a 10-minute Drive Time with Quintile Shading

Source: Authors mapping using ArcGIS.

Looking at the towns with the largest population in the state, once again I find those five towns are in the top quintile within CT with respect to the number of supermarkets within a 5 and 10-minute drive time. This adds further evidence that the urban towns in CT appear to have better access to supermarkets, including a large number of options available. However, even with more options or closer proximity, it may still not be distributed across the population in such a way that yields easier access for those without vehicles, a bigger problem in these same towns.

<u>Map 10: Map of Number of Supermarkets within 0.3 Miles</u>

Source: Authors mapping using ArcGIS.

Map 10 presents the same shading for the number of supermarkets within 0.3 miles. Not surprisingly there are a very large number of towns with zero supermarkets within this short distance. Looking at the towns that fall in the top quintile and are shaded in green one can see there are very few of these spread throughout the state, although one of the urban cities, Bridgeport, is one of them. Although outside the scope of this research, it would be interesting to look closer at the distribution of supermarkets and population within Bridgeport that has yielded this result especially since the other large towns in CT do not have similar findings.

Map 11: Map of Number of Supermarkets within 1 Mile with Quintile Shading

Source: Authors mapping using ArcGIS.

An alternative measure of walking distance is within a 1-mile radius, as shown in Map 11. This maps shows similar findings as Maps 7, 8, and 9 where there is no access clustered in the northwest and northeastern sections of the state. Additionally, the five largest towns by population size are once again in the top quintile with the greatest number of supermarkets within 1 mile. Finding better access in urban areas across multiple specifications reinforces the notion that urban CT towns appear to be well served, at least when examined at the town level. The maps of all five of these measures of access add support for the need to consider the spatial nature of these data and to account for the apparent spatial autocorrelation.

Looking now at the crime data in map form, Map 12 displays the major crimes with quintile shading. One can see some areas where there is no or very little major crimes shaded in white with red shading of slightly higher crime levels nearby. Towns with the greatest number of crimes are shaded in green and are spread throughout the

state. As one might expect the five largest towns are also in the largest quintile of with respect to the number of crimes, thus supporting the idea that major crimes are more prevalent in urban areas, however, there are rural areas of the state that also fall in the same quintile ranking.

Map 12: Map of Major Crimes with Quintile Shading

Source: Authors mapping using ArcGIS.

Map 13 shows the minor crime map, which has a somewhat different story than Map 12. This map shows a lot more clustering that occurs in the northeast area shaded in white (lowest numbers of minor crimes), central and southern coast area shaded in green (highest number of minor crimes), and southwest area shaded in red (lower number of minor crimes). From looking at these maps one would expect a greater degree of spatial autocorrelation with respect to minor crimes than major crimes.

Map 13: Map of Minor Crimes with Quintile Shading

Source: Authors mapping using ArcGIS.

6.5. Moran's I Test Statistic and Scatter Plots

While the maps show signs of spatial autocorrelation it is only with a proper test statistic that one can support the need for a spatial model. Figure 8 presents the Moran's *I* scatter plot of the standardized time to the closest supermarket on the x-axis and the spatial lag of that variable on the y-axis using a queen's rule weights matrix that is row-standardized (Equations (2) and (3)). There is obvious positive spatial autocorrelation present, for which the Moran's I calculated value of 0.416 indicates, a value that is statistically significant at the 1% level, and also depicted by the regression line. Figure 9 and 10 show the Moran's I scatter plot for the number of supermarkets within a 5 and 10-minute drive, respectively. The Moran's *I* test statistic is also positive and statistically significant at 1% with a value of 0.353 for the 5 minute threshold and 0.517 for the 10 minute threshold.

Figure 8: Moran's I and Scatter Plot: Time to Closest Supermarket

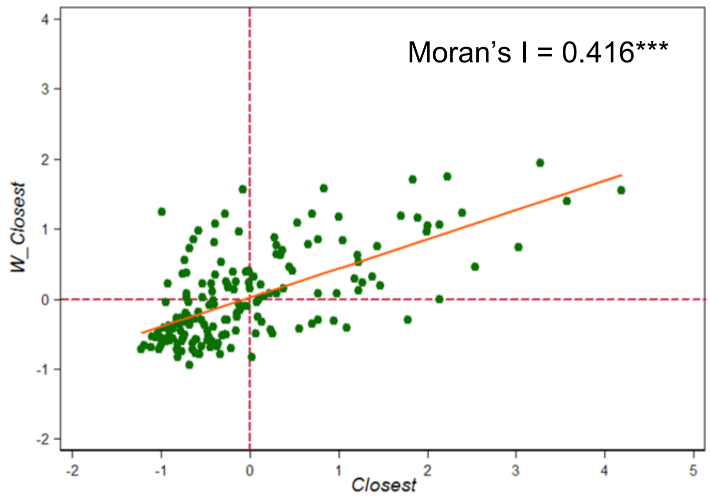
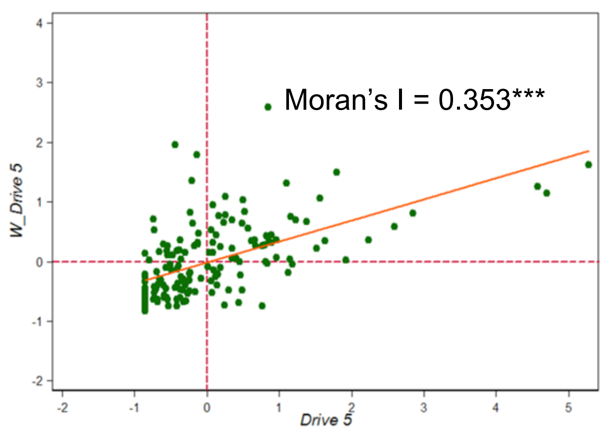


Figure 9 and 10: Moran's I and Scatter Plot: Number of Supermarkets within 5 and 10 Minutes



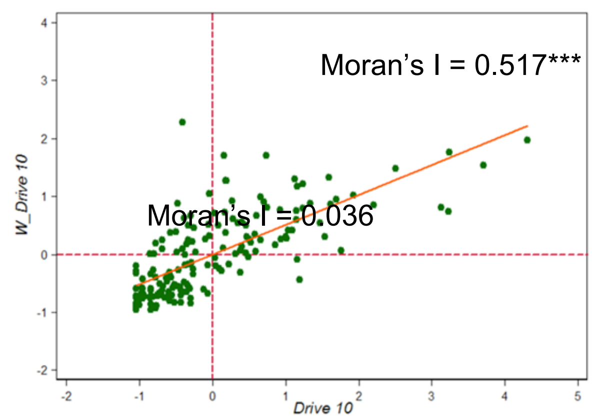
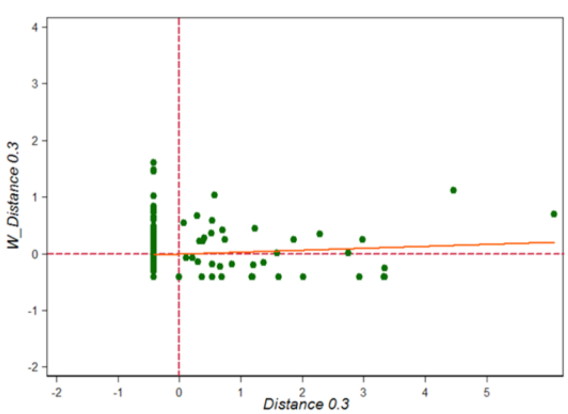


Figure 11 and 12: Moran's I and Scatter Plot: Number of Supermarkets within 0.3 and 1 Mile



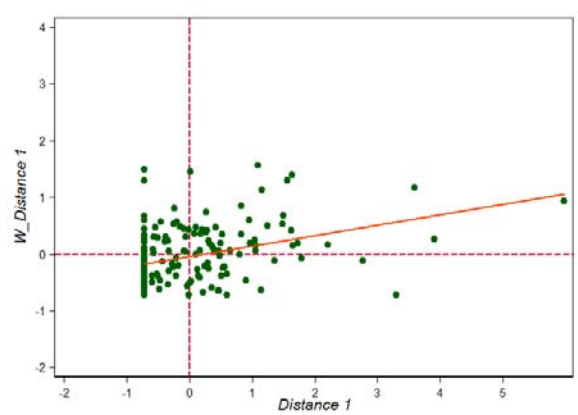
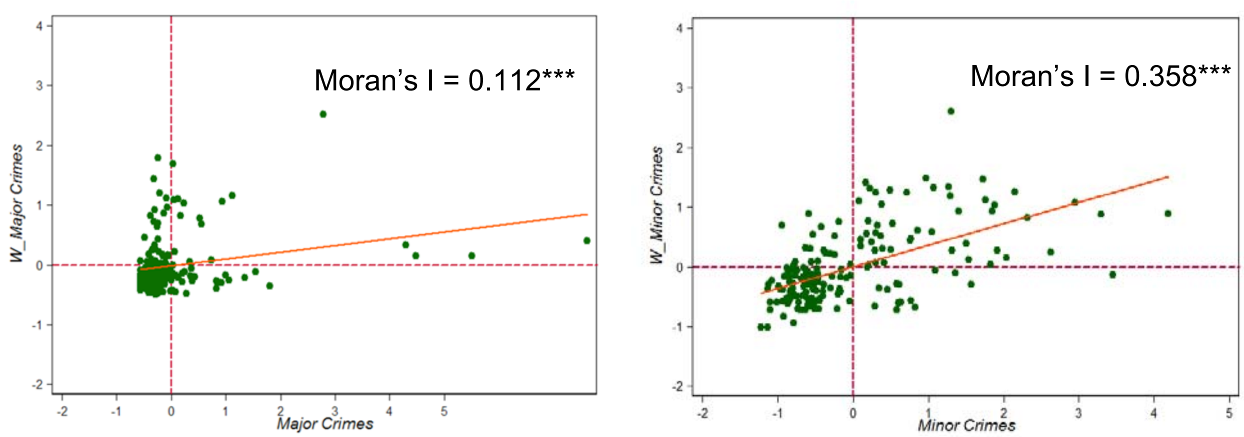


Figure 11 displays a Moran's *I* scatter plot for the 0.3-mile threshold. Here there is very little autocorrelation, and in fact the calculated Moran's *I* is 0.036 and not statistically significant from zero. Figure 12 shows the plot for the 1-mile radius, which does show some positive spatial autocorrelation. The statistically significant Moran's *I* value for the 1-mile radius is 0.184. What is indicated by four of the five access specifications is that positive spatial autocorrelation exists and should be accounted for in the modeling. Alternatively, the model with a 0.3-mile threshold exhibits spatial randomness.

<u>Figure 13 and 14: Moran's I and Scatter Plot of Crime Variable: Major and Minor Crimes</u>



Looking now at the Moran's *I* plot for the two crime variables, major crimes are shown in Figure 13 to have a slight but positive and significant spatial autocorrelation with a value of 0.112. As expected from viewing the maps, the minor crimes variable exhibits more spatial autocorrelation, at 0.358, which is also statistically significant, shown in Figure 14. It is unsurprising that criminal activity tends to cluster together throughout geographic space and thus the need for a properly modeled spatial econometric technique is justified.

Chapter 7

Empirical Analysis

The parameter estimates of the access and crime system of equations, defined by Equation 9, are presented in Tables 4-8. I first focus on the access and crime variables as these are the ones of greatest interest to this research. I will then also discuss some of the other variables in the model. Looking at Table 4, I present the results for the closest supermarket access measure for both major and minor crimes. As one can see in the first column, major crimes have no impact on the number of minutes to the closest supermarket, whereas the second column of results shows that a greater number of minutes are indicative of less major crimes. In other words, as the distance to the closest supermarket increase, major crimes decrease; thus areas with limited access also have less major crimes. Alternatively, better access is where there are also more major crimes.

Now looking at the estimation for minor crimes in the second set of results of Table 4, I find that increases in minor crimes have a negative effect on the distance to the closest supermarket. Additionally, minor crimes have a similar effect on supermarket access as major crimes, where greater distances result in less crime. These findings indicate that only minor crimes have an increasing effect on access yet supermarkets attract more of both major and minor crimes. Thus from the supermarket equations I find that where there are minor crimes there is better access, as measured by the distance to the closest supermarket. From the crime equations I find that where there is better access is also where there is more major and minor crimes occurring.

The result from the supermarket equation is contrary to expectation that crime would be a deterrent to supermarket access; however, the crime equation result gives insight into what was previously an unknown relationship. Before discussing these results in greater detail I examine the other results of this model as well as the other access measures to check for robustness. I then present a discussion of these results with policy implications in Section 8.

Table 4: Results for Closest Supermarket

	Supermarket		Major Crime		Supermarket		Minor Crime	
Variable	Ceoff	Std. Err.	Ceoff	Std. Err.	Ceoff	Std. Err.	Ceoff	Std. Err.
SuperTime			-0.091	0.048 *			-0.841	0.314 ***
MjrCrime	-0.362	0.330						
MnrCrime					-0.198	0.054 ***		
w1y_SuperTime	1.110	0.159 ***	0.267	0.075 ***	1.083	0.180 ***	0.293	0.568
w1y_MjrCrime	0.550	0.241 **	0.062	0.089				
w1y_MnrCrime					0.242	0.057 ***	0.555	0.125 ***
Hwy	-1.604	0.447 ***	-0.548	0.172 ***	-0.851	0.470 *	1.369	1.104
MedInc	8.67E-06	1.01E-05	1.14E-05	5.85E-06 *	3.88E-06	1.16E-05	-5.96E-05	3.88E-05
Mill	0.057	0.038	0.032	0.014 **	0.022	0.040	0.024	0.089
PctAfAm	0.017	0.039	0.042	0.013 ***	0.028	0.039	0.104	0.086
PctAsn	0.093	0.093	0.019	0.034	0.096	0.096	0.124	0.221
PctBHgrt			-0.008	0.010			0.047	0.063
PctBlwPov	-0.028	0.082			0.002	0.086		
PctGrp	-0.042	0.051			-0.026	0.050		
PctHisp	0.080	0.057	-0.029	0.020	0.115	0.057 **	0.141	0.136
PctNoVeh	-0.327	0.117 ***			-0.211	0.103 **		
PctPA			0.129	0.032 ***			0.423	0.206 **
PctUnEmp	0.152	0.113	-0.042	0.048	0.179	0.116	0.264	0.306
PctVacant	0.129	0.036 ***	0.021	0.015	0.139	0.038 ***	0.176	0.094 *
polsqden			-0.198	0.040 ***			-0.507	0.252 **
PopDen	6.34E-04	4.67E-04	1.55E-03	1.49E-04 ***	1.53E-04	3.54E-04	1.82E-03	9.57E-04 *
train			0.075	0.209			-0.355	1.305
TvlLt15min	-8.162	3.173 **			-8.507	3.168 ***		
_cons	-1.775	2.455	-2.800	0.778 ***	-2.014	2.776	3.332	6.224
ρ	0.550		0.062		0.242		0.555	
R^2	0.583		0.819		0.492		0.681	
N	169		169		169		169	

*: p<0.10, **: p<0.05, ***: p<0.01

In addition to the main crime variables of interest there are also other impacts on supermarket access and crime that are found in these results. Looking further at Table 4 one finds the parameter estimates for the spatial lag of access and crime. With respect to the major crime equations, the spatial lag of access in the access equation is positive and significant. This is interpreted to mean that an increase in a towns supermarket access is positively influenced by a neighboring towns supermarket

access, i.e. towns with better access are generally located nearby similar access towns. The impact of the spatial lag of major crimes on supermarket access is also positive and significant for the distance to the closest supermarket, thus neighboring towns with more major crimes have a deterrent effect on supermarket access. These same relationships hold true for the supermarket equation with the minor crime variables.

Regarding the crime equation for major crimes, there is no impact of the spatial lag of major crimes, however, there is a positive and highly significant impact of the spatial lag of supermarket access. This indicates there are more major crimes when neighboring towns have poorer access as measured by a greater number of minutes to the closest supermarket. For the minor crime equations there is a positive and significant effect for the spatial lag of minor crimes indicating towns have more minor crimes when neighbors have more minor crimes, while there is no effect of the spatial lag access measure.

Some of the other variables of interest in access studies are also statistically significant in Table 4. The percent of households without a vehicle variable, PctNoVeh, is negative in both supermarket access equations for major and minor crimes. This implies that towns with more households without a vehicle have less distance to the closest supermarket, i.e. better access. This result is important because it raises questions of whether the focus on food access policy in CT is warranted in areas with limited vehicles. The variable PctVacant, the percent of housing units that are vacant, is positive and statistically significant. Thus areas with vacant housing are further away from supermarkets. This also has significant policy implications and is discussed in Section 8 with regard to policy.

Another variable of interest in the supermarket access equation is the travel to work variable, which captures households that do not travel more than 15 minutes from their home. The estimation results in Table 4 indicate a negative and statistically significant parameter in both types of crime models. This implies that towns with a greater percentage of the population staying close to home have a supermarket closer to home. This is an important finding because it means that supermarkets are in fact serving populations close to home when they do not regularly travel to other areas for work. Given that existing research speculates that travel to work may be providing additional opportunities that are not considered, one would be concerned with limited access to populations that do not travel far from home. My findings indicate that supermarkets in CT are located closer to population areas that travel less than 15 minutes to work, thus there is little concern about access for this population. Furthermore, towns that have a larger number of residents that travel greater than 15 minutes to work have less access close to home but that does not necessarily mean they have an overall limited access to supermarkets. One would need to look at the travel patterns of this population segment to determine if there is adequate access when traveling to work.

In addition to the parameter estimates I also report other test statistics in Table 4. The spatial autoregressive parameter, ρ, is positive and statistically significant indicating there is spatial dependence in the error term. This implies that a random shock affects the town where it originated and its neighbors. The reported R^2 is based on Buse (1973), which is a pseudo R^2 based on the weighted predicted values and residuals. For the supermarket model it is 0.583 when estimated with major crime and 0.492 when

estimated with minor crime. The R^2 for the crime model is 0.819 and 0.681, for major and minor crimes respectively. Thus both models indicate relatively good explanatory power.

To check for robustness of the results for the closest supermarket I consider alternative measures of access, starting first with Table 5, which reports the results for the number of supermarkets within 5 minutes. In this model the supermarket access coefficient is only significant for the minor crime equation, where it is positive indicating an increase level of minor crimes where there are more supermarkets within a 5-minute drive time. Similarly, only the minor crime variable is significant in the supermarket access equations, thus areas with more minor crimes also have better access but there is no difference in access with respect to major crimes. These findings are consistent with the minor crime model for the time to the closest supermarket.

With respect to the spatial lag variables, the findings for the number of supermarkets within 5-minute drive time are similar to the time to the closest supermarket, although now the negative spatial lag access measure is statistically significant in the minor crime equation. Therefore, I consistently find that a town's access is positively influenced by a neighboring town's access and negatively influenced by a neighboring towns crime level. A town's crime level is negatively influenced by a neighboring town's access and for minor crimes, positively influenced by a neighboring town's crime level.

Table 5: Results for Supermarkets 5 minutes

	Supermarket		Major Crime		Supermarket		Minor Crime	
Variable	Ceoff	Std. Err.	Ceoff	Std. Err.	Ceoff	Std. Err.	Ceoff	Std. Err.
Super5Min			-0.106	0.122			2.483	0.813 ***
MjrCrime	-0.076	0.150						
MnrCrime					0.064	0.020 ***		
w1y_Super5Min	0.603	0.189 ***	-0.521	0.165 ***	0.784	0.169 ***	-2.454	1.238 **
w1y_MjrCrime	-0.313	0.116 ***	0.163	0.106				
w1y_MnrCrime					-0.108	0.025 ***	0.766	0.144 ***
Hwy	0.167	0.183	-0.399	0.157 **	-0.007	0.179	2.193	1.051 **
MedInc	-4.88E-06	4.47E-06	7.31E-06	5.43E-06	-6.37E-06	4.65E-06	-4.82E-05	3.78E-05
Mill	-0.014	0.015	0.027	0.013 **	-0.006	0.015	0.010	0.090
PctAfAm	0.032	0.016 **	0.045	0.013 ***	0.014	0.015	0.090	0.088
PctAsn	0.076	0.037 **	0.021	0.033	0.063	0.037 *	-0.011	0.229
PctBHgrt			0.003	0.010			0.088	0.064
PctBlwPov	0.024	0.033			-0.002	0.032		
PctGrp	-0.033	0.021			-0.027	0.020		
PctHisp	0.017	0.023	-0.025	0.020	0.007	0.022	0.121	0.135
PctNoVeh	0.011	0.049			-0.016	0.040		
PctPA			0.139	0.029 ***			0.461	0.193 **
PctUnEmp	-0.006	0.046	-0.024	0.046	-0.028	0.044	0.212	0.315
PctVacant	-0.011	0.013	0.015	0.013	-0.016	0.013	0.059	0.085
polsqden			-0.195	0.040 ***			-0.601	0.262 **
PopDen	4.96E-04	2.00E-04 **	1.60E-03	1.49E-04 ***	4.27E-04	1.34E-04 ***	1.26E-03	1.03E-03
train			0.047	0.204			-0.235	1.340
TvlLt15min	0.753	1.325			0.661	1.268		
_cons	0.575	0.832	-1.287	0.611 **	1.290	0.847	-3.260	4.735
ρ	-0.313		0.163		-0.108		0.767	
R^2	0.651		0.842		0.639		0.686	
N	169		169		169		169	

*: p<0.10, **: p<0.05, ***: p<0.01

Table 6: Results for Supermarkets 10 minutes

	Supermarket		Major Crime		Supermarket		Minor Crime	
Variable	Ceoff	Std. Err.	Ceoff	Std. Err.	Ceoff	Std. Err.	Ceoff	Std. Err.
Super10Min			0.088	0.041 **			0.439	0.284
MjrCrime	0.685	0.468						
MnrCrime					0.125	0.065 *		
w1y_Super10Min	0.984	0.180 ***	-0.289	0.056 ***	0.852	0.161 ***	-0.155	0.425
w1y_MjrCrime	-0.647	0.334 *	0.219	0.095 **				
w1y_MnrCrime					-0.181	0.072 **	0.553	0.130 ***
Hwy	1.194	0.568 **	-0.508	0.157 ***	0.479	0.555	2.259	1.047 **
MedInc	1.80E-09	1.37E-05	9.51E-06	5.31E-06 *	6.67E-06	1.45E-05	-8.11E-05	3.70E-05 **
Mill	-0.040	0.048	0.034	0.013 ***	-0.003	0.047	-0.018	0.088
PctAfAm	-0.001	0.050	0.046	0.013 ***	0.009	0.047	0.106	0.088
PctAsn	0.258	0.118 **	0.006	0.034	0.268	0.116 **	0.018	0.230
PctBHgrt			0.002	0.010			0.070	0.068
PctBlwPov	0.031	0.101			0.013	0.104		
PctGrp	-0.086	0.064			-0.088	0.063		
PctHisp	0.012	0.071	-0.023	0.020	-0.022	0.067	0.112	0.134
PctNoVeh	0.139	0.149			0.121	0.128		
PctPA			0.102	0.030 ***			0.560	0.208 ***
PctUnEmp	0.050	0.140	-0.027	0.046	0.029	0.136	0.045	0.311
PctVacant	0.002	0.042	0.006	0.013	-0.010	0.042	0.054	0.087
polsqden	0.031	0.101	-0.193	0.039 ***			-0.637	0.264 **
PopDen	-4.80E-04	6.77E-04	1.64E-03	1.49E-04 ***	4.16E-04	4.31E-04	1.99E-03	1.01E-03 **
train			-0.042	0.202			-0.092	1.374
TvlLt15min	0.645	3.930			1.198	3.915		
_cons	-1.186	2.478	-1.135	0.600 *	-1.072	2.529	2.553	4.397
ρ	-0.647		0.219		-0.181		0.553	
R^2	0.648		0.836		0.663		0.714	
N	169		169		169		169	

*: p<0.10, **: p<0.05, ***: p<0.01

Table 6 shows the results with the number of supermarkets within a 10 minute drive time as the measure of access. In this model the supermarket access coefficient is only significant for the minor crime equation, where it is positive indicating an increase

level of minor crimes where there are more supermarkets within a 10-minute drive time. This result for minor crimes is consistent with both the closest supermarket measure and the 5-minute drive time measure. However, the result for major crimes is now positive and significant for the access equations whereas the variable minor crime is no longer significantly different from zero.

The spatial lag variables for the 10-minute drive time indicate that a town's access is positively influenced by a neighboring town's access and negatively influenced by a neighboring towns crime level. This result is consistent with my findings for the closest supermarket and 5-minute drive time measures. For the crime equations, a town's major crime level is negatively influenced by a neighboring town's access, yet there is no impact for minor crimes. Both major and minor crimes have a positive and statistically significant impact on neighboring towns crime levels.

Table 7: Results for Supermarkets 0.3 Miles

	Supermarket		Major Crime		Supermarket		Minor Crime	
Variable	Ceoff	Std. Err.	Ceoff	Std. Err.	Ceoff	Std. Err.	Ceoff	Std. Err.
Super.3Mil			2.087	5.043			105.362	31.771 ***
MjrCrime	0.002	0.005						
MnrCrime					0.002	0.001 ***		
w1ySuper.3Mil	0.873	0.340 **	-21.958	9.234 **	1.115	0.321 ***	-250.555	56.613 ***
w1y_MjrCrime	-0.007	0.004 **	0.051	0.101				
w1y_MnrCrime					-0.003	7.98E-04 ***	0.765	0.116 ***
Hwy	0.008	0.007	-0.433	0.170 **	-0.001	0.007	2.178	1.096 **
MedInc	-3.36E-08	1.44E-07	6.28E-06	5.56E-06	-1.41E-08	1.42E-07	-5.59E-05	3.51E-05
Mill	-2.67E-04	5.56E-04	0.020	0.014	1.39E-04	5.51E-04	-0.056	0.092
PctAfAm	2.68E-04	5.52E-04	0.038	0.014 ***	-6.61E-05	5.30E-04	0.119	0.089
PctAsn	1.34E-04	1.34E-03	-0.001	0.035	-2.33E-04	1.32E-03	0.113	0.230
PctBHgrt			-4.95E-04	1.02E-02			0.124	0.063 **
PctBlwPov	2.09E-03	1.19E-03 *			1.16E-03	1.10E-03		
PctGrp	-4.14E-04	7.59E-04			-4.38E-04	6.77E-04		
PctHisp	1.75E-04	8.44E-04	-0.041	0.021 **	-1.29E-04	7.67E-04	0.104	0.134
PctNoVeh	-1.48E-04	1.79E-03			-9.63E-04	1.41E-03		
PctPA			0.162	0.030 ***			0.326	0.185 *
PctUnEmp	-1.10E-03	1.84E-03	0.004	0.055	-2.03E-03	1.80E-03	0.750	0.353 **
PctVacant	-3.49E-04	4.79E-04	0.025	0.013 *	-4.25E-04	4.69E-04	0.012	0.086
polsqden			-0.203	0.042 ***			-0.479	0.258 *
PopDen	1.84E-06	6.18E-06	1.43E-03	1.54E-04 ***	4.01E-06	4.75E-06	1.56E-03	1.02E-03
train			0.007	0.219			-0.541	1.333
TvlLt15min	0.003	0.047			0.010	0.042		
_cons	0.007	0.029	-1.346	0.646 **	0.016	0.028	-3.577	4.493
ρ	-0.007		0.051		-0.003		0.766	
R^2	0.100		0.818		0.062		0.626	
N	169		169		169		169	

*: p<0.10, **: p<0.05, ***: p<0.01

Table 8: Results for Supermarkets 1 Mile

Variable	Supermarket Ceoff	Supermarket Std. Err.	Major Crime Ceoff	Major Crime Std. Err.	Supermarket Ceoff	Supermarket Std. Err.	Minor Crime Ceoff	Minor Crime Std. Err.
Super1Mil			-0.394	0.570			10.465	3.745 ***
MjrCrime	-0.023	0.035						
MnrCrime					0.011	0.005 **		
w1y_Super1Mil	0.421	0.254 *	-2.751	0.909 ***	0.659	0.227 ***	-14.914	6.343 **
w1y_MjrCrime	-0.042	0.025 *	0.096	0.100				
w1y_MnrCrime					-0.018	0.006 ***	0.753	0.126 ***
Hwy	0.054	0.044	-0.425	0.166 **	0.030	0.043	1.858	1.085 *
MedInc	7.89E-07	1.02E-06	6.81E-06	5.43E-06	5.24E-07	1.04E-06	-7.32E-05	3.56E-05 **
Mill	-0.004	0.004	0.019	0.014	-0.002	0.004	0.008	0.093
PctAfAm	0.006	0.004	0.041	0.014 ***	0.003	0.004	0.090	0.089
PctAsn	1.22E-03	0.009	0.013	0.034	-6.71E-04	0.009	0.132	0.226
PctBHgrt			0.002	0.010			0.119	0.065 *
PctBlwPov	0.013	0.008 *			0.008	0.008		
PctGrp	-8.71E-03	0.005 *			-0.008	0.005 *		
PctHisp	0.003	0.005	-0.032	0.020	0.002	0.005	0.133	0.133
PctNoVeh	0.007	0.012			-4.78E-04	9.81E-03		
PctPA			0.156	0.030 ***			0.373	0.196 *
PctUnEmp	-0.003	0.011	-0.010	0.050	-0.007	0.011	0.366	0.330
PctVacant	-0.005	0.003 *	0.016	0.013	-0.006	0.003 *	0.045	0.087
polsqden			-0.199	0.041 ***			-0.588	0.265 **
PopDen	7.97E-05	4.51E-05 *	1.55E-03	1.53E-04 ***	6.01E-05	3.21E-05 *	1.61E-03	1.04E-03
train			0.018	0.215			0.040	1.380
TvlLt15min	0.326	0.313			0.314	0.306		
_cons	-0.035	0.195	-1.184	0.621 *	0.075	0.197	-2.345	4.506
ρ	-0.042		0.096		-0.018		0.753	
R^2	0.457		0.835		0.442		0.685	
N	169		169		169		169	

*: p<0.10, **: p<0.05, ***: p<0.01

Overall, Tables 4, 5, and 6 indicate robustness in the results that increases in crime are associated with increases in supermarket access; whereas increases in supermarket access are primarily associated with increases in minor crimes. Tables 7 and 8 add to this by examining the impact of walking distances 0.3 miles and 1 mile. In fact the results of both of these measures of access have parameter estimates that are positive for minor crimes and not statistically significant from zero for major crimes. Thus throughout the different modeling assumptions of access I find evidence of increased access where there is increased crime. Furthermore, the crime equations are also consistent throughout the different measures of access, where increased supermarket access is associated with increased minor crimes.

Chapter 8

Discussion and Policy Implications

The study of supermarket access in America has great implication on policy as it relates to American's health (Prevention Institute 2002, Karpyn and Axler undated), the Food Stamp Program (Feather 2003), and the economic development of central cities (Pothukuchi 2005). Understanding the environmental factors that influence where limited supermarket access exists is fundamental to advancing this issue. In this research I have estimated the impact of crime and supermarket access to further our knowledge of how these two factors influence each other as policy makers try to address concerns of limited access. Given the focus on city, state, and federal funding to improve supermarket access it is important to consider the implications of these policies with respect to the relationship with crime.

Throughout the empirical analysis presented in Section 7, I find that increasing rates of minor crimes results in better supermarket access, a result robust across multiple specifications of access. Major crimes, however, only have an increasing impact on access to supermarkets within a 10 minute drive. I also find that supermarkets attract crime, a result also more robust with respect to minor crimes. Overall, these empirical findings are contrary to expectation and worthy of further discussion.

As previously discussed, crime is generally portrayed as a deterrent to supermarkets, mainly from the increased cost of doing business and consumer preference to avoid areas of criminal activity. The simultaneous impact of supermarket

access on crime was one of an unknown relationship and first discussed in this research. Given the previous literature one needs to consider why my findings may occur. One statistical possibility for this result would be spurious correlation. It is possible that the model is missing a variable that is highly correlated with crime, and thus it is that relationship that is being captured by the crime variable. While acknowledging this possibility, the robustness across multiple specifications and general significance of the model indicates other factors are also worthy of discussion.

Thus I go back to Becker's 1968 work on the economics of crime for some theoretical insight. If in fact businesses seek an optimal allocation of resources and are thus willing to accept an optimal level of crime, it is possible that areas with higher levels of minor crimes would result in more supermarket activity and thus better access. Recall that minor crimes are crimes against property such as larceny, burglary, and motor vehicle theft, including shoplifting. It is accepted that supermarkets or other retail outlets will not choose to completely eradicate such crimes because it is not cost effective to do so. The fact that my findings indicate that supermarkets attract more minor crimes supports this conclusion. This latter result is also consistent with routine activities theory. Therefore, the use of a simultaneous equation model with findings of higher crime resulting in better access and better access resulting in higher crime appears to have a foundation in both economic and sociological theory.

With an understanding of the relationship between supermarket access and crime we can consider the impact on policies designed to increase access. Such economic development activities are focused on providing food to populations that are perceived to be underserved. From the results of my research it is shown that areas

where there are minor crimes there are no concerns of supermarket availability. The same holds true for areas with limited vehicle availability. Thus policy makers are advised to look towards other areas of concern or to focus on a community evaluation at an even more disaggregate level than the town, i.e. there may be more refined neighborhoods that represent pockets of need that cannot be captured from a town analysis. Furthermore, my research indicates a need to also address crime prevention activities if the decision is made to encourage supermarket development in a community. Without such additional consideration communities may face an increase of minor crimes that may result in other negative effects to society not addressed by this research.

In addition to direct supermarket development, cities can also address increased access through other means of community revitalization. One prime example is through the reduction of vacant housing which I have shown decreases the distance to the closest supermarket and also decreases crime. Interestingly, The Connecticut Policy Institute: Connecticut's Urban Housing Policy (2014) also recommends the acquisition and rehabilitation of existing homes rather than building new homes in Hartford. This policy recommendation came as a direct response to a neighborhood housing development project in Hartford that was funded by HUD's Neighborhood Stabilization Program. Thus it is possible for communities to address multiple problems by focusing on policies to reduce vacant homes. Given the recent housing bubble and lingering real estate market effects it seems prudent for policy to focus on reducing vacant housing to provide a previously unrealized positive effect on community food access. Rather than

focusing on direct impacts of supply, a direct impact on demand can produce supply effects in the community. Further research in this area is recommended.

Chapter 9

Conclusion

Supermarket access in America is an important policy issue that has been studied in various cities over the past 10 years. In the UK, Wrigley (2002) has documented how this problem of food access became a major policy issue and where research priorities have been identified. One such priority is a method to systematically identify where food deserts (grocery gaps) exist. Various tools exist to identify underserved areas but they lack identification of the underlying problems that is causing the lack of access. Furthermore, the impact of crime on supermarket access has received hardly any attention, yet policy makers continue to use public funds to incentivize the development of new supermarkets in underserved areas. In this research, I utilize GIS and spatial econometric techniques to examine the relationship between crime and supermarket access.

Using a simultaneous equation model, my primary findings are that increases in minor crimes results in better supermarket access and supermarkets also serve to attract more minor crime to CT towns. While these findings are of use in explaining the relationship of supermarket access and crime in CT, there is no obvious extension that indicates this relationship holds in other geographic areas. CT has some unique political features as well as income and population distributions that may limit the generalizability of these results. Thus an expansion to this research would be to test similar models in other geographic areas as well as with data over time. By doing such

research one can determine the robustness of these results as well as the applicability to other areas in the US.

Continuing to consider different geographic areas, it would be of interest to also split the current analysis based on rural areas and urban areas. While I do control for population size there are still very distinctly different features of the rural and urban areas of CT. In particular this would address concerns with the large number of zero access calculations in the shorter distance measures as these are most prominent in the rural areas.

The focus of this study on the number of crimes per 1,000 people in a town is also worthy of discussion. An alternative measures that may yield different findings is to consider the costs of crime to society rather than strictly the impact of crime on the victim. The societal impact of crime is both the direct monetary cost of crime as well as the potential to being a witness to a crime and the psychological impact of such occurrence. One method that can extend this analysis is the introduction of a density measure of crime similar to Bowes and Ihlanfelt (2001). In addition, the introduction of a nonlinear relationship between supermarkets and crime should be explored as there may be a maximum level of crime that supermarkets are willing to accept before changing behavior.

Another area of interest in this research is to focus on entry and exit of supermarkets as opposed to levels of current access. This is an important consideration because the decision process of supermarkets to stay in business given the established fixed infrastructure is different than that of supermarkets decision to enter a new market. With respect to crime it can be hypothesized that crime is a

deterrent to new development yet does not shutter supermarkets. Thus empirically testing a model of entry and exit of supermarkets can provide valuable new information that is not currently addressed in the literature.

Following this idea of changes in supermarket access are also changes in crime. The changing dynamics of a community can encourage development that may not otherwise occur. Given that the current research focuses on access levels at a snapshot in time it is not possible to determine whether trends in crime levels have an impact on access. This is another consideration for future research.

While I have identified a number of areas for further research, the results that I have presented in this research contribute to the existing literature and policy implications focused on supermarket access. As further research and policy is developed in this area it is prudent to look beyond the supply side of where supermarkets are currently not located. One must thoroughly examine the demand side as well as the sustainability of new supermarkets. Enabling a supermarket to locate in an underserved area does no good if there are underlying issues affecting demand for a supermarket to locate in that area. Criminal activity is just one of those components that needs proper consideration.

Appendix

Table A1: Mean of Selected Variables by Quintile Groupings of Median Income

	Range of Median Income				
Variable	<65,570	65,570<75,972	75,972<83,128	83,128<99,190	≥99,190
SuperTime	3.69	6.21	7.17	6.54	5.04
Super5Min	2.65	1.04	1.03	0.79	1.33
Super10Min	7.60	3.97	3.99	3.47	6.67
Super.3Mil	0.04	0.01	0.01	0.01	0.01
Super1Mil	0.50	0.13	0.16	0.10	0.22
MjrCrime	3.29	0.94	0.82	0.47	0.39
MnrCrime	25.89	15.35	13.34	9.30	9.65
PctNoVeh	10.34	4.43	3.57	2.64	2.41
PctAfAm	9.11	4.68	2.97	1.27	1.47
PctAsn	3.14	2.85	2.45	1.84	3.18
PctHisp	13.72	5.73	4.84	2.91	3.80

Table A2: Mean of Selected Variables by Quintile Grouping of Percentage of Households on Public Assistance

	Range of Median Percentage of Households on Public Assistance				
Variable	<1.98	1.98<2.95	2.95<4.26	4.26<7.32	≥7.32
SuperTime	5.95	6.45	6.91	4.88	4.55
Super5Min	1.07	1.05	0.70	1.47	2.51
Super10Min	4.79	4.93	3.14	5.47	7.30
Super.3Mil	0.01	0.01	0.00	0.01	0.04
Super1Mil	0.17	0.14	0.10	0.20	0.47
MjrCrime	0.48	0.36	0.67	1.05	3.26
MnrCrime	10.22	10.36	11.83	15.39	25.27
PctNoVeh	2.52	2.65	3.77	4.28	9.96
PctAfAm	1.49	1.20	1.28	6.20	9.10
PctAsn	2.60	2.02	2.50	3.34	2.96
PctHisp	3.24	3.38	3.36	7.09	13.63

Table A3: Mean of Selected Variables by Quintile Grouping: Percent Households without a Vehicle

	Range of Percentage of Households without a Vehicle				
Variable	<1.78	1.78<2.94	2.94<4.09	4.09<6.12	≥6.12
SuperTime	8.16	7.12	5.50	4.54	3.41
Super5Min	0.39	1.09	1.12	1.30	2.87
Super10Min	2.33	4.36	4.98	5.28	8.62
Super.3Mil	0.00	0.01	0.01	0.01	0.04
Super1Mil	0.05	0.15	0.18	0.19	0.52
MjrCrime	0.43	0.51	0.56	0.85	3.49
MnrCrime	8.91	10.67	11.99	15.64	25.85
PctAfAm	0.87	1.29	1.56	3.51	12.03
PctAsn	1.71	2.02	2.72	2.95	4.03
PctHisp	2.75	3.54	3.70	5.30	15.38

Table A4: Mean of Selected Variables by Quintile Groupings of Median Population Density

	Range of Median Population Density				
Variable	31.93<165.05	165.05<347.87	347.87<664.81	664.81<1,339.73	≥1,339.73
SuperTime	10.56	6.51	5.06	3.62	2.87
Super5Min	0.23	0.70	0.86	1.70	3.38
Super10Min	1.17	3.03	3.74	7.08	10.77
Super.3Mil	0.00	0.01	0.01	0.01	0.04
Super1Mil	0.01	0.13	0.15	0.25	0.55
MjrCrime	0.47	0.54	0.69	0.80	3.41
MnrCrime	7.59	9.00	12.26	16.86	27.89
PctNoVeh	2.72	2.78	3.44	4.52	9.93
PctAfAm	0.59	0.92	2.14	4.89	11.02
PctAsn	1.12	1.56	2.61	3.80	4.40
PctHisp	3.19	2.87	3.69	5.76	15.54

Table A5: Mean of Selected Variables by Quintile Groupings of Major Crimes per 1,000 people

	Major Crimes per 1,000 people				
Variable	0<0.25	0.25<0.48	0.48<0.79	0.79<1.32	≥1.32
SuperTime	7.17	6.37	5.82	6.01	3.35
Super5Min	0.73	0.84	1.27	0.90	3.05
Super10Min	3.49	3.60	5.45	4.25	8.80
Super.3Mil	0.01	0.01	0.01	0.01	0.04
Super1Mil	0.11	0.12	0.16	0.17	0.51
MjrCrime	0.06	0.35	0.60	1.01	3.79
MnrCrime	6.43	10.21	14.03	15.29	27.11
PctNoVeh	2.59	2.71	3.23	4.12	10.52
PctAfAm	0.64	0.98	2.75	2.62	12.27
PctAsn	1.53	1.85	2.79	3.86	3.39
PctHisp	3.47	3.13	4.04	4.58	15.47

Table A6: Mean of Selected Variables by Quintile Groupings of Minor Crimes per 1,000 people

	Minor Crimes per 1,000 people				
Variable	1.80<6.48	6.48<9.09	9.09<13.72	13.72<22.19	≥22.19
SuperTime	7.97	6.61	6.41	4.53	3.16
Super5Min	0.52	0.76	0.98	1.65	2.93
Super10Min	2.49	3.67	4.18	5.63	9.77
Super.3Mil	0.01	0.01	0.01	0.02	0.04
Super1Mil	0.07	0.15	0.14	0.25	0.49
MjrCrime	0.35	0.40	0.65	1.17	3.34
MnrCrime	4.90	7.92	10.72	17.80	32.29
PctNoVeh	2.59	2.95	3.22	4.94	9.67
PctAfAm	0.91	1.05	1.70	4.59	11.31
PctAsn	1.32	1.83	2.89	3.31	4.12
PctHisp	3.68	3.15	3.74	6.87	13.56

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