



Spatial Logic of Tenant-mix of Shopping Malls

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Abstract

Retail researchers have focused on internal composition of a shopping mall relying on the concept of inter-store externality and sometimes on the logic of urban spatial structure primarily been targeted at retail professionals. Customer density has been identified a significant factor behind tenancing decision making and is found to be governed by metric distance alone. The space syntax method, on the other hand, traditionally applied in architectural studies, provides the spatial logic behind human behaviours through quantifying configuration and relating it with behaviour. Space syntax measures have primarily been applied for predicting and analysing movement through a built environment. As identified in retail management literature, mall management strives towards influencing movement of visitors within shopping malls in an attempt to trigger and sustain shopping behaviour. Here, lies the scope of integration between retail management and architectural wisdom. The profit function of a tenant store in a shopping mall is developed from the classical bid-rent function, expanded with store type variables and solved simultaneously under condition of maximization of profit and perfect competition. The total revenue from a store is calculated from the optimal rent per unit area and optimal area of store and expressed in terms of customer density. To identify the superiority of visuo-spatial characteristics in determining customer density, data were collected from a convenience sampling method for navigational preferences in computer generated situations of shopping mall junctions. The visuo-spatial characteristics are examined through visibility graph analysis administering syntax 2D software. Natural movement is found to be governed by visuo-spatial measures and rent and area allocation decision depends on customer density, which is again a product of natural movement. Revenue maximization of a shopping mall relies on positioning of stores, which in turn depends on the visuo-spatial configuration: a combination of distance from the access point and visual integration.

Keywords: Anchor stores, Bid-rent model, Inter-store externality, Syntax 2D, Tenancing decision, Visibility Graph Analysis

JEL Classification: R30, R33

Paper Classification: Conceptual Paper

Introduction

Studies on retail have paid more emphasis on inter-store externalities than on 'spatial logic' in deciding location and rent within a shopping mall. Since inception of the format, studies on shopping malls focused on economic rationale of rental differentiation and area allocation of

tenant stores, relying on the concept of inter-store externality (e.g. Benjamin, Boyle & Sirmans, 1992; Brueckner, 1993; Eppli & Shilling, 1995; Pashigan & Gould, 1998). Researchers (e.g. Garg & Steyn, 2014; Yuo & Lizieri, 2013; Yiu & Xu, 2012) attempted to identify an 'ultimate tenant mix' that would have emerged as useful tool for the mall management. Other researchers, though, have argued that the notion of ultimate tenant mix is vague (Carter & Allen, 2012, quoting Stambaugh, 1978) and there is no magic formula or hard-and-fast rule for finding the 'ultimate tenant mix'; some notions are just better than others (e.g. Des Rosiers, Thériault & Lavoie, 2009).

During the same period, when studies on inter-store externality were gaining popularity, some studies focused on circulation or movement of customers within shopping centres (e.g. Brown, 1991; Fisher & Yezer, 1993; Sim & Way, 1989; Carter & Haloupek, 2002; Carter & Vandell, 2005) for describing tenant-mix. They relied on the concept of bid rent to explain and analyse the location decision of individual stores. They concluded that, as a rule, customers prefer shops that are easily accessible. Explanations for difference in customer distribution were based on the adaptation of Central Place Theory (Christaller, 1966) (highest density at the centre with decreasing density when moving away from it) and not on the logic of spatial arrangement. An understanding of spatial configuration within a shopping mall can aid considerably in optimizing design and improve area and rental allocation of individual stores i.e., tenanting decision making.

Research Objectives

A shopping mall can be defined as a 'built environment' "... (that) attempts to simulate commercial live centre of cities; artificially devised to recreate the same intensity of urban buzz (if not more) removed from the city streets" (Fong, 2003, p. 10.1). Therefore, movement and way finding logic applied in the urban scale can be implemented in shopping malls too. Store space allocations, store location within a planned shopping centre and even the lease pricing (most prevailing pricing method for stores in a shopping mall is leasing) of an individual store have spatial as well as commercial ramifications. Therefore, proper understanding of these issues requires interdisciplinary knowledge of retail management and architecture. Retail researchers have focused on the movement of customers within shopping malls and considered metric distance as the only spatial aspect (e.g. Carter & Haloupek, 2002; Carter & Vandell, 2005; Ingene & Ghosh, 1990) and the takeaways have been targeted at retail professionals. No study was conducted with spatial configuration characteristics as independent variables. Thus, there is a gap between the outcomes of the in-store-movement genre of research, which have not been actualized in spatial configuration terms and the architectural input, which, in spite of dealing with a design-centric holistic view, remains insufficient: too few studies on space syntax measures as independent variables have been conducted in retail environments. Retail design research has the potential to bridge this gap through an understanding of retail spatial arrangements and strategic implementations. As space syntax measures predict movement, (e.g. Hillier, Burdett, Peponis & Penn, 1987; Hillier, Penn, Hanson, Grajewski & Xu, 1993) and influencing movement is almost all of what mall management aspire towards, spatial configuration can be used as a strategic tool in shopping malls.

The specific objectives of the study are listed below:

- To examine the effect of customer density at a particular location within a shopping mall in predicting the optimum area and rent of stores around it and to understand the effect of critical customer density in tenanting mix decisions.

- To understand the effect of visibility in predicting customer movement within a shopping mall and the role of Visibility Graph Analysis (VGA) in predicting customer density distribution.
- To integrate Visibility Graph Analysis in rationalizing location and tenancing decision in shopping malls.

Literature Review

The research literature can be classified into two distinct approaches. The first focuses on the logic of location and rent decisions of stores in a mall while the second focuses on syntactical values of space in predicting human navigation patterns.

Location and Rent Decision of Stores in a Shopping Mall

In case of homogeneous mall space, the only factor that affects the rent level of stores is location. So, price discrimination takes place in shopping centre leasing (e.g. Benjamin et al., 1992). Area is added to a tenant store till Net Marginal Revenue for adding that space equates the marginal cost of adding the space less the externality it generates (Brueckner, 1993). Rent subsidies are provided to those who produce externality and rent premium are charged from those who 'free ride' on them (Pashigan & Gould, 1998). Fixed rent component varies inversely to sales externality while percentage rent component varies directly with sales externalities (Wheaton, 2000).

The earlier studies which considered the movement component in identifying leasing and location decision focussed on Central Place Theory (Christaller, 1966), the model as proposed by Alonso (1964) or Revised Central Place Theory as adopted by Carter and Allen (2012). Carter and Vandell (2005), in their analysis, considered highest traffic at the central place of the mall and tapering off traffic density as the distance from the centre increased. This assumption is applicable for a linear symmetric mall configuration with a central entry. This simplistic approach neither takes into account the location decision of anchor and non-anchor stores, nor does it provide a logical framework for the location decision. This is where studies on indoor navigation are relevant.

Human Navigation Pattern in Indoor Environment

Movement is critical in determining the traffic concentration within a built structure, which in turn depends on accessibility of a particular location compared to other locations in the spatial arrangement. Hillier (1996) stated that "natural movement is the proportion of movement on each line that is determined by the structure of the urban grid itself rather than by the presence of specific attractors or magnets" (p. 161). The logic of space syntax analysis was adopted from an urban scale and implemented in buildings. Studies on human navigation patterns in indoor environment (e.g. Peponis, Zimring & Choi, 1990; Haq & Zimring, 2003; Holscher, Brosamle & Vrachliotis, 2012) suggest that human route choices in a built space are influenced by syntactic properties of space.

Visibility Analysis (VA) was developed into a proper syntactic analysis tool through the works of Turner and Penn (1999) and Turner (2001). Visibility Analysis was incorporated in space syntax analysis by Benedikt (1979), initially as analysis of single view point or isovist. Isovists are central to modelling geometrical properties related to mental representations (Meilinger, Franz & Bulthoff, 2012) and aspects concerning geometry and movement (Batty, 2001, in addition

to reflecting the local properties of space (Weiner & Franz, 2005; Stamps, 2005). Visibility Graph Analysis has been defined as "... (A) Set of points distributed symmetrically in space between which inter-visibility can be analysed through isovists" (Abshirini & Koch, 2013, p.011:2). Holscher et al., (2012) have asserted that Visibility Graph Analysis acts as a strong predictor in navigation decision making. Other studies have suggested that Visibility Graph Analysis is best suited in enclosed spaces because of its simplistic approach compared to other methods of syntactic analysis (Axial Line and Convex Space) in highlighting location differences (e.g. Fong, 2003).

Methodology

Bid-Rent Analysis

The paper uses the Bid-rent Model in examining the impact of customer foot fall in predicting the rental and tenanting decision. Sim and Way (1989) and Brown (1991) suggested that a bid-rent model could explain the location decision of stores within a planned shopping centre. Carter and Vandell (2005) used an economic model, which is an adaptation of Alonso's (1964) model (Alonso's theory deals with location decision of firms where land use is a trade-off between choice for space and cost of transport) in 'closed city' form. This model is used in this paper to describe profit function for an individual store. It is solved simultaneously under the conditions of profit maximization and perfect competition, to establish the relationship of optimal area and rent in terms of foot fall. The model is extended to include the profitability of the entire store and to understand the concept of 'critical density'.

Data Collection

Measuring customer movement pattern, based solely on spatial properties in a shopping mall, can be complex in real world situations. Authors like Franz and Weiner (2008); Weiner, Franz, Rossmann, Reichelt, Mallot, & Bulthoff (2007) as well as Dalton (2003) have shown that abstracted computer-generated junctions, approximating real spaces, have been used, instead, as a viable tool for capturing behavioural tendencies. A survey was conducted to measure navigation preferences in a shopping mall where computer generated pictures (Figure 5) of junctions in shopping malls were shown to the respondents and their preferences for moving in a particular direction were recorded. It was conveyed to the respondents that there were shops of similar types with no perceivable 'brand' differences in all the directions available to them. Data collection was done for nine day period (January 23-31, 2017); survey tools were administered to a sample of 107 respondents, chosen employing the convenience sampling approach. People who visit malls less than 4 times a year were excluded from the survey.

Visibility Graph Analysis

Visibility Analysis of the spatial arrangements is performed to understand the logic behind respondents exercising their preferences in taking turns. The software program used for the analysis is Syntax 2D developed by Turner, Wineman, Psarra, Senske & Jung (2007) of University of Michigan. The analysis is further extended to study the importance of visibility measure in describing shopping malls.

Findings and Discussion

Bid-Rent Analysis of a Shopping Mall: A Conceptual Model

Consider a planned shopping centre (with n number of stores), where:

P_i = Total profit of store i

p_i = Average price per unit of goods sold for that store

a_i = Quantity of goods sold per purchasing customer visit for that store

A_i = Area of the store

$f_i(A_i)$ = Proportion of customer traffic per unit of store area, that actually leads to purchase

d_i = Density of customer traffic at store

C_{Fi} = Fixed cost that depends neither on the area of store nor on the quantity of goods sold

C_{Oi} = Operating Cost or cost of goods sold, depends on the quantity of goods sold for the store

C_{Mi} = Maintenance cost (maintenance, utility, tenant finish-out), depends on the area of the store

r_i = Rent per unit area of the store

The profit of the store i can be expressed as

$$P = p_i \cdot a_i \cdot f_i(A_i) \cdot A_i \cdot d_i^{k_{3i}} - [C_{Oi} \cdot [a_i \cdot f_i(A_i) \cdot A_i \cdot d_i^{k_{3i}}] + r_i \cdot A_i + C_{Mi} \cdot A_i + C_{Fi}]$$

Where, k_3 is the density elasticity of demand (as $\frac{\partial q}{\partial d} \cdot \frac{d}{q} = k_3 \cdot a \cdot f(A) \cdot A \cdot d^{k_3-1} \cdot \frac{1}{a \cdot f(A) \cdot A \cdot d^{k_3-1}} = k_3$). Normally, the total number of buyers for a store has decreasing returns to scale with increase in area. So, the relationship $f_i(A_i) \cdot A_i$ has decreasing returns to scale:

$$\text{i.e., } \frac{\partial f_i(A_i)}{\partial A_i} > 0 \text{ but}$$

$$\frac{\partial^2 f_i(A_i)}{\partial A_i^2} < 0$$

It can be expressed through a relationship $f(A) \cdot A = k_1 \cdot A^{k_2}$, where $0 < k_2 < 1$, considering decreasing returns to scale. This happens because the marginal revenue from adding an extra unit area is off set by the marginal cost (Brueckner, 1993).

By suppressing the subscripts for convenience, the relationship becomes:

$$P = p \cdot a \cdot f(A) \cdot A \cdot d^{k_3} - C_o \cdot a \cdot f(A) \cdot A \cdot d^{k_3} - r \cdot A - C_F - C_M \cdot A \quad \text{Equation 2}$$

As the purpose of the store is to maximize profit, the first derivative of the function will be zero, or,

$$\frac{dP}{dA} = p \cdot a \cdot f(A) \cdot d^{k_3} [p - C_o] - C_M - r + A \cdot \left\{ a \cdot d^{k_3} \cdot \frac{df}{dA} \cdot [p - C_o] \right\} = 0 \quad \text{Equation 3}$$

In a competitive market, store owners want to locate in a place where they can maximize their profit from operations. Excess profits are therefore bid away by increase in rent, so that $P=0$, so the profit function in Equation 2 becomes:

$$P = 0 = a.f(A).A.d^{k_3}(p - C_o) - C_F - C_M.A - r.A \tag{Equation 4}$$

Solving Equation (3) and Equation (4), we get optimal area of store (A*):

$$A^* = \left[\frac{C_F}{a.d^{k_3} \cdot (p - C_o) \cdot k_1 \cdot (1 - k_2)} \right]^{\frac{1}{k_2}} \tag{Equation 5}$$

The relationship in Equation 5 shows that optimal area of a store is a function of customer density, considering other things as constant. Allocated area of store, rent per unit area and customer density at different locations are the shopping mall’s decision variables, other variables (pi,a_i,,CFi ,COi, CMi, k1,k2 k3) are variables pertaining to tenant stores. While mall management does consider an optimum combination of the tenant store variables in the decision making process, it cannot control them.

$$\begin{aligned} \text{And optimal rent per unit area, } r^* &= C_F \cdot \frac{k_2}{1 - k_2} \cdot \left[\frac{a.d^{k_3} \cdot (p - C_o) \cdot k_1 \cdot (1 - k_2)}{C_F} \right]^{\frac{1}{k_2}} - C_M \\ &= C_F \cdot \left[\frac{k_2}{1 - k_2} \right] \cdot / A^* - C_M \end{aligned} \tag{Equation 6}$$

The total rent from a particular store i will be A.r ; From Equation (5) and (6)

$$\begin{aligned} A.r &= \left[\frac{C_F}{a.d^{k_3} \cdot (p - C_o) \cdot k_1 \cdot (1 - k_2)} \right]^{\frac{1}{k_2}} \cdot \left[\left(a \cdot d^{k_3} \cdot (p - C_o) \cdot k_1 \cdot \frac{1 - k_2}{C_F} \right)^{\frac{1}{k_2}} \right] - C_M \\ &= C_F \cdot \left(\frac{k_2}{1 - k_2} \right) - C_M \cdot \left(\frac{C_F}{a.d^{k_3} \cdot (p - C_o) \cdot k_1 \cdot (1 - k_2)} \right)^{\frac{1}{k_2}} \end{aligned} \tag{Equation 7}$$

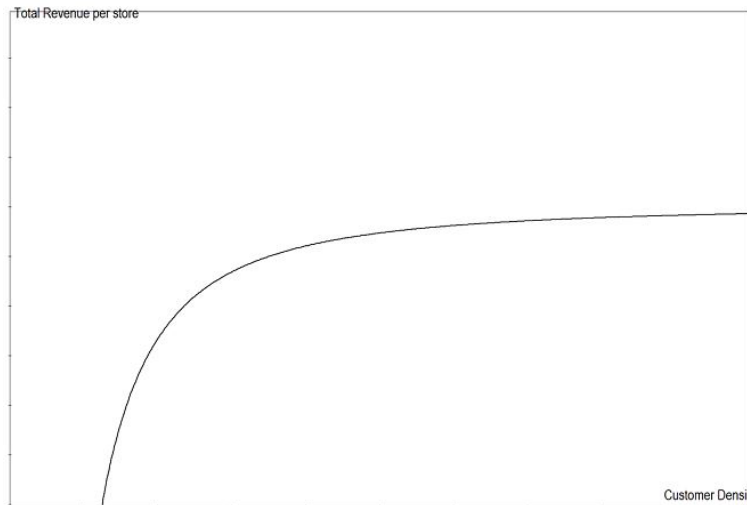


Figure 1. Total revenue curve for a tenant store in a shopping mall at different customer densities or foot fall

Figure 1 shows the relationship between total rent from a store and customer density when other factors remain constant. The relationship is such that at d=0 the function is undefined and the value of d at f'(d)=0, is also undefined. True maxima or minima are therefore unattainable. But, customer density should always be less than or equal to a certain value (for specific geographic locations) and the local maxima of the function is achieved at that point. The total revenue beyond that point is inconsequential as required density would be un-attainable under normal conditions based on demographic characteristics of the catchment area of the mall. It is evident from Figure1 that when customer density falls below a particular point, the total rent curve decreases dramatically. This particular point can be designated as critical density (d_i^c) for that store type.

When customer density falls below this critical point, it is not profitable to add stores of the same type in the shopping mall. This necessitates introduction of a new category of store in the mall to fill up the still vacant leasable area. The new category of stores should have C_F and $a.(p-C_o)$ more than and C_M, k_1, k_2, k_3 less than the previous category of stores to cut the curve of the former's from below. Figure 2 illustrates this logic:

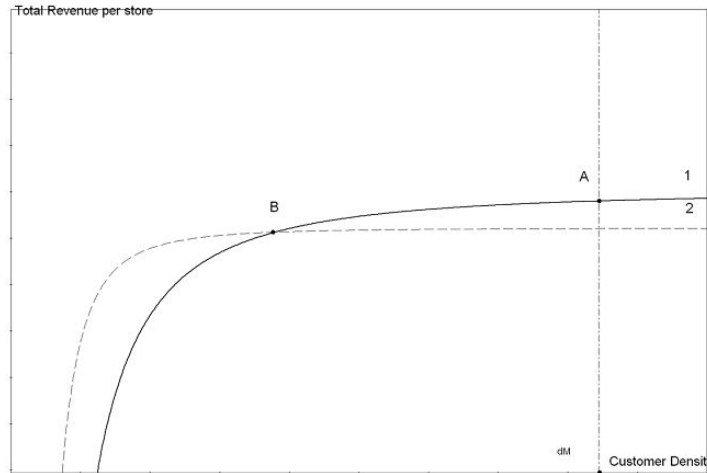


Figure 2. The logic of introducing new store types in a shopping mall when critical customer density point is achieved for a particular store type

Let d_M be the maximum available human density for a particular mall. Store types should be selected for total revenue maximization. Let, 1 be the type of store which has highest density elasticity of demand at the given situation (highest k_3). When at a particular location of the mall the customer density falls below the critical density level for store type "1" (d_1^c), introduction of new store type is inevitable. Let the curve for new store type be "2" which intersects the curve for type 1 at B. Beyond point B, it is profitable to include stores of type 2 than 1. For simplicity, the discussion will be limited only to two types of stores, Type 1 and Type 2.

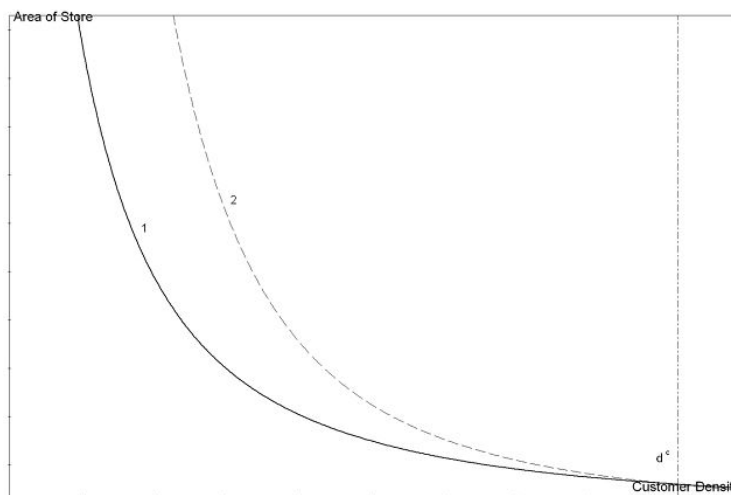


Figure 3. Optimal floor area of store at different customer densities for type 1 and type 2 store as shown in Figure 2

From Figure 3 it is clear that, stores of type 2 occupy more area than stores of type 1 for same customer density when customer density falls below the critical density of type 1 (d_1^c). Considering equal floor area A , corresponding optimal rents for type 2 and type 1 stores will be r_2 and r_1 respectively (Figure 4). Type 2 stores thus will have to pay an additional amount $(A \cdot r_2 - A \cdot r_1)$, as rent for the same store area.

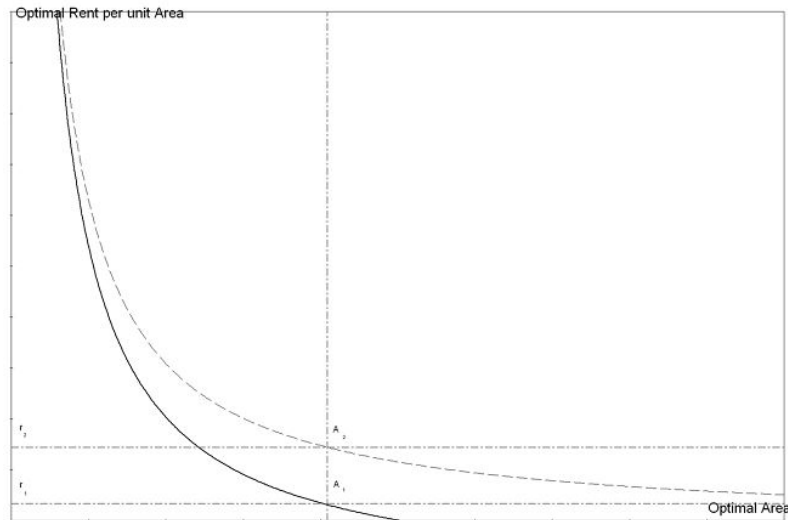


Figure 4. Rents per unit area for the same area of store of the two store types

Location of different stores are therefore dependent on customer density distribution throughout the mall. Contrary to the assumption of tapering off customer density from centre (Carter & Vandell, 2005), research results suggest strength of syntactic measures over metric distance in describing human density within a built environment (e.g. Peponis et al., 1990; Haq & Zimring, 2003; Holscher et al., 2012). Studying navigation pattern in a shopping mall is, therefore, important.

Respondent Navigation Behaviour in a Built Environment

As customer density in a shopping mall is very critical in decision making, the spatial logic behind customers' directional preferences at a particular intersection is of importance. This behaviour is rather difficult to measure in real situations: most of the movement decisions are guided by experience and it is difficult to segregate whether the movement is influenced by spatial factors or prior experience. Computer generated pictures are used for this purpose to record navigational intentions.

Table 1. Respondent Characteristics of the Survey

Characteristic	Percent Distribution
Gender	
Male	71.03
Female	28.97
Age	
Less than 21 Years	16.82
21-26 Years	26.17
27 -32 Years	12.15
33-38 Years	17.76
39-44 Years	14.95
45-50 Years	9.35
Over 50 Years	2.8
Mall Visit	
Less than once a month but more than 4 times a year	39.25
At least once a month	36.45
More than once a month	24.3

The pictures, shown to the respondents, are representative computer generated images of shopping mall junctions where different directional options are present. No directional cues are provided and no brands are shown in images. The intentions of individual respondents to move in a particular direction were recorded. In Figure 5, the situation on the left shows a foreground with a blank wall at one end. Visibility to the left beyond this wall is more than the visibility to the right, where another wall at right angle to the first narrows the gap and blocks vision. The second situation on the right shows a doubly loaded corridor with a closed end.

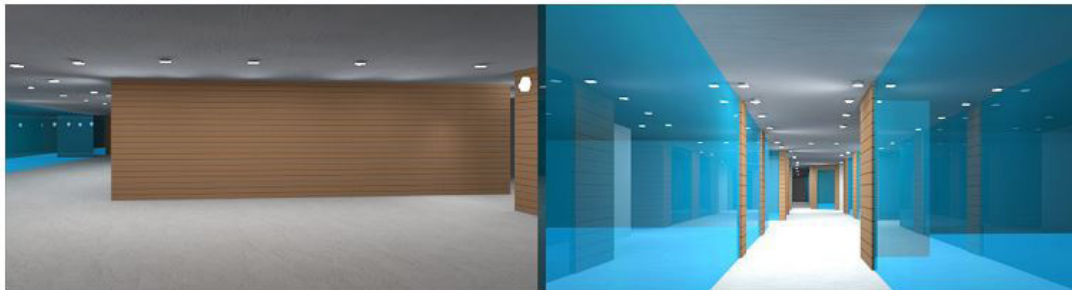


Figure 5. Computer generated mall junctions used in the survey for recording navigational preferences

For the first situation (Figure 5), 79 preferred to go to left and 28 to the right (out of 107). Participants have shown preference for a particular direction ($\chi^2 = 22.439$, $df= 1$, $p<0.0001$). For the second situation, 16 preferred to go to left, 23 to the right and 68 straight. Here also participants showed difference in preference ($\chi^2 = 44.676$, $df=2$, $p<0.0001$). By conventional criteria, this difference is considered to be statistically very significant.

Visibility Graph Analysis of the Simulated Situations

The purpose of this investigation is to analyse visual differences in simulated malls shown in the survey, to understand the importance of visibility in predicting navigation preferences. Space is normally described in qualitative terms making it difficult for comparing, correlating it with behavioural measures. Visibility Graph Analysis is used as one of the tools of the space syntax method to obtain an objective and quantitative description of spatial properties.

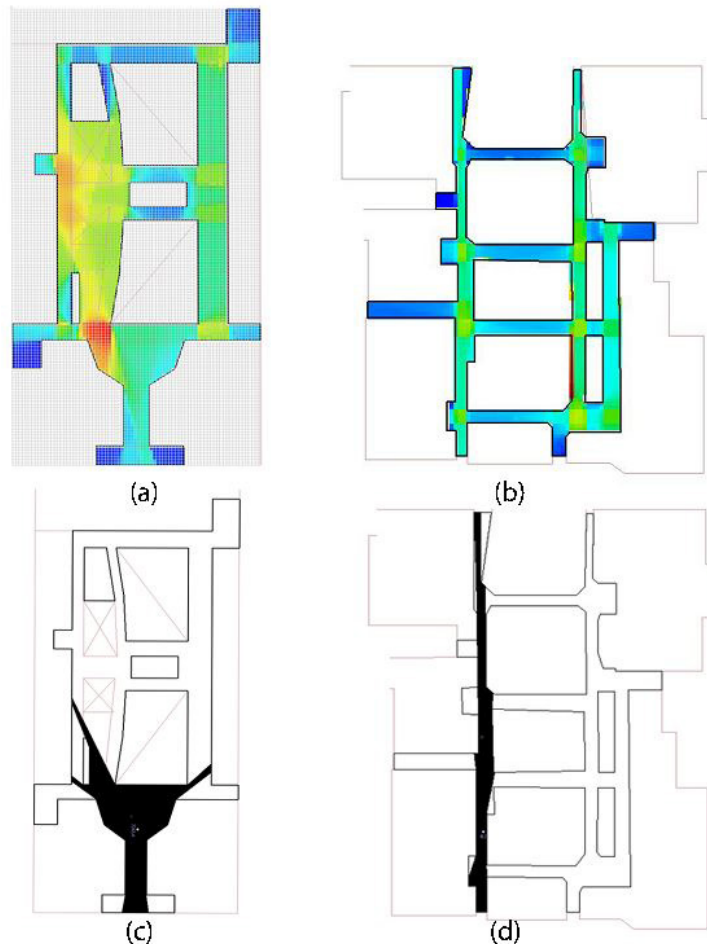


Figure 6. (a) and (b) VGA of the entire layouts; (c) and (d) isovists from the vantage points of the two situations respectively of Figure 5

The Visibility Graph Analysis of the corresponding entire mall (study situations) and isovists at the point from where views for survey are taken (Figure 6) show that people preferred to go to more visually integrated areas. In the first case, visual integration is highest in the straight direction and minimum in left side, right side falls in between. Density distribution follows the same pattern. For the second case, spaces on the right side get more visibility than the left side and more people preferred to go to the left. Majority decision to move in a particular direction yields greater density in that location. As majority prefer to go to more visually integrated areas, Visibility Graph Analysis can be used as a tool for predicting human density distribution throughout entire layout.

Conclusion and Implications

The customer density considered in development of the model of a shopping mall comprises two factors; natural movement and movement due to inter-store externality. Stores that exert externality are termed here as anchor and who enjoy the externality are non-anchor stores.

$$d_i = \beta_i + \sum_{\substack{j=1 \\ j \neq i}}^n S_j^{\delta_{ij}} \tag{Equation 8}$$

δ_{ij} is the cross store elasticity between shops i and j where, $\delta_{ij} \neq \delta_{ji}$ (externality generated on store i by store j is not same as that of externality generated on store j by store i). In Equation (8) β_i denotes natural density and density due to externality exerted by anchor stores is

$$\sum_{\substack{j=1 \\ j \neq i}}^n S_j^{\delta_{ij}}$$

Anchor stores are introduced in a mall as a 'destination' store to exert positive externality over others, so, there should be a sound spatial rationale for locating them. When natural density reduces, anchor stores (Type 2, in this case) are introduced into a mall. In practice, for attracting anchors into a mall for occupying larger area, rent subsidy is given. Logically, subsidy should be equal to externality generated on others. This mechanism will bring the rent per unit store area to less than r_2 as specified earlier. Let i be non-anchor stores (Type 1, in this case) and j be anchor stores (Type 2) and there be m non-anchor stores out on n total stores. The externality generated by anchor store j will be:

$$\frac{\sum_i^m A_i r_i (for\ d'_1\ to\ d'_2) - \sum_i^m A_i r_i (for\ d_1\ to\ d_2)}{\sum_{j=m+1}^n A_j} A_j$$

Where, d'_1 (With anchor lower density) $> d_1$ (without anchor lower density) and d'_2 (With anchor upper density) $\geq d_2$ (without anchor upper density)

(Increase in revenue from non-anchor stores for additional density generated by anchor stores, considering all anchor stores exerting equal externality). The externality amount, if subtracted from the rent collected from anchor stores, provides a logical framework for subsidizing anchor stores.

$$P = \sum_{i=1}^m A_i \cdot r_i + \sum_{i=m+1}^n \left(A_{ji} \cdot r_j - \frac{\sum_i^m A_i r_i (for\ d'_1\ to\ d'_2) - \sum_i^m A_i r_i (for\ d_1\ to\ d_2)}{\sum_{j=m+1}^n A_j} A_j \right) -$$

(FC +

$A_c \cdot MC$)

Equation 9

Where,

A_i = Area of Non-anchor stores

r_i = Rent per unit area of non-anchor Stores

A_j = Area of Anchor stores

r_j = Rent per unit area of Anchor Stores

FC= Fixed Cost of mall

A_c = Common Area

MC= Maintenance cost

The model has a number of constraints that need to be included in the problem formulation.

First, there is a capacity constraint or physical constraint, where area requirement for all n shops will not exceed total leasable area (ALE). Second, is the availability constraint, where quantity of goods sold for all the stores cannot exceed a specific level of Q* and total customer density cannot exceed D* depending on the location characteristic of the shopping mall. Third, there are control constraints. The area ALi and AUi are the lower and upper bounds for space allocated to store i. Lower bounds may be set for retailer’s pre-conceived notion of ‘image’, irrespective of immediate profitability, and upper bounds to meet sustenance and design obligations.

Finally, there are non-negativity constraints to ensure reasonable solution values.

As the purpose of the centre is to maximize profit, the model will be:

$$Max[\sum_{i=1}^m A_i \cdot r_i + \sum_{i=m+1}^n (A_{ji} \cdot r_j - \frac{\sum_i^m A_i r_i (for d_1' to d_2') - \sum_i^m A_i r_i (for d_1 to d_2)}{\sum_{j=m+1}^n A_j} A_j) - (FC + A_c \cdot MC)]$$

Subject to:

$$\sum_{i=1}^m A_i + \sum_{i=m+1}^n A_{Aj} = A_{LE}$$

$$A_{LE} + A_c = A \text{ (Total built Area of the shopping mall)}$$

$$d_i \leq D^*$$

$$\sum_{i=1}^n a_i \cdot f_i(A_i) \cdot A_i \cdot d_i \leq Q^* \quad i=1,2,3,\dots,n$$

$$A_i^L \leq A_i \leq A_i^U \quad i=1,2,3,\dots,n$$

$$A_{LE}, A_c, A_{Vi}, A_{Ai} r_{Vi}, r_{Ai}, d_i, a_i, FC, MC \geq 0 \quad i=1,2,3,\dots,n$$

The same model can be extended for k category of stores with different number of stores for each category

$$\sum_{i=1}^a A_{1i} \cdot r_{1i} + \sum_{j=1}^b A_{2j} \cdot r_{2j} + \dots + \sum_{k=1}^m A_{ki} \cdot r_{ki} \tag{Equation 10}$$

Where, a+b+c+.....+m=n

Research findings in the field of space syntax and the present study highlight the importance of syntactical values (VGA in this case) in predicting accessibility of a location over metric distance (Hillier, 1996; Turner & Penn, 1999; Turner, 2001). Customer density (natural) at a certain location within a built environment can be described as a function of accessibility of that location:

$\beta=f(\text{Accessibility})$, The more accessible areas will generate higher density and vice versa. Accessibility of a location in mall depends on the distance from the access point and visual integration of that particular location. If ‘t’ denotes metric depth, ‘vi’ denotes visual integration and ‘Ac’ denotes accessibility of a location, then,

$$Ac=f(t,vi), \text{ where, } \delta Ac/\delta t < 0 \text{ and } \delta Ac/\delta vi > 0. \tag{Equation 11}$$

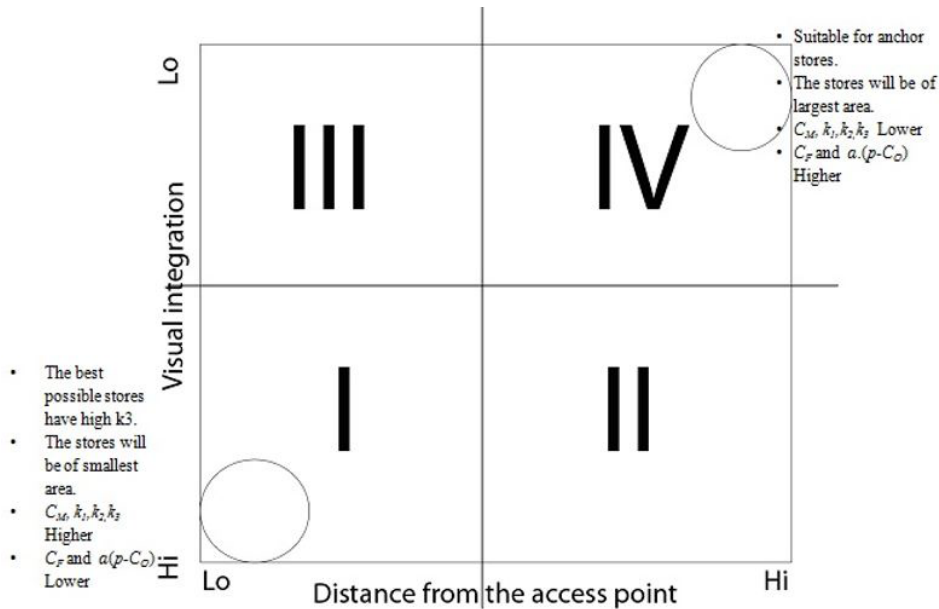


Figure 7. Spatial decision making model of a shopping mall

Figure 7 shows conceptual spatial decision-making model of a shopping mall which summarizes the entire discussion. The model, for simplicity, can be conceived as a 2X2 grid where distance from the access point is shown on the X Axis and visual integration is shown on the Y Axis.

Cell I of the model has low distance from the access point and high visual integration. From the relationship in Equation 11, this location of the mall has maximum accessibility and thus, enjoys maximum natural density. The best possible stores for that particular location will be those that have high density elasticity of demand or stores that bank on ‘impulse purchase’. The quantity of goods sold per purchasing customer visit and proportion of customer traffic per unit of store area that actually leads to purchase should be the highest compared to stores in other cells. The stores in this location will be of smallest area.

Cell IV of this model describe locations farthest from the access point and with minimum visual integration with other locations within the entire spatial arrangement. Natural densities at these locations are lowest. So, these places should be converted into ‘destinations’ that can attract people. These locations are suitable for anchor stores. The quantity of goods sold per purchasing customer visit and proportion of customer traffic per unit of store area that actually leads to purchase are both the lowest for the stores. Maximum and minimum natural density areas of the entire shopping mall are located at south-west and north-east corners of the model respectively.

Cell II and cell III enjoy moderate natural density (not as high as cell I and not as low as cell IV). As cell II describes locations with high distance from the access point and high visual integration, it enjoys higher natural density than cell III, syntactic values being more important than metric distance (Hillier, 1996; Turner & Penn, 1999; Turner, 2001). Introduction of new access points or introduction of certain attractors at locations of cell II will facilitate the functioning of this area. Locations described by characteristics of cell III are suitable for service or transit areas. They can be made more accessible by either increasing visibility or through proper signage. The values of quantity of goods sold per purchasing customer visit and proportion of customer traffic per unit

of store area that actually leads to purchase for the category of stores for cell II and III fall between the values for cell I and cell IV.

Space Planning, thus, is not an end, rather a tool for strategic decision-making concerning location and rent of stores in a shopping mall. It is not only 'form' and 'functions' that are closely related but also 'form' and 'profit'.

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