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Measurement of Retail Concentration and Variety in Vertically-used Large-scale Retail Properties

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Abstract

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One of the features of compact city is high density and more vertically-used of floorspaces. A multi-unit retail property is the agglomeration of retailers and service providers seeking maximum profit in an architecturally unified building or buildings. Owing to its consumer-oriented nature, the smoothness of pedestrian flows and the efficiency of space allocation are the major concerns for developers and operators. Thus the design of the shopper's circulation needs to consider product varieties, the purposes and behaviours of incoming consumers, and other operational issues. Normally, even with elevators and escalators, vertically movements for shoppers are advised to be avoided. This is because the higher the floor levels the less the motivation; and the higher the searching costs for shoppers. Therefore, the maximum number of floor levels in 148 UK regional shopping centres in 2002 is only 4 levels.

However, it is difficult to prevent vertical use of retail buildings in precious central urban areas. In the existing 70 large-scale (over 300,000 sq ft.) shopping centres and department stores, these buildings are with 10 floor levels in average and two of the department stores even with 19 levels. With the spatial data generated from GIS software, this paper aims to reveal the efficiency concerns of the usage of floorspace. And one of the reasons for departmentalizing of retail categories in these high-rise retail properties is to transform non-purposive shoppers into purposive and guided shoppers, which is an opposition from the dispersion result suggested by Carter and Haloupek (2002). The higher and more complex the building is, the more purposive and logical of product variety is needed for customer searching. Hence, retail concentration is a necessity in these properties.

Keywords: space allocation, shopping centre, high-rise property, Geography Information System (GIS)

I. Introduction

The study of micro-scale location and allocation problems within shopping centres has been one of the central concerns in the research of retail properties for over a decade. A multi-unit large-scale[1] retail property, by its nature, is an agglomeration of retailers and service providers seeking the maximum agglomeration economies. Thus, the interactions among players and customers are meant to be complex. And the dimensions of this complexion could be varied from the location, planning and design, and the concepts of operation system of the property. Yet despite of the multifaceted nature, researchers had started forming basic principles for the location and allocation of retail spaces. Brown (1991), Miceli *et al.* (1998), Carter and Haloupek (2002), Yuo (2004), Yuo et al (2004), Carter and Vandell (2005), and Des Rosiers et al. (2009) were all contributors in micro-scale retail location theory[2] within planned shopping establishments. This kind of shopping facilities was suggested by Carter (2009) as: "*the most successful retail establishments of the twentieth century*" because, in our interpretation, of its planned nature. Hence, it has the ability to enhance the total retail agglomeration economies to its maximum through optimizing the mall configuration, predicting shopping behaviours, and allocating total floorspace according to the previously planned tenant mix strategy[3].

For a planned shopping centre, the main objective is "*to ensure that the maximum number of people pass the maximum numer of shops…*(Morgan and Walker, 1988)". And the developer's main consideration should be "*placement of the key or anchor tenants, which must be positioned so that they draw shoppers between them and past other tenants.(ULI, 1999, p97)*". Fong (2003) therefore suggested that, under morphological analysis, big dumb bell is the basic configuration of mega shopping malls. Thus, the basic mall configuration for a shopping centre should be linear with anchor stores at each end of the mall or its extension format, such as I, L, Y, X, Z(Morgan and Walker, 1988; *ULI, 1999*). And according to the retail gravity model and bid rent theory, the rent level of a store within a mall should based on its distance from the mall centre, normally the spot with the highest pedestrian flow, the nearer the higher (Carter and Vandell, 2005).

Carter and Haloupek (2002) also observed an interesting pattern: the

[1] The term "large-scale" here is based on the minimum scale of regional shopping centres defined by the ULI (1999) as over 300,000 sq ft. gross leasable area(GLA). And "multi-unit" means exclude the properties with only one or few mega-stores, such as Ikea, or other hyper-store with only few retail sotres, say 20 stores like retail park, but over 300,000sq ft. Normally, it has to be with over 100 retail units, thus, including shopping centres, department stores without self-operated merchandises, and other complex buildings and their retail space qualifying over 100 units and over 300,000sq ft.

[2] Brown (1994) was one of the pioneer researchers in this field and has described this location problem within a relatively smaller area or floorspace as "retail location at the micro-scale".

[3] Abratt et al. (1985) and Yuo(2004) suggested that the four basic elements for this tenant mix strategy were type, size, location and number.

non-anchor stores of the same retail category are tend to be dispersion. The reason for this dispersion, although still arguable and not quite agreed by this research, is because it can minimize the total distance of supply points from demand points. Using the concept of P-median problem, "*if stores of the same type…will be where transportation costs between the stores are minimized.*" (Carter and Haloupek, 2002, p302)

These micro-scale location and allocation theories were generally widely agreed by researchers for (suburban or out of town) shopping centres. However, this research found that most of these principles were difficult applying to the cases in Taiwan and other urban/metropolitan or city-based countries with high population density, such as Hong Kong, Singapore Japan, and China. Shopping establishments in these areas were with same characteristics: extremely high land price, various land shape, mixed-use with other public facilities. Hence, vertically-used, high complex floor plan, and high flexible, are the common challenges for retail space managers. Moreover, especially in Taiwan, the size of retail tenants in a multi-unit large-scale retail property is generally smaller and most of the time, lack of major anchor stores. For these reasons, the minimum total floor levels for total 70 multi-unit large-scale retail properties in Taiwan in 2008 is 5 levels (excluding parking levels) and the maximum is 19 levels, 10 levels in average. Comparing these numbers to the UK cases, in 2002, the average floor levels of total 148 regional shopping centres is 2 levels, and the maximum total levels is only 4. These large-scale shopping facilities in Taiwan are basically vertically structured.

Consequently, the micro-scale location principles were no longer sustained in these retail centres. These principles include:

1. The floor plan configuration should allow maximum number of customers pass the maximum number of shops (Morgan and Walker, 1988)
2. Dumbbell shaped or its extension to I, L, Y, X, Z. Anchor stores at the mall ends and standard/smaller tenants along the single corridors that connecting the anchors. (ULI, 1999; Fong, 2003; Carter and Vandell, 2005)
3. Dispersion of non-anchor stores of the same type. (Carter and Haloupek, 2002)

In contrast to these high population density in-city cases, the typical western-style regional shopping centres are with larger site area, low total floor levels, simple floor plan (low complexity), simple geometric configuration, larger and lesser store units and anchor-store oriented. The first objective of this research is to reveal the differences of the cases between these two fundamental concepts, i.e. horizontally-used retail properties (out-of-town shopping centres) and vertically-used retail properties (shopping facilities within the high density areas). Thus, the first two principles listed would not be achieved under vertically-used cases. The second objective is to show that dispersion of non-anchor stores of the same type also would not be sustained under vertically-used cases. This research use geographic information system (GIS) to generate 12 cases from US, UK, Taiwan, and Singapore, which produced more than 60 floor plans. Empirical study for the above two objectives would be examined though these spatial data.

II. Literature review: optimum space allocation strategy

Optimum space allocation strategy has been one of the major concerns for shopping centre research. Bruckner (1993) has fundamentally established the linkage between inter-store externalities and the principle of space allocation in shopping centres. Hence a profit maximizing shopping centre should allocate more space to stronger positive externalities-generators. Miceli *et al.* (1998) further suggested that for optimizing space allocation in a multi-unit centre, the developer is interested not only to individual store profits, but also the pedestrian flows they generate throughout the centre. The competition among identical stores increase the overall traffic, which can create an offsetting effect that favours multiple outlets. Brown (1991), on the other hand, more concerned about the shopper circulations and tenant placement using observation survey, which highlighted the significant role of magnet stores and the beneficial effects for the proximity of compatible outlets. Nevertheless, micro-scale location principles were still suggested under observation and empirical surveying but lack of theoretical modelling. A detail of these store location/allocation literature related theory could be seen in Carter and Vandell (2005), Des Rosiers et al. (2009), and Carter (2009).

Here the concern will focus on the concept suggested by Cater and Haloupek (2002) that non-anchor stores of the same type have economic tendency to be located in dispersion. This result is derived from the data of single-level malls only, the authors excluded the multilevel centres because of "... *the difficulty in equating horizontal and vertical distances.*" Cater and Haloupek (2002) suggested, based on central place theory and p-median problem, this dispersion is the results under minimum total transportation costs within the centre. 「Assume demand occurs on the note set $V = \{v_1, v_2, ..., v_m\}$. Let $c_k(x,v)$ be the unit cost of transporting commodity k from point *x* (facility) to node *v* (demand). A demand at v_i could be serviced by any of the facility, but for obvious reasons will be serviced from the facility for which transportation costs are lowest. Total transportation costs are $TC(X_p) = \sum\sum w_{ki} \min\{c_k(x_j, v_i) : x_j \in X_p\}$ where w_{ki} is proportional to demand for commodity *k* at node v_i.」

III. Space usage efficiency vs. maximum spillover effect

Nevertheless, this research argues that p-median problem, i.e. minimizing total distance from facilities to demand nodes, may not be a proper concept to explain the dispersion of retail store of the same type.

The Reasons for this were because:

A. The “facilities” of the same type that fulfil the demands are actually satisfying comparative and selective purpose, hence, different from the “facilities” such as elementary school, parking facilities, library in the community should be distributed evenly to minimizing the “demands” from a set of nodes. Customers purposive for the same type, such as ladies fashion wear, will go to every store to compare and select products. Hence minimizing distance should be agglomerate (departmentalized within) for the same type, not in dispersion.

B. Consequently, this research argues that minimizing total distance, or transportation cost, is not the main reason for dispersion. But generate spillover effects to maximizing the agglomeration by searching every store within the centre in main corridor(s), is the main purpose for this dispersion of the same type.

Nevertheless, for a vertical project with greater complexity floor plans, developer/manager has to consider the space usage efficiency and effectiveness before pursuing maximum retail agglomeration. In other words, manager for a vertically structured retail centre has to solve the vertical shoppers circulation and the effectively distribute pedestrian flow before considering inter-store externalities. This research suggested that: departmentalized retail categories, i.e. clustering retail tenants of the same type, may be the solution for a complex and vertically structured case. It could clearly define the searching area, avoiding wayfinding problem and product searching costs. And it can also convert a non-purposive searching to a purposive searching, then locating the purposive products (restaurants or book store) on the higher floor levels could pull up the purposive pedestrians. Hence, the core space allocation issue is generated from the different nature of vertical and horizontal projects, namely the pursuing for space efficiency and spillover effect. Therefore, the location of non-anchor stores of the same type would not be necessary in dispersion. Generally speaking, for a planned shopping centre without any constraint (lot size, shape, and other physical/non-physical subjects), the three general principles listed above would be the optimum. Then dumbbell is the solution for mega shopping mall (Fong, 2003). However, this is not the case for the projects in Taiwan, and other

Asian counties that need to be built under strong demand but with stronger physical constraints.

Scenario simulation:

This could be further discussed through a scenario simulation. If we still hold the total building size in constant, the fundamental difference between vertical and horizontal projects could be like case A and Case B in Figure 1.

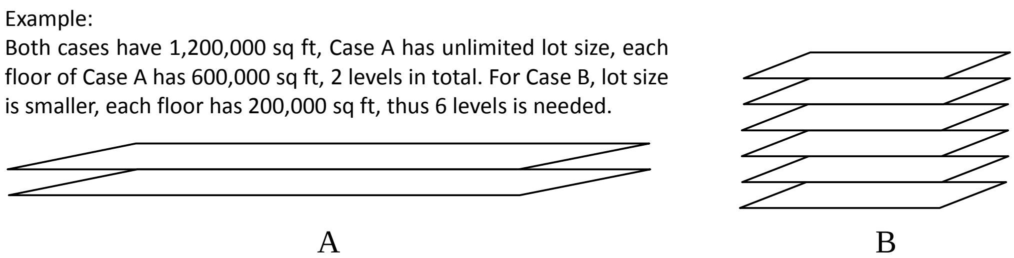

Figure 1: Floorspace distribution of horizontal (A) and vertical (B) projects

Figure 1 shows that, under the same total floorspace, Case A is a typical US/western style regional shopping mall. Its characteristics are low total levels (under 4), simple internal of routes (low complexity), anchor stores powering the total customer drawing power, variety along the connected routes between anchors. The strategy for shopper circulation is simple (Figure 2): using the simplest pedestrian flow to pass all retail tenant, so as to provide greatest transaction opportunity to all tenants.

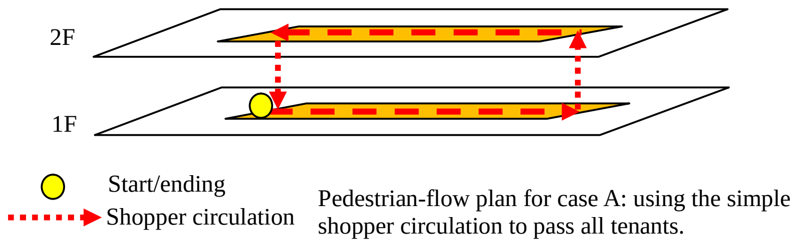

Figure 2: Shopper circulation for horizontal cases

On the other hand, Case B is the results from small lot size thus the floorspace must distributed in vertical. It is typical for the cases in Taiwan. And normally, a vertical project starts from basement 2 (B2) or even from basement 3 (B3), with additional underground parking levels from B4 to B6. Therefore the total floor levels for the whole building is higher than operating levels.

The physical feature for Case B easily breaks the first two principles for suburban regional shopping centre. It is hardly possible to achieve 1) maximum visited customers to pass maximum number of retail tenants. And 2) it breaks the law of retail gravity from vertically-used of floorspace. Consequently, the third principle would not hold because if the retail store of the same type (or same demand) were to be located in dispersion. Shoppers will face a jungle of stores to search their intended goods and services, searching costs could be extremely high. Moreover, cases like this face their greatest challenge: how to concert the pedestrian flows from horizontal into vertically. Vertical movement of customers has always been the greatest fear for any retail managers, but now the average total floor levels of 70 cases in Taiwan is 10 floors[4]. Hence, departmentalization of retail categories is the only solution.

Scenario 1: Tenants of the same type in both Case A and B were allocated in dispersion.

In scenario1, a certain customer wishes to go shopping for ladies fashion wear, say the tenants in Figure 3 marked in light blue. When this customer goes to Case A, she/he only needs to finish the simple pedestrian flow to pass all tenants (Shown in Figure 2). During this passage of all tenants, the searching and comparing costs for blue tenant is low, comparing to Case B. This simple feature could be extended from this linear shape to a △, X, +, Y, or Z, all designed under the same concept of low total level, simple circulation[5].

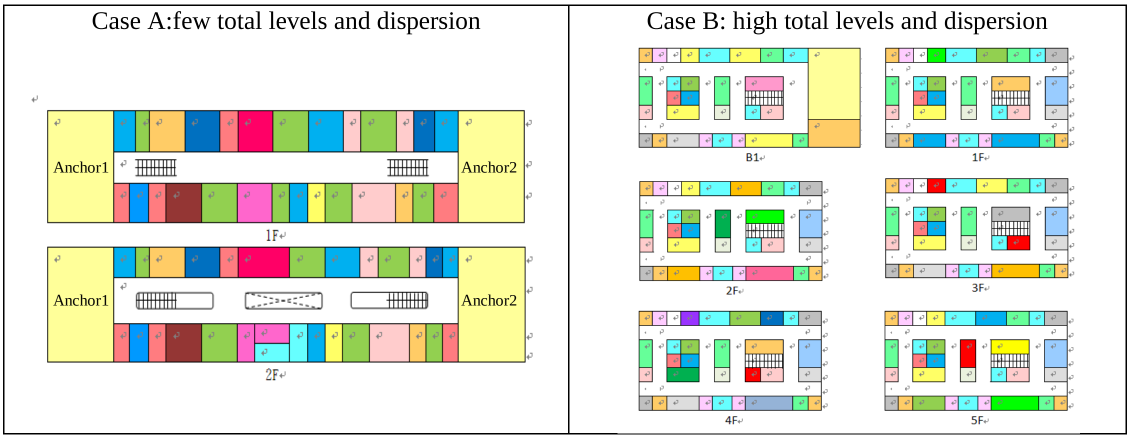

Figure 3: Scenario 1(Tenants of the same type in Case A and B both located in dispersion)

In case B, as for the limitation form physical feature, the building has 6 levels. The configuration of the shopping establishment could no longer be as simple as a “dumbbell”. If the “tenants of the same type should be in dispersion” still sustain, then it would be like Case B in Figure 3. For blue retailer searcher, he/she has to go

[4] High-rise retail centres are not only happening in Taiwan, but a trend in Asian countries. Yiu et al (2008) has listed out some high-rise retail centres in Hong Kong, Taiwan, China, Japan, and Malaysia.

[5] The linear configuration for Case A if built in 600,000 sq ft. The distance between anchors will be way longer then the optimum shoppers walking distance suggested by ULI (1999). Therefore, multi anchor stores and the configuration has to extend into other simple geometric shape, like Bluewater(UK) in to a triangle.

through each of the 6 levels and every corner of each floor. While the size of each floor is large, complex and the location of retailers were not certain, searching and comparing costs for comparative goods would extremely high. Hence, it is simple to find the real case of Case A, such as the Bluewater in the UK (Figure 4), but Case B was not easily found.

Figure 4: Bluewater (Greenhithe, UK) 2 levels, total 1,600,000sq ft in GLA

Scenario 2: Tenants of the same type in both Case A and B were allocated in departmentalization.

In contrast to the situation in Scenario 1, Scenario 2 is just the opposite case (Figure 5): tenants in both cases were located in departmentalization. Shoppers for light blue retailers (Women's Fashion wear) for both cases could be easily found their targeted goods. Hence, even the floor plans and shoppers circulations in Case B are more complex in both horizontally and vertically, departmentalizing retail categories can still reduce searching and comparative cost dramatically. This is exactly the case in all department stores.

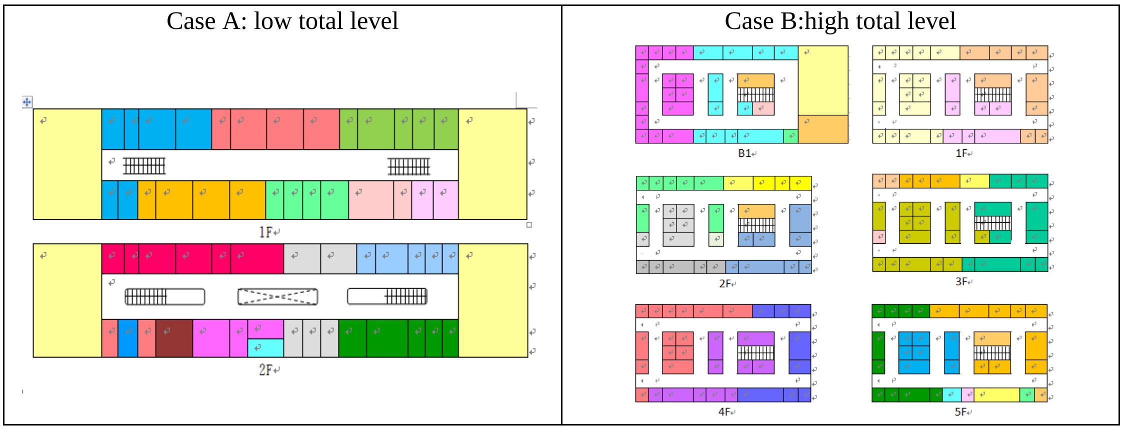

Figure 5: Scenario 2(Tenants of the same type in Case A and B were both located in departmentalization)

However, if the managers in Case A also place all the tenants in departmentalization, the result would be like in Panel A of Figure 5. In a simple configuration and low complexity floor plan, if the stores of the same type were to located in clustering, then it would reduce spillover effects among stores. While the shopping centre is huge, shoppers will stay in a certain area for their purpose without shopping along the planned routes for circulation. Therefore, it is easier to find a high total floor level, complex in floor plan case locating tenants in departmentalization, such as the Miramar in Taipei, Taiwan (Figure 6).

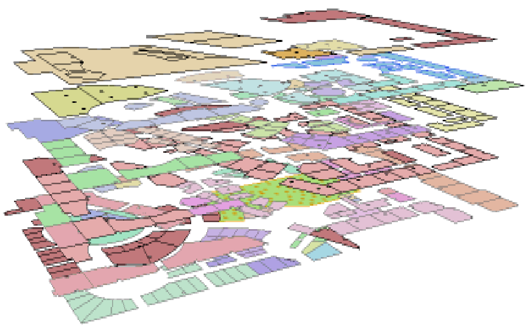

Figure 6 : Miramar (Taipei, Taiwan) 8 levels total 1,352,192sq

Figure 7 shows the comparison of the real case for Case A and Case B in the scenario simulation. For cases over 1,000,000sq ft, the configuration and the floorspace distribution for vertical projects no longer adaptable the previous three principles.

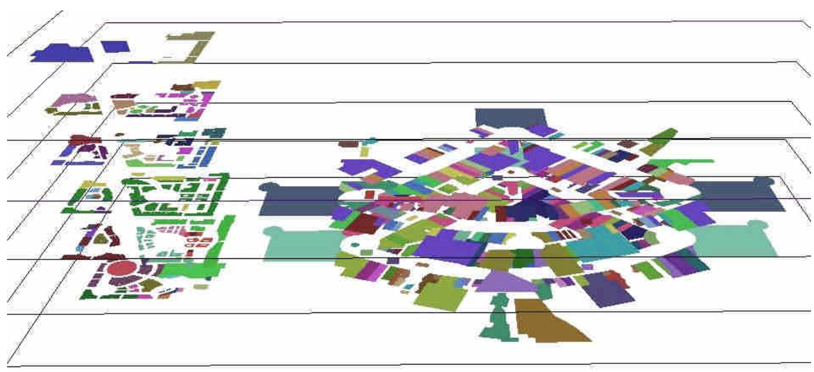

Figure 7: Comparison of Bulewater and Miramar in correct scaling

Other than the basic spatial database, some further spatial analysis function provided by geographic information system (GIS) software were used to analysis the degree of departmentalization of the same retail type. Figure 8 shows the results of a measurement for retail categories clustering within the distance of 5 metres. It is clear that, the retail tenants are highly departmentalized in the Miramar; and the Bluewater is in dispersion. The index for this degree of departmentalization of the same retail type is introducing in the next section.

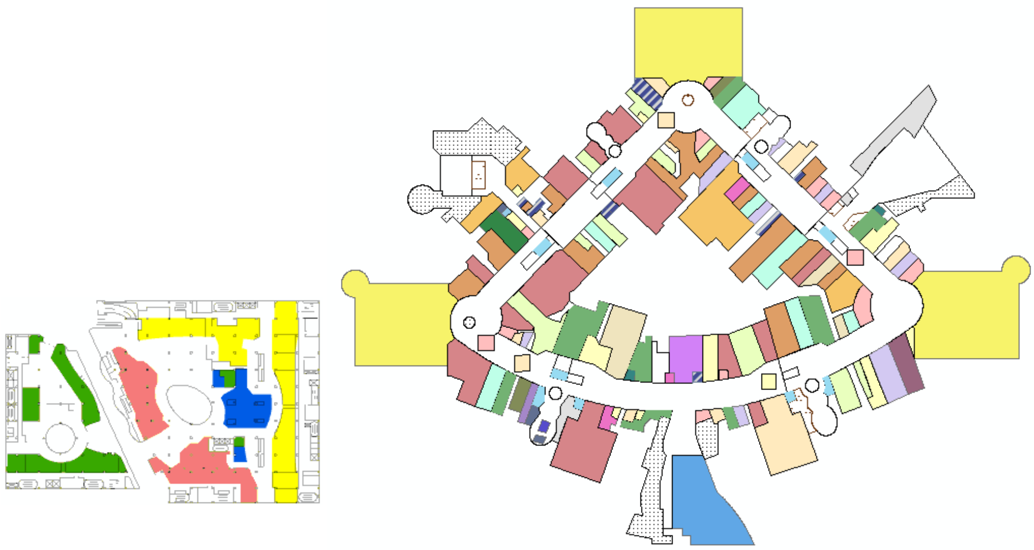

Figure 8: Aggregate polygons in 5m for Mirama 1F(Taiwan) and Bluewater 1F(UK)

The Miramar is certainly not the only case for vertically used large scale retail property. Figure 9 is a 3D model for the Living Mall in Taiwan. Its scale is even larger than Miramar, and is still smaller than the Dream Mall located in southern Taiwan, which contains 9 levels, 2,775,510 sq ft in GLA and 4,305,664 sq ft. in total construction floorspace (Figure 10).

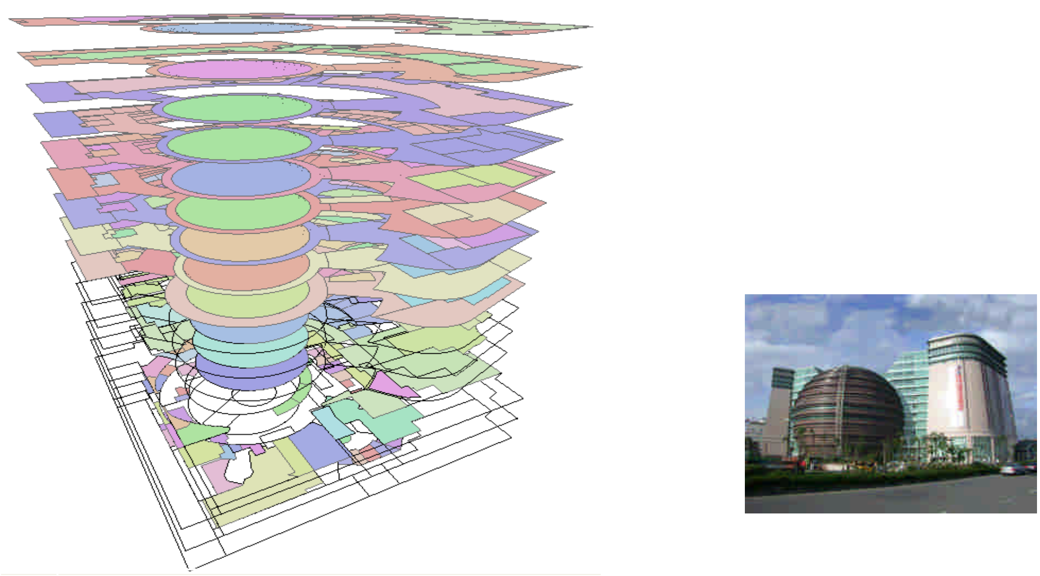

Figure 9: Living Mall (Taipei, Taiwan) B3-12F (15 levels) 2,201,548 sq ft

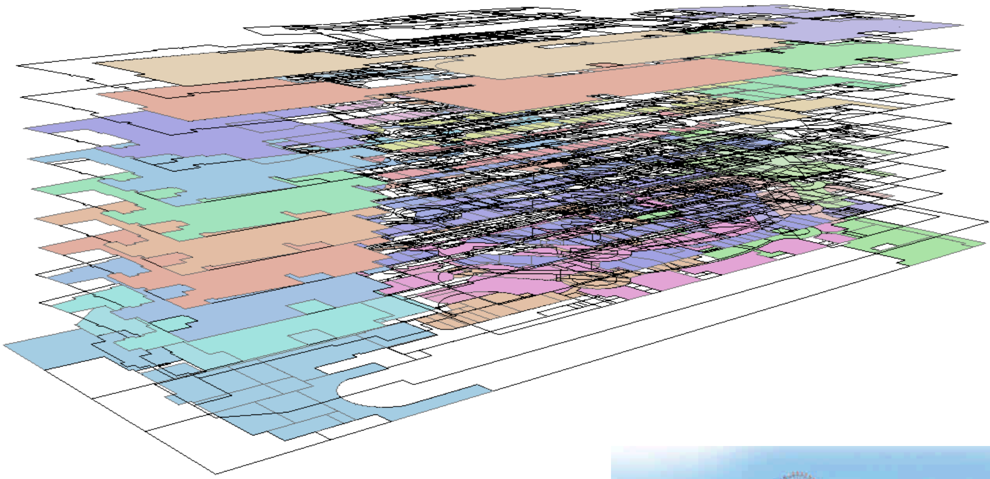

Figure 10: Dream Mall, (Kaohsiung, Taiwan)
B2-9F(11levels), 2,775,510 sq ft in GLA and 4,305,664 sq ft in total construction floorspace

IV. Empirical study

Research Design

This research established a GIS-based spatial database of multi-unit large-scale retail properties around the world, including the projects from the US, UK, Finland, Taiwan, Singapore, Hong Kong, China, Malaysia, and Japan. The intension is to collect and established a GIS-based database, which is capable for both micro-scale and macro-scale spatial analysis.

In this research, the main purpose of empirical analysis is to examine the relationship between the degree of departmentalization and total floor levels. The research hypotheses for a multi-unit large-scale retail property are

H1: The lower the total floor levels, the larger single floor area, and the less complex of pedestrian routes, retail tenants of the same type has to be located in dispersion: so as to stimulate shoppers circulation, and generate higher inter-store externalities among tenants. The goal is to achieve the maximum rental values. In contrast to this hypothesis, the opposite concept should also stands,

H2: The higher the total floor levels, the smaller single floor area, and the more complex of pedestrian routes, retail tenants of the same type has to be located in departmentalization: so as to increase the vertical space usage efficiency. The goal is also to achieve the maximum rental values.

Measurement of retail concentration and floorspace complexity

In order to build the model for testing the above hypotheses, a few variables have to be introduced here. The first variable is the index measuring the degree of departmentalization of retail categories (A_{5ij}): measuring the departmentalization of retail categories (more then 3 units) clustering within 5 metres in each floor level:

$$A_{5ij} = \frac{\sum_i f_{ij}}{F_j} \qquad [6]$$

where

A_{5ij}: The index to measure the degree of same retail categories i agglomerate within 5 metres in floor j

f_{ij} : departmentalized floorspaces (5 metres) within floor j.

F_j ：Total floorspace for floor j

The second variable is the index measuring the degree of complexity of each floor plan. This measurement is constructed under the concept of InterConnection Density suggested by O'Neill(1991). However, in this paper we refined the index into a Space-Weighted InterConnection Density (SWICD), so as to measure the complexity under various scale of space weighted. The measurement is defined as:

$$SWICD_i = \left[\left(\frac{P_i \times D_i}{S_i}\right)\right]$$

Where, $SWICD_i$: is the space-weighted inter-connection density of floor *i; D_i*: is the total number of links in floor *i*; P_i: is the total decision points in floor *i; and S_i*: is the size of floor $_i$.

Other variables in the model are generated through the digitizing process of floor plans. And non-spatial data, such as name of retailers, retail categories were given to link with related spatial features. The basic model is a multi-regression model:

$$A_{5ij} = f(Totalev, SWICD, units)$$

Here, the expected direction for total floor levels (*Totalev*) is positive, which means the higher the total floor levels, the greater the degree of departmentalization. And for the variable "*SWICD*", it should be also the more complex of the floor plan, the higher the degree of departmentalization is needed. The last variable is "units", which represent the number of units within the floor. The concept is the more units within a retail floorspace, the higher the complexity, hence the degree of departmentalization should also be higher.

The data used in this empirical study was collected from 9 retail properties within US (2), Singapore (1), and Taiwan (6). And in the final dataset total 53 floor plans was established.

The results

The result of this empirical study is shown in Table 1. It is obvious that the variable "totalev" is strongly related to the degree of departmentalization. And the higher the total level the stronger the degree of departmentalization.

Table 1: multi-regression results of degree of departmentalization

$Y=A_{5ij}$	β	SE	p	VIF
α	0.182	0.141	0.2050	
Totalev	7.43E-02	0.016	0.0000***	2.366
SWICD	2.82E-03	0.002	0.0720*	1.425
Units	4.44E-04	0.000	0.0130**	2.528
R^2		0.401		
Adj R^2		0.364		
F test		10.929***		
Sample size		53		

Note: *:90% of significance, ** for 95% of significance, *** for 99% of significance

And the measurement of complexity also shows, although it has only 90% of significance, that the more complex the floor plan is the higher the degree of departmentalization. And finally, the variable "units" also supported this concept under the significance of 95%. The matching result to the hypotheses could also be seen from the only-way ANOVA.

Table 2: the ANOVA of Degree of departmentalization and total floor levels(break in 4^{th} level)

	Sum of squares	df	Mean square	F value	Pr>F
Model	3.0163	1	3.0163	63.8007	0.0000
Error	2.4584	52	0.0473		
Corrected Total	5.4748	53			

Table 3 Average degree of departmentalization on the 4 level (above and under)

Class	N	Average degree of departmentalization	Sd	SE	Means 95% range		Min	Max
					lower	upper		
Under 4 levels	8	0.1088	0.1052	0.0372	0.0208	0.1967	0.0000	0.2779
Above 4 levels	46	0.7740	0.2300	0.0339	0.7057	0.8424	0.0755	1.0000
Total	54	0.6755	0.3214	0.0437	0.5878	0.7632	0.0000	1.0000

In Table 2 and Table 3, it is confirmed that the difference for the average degree of departmentalization for the floor plans under and above 4 levels were significant. The average degree of departmentalization for the projects less than 4 levels is only 10.88%; while the number for projects above 4 levels is 77.40%.

V. conclusion

The development concept for a vertically-used multi-unit large-scale retail centre is fairly different from horizontal layouts. Principles developed from out-of-town centres are no longer suitable for vertical projects, either in pedestrian flow strategy or physical features. The three basic principles for shopping centres to generate maximum retail agglomeration economies are:

1. The floor plan configuration should allow maximum number of customers pass the maximum number of shops
2. Dumbbell shaped or its extension to I, L, Y, X, Z. Anchor stores at the mall ends and standard/smaller tenants along the single corridors that connecting the anchors.
3. Dispersion of non-anchor stores of the same type.

This research agrees that these principles are suitable for a planned shopping centre with no physical restriction in lot size and shape, low total floor levels and simple geometrical pedestrian flow. Nevertheless, the first principle is difficult to sustain, while the case with characterises of multi-level (more than 4 levels in total), high complexity of floor plans. The second principle also is not possible to stand under a vertical structured building. The anchors would not be a simple “in the ends” location, but have to find the locations for their original roles. That is to enhance the total spillover customer drawing power to other small tenants, but the locations for anchors may not be as simple as in the ends of main corridors anymore.

In this research, another major argument is focused on the third principle, namely the relationship between total floor levels and the space location for the retailers of the same type. Cater and Haloupek (2002) suggested that, under P-median problem, non-anchor retail stores of the same type should located in dispersion, so as to enjoy the minimized total distance from supply points to demand points. However, although agree with the dispersion concept in suburban shopping centres, we argue that the main reason for this dispersion is not for minimizing total distance but to enhance inter-store externalities of the whole centre.

It would be an opposite situation for the third principle. While a retail project has a vertical structure and the complexity for shoppers circulation is high, centre managers has to reduce this complexity by departmentalizing the stores of the same type to transform the floor plan into purposive zones. Hence the shoppers could identify the place without wayfinding difficulties.

This research further introduced the indexes for measuring the degree of departmentalization retail stores of the same type and the degree of complexity for floor plans. From the micro-spatial data collected from 9 cases of US, Taiwan, and Singapore with total 53 floor plans in detail. The empirical results show that the higher the total floor levels, the higher the degree of departmentalization. And for the floor with more complexity and more retail units, the degree of departmentalization is also higher. The critical number for total floor levels is 4 levels. And from the results of ANOVA, the difference of the degree of departmentalization between cases with above and under 4 levels is quite significant.

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