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The retail site location decision process using GIS and the analytical hierarchy process

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ABSTRACT

The opening of a new establishment is a critical factor for firms in the retail sector because the decision carries with it a series of very serious financial and corporate image risks. This paper presents the development of a methodology for the process of selecting a retail site location that combines geographic information systems (GIS) and the analytical hierarchy process (AHP). The AHP methodology shows that the success factors for a supermarket are related to its location and competition. The proposed retail site location decision process was applied to the opening of a new supermarket in the Spanish city of Murcia.

Introduction

Geography plays a key role in the success of a business (Alcaide, Calero, & Hernández, 2012; García-Palomares, Gutiérrez, & Latorre, 2012). In the retail sector, the opening of a new site is a critical decision because the choice of location implies serious financial and corporate image risks for the firm in question (Alarcón, 2011). For this reason, it is crucial to perform a solid analysis of the possible locations for new store openings (Hernández & Bennison, 2000).

Church (2002) asserted that the success of many future applications for retail site location selection may be closely linked to geographic information systems (GIS) because these are the systems used when working with spatial information. One of the reasons for the success of GIS is their capacity to generate visualizations of data, which greatly assist in such a complex decision-making process as retail site location (Hernández, 2007; Musyoka, Mutyauvyu, Kiema, Karanja, & Siriba, 2007). This facet of GIS allows managers who lack technical knowledge to understand geographic information, thereby helping them to make difficult yet highly important decisions (Ozimec, Natter, & Reutterer, 2010). In addition, GIS are capable of dealing with large quantities of information and linking digital maps to relational databases. The characteristics described here make GIS indispensable tools in the development of decision processes associated with retail site location selection (Mendes & Themido, 2004).

One of the factors that influence market share and substitution patterns between available commercial options is the spatial dispersion of both consumers and vendors (Davis, 2006). This spatial dispersion may be helpful in determining sites for new commercial establishments (Baviera-Puig, Castellanos, Buitrago, & Rodríguez, 2011). Two key concepts stem from this idea: geodemand and geocompetition. Geodemand can be defined as the location of the customers who purchase a product or service in a specific market. Geocompetition is the location of the competitors of a business and the delineation of their trade areas in a particular market. A trade area can be defined as the geographic area in which a retailer attracts customers and generates sales during a specific period (Applebaum & Cohen, 1961; Baviera-Puig, Buitrago-Vera, & Mas-Verdú, 2012).

Possible locations for a new retail establishment can be identified by jointly analyzing geodemand and geocompetition. However, on many occasions, the complexity and importance of deciding whether to open a new store goes much further than simply identifying several possible locations. The location strategy also implies making a decision as to the most suitable location from a list of possibilities (Wood & Reynolds, 2012).

Although the theory of location and the theory of GIS have evolved practically independently, they currently support one another. These theories can complement the study of decision-making models, where the techniques are equally applicable in both spatial and non-spatial fields (Church & Murray, 2009). Decision making is the process of choosing the best way to achieve an objective. To aid this process, decision makers often use multi-criteria decision models, which facilitate the decision-making

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process by identifying one or more solutions from among the available alternatives, according to some criteria (Rybarczyk & Wu, 2010). In their research, Berumen and Llamazares (2007) differentiated between discrete multi-criteria decision problems and multiobjective decision problems. Multi-criteria decision problems present finite alternatives (Simon, 1983, 2005; Thaler, 1986), whereas multiobjective decision problems have an infinite number of possible solutions. The main discrete multi-criteria decision methods are linear weighting (scoring), multiattribute utility (MAUT), overrating relations and the analytic hierarchy process (AHP), the last of which is the principal method employed in this study.

The analytic hierarchy process (AHP) was developed by Saaty (1980) and consists of defining a hierarchical model that represents complex problems through criteria and alternatives that are set out initially. This procedure is designed to break a complex problem into a set of simpler decisions, thus making the problem easier to understand and therefore easier to solve (Arquero, Álvarez, & Martínez, 2009). Using multi-criteria decision models, it becomes possible to select and/or prioritize the opening of different retail sites. At the same time, AHP determines the criteria that affect the success of the chosen business (Gbanie, Tengbe, Momoh, Mebo, & Kabba, 2013; Suárez-Vega, Santos-Peñate, Dorta-González, & Rodríguez-Díaz, 2011).

We analyzed the commercial distribution sector of frequently purchased products in Murcia (Spain). The main aim was to develop a methodology that identifies sites for new supermarkets using GIS and multi-criteria decision models. This general objective can be broken down into two more specific aims: 1) the determination and weighting of the main factors or attributes that affect the supermarket's success, based on the existing literature; and 2) the ranking of possible sites for a new commercial opening, via the joint analysis of geodemand and geocompetition.

Section 2 (The retail site location decision process) presents the proposed retail site location decision process; Section 3 (Factors that affect the success of a supermarket) describes the success factors for a supermarket, determined with the help of AHP; Section 4 (Locating a new supermarket in Murcia) presents an example of a supermarket site location selection using the proposed procedure; and Section 5 (Conclusions) summarizes conclusions drawn from this research and suggests future lines of research to extend the work presented in this paper.

The retail site location decision process

To determine the best site for a new retail outlet, we first conduct an analysis of geodemand, which is used to locate the clients of a product or service. Second, geocompetition is analyzed, which means spatially locating the firm's competition. Third, the possible commercial sites are determined by combining the results of the two previous steps, together with the use of kernel density analysis. The software used in these three steps is ArcGis 10. Finally, depending on the resources available to the firm, multi-criteria decision models are used to help select the best location from among the possibilities identified in the previous analysis steps.

Identifying geodemand and geocompetition

When geolocating the demand, our procedure drills down to the city block level, which provides a greater level of detail than that available from other site selection procedures, which work with information at the census tract level. This high level of detail makes it necessary to calculate the number of housing units per city block from the cadastral data and, based on this number, to estimate the average number of residents per city block.

First, to calculate the number of housing units per city block, alphanumeric data from the municipal cadastral database are linked to the graphical data of the city blocks using GIS. Second, to estimate the average number of residents per city block, data from the municipal census are linked to the number of housing units per city block. This process yields an estimate of the number of people living in each city block. This second step is more complex than the previous one because the information from the municipal census pertains to the census tract level, and a census tract consists of several city blocks. To complete this second step, we first use the municipal census to identify the inhabitants of the municipality in question, along with the census tracts in which they live. The inhabitants are then allocated among the housing units in each census tract, taking into account multi-family and single-family units.

After identifying and geolocating the competition, spatial Cartesian coordinates (x, y) are allocated to the addresses of the selected commercial establishments. The establishments of the chain that is planning to open a new store are also included because these existing sites can be considered competition due to the phenomenon of cannibalization (Suárez-Vega, Santos-Peñate, & Dorta-González, 2012). Once the geocompetition has been identified and analyzed, the trade area for each of the retail outlets is calculated. In contrast with other theories (Christaller's central place theory, Hotelling's duopolistic competition and Losch's concept of the range of the good), Reilly (1931) proposed that consumers consider not only the distance to but also the attractiveness of different retail alternatives. Huff (1963) suggested that the utility of a store is positively related to the size of the outlet and negatively related to the distance. For this reason, the trade area of a supermarket is defined as an isochrone based on its sales floor area. This isochrone takes into consideration the physical features of the urban landscape. According to Table 1, a site with a surface area of 500 m^2 corresponds to an isochrone of 5 min, which is equivalent to a maximum distance of 333 m for pedestrian customers. This distance increases with the surface area of the supermarket and decreases accordingly if the supermarket has a smaller sales floor area.

Determining the possible locations

We match the information resulting from the joint analysis of geodemand and geocompetition to obtain a third layer that shows areas where the population does not have any range of commercial offer or where the range of commercial services is poor. At this stage, kernel density analysis can identify the areas with higher concentrations of potential clients.

Kernel density estimation is a non-parametric way to estimate the probability density function of a random variable (Rosenblatt, 1956). Conceptually, the goal of kernel density estimation is to calculate the density of points in a given area using the distance between the points, if and only if the points have the same weight. However, different weights may be assigned to each point to assign greater importance to specific points relative to the rest. The final result is expressed in units of a particular phenomenon per unit of surface area.

Table 1
Trade areas of supermarkets based on the sales floor area.

Sales floor area (m^2)	Time/isochrone (minutes)	Maximum distance traveled (m)
$300 < S \leq 600$	5′	333
$600 < S \leq 1000$	8′	533
$1000 < S \leq 2500$	10′	667
$S > 2500$	18′	1200