Combining GIS and the Huff Model to Analyze Suitable Locations for a New Asian Supermarket in the Minneapolis and St. Paul, Minnesota USA

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Abstract

Location selection for a new supermarket is an interesting and challenging task that has a significant role in determining the success of a business. This project uses GIS technology to analyze potential locations for a new Asian supermarket in the Minneapolis and St. Paul, Minnesota USA. Methods utilized in this project combined the Huff model with GIS to find the best location for supermarkets, and show the sales potential of the best locations.

Introduction

According to the introduction from the Great Wall supermarket's website (www.gw-supermarket.com, n.d.), both food and service are good quality in traditional Asian supermarkets and can meet the needs of Asian immigrant families in the United States but some problems still exist. Some stores are small and do not have economies of scale, the ability to cut costs by increasing production. Therefore, small stores' costs may be significantly higher than the other larger supermarket (Bucklin, 1967). Another problem is the shopping environment. The shopping environment is impacted by the micro variables which are specific to particular shopping situations and confined to a specific geographic area. Factors such as in-store background music, store display, scent, in-store promotions, prices, shop cleanliness, shop density or congestion and store personnel all contribute to the in-store shopping environment (Zhou and Wong, 2004). Examples of the shopping environment problems include: some Asian stores have a bad smell, the employees cannot speak English very well, and the parking lots are not always convenient. Some Asian stores' parking lots also are small with poor design - like parking spaces that do not take into consideration the aisle space needed for cars to back out (Wan, 2004). Because of these problems, most Americans do not want to shop in typical Asian stores (Luo, 2005). H Mart is a South Korean supermarket, which specializes in providing Asian foods in the United States. By 2005, the H Mart had 17 supermarkets; the number was 34 in 2010 (www.hmart.com, n.d.). H Mart is bigger than most Asian grocery stores, so they have more products available and goods are fresher because they sell faster and new orders are made more regularly. In addition, products are consistently available and organized within the store. The shopping environment is like that of Wal-Mart, but the products are oriental (Cui and Liu, 2000). There is not an Asian supermarket like H Mart in the Minneapolis or St. Paul. According to the

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data from the census bureau, in the year 2000, Asian people made up 8.1% of the total population in Minneapolis and St. Paul. The number increased to 9.6% in the year 2010. In the year 2005, there were 50 Chinese students learning at the University of Minnesota. The number grew to around 1400 in the year 2010 (www.umn.edu, n.d.). There are six famous Asian supermarkets in the Minneapolis and St. Paul (www.minnesotachinese.com, n.d.). Table 1 shows these six Asian supermarkets and their year of establishment.

Table 1. Existing Asian supermarkets and their year of establishment.

Existing Asian supermarket	**Built year**
Dragon Star Oriental Foods	1993
Double Dragon Foods	2003
Shanghai Wholesale	unknown
Shuang Hur Super Market	1992
United Noodles Oriental Food	1972
Shanghai Market Inc	1998

From the table above, most big Asian supermarkets were built in the Minneapolis and St. Paul before 2003 (www.manta.com, n.d.). From the description, business environments may lend itself to a big, standard Asian supermarket in Minneapolis or St. Paul.

If developers want to take advantage of potential growing markets, they need to find out which locations are suitable to build an Asian supermarket, and which place is the best. Location selection for a supermarket is an interesting and challenging task that will affect its subsequent success (Aaker and Morgan, 1971). From the profitability point of view, a location with good accessibility can attract a larger number of customers and achieve high product turnover with resulting profit. From the loss point of view, it is difficult to change the location of a store once established (Achabal, Kriewall, and Munson, 1982). The conventional methods of location selection for a supermarket usually utilize the expertise of analysts and their backgrounds and experience may influence significantly the final evaluation results. This also means high cost on human resources (Bai, 2007). Due to the ever-growing uses of GIS, there are already huge amounts of spatial data, which provide many opportunities to handle supermarket location selection. The Topologically Integrated Geographic Encoding Referencing and Census Bureau provide spatial population attribute data (Trainor, 2003). This project uses the Great Wall supermarket's sale report (www.gw-supermarket.com, n.d.) as the criteria and then uses a GIS and Huff model to find suitable locations. The Great Wall supermarket is a successful Asian supermarket, which has 15 stores in the United States.

According to the Great Wall supermarket's experience, seven criteria should meet for a new Asian supermarket. These criteria include (www.gw-supermarket.com, n.d.):

1. the density of Asian people is greater than 300 per square kilometers.
2. density of total population is greater than 3000 per square kilometers.
3. the location should be at least two miles away from the main competitors.
4. a nearby main road is within 500 feet.
5. the land is zoned for business use.
6. it is better to be near to the

university.

7 . it should be within 1500 feet of bus stops.

The first five criteria are of higher priority and more important than the last two. The data for this project were collect from different sources. Population data were obtained from the U.S. Census Bureau (2008); competitors' data were obtained from the website (www.minnesota chinese.com, n.d.); University of Minnesota data was from the university's website (www.umn.edu). Other data were obtained from the DataFinder website (www.datafinder.org).

Methods

Technology and Software Requirement

Computer-based technology using GIS software was used to conduct the study. The following software and applications were used: ArcGIS 10, Spatial Analysis tools, network analysis, Huff model, Microsoft Excel, Microsoft Access, and Google Earth Pro.

Data Analysis

Step 1

The first step was to select the study area in the Minneapolis-St. Paul Metro Area (Figure 1).

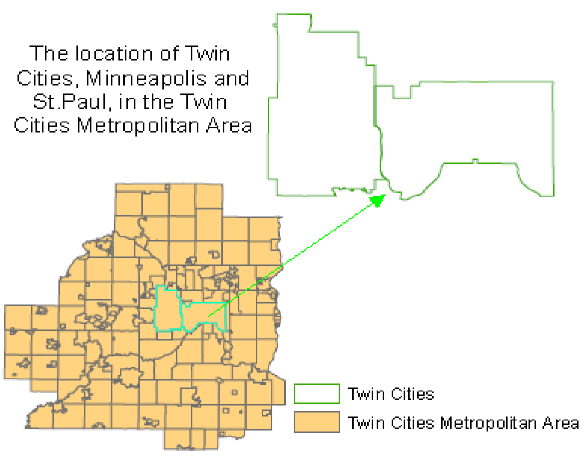

Figure 1.The Study Area: Minneapolis and St. Paul, in Minneapolis and St. Paul Metropolitan Area.

Step2

In order to analyze the density of the total and Asian population, Microsoft Access was used to import, edit, and extract the census 2010 data to Microsoft Excel. The join function was used to join the Excel data in ArcMap. After joining, the utilities function of the spatial statistics tool was used to calculate each block's area to get population density information. In the project, the block data were chosen because the block is the smallest unit, and it excludes the open water and park areas (U.S. Census Bureau, 2008). An interpolation was used with the block group statistics data and produced density distribution maps (Figure 2 and Figure 3).

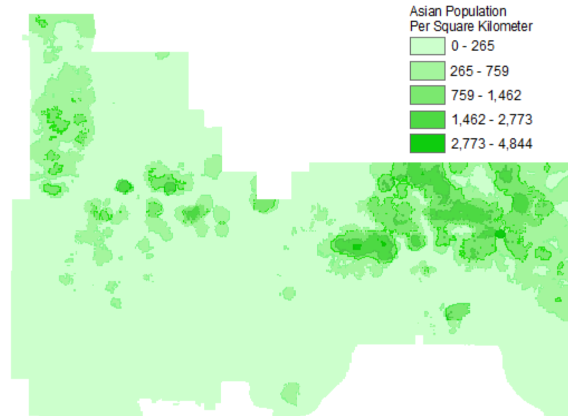

Figure 2. Asian Density per Square Kilometer.

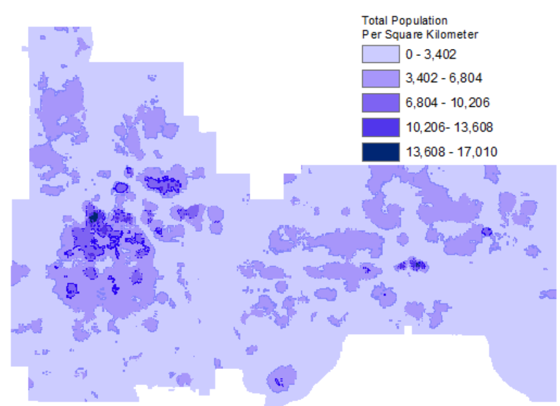

Figure 3. Total Population per Square Kilometer.

According to the density criteria from the Great Wall supermarket (www.gw-supermarket.com, n.d.), the density of Asian people should be greater than 300 per square kilometers and the density of the total population greater than 3000 per square kilometers. To account for these specific variables, the reclassify function was used. For Asian density, in the reclassify interface, values less than 300 were eliminated and the rest of the values were segmented into five equal intervals, ranging the weight one to five from low to high. The same process was used for total population. The reason for choosing numbers one to five was to make the data more consistent so it could be more easily compared with the rest of the criteria. Because the density of population is the most important factor to an Asian supermarket (Gonzalez-Benito and Gonzalez-Benito, 2005), it had the highest value, five.

There are four hierarchies of roads in United States: freeways, arterials, collectors, and local roads. For the road data, each category of road was separated from the road shapefile data, with a 500-foot buffer for each, and then values were set at four for freeways, three for arterials, two for collectors, and one for local roads. Finally, the reclassed data were converted to raster data; nodata was reclassified to zero and the extent was set as the whole study area in the environment interface so that all criteria data could be added together (Figure 4).

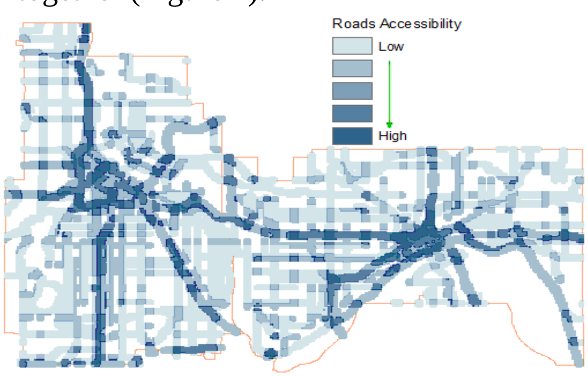

Figure 4. Road Access Buffered 500 Feet.

The geocoding function was used to add the University of Minnesota data and convert it to raster format. The Euclidean distance function was used to calculate distance, making sure to set the extent as a Minneapolis and St. Paul layer area. The value of two was assigned for the areas near 800 feet. The values for the distances between 800 feet and 1600 feet were assigned a value of one. The range of 800 and 1600 was obtained from a research relative to customers' shopping behavior in Shanghai, China. This research indicated customers would walk to shop up to one kilometer though they prefer to walk 500 meters or less (Gu, 2009).

In the Minneapolis and St. Paul, there are 4,448 bus stops and nodes. The transit stops shapefile was useful in determining areas with frequent service, since stops give a more accurate picture of transit accessibility than do bus route segments. In order to get the concentration of bus stops, the Point Density function was used to analyze bus stops. The stops value was reclassified from one to five (Figure 5). The numbers one to five match the population density values, so that data layers can be added together

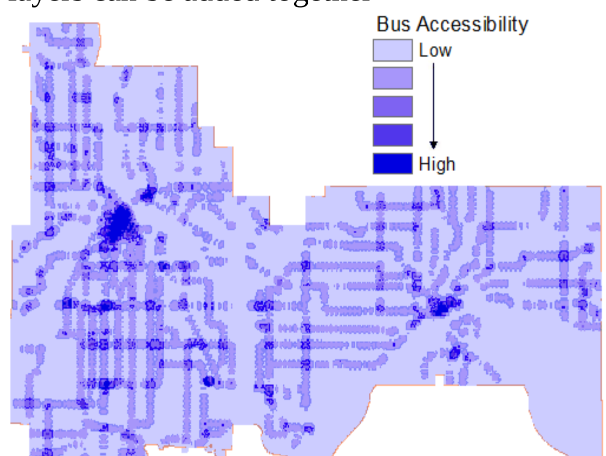

Figure 5. Density Degree of Bus Stops.

Step 3

There are six major Asian supermarkets in the Minneapolis and St. Paul. The new Asian supermarket must not be located within two miles of these to minimize competition. The six competitors were typed into Excel by address, city, state, and zip code. They were added into ArcGIS using the geocoding function. Because the Huff model requires layers to have the same coordinate system, the project tool was used after geocoding to achieve this.

A network analysis is a better way to analyze distance than just conducting a straight-line buffer from the competitors' location (Nwogugu, 2006). ArcCatalog was used to build a network dataset based on the road shapefile. The new service area function was used to find the 2-mile competitor's service area. Figure 6 shows the competitors' service areas:

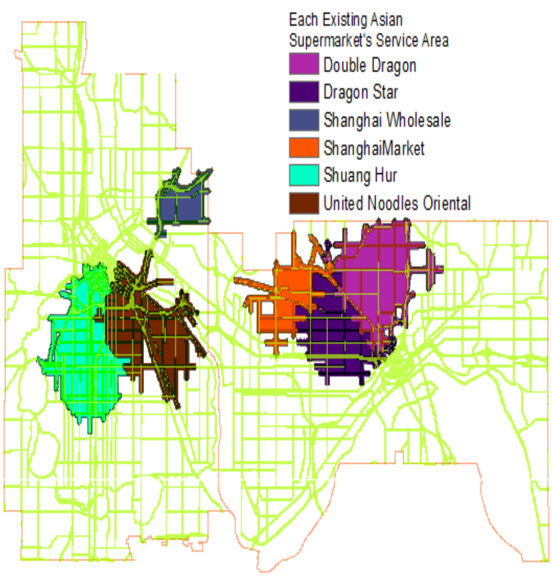

Figure 6. Each Existing Asian Supermarket's Service Area.

The service area raster data was reclassified to change nodata to zero and to switch the service area to nodata. This removed the service area when adding all criteria together.

Step 4

The land use shapefile was converted to grid data. After all steps of processing criteria were finished, raster calculator was used to add these seven criteria together to obtain suitable locations (Figure 7).

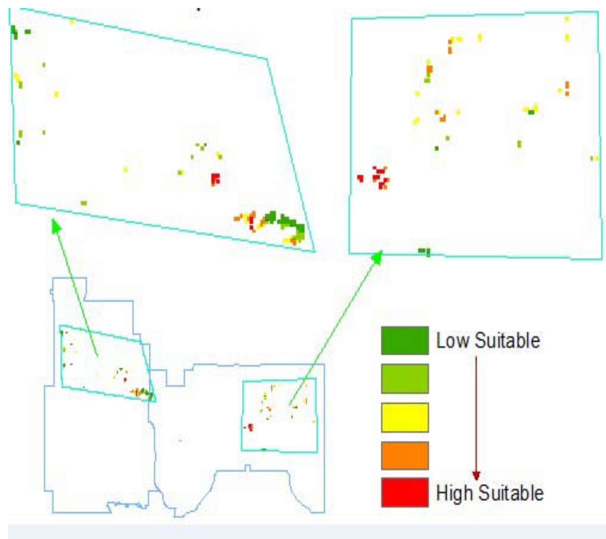

Figure 7. Suitable Locations to Build a New Asian Supermarket.

Step 5

There are many suitable locations. Of these, which location is the best? Does this location have the most sales potential? To answer these questions, the Huff model was used. The Huff model was introduced by David Huff in 1963 (Huff, 1963). Its popularity and longevity can be attributed to its conceptual appeal, relative ease of use, and applicability to a wide range of problems, of which predicting consumer spatial behavior is the most commonly used application. The probability (P_{ij}) that a consumer located at *i* will choose to shop at store *j* is calculated according to the following formula (Huff, 1963):

$$P_{ij} = \frac{A_j^{\alpha} D_{ij}^{-\beta}}{\sum_{j=1}^{n} A_j^{\alpha} D_{ij}^{-\beta}}$$

Where:

- Aj is a measure of attractiveness of store j, such as square footage
- Dij is the distance from i to j
- α is an attractiveness parameter estimated from empirical observations
- β is the distance decay parameter estimated from empirical observations
- n is the total number of stores including store j

In order to achieve this analysis, the Huff model tool from the ESRI website was used. First, this model was added to the ArcTool box and then the suitable locations were converted to shapefile data. A total of 64 polygon shapefiles were created. The Huff model was used to analyze each of these and to compare which sales potential was the greatest. For the Huff model in this project, Aj is the square footage to be used for each store's attractiveness. This square footage was found by using a rule tool in Google Earth Pro. Travel time was used as the Dij calculation because most Americans drive to their destination to shop. The Asian population field was used as the sales potential field because Asian people still make up the majority of customers in an Asian supermarket, although Asian supermarkets hope there will be more non-Asians shopping there in the future. After comparing the 64 suitable locations, the best area had a potential of 27,266 Asian demographics that fall within the market trade area. Figure 8 shows the best location and the trade area. Figure 9 shows ranges of potential market density for people who may utilize such a market.

Conclusions

This project used GIS technology to locate suitable areas for a new Asian supermarket in the Minneapolis and St. Paul area demonstrating the role of GIS and the Huff model detailing an analysis on 64 suitable locations. Most results reflect the higher the value, the higher the sales potential. However, from Figure 8, the best location may not be the most suitable (Figure 7). The reason for this is thought to exist in

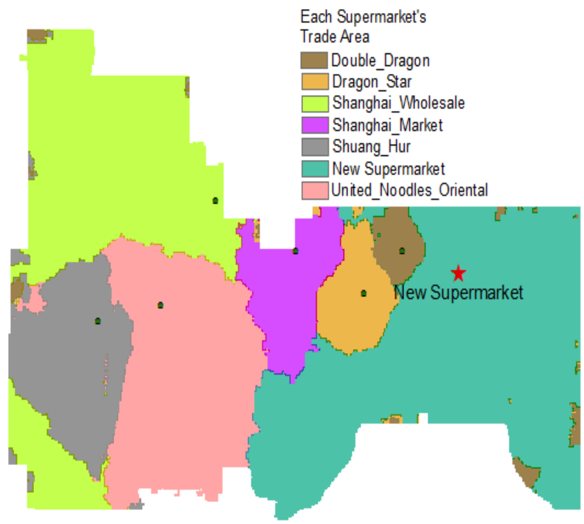

Figure 8. Each Store's Trade Area.

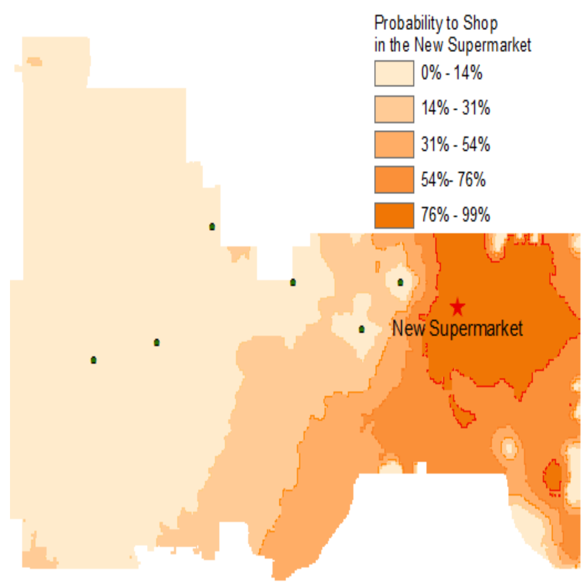

Figure 9. Ranges of Potential Customer Market Density.

the Huff model, which uses different criteria. For example, the Huff model uses a supermarket's size as well as different theory and methods for calculating market areas. Because of this, some deviations in results are anticipated. The Huff model has a stronger specific function to analyze the business in a specific area. However, without using spatial analysis to narrow down the areas, the Huff model is difficult to use.

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