

SPATIAL DELINEATION OF MARKET AREAS:

A PROPOSED APPROACH

by

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DEDICATION

I dedicate this document to my parents, grandmother, sisters and friends, for their constant support.

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LIST OF ABBREVIATIONS

BDS	Business Analyst Dataset
CEX	Consumer Expenditure Survey (US Census Bureau)
MCI	Multiplicative Competitive Interaction
MSA	Metropolitan Statistical Area
NAICS	North American Industry Classification System
SSI	Spatial Sciences Institute
USC	University of Southern California

ABSTRACT

In business sectors such as consumer staple goods, the location of a retail store is central to a consumer's decision to purchase items at a given location. As such, customers of some retail segments (e.g. groceries) could be considered spatial entities, with behavior directly tied to their location relative to the location of a retail store. A "trade area" represents the geographical space from which a business draws customers and "market area" refers to the larger geographic region in which several businesses compete. Market areas are usually defined by an arbitrary spatial extent, such as a political boundary or radius around a given point, which injects arbitrariness into any market share calculations. In the staple goods retail sector, travel time and physical location are critical to consumer store preference. Therefore, the accurate delineation of a store's geographical trade area and surrounding market is needed for precise performance measurement and market share calculation. A framework is proposed for defining retail market areas based on degrees of spatial separation between a store and surrounding customers and competitors. Four degrees of customer separation are proposed, classifying customers based on their consideration of, and/or preference for, a specific store location. The result is a less arbitrary definition of a market. This approach was modeled for the grocery sector of Worcester, Massachusetts and the resulting market share calculations were compared and implications of using one method over another are discussed.

CHAPTER ONE: INTRODUCTION

The customer is paramount in retail, and profits are made and lost based on the ability of a store to draw consumers to their doors. Thus, retail businesses place great emphasis on understanding the decision-making processes which influence their customer base to shop with them versus a competitor. These decisions are extremely complex and vary infinitely based on the consumer and store in question; yet, in particular retail sectors, a consumer's spatial proximity to a store may be the dominant factor contributing to a consumer's willingness to shop at a given location. "How long will it take me to get to store x versus store y for product n ?" is central to deciding between competing locations, especially where staple goods and low price differentiation are present.

The importance of the above question to particular retail sectors means that customers are essentially spatial entities from the perspective of a store manager or business planner. Thus, the ability of a business to accurately delineate the geographic space from which its customers originate is crucial to accurate sales forecasting, marketing efforts and thorough understanding of the competitive environment in which the business operates. Under these assumptions, the calculation of market share – one of the most critical metrics in assessing retail performance – is based on a delineation of geographic space.

A "trade area" represents the geographical space from which a business draws customers and "market area" refers to the larger geographic region in which several businesses compete. Retail businesses, especially those focused on staple goods or convenience purchases, define their trade and market areas spatially. Businesses from all sectors can be said to have spatially-defined market areas, but the emphasis on the exact

size and shape of that area is of greater importance in highly competitive, staple goods markets with low product and price differentiation. A luxury goods business may draw customers from great distances, sporadically placed, and those customers may be highly brand-loyal. Grocery stores or gas stations, however, tend to draw customers from nearby, who prioritize the convenience of the business's location over the brand of the business itself.

A store must understand both its trade area and the trade areas of its competitors in order to compete effectively in their market. Familiarity with their own trade area is useful in learning about the characteristics and preferences of their existing customer base. Understanding the trade areas of their competitors informs them of both their competitors' relative strength versus their own, and where opportunities exist for capturing additional customers or market share (Huff, 1963).

1.1 Defining market areas

Much attention has been given to methods for determining a single store's trade area. Multiple techniques exist and have been in use for decades (e.g. Applebaum, 1966; Huff, 1964). Less attention has been given to methods for spatially defining the larger market in which a store competes. Historically, political boundaries such as a city, county or Metropolitan Statistical Areas (MSA) served as a sufficient proxy for a store's competitive market, or markets were defined as space a given distance away from a central location (Huff and McCallum, 2008).

While one or more of these proxies is satisfactory for most market share analyses, they lack accuracy and customization to a particular market's nuances, and in certain

situations, can be misleading. Should a political boundary exclude important players in a store's competitive environment, or include businesses within a boundary who do not compete for any of the same customers as the target store, inaccurate conclusions may be drawn. Both of the aforementioned outcomes constitute the "edge effects" accompanying the market area definition and will be discussed in more detail below.

1.2 A proposed framework for defining market areas

A more accurate method for defining a store's market would be to classify the customers and competitors surrounding a target store location based on their likelihood to impact the performance of the target store. Such a classification system could group customers regardless of any political boundary or distance threshold they do or do not fall within, as:

- 1. First-degree customers:** Customers falling within the target store's trade area;
- 2. Second-degree customers:** Customers falling within a trade area directly adjacent to, or touching, the target store's trade area (these trade areas would belong to "direct" competitors);
- 3. Third-degree customers:** Customers falling into the trade areas directly adjacent to the trade areas of "direct" competitors (these trade areas would belong to "indirect" competitors); and
- 4. Fourth-degree customers:** Customers not included in the trade areas of the target store or its direct or indirect competitors.

This classification begins to separate customers according to their “degree of separation” from a given grocery store. Those customers who shop with a target store could be said to be “first-degree customers” because the location and offerings of the target store are preferred over any other competitor. Other customers who may not consider a target store as their primary source for groceries are separated from the target store by other competing groceries, or by one spatial “degree” or more from the target store’s location. Fourth-degree customers are conceptually more complex than the other degrees. They serve as a “catch-all”, in that they encompass all customers existing beyond the third degree. Without a fifth degree of separation, fourth-degree customers expand continuously into space outside the boundaries of third-degree customers, with no outer limit. The utility of defining fourth-degree customers is to find the new boundary of a market area. Where third-degree customers (i.e. customers of a target store’s indirect competitors) begin abutting fourth-degree customers, a target store’s competitive market area ends.

A similar type of classification could be applied to competing grocery stores to emphasize the degree of competitive threat each one poses to a target store. Groceries competing with the target store for the same customers, or whose trade areas overlap or are adjacent to the trade area of the target store, could be considered direct competitors. Since the performance of those competing groceries may result in the target store either: (1) losing some of its customers to the direct competitor; or (2) “stealing” customers from the direct competitor and converting them to customers, the competition is direct. If instead, a nearby grocery store only competes for customers with the target store’s direct competitors, and not with the target store itself, competition could be said to be indirect.

Such indirect competitors do impact the performance of a target store's direct competitors, and are therefore worthy of consideration in a market analysis, but their performance carries less weight relative to the immediate success of a given grocery store. Existing customers are unlikely to be gained or lost as a result of the presence of an indirect competitor, unless the indirect competitor is capable of putting a direct competitor out of business or they force the direct competitor to focus more of its marketing efforts on the store of interest.

The final classification of competitors serves as a catch-all, much like the concept of fourth-degree customers. If political boundaries are no longer treated as the outer spatial limit at which additional groceries should be considered a part of a market area, the new outer limit becomes that point at which competing groceries no longer impact the performance of the target store. In other words, once neighboring groceries are neither direct nor indirect competitors, they fall into a "non-competitive" degree of separation and the market area boundary is drawn around the outermost indirect or direct competitors surrounding a target store.

As presented, the degrees of separation approach to market area definition uses binary relationships to describe consumer behavior across space. The definitions of each degree of separation assume a hard line between customer "degrees", corresponding to the presence or absence of adjacent trade areas. This may be too simplistic an approach, and does not address issues like trade area overlap or the "fuzzy boundary" phenomena identified by Huff (1964) in retail trade areas. The definitions of each spatial degree of separation are meant as a foundation upon which more nuanced definitions can be built. For example, in dense urban areas with much trade area overlap, the question of how the

overlap will be classified into degrees must be answered. Perhaps overlap will be classified as its own degree (e.g. overlap between the target store's trade area and its next-door competitor might be considered second-degree customers, and the direct competitor's customers classified as third-degree customers); or perhaps overlap will be classified as belonging to the degree of either the nearest or farthest competitor (e.g. as in the previous example, overlap between a target store's trade area and that of its direct competitor would either be classified as only part of the target store's trade area, or as part of the direct competitor's trade area.) In either case, the framework for identifying degrees of separation gives the exercise of market area delineation a common language and robust conceptual approach .

Figures 1-3 illustrate the concept of degrees of spatial separation in market area determination using a series of admittedly simplistic examples.

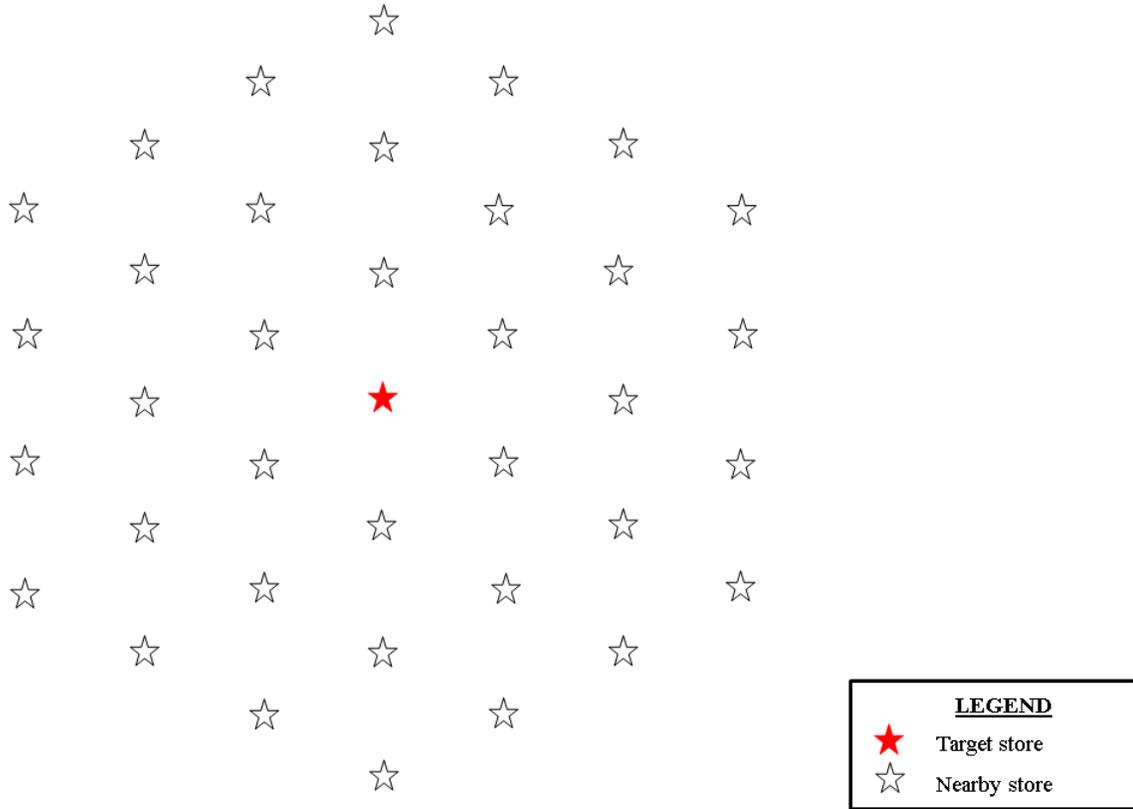


Figure 1: A series of hypothetical store locations shown on a plane; a target store for which a market area is desired is shown in red; nearby stores are shown in white. An attempt will be made to define a market area for the target store irrespective of any political boundaries or distance thresholds.

To execute the degrees of separation market delineation method, a target store and surrounding stores must first be identified (Figure 1). Once store locations have been confirmed, trade areas should be created around each business. This allows for each store to be classified as direct, indirect, or non-competitive, and allows each store's trade area and customers to be classified according to their degree of separation from the target store. In Figure 2, the target store's trade area has been shaded red, and all trade areas which touch the target store's trade area have been classified as second-degree customers, with their corresponding stores labeled direct competitors. Next, all trade areas touching

the trade areas of direct competitors, but not the target store's trade area, are classified as third-degree customers, with their corresponding stores classified as indirect competitors. Non-competitive stores are those whose trade areas touch those of indirect competitors or other non-competitors, and they contain fourth-degree customers.

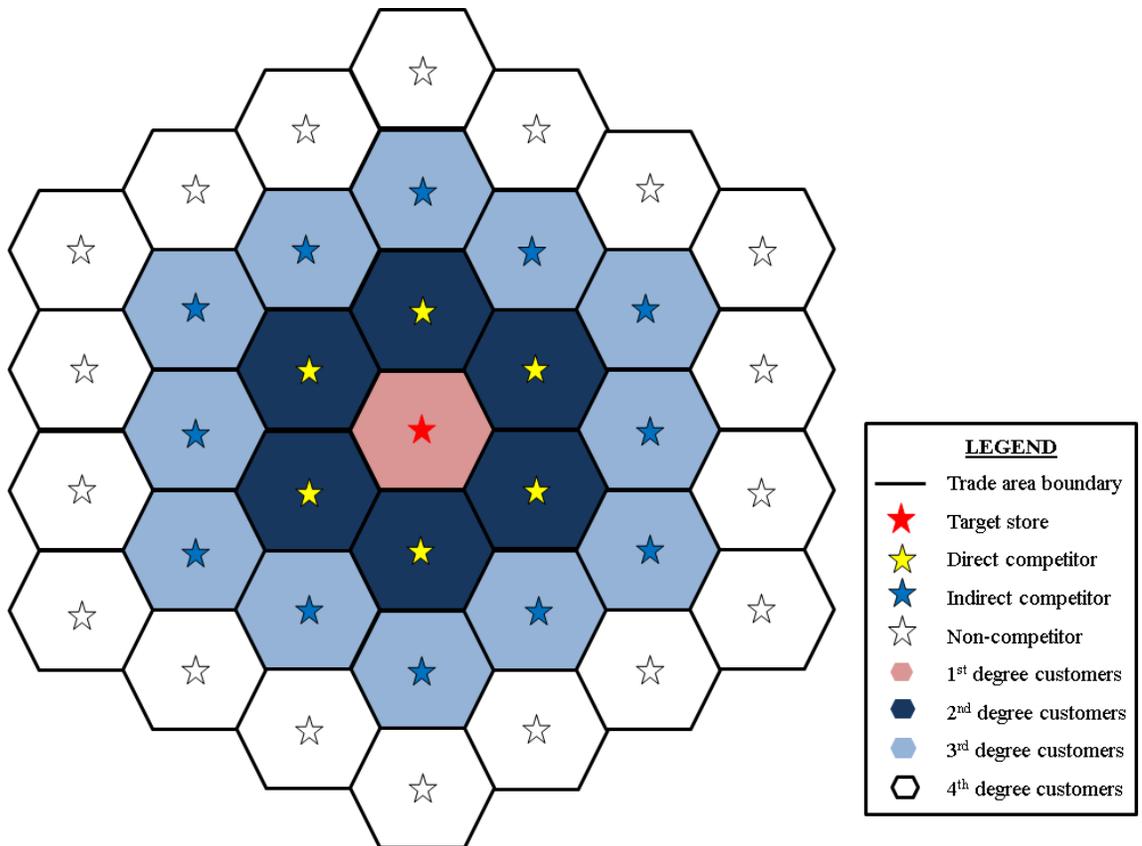


Figure 2: Store locations from Figure 1, with hypothetical trade areas generated for each store location; stores have been re-classified as direct, indirect or non-competitors; customers within each trade area have been shaded according to the degree of separation between them and the target store.

To calculate the market area for the target store, the trade areas of the target store, the target store's direct competitors, and the trade areas of the target store's indirect competitors are merged. In Figure 3, these trade areas are shaded in black. An alternate

way to define the boundary of the trade area would be the boundary between all third- and fourth-degree customers, or between indirect and non-competitive store trade areas.

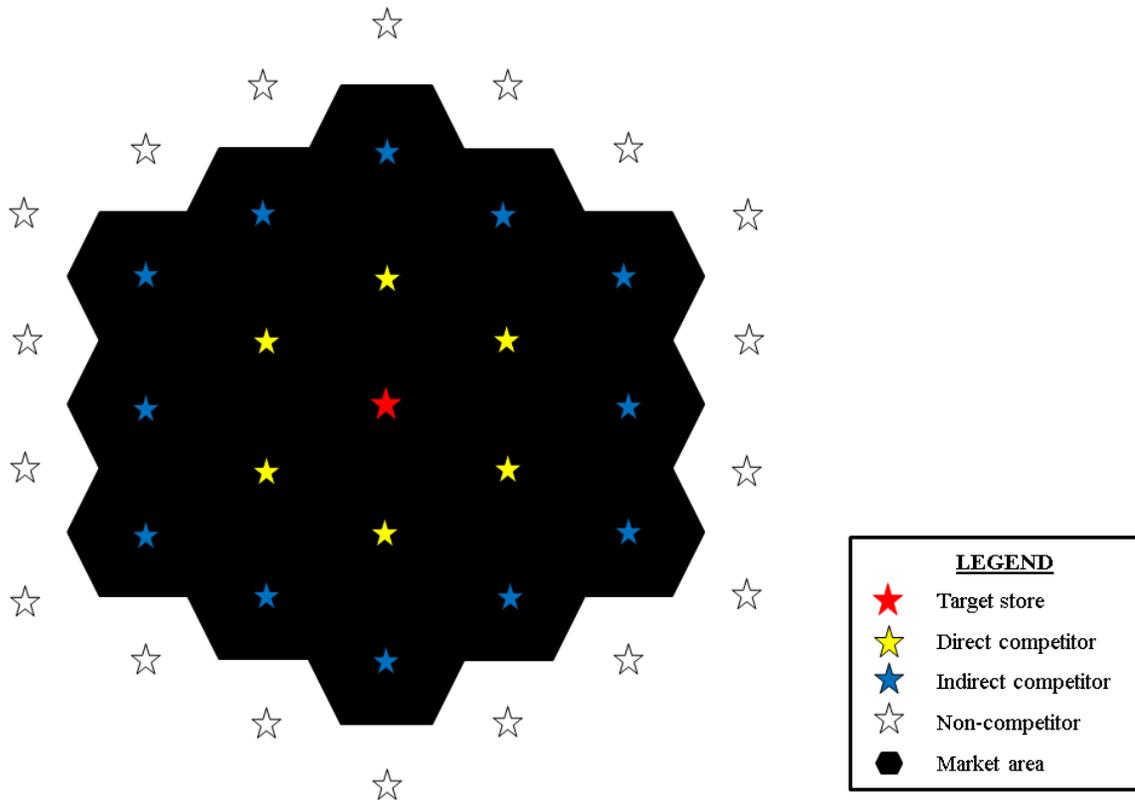


Figure 3: The market area for the target store has been defined as the combination of the trade areas of the target store’s trade area and the trade areas of the target store’s direct and indirect competitors.

This alternate definition of a market area prioritizes the degrees of separation between a store and its surrounding competitors and customers and results in a market area consisting of the sum of the trade areas belonging to the target store and its direct and indirect competitors (Figure 3). There are two primary benefits to this “degrees of separation” method over the use of administrative boundaries:

- This definition of a market captures all of the consumers and competitors who impact the success of the target business, and none who do not.
- This method lessens the impact of edge effects on market share calculations; it improves market analysis accuracy for businesses located near the edge of a political boundary or distance threshold, where competition with stores across the boundary may be ignored, or where competition with stores near the boundary may be overstated.

This method of market area definition is not dependent upon the method of trade area creation used. Any of the methods included in Esri's Business Analyst, or a customized method, could be used to create the individual trade areas. The method, data and parameters chosen for the creation of the trade areas will be dependent upon the individual scenario being mapped. The purpose here is not to investigate the most appropriate method of trade area delineation, but rather the best way to use already-created trade areas to inform the delineation of a wider market area.

That is not to say that this method of market area delineation would be applicable to, or useful in, all scenarios. There are clear strengths and weaknesses of this approach which render it more helpful in some and not other situations. The utility of degrees of separation may be weakened, for example, in scenarios involving dense, urban areas with a high number of competing businesses in a small area; in those cases, there may be such great overlap between trade areas that defining customers by degrees is impossible. As discussed earlier, in situations of great urban density, the definitions of each "degree" may take on nuances according to the situation. Degrees of separation would still exist in dense environments, but the number of direct and indirect competitors might be quite

high, and careful consideration of the treatment of overlapping trade areas would be required.

The overarching goal of the thesis was to implement the new approach described in Section 1.2 in Worcester, Massachusetts and to evaluate its performance across a range of stores in varied geographic settings. An experiment was conducted to illustrate the pitfalls of using political boundaries and threshold distances as market boundaries, by comparing a market share analysis using political boundaries and threshold areas to define a market area against an analysis using the proposed “degrees of separation” method. Using the city of Worcester, Massachusetts as a test site, trade areas were created for the grocery stores in and around the city. The market areas of several target stores in the city were delineated, using both the degrees of separation method and the city limit boundary of Worcester as a market area. Market share was calculated for each target store under each market area delineation method to test the relative and absolute sensitivity of market share calculations according to how market areas are spatially defined.

1.3 Thesis Organization

The remaining chapters of this thesis attempt to build the case for the use of a standard framework when discussing market area delineation, and propose a degrees of separation approach as a logical solution given the lack of an existing framework. Chapter two situates the need for common language and conceptualization of market area delineation in the context of the history of trade area delineation methods. Trade area delineation has a lengthy history of research, experimentation and discussion, which is in contrast to the

dearth of dialogue around market area delineation. Chapter two highlights the few cases in which market area delineation is discussed, or a lack of a solution is noted, in professional writings. This leads to chapters three and four, which detail the setup of a market area delineation experiment using the proposed degrees of separation approach and report the results using this new method and one based on Theissen polygons and political boundaries. Chapter five discusses the implications of using the proposed market area delineation framework, noting its strengths and weaknesses, and by imagining how this new approach would play out in wider use.

CHAPTER TWO: RELATED WORK

This chapter explores the historical and current treatment of market areas as spatial entities primarily based on political boundaries or distances from a given center point. The conceptualization of a market area as a political boundary or distance threshold is not inherently wrong or misguided; often, it is sufficient to achieve desired results. When used consistently over time, all things being relative, the results from these methods can still be useful. However, it is worth noting the general dearth of investigations into the spatial definition of market areas; especially when methods of spatial delineation of individual trade areas have been researched and refined for decades. Multiple researchers have noted this gap in trade area research, but few have suggested structured approaches for defining and delineating market areas.

2.1 Trade Area Delineation Methods

While the focus of this thesis is the delineation of market area boundaries, a brief review of the techniques used to define individual store trade areas is provided below. The proposed degrees of separation approach is not dependent on a particular method for delineating trade areas, but because it uses trade areas to compose a market area, an understanding of commonly used trade area definition methods is valuable to the reader. Additionally, this section points out the typical undervaluing of market area delineation in favor of individual trade area definition, as an important part of retail trade analysis.

Trade area delineation followed a general evolution from the early 20th century of thinking about singular trade areas based on simple circles, to irregular polygons taking into account multiple environmental factors, to deep concern with consumer decision-

making and probabilities. Generally, the discussion moved from a very black-and-white conceptualization of trade area space, to an understanding of trade areas as flexible, irregular and highly sensitive to consumer behavior. In the latter half of the 20th century and early 2000s, research focused more on quantification of various factors influencing consumer choice, such as pricing, store appearance, driving behavior and brand loyalty.

However, the impact of competitive forces on trade areas has remained relatively unexplored, or simplistically treated, throughout this period. Research focused either entirely on how to define a single store's trade area, as if in a vacuum void of competitors; or it did not adequately explain how or why particular stores were chosen as competitors to a given store, while others were not. In other words, there was no discussion of how to define the competitive market in which a single store operates.

2.1.1 Ring models

One of the simplest ways to conceptualize a store's trade area is by drawing a circle around the store location, with the store as the center point, assuming that all individuals or households falling within the circle are customers of the store. Applebaum and Cohen (1961) and Applebaum (1966) were some of the first researchers to formalize methods for determining circular, or ring, trade areas. Generally, trade areas were delineated by drawing concentric circles around a given store location until 80 percent of the total number of the store's assumed customers were included in the circle. This method assumed that an analyst would have prior knowledge of the store's customer base, and assumed that customer behavior and customer attributes were uniform across the space encompassed by the trade circle.

Decades later, Patel, Fik and Thrall (2008) presented a novel and clever update to the idea of ring models with their wedge-casting trade area tool. They proposed defining trade areas based on wedges which independently expand around a store location until a given percentage of the customer base is accounted for. There are major flaws in this design, such as ignoring competitive forces and as usual, assuming a homogenous customer dispersion; but the concept breaks away somewhat from the the idea of trade areas as simple, smooth polygons by allowing for very varied trade area shapes.

2.1.2 Gravity models

The most well-known and heavily imitated method of trade area delineation is the gravity model, first adapted by David Huff (Huff 1964) for use in retail trade area delineation from earlier versions introduced by William Reilly (Reilly 1931). Huff's original gravity model assumed that customers choose one retail site over another based on two factors: (1) Euclidian distance to the store; and (2) the physical size of the store. Huff later refined his model to include probabilities, so that boundaries between one retail site's trade area and a competitor's could be blurred, or gradual, and that the surface of the trade area polygon varied in saturation based on the probability that consumers would shop there (Huff 1964).

Later researchers adapted Huff's gravity model by experimenting with the influence of factors other than store square footage on consumer store choice. Bucklin (1971), for example, made the important point that multiple trade areas might exist for a single store, depending upon the type of product being examined. Many retail businesses sell to a wide range of customer bases, meaning that the trade areas for certain product

groups may be different from the trade areas for other products. Bucklin (1971) also reiterated that boundaries between trade areas should not be thought of as distinct, clear lines, but rather as gradations. Huff (1984) later responded to Bucklin's ideas on multiple trade areas for individual stores by proposing a "best fit" trade area which averages multiple trade areas for a store into a single trade area.

The gravity model of trade area delineation has achieved widespread use due to its ability to include multiple gravitational factors (i.e. store size, consumer demographics, consumer preference factors, travel distance, or other metrics) to best suit the situation being studied.

2.1.3 Voronoi (Thiessen polygon) models

Voronoi, or Thiessen polygon, trade area methods provide a quick and simple way of defining trade areas. Based on the mathematical concept of Thiessen polygons, they essentially assume no other influencing factor than Euclidian distance on the formation of trade areas. In practical terms, they assume that customers frequent the store closest to them. Boots and South (1997) did propose a Thiessen polygon method which was capable of accounting for consumer preferences, bringing it closer to the gravity model method. Of note in their research was the exploration of consumer tendency to split purchasing between multiple locations on a regular basis. In their case, this splitting behavior was quantified as a probability that a consumer would shop at a given location at any given time. This too, is similar in thinking to Huff's proposal that borders between trade areas are gradual, and based on likelihoods rather than binary relationships.

2.1.4 Trend Surface Area models

Trend Surface Area models introduced an important debate on the heterogeneity of trade area surfaces under pre-existing models. MacKay (1973) and Peterson (1974) discussed the unlikelihood that trade area polygons were consistent throughout in terms of consumer behavior and shopping choices. Because the concept of trade areas had at that time been that of enclosed, homogenous polygons, MacKay and Peterson's arguments were ground-breaking in that they argued for non-homogenous, and even non-contiguous, trade areas. Unfortunately, the methods they proposed for determining inter-trade area variation were not practical for widespread use, as surveys and primary, household-level data collection were presented as the most effective methods for data capture. Huff's previous assertions about trade area border gradation and his statistical approach to variation in customer behavior were perhaps less realistic, but more practical, than the methods of MacKay (1973) and Peterson (1974).

2.1.5 Consumer behavior in trade area models

The topic of trade area creation became a heavily mathematical and statistical one when consumer behavioral factors became more important to trade area definitions. Nakanishi and Cooper (1974), Davies (1977), Fik (1988) and Fotheringham (1988) initiated discussions around the many factors influencing consumer choices, and Drezner (2006), a mathematician, directed trade area delineation toward much more statistical analysis than had been suggested by Huff and others.

Nakanishi and Cooper (1974) developed the multiplicative competitive interaction (MCI) model. The MCI model added a level of consumer-oriented complexity to Huff's

gravity model by allowing for independent weighting of gravity variables according to individual consumer preference. Fik (1981) and Fotheringham (1981) went much deeper into specific decision criteria for consumers who are selecting retail locations. Fik (1988), for example, attempted to quantify the relative weight of price differences against travel distances, and as such, provided a simple update to Huff's original gravity model (by essentially adding price as an additional gravitational factor). Fotheringham (1988), on the other hand, argued that consumer decisions are hierarchical, and introduced the idea of amenity clusters as an influencing factor on consumer behavior.

Drezner (2006) attempted to quantify the "soft" quality of store "attractiveness" in consumer decisions. Her methods included direct customer surveys to validate her findings, and are very specific to her particular case study of shopping malls, but the metrics used and her approach to defining more complex consumer behavior was a breakthrough in the field. Drezner also wrote on the need for the use of uncertainty in trade area modeling, such that users of a trade area delineation tool could understand the impacts of various scenarios on the shape and size of a trade area (Drezner 2009, 2011). It was yet another step away from the older idea of trade areas as static, homogenous and binary, and an endorsement of the use of trade area delineation as a continuous business decision-making tool.

2.2 Esri's Approach to Market Area Definition

Esri's Business Analyst software provides an extensive toolkit with which to build trade areas. Ten trade area creation methods are available in the software, some of which have additional, branching options for the inclusion of particular variables or sub-methods

(Table 1). The software allows for the inclusion of custom data obtained by the user, and is also integrated with Esri’s Business Analyst’s repository of demographic data, spending data and business listings. As such, it is an example of a thoroughly-researched trade area creation toolkit capable of handling substantial complexity.

Table 1: Descriptions of the ten trade area creation tools available in Esri’s Business Analyst 10.1.

Trade Area Creation Method	Description
Customer Derived Areas	Trade areas are created based on the locations and attributes of customer data. Actual customer locations and attributes must be known prior to analysis; primarily used to illustrate attributes of a given subset of known customers (i.e., understanding the nearest or top 30% of customers in a trade area)
Simple Rings	Rings are created around store locations based on a user-defined distance radius
Drive-time Areas	Trade areas are created using Esri street networks and based on estimated driving time from a store to a consumer locations
Threshold Areas	Trade areas expand around store locations until a user-defined threshold is met, such as drive time, sales volume, customer count, etc.
Hand Drawn Areas	Trade areas are drawn by the user
Data-Driven Rings	A ring method which uses a user-defined metric to determine the size of the ring; for example, store sales, or customer counts, could be given a proportional distance (e.g., \$1 million in sales = 1 mile of trade area)
Equal Competition (Thiessen)	Trade areas are Thiessen polygons created around store locations, resulting in a Voronoi diagram
Huff Equal Probability	User-defined variables such as distance, store attractiveness, etc. are given a coefficient by the user, which are weighted and used to create polygons around store locations according to Huff’s gravity model
Non-overlapping Rings	Rings of a user-defined radius are created around store locations, and overlap is automatically removed by the software. A straight line is drawn between the intersecting points of overlapping polygons; results can be very similar to the Equal Competition method
Standard Geographies	Each unit of a standard set of geographic polygons (e.g., ZIP codes, counties, states) are created as separate trade areas

If a user desired to calculate the market share commanded by a particular store’s trade area, Esri’s Business Analyst Market Penetration tool could be used. (Market penetration and market share are not always interchangeable concepts, but the structure of Esri’s Market Penetration tool effectively allows for market share calculation.) The

tool takes a customer layer (i.e. trade area layer, or customers known to “belong” to a given store) and a base market layer as input, and divides the customers into the market layer to determine penetration. Available options for the market layer are any layer existing in the table of contents, or one of the preset Business Analyst Data Source (BDS) layers. BDS layers are demographic and boundary files based on political and census divisions, such as census blocks or ZIP codes. So, while it would be feasible for a user to create a workaround by defining their own custom market layer in the Table of Contents, there is no preset method for selecting multiple trade areas as a market area. Political boundaries are emphasized instead.

2.3 Other Approaches to Market Area Definition

Examples of confusion surrounding how market areas should be spatially defined are evident in both scholarly research and real-life case studies. David Huff, creator of the Huff model for trade area creation (Huff 1966), wrote an Esri White Paper with Bradley McCallum in 2008 (Huff and McCallum 2008) which treated the concept of a market area as simplistically as drawing a freeform boundary around a pre-selected set of store trade areas, and further reducing the area based on the placement of “barriers”, or major roadways (Figure 4). Admittedly, Huff and McCallum (2008) were primarily focused on demonstrating how to calibrate the Huff Model available through Esri’s Business Analyst. However, the notion that competitive market areas could be defined that way illustrates the lack, even decades after his groundbreaking research into trade area creation, of tools for simply concatenating trade areas into competitive market areas in a methodical and repeatable manner.



Figure 4: Drawing a freehand boundary around the trade areas of the outermost stores and further restricting the polygon according to roadway barriers (in image, the multi-colored lines intersecting the polygon) to form a competitive market area for a proposed store location (Huff and McCallum 2008).

In other cases, it is simply taken as an assumption that the most appropriate market boundary is a political one. For example, Boots and South (1997) proposed an improved version of the Thiessen polygon (Voronoi diagram) method for delineating trade areas. They improved on the original model by allowing for consumer choice around a set of options in a market and the assumption that consumers could patronize more than one supermarket location at a time. However, in demonstrating their method

using the supermarket chains in the towns of Kitchener and Waterloo in Ontario, Canada, it was assumed that the administrative boundaries of the two towns were the hard boundary at which competition and trade areas stopped. Figure 5 shows some of the trade area definitions resulting from their research, and the sharp cutoffs of the trade areas where they meet town boundary lines.

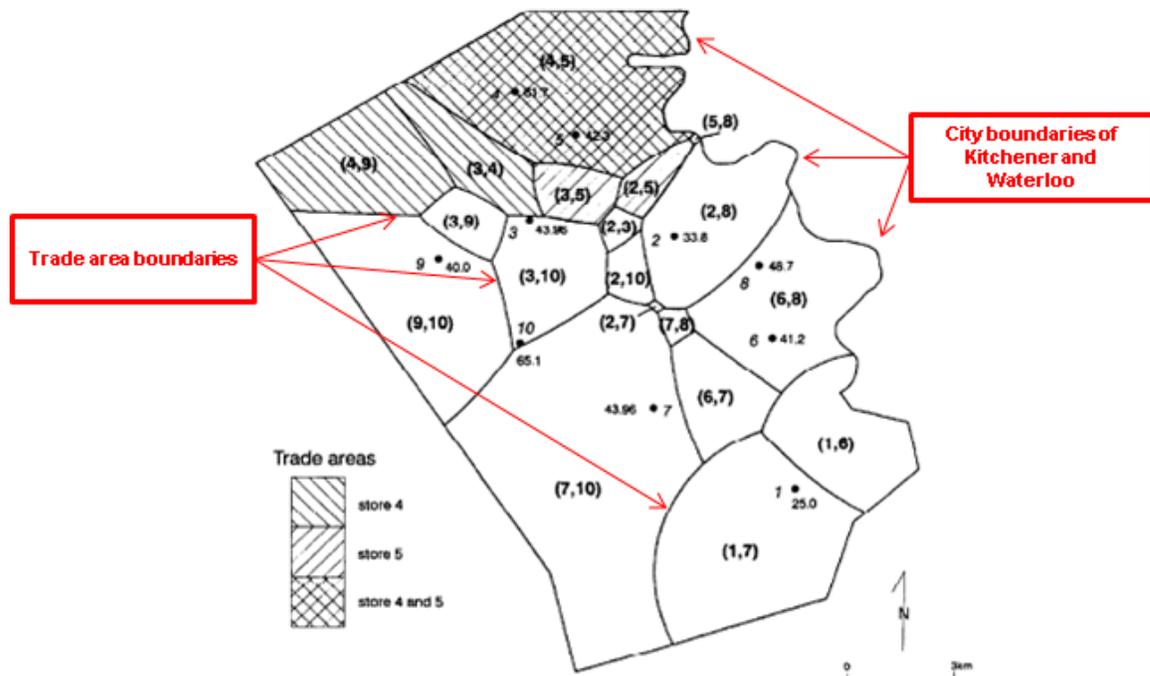


Figure 5: Trade areas created with the multiplicatively weighted Voronoi diagram trade area calculation method of Boots and South (1997). The outer shape of the image is made up of the city boundaries of Kitchener and Waterloo in Ontario, Canada. Inside the city boundaries, trade areas are created (some are shaded) and cut off where they intersect the city boundaries. The results are particularly jarring in the bottom right of the image, where two curved trade area boundaries intersect the irregularly-shaped city limits.

The trade area creation methods proposed by Boots and South (1997), as well as many methods proposed by other researchers, are adding impressive levels of detail and

customization to our ability to define trade areas. However, when trade areas sit within an ill-defined or arbitrary market area, the value of their accuracy is seriously denigrated. In Figure 5 above, the abrupt chopping off of some of the trade area boundaries would result in inaccurate assumptions about customer counts, revenue potential and market shares. It is highly probable that the actual trade areas in Kitchener-Waterloo extend over the administrative boundaries and include some of the customers of competitors on the other side of these boundaries as well.

Several researchers have discussed the potential error introduced by arbitrary market boundaries and the need for a more formal framework for defining geographic market areas. Weiss (1972) noted the incompatibility of political boundaries with empirically-verified market areas. Twenty-three years later, Brooks (1995) observed that “market definition is an important and unresolved problem in studies of market structure-performance relationships.” Brooks (1996) was one among multiple authors to relate the question of spatial market definition to the hospital industry and patient services (Ill et. al. 2004; Gaynor et. al. 2013). Brooks calculated market areas for hospitals in the San Francisco, California area, using his “enacted market” approach (based on defining a market using locations of past activities; in this case, where services have historically been rendered by a set of hospitals) to calculate market boundaries and shares, and then comparing results to the same example using political boundaries to define the market areas and shares. Significant variability existed between his enacted market share calculations and those rendered by the political boundaries approach. Brooks’ (1995) work is a strong argument for developing and validating more thoughtful methods for defining market areas. His “enacted market” approach, however, relies on the availability

of historical sales or services records for the target location and its competitors. This thesis will suggest options for market area definitions when such data is not available.

In his 1995 *Defining Market Boundaries* article, Geoffrey Brooks noted “market definition is an important and unresolved problem in studies of market structure-performance relationships”, and he stressed the relationship between market share calculations and an accurate geographic market definition, saying, “calculations of market share or market concentration, terms typically used to assess conditions of competition, have little meaning if the boundaries of the market have not been correctly defined.” Bronnenberg and Albuquerque (2002) also referenced the lack of a “formal definition” of a market area, but proposed to define it based on “consumer arbitrage”, or the idea that markets could be separated and defined based on whether or not consumers would invest in traveling to one or the other to benefit from price differentiation. This was a meaningful step in placing the burden of market definition on consumer behavior rather than store placement, and is relevant when considered at a national or international scale, but falls short of providing a detailed framework for defining market areas under various, smaller scale (i.e. small area) conditions.

This thesis provides criteria for classifying a given location in space as part of one market area or another, but stops short of offering a method for defining a continuous and/or fuzzy boundary between adjacent market areas. The next chapter documents this method and the experiment that was implemented to test its efficacy.

CHAPTER THREE: METHODS AND DATA

A case study was undertaken to evaluate the performance of the degrees of separation approach for defining market areas that was introduced in Chapter 1 using a variety of political boundaries and distance thresholds. The grocery markets of Worcester County, Massachusetts were used for this case study. Trade areas for groceries in the county were created using Esri's Business Analyst, and the market areas for multiple groceries located in varied settings throughout the county and city of Worcester, were defined. The complete workflow is summarized in Figure 6 and the various sections that follow describe the geographic setting, data sources, and methods used.

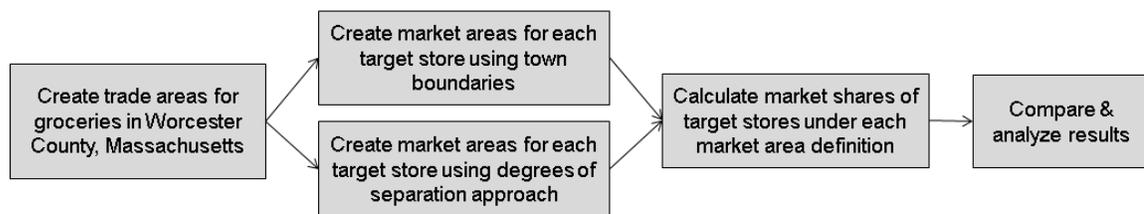


Figure 6: Project workflow

The objective of the case study was to create a geographic market area for a given grocery store market using two different techniques, and to compare the resulting market share calculations under each method for a particular set of retail stores. Under the boundary method, store trade areas were created independently of the market area, which was defined as the town boundary surrounding the stores. Under the new and innovative degrees of separation approach, store trade areas were categorized into “degrees of separation” from the target store’s trade area, based on whether or not they shared a boundary with the trade area of the target store. First-degree customers were defined as those within the target store’s trade area; second-degree customers were those in trade

areas bordering the target store’s trade area; and third-degree customers were defined as those in trade areas bordering the trade areas of second-degree customers. The entire market area for a target store was then defined as the space occupied by first, second, and third-degree customers. Figure 7 summarizes the progression of steps taken to determine market area under this new degrees of separation approach.

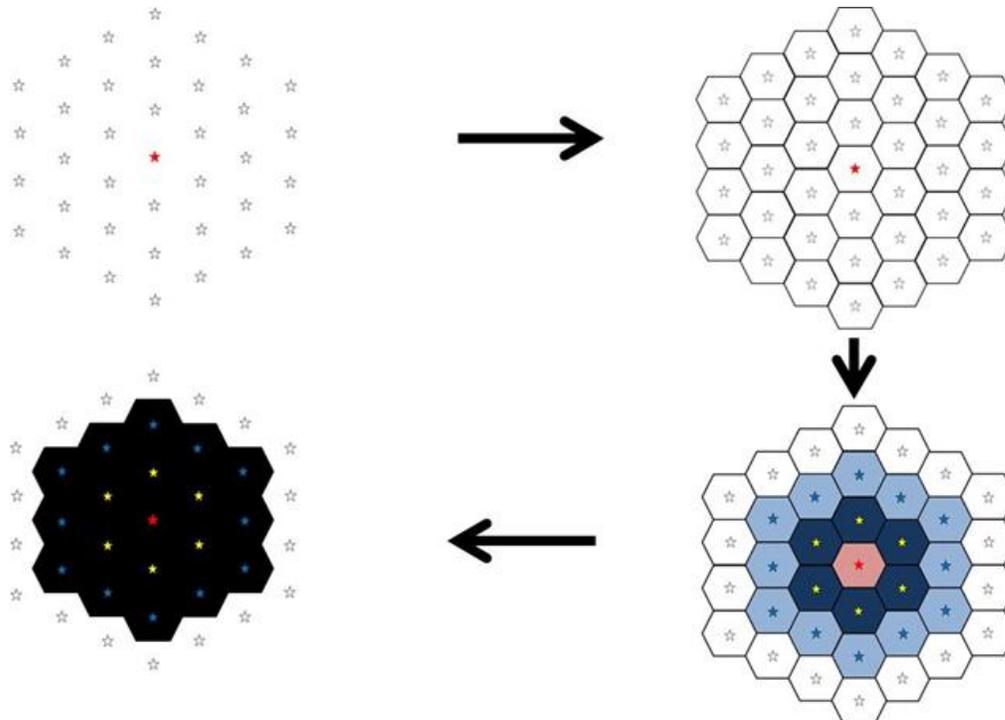


Figure 7: The progression of spatial analysis tasks completed to determine a market area using a degrees of separation approach. Stores (upper left) are assigned individual trade areas (upper right); stores with trade areas bordering the trade area of the target store are categorized into “degrees of separation” from the target store (bottom right); finally, the space occupied by each group of trade areas is considered the market area for the target store (bottom left).

3.1 Description of Study Area

The experiments focused on three cities in Worcester County, Massachusetts. As a medium-sized county with several small urban centers, and suburban and rural areas at its

edges, it provided a mix of built environments. It also has a mix of large, national supermarket chains, some regional grocery chains and many independently-owned markets, groceries and bodegas.

Worcester County covers approximately 1,513 square miles, and had a population of 798,552 as of the 2010 US Census. The county extends the full length of the state, and is bordered on the north by New Hampshire, and on the south by Connecticut and Rhode Island (Figure 8).

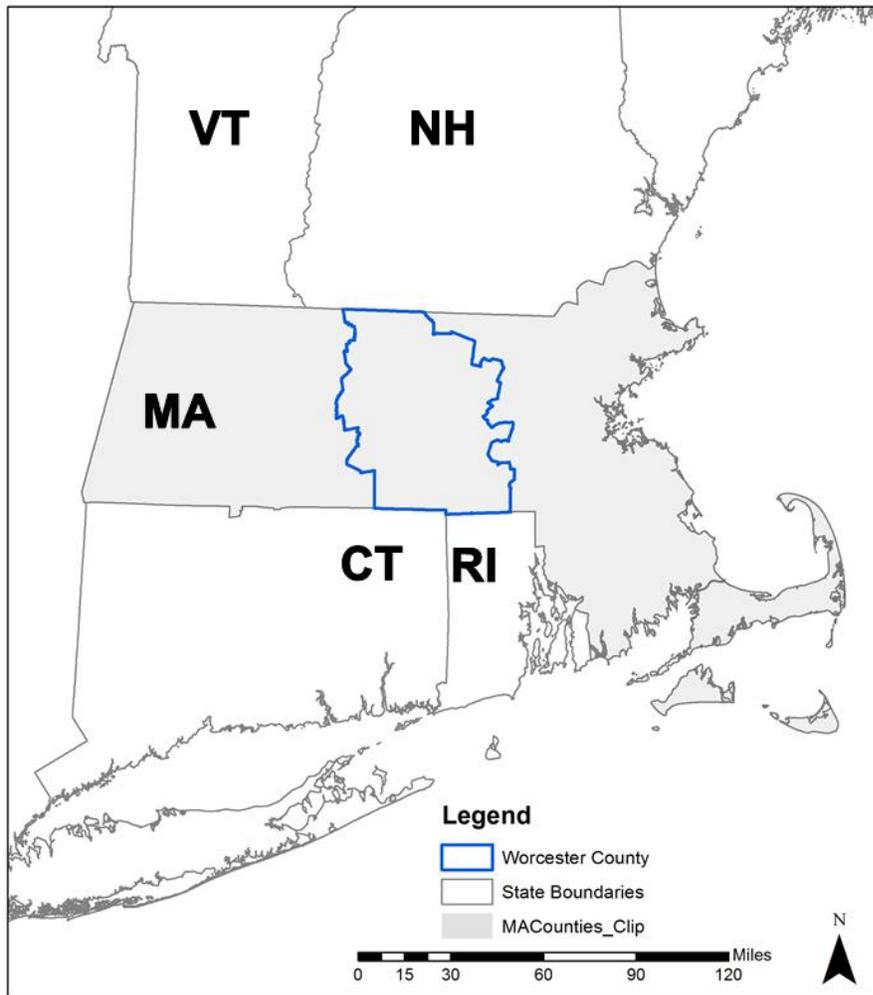


Figure 8: Map of Massachusetts and surrounding states, with Worcester County highlighted

While the choice of Worcester County offered advantages in terms of the number and diversity of grocery stores it provided for analysis, the unique character of the county and town places it on the declining socio-economic side of the average American county and town. This warrants special consideration of the impacts to the study which may arise from the particular socio-economic conditions in the area. Being an older northeastern town, Worcester has a denser physical infrastructure, making travel over short distances more time-consuming, but more heavily populated with retail establishments than what can be found in other parts of the country, particularly the sprawling American Midwest and West. Being more economically depressed than other regions of the country may also lead to consumer behavior outside “the norm” for American grocery shoppers. Lower levels of disposable income may lead to greater price sensitivity and higher willingness to travel for lower prices on grocery items; conversely, the same limitations in spending may lead to a dependence upon proximity for purchasing decisions, to reduce travel costs. Urbanized northeastern towns like Worcester tend to be more walkable than cities in other parts of the country, which may also skew the behavior of customers towards shopping based on proximity and access relative to more automobile-dependent areas.

3.2 Geographic Data Sources

Data for this project was collected primarily through Esri’s Business Analyst Data Repository, which contains a database of business listings and extensive demographic data, as well as shapefiles for boundary features such as counties, ZIP codes and roads.

3.2.1 Grocery data

“Groceries” in this analysis were defined as businesses with a 2012 North American Industry Classification System code (NAICS) of 445110, representing “commissaries, primarily groceries”, “delicatessens primarily retailing a range of meats”, “Food (i.e. groceries) stores”, “grocery stores” and “supermarkets”.

Data about each grocery store was collected by Infogroup, and accessed through Esri’s Business Analyst. The dataset was current through 2012. To verify that the business listings were up-to-date, all groceries listed as being in the city of Worcester were either phoned to verify that they were still open for business, and self-identified as a place to buy groceries, or in the case of chain retailers, company websites were visited and business listings from Infogroup were cross-checked with the locations listed on the web page. This additional verification step resulted in the dataset being reduced from 171 to 150 listings located in the county.

For those locations which were phoned, the question, “Do you identify as a grocery store, bodega, specialty foods store, or convenience store?” was asked, and if the employee responded affirmatively to being a grocery store, bodega, or specialty foods store, their business listing was retained in the study dataset. If the person answering the phone indicated that the number called was no longer in business, or if an employee identified the business as a convenience store, the listing was removed from the study dataset. If the employee was unsure how to respond to the question, they were asked the explanatory question of, “do customers mostly shop with you for basic foods like milk and bread for their weekly meals?”. If the response was affirmative, the record was retained.

Of the 21 records which were removed from the dataset, nine were found to be closed, four self-identified as convenience stores, three identified as clothing stores, one identified as a restaurant, one was discovered to be a duplicate listing for the same store, one self-identified as “not a food store”, and two listings could not be reached by phone after three attempts at various times of the week.

Six grocery stores in Worcester County were chosen as “targets” to be investigated more closely, and for which market areas would be formed. Four were located within the densely urban Worcester city boundary; one was located in suburban Leominster, and one was located in suburban Northbridge, MA. Table 2 profiles each city chosen as part of the study, and Table 3 profiles the six target groceries.

Table 2: Demographic profile of Worcester County cities chosen for market area delineation study

Town	Area (mi ²)	Population (2010 Census)	Population Density (per mi ² , 2010 Census)	Median household income (2010 Census)
Northbridge	18.1	15,707	868	\$50,457
Leominster	29.8	40,759	1,400	\$44,893
Worcester	38.6	181,045	4,678	\$61,212

Table 3: List of target groceries

Grocery Name	Town
Price Chopper	Worcester
Shaws	
Super Stop & Shop	
Colemo's Market	
Hannaford's	Leominster
Shaw's	Northbridge

3.2.2 Demographic data

Demographic data provided by Esri's Business Analyst database includes estimates for "food at home" expenditures by block group. The "food at home" data combines consumer expenditure diary-keeping surveys and quarterly expenditure interviews from the Bureau of Labor Statistics' Consumer Expenditure Surveys (CEX). The data is derived from survey respondents and interviewees either keeping a detailed journal of daily expenses, or by estimating a monthly total during a quarterly interview for food eaten at home. In 2011, the Bureau of Labor Statistics cited that:

...the weighted calendar period estimated mean expenditure for total food by all consumer units in 2011 is \$7,143.84. The standard error for this estimate is \$50.30. A 95 percent confidence interval can be constructed around this estimate, bounded by values 1.96 times the standard error less than and greater than the estimate, that is, from \$7,045.25 to \$7,242.43. We could conclude with 95 percent confidence that the

true population mean expenditure for food for all consumer units in 2011 lies within the interval \$7,045.25 to \$7,242.43.

This level of confidence by the Bureau of Labor Statistics was an acceptable threshold for this project.

3.3 Calculation of Trade Areas

Trade areas were calculated for all groceries in Worcester County, using the trade area creation tools available in Esri's Business Analyst. For this project, the Equal Competition (Thiessen polygon) method was used to create the trade areas. Since the focus of the project is on the creation of a market area boundary, rather than the creation of individual trade areas, this method was chosen for its relatively simple input requirements. It is worth noting again, however, that the degrees of separation approach is intended to function similarly, regardless of the exact method chosen for trade area creation.

The input required to create trade areas using the Equal Competition method were grocery store locations in a points shapefile layer. The Trade Area Creation window required the identification of this layer, and a unique identifier for each feature in the layer (Figure 9).

As described in Table 1, the Equal Competition (Thiessen polygon) method functions by creating polygons around points on a plane, such that any point within the created polygon is closer to the point at its center than any other point on the plane, in terms of Euclidian distance.

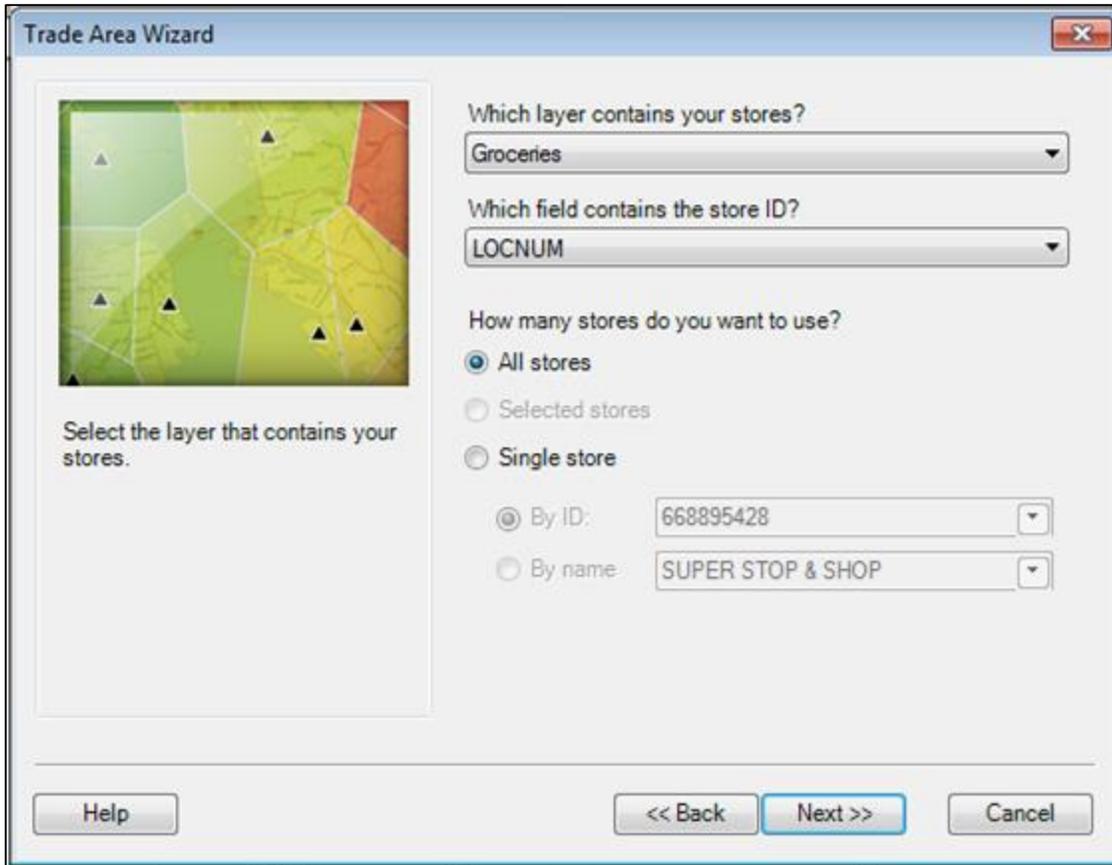


Figure 9: Esri’s Business Analyst Equal Competition Trade Area Creation wizard window in which a groceries layer is identified, along with a unique identifier for each grocery location; selecting “All stores” creates trade areas for each feature in the groceries layer

3.4 Calculation of Market Areas

Market areas were calculated for each of the six target stores using two different methods. First, market areas were calculated using an administrative boundary as the assumed market area boundary. For the target stores, the city boundary for the city in which they reside was used as the market boundary. Shapefiles for the city boundaries were obtained from the MassGIS website, a repository of GIS data and shapefiles maintained by the state government of Massachusetts.

Market areas were next calculated for each of the target stores using the degrees of separation approach that was proposed in Chapter 1. The objective was to form a market area composed of each store's individual trade area, the trade areas of its direct competitors, and the trade areas of its indirect competitors. To identify the various degrees of separation, the SELECT command in ArcMap was used to progressively select each new set of customer degrees of separation. First, the trade area of the target store was identified, and saved as its own layer. Second, a new selection was created in ArcMap which selected those trade areas which were adjacent to the target store's trade area (thereby selecting all second-degree customers). The BOUNDARY_TOUCHES command under the Select By Location tool was used to execute the selection, although INTERSECT would have achieved the same result. This new selection was saved as a layer, named according to its status as the set of second-degree customers belonging to the target store. Next, a new selection was created which selected all trade areas adjacent to the second-degree customers layer. This operation was carried out with the same BOUNDARY_TOUCHES command that was used for the selection of second-degree customers. The additional step of removing the target store's own trade area (i.e. first-degree customers) was needed here, because the first-degree customers are also adjacent to the second-degree customers. This was accomplished manually, by removing the first-degree customers polygon from the selection with the REMOVE FROM SELECTION interactive selection option. Then, this new selection was saved as its own layer, named according to its target store association and selection of third-degree customers.

Once the first-, second-, and third-degree customers were saved in their own layers for a given target store, the three layers were combined, to account for the entire

market area of the target store. This was executed by selecting the entire contents of each layer, and saving the selection as a new layer. It would also have been feasible to use the DISSOLVE command to create a new market area layer consisting of a single polygon.

3.5 Associating Expenditure Data with Trade and Market Areas

The trade and market areas as originally created, did not contain any attribute information other than their own location, shape and size. To carry out market share calculations using the trade and market areas, it was necessary to associate Food at Home expenditure data (stored in the block group polygon layer) with each trade area. However, because the block group polygons and trade area polygons did not match in size, and had many overlapping boundaries, a method was needed to proportionally associate Food at Home data with the trade area polygons overlaying the block groups. Business Analyst's Append Data tool, found under the Analysis toolset, was used for this task. Its function is to overlay two shapefile layers, in this case, two polygon layers, and transfer attribute data from one layer to the other. It is sophisticated enough to apportion quantities in the attribute table of one dataset according to how much overlap exists between it and the other layer. This apportionment can be accomplished in one of two ways. First, the apportionment could be based solely on the proportion of overlapping space between the two layers. For example, if exactly half of one block group overlapped a trade area, then exactly half of the Food at Home expenditures in that block group would be added to the new Food at Home expenditure attribute in the trade area attribute table. The second method for apportionment makes use of Business Analyst's awareness of the locations of individual block centroids within each block group. Blocks within a block group may

have centroids which are unevenly distributed across a block group, and the Append tool can use this information to apportion more realistically. For example, if exactly half of a block group's total area overlapped a given trade area, but 75% of its block centroids were contained in that overlap, the tool would apportion 75% of the block group's Food at Home expenditures to the trade area it overlapped. This second method was used for this project, as it mirrors population density and from this vantage point is probably more reflective of reality.

Using block centroid apportionment, each trade area in Worcester County was given a new attribute of total Food at Home Expenditures. This information was used to calculate market shares, as described in the next section.

3.6 Calculation of Market Share

The goal of creating trade and market areas for each target store was to ultimately calculate the market share of each store under both market area delineation techniques.

The basic market share calculation formula is:

$$\text{Market Share} = \frac{\text{Sales captured by target store}}{\text{Total sales in market area}} * 100 \quad (1)$$

where Market Share is reported in percent. Specifying this process in terms of this project, the formula used to calculate the market share using city boundaries as market areas, was:

$$\text{Market Share} = \frac{\text{Food at home spending captured by target store}}{\text{Total food at home spending in market area}} * 100(2)$$

Total sales in market area

To calculate market share under the degrees of separation method, the formula was:

$$\text{Market Share} = \frac{\text{Food at home spending captured by target store}}{\text{Total food at home expenditures captured by first-, second-, and third-degree customers}} * 100(3)$$

3.7 Evaluation of Model Results

The case study was purposefully structured such that the only data used in the experiment is readily available from Esri's Business Analyst data repository and the US Census Bureau. Market area definitions inherently involve assumptions about the competitors in a market, and primary data on competitor sales and performance are typically not available to business managers wishing to model trade area scenarios. For this reason, it was deemed most relevant to use data that any manager could obtain with relatively little investment.

Given those parameters, the market shares of the target stores were calculated and compared to one another to assess the level of sensitivity of a market share calculation to the spatial character of the market area, or market share denominator. The biggest inconsistency coming out of the formation of the trade and market areas was the conundrum posed by first-degree customers in a target store's trade area which overlapped political boundaries. This occurred for three of the six target stores, and posed an interesting question with respect to the treatment of similar scenarios. When some of a target store's primary customers reside outside the politically-based market boundary, how are those customers to be treated? As noted in the discussion of the Kitchener-

Waterloo problem in Chapter 2, one solution which has been used in the past, is to simply remove the portion of the trade area located outside the political boundary. This action would have less impact if it were not the target store's *primary* customer base being altered. If the customers being removed were third- or fourth-degree customers, their loss would be arguably less critical. However, removal of any customers from a trade area, merely for the sake of aligning with a political boundary, is highly questionable. While such a scenario may not occur in all situations, it highlights again the motivation that guided the choice of this thesis topic – there is a need for a more thoughtful approach to market area definition.

For the sake of consistency, however, the target store trade areas which spilled over a political boundary *were* clipped to fit within city limits for the political boundary-based market area calculations. Otherwise, market share calculations would have displayed drastic inconsistencies.

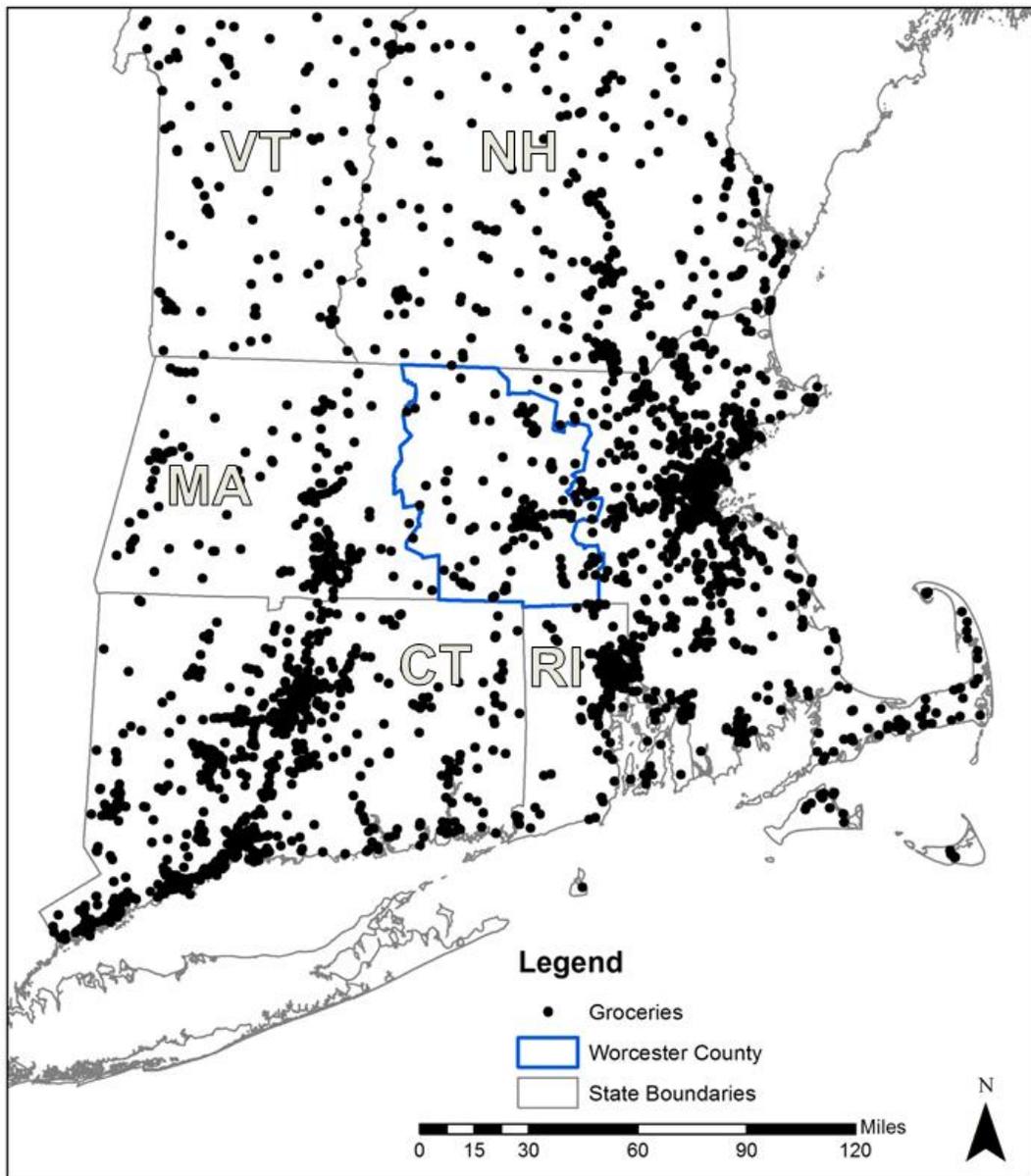


Figure 10: Groceries in the Worcester County area shown with Massachusetts county boundaries; Worcester County outlined in blue; groceries were identified for surrounding states to allow for trade area creation across the Worcester County border.

The distribution of groceries in Worcester County is summarized in Figure 10. There are 150 total groceries, ranging from large, national supermarkets like Shaw's, to regional

chains like Market Basket, and Hannafords, to local stores like D’Errico’s Market. Groceries for the entire state of Massachusetts, New Hampshire, Vermont, Connecticut, and Rhode Island were collected, since Worcester county borders those areas. This inclusion of the groceries at the border of the county allowed the creation of more realistic trade areas, since spillovers across boundaries are inevitable.

The resulting Thiessen polygon trade areas for groceries located in or near to Worcester County are shown in Figure 11.

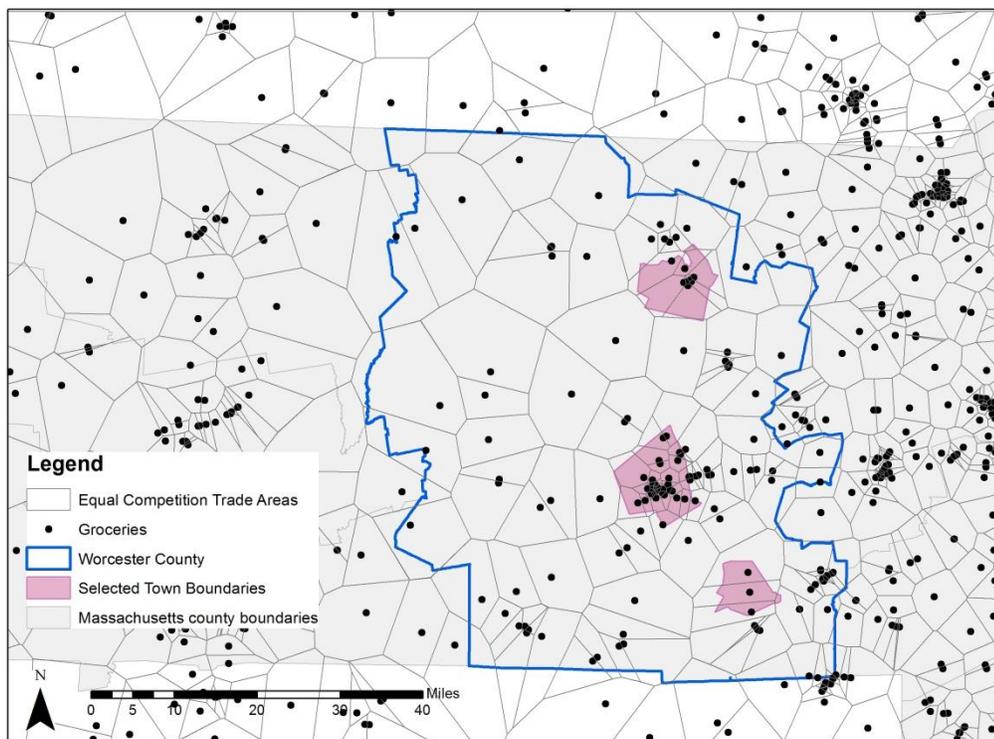


Figure 11: Thiessen polygon trade areas created for groceries in or near Worcester County; the city boundaries of Worcester, Leominster and Northbridge are shown in pink, with Worcester in the center, Leominster to the north, and Northbridge to the south.

Six groceries were chosen as “targets” to illustrate the various methods of market area delineation. Four were within the densely urban Worcester city boundary; one was in suburban Leominster, and one was in suburban Northbridge, MA. Figure 12 shows

the trade areas created around each target grocery store. Four of the six target stores had trade areas which overlapped the relevant city boundary.

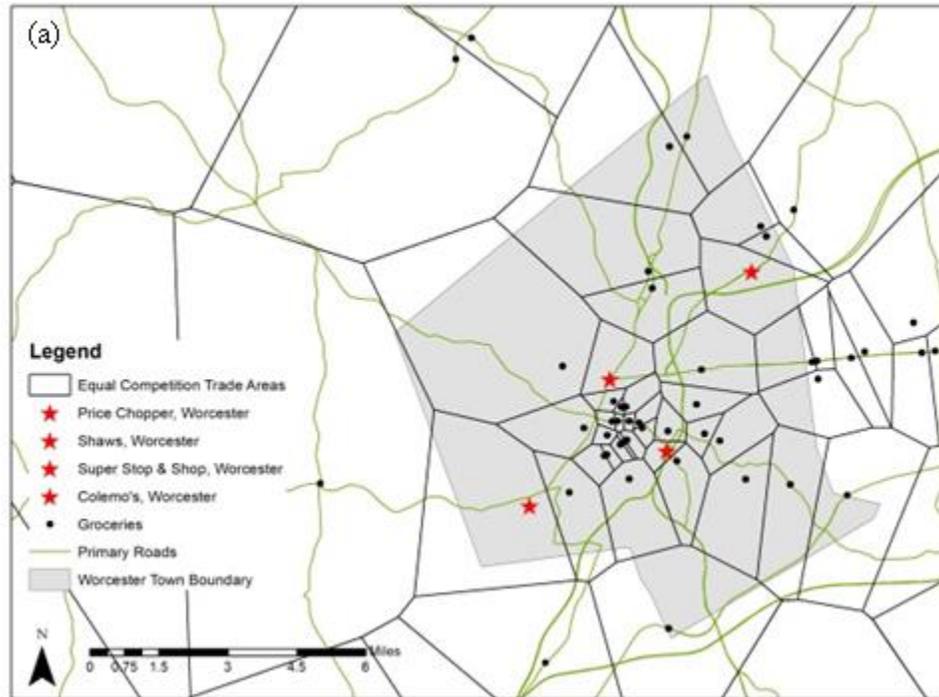


Figure 12: Views of the trade areas created around each target store (represented by a red star) for each town: (a) Price Chopper, Shaw's, Super Stop & Shop, and Colemo's Market groceries in the City of Worcester; (b) Hannafords grocery in Leominster; and (c) Shaw's in Northbridge (next page).

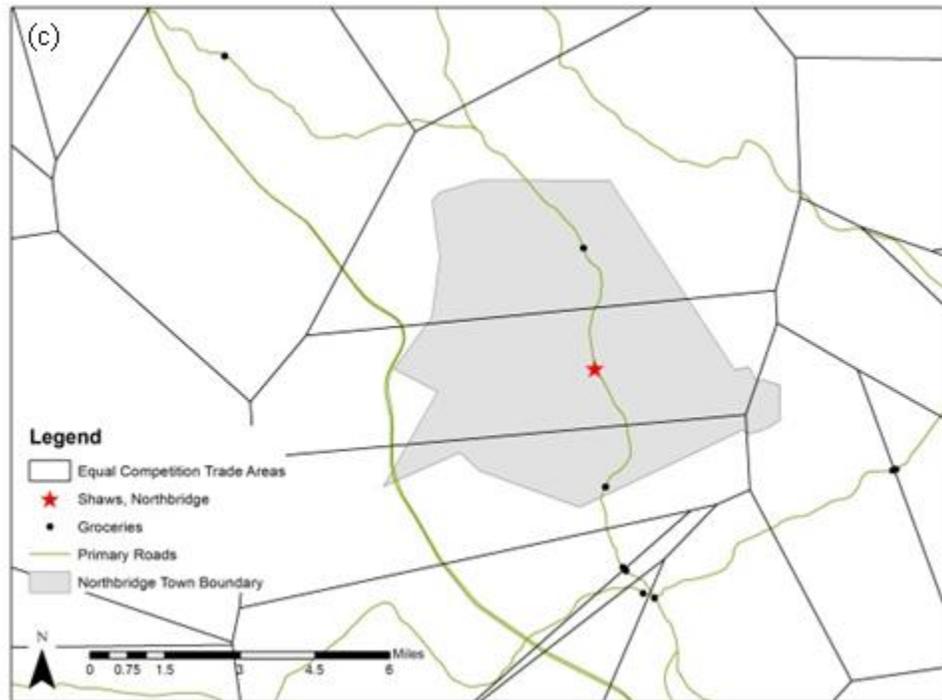
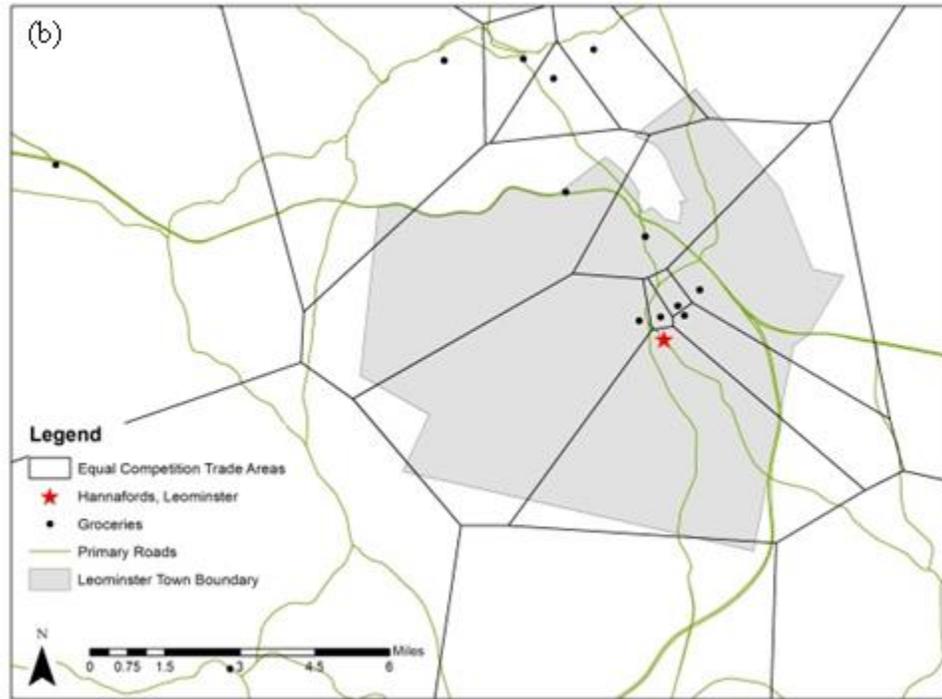


Figure 12: Continued

The market areas for each grocery were defined in two separate ways. First, the political boundary of the town in which the grocery resided was used as the market extent. Second, the market areas were defined by identifying the trade areas of the direct and indirect competitors of the grocery, as defined by the degrees of separation method.

When defining market areas based on the boundary of a town, the overlap created by many of the target store's trade areas were resolved by clipping the trade areas by the town boundaries, and reapportioning food at home expenditures. This kept market share calculations consistent and prevented expenditures from outside the town boundary from factoring into the market share calculations. Figure 13 shows the clipped portions of the trade areas for the target stores.

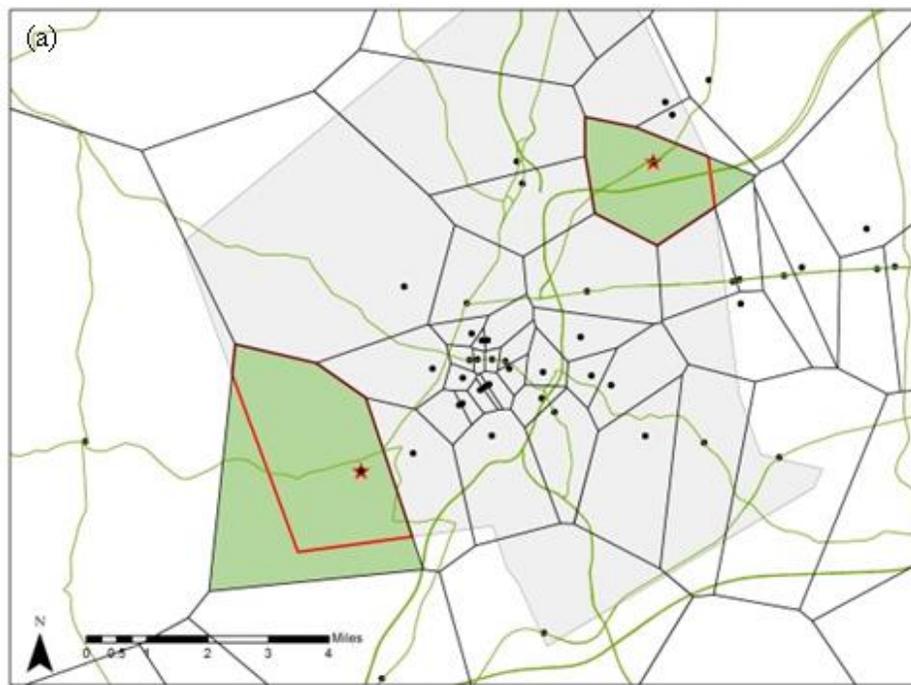


Figure 13: The trade areas for the Shaw's and Super Stop & Shop in Worcester (a) were clipped for the market share analysis using the Worcester town line as a market area boundary. The portions of the trade areas that were retained are outlined in red. The trade areas for the Hannaford's in Leominster (b) and the Shaw's in Northbridge (c) were also clipped.

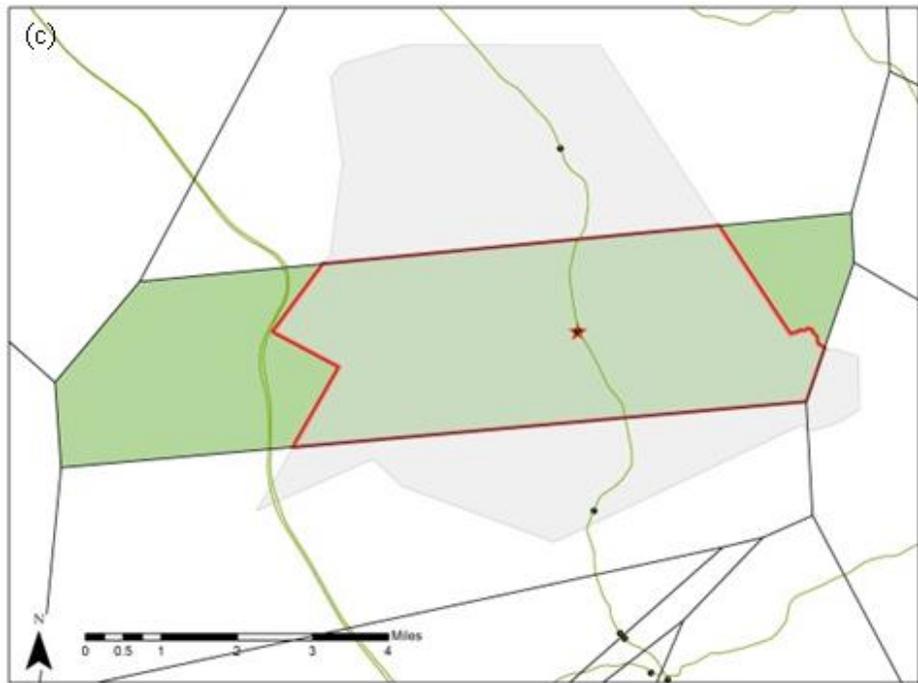
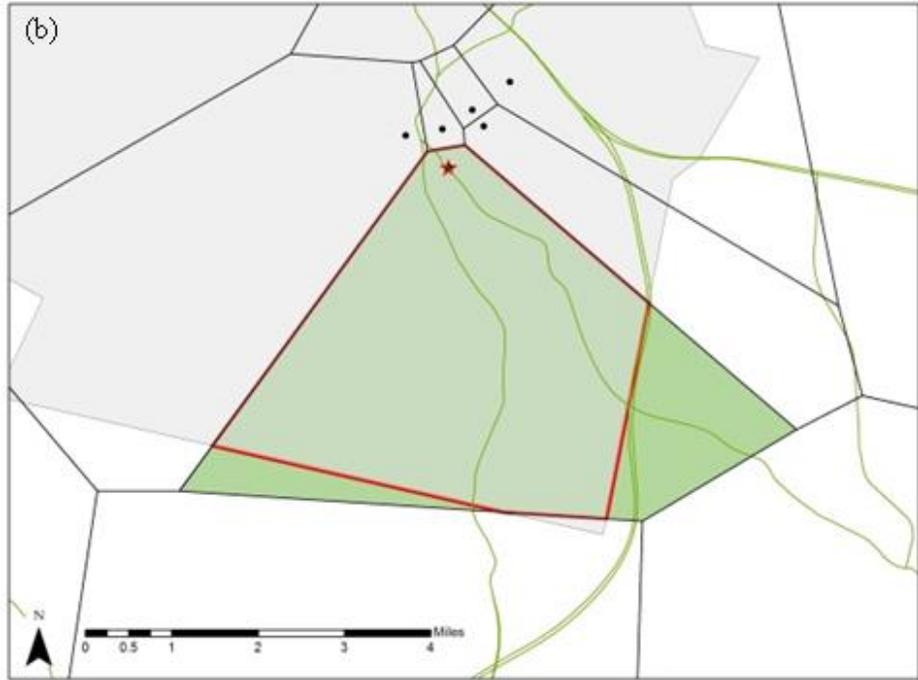


Figure 13: Continued

Once all trade areas were clipped by the town boundary they resided within, the food at home expenditures within the clipped trade areas of each target store were calculated and divided by the total food at home expenditures for each town to calculate market share using Equation (2).

The results of using the political boundary market definition method to estimate the market share for each target store are summarized in Table 4. The third and fourth columns in the table represent the total food at home expenditures contained in the trade areas of the target stores, first unclipped, and second, clipped by the political boundary such that only those records inside the political boundary were counted as part of the target store's trade area. The fifth column in Table 4 represents the denominator for the market share calculation, or the total food at home expenditures contained within the city boundary. The sixth column calculates market share by dividing the target store's clipped food at home expenditures into the town's total food at home expenditures, and represents market share in percent. For context, the final column notes the total number of groceries inside the relevant town boundary.

For the degrees of separation approach, first degree customers were identified by the location of the target store's trade area. For second-degree customers, a new layer was created containing all those trade areas which touched the target store's trade area. Third-degree customers were identified in a new layer containing all those trade areas which adjoined the trade areas of the second-degree customers, as was explained in Chapter 3. In Figures 14 through 19, first- and second-degree customers for each target store are shown together in one color, and third-degree customers are shown in a separate color.

Table 4: Market share calculation results using political boundaries as market areas

Town	Target Store Name	Target store food at home expenditure (unclipped)	Target store food at home expenditure (clipped)	Total town food at home expenditure	Market share of target store (clipped where needed)	Total number of groceries in town
Worcester	Price Chopper	9,337,804	n/a	280,963,154	3.32%	37
	Shaws	23,141,849	17,329,772		6.17%	
	Super Stop & Shop	10,022,388	9,908,091		3.53%	
	Colemo's Market	2,212,495	n/a		0.79%	
Leominster	Hannaford's	22,317,781	21,911,428	74,076,162	29.58%	8
Northbridge	Shaw's	15,472,076	12,931,965	29,190,462	44.30%	3

As seen in Figure 14, the Price Chopper's trade area in Worcester is contained entirely within the Worcester city limits, but some of the store's direct and indirect competitors are drawing revenue from outside the city. Also, several of the groceries in the southeastern part of the city are not considered part of the competitive market under the degrees of separation method. The Worcester Shaw's location's first- and second-degree customers actually spill over the city boundary (Figure 15), and much of the eastern half of the town is not considered part of the store's competitive market.

Similar to the Worcester Shaw's location, the Super Stop & Shop's first- and second-degree customers spilled over the town limits (Figure 16). The store's position in the northwestern portion of the Worcester town limits means that, under the degrees of separation method, nearly half the groceries in the city – those in the southern half of the city – are no longer considered part of the Super Stop & Shop's market area.

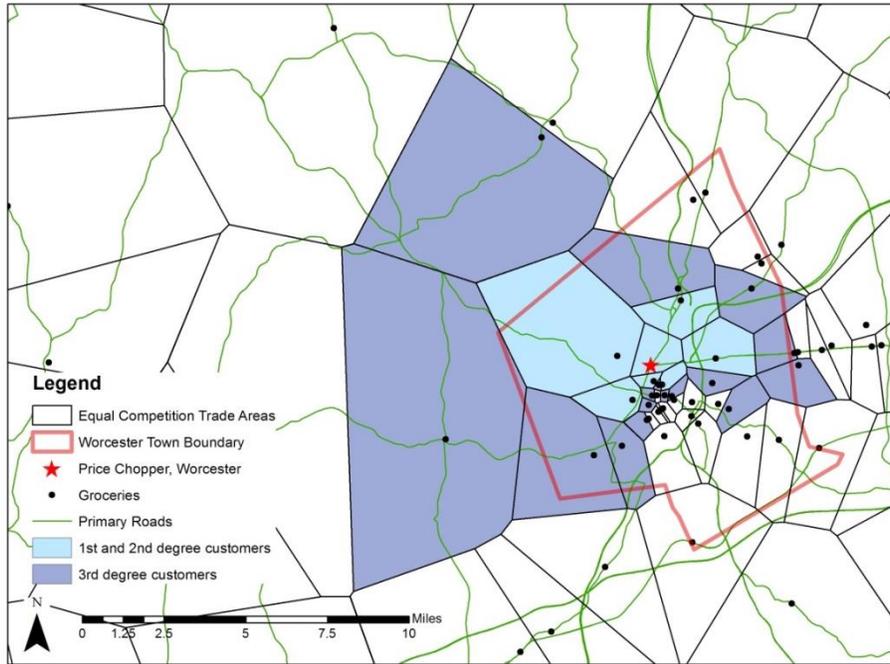


Figure 14: Degrees of separation market area for a Price Chopper in Worcester, Massachusetts

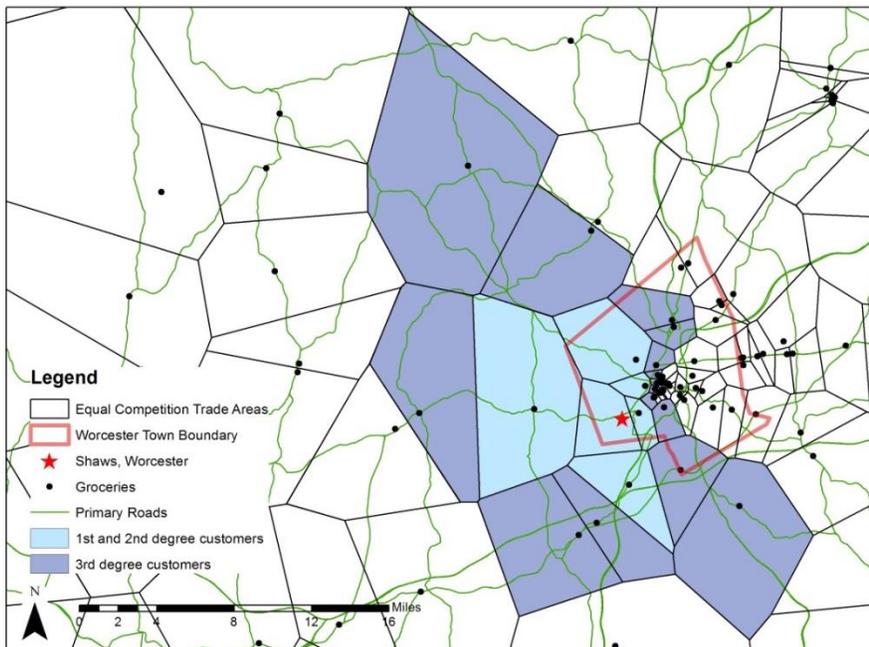


Figure 15: Degrees of separation market definition for Shaw's in Worcester, Massachusetts.

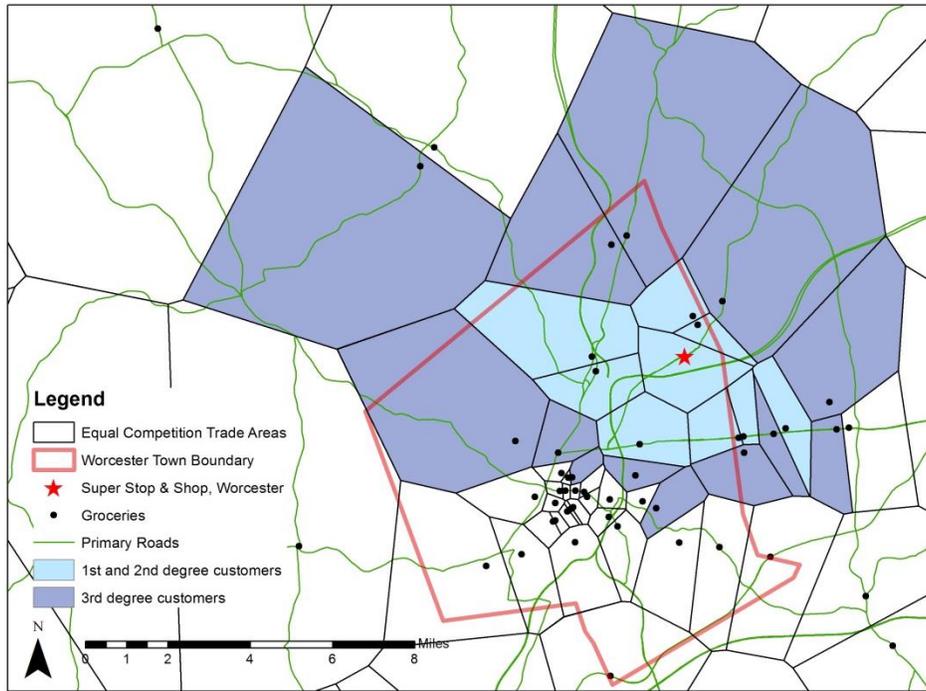


Figure 16: Degrees of separation market definition for the Super Stop & Shop in Worcester, Massachusetts.

Located in the urban center of the city, the Worcester Colemo's first- and second-degree customers cover a smaller area than those of the other target Worcester stores (Figure 17). Colemo's location in a dense downtown area highlights the weakness of defining markets based on only two or three degrees of separation. It would be reasonable to assume that the non-competitive stores to Colemo's north, also in the downtown Worcester area, are in fact active competitors.

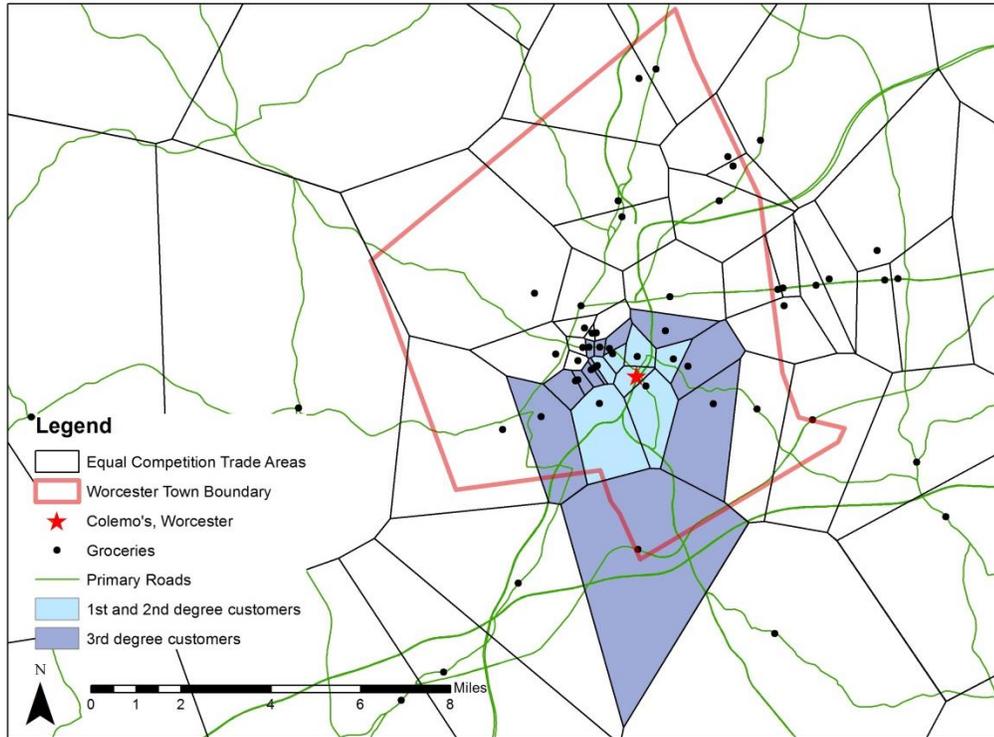


Figure 17: Degrees of separation market definition for Colemo's Market in Worcester, Massachusetts.

The Leominster Hannaford's location had a trade area with portions outside the city boundary, and was located in a tight cluster of groceries near the town center (Figure 18a). The dense grouping of groceries around the Hannaford's store renders the strict definition of degrees of separation less relevant than if the stores were more evenly distributed (Figure 18b). For a more accurate view in dense areas, there may be minimum distance thresholds inside which neighboring groceries should be considered direct competitors.

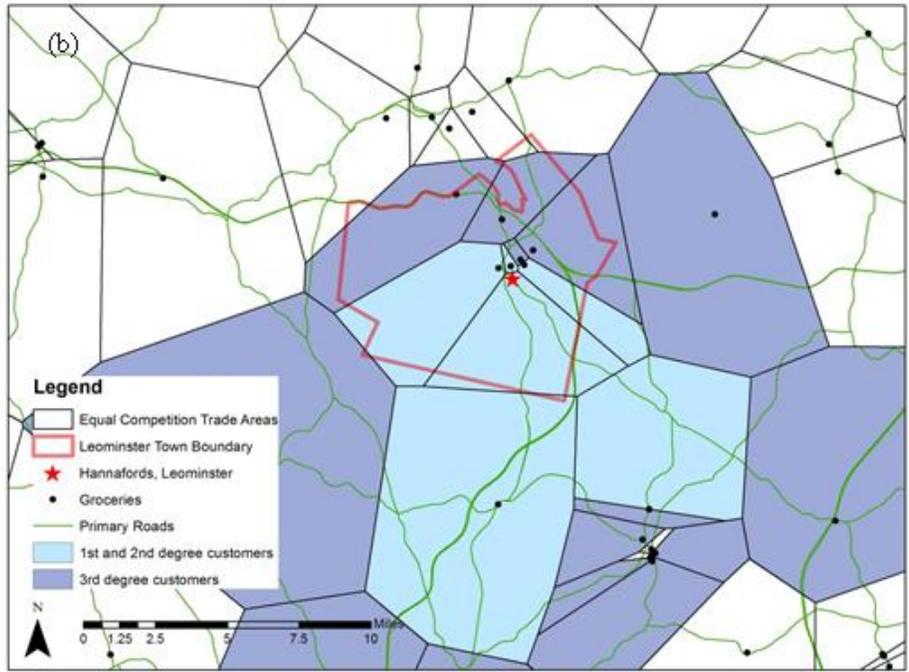
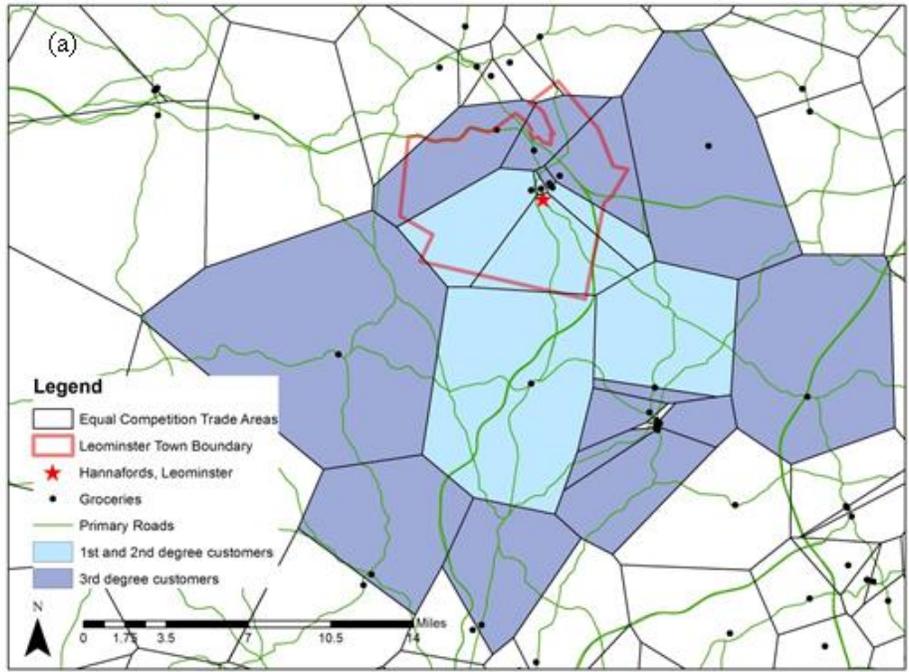


Figure 18: Degrees of separation market definition for Hannaford’s in Leominster: (a) Map showing full solution; and (b) large-scale map showing partial solution

The customer degrees shown in Figure 19 for the market area of the Northbridge Shaw's are an example of a more dispersed grocery network resulting in a market area which is much larger than the administrative boundary in which the target store sits. If the Shaw's location was considered only in the context of the other two groceries in the town, the competitive impact from the clusters of stores to the east and south would be completely ignored.

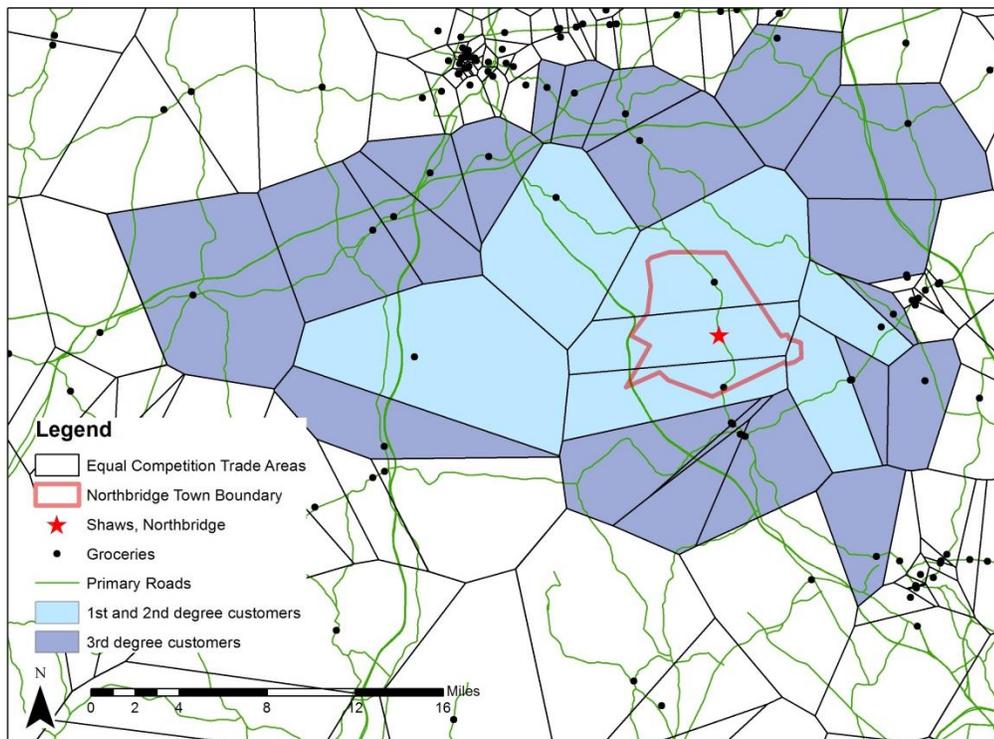


Figure 19: Degrees of separation market definition for Shaw's in Northbridge, Massachusetts.

The market shares for the target stores under the degree of separation market definition method are summarized in Table 5. Note that no clipping of trade areas was required in this analysis. The Worcester stores resulted in a range of market shares, from

3% for the smaller Colemo’s Market, to 8% for Shaw’s supermarket. The Hannaford’s in Leominster held nearly 10% market share against its seven other competitors in the city. The Northbridge Shaw’s earned nearly 4% market share in its area. Table 4 summarized the market share calculation results under the political boundary approach. The Worcester groceries had a range of 1-6% market share using the political boundary market definition, while the Leominster and Northbridge groceries held 30% and 44% market shares, respectively.

Table 5: Market share calculations for target stores using degrees of separation method for market definition

Town	Target Store Name	Target store food at home expenditure	Food at home expenditure of first-, second-, and third-degree customers	Market share of target store	Total number of groceries in town
Worcester	Price Chopper	9,337,804	227,101,434	4.11%	37
	Shaws	23,141,849	288,851,577	8.01%	
	Super Stop & Shop	10,022,388	257,594,485	3.89%	
	Colemo’s Market	2,212,495	86,101,290	2.57%	
Leominster	Hannaford’s	22,317,781	225,112,570	9.91%	8
Northbridge	Shaw’s	15,472,076	428,478,709	3.61%	3

Market share calculations for both methods are compared in Table 6. For the Worcester stores, small differences exist between the market share results of the two methods. All Worcester groceries received a higher market share under the degrees of separation method; the Price Chopper and Super Stop & Shop locations gained less than one percentage point in market share, while the Shaw’s and Colemo’s Market groceries each gained nearly two percentage points.

Table 6: Comparison of market share calculations between boundary and degrees of separation methods for delineating market areas

Town	Target Store Name	Market share (boundary method)	Market share (degrees of separation method)
Worcester	Price Chopper	3.32%	4.11%
	Shaws	6.17%	8.01%
	Super Stop & Shop	3.53%	3.89%
	Colemo's Market	0.79%	2.57%
Leominster	Hannaford's	29.58%	9.91%
Northbridge	Shaw's	44.30%	3.61%

The differences between the two methods are much larger in the less-dense neighborhoods of Leominster and Northbridge, with both groceries experiencing a decrease in market share under the degrees of separation approach. The Hannaford's in Leominster declined from a 30% market share using political boundaries, to a 10% market share using degrees of separation. Likewise, the Shaw's in Northbridge lost 40 market share percentage points, moving from 44% under the political boundaries method, to 4% using the degrees of separation method.

CHAPTER FIVE: DISCUSSION AND CONCLUSIONS

While the calculations undertaken in this project point toward the sensitivity of market share calculations to market area definitions, and begin to suggest alternative methods for delineating market areas, the data used here would be more valuable were it validated through primary research into actual grocery store sales for a competing set of groceries. That said, the project results demonstrated the sensitivity of the market area estimates to the delineation approaches that are chosen, and they point to ways to refine the degrees of separation-like framework that was the focus of this thesis for market area delineation.

5.1 Broader Significance of the Worcester County Results

As seen in Table 6, the absolute differences in market share between the two methods are relatively small for groceries in the town of Worcester. However, the results for the four groceries in the Town of Worcester do show that the degrees of separation method tended to estimate a higher market share for urban area groceries compared to the boundary method (Table 6). This could be due to the high number of groceries inside the city boundary. The degrees of separation method resulted in a smaller set of groceries with which to compete than in the boundary method, so resulting market shares were generally higher. Figure 20 illustrates the absolute differences in overall market size for each grocery under each method. For three of the four urban groceries, the market sizes were relatively similar under both approaches, but wide variation can be seen in the rural markets. The Hannafords market in rural/suburban Leominster, for example, was three times larger under the degrees of separation approach than the boundary method.

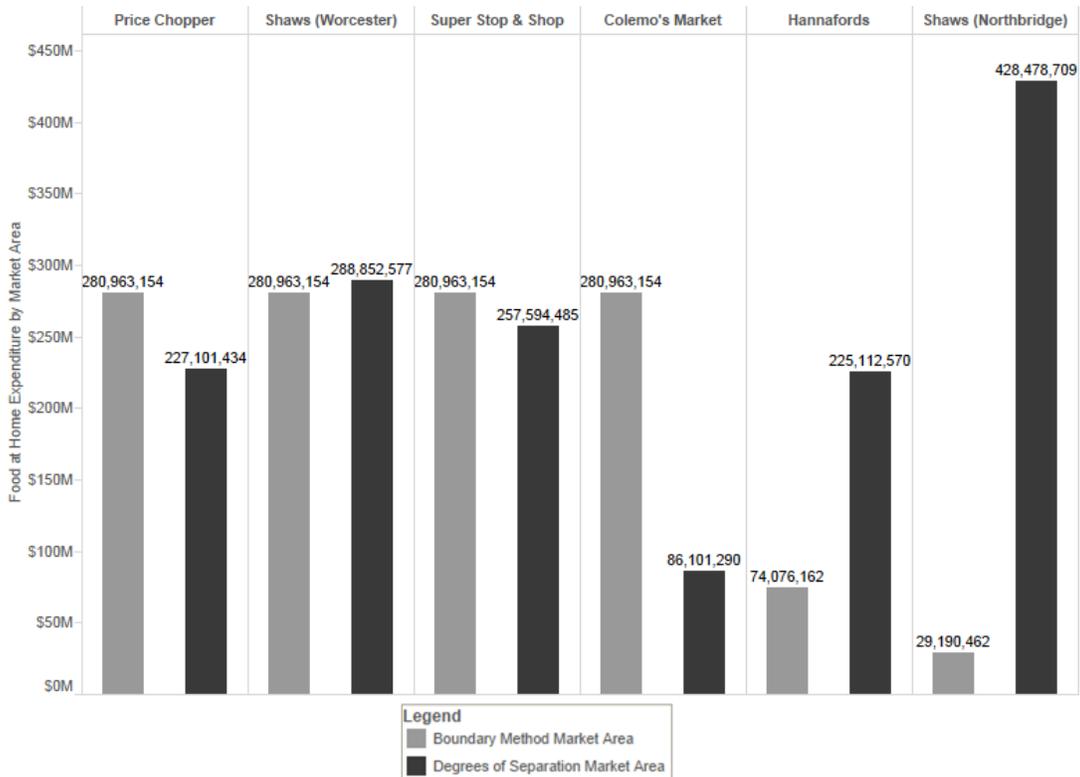


Figure 20: Comparison of results from two market area definition methods; dollars in food at home expenditure per year on Y-axis, by-store results under boundary and degrees of separation method shown on X-axis

The Worcester stores also illustrated where the degrees of separation method can break down and therefore be less useful than in situations with a wider dispersion of competitors. Figure 21 shows a close up view of multiple downtown Worcester grocery stores relative to the target Shaw’s location. Many of the urban groceries are excluded as competitors, yet other groceries north of the city, whose consumers would presumably drive through downtown Worcester to reach the Shaw’s location, are considered more of a competitive threat than the stores located (more or less) between them and Shaw’s.

A similar situation is seen in the Leominster example, as reproduced in Figure 22. Groceries, in this instance, that are located within a mile of the target store are considered

only “indirect” competitors, a function of the model’s strict definition of what constitutes a degree of separation.

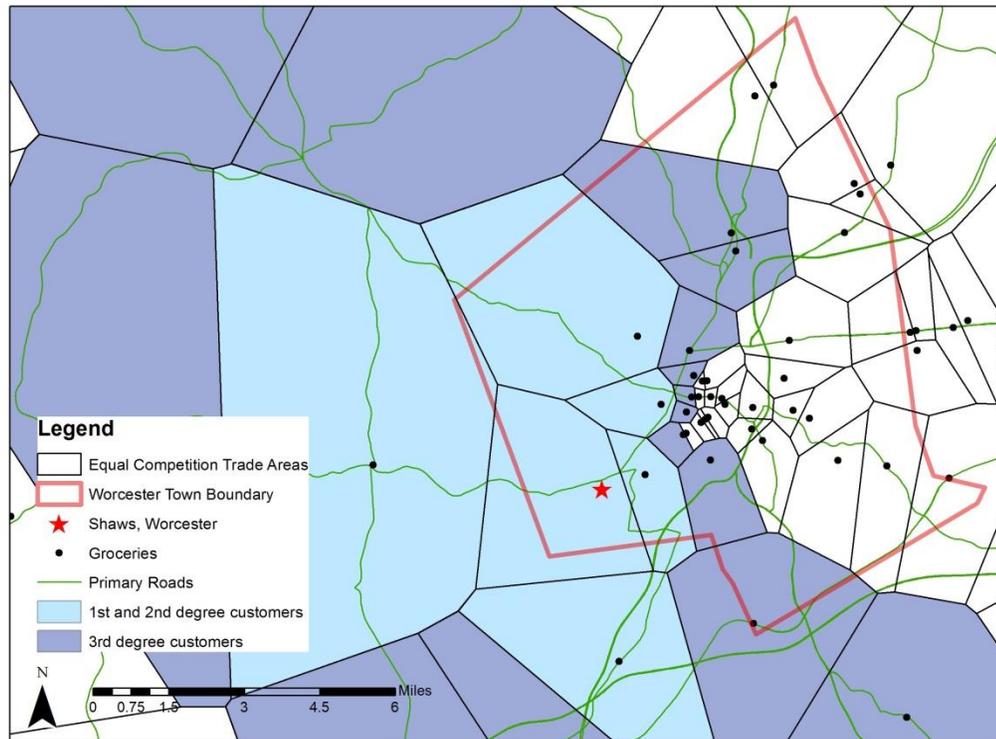


Figure 21: Closer view of the Shaw’s location in Worcester. The cluster of downtown groceries complicate the degrees of separation approach by treating different distances between competitors as effectively equal in their impact on competitive threat.

The degrees of separation model might be improved by adding minimum distance thresholds between stores as grounds for automatic direct competition. Additionally, the fact that the examples provided used non-overlapping trade areas likely oversimplifies the extent of competitive areas. Had overlap been included in the trade area creation method, it is likely that clusters of close stores as in Figures 21 and 22 would have all

been considered direct competitors. These ideas are taken up in more detail in Section 5.2 below.

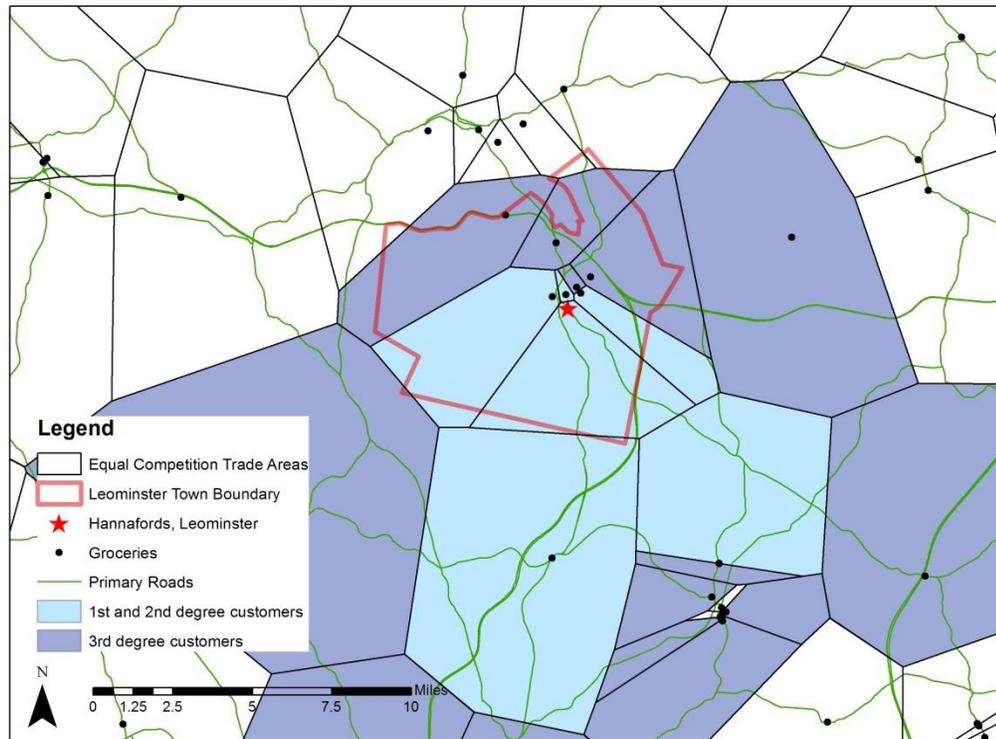


Figure 22: Closer view of the Hannaford's market area in Leominster.

Another potential improvement in the degrees of separation method could be to consider different thresholds for degrees of separation according to the density of the competitive environment. For example, if instead of a minimum distance threshold, a maximum threshold of four or five degrees of separation were considered in urban areas, and perhaps only two degrees in sprawling rural areas, the nuances of different competitive densities might be handled better.

In contrast to the Worcester examples, the results of the Leominster and Northbridge analyses appear to result in more sensible trade areas through the degrees of separation method. In Northbridge, a town with only three groceries within its limits, it

becomes clear that political boundaries can be quite misleading. The trade areas of all three groceries extended well beyond the city limits. Using the degrees of separation method, it appears that groceries nearly within the Worcester city limits are actually competing indirectly with the Northbridge Shaw's. The major highway linking Northbridge and Worcester likely adds to this competition. Furthermore, with an initial calculation of 40% market share within the city boundary, it would be simple for such a metric to understate the competitive force of the groceries directly south, and just outside, the city of Northbridge. It could be that the presence of these stores threatens the Shaw's existing market share in the city limits, or conversely, they might represent an opportunity for additional market share and revenue gain. Either way, their potential impact could be underestimated with a poorly defined market area.

Using the degrees of separation approach in Leominster, the market area does in fact cover the city limits, but it also extends south to include groceries like Appletown Market, Next Door Market and another Hannaford's location. Also linked directly to Worcester by highways, the competition extending southward toward the city nearly intersects the Worcester city limits.

Leominster's Hannaford's reached a 30% market share estimate using its city limit as a market area. While this is positive news for the grocery, and a useful statistic, it ignores the market potential existing just over the boundary which may already be a part of the store's market share, or may be prime for the taking. The three stores directly south of the Hannaford's Leominster location lie outside the city limits, but within 10 miles of Hannaford's. With a relatively sparse grocery market to the south of Leominster, it is unlikely that these stores do not vie for similar customers. On the other hand, there is a

cluster of stores in the town of Fitchburg 10 miles to the north of the Leominster Hannaford's. While a similar distance away, the higher number of competitors in the Fitchburg micro-market would be less likely to compete with the Hannaford's to the south. This demonstrates the utility of using a degrees of separation approach over a method like a ring definition for delineating market areas. Assuming a simple buffer distance around stores to delineate a market area, as Huff and McCallum (2008) did, relies on the seemingly risky assumption that competitive forces act at a constant rate across space. In the Leominster example, it does not appear that the competitive picture is the same 10 miles north versus 10 miles south of the target store, and the degrees of separation method used helped to point out that nuance in a simple but effective way.

5.2 Opportunities to Improve the Degrees of Separation Framework

There are several possible ways to improve upon the degrees of separation method that was conceived and implemented in this thesis.

First, it would be useful to test the results of the model using validated store and competitor sales data, as well as the perceptions of managers regarding the spatial extent of the market in which they operate.

Second, while the degrees of separation framework is intended to be flexible enough to work with any type of trade area delineation method, it would be beneficial to test it using methods other than the Equal Competition (Thiessen polygon) approach. Threshold rings, drive time analyses, and trade areas with overlapping segments would provide a different set of nuances to test the applicability of the degrees of separation method. Also, only one type of political boundary was used in this analysis. Town and

city limits are easy to relate to, but ZIP codes, census block groups or some other political boundaries could be used as market boundaries and compared against the degrees of separation results.

Third, it would be interesting to test the method at a larger scale, perhaps with an entire regional retail chain, or using a retail sector with low-order goods but high brand loyalty, such as apparel.

Finally, it would be necessary to test the method in a diverse set of geographic areas. As mentioned, the particular character of Worcester county as a northeastern, historically industrial, and socio-economically declining area lends a particular set of assumptions and practices to the creation of accurate trade areas. A different set of best practices may exist for creating trade areas in sprawling cities, rural areas, or coastal towns. While the methods chosen for creating trade areas do not fundamentally alter the degrees of separation market area delineation framework, it would be interesting to assess the varying shapes and sizes of markets that result from separate sets of underlying trade area creation practices.

5.3 Closing Thoughts

The degrees of separation market delineation approach sought to take advantage of the wealth of research already underway on trade area delineation. There should be no cause for “re-inventing the wheel” for market area definitions, and certainly no cause for using arbitrary market definitions based on a different spatial unit than pre-existing trade areas (such as using census block groups to define trade areas, and then town boundaries to define a market area). The approach proposed here suggests that three degrees of

separation between a target store and customers is appropriate for the grocery market; but the intent is also to suggest flexibility in how “degrees” are handled on a case-by-case basis. What works for groceries may not work for gas stations; but a common language for what separates competitors from one another and ultimately forms a spatial market extent is just as important as accurately defining an individual store’s trade area. If a common language and theory can be established around the task of spatially defining retail markets, the robust methods which support individual trade area delineation may be applied to market area delineation as well.

Taken as a whole, the results presented in this thesis suggest that we have some way to go before we can fully exploit location in retail business analytics and economic decision-making. This discovery points to the need for fundamental geospatial research to complement the business applications touted by Esri and many others in their business location analytics promotional materials.

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