

THE "WALKABLE" NEIGHBORHOOD BASED ON RETAIL REQUIREMENTS
IMPACT OF POPULATION DENSITY ON MARKET AREA

by

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Presented to the Faculty of the Graduate School of
The University of Texas at Arlington in Partial Fulfillment
of the Requirements
for the Degree of

MASTER OF CITY AND REGIONAL PLANNING

THE UNIVERSITY OF TEXAS AT ARLINGTON

December 2010

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ACKNOWLEDGEMENTS

Much thanks to Ardeshir Anjomani for his insights, commentary, and ever-present emphasis on graphics; Ivonne Audirac for pointing me to the dark underbelly of New Urbanism, Fred Forgey for patiently explaining the mathematics of decision making; Stephen Pope for a million tiny but important observations; everyone involved in the planning and design of University Park, Texas, for providing me my personal urban laboratory; Matthew Minnix for helping me on my 30-year quest to understand the city; and perhaps most of all Allison, who has always been there to listen, read, and give her opinion, and who has now heard more about Central Place Theory than really anyone should have to.

November 2, 2010

ABSTRACT

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The University of Texas at Arlington, 2010

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Recent planning thought has focused on how to configure the city to reduce dependence on private automobiles. One important strain of this thinking is how to promote a city where daily needs can be satisfied on foot. Using the tools of Central Place Theory and Demand Threshold analysis, this work studies the required population density to bring grocery shopping within pedestrian range of the population. The analysis is based on the grocery market in Dallas County, Texas. As long as economies of scale and consumer price sensitivity continue to operate as they have, the alternatives will remain much higher density or only partial access. The suggested policy implication is that neighborhood design issues should be decoupled from economic land-use arguments for the purposes of discussion by policy makers.

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CHAPTER 1
BACKGROUND AND LITERATURE REVIEW

1.1 Introduction and Objective

1.1.1 Introduction

The structure of city life is intimately connected with transportation. How one accesses all of the components of the city determines a great deal of the character of living there. Since the publication of *The Death and Life of Great American Cities* fifty years ago the planning community has begun to rethink the urban structure. This movement has culminated in a push to revise the urban fabric to reduce the dependence on the automobile that has characterized the Twentieth Century. Exactly how this should be done is still at issue.

There have been many claims made about restructuring cities away from the car. Many of these center around the creation of an environment where daily needs can be met on foot, by bicycle, or by mass transit. Mark Hinshaw and Brian Venneman write in the March 2010 issue of *Planning* magazine that a neighborhood "contained within a radius of four or five blocks" from a "two-sided street three or four blocks long" would be a workable place for walking.¹ Conversely, the Thoreau Institute contends that a community where daily needs could be met on foot would need to be "almost 124,000 people per square mile" which is "about two-and-one-half times the density of Manhattan."² What kind of city would enable its citizens to go about their daily lives without resort to the private auto is still undecided.

¹ Hinshaw, 2010, 31

1.1.2 Importance of Retail

Of all of the aspects of "walkability," from landscaping to social character, the one probably most directly connected to "daily needs" is access to services. It is these destination points, and the commercial and institutional land uses associated with density and diversity, that are thought to be essential if transportation and circulation patterns are to change in a meaningful way. "Having nice sidewalks, attractive landscaping, and other pedestrian amenities in a low-density, residential-only neighborhood is unlikely to prompt many residents to walk to shops and stores."³ Hollie Lund's analysis of New Urbanist projects in Oregon determined that the best predictor of success by a number of metrics was community access to nearby retail. In her words, "local access to retail shops appears to be of particular importance - at both the individual and neighborhood levels. Residents do appear to be using - and walking to - their local shopping area, if there is one"⁴ It would seem, therefore, that the ability of a pedestrian living environment to satisfy the needs of its population is intrinsically bound up in whether it includes access to viable retail.

1.1.3 Objective

If a neighborhood is to include access to viable retail for its residents, then it is important to know what factors influence the viability of retail. An empty storefront no more serves residents than an empty lot, and not only the initial presence, but also the durable success of neighborhood retail is important in determining what kind of place would support a "walkable" lifestyle. While inexact, there has been much research done on the subject of what retail needs to succeed, and this can be consulted to help determine which kind of neighborhood would succeed for its residents and which would not.

² O'Toole, 2001

³ Cervero, 1997

⁴ Lund, 2003, 246

The goal of this thesis is to determine "what does a 'walkable' neighborhood look like?" Phrased in another way, the goal is to develop a tool to model theoretical structure of the neighborhood based on residential population density that would place the population within walking distance of their "daily needs." The model will be based on the structure of retail outlets of a basket of lower-order goods. This model will primarily consist of a spreadsheet with two purposes. The first will be to determine the appropriate population density for pedestrian access to goods and services based on input market conditions. The second will be to evaluate proposed neighborhood structures (specifically their proposed densities,) in light of the retailing structure required to make them viable.

1.2 Claims made about walkability

1.2.1 Introduction

There has been much written on the subject of "walkability." Pedestrian accessibility has become the darling of researchers, educators, and consulting firms. Before setting about to discover what kind of neighborhood would place goods and services within a "walkable" range, it is worth looking into why the issue is considered important, and what kind of things are to be accomplished by bringing the city within reach of the pedestrian. There are long and extensive claims made about the benefits of configuring the city to be more accommodating to the pedestrian. These claims fall into a few categories:

1.2.2 Economic claims

There are a number of arguments advanced that reconfiguring the city to be more oriented to the pedestrian will have beneficial economic effects. The potential influence on behavior in the economy has been studied by several researchers, of which the team of Robert Cervero at the University of California, Berkeley is one of the more productive. They have

studied how land-use and the availability of services along a path of pedestrian travel influence the mode choice of residents. In their words:

"While charges of social engineering and environmental determinism have been levelled at [certain] urban design movements, from the perspective of travel-demand theory, the physical make-up of places (i.e. trip origins and destinations) is unquestionably relevant to understanding travel behavior. Just as utility theory says that travel time differentials between car and bus can influence mode choice between origin-destination pairs, it also tells us that a dense, mixed-use, pedestrian-friendly downtown destination is more likely to induce transit riding than a sprawling, single-use, auto-oriented suburban one. That is, characteristics of trip ends, and not just trip interchanges, influence travel behavior and choices."⁵

A major advocate of a new urban transportation network is Peter Calthorpe, his many writings address the impact of neighborhood configuration on lifestyle. He contends that "the urban space regularly traversed by the typical American is not really a "community" at all, but rather a series of connected urban and suburban districts that often stretch across a vast geographical space," and observes that "very few people in [the United States] today can cover the entirety of their daily travels in a five- or ten-minute walk."⁶ He proposes the idea of "pedestrian pockets" centered around mass transit stations to improve the workings of the community from an economic standpoint.⁷

Perhaps foremost among the advocates of pedestrian-friendly configurations for economic reasons are the founders of the Congress for the New Urbanism (CNU.) The New

⁵ Cervero and Kockelman, 1997

⁶ Calthorpe and Fulton, 2001, 15

⁷ Kelbaugh, 1989

Urbanists argue that neighborhood configuration can allow households to eliminate the need for cars, and have other beneficial economic benefits. Their vocal founder, Andres Duany, says walking to shops can allow a household to eliminate a car, thereby reducing their financial burden in a significant way.

“The middle class, . . . are forced into multiple automobile ownership. The average yearly cost of car ownership is \$5,000, which is the equivalent of a \$50,000 mortgage payment. The possibility of owning one less car is the single most important subsidy that can be provided towards affordable housing. By forbidding mixed use areas, the investment of personal time in the activity of commuting is mandatory. A person who drives 2 hours a day spends the equivalent of 8 working weeks a year in the car.”⁸

Another New Urbanist, Peter Katz, says the time and money saved by not driving will add up to a large difference. "The advantages of time and money saved by *not* driving long distances to work and having increased time available for family and friends are evident."⁹ In addition to the leadership of the CNU, there are others within the planning community that see reconfiguration of the city to a more “walkable” form as the solution to economic development. Writing in the American Planning Association’s book of standards, David Dixon and David Spillane propose that “density provides the people and disposable incomes required to revitalize older urban neighborhoods,” and that “1,500 to 2,500 new housing units within walking distance are required to sustain a new block of main street retail.”¹⁰

It is claimed, then, that if the fabric of the city was configured such that people could go about their daily lives on foot, then households could forego the expense of more than one auto,

⁸ Duany, 1998

⁹ Katz, 1994, x

¹⁰ American Planning Association, 2006, 470

people would be able to spend more time with their families, and that hitherto neglected parts of the city would be able to regenerate economically. These are among the claims that analyzing the density effects of market structure should be beneficial in evaluating.

1.2.3 Environmental Claims

Of the advocates of the “walkable” city, those that present environmental arguments promoting the idea tend to be the most passionate. Many of these arguments center around the notion that a transition to activities conducted on foot will change the transportation demand of community residents, and thereby reduce the vehicle miles traveled (VMT) of a community. This is often the justification behind Transit Oriented Development (TOD) in lieu of other kinds of development. Those that encourage TOD as a method of reducing vehicle travel due to neighborhood configuration include Peter Calthorpe, who asserts that a reconfigured neighborhood could “preserve open space, support transit, reduce auto traffic, and create affordable neighborhoods.”¹¹

The environmental logic is that every trip made on foot, whether on the way to a transit stop or not, is a trip not made by burning fossil fuels, and thereby more trips on foot mean a reduction in greenhouse gas emissions and associated benefits. This is the origin of environmental “sustainability” claims due to increased population density. It is not proposed that population density itself is necessarily desirable, but the assumed reduction in fossil-fuel-based transportation produces environmental benefits. Or, put another way, “one ecological purpose for higher-density living environments is to make pedestrian life possible again, thereby reducing the energy, land, and pollution demands of the auto.”¹² Following in this vein, the US Green Building

¹¹ Calthorpe and Fulton, 2001, 16

¹² Van Der Ryn and Calthorpe, 1986, 10

Council and their LEED criteria have for years included in their available compliance points the inclusion of bike racks and showers, as well as proximity to transit stations.¹³

The Urban Land Institute has produced their own work on the potential effects of increased population density and associated pedestrian travel on VMT and emissions reduction. Among their findings was that simply promoting commuting by mass transit would not produce a substantial impact if housing and retail configurations remained unchanged:

"Moreover, an important, and possibly surprising, fact is that daily commutes produce only 20 percent of the total VMT in a region. So although compact mixed-use infill near places of employment holds the most promise for reducing VMT, significant reductions in VMT can be accomplished through compact development even when people are not located within walking distance of their jobs. Reducing the distance between homes and grocery stores, schools, dry cleaners, movie theaters, and restaurants will correspondingly reduce VMT along with [greenhouse gas] emissions. Ideally, having these uses within walking distance can reduce the VMT to zero (and create a healthier and higher quality of life), but just reducing average VMT reduces GHG emissions. Simply put, compact mixed-use development allows us to spend less time in our cars running errands and could help save the planet - not a bad combination."¹⁴

Exactly what configuration of the population produces all of these beneficial effects has yet to be definitively determined. In *Transit Villages in the 21st Century*, Bernick and Cervero, concerned primarily with the density configuration that supports the use of mass transit, ask "are there any special mixes of services that are compatible with a transit-oriented community?" and answer that it all depends. Calculating that "at blended densities of around 12 units per acre, a

¹³ U.S. Green Building Council, 2001, 5

transit village with a one-quarter mile radius can accommodate a residential population of around 3800 (assuming an average of 2.5 persons per household),” they go on to assert that “this range is generally large enough to support most neighborhood commercial uses, like a bakery or deli.”¹⁵ They then go on to contrast “today's typical suburban planned unit developments” which are “designed at 5 to 6 dwelling units per residential acre (dua), well below the minimum of 12 dua necessary to support moderate levels of rail transit services.” However, even this bold solution admits that “of course, communities are not designed singularly for the purpose of shaping travel behavior, much less to lure people to mass transit.”¹⁶

The environmental claims are that if more of the city was accessible on foot ,then people would drive by necessity far less, using fewer resources and producing less pollution and greenhouse gasses. Additionally, it is proposed that the use of mass transit would increase if non-work trips could be conducted by walking. These claims make a neighborhood configured to give pedestrians access to goods and services environmentally important as well.

1.2.4 Public Health Claims

There are also Public Health claims made about the superiority of walking instead of driving as a mode of transportation. As an example, the Minnesota Design for Health Handbook uses neighborhood configuration as an index of exercise.¹⁷ In their words "physical activity is pursued in four purpose-related activity categories: work related, household-related, recreational or leisure-time, and transportation-related. Some have hoped that by creating environments that increase travel walking and cycling, total physical activity will increase.”¹⁸ In fact, many studies

¹⁴ ULI, 2008, 4

¹⁵ Bernick and Cervero, 1996, 87

¹⁶ Bernick and Cervero, 1996, 84

¹⁷ Forsyth, 2008

¹⁸ Forsyth, 2008, 16

have been done to try to assess the preference of walking or biking on health and obesity.¹⁹ "Finally, in the field of public health, similar contributions are made to metrics for walkability or pedestrian quality as a basis for addressing obesity, cardiovascular disease and other prevalent conditions."²⁰ Even in light of all of this research, the data is not universally conclusive. Once again the Minnesota Handbook admits that, "however, research to date is mixed, particularly in terms of whether the environment rather than social and psychological factors affects total physical activity. What matters is creating opportunities for physical activity, rather than saying one environment is healthier than another."²¹ They recommend an increase in activity, but leave the configuration of that environment up to others.

To summarize, public health advocates claim that an environment where goods and services are accessible to the pedestrian would promote more physical activity among the residents as people conduct the useful errands of their lives while walking. By increasing cardiovascular activity and reducing activity, a "walkable" neighborhood ought to make its residents happier and healthier.

1.3 Neighborhood design for walkability

1.3.1 History of Walkable Design

Having established the importance of studying the subject, we next turn to ideas about arranging the city to agree with the walker. Organizing the places people live to take advantage of walking has been an element of planning from the beginning. The principle of Neighborhood Unit Theory organized the city in small units, and in the 1929 regional plan of New York, Clarence Perry proposed a compact, independent neighborhood with stores at the perimeter and an

¹⁹ Frank et al, 2004

²⁰ Lo, 2009, 162

²¹ Forsyth, 2008, 16

elementary school at the center.²² This thinking had begun with Ebenezer Howard's proposal to create village-like "garden cities" surrounding the core city, and continues with others up to the present day.²³ A 1991 ULI pamphlet on "successful new communities" observes that "many new communities are organized around villages with their own commercial centers, recreational facilities, schools, and complete mix of housing. The idea is to create units self-contained with regard to all daily functions except work."²⁴ Echoing the internally-focused ideas of Perry they propose that these areas be "insulated from through traffic and separated from one another by roads and open spaces."²⁵ The historic idea was to create self-contained areas that could serve the functions of daily life on foot, similar to the project today.

1.3.2 Modern Designs for Walkability

Executing the pedestrian-oriented neighborhood has been a more difficult matter, and more modern ideas of how to create a neighborhood that satisfies the needs of daily life on foot are legion. Work by Adrienne Schmitz and Jason Scully proposes that "to succeed, a retail district must address the needs of both retailers and shoppers. The key is to ensure enough density for businesses to thrive while relying largely on pedestrian traffic."²⁶ Their solution is to increase diversity as much as possible, on the logic that the more types of needs there are, the more types of business will be able to serve them. They go on to say that, "according to one rule of thumb, at least 200,000 square feet of retail and other commercial space and at least 2,000 dwelling units should be located within a ten-minute walk of each other."²⁷ Quoting a prominent advocate that "a ten-minute walk translates to about six blocks," they propose that all successful

²² Taylor, 1998, 33

²³ Taylor, 1998, 21

²⁴ Ewing, 1991, 75

²⁵ Ewing, 1991, 75

²⁶ Schmitz, 2006, 31

²⁷ Schmitz, 2006, 31

retail streets are two-sided and, "if both sides of the street are used, six blocks offer enough space for about 120,000 square feet of retail."²⁸

The APA handbook promotes a similar neighborhood design concept, but uses different numbers, with a dense center and less dense remainder of the neighborhood.

"The viability of a neighborhood center depends on the degree of dependency that can be established between the uses in the center and the neighborhood population. This is a function of the number of people that are within a walkable distance of the center. This walkable population must be of sufficient size to provide a consistent source of demand for the center's retail goods and services. Local market conditions, such as per capita disposable income and regional competition, will generate different population thresholds for this demand. However, the average population density that is within the walkable distance to the center must be several times the density of the neighborhood outside the center, called the 'background density'. In traditional low-density neighborhoods, the background density is typically around 15 people per net acre (6 du/acre x 2.5 pp/du.) For the center, an average density of 45 people per net acre (30 du/acre x 1.5 pp/du) should be the target, with a somewhat lower density near the edges and higher in the middle of the center."²⁹

These solutions propose configurations that claim to place goods and services within reach of the pedestrian, but don't agree on what kind of population needs what kind of retail, and also fail to agree on how the population should be configured.

1.3.3 Effects of Design on Behavior

²⁸ Schmitz, 2006, 31

Work has also been done to determine if, in fact, a more "walkable" configuration would promote people to pursue more of their lives as pedestrians. Much of the intent of these proposals is to increase pedestrian access to retail, both in conjunction with and without access to mass transit. Cervero's team at Berkeley proposed that "conveniently siting grocery shops and the like between transit stops and residential neighborhoods" would encourage people who would otherwise drive to their errands to "link work and shop trips, via foot, when en route to home in the evening."³⁰

Research has been done on the effects of configuration on behavior, including a walkable retail study of Austin, Texas that looked into connectivity and walking behavior. "The key to reducing automobile dependence, according to this concept, is to bring destinations back within walking (and biking) distance and ensure safe and attractive connections for pedestrians."³¹ The destinations explored in the study included transit stops, civic facilities, schools, and retail centers. Their recommendations covered a range of design issues from street-grid configurations to building setbacks to street furniture and paving material with the intent of "making shopping areas more comfortable for pedestrians. Together these strategies may reduce driving not only by encouraging alternatives – walking, biking, and transit – but also by reducing the distances that residents drive when they still get in their cars."³²

Cervero's team at Berkeley also saw environment design as an important factor in promoting pedestrian travel and even use of mass transit for commuting farther afield:

"Notably, controlling for factors like trip distance and transit service intensities, pedestrian-friendly environments and the presence of convenience stores within a quarter mile of residences appears to induce commute trips via transit and non-

²⁹ American Planning Association, 2006, 413

³⁰ Cervero, 1997

³¹ Handy, 2001a, 318

motorized modes. In fact, the model suggests that the probability of commuting by a non-personal vehicle mode is nearly three-quarters higher in a neighborhood where everyone lives within a quarter mile of a convenience store vs one where no one lives this close, holding constant factors like transit service intensity, commute distance, gender, and the like. Importantly, these model results suggest that plentiful neighborhood retail shops and pedestrian-oriented designs, and not residential densities, are significant factors in encouraging people to commute by transit and non-motorized modes."³³

Paul Zykofsky and Dan Burden see land use diversity as the key element in promoting increased pedestrian commerce. They propose that “at the macroscale, the mix of land uses is key to ensuring that there are nearby destinations to which people can walk. Walkable community design is based on the patterns of traditional neighborhoods that include retail, civic, educational, and recreational uses in close proximity to residential uses.”³⁴ They further define a “pedestrian shed” as the distance covered by a one-quarter to one-half mile, considered walking distance, and claim that “at appropriate density levels, a pedestrian shed can typically support a neighborhood commercial center or school.”³⁵

Studying the effects of configuration and land uses on pedestrian access to services, The Congress for the New Urbanism commissioned a whitepaper on retail, which concluded that an increase in population density would result in an increase in retail. The paper asserts that by segregating land uses, “conventional suburban development effectively severed retail from its traditional, intrinsic relationship with the community it served.” This, in addition to street-network effects due to “wider spaced, but substantially larger, high-speed, high-capacity thoroughfares”

³² Handy, 2001a, 318

³³ Cervero, 1997

³⁴ American Planning Association, 2006, 479

led retailers in the suburbs to respond “in kind, with increasingly larger retail formats, spaced ever further apart.”³⁶

All of this work assumes that within the proposed configuration the destination point is active and available. A transit stop, neighborhood center, or "main street" where all of the planned destinations are no longer in business will produce no beneficial effects regardless of the configuration. For the area to succeed, the retail must be able to survive and thrive. This requirement, among others, has left "walkability" proposals open to criticism.

1.3.4 Critiques

Among the myriad of proposed designs to increase pedestrian use, there has also been skepticism. Certain researchers at the ULI have observed that "self-contained villages are an outgrowth of a concept from the greenbelt era, the concept of neighborhood units." This idea is problematic, however, for “most suburbanites do not naturally organize themselves into such units, and the attempt to fit all services into the same size unit, whether a village or neighborhood, is basically inefficient.”³⁷ Neighborhood self-containment also became the subject of a learned team at Florida State University, who noted that the New Urbanists “seldom admit that the commercial viability of the [Traditional Neighborhood Development] or TOD retail-service mix largely depends on regional catchment areas, i.e., attracting residents of other neighborhoods (those willing to forgo their own local accessibility to goods and services) for the regional choices proffered at TND or TOD destinations, thus ultimately offsetting the avowed transportation benefits.”³⁸ The viability of the neighborhood designed for use by the pedestrian is far from resolved.

³⁵ American Planning Association, 2006, 479

³⁶ Seth Harry Associates, 2004, 4

³⁷ Ewing, 1991, 75

1.4 Central Place Theory

1.4.1 Central Place Theory

In order to understand how an area might be configured to place market services within reach of a walking population, it is useful to understand how markets are structured across space generally. First formulated in 1933 by Walter Christaller, Central Place Theory deals with the structure of markets on the landscape. Studying the distribution of towns in Europe, Christaller observed that markets tend to be organized in a hierarchy. Firms that distribute goods to a wide area locate relatively far apart, and those that supply more immediate needs locate much more frequently, in predictable patterns.³⁹ August Losch, the location theorist, explained how a network of markets organized itself across the landscape "We have seen that there is only *one* suitable shape for market areas, and only a *limited* number of possible sizes and situations. Because of the restricted number, the most favorable area is uniquely determined for every commodity."⁴⁰ He also explained how Central Places are established by the relative order of the goods supplied there. "One and the same area will usually be the market for several goods, since there are more products than regional sizes. But beyond the market area these goods need have nothing in common."⁴¹ This leads to a hierarchy of sizes of market places for goods (the distribution observed by Christaller) according to the nature of the demand for the goods. "Market areas need no longer be classified according to goods, therefore, but according to size. Goods whose necessary market areas are equal are included in one class. Because of their shape the areas of the same size lie in immediate contact with one another, and form a honeycomb network that covers the whole area."⁴² Figure 1 is the diagram Losch used to illustrate this arrangement.

³⁸ Audirac , 2005, 5

³⁹ Dent, 1992, 137

⁴⁰ Losch, 1954, 122

⁴¹ Losch, 1954, 122

⁴² Losch, 1954, 123

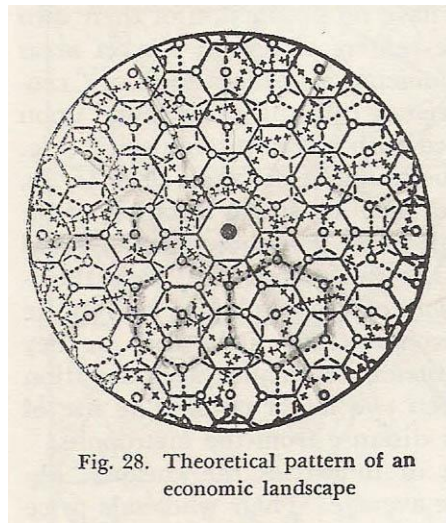


Figure 1 - Losch's Theoretical Landscape⁴³

Building on the work of Losch, Walter Isard, the American economist, studied the effect of population density on market hierarchies. "Perhaps the most serious deficiency of this Loschian construction is that it yields different sizes of concentrations of industrial activity and thus jobs at various production centers, and yet it postulates uniform distribution of consuming population."⁴⁴ His main addition to the Loschian network was that the shape of the market areas changed relative to the population densities within those areas. "Because Losch's construction implies a relatively high density of laborers and thus population at the core, the size of a market area in square kilometers necessary to generate sufficient demand for a commodity to justify production is much smaller at the core than at a great distance from the core."⁴⁵ This means that market areas for the same class of good (i.e. the same demand) are geographically smaller where there is a higher population density and larger where there is a lower density, thus including equivalent populations. He remarked that "at a great distance from the core, market areas must be much

⁴³ Losch, 1954

⁴⁴ Isard, 1956, 271

⁴⁵ Isard, 1956, 271

larger because not only are production sites and industrial population fewer in number but also, as a logical consequence of differential industrial population, agricultural activity is less intensive and agricultural population more sparse than in the immediate hinterland of the central city."⁴⁶

Figure 2 is Isard's variant of the Loschian landscape.

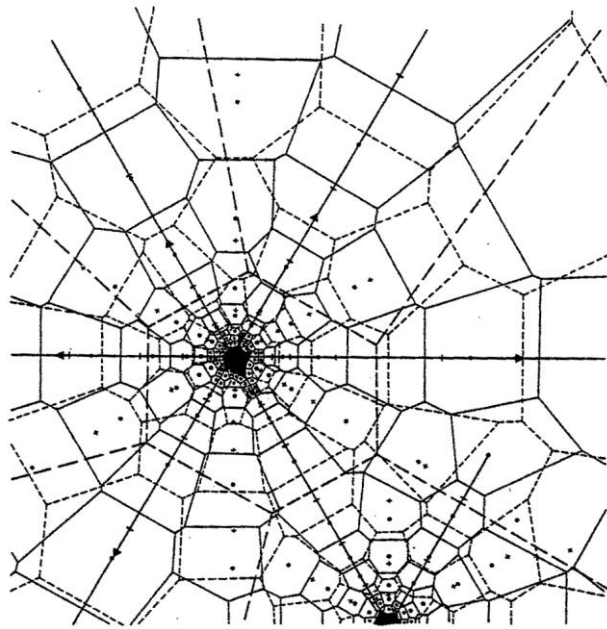


Figure 2 - Isard's Landscape of Varied Density⁴⁷

Economic geographers have since incorporated this fundamental theory in their description of economic activity across landscapes. Community economics texts as recently as 2004 still explain distribution networks in the framework of Central Place Theory. "The number of different economic (central) functions available differentiates places. The number of central functions performed depends directly on the cost structure of businesses and the population of the spatial economy."⁴⁸ Which good falls where in the hierarchy depends on the nature of the costs for that good. "Since costs vary among types of goods or services (i.e. central functions), some goods or services are available only in the higher-level places, while others are available in

⁴⁶ Isard, 1956, 271

⁴⁷ Isard, 1956

even the smallest places. There is a pattern of similarity between market size within a given hierarchical level and the differences between hierarchical levels."⁴⁹

The differences between the types of goods and services, especially their place in the hierarchy of markets is embodied in the concept of the Range of a Good. Brian Berry wrote one of the most fundamental explanations of how the range of a good relates to market size. "One important element in central place theory is the notion of the range of a good. This range marks out the zone or tributary area around a central place (urban center) from which persons travel to the center to purchase the good"⁵⁰ This range of the good is directly associated with the Threshold Population. "The definition and meaning of threshold populations as these populations are identified here is straightforward. Threshold population is the minimum population size of an urban center for the support of an urban function" . . . "that critical level of demand for a good that occasions its provision by an urban center. Below this critical level the diseconomies of scale are so great that the good may only be provided by some other more complex center."⁵¹

Threshold population operates both between small communities and within larger metropolitan regions. "In communities with high population density, the effective spatial market (i.e. range) can be small, whereas in rural areas the spatial market can be quite large."⁵² Within a community, the number of outlets in a market for a particular good increases with population – but as a geometric function, not an arithmetic one. "Specifically, two businesses require more than double the population required to support [only] one business. The first reason is that the number of people shopping at the second store will also shop part time at the first store; that is, there is no reason why one firm cannot service more people. A second reason is that the indivisibility of

⁴⁸ Shaffer, 2004, 70

⁴⁹ Shaffer, 2004, 70

⁵⁰ Berry, 1958, 305

⁵¹ Berry, 1958, 306

⁵² Shaffer, 2004, 274

the investment in a business prevents marginal adjustments until some critical market mass is reached and an additional firm appears."⁵³

The lesson of Mssrs. Christaller, Losch, and Isard is that the frequency of a market in space is a function of the number of people required to support that particular market and the concentration of people within space. Knowing this, Central Place Theory provides the most fruitful insight in explaining which markets can support businesses within the reach of those on foot and which can't. If a sufficient number of people can be placed with the reach of a category of market, then that business ought to be viable, and thereby durable.

1.4.2 Demand Threshold Analysis

Translating the structural implications of market distribution into practice, we can then look at how to apply the theory to analysis. Applications of Central Place Theory to these questions take the form of Demand Threshold Analysis. The textbook definition of Demand Threshold is "the minimum market required to support a particular good or service and still yield a normal profit for the merchant."⁵⁴ More technically, "the concept of demand threshold, based on the internal economies of the firm and the characteristics of consumer demand, is defined where average cost is just equal or tangent to average revenue. Because of this, demand thresholds are not absolute; they vary with the type of good or service."⁵⁵ For analysis purposes, the threshold is translated into a number of people, or threshold population. "Demand thresholds usually are measured in terms of population, rather than quantity sold, by assuming consumers are homogenous in their buying power (income) and tastes."⁵⁶

⁵³ Shaffer , 2004, 274

⁵⁴ Shaffer, 2004, 68

⁵⁵ Shaffer, 2004, 68

⁵⁶ Shaffer, 2004, 68

1.4.3 Applications of Demand Threshold Analysis

Demand threshold analysis continues to be used to study market dynamics in a number of circumstances. A 2007 study of the rural areas in the Southern United States found that the threshold population required to support a retail outlet was appreciably lower in rural areas than within metropolitan areas. "Every retail sector except Motor Vehicle & Parts Dealers exhibits higher demand threshold in [Metropolitan Statistical Area] regions than in a non-MSA regions. Conversely, results show that greater population is required to support higher numbers of establishments in non-MSA zip codes than in MSA zip codes."⁵⁷ They also found that a larger neighboring population correlated with a reduced number of retail outlets (that is, evidenced a larger threshold population,) independent of metropolitan status. "However, total population of neighboring areas has a negative effect on the number of establishments of the place in most retail sectors for both non-MSA and MSA. More people in a neighboring zip code reduce the number of retail establishment in one's own zip code"⁵⁸

Further studies in South Dakota confirm Berry's observations about the range of a good as recently as 2008. "The population required to support different businesses varies greatly. Full-service restaurants and insurance agencies have relatively low thresholds, while businesses like home centers, floor covering stores, and household appliance stores have high population thresholds."⁵⁹ South Dakota's cooperative extension service relies on Demand Threshold Analysis to make economic recommendations. "In rural South Dakota, retail threshold levels can be useful in determining which businesses are likely to survive, and which should be merged to maintain services in towns and counties with long-term population decline. Threshold levels can

⁵⁷ Hong, 2007,8

⁵⁸ Hong, 2007,9

⁵⁹ Khatiwada, 2008, 3

also be useful for deciding if a new enterprise has a good chance by itself, or if it might be beneficial to include a secondary enterprise."⁶⁰

Applications of Demand Threshold Analysis extend beyond rural areas, and into the internal workings of metropolitan areas. The provincial government of Ontario, Canada promulgates a demand threshold technique for analyzing central city opportunities for redevelopment. They explain that "the analysis will automatically divide the population of your market area by the threshold population for the particular activity - this will tell you the theoretical number of establishments of that type that should be supported by the population."⁶¹ Their technique then compares the market supplied with the market anticipated by the demand thresholds. They propose that "if there is a gap, then this may represent a retail or service opportunity for [revitalizing the area]."⁶²

Applying this common technique to pedestrian access should provide valuable information. If the structure of a market is known in the form of a Demand Threshold, then determining whether that business could be supported by a walking population becomes a matter of knowing if the population within walking range is large enough to meet the Demand Threshold. If it is, then the configuration is viable; if it is not, then the business will either fail (or fail to be located there in the first place,) or require customers from beyond the walking range to survive.⁶³

⁶⁰ Khatiwada, 2008, 3

⁶¹ Ontario, 2008, 7

⁶² Ontario, 2008, 7

1.5 Retail structure

1.5.1 Basic Retail Structure

Knowing how markets are distributed across a landscape of population, and how to analyze this distribution, it is then important to understand the forces that create a particular distribution. The internal workings of retail trade determine this distribution.

There is an essential business logic that permeates the business of retailing. Retail businesses have fixed, variable, and semi-fixed costs. Fixed costs, which do not change with the quantity of goods sold, are things like buildings, equipment, and utilities and mostly related to the size of the store. Variable costs increase with the quantity of goods sold, and are things like inventory costs and sales commissions. Semi-fixed costs increase in increments, and are comprised of things like labor. The goal of the industry is usually to keep all costs as low as possible relative to revenues by configuring the most efficient cost structure possible.⁶⁴

The business of retailing revolves around gross margin and inventory turnover. Gross margin is the sum of new sales minus the cost of goods sold, and is used to pay non-inventory operating expenses before a profit can be realized. Inventory turnover is the frequency with which the goods in the store are sold, usually expressed in the average number of times in a year that the inventory is sold. Of the four combinations of the two variables, low-margin / low-turnover businesses rarely survive long. Volume discounters depend on low-margins with high-turnovers (making them very turnover-sensitive.) Other structures, most notably convenience stores, are able to operate with high-margins and high-turnover. Their high-margins give them price flexibility (i.e. the ability to reduce margin) when they encounter competitive pressure.⁶⁵

⁶³ A third solution would be a subsidy to make up for the revenue of the missing customer base.

⁶⁴ Dunne, 1999, 112

⁶⁵ Dunne, 1999, 17

Most retailers operate close to the point where total revenues equal total expenses, called the break-even point. While some businesses, like general merchandise retailers have had historically higher gross margins (and thus lower break-even points,) some categories, most notably supermarkets, have very low gross margins, and thus even a modest drop in the volume of sales will render them unprofitable.⁶⁶ As margins decrease, then turnover must increase for the firm to remain profitable; alternately, as turnover decreases, then gross margin must increase.

In retailing, size and ability to compete in pricing have an inverse relationship. Small retailers, lacking volume purchasing power, usually are required to pay more for their inventory and have higher expenses in relation to sales (and thus a lower margin.) Even joining voluntary cooperative associations, small retailers have not been able to compete historically with the cost advantages of larger operations, forcing them to focus their competitive strategy on convenience and service rather than price.⁶⁷

1.5.2 Retail Location Factors

Retailers look at the income and demographics in their market area to try to determine the sales potential of a location. While inexact, this simple process has been summarized by the University of Texas, Arlington's Institute of Urban Studies:

"The average household income will help determine the level of disposable income in each of the trade areas. [. . .] The income level within the trade area can be derived from the census as well as information on how much is spent by family income ranges for categories of goods and services such as food, general merchandise, apparel, furniture and home furnishings, and automotive parts and accessories. Consumer expenditures can then be estimated from the purchasing

⁶⁶ Dunne, 1999, 119

power in each of the segments of the trade area. To approximate the total buying power in the trade area, the number of persons is multiplied by the average per capita expenditures for general merchandise and apparel. The sales potential of the trade area comes into focus when the number of expected customers is multiplied by average annual expenditures for consumer items."⁶⁸

When adding a new store to an existing market, analysts look at "capture rates," also called "penetration rates," to try and predict how much of that market will be "captured" by the new retail outlet. More important to the analysis here, another technique is to calculate the capture rate that would be required to make the location successful, and then determine if that rate is realistic.⁶⁹ This determination of "whether a projected capture rate is reasonable or excessive requires judgment based on experience and seasoned judgment. No hard and fast rules exist."⁷⁰ Each market is individual, and what may be a realistic assumption in one market may not be in another. The ULI's handbook for retail development reminds us that while "it may be appropriate for a well-conceived project in an underserved but dynamic market (with a growing number of income-qualified households or a surge in jobs) to assume a high capture rate. Just how high depends on the amount of competitive space coming on line at the same time. In contrast, a niche product serving a select group of potential customers will, under the best of circumstances, attract only a small share of demand and should assign a lower capture rate."⁷¹

1.5.3 Theoretical Retail Structure

The theoretical underpinning of retail structure is based on a number of well-respected sources. Harold Hotelling, the mathematical statistician and economic theorist, addressed

⁶⁷ Dunne, 1999, 360

⁶⁸ Goldstein, 1984, 4

⁶⁹ Kramer, 2004, 65

⁷⁰ Kramer, 2004, 66

⁷¹ Kramer, 2004, 66

distance effects in retail, with his observation that the willingness of customers to patronize a shop was directly affected by the distance that the shop was from the consumer. In a Hotelling model, travel time determines which outlet a customer will patronize. These models set all other factors (most notably price) equal, and use distance only to describe the behavior of the consumer.⁷²

David Huff at the University of Texas in Austin developed models of behavior based on the principle of gravity. These "gravity models" describe the attraction of location to their customer base. White and Gray describe the use of a gravity model this way:

"Gravity models are commonly used for convenience good retailers such as supermarkets and drugstores. The sales projections for these retailers are highly dependent on their proximity to a significant population base. The gravity model attempts to simulate a market place as it currently exists, measuring the density of individual trade area sectors, the sector's distance to competing stores, and the strength of the competition."⁷³

A gravity model expresses mathematically what Christaller and others found empirically, that at a certain distance a store becomes no longer attractive to consumers and they choose a closer option. Differences in the "attraction" of different categories set the distance that consumers are willing to travel (often measured in time rather than distance,) with a greater willingness to travel longer for higher-order goods than for lower-order goods. Equal "probability contours" can be used to determine market dimensions for competitors in different locations.⁷⁴

⁷² Bogart, 1998, 45

⁷³ White 1996, 125

⁷⁴ Dent, 1992, 389

Gravity models, by their nature, work best where factors other than location are equal. The weights used in gravity models are a proxy for other competitive pressures such as price, variety, format convenience, or level of service. Consumers are expected to weigh the relative locations of competing firms against whichever differences in the other factors that render one more competitive than the others. The concept of a market hierarchy is one way of combining the distance effects of Hotelling and Huff with the size-dependant observations of Christaller and Berry.

1.5.4 Retail Hierarchies

Moving beyond the theoretical literature and into the world of day-to-day business decision making, markets are classified in hierarchies. These classifications are essentially simplified ways to think about the concept of the range of a good that Berry and others identified. In *The Retail Environment*, Ken Jones and Jim Simmons explain that "at the lower end of the retail hierarchy a household can choose between several different centers of differing sizes within a daily travel distance and the centers becomes specialized to provide daily, weekly, or occasional shopping facilities." Also, echoing Losch and Christaller, they describe how "the larger centers serve extensive areas while small centers provide convenience goods for nearby residents,"⁷⁵ and that "consumers are attracted to shopping in a larger market because of the diversity and specialization that occur there."⁷⁶

The International Council of Shopping Centers (ICSC) classifies shopping centers into four broad categories. These are neighborhood centers, community centers, regional centers, and super-regional centers.⁷⁷ Each category has a corresponding trade area. "The primary trade

⁷⁵ Jones, 1990, 151

⁷⁶ Jones, 1990, 152

⁷⁷ Kramer, 2008, 9

area is the geographical area from which the retail center will derive its largest share of repeat sales. This area typically extends to 1.5 miles for a neighborhood center, three to five miles for a community center, and eight to 12 miles for a regional mall.” Associated with each center type is also a driving time for 70 to 80 percent of the regular customers, from five minutes for a neighborhood center to 30 minutes or more for a super-regional center.⁷⁸ Of the categories, the share of the market between them is not necessarily proportional. Super-regional centers, the “truly heavyweight shopping facilities,” take more sales in the region than even their large size would indicate.⁷⁹ More recently, a fifth classification, that of the “power center” has crept into ICSC definitions. “The ICSC defines a power center as a center 'dominated by several large anchors, including discount department stores, off-price retailers, warehouse clubs, or category killers.' Retail facilities known as category killers get their name from their focus on vast selection of goods and expertise at low prices.”⁸⁰

Each retail category carries with it a logic of market area and location. Supermarkets, for instance, are ideally sited away from regional or super-regional shopping centers, but sometimes next to a discount department store. Clear, convenient road access is seen as “essential because the store formats can generate from 20,000 to 40,000 trips per week.”⁸¹ Avoiding any business that could compete with the categories contained within, like a delicatessen or bakery, the modern supermarket is assumed to collect traffic from an area ranging from one to five miles, depending on the scale of the store itself. “For a traditional combo store (supermarket/pharmacy), a population of about 50,000 to 70,000 would be considered minimal, assuming standard competition.”⁸²

⁷⁸ Kramer, 2008, 51

⁷⁹ White, 1996, 58

⁸⁰ White, 1996, 56

⁸¹ White, 1996, 133

⁸² White, 1996, 133

Embedded within the structure of the retail hierarchy is the concept of economies of scale. An economy of scale is when an increase in firm size allows lower costs, thereby making either increased profits or lower prices possible. In the retail sector, economies of scale enabled by serving an increased number of customers allow “higher sales per store, more employees per store, and higher sales and wages per worker. Lower [cost] margins and greater profitability result in a fundamentally different operating environment” when these economies of scale can be brought into play.⁸³

One retailer in particular has become linked with this effect. The economies of scale that Wal-Mart has brought into retail have had a large impact across the industry. In comparison to their smaller-scale competitors, “Super Wal-Mart shopping centers have larger trade areas than grocery-anchored centers, often ten miles or more, more in line with the drawing areas of regional malls.”⁸⁴

1.5.5 Trends in retail structure

The trend in retail has been toward larger and more concentrated outlets. Attempting to take advantage of better transportation networks and efficiencies in the supply chain, “retailers counter their competition by expanding the size of their store to take advantage of economies of scale, or by becoming more specialized in a limited number of products or clientele.”⁸⁵ As of 1996, industry experts identified the major factors in the industry to be increasing concentration of the market, the expansion of low-price or “value” retailing, a larger variety of formats as traditional divisions break down, and an increased role for online and indirect shopping.⁸⁶ As part of these phenomena, the supermarket and drugstore have been expanding in scale.

⁸³ Jones, 1990, 152

⁸⁴ Kramer, 2004, 46

⁸⁵ Jones, 1990, 152

Beginning in 1920, the food retailing market underwent a long transition to one-stop shopping, acting on the observation that one large business is more efficient than two smaller businesses. By the 1960s, this market would transform into the high-volume, large, self-service, departmentalized, cash-and-carry supermarket where customers could purchase all of their food needs at one store. To this day, volume and completeness (i.e. economies of scale and economies of scope) are the bywords of modern food retailing. Between 1920 and 1970 the number of grocery stores in the U.S. fell by 44.5 percent, while the number of items carried in them increased by 1014.3 percent.⁸⁷

Increases in store scale have had an accompanying effect on the place outlets occupy in market hierarchies. "The emergence of the supermarket or super drugstore and the efficiency of large gasoline stations require substantial locational adjustments. Fewer but larger outlets are needed and each outlet requires access to a larger market." In order to access this larger market as the categories move up in the hierarchy, "an accessible site on an arterial road with a high traffic volume replaces the corner store within the residential neighborhood."⁸⁸

In addition to the changes in the supermarket and drugstore categories, there has also been substantial growth in large-format discount categories. "These are categories that did not exist until the early 1980s and now represent reasonably significant numbers - particularly in the power center category. Power center space - much of which has been developed in conjunction with the expansion of Wal-Mart, surely *the* retailing phenomenon of the last decade or two - now represents [as of 1996] approximately 2% of all shopping center space."⁸⁹ The enlargement of existing categories, as well as the emergence of new and larger-scale categories, is the culmination of a steady increase in store size that has been ongoing since the 1930s. "The initial

⁸⁶ White, 1996, 71

⁸⁷ Peak, 1977, 14

⁸⁸ Jones, 1990, 262

impetus to increase store size derived from the very nature of the independent retail enterprise. As real income levels increased overall, the merchant also demanded a higher rate of return, hence more sales, and this could be accomplished by modest investments in technology, such as cash registers and self-service, when accompanied by greater customer mobility."⁹⁰

These forces have continued to operate in many retail sectors. Jones and Simmons describe the process this way: "Scale economies in supermarkets and in gas stations are well documented. The prerequisites include (1) customer willingness to travel, (2) a production function that permits labor saving or deskilling, and (3) inexpensive real estate By assembling a large number of customers and minimizing the amount of internal competition, [larger stores] defined a cost curve that forced other stores, even independents, to respond."⁹¹

As the scale of retailing increases, ownership also concentrates into ever-fewer hands. "Too many" shopping centers give way to a lesser number of outlets owned by a smaller number of owners.⁹² In the food retailing market in particular, the fundamental structure of the enterprise has changed: "Today's modern supermarkets offering banking, fast food, floral arrangements, and pharmaceuticals are also a breed of category killers. These retailers have begun to make their presence felt as they divert business away from the more traditional outlets such as general merchandise and the old-fashioned grocery stores; more than 40,000 such stores have closed since the mid-1980s."⁹³

The changes within the retail sector can be seen as just part of a larger process of change throughout the entire society as traditional hierarchies in the city break down. Smaller

⁸⁹ White 1996, 57

⁹⁰ Jones, 1990, 263

⁹¹ Jones, 1990, 263

⁹² White 1996, 71

⁹³ Dunne, 1999, 9

shops increasingly give way to ever-larger ones, school populations spread over increasingly larger areas, regulations overlap and daily life grows into multiple jurisdictions, and accepted patterns of living and working change.⁹⁴

1.6 Summary

In summary, a large part of what makes a neighborhood "walkable" is access to goods and services by walking. A community that provides this access in a consistent, durable way could yield economic, environmental, and health benefits. While it has been given much attention, there is no authoritative consensus on how a neighborhood that provided pedestrian access to the needs of daily life would be structured. The retail outlets that would provide the goods and service to be accessed will follow the hierarchical structure of Central Place Theory, and locate in relation to the number of population that can access them.⁹⁵ To each kind of retail outlet corresponds a number of people, or Demand Threshold, that gives it enough of a customer base to survive. This Demand Threshold is determined, not arbitrarily, but by the internal costs and consumer demand structure of the particular retail market that the business operates within. These demand thresholds have been increasing over time as economies of scale encourage retailers to become ever larger. We turn next to using the Demand Thresholds of a particular market, Dallas County, Texas, to determine what kind of population density structure would be required to support pedestrian access to goods and services.

⁹⁴ Friedman, 2002, 100

⁹⁵ A critique of Central Place Theory is that it makes no accommodation for agglomeration economy effects. While a valid critique, agglomeration economies tend to occur with higher-order goods, and as the daily needs of life are almost by definition lower-order, the structure of the Central Place should be valid for this enterprise.

CHAPTER 2
METHODOLOGY
2.1 Basic Method

2.1.1 Adapted Threshold Demand Analysis

To determine what kind of configuration places a population within walking distance of their daily needs, we will proceed to analysis. Generally, the analysis method used to study the issue will be an adapted Threshold Demand Analysis. The first step will be to determine the threshold population required to maintain the retail outlet. This is the total number of people that the market structure requires to make the business viable. The second will be to set the number of the store's patrons that will be able to walk. This is the portion of the threshold population that is within walking distance of the store. This constitutes the "walkable" population. Of note is that it is not important to this study whether the patrons within the "walkable" population choose to walk, bicycle, or drive to the store, only that they are able to walk if they desire. The remainder of the threshold population will be assumed to be made up of patrons driving in from a farther distance away. This "drivable" population will allow analysis to be done without the artificial limits of a walking population only. The third step will be to use the model to determine (essentially through geometry) the required population density (in persons per square mile) needed to meet the selected portion of the threshold population within the determined walking distance.

2.1.2 Market Area Shape

The assumed shape of market area could take several forms. Classic Loschian market areas analysis assumed hexagonal market areas:

"The average demand in the small circle is obviously greater than in any polygon of equal area. But because circles leave empty corners, the demand per unit of

the entire area in the case of the hexagon exceeds not only that of a square and a triangle, but even that of a circle. In other words, among all the possibilities of realizing the same total demand, the most land is required with a triangle, and the least with a regular hexagon. *The honeycomb is therefore the most advantageous shape for economic regions.*"⁹⁶

Isard's work explored the characteristics of other shapes, notably curvilinear nested shapes and triangular nets.⁹⁷ Ardeshir Anjomani at the University of Texas, Arlington and others have studied transportation network effects and the resulting diamond shapes of the market areas that grids of street transportation tend to create.⁹⁸ For this study the areas selected will be the hexagons of the Loschian honeycomb, as they nest well together, are a familiar shape for analysis, and more nearly approximate the circular area accessible to a pedestrian if there were no buildings and infrastructure to be contended with.

2.1.3 Density Units

The unit most commonly used throughout the analysis will be persons-per-square-mile (ppm2.) This is a unit of average density, and records how many people would fit into a square mile if the density of the area in question were extended over an area exactly that size. It is important to note that when dealing with areas of less than a mile square, the ppm2 densities will be larger than the actual required population. For example, if 20,000 people were to be housed in an area one-half mile by one-half mile (which would be an area of 0.25 square miles) then their density would be 80,000 ppm2. There would still be only 20,000 people in the area, but they would be bundled into a configuration that, if extended over an area one mile long and one mile wide, could house 80,000 people. The use of the consistent unit allows comparison of population

⁹⁶ Losch, 1954, 112

⁹⁷ Isard, 1956

⁹⁸ Anjomani, 2008

density across areas of differing sizes in a uniform way. The calculated densities will be per gross area, with any area devoted streets and open space included in the number; this allows density requirements to be discussed independent of a particular urban configuration.

2.2 Partial walkability

To extend the possible range of analysis, a method for supplementing threshold populations from beyond the range considered “walkable” will be included. This reflects assessments by Bernick, Cervero, and others that it may be realistic to assume that a wider range of population is required to make retail viable.⁹⁹ The hexagonal area determined for walking will be calculated by setting the radius of the hexagon (the distance from the centroid to the farthest part away) at the determined maximum walking distance. The area of the driving hexagon will be set by taking the remainder of the population required to meet the demand threshold, multiplying that population by the assumed density in "drivable" areas, and then calculating the required radius of a hexagon that will include the area required after subtracting the area classified as "walkable" (in the center of the hexagon.) While there are a number of possible ways to set the assumed density for "drivable" areas, the number used will be the average population per square mile in the City of Dallas in the 2000 census. Figure 3 illustrates pictorially how the walking and driving populations combine to make a single population.

⁹⁹ Bernick, 1996, 87; Audirac, 2005, 2

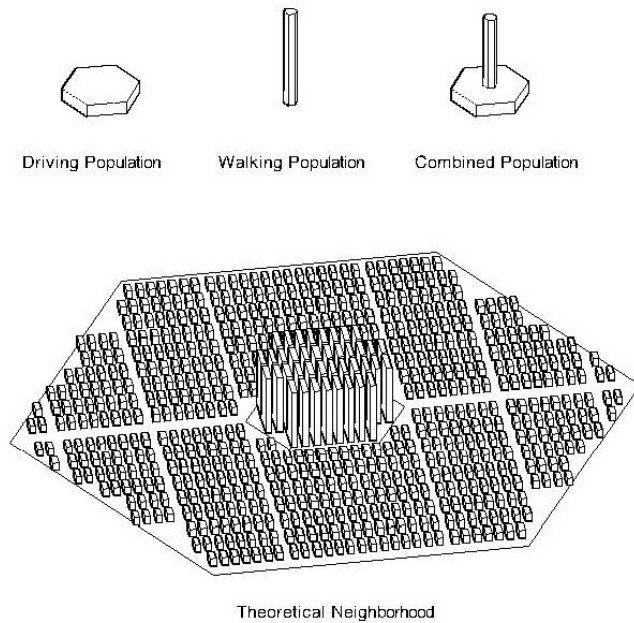


Figure 3 - Illustration of Combined Market Areas

2.3 Existing density in Texas cities

In Texas, (overall) population density in towns and cities ranged from a handful through 11,911 people per square mile at the "place" level in the 2000 census. However, towns and cities with more than 10,000 inhabitants vary less, and break into a few broad (but closely spaced) density categories by size. For all towns and cities in the 2000 census enumeration, the mean of place-level densities weighted by population is 2270.90; that is to say, the average Texan lives in a city with a population density of around 2270 persons-per-square-mile.¹⁰⁰ Figure 4 shows the distribution of Texans at place-level densities, and Figure 5 the distribution of the places themselves by density. For the purposes of the analysis of the Dallas County market, the 2000 census density of the City of Dallas, which was 3469 ppm2, will be used as the "background" density for the driving population.

¹⁰⁰ Pope, 2009

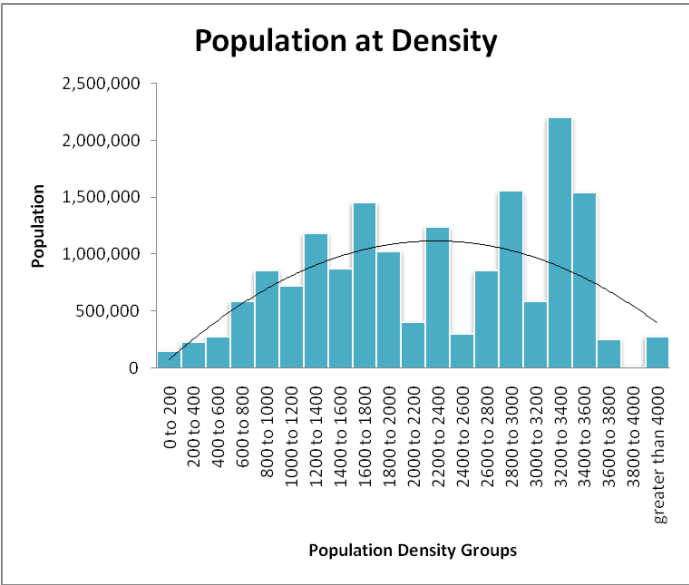


Figure 4 - Distribution of Place-level Density¹⁰¹

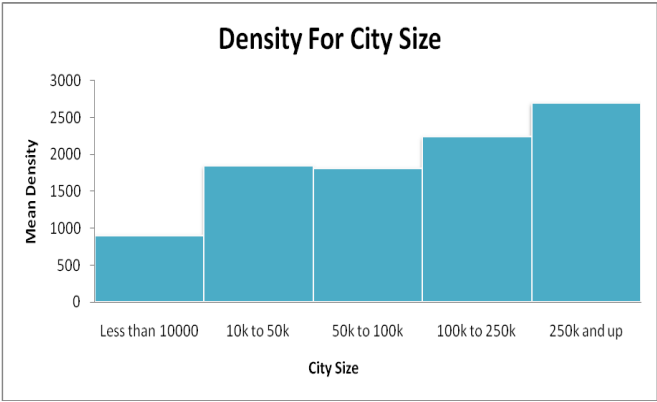


Figure 5 - Mean Densities of Texas Cities by Size¹⁰²

To establish the City of Dallas and greater Dallas County in context, it is useful to know the limits of localized density in the state of Texas. Texas has vast tracts of near-uninhabited

¹⁰¹ Analysis of 2000 US Census Data

¹⁰² Pope, 2009

agricultural land, but Texas also has a number of truly large metropolitan areas. Density at the tract level varies more than at the place level, recording pockets of concentration within the area of some of the larger cities. The maximum population densities in the state are to be found in these urban areas, and of the census tracts with the highest population densities in the state, seven of the top ten are to be found in Dallas County. Table 1 records the twenty highest density census tracts in Texas in the 2000 census. Of the fifty densest tracts in the state, forty-nine have a density greater than 4000 persons per square mile.

Table 1 - 20 Highest Density Census Tracts in Texas¹⁰³

Census Tract	Population	Density Per Square Mile
CT007818, Dallas Cnty, TX	8,358	57,710
CT007202, Dallas Cnty, TX	11,739	32,708
CT421400, Harris Cnty, TX	15,345	32,563
CT311600, Harris Cnty, TX	7,407	31,332
CT019209, Dallas Cnty, TX	10,046	25,787
CT009804, Dallas Cnty, TX	9,789	23,120
CT421200, Harris Cnty, TX	10,269	22,860
CT007201, Dallas Cnty, TX	11,680	20,899
CT014114, Dallas Cnty, TX	2,657	20,330
CT018503, Dallas Cnty, TX	4,922	19,780
CT210100, Harris Cnty, TX	5,537	19,697
CT000604, Travis Cnty, TX	5,529	19,650
CT322000, Harris Cnty, TX	6,373	19,583
CT000900, Dallas Cnty, TX	7,982	18,177
CT002315, Travis Cnty, TX	3,779	17,644
CT002316, Travis Cnty, TX	4,797	17,361
CT000603, Travis Cnty, TX	5,215	17,315
CT013711, Dallas Cnty, TX	3,675	17,349
CT433500, Harris Cnty, TX	14,815	17,155
CT001503, Dallas Cnty, TX	4,183	17,003
CT000601, Dallas Cnty, TX	9,593	16,879

¹⁰³ 2000 US Census data from SimplyMap server

Returning to Dallas County specifically, density information is also available on the block group level (as distinct from place-level or tract-level information above.) Taking all of the block groups in the county, and weighting them by their resident population¹⁰⁴, it is possible to determine the distribution of population by density of living environment within the County (see Table 2, Table 3, and Figure 6) Descriptive statistics tell us that (with the population density in the tract considered the value, and the total number of citizens serving as 'n'¹⁰⁵) the mean density among the population is 7421 ppm2, and the median density is 5256 ppm2. This is to say that one-half of the residents live at a density greater than 5256 and one half below, while weighting high and low-density areas by their resident population means that the "average" Dallas County resident lives at a population density of 7421 ppm2.

¹⁰⁴ That is, mean and median are determined for the population, not the area. The technique is to set every person in the enumeration as a sample, with the density of their block group as a value. This allows distribution to be determined for population, not geography.

¹⁰⁵ As the exact location of each person in the county is not available, knowing how many people live in block groups of a certain density gives an indication of what the environment is like. This technique can distinguish between a population concentrated in a small area surrounded by open space (i.e living densely) and a population spread uniformly throughout a large area (i.e. living sparsely,) in areas of identical average densities. This gives a more accurate picture of the living configuration than the other levels of data.

Table 2 - Weighted Density in Dallas County¹⁰⁶

Dallas County	
Total Population	2,218,899
Number of Block Groups	1681
Maximum Density	76061.43
Minimum Density	0
Density Range	76061.43
Mean Density	7421
Median Density	5255.88
Variance	65855903
Standard Deviation	8115.16
Standard Error	5.45

Densities in Persons per Square Mile

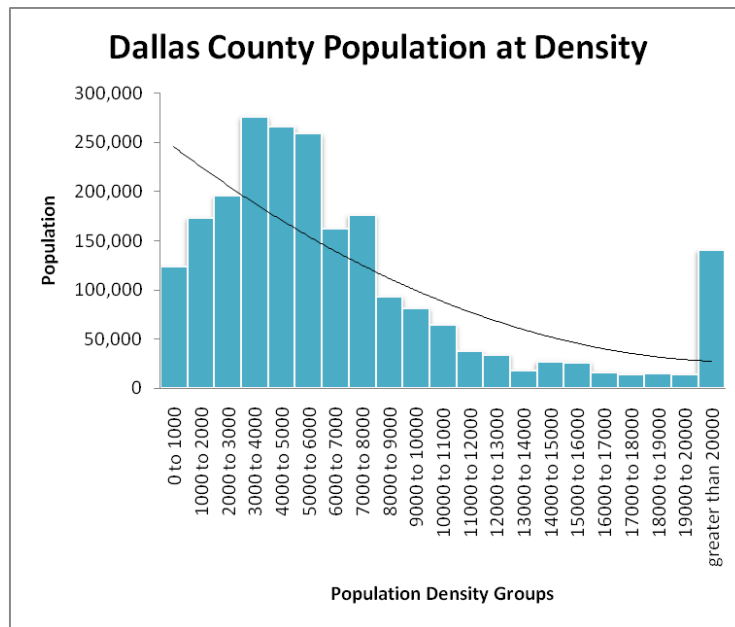


Figure 6 – Distribution by Block Group Density¹⁰⁷

¹⁰⁶ Analysis of 2000 US Census data

¹⁰⁷ Analysis of 2000 US Census data

Table 3- Population Distribution in Dallas County Block Groups¹⁰⁸
Population Distribution in Dallas County Block Groups, per 2000 Census

Density Group	Frequencies		
	Number of Block Groups	Population	% Pop
0 to 1000	112	124,116	5.59%
1000 to 2000	135	173,673	7.83%
2000 to 3000	161	196,051	8.84%
3000 to 4000	233	276,544	12.46%
4000 to 5000	220	266,760	12.02%
5000 to 6000	205	259,107	11.68%
6000 to 7000	131	162,226	7.31%
7000 to 8000	125	176,512	7.95%
8000 to 9000	74	93,507	4.21%
9000 to 10000	61	81,309	3.66%
10000 to 11000	39	64,316	2.90%
11000 to 12000	23	37,695	1.70%
12000 to 13000	22	34,299	1.55%
13000 to 14000	12	17,981	0.81%
14000 to 15000	19	27,388	1.23%
15000 to 16000	13	26,603	1.20%
16000 to 17000	9	16,717	0.75%
17000 to 18000	8	14,691	0.66%
18000 to 19000	10	14,843	0.67%
19000 to 20000	7	14,005	0.63%
greater than 20000	62	140,556	6.33%
Totals	1681	2,218,899	100.00%

¹⁰⁸ Analysis of 2000 US Census data

2.4 Market being studied

With the general structure in place, it becomes important to define exactly which retail market will be studied. Defining the “daily needs” of the community from the standpoint of retail is potentially complex. Behaviors and patronage vary from individual to individual and have been shown to vary somewhat from city to city and across socio-economic categories. However, the entire population does have a need for food and, barring unusual circumstances, will need to engage the grocery category of retail frequently. In fact, in 2004, 85 percent of households shopped for groceries at least once in an average week.¹⁰⁹ Looking at spending in the same year, of the categories on which Americans spent their income, the list was topped by taxes (for Social Security,) vehicle purchases, and then groceries. The only other retail category in the top ten was gasoline and motor oil.¹¹⁰ Groceries are also a very frequent purchase; in 1996, shoppers visited a supermarket an average of 2.1 times a week.¹¹¹

For the purposes of this investigation, then, analysis will concentrate on access to NAICS code 4451 Grocery Stores (see below,) defined as “establishments primarily engaged in retailing a general line of food products,” and specifically code 445110, which comprises all of the establishments in 4451 with the exception of 44512 “convenience stores.”¹¹² This basic category should be able to serve as a general, common, and fruitful proxy for “daily needs” for the purposes of this investigation.

¹⁰⁹ New Strategist, 2006, 18

¹¹⁰ New Strategist, 2006, 276

¹¹¹ Gutierrez, 1997, 44

¹¹² US Census Bureau, 2007

2.5 Origin of data

2.5.1 NAICS Classifications

The North American Industry Classification System is used by the U.S. Federal government to sort commercial activity by type. For assigning a code, the Census Bureau says that: "In the process of collecting, tabulating, presenting, and analyzing statistical data, the U.S. Census Bureau assigns and maintains only one NAICS code for each establishment based on its primary activity (generally the activity that generates the most revenue for the establishment)."¹¹³ Much of the data used for analysis will be taken from NAICS code classifications.

The code used to analyze the grocery market will be 445110 (which is identical to 44511.) Classification 445110 Supermarkets and Other Grocery (except Convenience) Stores is defined as "establishments generally known as supermarkets and grocery stores primarily engaged in retailing a general line of food, such as canned and frozen foods; fresh fruits and vegetables; and fresh and prepared meats, fish, and poultry. Included in this industry are delicatessen-type establishments primarily engaged in retailing a general line of food."¹¹⁴

This category includes all establishments that primarily sell food, with the exception of those in 445120 Convenience Stores, which is defined as "establishments known as convenience stores or food marts (except those with fuel pumps) primarily engaged in retailing a limited line of goods that generally includes milk, bread, soda, and snacks."¹¹⁵ The convenience market has traditionally been seen as a different category by the food retailing industry, as they generally do not sell fresh produce or meat, and 60 percent of convenience store sales come

¹¹³ US Census Bureau, 2007

¹¹⁴ US Census Bureau, 2007

¹¹⁵ US Census Bureau, 2007

from tobacco, beer, soft drinks, milk, magazines, and newspapers alone.¹¹⁶ The limitation of the goods offered in 445120 preclude their inclusion in “daily needs,” and leave the analysis to 445110.

2.5.2 Walking distance

To establish what is "walkable," the appropriate distance travelled will need to be determined. The origin of the values used for walking distance will be taken from studies in the literature of the behavior of pedestrians. "The old transit industry standard that transit users will walk a quarter mile, or five minutes at three miles per hour, to a bus stop is better than we might have guessed. If we convert reported walk times from the 1990 Nationwide Personal Transportation Survey (NPTS) into distances, and plot and smooth the resulting frequency curve, the median walking distance to and from transit stops is almost exactly a quarter mile."¹¹⁷

2.5.3 Market capture assumptions

The data used in the analysis will be taken from existing metropolitan retail data, either existing or anticipated. As such, market share captured by an individual retail outlet will be assumed to be the same as it is (or is anticipated to be) within the market of the data source. For the retailer requirements and ICSC rules-of-thumb, the required population is simply as stated, with the capture rate anticipated by the retailer or ICSC built in. For the empirical data, the population required is that required as the market currently is, with each store capturing an equivalent part of the population (and thus its turnover,) to what it did when the data was collected. This procedure takes much of the guesswork out of actual market performance, and is therefore felt to be a reasonable predictor. Differences of market capture, along with differences in household income and any other number of factors, may affect the thresholds to an extent in specific situations.

¹¹⁶ Marion, 1979, 58

2.5.4 Person-share

For the purposes of this exercise, one person will be deemed to be like another in their grocery buying behavior. While in practice the grocery purchases of the population vary across income, age, and occupational lines, this level of granularity is beyond the scope of the present project. A person-share of the grocery market will be assigned as uniform for determination of population density, with the hope that future work can study the density implications of different populations on metropolitan grocery configurations.

2.6 Spreadsheet format

The density analysis will be done using an excel spreadsheet. This spreadsheet will calculate the required population density to satisfy demand threshold requirements within the areas defined for walking and driving. All distance values used will be in linear or square miles as appropriate, and all population values will be in numbers of persons (as opposed to thousands of people or something else.) The values input into the analysis will be: 1) The area of a hexagon defined in relationship to its radius, with the radius defined as the point furthest from the centroid of the polygon. This is a simple geometric constant. 2) The distance defined as maximum for walking. This will be taken from the literature and can vary from analysis scenario to analysis scenario if required or can be left constant across all scenarios. 3) The demand threshold required of the business in question. This comes from one of the specific data sources calculated in detail as outlined below. 4) The walking-to-driving ratio. This is the portion of the demand threshold that falls within the walking hexagon. This number is used to set the driving spacing from the remainder population not served by walking. For example, a walking ratio of 80 percent would assign 80 percent of the required threshold population to the walking area and 20 percent outside of the walking area.

¹¹⁷ Ewing, 1999, 5

Also included for comparison will be calculations of Dwelling Units per Acre and Floor-Area-Ratio (FAR.) While not instrumental in this study, these figures are often used in the literature, and allow comparisons to be made with the tables calculated for persons per square mile. To facilitate these calculations, the input will also include 5) Household Size, which will be arbitrarily set at three, 6) Housing Area Per Person, arbitrarily set at 400 square feet, and 7) net-to-gross area ratio (as the units / acre calculation will be per area with streets and infrastructure removed;) this will be arbitrarily set at 80 percent. To evaluate a specific proposal expressed in units / acre or FAR, these values could be modified as necessary.

The basic equations used are:

Walking Density = Walking Population / Walk Area

Walking Population = Total (threshold) Population X Walking Ratio

Driving Population = Total (threshold) Population X (1 – Walking Ratio)

Walk Area = Walk Distance Squared X Area of Hexagon (constant)

Radius for Driving (spacing) = Square Root of (quantity of Driving Population / Mean Density + Walk Area all divided by Area of Hexagon (constant))

The output of the spreadsheet will be in calculated values, with required density-per-square-mile of the walkable area, radius of the driving population from the center, and percent of the threshold supplied by a particular area.

2.7 Specific methods of analysis

2.7.1 Data Source One: Rule-of-Thumb Numbers

Five sources of data will be used to determine the appropriate demand threshold. These will be industry rules-of-thumb, the population requirements listed on specific retailer websites, the NAICS code category count from the 2007 U.S. Economic Census, historical market-share

data from the cites in the region, and detailed market-share numbers from a proprietary database of 2008 data.

The first and simplest method of analysis will be the International Council of Shopping Centers' broad classification of market areas for a given type of shopping center. There is a wealth of general literature describing roughly the population apportioned to a "neighborhood" or "regional" shopping center. The numbers will be taken from Jones and Simmons *The Retail Environment*¹¹⁸ and White and Gray *Shopping Centers and Other Retail Properties*¹¹⁹ These general handbook numbers will be fed into the model to determine the required population density. Figure 7 illustrates the concept.

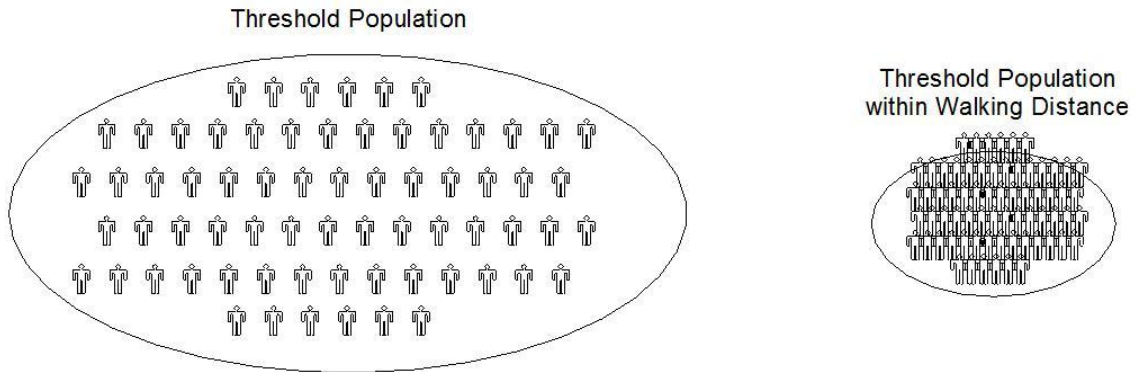


Figure 7 - Concentration of Threshold Population

2.7.2 Data Source Two: Retailer Website Requirements

A second method of analysis will be using the population requirements listed by supermarket retailers themselves as requirements for location. Taken from retailer websites, these list the population required in the area to consider locating an outlet there. Two companies' requirements will be used: the Aldi grocery chain and the Save-a-Lot grocery chain. Both of these companies list a target population as the minimum base to consider opening a store in a

¹¹⁸ Jones, 1990

¹¹⁹ White, 1996

location. These specific numbers will be fed into the model to determine required population density based on the individual companies' claimed requirements.

2.7.3 Data Source Three: Empirical Demand Thresholds

The third method of analysis will be a simplified demand threshold determination based on outlets per population. The number of retail outlets classified as NAICS code 445110 in the 2007 economic census in Dallas County will be collected, and then divided by the contemporary population of Dallas County. This will give an absolute population-per-outlet number, which constitutes an effective demand threshold to include in the model. Figure 8 illustrates the technique.

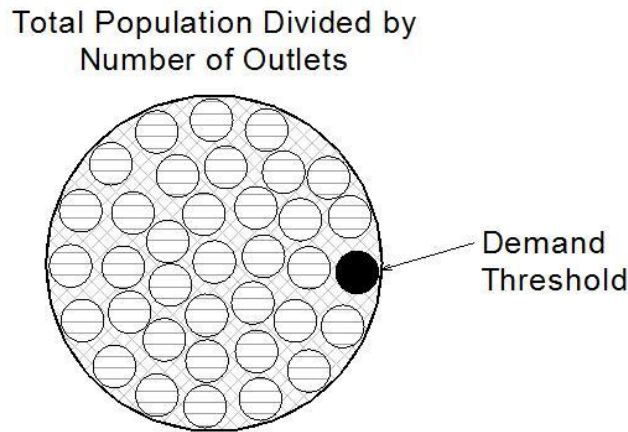


Figure 8 - Basic Demand Threshold

2.7.4 Data Source Four: Regional Supermarket Numbers

The fourth method of analysis uses collected sales data from supermarkets in Southern plains regional cities to determine the appropriate market threshold. Fairchild Publications' *Distribution Study of Grocery Store Sales*¹²⁰ records the sales volume of groceries in major cities throughout the U.S. While this data is from 1987, it provides both regional and historical context, as well as being one of the more comprehensive available sources. The cities (and their

metropolitan areas) used for this analysis will be Dallas, Fort Worth/Arlington, Houston, Austin, San Antonio and Oklahoma City. The way the data is recorded, "Leading Chains", "Leading Independents", and "Other" are recorded along with number of stores and percent of market share by each; often the data are not complete to 100 percent, with the remainder of sales distributed to other unrecorded outlets. Of particular use in this source, the "convenience" market is tabulated separately (with number of outlets left out,) and just the major supermarkets share of the overall grocery market is recorded. From this data, the portion of the market (in a dollars-spent sense) can be ascertained, and the number of outlets serving that portion of the market can be counted. As the number of people at the time in the MSA is known, and the percent of the grocery sales spent at the number of recorded outlets is known, then the percentage of grocery spending per outlet can be multiplied by the total population served (setting, for analysis sake, all people to an equal amount of grocery spending) to get the number of people served by each outlet. This "person-share" analysis, while not necessarily the same as actual spending habits (every person does not do 100 percent of their shopping in an assigned place) nevertheless gives a good idea of the number of people required per grocery outlet. An illustration of this technique is Figure 9.

¹²⁰ Fairchild, 1989

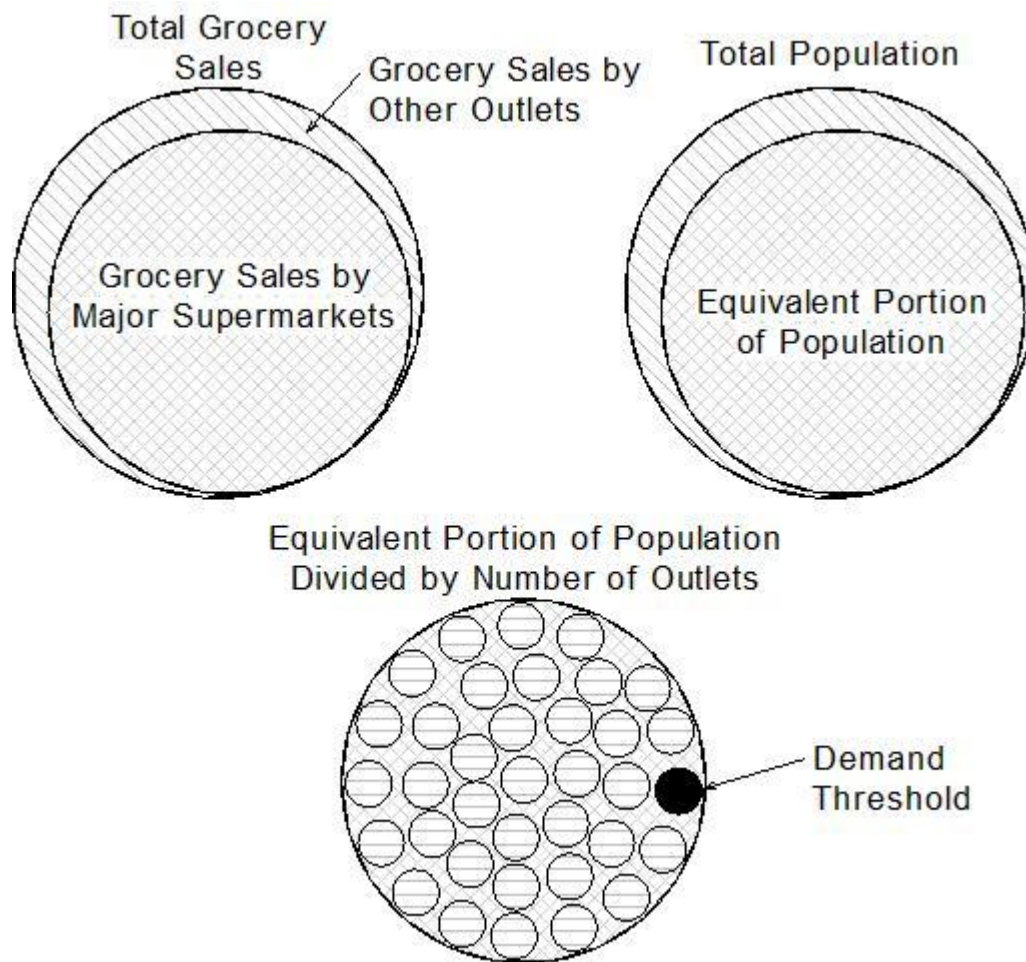


Figure 9 - Threshold Determined by Market Share

2.7.5 Data Source Five: Dallas County 2008 Numbers - ESRI

The fifth and most detailed method analysis uses 2008 sales data from grocery stores in Dallas County. The Environmental Systems Research Institute's (ESRI) Business Analyst database contains sales data for businesses by NAICS code classification. These numbers will be used for Dallas County, and limited to NAICS code 445110. The location-specific sales numbers reveal a phenomenon of grocery retailing today: While there are a total of 512 grocery outlets in Dallas County, more than 93 percent of the sales volume in the county is conducted at only 169 locations (refer to Figure 10 and Figure 11 below.) While overall threshold numbers can

be calculated similar to the more general NAICS data discussed previously, this data set provides an opportunity for a more detailed, and perhaps more realistic calculation. Taking the larger outlets that comprise the lion's share of the sales only, a portion of the population can be apportioned to these outlets (using the same technique as the regional data) to give a population threshold for these larger, one could almost say "normal" outlets. Figure 12 diagrams the method.

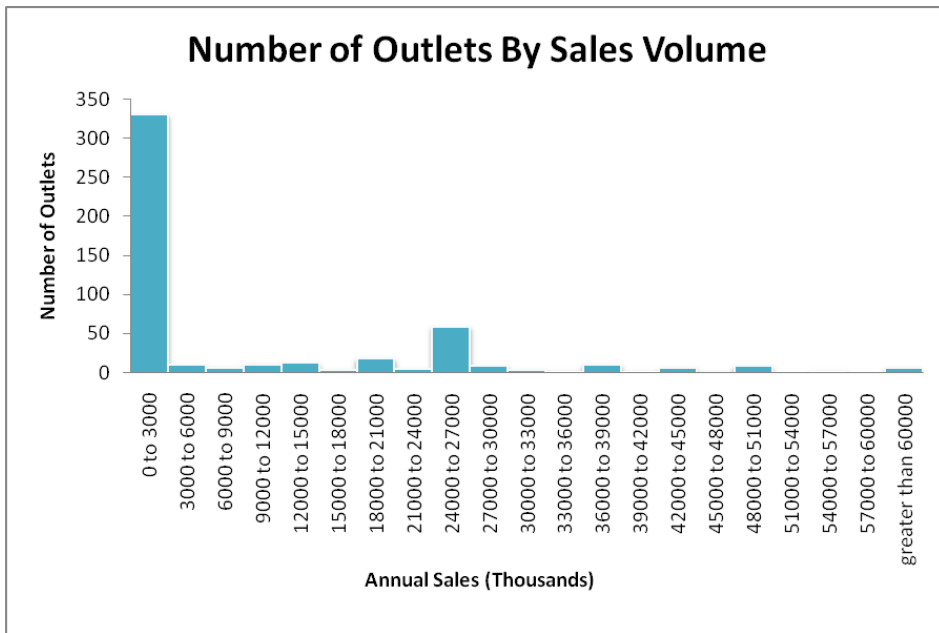


Figure 10 - 445110 Outlets by Sales Volume¹²¹

¹²¹ Analysis of data from 2009 ESRI Business Analyst package, courtesy of Institute of Urban Studies, UT Arlington

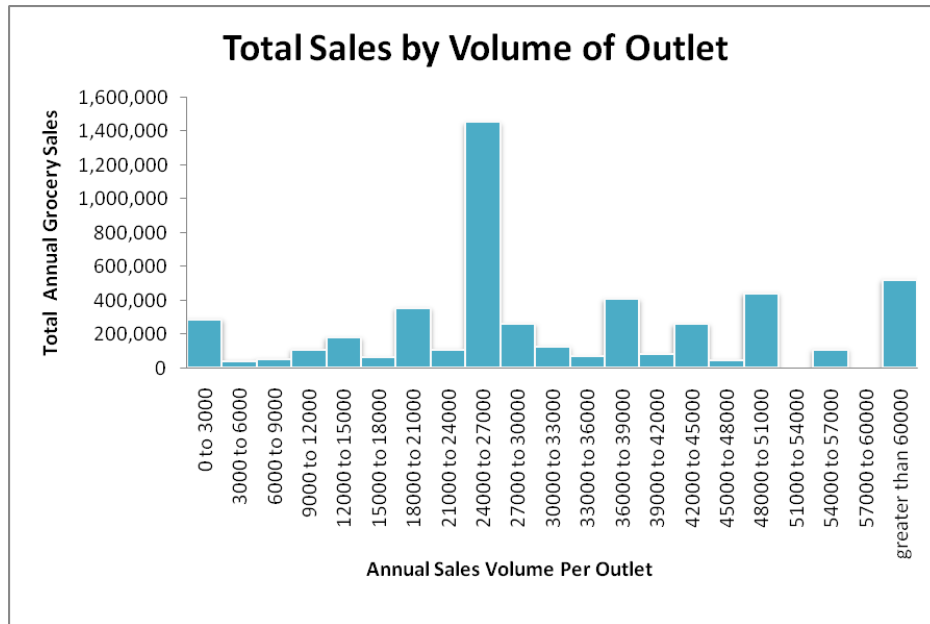


Figure 11 - Total 445110 Sales by Volume of Outlet¹²²

¹²² Analysis of data from 2009 ESRI Business Analyst package, courtesy of Institute of Urban Studies, UT Arlington

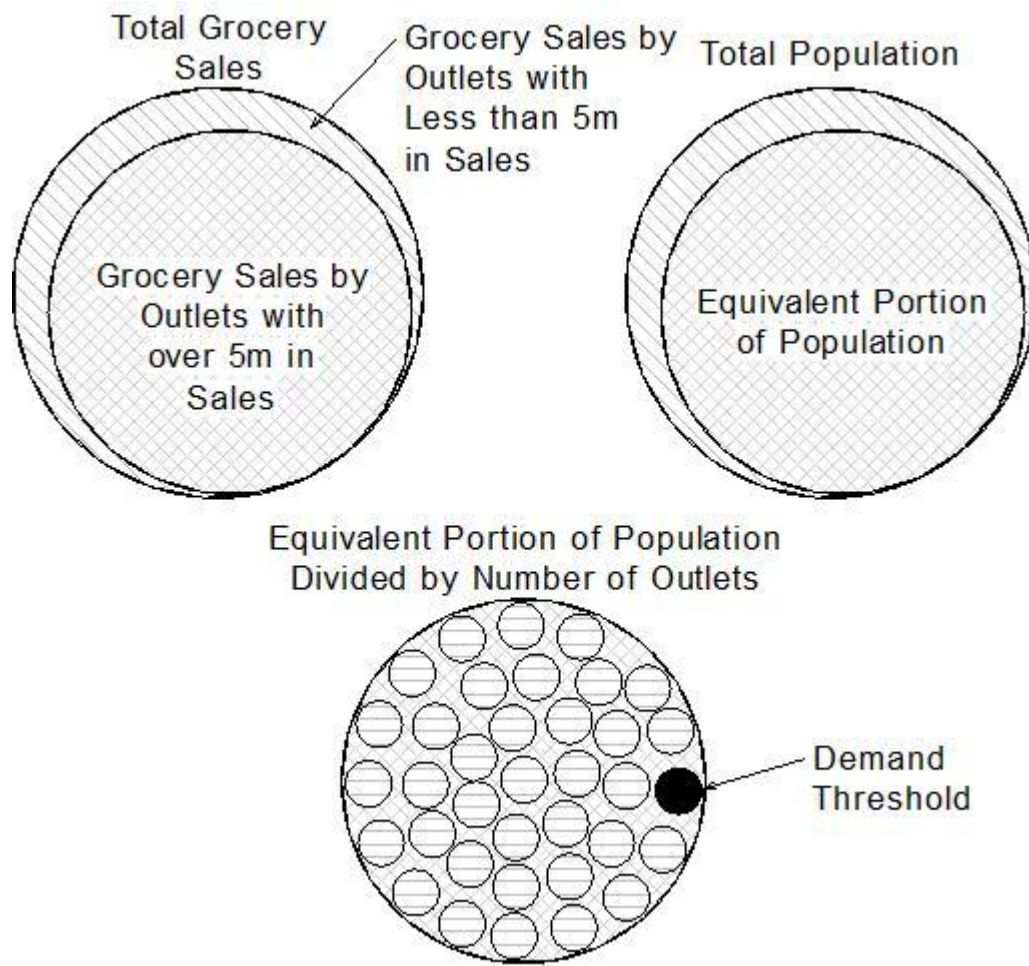


Figure 12 - Demand Threshold Determined by Sales Data

CHAPTER 3

ANALYSIS

3.1 Data source one: Rule-of-thumb numbers

For the numerical analysis, we begin with the simplest of the five sources, the rule-of-thumb numbers. The International Council of Shopping Centers defines a "Neighborhood Center" as "probably anchored by a supermarket" and serving a population of 2,500 to 40,000 living within 1.5 miles.¹²³ There are a number of variables that can be included in the analysis: If the Supermarket threshold is defined at the minimum of 2,500 people, and 100 percent of the threshold population is set to be within walking distance, then required population densities vary from 3,849 persons-per-square-mile for one-half mile walking distance to 15,396 persons-per-square-mile (ppm2) for a one-quarter mile distance. The maximum population number of 40,000 people per center, once again set at 100 percent walkable, varies from a required density of 61,583 ppm2 at one-half mile to an astounding 246,334 ppm2 for a maximum walking distance of one-quarter mile. This means that, to place the 40,000 person maximum rule-of-thumb for a neighborhood center within one-quarter mile of the center, the average population density for that area would need to be over 200,000 people per square mile. Relaxing the walkability standards to 50 percent within the walking range, the density requirements range from 1,924 ppm2 with a threshold of 2,500 and a walking distance of one-half mile up to 123,167 ppm2 with the higher threshold of 40,000 and the lower walking distance of one-quarter mile. This means that, if half of the rule-of-thumb population is within walking distance of the center, it depends on both the walking distance and whether it is the minimum or maximum of the range how dense it would need to be; The farthest walk and fewest number would require a density around 2,000 persons-per-mile, while even half of the larger number and shorter walk would require over 100,000

¹²³ White, 1996, 55

persons-per-mile. The driving-traffic radius for each of these scenarios (to make up the other 50 percent of the population) ranges from 0.62 to 1.51 miles respectively.

3.2 Data source two: Retailer website requirements

Specific business requirements can also be used. The Aldi and Save-a-lot grocery chains are both low-margin basic grocery retailers. For considering a new store location, according to their website, Aldi requires a "trade area population of 35,000+ within 3 miles,"¹²⁴ and Save-a-Lot uses "population of at least 50,000 in primary trade area."¹²⁵ Incorporating these values into the model, we get, for a walking distance of one-half mile and 100 percent of the population within walking distance, a required density of 53,886 ppm² for Aldi and 76,979 for Save-a-Lot.

Restricting walking distance to one-quarter mile, the requirement increases to 215,542 ppm² for Aldi and 307,917 ppm² for Save-a-lot. If only half of the required market is within the walk area, then Aldi has values of 26,943 ppm² for one-half mile and 107,771 ppm² within one quarter, with drive radii of 1.48 and 1.41 miles respectively. The equivalent Save-a-Lot numbers are 38,490 ppm² for one-half mile and 153,959 for one quarter, with radii of 1.74 and 1.68. These requirements seem somewhat less than realistic.

3.3 Data source three: Empirical demand thresholds

A more precise way to determine a demand threshold is to use economic census data. The 2007 economic census¹²⁶ lists 392 grocery outlets (NAICS code 445110) in Dallas County, Texas. At that time the population of Dallas County was 2,218,899 people. This gives an average of 5660 people per grocery outlet. This could then serve as a ready, empirical demand

¹²⁴ Aldi, 2010

¹²⁵ Save-a-Lot, 2010

¹²⁶ US Census Bureau, 2007

threshold. Placed in the model, a one-half mile walking distance would place 100 percent of the threshold population within reach at a density of only 8,714 ppm², and a one-quarter mile distance would require 34,856 ppm². If only 50 percent of the threshold population is required within pedestrian range, then the requirements change to 4,357 ppm² at one-half mile and 17,428 ppm² within one-quarter. The supplemental driving radii are then 0.75 and 0.61 miles.

3.4 Data source four: Regional supermarket numbers

While aggregate outlet counts are useful, there is also data available for regional sales receipts and market share. The six closest metropolitan markets with the (Southern Plains) region have populations ranging (in 1987) from Austin's 758,510 to Houston's 3,233,000 people. The Dallas MSA (which includes Dallas and Collin County but not Tarrant) had 2,430,200. The grocery outlets of each MSA all have the majority of sales in this sector concentrated in a smaller number of major chain or major independent stores, and this sales data is the most readily available. The market share (in sales) of these outlets is known, and with share of population set equal to share of sales (analysis other than which goes far beyond the scope of this work,) then the portion of the population served by these outlets can be determined.

Dividing population by this market-share proportion, a demand threshold for each city, and the overall region can be determined. The person-per-store numbers vary somewhat from Oklahoma City's 9,107 to San Antonio's 14,135, with the Dallas MSA coming in at 13,912. Total population served by these outlets in the entire region divided by total regional outlets gives a regional demand threshold of 10,945 people per store.

Inserting the Dallas and regional numbers in the model we get a required density of 21,419 ppm² for placing 100 percent of Dallas' 13,912 threshold within one-half mile of the center. At one-quarter mile the 100 percent Dallas number grows to 85,675 ppm². The region's

10,945 threshold can accommodate 100 percent of the population within one-half mile at 16,851 ppm2 and within one-quarter at 67,403 ppm2. If only 50 percent of the threshold population falls within the walking area, then Dallas gets values of 10,709 ppm2 with a half-mile distance, and 42,837 with a quarter. Driving radii stand at 1.01 and 0.91 miles. The 50 percent number for the regional threshold demands 8,425 ppm2 with a walking radius of one-half mile and a driving radius of 0.92 miles, along with 33,702 ppm2 at one-quarter mile on foot and 0.82 miles by car. The number of outlets that produce the lion's share of the sales within the region produce substantially different density requirements than the overall NAICS code numbers. Table 4 shows the market share for each city in the region and the calculated demand thresholds.

Table 4 - Regional Supermarket Demand Thresholds¹²⁷

City (MSA)	Population	Market Share	Population Served	Number of Outlets	People per Store
Dallas	2430200	85.30%	2072960.6	149	13912
Fort Worth / Arlington	1256400	62.00%	778968	76	10250
Houston	3233000	76.00%	2457080	261	9414
San Antonio	1271500	85.60%	1088404	77	14135
Oklahoma City	989100	93.00%	919863	101	9108
Austin	758510	80.00%	606808	60	10113
Total	9938710	79.72%	7924083.6	724	10945

3.5 Data source five: Dallas County 2008 numbers – ESRI

There is even better data available for supermarket sales numbers. ESRI's Business Analyst database records sales figures for 2008 in the grocery (again 445110) category. While an analysis similar to the population-per-outlet threshold from the raw census data could be done, there is another way to look at the data. Of the 512 grocery outlets recorded for 2008 in Dallas County¹²⁸, 343 have sales less than \$5,000,000 per year (Figure 13 below maps grocery outlets by sales volume.)

¹²⁷ Analysis of data from Fairchild, 2009

¹²⁸ These outlets number differ somewhat from the 2007 Economic Census numbers, as they are from different sources. The conjecture is that, while the Census Bureau restricts its classifications by majority of sales, the ESRI data contains some category overlap, most likely with 445120.

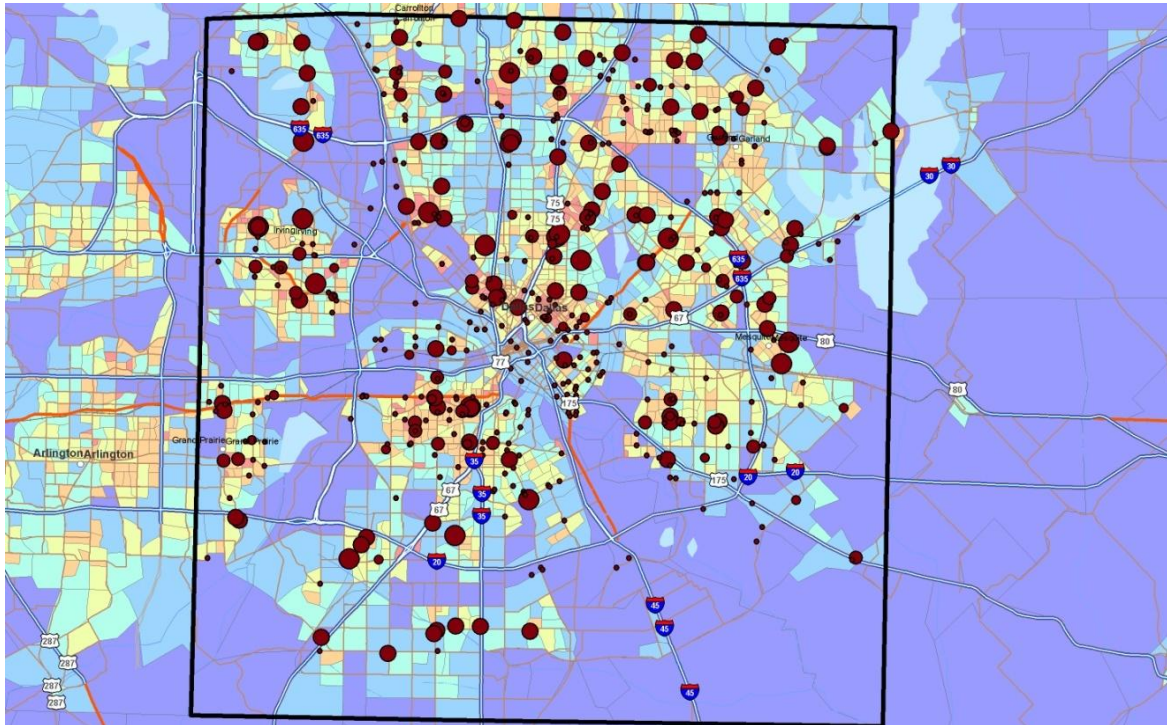


Figure 13 - Grocery Stores in Dallas County by Sales Volume¹²⁹

This means, adding up overall sales in the grocery space, that more than 93 percent of the grocery sales in Dallas County are conducted by 169 outlets (refer back to Figure 11 for the distribution.) These outlets are therefore supplying the vast majority of the groceries in the county, and are useful to examine as a market. The total population of the County in 2008 was 2,412,827. Of the \$5,001,676,000 in grocery sales in 2008, \$4,667,238,000 was done in the largest 169 outlets. This represents 93.31 percent of the total sales. Figure 14 and Figure 15 illustrate the distribution of the largest outlets.

¹²⁹ Analysis of data from 2009 ESRI Business Analyst package, courtesy of Institute of Urban Studies, UT Arlington

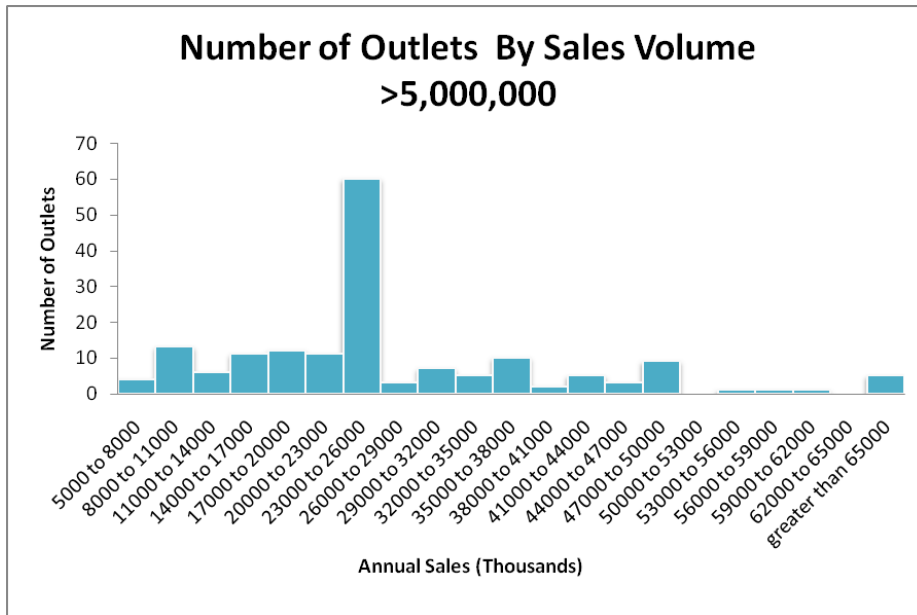


Figure 14 - Outlets by Sales Volume (over 5mil)¹³⁰

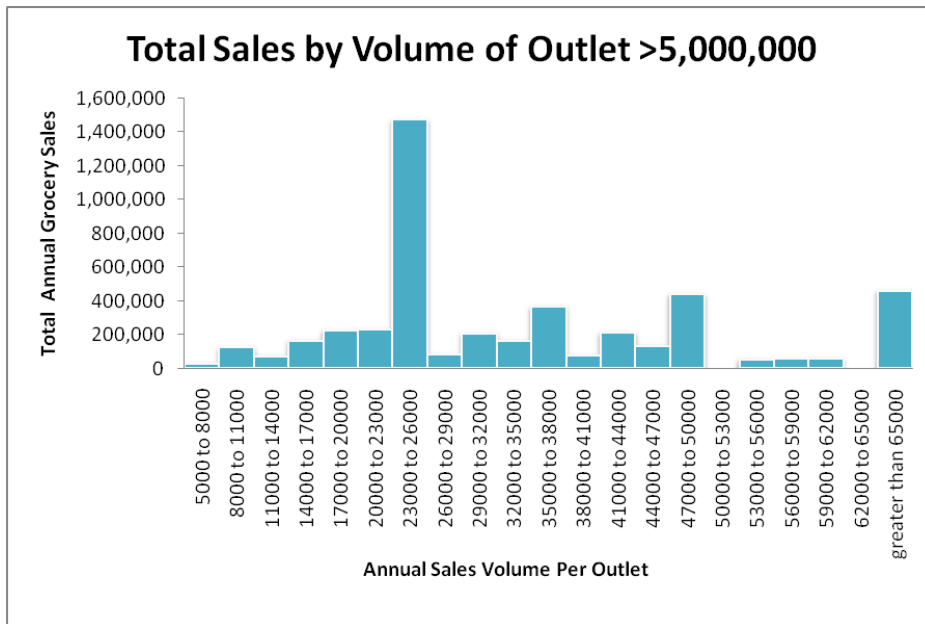


Figure 15 - Sales by Volume (over 5mil)¹³¹

¹³⁰ Analysis of data from 2009 ESRI Business Analyst package, courtesy of Institute of Urban Studies, UT Arlington

¹³¹ Analysis of data from 2009 ESRI Business Analyst package, courtesy of Institute of Urban Studies, UT Arlington

Setting the proportion of sales equal to the proportion of shoppers, these 169 outlets can be said to serve an equivalent population of 2,251,493 people annually. Dividing the one by the other, the effective demand threshold for the outlets conducting over 90 percent of the grocery trade in Dallas County is 13,322 people. Table 5 summarizes the calculations.

Table 5 - Population Served by Dominant Outlets in Dallas County¹³²

2008 BA Numbers - 2008 US Census Estimates	
Total Population	2412827
Total NAICS sales	5001676
# Outlets	512
Large NAICS sales	4667238
# large outlets	169
% total by large	93.31%
Population Served by large	2251493
Population per large	13322.44

Placing this in the model, an 100 percent walkable population would require a density of 20,510 ppm2 at a half-mile distance, and 82,041 ppm2 at one-quarter mile. If only 50 percent of the threshold is required within walking distance, then the density at a half-mile range would need to be 10,255 ppm2 and at a quarter mile 41,021 ppm2. The driving radius for the first is 0.99 miles, and the second 0.89 miles. These values fall in the middle of the extremes of the low population-per-outlet numbers and the high rule-of-thumb numbers.

¹³² Analysis of data from 2009 ESRI Business Analyst package, courtesy of Institute of Urban Studies, UT Arlington

CHAPTER 4
RESULTS AND CONCLUSIONS

4.1 Discussion

What, then, does all of the data tell us? The required density numbers fill a broad range from 1,924 ppm² for 50 percent of the low end of the ICSC rule-of-thumb requirements up to 307,917 ppm² to place 100 percent of Save-a-Lot's recommended trade area within one-quarter mile. As the densest census tract in the entire state of Texas in 2000 (which is in Dallas) held 57,710 ppm², large areas of population density more than twice this are probably not realistic within the foreseeable future. This raises concerns about the possibility of 100 percent walking populations, and possibly the realism of the one-quarter mile radius. The empirical threshold data is probably the best indicator of actual market forces, but it also has a range. The least dense empirical figure is the persons-per-NAICS-outlet number, assuming a 50 percent driving population and a range of one-half mile; this comes out to 4,357 ppm². The densest scenario uses 85,675 ppm², which is placing the Dallas MSA threshold for regional major-supermarket numbers entirely within a quarter-mile radius. Table 6 summarizes the findings. As these figures are too disparate to provide any kind of policy guidance, some further analysis is necessary.

Table 6 - Summary of Demand Thresholds

Business Description	Total Pop	walking ratio	Walk Density	Units / Acre	FAR Required	Radius at Mean	walking pop
Rule of thumb minimum	2,500	100%	15,396	10	0.28	0.25	2500
Rule of thumb minimum	2,500	50%	7,698	5	0.14	0.45	1250
Rule of thumb maximum	40,000	100%	246,334	160	4.42	0.25	40000
Rule of thumb maximum	40,000	50%	123,167	80	2.21	1.51	20000
Aldi recommendation	35,000	100%	215,542	140	3.87	0.25	35000
Aldi recommendation	35,000	50%	107,771	70	1.93	1.41	17500
Save-a-Lot recommendation	50,000	100%	307,917	200	5.52	0.25	50000
Save-a-Lot recommendation	50,000	50%	153,959	100	2.76	1.68	25000
2007 NAICS raw 445110 threshold	5,660	100%	34,856	23	0.63	0.25	5660
2008 NAICS raw 445110 threshold	5,660	50%	17,428	11	0.31	0.61	2830
1987 Dallas MSA major supermarkets	13,912	100%	85,675	56	1.54	0.25	13912
1987 Dallas MSA major supermarkets	13,912	50%	42,837	28	0.77	0.91	6956
1987 Southern Plains major supermarkets	10,945	100%	67,403	44	1.21	0.25	10945
1987 Southern Plains major supermarkets	10,945	50%	33,702	22	0.60	0.82	5473
2008 Dallas County major supermarkets	13,322	100%	82,041	53	1.47	0.25	13322
2008 Dallas County major supermarkets	13,322	50%	41,021	27	0.74	0.89	6661

Returning to the intent of the exercise, which is to determine what density is likely to place people within walking distance of their needs, the nature of the grocery function becomes important. Whether by car or on foot, the residents of Dallas County satisfy their needs at a certain scale of grocery, those with sales volumes larger than 5,000,000 (by ESRI's measure) the vast majority of the time. If the other, smaller-volume outlets satisfied the same needs as often as the larger-volume outlets, then they would fill more than a small fraction of the sales. Thus, all other factors put aside, the empirical outlet study using the ESRI numbers (Data Source Five) would seem to be the best indicator of the required threshold to meet the needs of the people in a market with the tastes and composition of Dallas County. Of all of the thresholds proposed, then, the 13,322 number from larger-volume outlets in Dallas County will be used for subsequent analysis.

With one-quarter mile selected as the appropriate walking distance the question then becomes "what portion of the population should be placed within pedestrian reach of the outlet?" The relationship between required density and walking portion is linear, and can be easily illustrated by the graph shown in Figure 16.

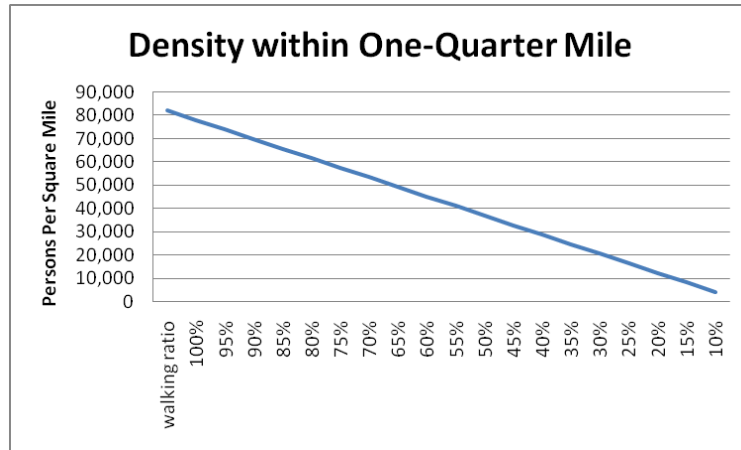


Figure 16 - Density versus Percent Walkable at 1/4 mile

The 100 percent walkable figure would require a density (for a quarter-mile in any direction) of 82,041 ppm². Figure 17 shows what this configuration would look like with the population in 5-story apartment buildings, with an average unit size of 1000 square feet and an average of two persons per unit, and Figure 18 shows the view from the street in a configuration like this (in Brooklyn.) As this density is 1.42 times the density of the densest census tract in Texas, 23.7 times as dense as the average of the city of Dallas, and 36.1 times as dense as the city-wide density of the average urban Texan, perhaps other options should be considered.

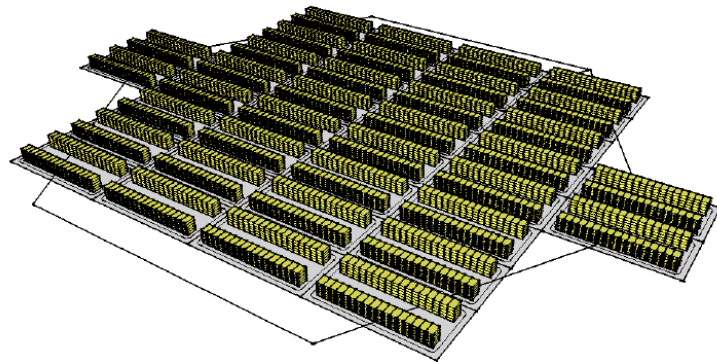


Figure 17 - Scale Model of 13,000 people within 1/4 mile



Figure 18 - Street View of 17th Street, Brooklyn, New York¹³³

Extending the walking radius to one-half mile reduces the 100 percent walkable density to 20,510 ppm², which may be a more manageable result, but incurs the issues associated with both increasing the required walking distances (which, it is worth remembering, due to the laws of geometry places more of the population at a range of over one-quarter mile away than it does within one-quarter mile,) and requiring a larger area of the city to be built at this increased density at odds with the concentration recommendations of many in the planning community. The graph in Figure 19 illustrates the density relationship over one-half mile.

¹³³ image from Google

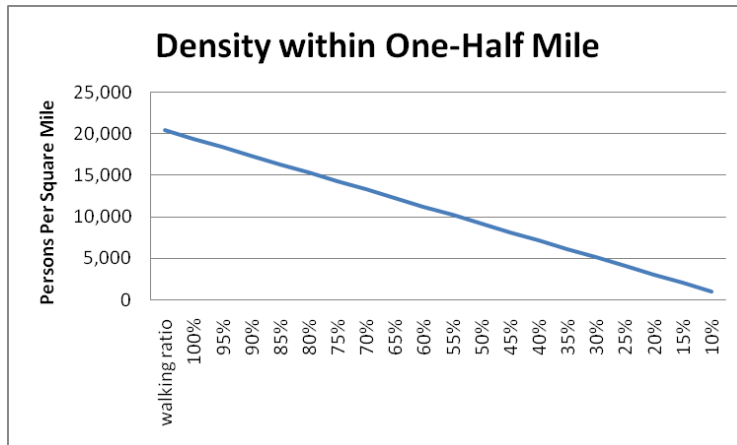


Figure 19 - Density versus Percent Walkable at 1/2 mile

The other option, reducing the walking distance back down to one-quarter mile, is to capture a portion of the required threshold population from vehicle-borne outsiders.

The relationship between portion of the population walking and the driving distance required to make up the difference is quadratic, and can be illustrated by the graph in Figure 20.

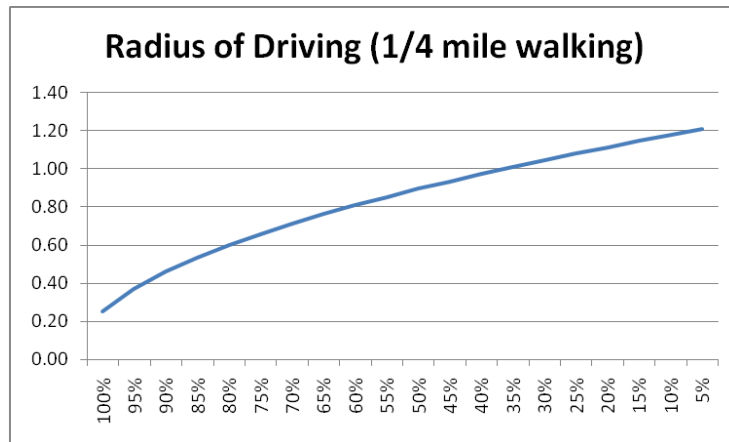


Figure 20 - Driving Radius versus Percent Walkable (at 1/4 mile)

Beginning (of course) as the same trade area radius for all modes, the driving distance increases predictably to 1.21 miles away with only five percent of the threshold population within

walking distance. Or, put another way, the entire customer base can be supplied within 1.2 miles away, with 95 percent of it driving in from between 0.25 and 1.21 miles distant. However, at that low portion, one can argue if there is any difference between the five percent city and the totally car-oriented city. The most effective solution probably lies between the two extremes of 100 and five percent.

Handy and Clifton's fascinating work with alternate-mode retail in Austin discovered that neighborhoods where residents were able to do their shopping on foot showed an increase in those that chose to travel on foot, but only up to a point. Their finding for the Travis Heights neighborhood, where 16 percent of residents listed either walking or biking as their usual mode of travel to the store, may be useful for exploring what portion of the threshold population should be in pedestrian range.¹³⁴ Increasing their findings slightly for simplicity, a 20 percent number gives us a required density of 16,408 ppm², and a driving distance of 1.11 miles. This means that, if 20 percent of the population is anticipated to want pedestrian access to a full service grocery, then configuring the urban fabric to enable that access will result in a denser core and less-dense periphery. As a policy guideline, this results in an urban configuration that has a blended density of 16,400 ppm² within one-quarter mile of the center, and a "background" density (in this case again the 2000 City of Dallas average density of 3479) from 0.25 to 1.11 miles from the center. This would mean the repetition of the neighborhood center cluster every 2.22 miles throughout the landscape. This is enough information to examine the configuration in more detail.

4.2 Theoretical design

In a world of abstraction, then, what would be the design of the city to meet the market requirements of daily life? If we configure the population where 20 percent is within the defined walking radius to a central location with a supermarket, then the prescribed configuration is a

¹³⁴ Handy 2001, 336

hexagon of one-quarter mile radius with a blended density of 16,400 persons-per-square-mile placed every 2.22 miles throughout the city, and a “background” population density of around 3500 ppm2 in the areas between. This multi-nodal configuration resembles both the Loschian net and Calthorpe’s urban network proposals (albeit with perhaps different dimensions.)

Visualizing this configuration for planning purposes becomes possible. The Lincoln Institute of Land Policy has issued, under the title of *Visualizing Density*, a series of images of population densities within the U.S. While their categories are in the problematic dwelling-units-per-acre (DUA,) this tool is a good starting point for explaining the on-the-ground effects of the configuration in question. With a household size of 2.5 persons per household, the DUA count for 16,400 ppm2 is 13 units / acre. With a household size of 3.0 it becomes 11. The center of the neighborhood (using the Lincoln Institute’s methods) could then resemble the photograph in Figure 21. It’s worth remembering that this would need to be the average density for an area roughly one-half mile by one-half mile.¹³⁵



Figure 21 - 11 units / acre in Mountain View, California¹³⁶

The surrounding area could resemble the current City of Dallas, with its abundant single-family detached houses on independent lots. Other configurations, of course, are possible as long as the average blended population densities of the districts are as stated. Figure 22 shows

¹³⁵ Campoli, 2007

¹³⁶ Campoli, 2007

what a configuration with the dense "walkable" center and a mile of lower-density housing (around Dallas' 3479 ppm2) surrounding it might generally look like.

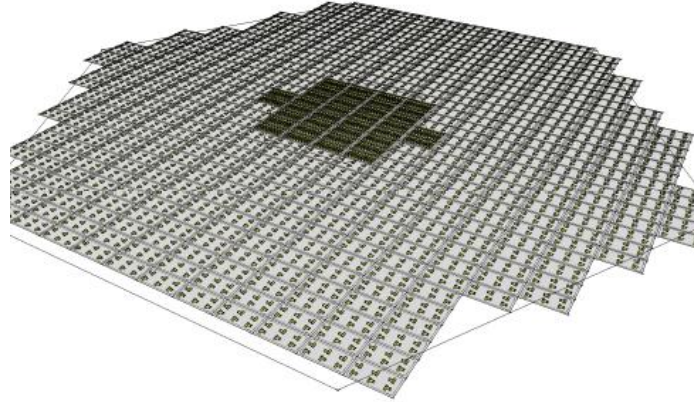


Figure 22 - Scale Model of 20% Neighborhood

Revisiting the other population threshold sources in this scenario, one gets the range of walking ratios (i.e. the amount of the threshold in the walkable core) shown in Table 7. This table illustrates both the importance of the threshold population to the percentage able to walk and the middle place in the population range occupied by the Data Source Five (2008 Dallas County major supermarkets) value.

Table 7 - Demand Thresholds of Five Methods

Business Description	Total Pop	walking ratio	Walk Density	Units / Acre	FAR Required	Radius at Mean	walking pop	driving pop
Full Service Supermarket	13,322	20%	16,408	11	0.29	1.11	2664	10,658
Rule of thumb minimum	2,500	100%	16,408	11	0.29	0.25	2664	0
Rule of thumb maximum	40,000	7%	16,408	11	0.29	2.05	2664	37,336
Aldi recommendation	35,000	8%	16,408	11	0.29	1.91	2664	32,336
Save-a-Lot recommendation	50,000	5%	16,408	11	0.29	2.30	2664	47,336
2007 NAICS raw 445110 threshold	5,660	47%	16,408	11	0.29	0.63	2664	2,996
1987 Dallas MSA major supermarkets	13,912	19%	16,408	11	0.29	1.14	2664	11,248
1987 Southern Plains major supermarkets	10,945	24%	16,408	11	0.29	0.99	2664	8,281
2008 Dallas County major supermarkets	13,322	20%	16,408	11	0.29	1.11	2664	10,658

4.3 Claim evaluation

4.3.1 Calthorpe's Claims

With a method for determining required densities in place, it can also be used to evaluate economic claims made about the built environment. Peter Calthorpe's seminal 1989 essay "Pedestrian Pockets: New Strategies for Suburban Growth," explicitly proposes a community designed around pedestrian access. His proposal is to place a population of 5000 people within one-quarter mile of a "main street" that includes a transit station and retail.¹³⁷ Based on the demand threshold, it is possible to determine the likelihood of success, and thereby continued availability, of a supermarket in one of these "pockets." Table 8 shows the results of this analysis.

Table 8 - Pedestrian Pocket Analysis

Business Description	Total Pop	walking ratio	Walk Density	Units / Acre	FAR Required	Radius Mean	at walking pop	driving pop	
Pedestrian Pocket Population	5,000	100%	30,792	20	0.55	0.25	5000	0	
Rule of thumb minimum	2,500	100%	30,792	20	0.55	0.25	5000	0	
Rule of thumb maximum	40,000	13%	30,792	20	0.55	1.98	5000	35,000	
Aldi recommendation	35,000	14%	30,792	20	0.55	1.84	5000	30,000	
Save-a-Lot recommendation	50,000	10%	30,792	20	0.55	2.25	5000	45,000	
2007 NAICS raw threshold	445110	5,660	88%	30,792	20	0.55	0.37	5000	660
1987 Dallas MSA major supermarkets	13,912	36%	30,792	20	0.55	1.02	5000	8,912	
1987 Southern Plains major supermarkets	10,945	46%	30,792	20	0.55	0.85	5000	5,945	
2008 Dallas County major supermarkets	13,322	38%	30,792	20	0.55	0.99	5000	8,322	

While it does include enough population to meet the minimum number for the ICSC rule-of-thumb to be classified as a "neighborhood center," the population falls well short of the required threshold calculated by all of the other methods, with the possible exception of the problematic direct population-per-outlet numbers directly from NAICS codes. Only 38 percent of the threshold population for the 2008 major supermarket category (Data Source Five, which is felt to be the best estimate) falls within the pocket, with a surplus market population of 8322 people required to complete the demand. Mr. Calthorpe's pedestrian pocket, from a supermarket access

¹³⁷ Kelbaugh, 1989

standpoint, would seem to require to be surrounded by a mile of conventional single-family housing (or some other configuration that required driving) if the access to supermarket retail is to be sustained.¹³⁸

4.3.2 *Duany's Claims*

The celebrated Andres Duany has planned a number of neighborhoods. His espoused planning solution is a neighborhood that, "is limited in size so that a majority of the population is within a 5-minute walking distance of its center (1/4 mile). The needs of daily life are theoretically available within this area. This center provides an excellent location for a transit stop, convenience work places, retail, community events, and leisure activities."¹³⁹ It is possible to assess the potential success of one of the executed plans of his firm, Duany Plater-Zyberk, with the model.

Cornell in Ontario, Canada, (outside of Toronto,) was conceived as 30,000 people on 1275 acres (1.992 square miles) of land at its maximum build-out.¹⁴⁰ Planned by DPZ as a model "walkable" community, this would give it a density of 15,060 ppm². If we take a hexagon of one-quarter mile in radius at this density and place it in the model, the model tells us that the community ought to be able to support 18 percent of a supermarket within walking distance.

¹³⁸ In his 2002 work, Calthorpe revises his recommendations somewhat; the new configuration now supports placing 10,000 people within a radius of a little over one-half mile around a "Village Center." The source of the new configuration, the origin of the new 10,000 threshold, and the logic for departing from the strict quarter-mile distance remains unclear.

¹³⁹ Duany, 1998

¹⁴⁰ Talbot, 2004

Table 9 - Analysis of Cornell, Ontario, Canada

Business Description	walking		Units /		Radius at			
	Total Pop	ratio	Walk Density	Acre	FAR Required	Mean	walking pop	driving pop
Cornell, Ontario, Canada	2,445		15,060	10	0.27	0.25	2445	0
ICSC rule of thumb minimum	2,500	98%	15,060	10	0.27	0.26	2445	55
ICSC rule of thumb maximum	40,000	6%	15,060	10	0.27	2.05	2445	37,555
Aldi recommendation	35,000	7%	15,060	10	0.27	1.91	2445	32,555
Save-a-Lot recommendation	50,000	5%	15,060	10	0.27	2.31	2445	47,555
2007 NAICS raw 445110 threshold	5,660	43%	15,060	10	0.27	0.65	2445	3,215
1987 Dallas MSA major supermarkets	13,912	18%	15,060	10	0.27	1.15	2445	11,467
1987 Southern Plains major supermarkets	10,945	22%	15,060	10	0.27	1.00	2445	8,500
2008 Dallas County major supermarkets	13,322	18%	15,060	10	0.27	1.13	2445	10,877

This may explain the National Post’s post-occupancy observation that in Cornell: “Some retailers have not been able to keep regular hours, grocery stores with fresh produce never bothered to settle in, and some businesses that did take the risk of opening in Cornell complain about limited parking — a result of a pedestrian-centric New Urbanist plan coupled with the unexpectedly rampant reliance on cars," which the Cornell's town Councilor called a "conundrum" for a neighborhood ostensibly designed for the pedestrian.¹⁴¹

4.4 Conclusion

4.4.1 What have we learned?

It would seem that there are two choices for configuring the urban fabric to allow access to a supermarket on foot. The first is to increase the population density to an intensely urban 84,000 people per mile, and concentrate the city in a substantial way. The second is to increase the density of the existing fabric slightly and surround clusters of concentration with large swaths of conventional auto-oriented suburban development, with the full knowledge that a portion – but only a portion – of the population will be able to choose pedestrian access as an option. This is not to say that a hybrid solution, perhaps something with high-density pedestrian access at the

walkable center and medium-density car-dependant development further out, might induce more of the population to walk beyond the quarter-mile of the literature and reduce the area occupied by the overall structure. However, short of a fundamental change in the economics of supermarket retail as presently structured, the self-contained, “walkable” neighborhood with single-family housing doesn’t seem to be in the cards. As long as economies of scale and consumer price sensitivity continue to operate as they have, the alternatives will remain much higher density or only partial access.

Happily, this may better accord with actual citizen preference, as studies tend to show that a substantial part of the population prefers low-density living almost regardless of the consequences.

"The reality is that most Americans prefer low-density areas with detached buildings not because they like spread-out development per se, but rather because they perceive such settings as safer and less hectic. Residential preference surveys consistently show that upward of 95 percent of Americans prefer single-family to multifamily dwellings. Many associate density with noise, overcrowdedness, urban blight, and stress. Preference for single-family living also reflects the strong North American value placed on home ownership, secured tenancy, and privacy."¹⁴²

4.4.2 Policy implications

From a public policy standpoint, there are a number of implications of this exercise. One is the importance of retail location. For the assumptions of Central Place Theory to be valid, the supermarket must be placed in the concentrated center of the neighborhood, with alternate

¹⁴¹ Carlson, 2009

¹⁴² Bernick, 1996, 84

locations restricted to prevent the market from locating in the deconcentrated areas and the accessibility advantages of increased density at the center be negated. Secondly, economic and environmental claims of the benefits of small increases in density need to be carefully reconsidered. To date, much of the discussion of "walkability" has centered around urban design configuration and land use regulations, leaving the implicit assumption that if the pedestrian network were constructed, pedestrian destinations would naturally survive. However, if these destinations are competitive commercial enterprises they will need an adequate customer base as well as adequate access to remain viable. While things like narrower streets, smaller lots, and accessory dwellings may have positive attributes for other reasons, they are unlikely to allow the population to have pedestrian access to a supermarket if they would not otherwise. This work suggests that neighborhood design issues should be decoupled from economic land-use arguments for purposes of discussion by policy makers.

4.4.3 Alternate Market Structures

There are planning concepts that propose to change the structure of the grocery market to increase walkable access without substantially increasing population density. While it is beyond the scope of the present project, work has been done at the University of Washington, Seattle¹⁴³ and the University of Michigan¹⁴⁴ on the effects of a changed grocery market structure on city planning (as an attempt to alleviate the problem of "food deserts".) Rather than the structure as it presently exists in Dallas County and other places in the U.S., if the market were composed of a larger number of outlets with a smaller demand threshold, it would require lower densities to make each outlet viable. However, these changes to the market structure each run into the fundamental retailing requirement of needing either higher margins (along with either a higher price or accompanying subsidy,) or a higher turnover-per-person than the existing store

¹⁴³ Born, 2009

¹⁴⁴ Himes-Ferris, 210

structure if they are to overcome the higher fixed and semi-fixed costs associated with a larger number of smaller outlets selling the same inventory. The present study concentrates on the grocery market as it is rather than as it perhaps ought to be.

4.4.4 Caveats and Weaknesses

There are always issues with gathering and analyzing data, especially those taken from the complex environment of existing markets. This study rests on the essential assumption that the grocery market operates according to the principles of Central Place Theory, and that the structure of the market is consistent and predictable. The vagaries of competition and the overlap of shopping behavior between different outlets mean that the environment may be substantially more complex, as all human behaviors are, than the simplified mechanism of the model. However, lacking more detailed consumer data and a larger and more detailed project generally, it is hoped that this may serve as an introduction to a larger body of future research.

4.4.5 Research Recommendations

This effort provides an initial entry into the subject at a broad level. Much future research remains to be done. One direction would be to study the impact of variations in income and spending levels of the population on the potential for a sustained grocery outlet within pedestrian range. Another would be to repeat the methods of this work using other categories of retail or restaurant formats. Yet another would be to conduct a comparative analysis of different grocery market environments to determine if there are other counties that have market structures more or less conducive to grocery access on foot. The subject is hardly exhausted and there is great potential for further discovery in the topic.

4.4.6 Concluding Summary

Using the tools of Central Place Theory, specifically an adapted demand threshold analysis, this work takes the population required to make a grocery outlet viable and studies the density implications of placing it within pedestrian range of the outlet. Five different data sources are used to determine a demand threshold in Dallas County, Texas: rule-of-thumb numbers from the ICSC, population requirements listed on retailer websites, the number of outlets classified by NAICS code in the 2007 economic census, regional grocery sales data from metropolitan areas in the Southern Plains region, and detailed grocery sales data from Dallas County. The most accurate of these is felt to be the total population patronizing the most dominant form of grocery retailer in the county, divided by the number of outlets of this type.

Placing a threshold population within a one-quarter mile radius of the grocery outlet would result in a radical increase in population density compared to current and historical densities in the county. Placing this population within a one-half mile radius would result in substantial, but less radical, increases in density, but would place most of the population farther from the outlet than the one-quarter mile distance most often recommended in the literature. Consciously placing only a portion of the threshold population within a one-quarter mile radius would allow for this portion of the population to benefit from only a modest increase in density, but require the retailers involved to be supplemented by an additional population with vehicle access from farther away.

4.4.7 Final Thoughts

The dreams of neighborhoods in service to the pedestrian would seem to be farther off than was thought. The dynamics of the modern retail environment would seem to preclude placing most citizens within access on foot. However, with careful planning and a thoughtful location strategy, the ideal can be realized for at least a portion of the population. To quote

Handy and Clifton, while “local shopping may not do much to reduce driving it does give residents the option to drive less and this option is something residents clearly value.” For a select few, retail as a pedestrian “does show promise as a strategy for enhancing quality of life in neighborhoods, at least partly by making driving once again a matter of choice.”¹⁴⁵

¹⁴⁵ Handy, 2001, 317

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