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Review Paper

Finding New Retail Store Location: Kernel Density and Analytical Hierarchy Process Technique

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Abstract
Determining location for establishment of a new retail store is major decision in locational analysis. Such evaluation of location was completed in two steps in this study. Firstly, geo-demand and geo-competition data along with estimated kernel density values were used to find probable locations. Kernel density estimation is used to find most feasible alternative locations out of number of commercial areas (wards) in the city. Secondly, best location from identified alternatives was found by using Analytical Hierarchy Process (AHP) as a multi-criteria decision technique. This determination of new store was done for an organized retail store to be located with regard to a famous traditional shopping street and a largest shopping mall in the city of Chandigarh. Kernel density estimation of both shopping street and mall gave two different alternative locations for setting up of new store. Results of AHP helped in ranking the various criteria and sub-criteria which were used in assessing a retail location. In case of shopping street distance as accessibility factor was considered as most important sub-criteria. Lastly, global weights of AHP analysis implied that for opening a new store in a shopping street or in a mall the commercial area of ward 22 was most appropriate.

Keywords: *Location, Kernel density, Analytic Hierarchy Process (AHP), traditional shopping street, shopping mall.*

I. INTRODUCTION

Geology assumes a key part in the achievement of a business (Alcaide et al., 2012; García-Palomares et al., 2012). In the retail segment, the opening of another site is a basic choice in light of the fact that the decision of area infers genuine budgetary and corporate picture dangers for the firm being referred to (Alarcon, 2011). Thus, it is significant to perform a strong investigation of the conceivable areas for new store openings (Hernandez and Bennison, 2000). Church (2002) attested that the accomplishment of numerous future applications for retail site area determination might be firmly connected to understanding of certain software applications such as Geographic Information System (GIS) and integration of various multi-criteria decision techniques such as Analytical Hierarchy Process (AHP). Due to simultaneous interplay of various factors such as size of family, varying household income, demographic characteristics, frequency of shopping and other qualitative factors location decision making has become a complex procedure. Thus various studies (Musyoka et al., 2007; Ozimec et al. 2010) have combined applications of GIS and AHP in deciding new location for retail stores.

The entire process of determining new retail store location predominantly involves two steps. In the first step geo-demand and geo-competition data along with estimated kernel density values were used to find probable locations with regard to both street and mall shopping. Geographic Information System (GIS) could be used for pictorial representation of alternatives which indicate higher densities of population which are not currently offered an adequate store choice. In the second step best location from identified alternatives was found by using Analytical Hierarchy Process (AHP).

This study has not shown the process of obtaining results from application of GIS used in determining factors related to geo-demand and geo-competition. On other hand this study has focussed itself only on estimation of alternative locations for new retail store through kernel density estimation concept and zeroing on best possible location from all these alternatives through application of AHP.

Concept of Kernel density estimation

Kernel density estimation is a non-parametric approach to assess the likelihood denseness capacity of random variable (Rosenblatt, 1956). This denseness representing generally population density or demand of particular area is measured in terms of probability values. A particular demand area comprises of points and kernel density estimation measures how closely they are placed with each other by measuring distance or separation between these points. If they are clustered closely with each other then separation distance would be less whereas it would be higher if points are away from each other. Another inference that this denseness provides is that close clubbing of points indicates higher population density in that area implying higher unmet demand. Thus a retailer looking for establishment of new store would be more inclined to open in such area rather than areas with lower kernel density. Morneo (2007) in their study of estimation of new location for a retail store considered each demand centre within given area as pixel or unit of the study. Here demand centre implies location where a retailer would like to establish new store which would increase its sales. Mostly every demand centre is represented as a circle so that its radius can be calculated. For instance if a particular geographic area has three demand centres each represented by circle then 'r' represents the distance between existing retail location and commercial area of each demand centre. If there are three commercial centres then there would be three 'r'. In such case shortest value of 'r' representing distance is selected. This is represented by 'r' in the formula. In addition 'd' represents the distance between each commercial area (in our illustration we have assumed three demand centers so there would a 'd' for each centre) and existing retail location. So there would be three values of 'd' in this case. Kernel density is calculated for every demand or commercial centre (in this case three) and a sum is taken by using following formula. This can be communicated as takes after (Moreno, 2007; Silverman, 1986):

$$L_j = \sum (3/\prod r^2) \, [1-(d_{ij}^2/r^2)]^2$$

where:
L_j = estimated density of the pixel;
d_{ij} = distance between points i and j;
r = search radius

Multi-Criteria Decision Analysis techniques (MCDA)

Multi-Criteria Decision Analysis techniques (MCDA) have been developed to solve decision problems that involve a large set of feasible alternatives that are evaluated on the basis of multiple, conflicting and incommensurable criteria. The location strategy also implies making a decision as to the most suitable location from a list of possibilities (Wood and Reynolds 2012). This decision-making process of identifying one or more solutions from among the available alternatives according to some criteria is often aided by multi-criteria decision models. Analytic Hierarchy Process (AHP),is the principal multi-criteria decision model employed in this study.

Analytical Hierarch Process (AHP) technique

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. 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. The model proposed by Saaty (1980) is based on the construction of a hierarchical model with three levels: objectives, criteria and alternatives. Once the hierarchy is built, the decision makers systematically evaluate its various elements by comparing them to one another two at a time, with respect to their impact on an element above them in the hierarchy. In making the comparisons, the decision makers can use concrete data about the elements, or they can use their judgments about the elements' relative meaning and importance.

The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision making techniques.

II. METHODOLOGY

The endeavour of fulfilling above mentioned objectives was carried out by taking respondents of a planned agglomeration i.e. a shopping mall (Elante mall) and an unplanned agglomeration i.e. a street shopping centre (Sector-17 plaza). These centres were selected from major city of Chandigarh, India. Both agglomerations represent largest retail agglomerations of the city and are among the largest in area in terms of reported sales figures. They compete for consumers with similar demographic characteristics, thus, resulting in

fairly limited store heterogeneity with the consequence that two selected retail agglomerations can be regarded as comparable with respect to their competitive standing in relevant market. To maintain homogeneity among selected retail stores in two agglomerations only respondents of apparel stores were studied.

The entire process of determining new retail store location predominantly involves two steps. In the first step *estimated kernel density* values were used to find probable locations with regard to both street and mall shopping. Kernel density estimation is mathematical technique which used data derived from distances indicating commercial area activity for each ward of city. Thus no new primary data was required for such estimation. The values obtained in pixels or in probability terms were used to find best possible alternative locations for establishment of new stores both with regard to shopping street and mall. In the second step *Analytical Hierarchy Process (AHP)* as a multi-criteria decision technique was applied to judge the best possible alternative new location for retailers who intend to open a new retail establishment in either a shopping street or a mall.

As discussed in literature review purpose of AHP technique is to construct the problem into a hierarchical model involving criteria and sub-criteria. All the alternatives selected are evaluated on these criteria's. Thus it becomes important to decide carefully two aspects: firstly the various alternatives which in this study were found in step 1 involving kernel density estimation; secondly selection of criteria and sub-criteria on which these alternatives would be evaluated. Attributes or criteria affecting success of apparel stores under study in two types of agglomerations were identified by carrying out extensive study of literature. The selected criteria would be evaluated using the responses to a structured questionnaire obtained through pair-wise comparison. These questionnaires would be subjected to managers of retail stores under study.

The primary data for this research was collected through questionnaire put to 50 retail managers each from Sector-17 plaza and Elante mall. The intention was to infer that if managers of shopping street retail stores are given a choice to open a new store in another shopping street of the city then which geographic area would be considered as most suitable and which attribute of attractiveness would be given highest importance. For this purpose 50 randomly selected apparel store managers from secotr-17 shopping street were administered a structured questionnaire. The questions were designed by using paired comparison scale where each sub-criteria in particular criteria was compared with all other criteria's on a five point scale where '5' meant extremely important and '1' meant equally important. For instance if accessibility factor is one of the criteria involving sub-criteria's like distance from customer, parking space, and visibility of store to customer then firstly respondents are asked to select one sub-criteria from a pair such as from distance from customer and parking space. Next they were asked to rate the importance of selected sub-criteria on decided five point scale. This was done for all attributes. Similar process was adopted to get responses from 50 managers of retail stores of Elante mall who were given an option to open a retail store in a mall in other parts of city.

III. RESULTS

Step 1:

In kernel density estimation a pixel size is decided in terms of distance. In our case as smallest commercial area is 9.55 acres for ward 16 so we assume smallest common area or pixel size to be 9 acres or 9 * 4046.86 square metres = 36421.74 sq m or 190.84 metres. Thus for ward 3 if kernel density is 0.8852 pixels then it can be interpreted as that a manager looking to open new store should open within a commercial area distance of 190.84 * 0.8852 = 168.92 metres of ward 3.

Each ward is formed of number of sectors as shown in the following table. The following analysis is for estimating new store location if manager considers Sector-17 plaza as central location or would like to establish it close to plaza. For this purpose 'r' is taken as shortest distance between sector 17 plaza and commercial area of each ward. 'd' represents the distance between estimated new retail centre and other commercial centres of same ward. For instance, ward 3 has three sectors namely sector-22, 17 and 16. The shortest distance between sector-17 and commercial area of ward 3 was found to be 1.20 km. The distance between centroid point at 1.20 km and other commercial area of three sectors was represented by 'd1' (1.10 km), 'd2' (0.00 km) and 'd3' (0.80).

The results (Table 1) can further be inferred as that a manager of new retail store who intends to open a new store by taking into consideration effect of Sec-17 plaza could consider opening in either of ward 3 or 17. This is because of significantly high kernel density values as well as these wards being adjacent or very close to Sec-17. Thus a new store manager would have high chances of success if store is opened in ward 3 as its span of incurring potential sale is in wider area as compared to other wards. Similarly ward 17 has a span of 19.59 metres implying that new retail store in the radius of 19.59 metres of ward 17 commercial area would have higher chances of success. Lastly, other wards were not considered as alternatives for location of new store as calculated pixels were quite small or insignificant distances were measured implying that suggested locations were infeasible for new locations.

TABLE 1: KERNEL DENSITY ESTIMATION OF SEC-17

Ward no.	Sector	d1	d2	d3	d4	r	Kernel density (in pixels)	Kernel density (in metres)
3	22,16,17	1.10	0.00	0.80		1.20	0.8852	168.92
17	18,19,21	1.20	2.00	2.10		2.16	0.1027	19.59
1	7,8,9	3.50	3.10	2.40		3.57	0.0272	5.18
15	34,35,44	4.80	3.80	3.90		4.83	0.0109	2.08
16	20, 33	4.20	4.50			4.85	0.0033	0.634
10	41,42	5.10	5.20			5.60	0.0015	0.279
13	49,50,51	8.60	8.50	7.40		8.70	0.0010	0.190
11	53,54,55,56	7.10	7.60	8.00	7.90	8.08	0.0010	0.186
21	32, 46	6.10	6.60			6.85	0.0010	0.186
22	47,48,31	8.80	8.30	7.40		8.33	0.0008	0.1523
9	39,40	7.00	6.70			7.35	0.0007	0.1256
12	43,52	6.00	5.80			6.10	0.0003	0.0503
14	45	6.90				6.90	0.0000	0.0000
20	IA Ph-1	7.00				7.00	0.0000	0.0000
23	IA Ph-2	11.00				11.00	0.0000	0.0000

Elante mall: The following analysis is for estimating new store location if manager considers Elante mall as central location or would like to establish it close to mall. For this purpose 'r' is taken as shortest distance between Elante mall and commercial area of each ward. 'd' represents the distance between estimated new retail centre and other commercial centres of same ward. For instance, ward 22 has three sectors namely sector- 47, 48 and 31. The shortest distance between mall and commercial area of ward 22 was found to be 4.30 km. The distance between centroid point at 4.30 km and other commercial area of three sectors was represented by 'd1' (4.30 km), 'd2' (4.10 km) and 'd3' (2.90).

For new store location if manager intends to open by considering the effect of closeness with Elante mall then according to kernel density analysis (Table 2) top three potential locations which are adjacent or close to Elante mall location would be commercial areas of ward 22, 1 and 16. Ward 22 was found to have highest span of 3.01 metres within which a new store can be located. As its span is highest as compared to other wards thus likelihood of new store's success in commercial area of ward 22 would be highest. Commercial area of ward 1 comes second in the list with a span of 1.519 metres and last selected destination for new store was 1.401 metres of commercial area of ward 16. These are very small distances which seemed to be infeasible as no store cannot be opened within a radius of such small values. For instance, opening of new retail store within a radius of 3.01 metres of commercial area of ward 22. Kernel density in pixels represents the probability values. The results in table are arranged in descending order of these probability values. Ward 22 has relatively highest probability of 1.52% with regard to feasibility of opening of new store. Probability of ward 16 is similar to ward 1 but as it is adjacent to ward 20 so in addition to ward 22, ward 16 was considered as alternatives to of location of new store with regard to Elante mall.

TABLE 2: KERNEL DENSITY ESTIMATION OF ELANTE MALL

Ward no.	Sectors	d1	d2	d3	d4	r	Kernel density (in pixels)	Kernel density (in metres)
22	47,48,31	4.30	4.10	2.90		4.30	0.0158	3.0121
1	7,8,9	4.80	5.40	6.40		6.73	0.0080	1.5193
16	20, 33	3.30	3.60			3.95	0.0073	1.4013
17	18,19,21	4.90	4.60	4.80		5.43	0.0052	1.0016
21	32, 46	3.80	4.30			4.55	0.0048	0.9065
13	49,50,51	6.20	7.20	7.30		7.30	0.0014	0.2682
15	34,35,44	5.90	6.30	6.10		6.40	0.0007	0.1419
3	22,16,17	6.40	6.20	6.20		6.60	0.0007	0.1306
12	43,52	8.00	7.40			8.20	0.0005	0.0997

10	41,42	8.20	8.60			8.90	0.0003	0.0627
11	53,54,55,56	10.40	10.90	11.30	11.20	11.35	0.0002	0.0460
9	39,40	10.30	9.80			10.60	0.0002	0.0393
23	IA Ph-2	2.00				2.00	0.0000	0.0000
14	45	6.30				6.30	0.0000	0.0000

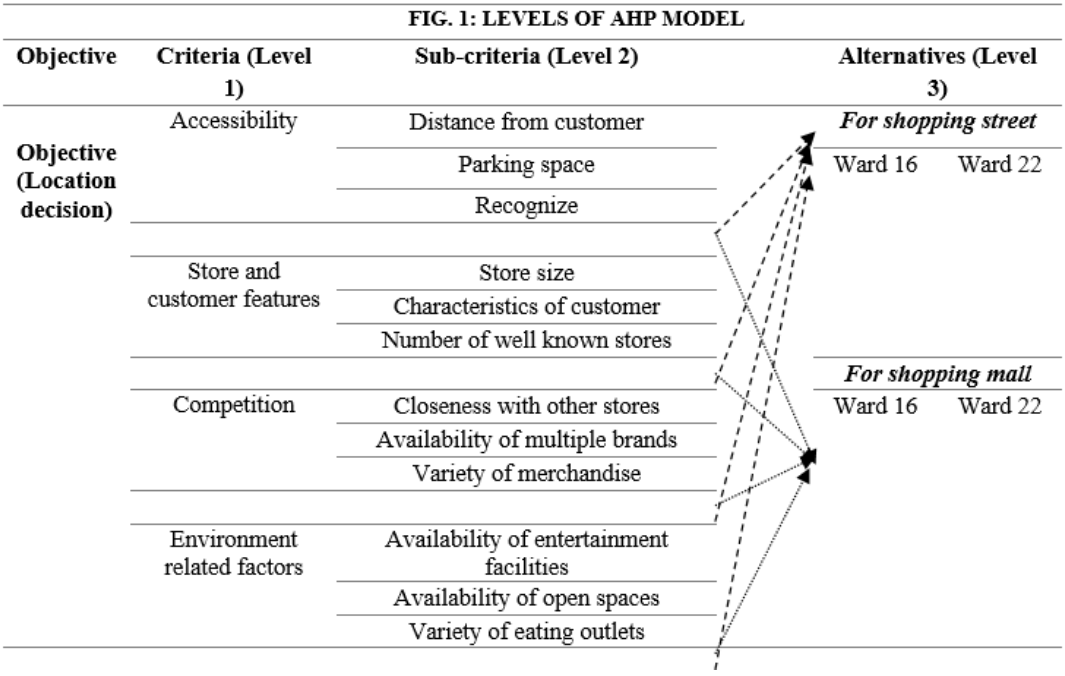
Step 2:

Formation of AHP Model:

Levels and dimensions in each level regarding new retail store location decision out of identified alternatives is shown in Fig.1. Literature (Baviera-Puig, et al. 2012; Roig-Tierno, et al. 2013) and empirical study conducted by Singla and Rai (2016) regarding identification of factors which would make a particular location attractive were used to set four criteria i.e. accessibility, store and customer features, competition and environment related factors. Further each of the criteria was explained by three sub-criteria. Accessibility as first criteria pertains to convenience of reaching and finding a store. Our findings (Singla and Rai 2016) suggested that customers take into consideration reaching a particular store by vehicle easily as an important feature in selection process. Further the store less is inclination towards accessing a store. With increase in congestion during peak hour's parking space was found to be significant factor in accessing a particular store location. Lastly, recognisability of a store would make it distinct from other stores encouraging customers to access it more frequently.

Second criterion, store and customer features include store size: smaller stores tend to discourage customers; characteristics of customers which include age, education and income features of potential customers; and number of well known stores which help in enhancing visibility and attracting customers.

FIG. 1: LEVELS OF AHP MODEL



Third criterion related to competition factors. It included all sub-criteria: closeness with other stores, availability of multiple brands and variety of merchandise which results in agglomeration effect. Presence of these attributes provides choice to customers and encourages them to indulge in multiple shopping thus enhancing sales potential of stores. The fourth and final criterion included not products or features offered by stores but other facilities which significantly influence buying decision. Thus this criterion was termed as environment related factors which included availability of entertainment facilities, availability of open spaces and variety of eating outlets. These facilities were found to encourage customers spend more time at store location and in turn influencing their purchase decision.

Level 3 indicates various alternatives out of which best location would be selected. This was achieved by analysing all selected locations with regard to four examined criteria. Step 1 of this study indicated that for both street and mall shopping commercial areas of ward 16 and ward 22 are the potential locations.

Ranking of attributes that influences a store's success:

Priority scores as shown in Table 3 suggest 'environment related factors' more significantly important (0.36) than other factors to assess location decision if retailer considers opening a new store in a mall. Whereas if a retailer intends to open a new store in a shopping street then 'accessibility' was found to be deciding criteria. As a mall lacks open spaces thus managers who were interviewed gave high importance to availability of open spaces sub-criteria (0.59). This dimension was considered by respondents as one of most important differentiating factor between mall and shopping street. Similarly, for a shopping street as literature indicates customers intend to buy more frequently from shops closer to their home or work place than planning to visit a particular shopping street. The results substantiated this aspect by giving highest priority to distance from customers sub criteria (0.63). Lastly, priority scores implied that managers of both mall (0.8) and shopping street (0.8) considered ward 22 as a better location than ward 16 for opening of new store if they are considered bereft of mentioned criteria and sub-criteria. When these scores were analyzed with four criteria and three sub-criteria each then priority scores implied commercial area of ward 22 as more appropriate location. Thus for opening a new store in a shopping street or in a mall the commercial area of ward 22 was found to be more appropriate location. It is important to mention here that priority values imply higher importance given to particular criteria or sub-criteria in relation to other factors.

TABLE 3: PRIORITY SCORES FOR VARIOUS CRITERIA AND SUB-CRITERIA

Level 1	Level 2	Level 3	Mall	Shopping street
Accessibility			0.30	***0.64***
	Distance from customer		0.64	*0.63*
	Parking space		0.24	0.27
	Recognize		0.12	0.10
Store and customer features			0.21	0.09
	Store size		0.14	0.66
	Characteristics of customer		0.49	0.22
	Number of well known stores		0.10	0.12
Competition			0.13	0.08
	Closeness with other stores		0.09	0.58
	Availability of multiple brands		0.25	0.30
	Variety of merchandise		0.66	0.12
Environment related factors			***0.36***	0.19
	Availability of entertainment facilities		0.11	0.67
	Availability of open spaces		*0.59*	0.23
	Variety of eating outlets		0.30	0.10
		Ward 22	*0.8*	*0.8*
		Ward 16	0.2	0.2

Global weights (Shopping street)

	Accessibility	Store and customer features	Competition	Environment	*Priority value*
ward 22	0.3226	0.0475	0.0371	0.1018	***0.5090***
ward 16	0.0806	0.0119	0.0093	0.0255	***0.1273***

Global weights (Mall)

	Accessibility	Store and customer features	Competition	Environment	*Priority value*
ward 22	0.1536	0.0823	0.0686	0.1699	***0.4745***
ward 16	0.0384	0.0206	0.0172	0.0425	***0.1186***

IV. CONCLUSION

The respondents indicated undeveloped commercial area, high density of population and relatively higher median household income as major reasons for considering ward 22 as better location than the alternative to target potential customers. Data accessed from Chandigarh master plan-2031 illustrated planned commercial area of ward 16 (9.55 acres) to be much lower than that of ward 22 (35.60 acres) making ward 22 a much better potential location for establishment of new store. The data from census report of 2011 showed that ward 22 comprising of sectors 31, 47 and 48 had higher number of households (7680) than ward 16 (number of households = 6201). Median household income per month of ward 22 was found to be lesser (Rs.11537.42) than ward 16 (Rs.13520.86). But if it is assumed safely that each household on an average comprise of four spending members and 5% of median income per household is being spend on purchase from retail stores of either shopping street or mall then total amount of such spend for entire ward could be estimated. It is termed as budgeted income. It was found that due to higher density of population of ward 22 its budgeted income was Rs. 1107592.225 whereas that of ward 16 was Rs. 1048035.711. Thus, this inference also suggests that results of kernel density and AHP are suitable in suggesting commercial area of ward 22 as location for establishing a new store.

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