

## #34

### MOVEMENT DISTRIBUTION AND CLUSTERING OF TENANT TYPES IN THE MULTI-LEVEL COMMERCIAL COMPLEX

---

WANG HAOFENG

Shenzhen University; Shenzhen Key Lab for Optimizing Design of Built Environment, China  
whf@szu.edu.cn

ZHANG YUPENG

Shenzhen University; Shanghai Construction Design & Research Institute Co. Ltd. China  
zhangyupeng@scdri.com

RAO XIAOJUN

Shenzhen University; Shenzhen Key Lab for Optimizing Design of Built Environment, China  
raoxj@szu.edu.cn

---

#### ABSTRACT

With intensification of urban development in Chinese cities, mixed land use in urban centres extends vertically into 3-D and expands its scale from a single building to commercial clusters. The multi-level pedestrian system in urban centres also changed its role from one of traffic isolation to spatial integration, where transit nodes, street sidewalks, squares, building entrances, atriums, and corridors are interconnected both horizontally and vertically into a whole spatial system. As commercial facilities would like to take advantage of such spatial system to locate themselves for a better market competition, the question is, are there any relationships between socio-economic variables and spatial design characteristics of the multi-level shopping complex?

This paper applies space syntax and investigates the effects of spatial pattern on pedestrian movement and clustering of tenant types in the high-density Nanshan Commercial Cultural District (NCCD), a multi-level system consisting of a cluster of commercial buildings located in Shenzhen, China. The research findings points to the importance of interactions between syntactic variables and other spatial variables, in particular the interplay of local integration measure and location of escalators, which not only contributes to a powerful explanation on the movement distribution, but also has certain effects on the clustering and business performance of tenant types in the multi-level spatial system.

#### KEYWORDS

Multi-Level, Commercial Complex, Movement Distribution, Tenant Types, Spatial Pattern

#### 1. SPACE SYNTAX RESEARCH OF MULTI-LEVEL SPACE

Contemporary urban development in China is characterized by high density and mixed land-use. In big cities like Shenzhen, where density and mixed land use are highly intensified, commercial space not only extends vertically into multi-levels but also expands its scale from a single complex into cluster of buildings. Such cluster of commercial complexes is usually integrated with urban streets and public transport nodes, with elevated circulations linking them together into a huge multi-level spatial system which by itself functions as a centre or sub-centre of the

city (figure 1). As commercial facilities would like to take advantage of such spatial system to locate themselves for a better market competition, the question is, to what extent does the multi-level spatial structure of commercial building clusters influence distribution of movement flows and the clustering of commercial facilities?



Figure 1 - Shopping cluster formed by multiple commercial buildings.

Previous empirical studies of space syntax have established that the configuration of a spatial system influences different kinds of behaviours and cognitive processes in building and urban layouts. More specifically, movement flows tend to be more biased towards better accessible spaces measured in terms spatial integration (Hillier et al, 1993; Hillier 1996).

Chang and Penn (1998) applied the space syntax method to investigate a multi-level urban context of London. They found that, due to the unintelligibility of the multi-level space, pedestrian movement is less predictable from integration measures but strongly biased by other spatial design factors and their interactions, such as entrance location, height variation, main route, and vertical transitional space. They put forward research direction to unveil the significance of local urban design parameters in modelling the patterns of movement. Their analytical framework was extended into the study of a high-density vertical commercial complex in Hong Kong (Parvin et al, 2008). They developed an integrated model including both integration and other spatial parameters like metro stations, level variations, and the location and type of vertical transitions that are characteristic to the site, in order to account for the effects of urban design parameters observed in statistical analysis. This integrated model was elaborated further and used to evaluate the configuration of multi-level commercial complexes in Shanghai (Zhang et al, 2012). In recent years, there has been an increasing interest in the space syntax on multi-level systems (Ueno et al, 2009; Fujitani & Kishimoto, 2012), and a wider scope of reach (Kong & Kim, 2012; Ook et al, 2015; Penn, 2005).

Despite of the success of these studies, research on multi-level spaces is still limited to a few cases, and confined to individual buildings. Little is done about the effect of spatial patterns in the more complex multi-level settings in which commercial buildings are clustered and interwoven with the urban context as mentioned above. How spaces in this setting are configured is a crucial issue of urban design, not only for the reason that pedestrian flows can be guided with accessibility and legibility, but also for the reason that functional activities can be better arranged.

This study attempts to investigate these issues through a characteristic case study of Nanshan

Commercial Cultural District (NCCD) in Shenzhen, China. The study is an extension of a pilot research, conducted in conjunction with Space Syntax Ltd. in May 2013 and reported partly in Yin et al (2016). We hypothesize that the interactions between syntactic variables and other design parameters would not only contribute to more robustly address the patterns of movement, but also have an effect on the clustering and performance of shopping facilities in the multi-level commercial space.

## 2. THE STUDY AREA

NCCD is located in the west of the main city of metropolitan Shenzhen. Developed rather recently in 2002, NCCD has now become a major urban centre of the metropolitan area, and consists of four buildings: Coastal City, Baoli Culture Square, Tianli, and Hai'an Mansion. The former two buildings are shopping complexes, and the latter ones are a mixture of shops in podia with offices and hotels in high-rise towers. Figure 2 shows the location of these buildings.

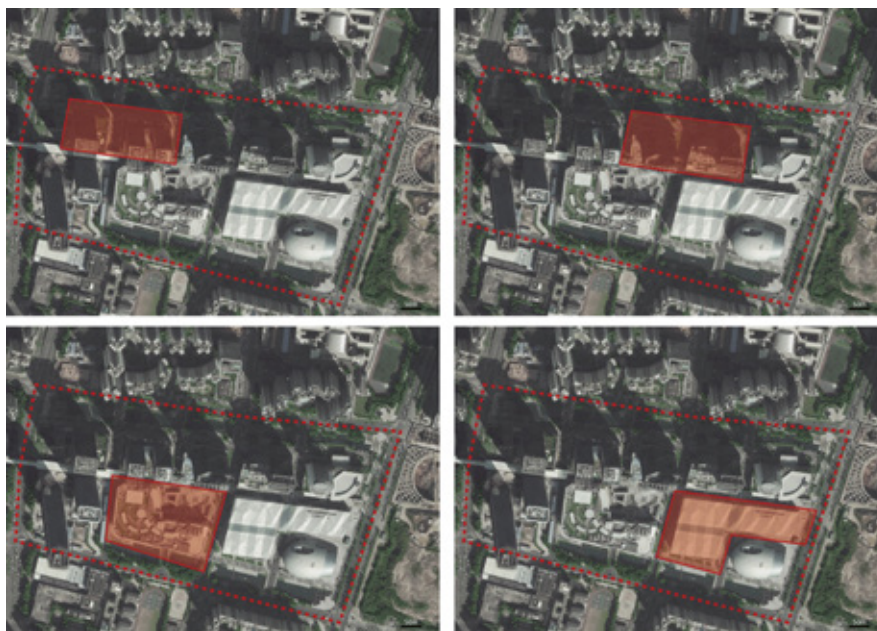


Figure 2 - The site of study area, showing locations of the four commercial complexes from bottom left in clockwise: Coastal City, TianLi, Hai'an Mansion and BaoLi.

The street pattern of the site is characterized by a small grid size, contrary to the super grid structure surrounding the site. In order to accommodate large retail complexes and separate vehicles from pedestrians, a huge elevated platform is created along the central axis of the area, running from east and west. Vertical connectors such as escalators, staircases and lifts, are deployed in multiple locations linking the elevated platform with its surrounding streets. The whole spatial system has 98 escalators and 47 lifts, which are distributed rather evenly across building interiors and exteriors to facilitate vertical transitions between levels (figure 3). In comparison, the number of staircases is much lower. They are predominately used for evacuation purposes, and thus recede from the main circulation areas of building interiors.

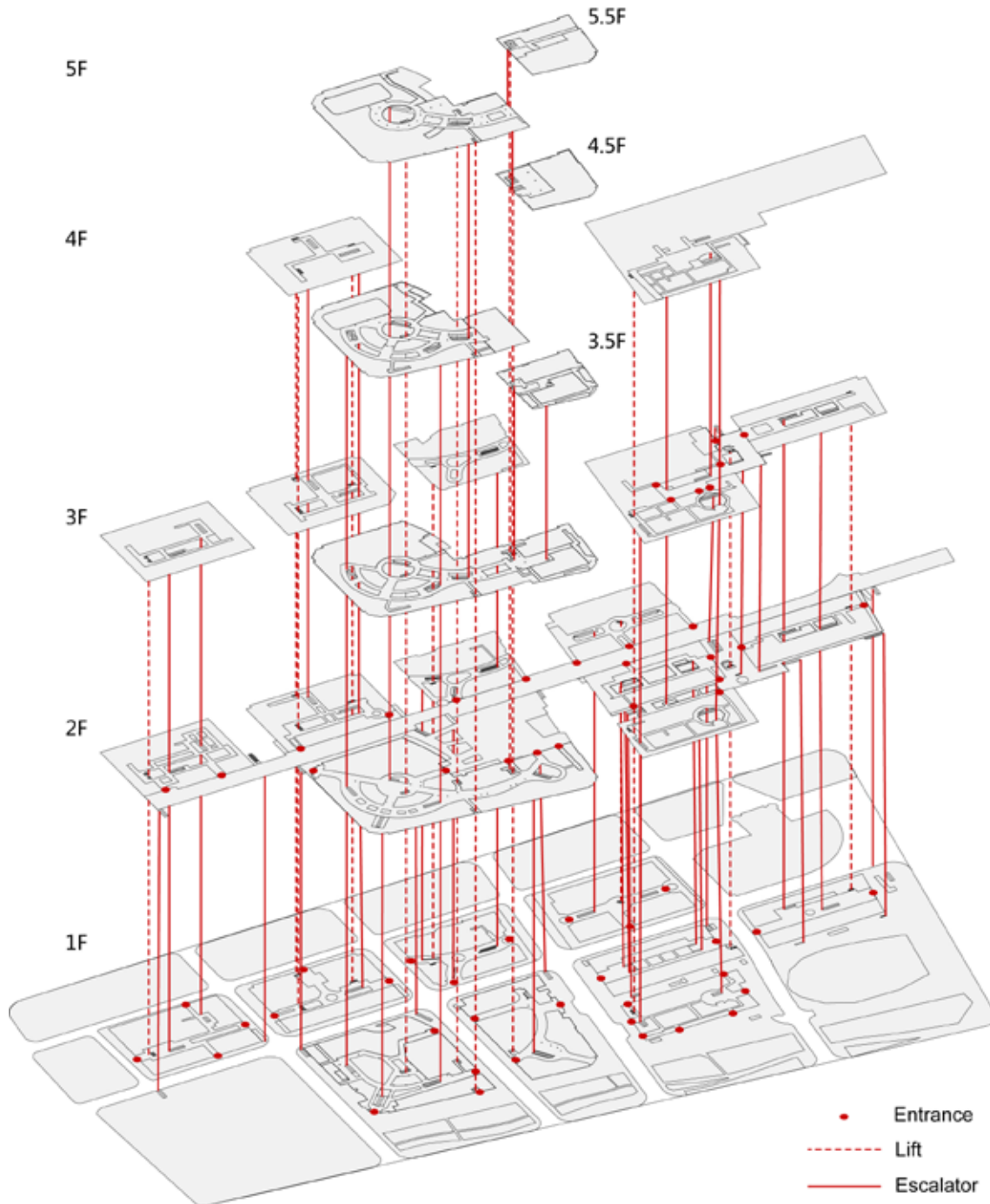


Figure 3 - Locations of vertical transitions and entrances in the study area

All the 4 commercial buildings are designed in a similar layout fashion to that of shopping malls, with one or more spacious atriums, double-to-quadruple-height circulation spaces, and wide corridors formed into various shapes from case to case. Although varied in size and commercial marketing strategy, all the commercial buildings have a rich tenant mix. The multi-level spatial complex with its highly mixed commercial facilities offers rich experiences of shopping, and brings with it the reputation as the most popular commercial area of the city of Shenzhen with annually increasing number of shoppers and rising rental prices.

### 3. METHODS

The study applies the axial model to analyse the spatial configuration of NCCD. Axial lines of individual floors are linked together at locations of vertical transition (figure 4). Staircases are modelled according to the number of flights in an individual staircase in order to simulate the actual number of directional turns involved in movement. Lifts, which are usually across multiple levels, are represented by one single axial line, and thus height change between any floor levels is counted as one syntactic depth.

Movement data of the shopping area were collected on a sunny weekend in April, using the "gate count" method. There are 134 gates surveyed, of which 114 are located in building interiors and 20 in exteriors. Each of these gates was surveyed 5 times and 5 minutes per session, from 10:30am to 6:30pm. Figure 5 shows the average rates of movement flow passing through each gate presented in terms of adults per hour.

Tenant mix is used as an indicator of commercial market segmentation. In this study, shops are categorized into 8 types: retail store, catering, costume, jewellery, educational service, cosmetic, electrical appliance, and entertainment. Locations of each type of shops were determined by on-site investigation. Tenant mix is measured in terms of the percentage of each type of shop occupying the total rentable floor area of a commercial building. Business performance of shops is evaluated based their rental prices and vacancy rates. It is well known that rents and sales records are notoriously difficult to obtain. Although we are unable to get actual lease prices for individual shops or shop categories, we could finally obtain a quarterly average rent and shop vacancy rate for individual shopping complexes, as offered by a local real-estate agency. The rent data were derived from the agency's monthly reports between 2012 and 2014, and we double-checked them by a consulting with the managerial department of each shopping complex. In spite of imperfections, these data allow a qualitative evaluation for the performance of individual building, and will be presented in the analytical sections accordingly.



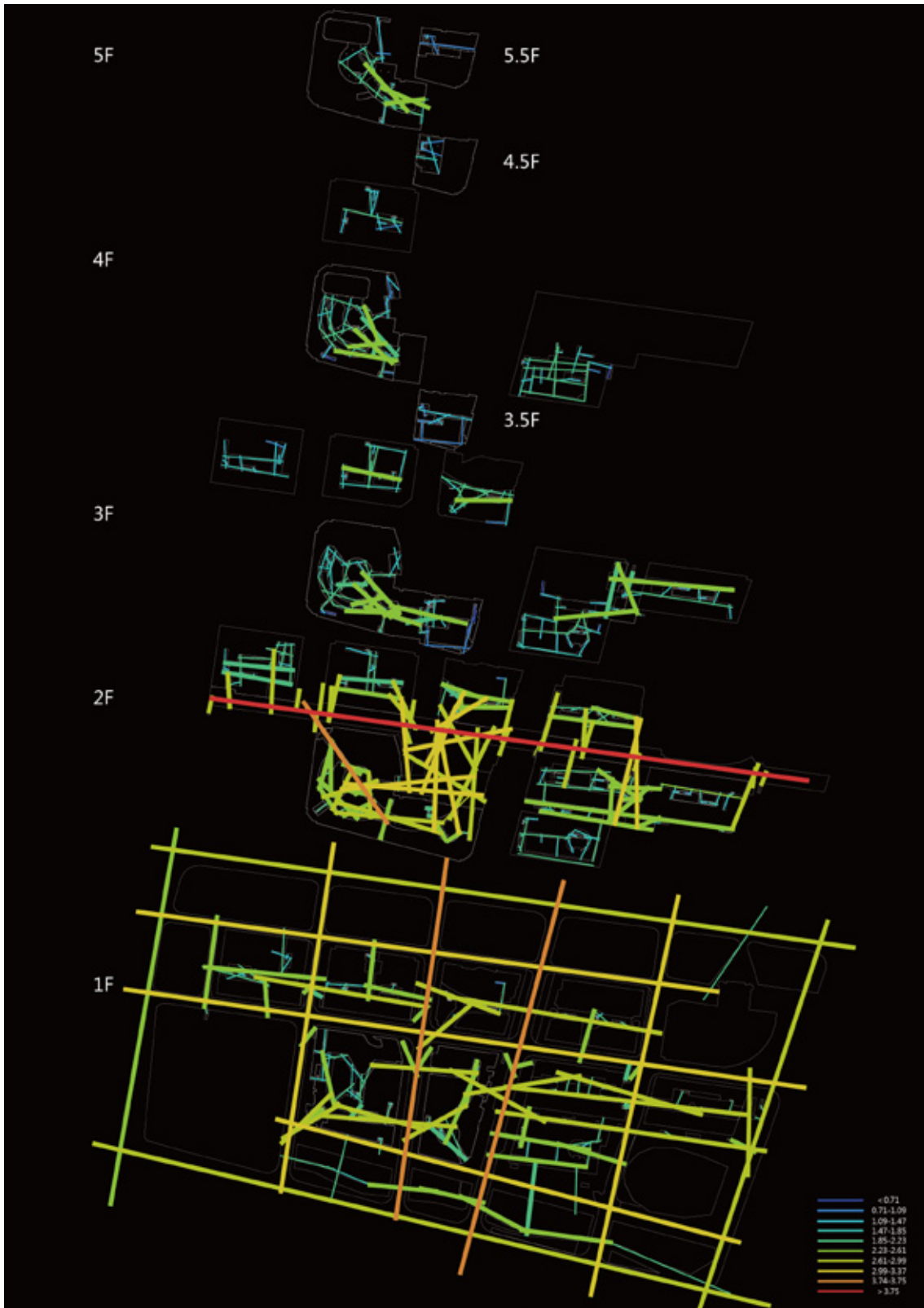


Figure 4 - R3 integration analysis of the multi-level commercial system, with bolding lines showing the top 30% integrated spaces.

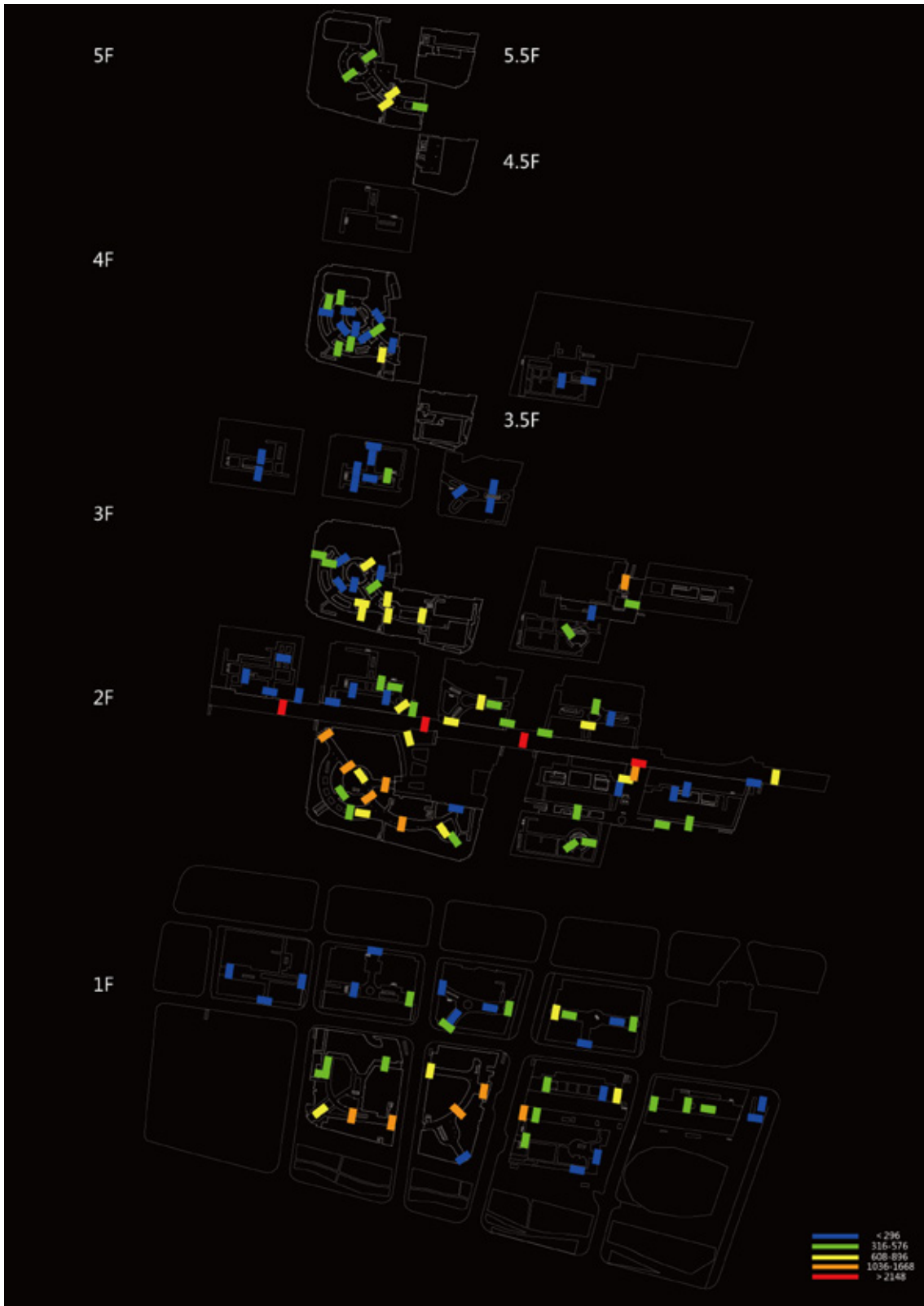


Figure 5 - Location and density of observed pedestrian flows in the study area.

## 4. MODELING MOVEMENT DISTRIBUTION

### 4.1 INDEPENDENT SPATIAL VARIABLES

The previous reach of space syntax suggests that pedestrian flows in the multi-level spatial system are highly biased by a number of local spatial parameters such as functional attractors, vertical transitions, level variations and entrances (Chang & Penn, 1998; Parvin et al, 2008; Zhang et al, 2012). Effects of those local spatial parameters are accounted by measuring the step depth away from these spatial parameters. The following summarizes all the independent variables adopted in the study.

### 4.2 SYNTACTIC VARIABLES: CONNECTIVITY, R<sub>3</sub> AND R<sub>N</sub> INTEGRATIONS.

Vertical transition variables: including 2 variables, step depth from escalators (SDE) and from lifts (SDL), which measure the distance from a space to its nearest vertical transition.

Functional attractor variables: measuring the step depth from the nearest major functional attractors (SDFA) in NCCD, including the supermarket (JUSCO) located on the underground floor of Coastal City and the KTV and cinema on the upper floors of Baoli and Coastal City. A parallel dummy variable (0 for “no attractor” and 1 for “with an attractor”) is created with respect to these functional attractors (DFA) in order to determine which description would better capture their influence on movement.

Level variation variables: accounted by 2 factors, step depth from the elevated platform (SDP), and level (L) measured in floor numbers.

### 4.3 PRELIMINARY BIVARIATE CORRELATIONS

Preliminary linear regressions between the density of movement flows and each independent variable are provided in table 1. Syntactic variables produce moderate to relatively strong correlations with the square root of movement, and their coefficients are all significant. The strongest correlation is given by R<sub>3</sub> integration, with an R<sup>2</sup> = 0.49, indicating that nearly half of movement variations in the shopping area can be explained by this single variable. Following are measures of Connectivity and R<sub>n</sub> integration, which display moderate strong correlations with movement density.

In contrast, correlations of local spatial variables are rather weak and thus less influential on movement patterns. They are all negatively correlated with the dependent variable. However, only three out of five are significant: step depth from the elevated platform, step depth from functional attractors, and step depth from escalators. Only one of these, step depth from the elevated platform, accounts for more than 10% of the movement variation. Other variables, such as step depth from lifts and level changes, are not only insignificant but also so weak as to be negligible.

The bivariate correlation analysis of the present study shows R<sub>3</sub> integration is the strongest singular variable influencing movement patterns in the multi-level spatial system of NCCD. This finding is similar to the result of the pilot study examining Coastal City only in 2013 (Yin et al, 2016). In spite of the much-expanded study area and the more complicated spatial model involved, strong correlation with movement distribution stays with the same syntactic variable and the strength of its correlation remains almost at the same level. We consider this as a proof of the consistency and validity of the reach methods used in these studies.



	Connectivity	R <sub>3</sub> Integration	R <sub>n</sub> Integration	SDP	SDE	SDL	SDFA	L
R <sup>2</sup>	0.415	0.493	0.305	-0.166	-0.028	-0.002	-0.091	-0.008
Sig.	0.000	0.000	0.000	0.000	0.027	0.308	0.000	0.160

Table 1 - Bivariate correlation coefficients of movement flows (in square root) and spatial variables.

#### 4.4 MULTIVARIATE CORRELATION ANALYSIS

Since one purpose of the present study is to examine how the dependent variable is influenced by interactions of independent variables, we apply a sequential regression method rather than a normal "step-wise" multivariate regression analysis. In short, the independent variables are grouped into 3 blocks: The first block includes functional attractor variables and level variation variables; the second block includes vertical transition variables; the last block includes syntactic variables of connectivity, R<sub>3</sub> and R<sub>n</sub> integrations. Each block of variables is added step-wise into the multiple regression analyses in order to foreground any model variations.

Table 2 summarizes the statistical results of the multiple regressions mentioned above. When only those variables in the first block are considered, the multivariate regression suggests two variables are significant: step depth from the elevated platform and functional attractors as a dummy variable. They together explain about 23% of the variation in movement flows. Adding vertical transition variables in the second block into the model results no change at all. This indicates that there is almost no interaction between these variables that can contribute to the variation in movement flows. However, when syntactic variables are then added into the model, we observe strong multiplicities of syntactic variables and other independent variables, of which connectivity (in square root) and R<sub>3</sub> integration, in conjunction with SDE, DFA and SDF, results in a correlation coefficient (R<sup>2</sup>) of 0.64. In other words, nearly two-thirds of the variation in commercial flows can be explained by the independent variables used in this study.

Sqrt Movement	Block 1 Variables				+ Block 2 Variables				+ Block 3 Variables			
	B	T	Std B	VIF	B	T	Std B	VIF	B	T	Std B	VIF
DFA	10.667	3.690	0.281	1.007	10.667	3.690	0.281	1.007	9.205	4.453	0.243	1.102
SDFA	-	-	-	-	-	-	-	-	-	-	-	-
L	-	-	-	-	-	-	-	-	-	-	-	-
SDP	-1.949	-5.039	-0.384	1.007	-1.949	-5.039	-0.384	1.007	-	-	-	-
SDE	-	-	-	-	-	-	-	-	-2.874	-3.946	0.211	1.066
SDL	-	-	-	-	-	-	-	-	2.049	3.335	0.185	1.146
Sqrt Connectivity	-	-	-	-	-	-	-	-	4.317	3.976	0.342	2.753
R <sub>3</sub> Integration	-	-	-	-	-	-	-	-	9.557	5.586	0.472	2.648
R <sub>n</sub> Integration	-	-	-	-	-	-	-	-	-	-	-	-
N = 134												
R <sup>2</sup>	0.245	0.245	0.655									
R <sup>2</sup> adjusted	0.233	0.233	0.642									
DW statistics	1.348	1.348	1.894									

Note: all presented coefficients are significant at P < 0.01.

Table 2 - Effect tests for multivariate regressions estimating square root movement flows.

As expected, given the results of bivariate analysis, the  $R_3$  integration has the strongest impact on the movement distribution (Std. Beta 0.472), followed by connectivity (in square root, Std. Beta 0.342). Higher volume of movement density is associated with a space that offers not only better accessibility within a larger spatial environment, but also more immediate neighbours. In the third place, the presence of functional attractors (as a dummy variable) is associated with higher movement distribution in the multi-level shopping complex. The remaining two significant factors are related to the vertical transitions: SDE and SDF, with Std. Beta values of 0.211 and 0.185, respectively. The result of the model indicates a negative relationship between step depth from escalators and movement distribution. However, what is slightly unexpected is the positive sign of correlation given by lifts. In the final regression model, Variable Inflation Factors (VIFs) are in all cases no more than 2.8, indicating there is no prohibitive degree of collinearity between those independent variables.

The results of the multivariate regression models highlight the importance of studying the interaction of various spatial variables when seeking to explain movement distribution in high-density multi-level commercial space. A few points can be drawn from the analyses. First, the syntactic properties of spatial configuration, namely, accessibility within a few step depths from a space, and the number of other spaces directly linked to that space, have the highest predictive power of movement distribution in the multi-level spatial system. Second, a multiplicity of syntactic variables and some other spatial parameters together contribute to a more robust address of the distribution of movement flows. Particularly noteworthy is the interaction between  $R_3$  integration and step depth from escalators, as these two variables explain 55% of the variation of the dependent variable, which is noticeably larger than that of any of the other variables. This result points to the importance of considering the escalator as a more important vertical transitional space than the lift or the staircase in a multi-level shopping system. In the design of modern commercial buildings, the escalator has been increasingly used as the major device to transport commercial flows between lower and upper floors. The large quantity of escalators presented in the study area is apparently in accordance with this practice.

On the other hand, step depth from lifts, when examined in conjunction with syntactic variables, acquires a relevance that was not observed either in the bivariate correlations or in the multivariate analysis that takes into consideration only those variables in the first block. We suggest that the lift is a moderating factor that exerts an impact on movement patterns indirectly, by intervening in the relationship between syntactic variables and movement flows. We estimate this is the case for a few reasons. Waiting is perhaps a major reason prohibiting lifts from becoming important attractors to movement, especially during rush hours. Actually, lifts in the shopping complex are used as a complementary vertical connector, and thus usually are located in the gap spaces between escalators in order to facilitate a faster connection across more than 2 level changes. In the study area, a significant number of lifts are located on less integrated spaces or are hidden from the main circulations of building interiors, due to the building regulation that requires a buffer area or independent lobby associated with lifts for evacuation purposes. It is also perhaps because of these reasons that the correlation sign of lifts, when studied in conjunction with other independent variables, is inverted to positive, which is contrary to the priori expectation.

Functional attractors are found to be significant as dummy variables instead of as continuous variables, measured in syntactic depth from them. This seems to indicate that when taken as a whole, the presence of functional attractors has no apparent radiation effect on the distribution of commercial flows, partly because these attractors are not well integrated with other spaces in the system. Intuition suggests this may be the case. For example, the supermarket located on the underground floor of Coastal City, the KTV on the 3rd floor and the cinema on the 4th floor of Baoli, are rather isolated from other spaces with limited access directed to them. Moreover, when  $R_3$  integration is introduced into the multivariate regression, step depth from the elevated platform, the principal integrator of the whole spatial system, is no longer a significant predictor of the dependent variable. This is mainly because the elevated platform is well structured with the surrounding urban context and building interiors, and a description of the syntactic structure of the overall spatial system is already a description of the relationship

with respect to the platform. Finally, level variation measured in floor height is not significant in all cases of bivariate and multivariate regressions. This result is in contrast to some previous research (Parvin et al, 2008; Zhang et al, 2012). We suggest this is due to the case difference between these studies. The multi-level spatial system presented in this study consists of a cluster of 4 shopping buildings organized in the fashion of an urban space itself, instead of as an individual building with limited access from urban space. What can be inferred from the present study is that, for a complicated multi-level spatial system like NCCD, the integration of streets and building interiors, the strategic distribution of vertical connectors, and the presence of functional attractors can overpower the barrier of floor change and effectively direct commercial flows onto upper floor levels.

## 5. CLUSTERING OF TENANT TYPES

The next question we ask is whether the impact of those spatial variables on movement distribution can also be related to the clustering and performance of shopping facilities operated in different business modes in the multi-level commercial system. We examine this by starting with a review of the business performance of shops. The business performance is evaluated at the aggregated building level in terms of rent and vacancy rate. Coastal City and Hai'an Mansion have the highest rent and the lowest vacancy rate, followed by Tianli with a medium level of rent and vacancy rate. Baoli, on the other hand, presents an almost inverted example to the former two buildings, and performs as the worst case by having the lowest rent and the highest vacancy rate.

The sharply varied commercial performance among these shopping complexes cannot be simply explained their available space. For example, Baoli and Tianli have a noticeably larger floor area than Han'an Mansion, but their advantage in size apparently has not been turned into business success. Moreover, although Baoli and Tianli are comparable in size, they perform quite differently in terms of shop rent. The study suggests the performing difference in the retail market could be explained by examining the movement influencing factors, in conjunction with the clustering patterns of shops presented in each individual building. We first investigate the integration structure of the multi-level spatial system, and its relationship to the vertical transitions and entrances with respect to each commercial complex, given the observation that the interaction between these variables contributes to a more robust address of the distribution of movement flows.

We define the axial lines whose  $R_3$  integration values lie within the top 30% in terms of the total number of lines as the "core structure" of the multi-level spatial system. We ask how many vertical transitions such as escalators and lifts, and entrances are directly linked to this core structure. The results are presented in table 3, along with the average syntactic values for each individual commercial complex. Coastal City and Hai'an Mansion, which have a better performance in the retail market, outperform Tianli and Baoli in every aspect of the syntactic properties, especially for  $R_3$  integration (above 4.62 vs. below 3.68), connectivity (above 1.87 vs. below 1.76), and intelligibility (above 0.30 vs. below 0.16) measures. The core structure of  $R_3$  integration covers a more extensive area in Coastal City and Hai'an Mansion in the form of continuous loops, which is particularly prominent on the first and second floors. It is noted that Coastal City is the only building in which the core structure spreads vertically up to the fourth floor and above. Moreover, more than 85% of the escalators in Coastal City and Hai'an Mansion are linked directly to the core integration structure, whereas the percentage of core-linked escalators at Tianli and Baoli is less than half of the former. The difference in strategic locations of entrances between these buildings is also pronounced, although to a lesser degree.

	The System	CC	BL	HAM	TL
Connectivity	4.31	4.62	3.58	4.85	3.68
R <sub>3</sub> Integration	1.92	1.87	1.75	2.10	1.76
R <sub>n</sub> Integration	1.11	1.06	1.02	1.20	1.06
Intelligibility	0.22	0.38	0.12	0.30	0.16
Escalator	0.71	0.85	0.41	0.86	0.38
Lift	0.53	0.48	0.58	0.60	0.40
Entrance	0.83	1.00	0.65	1.00	0.91

Table 3 - Syntactic properties of individual commercial building, and the percentages of their vertical transitional spaces and entrances located on the core structure.

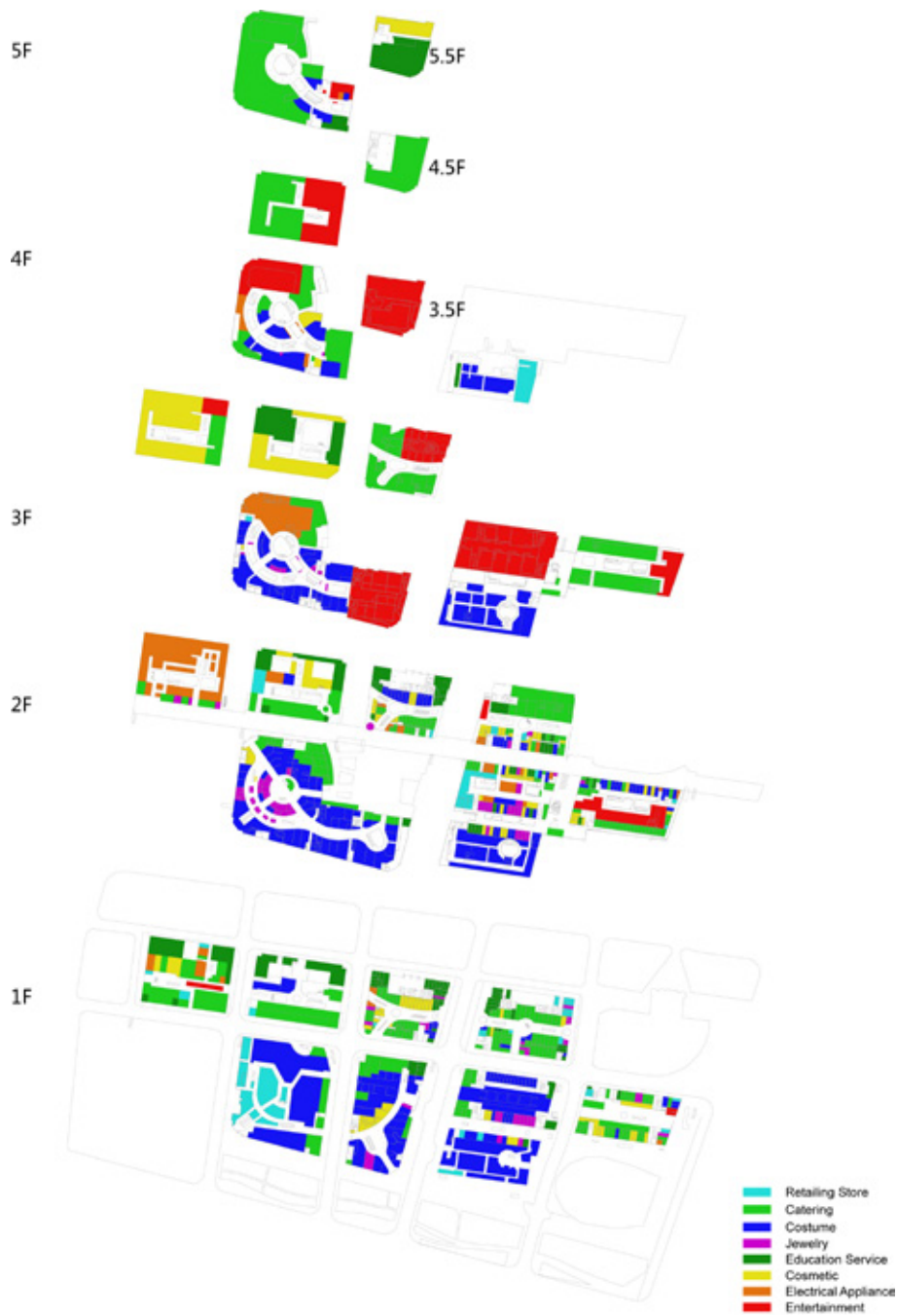


Figure 6 - Distribution of the 8 tenant types of shop in the spatial system.

These results indicate that Coastal City and Hai'an Mansion are better embedded into the overall spatial system. These complexes support higher connectivity of space at both local and global levels, and are organized in a more intelligible way; their more expansive core structures are associated with legible orientation to vertical transitions and entrances, either by access or by eyesight. It is concluded that a stronger interaction between syntactic properties and other spatial parameters creates an interface upon which pedestrian flows are guided to the core structure and directed to various floor levels, such that the commercial space is effectively presented and commercial flows are balanced.

We then examine the clustering patterns of shops in each building, based on 8 the tenant types of shop: retail store, catering, costume, jewellery, educational service, cosmetic, electrical appliance, and entertainment. In a broad sense, the former 4 types can be roughly characterized as non-purposeful shopping, and the latter 4 types as thematic or purposeful shopping (Applebaum, 1968). An important difference between them is that the former is more spatially dependent on accessibility and tends to convert passing commercial flows into potential shoppers, while the latter is more goal-oriented and less dependent on location.

The four shopping buildings display both similarity and difference in terms of tenant mix, measured in square meters of each category of rentable space. In Coastal City and Baoli, tenant mix is dominated by costume, catering and entertainment, and they together take up about 80% of total rentable area. Hai'an Mansion is dominated by catering, education service and entertainment, of which catering alone occupies more than half of total area. Tianli appears to have a more even composition of tenant mix, with its primary functions of catering, cosmetic and education services taking up about 72% of total rentable space. When the 8 shop types are aggregated into larger categories defined as "purposeful" and "non-purposeful" shopping, we see a clearer picture of tenant mix among these buildings. For all buildings except Tianli, the proportion of non-purposeful retailing shops is about two-thirds of the total rentable area, while it is only slightly more than one-third in Tianli.

In terms of spatial pattern, large shops of retailing store (supermarket), electrical appliance, entertainment and high-end restaurant are in all cases located either on upper levels (3rd floor and above) or at a far end of building interior. Small shops are likely to locate themselves on the ground and second floors, and they become more intensified and diversified along the large elevated platform. There is an obvious increase in shop size when moving to the upper floors. When compared with the syntactic structure of the spatial system, catering, costume, jewellery and retail stores in general tend to be more closely related to the core structure of R<sub>3</sub> integration, with their shops directly opened to that structure. On the other hand, education services, cosmetics, electrical appliances and entertainment appear to be distributed slightly more distantly from the core structure, although they are no more than 1 or 2 step depths from it (figure 6).

In order to further highlight the spatial pattern of variation among those shop clusters, we compute the integration value of each commercial type in the tenant mix of individual buildings. Each shop is assigned to the R<sub>3</sub> integration value of the axial line to which it is attached, and this value is weighted by the percentage of square meters that a shop takes up in a commercial category. When summing up the weighted values of all shops within a category, we obtain the commercial type integration measure for each individual building. With the assistance of numerical values, a finer scale of variations can be observed in the spatial patterns of shop clustering. Coastal City and Baoli, while sharing a similar configuration of tenant mix, have rather different internal structures. The former is spatially dominated by non-purposeful shopping facilities, in the sense that jewellery, costume, retail and catering occupy more accessible spaces; the latter gives its advantaged spaces to goal-oriented shopping such as cosmetics, educational services and electrical appliances. Tianli, with a tenant mix focusing on purposeful aspects of shopping, has a similar spatial pattern of distributing commercial types to that of Coastal City. Hai'an Mansion, on the other hand, has a less differentiated structure, with spatial accessibility being allocated to each category of shops in a relatively even manner.



	Store	Catering	Costume	Jewellery	Education	Cosmetic	Electrical	Entertainment
CC	2.15	2.05	2.49	2.50	1.35	1.82	1.87	1.49
BL	1.92	2.60	2.11	2.83	2.81	2.84	2.66	1.77
HAM	2.82	2.64	2.87	3.01	2.84	2.78	2.95	1.92
TL	2.65	2.18	2.05	3.51	2.29	1.86	2.03	1.47

Table 4 - Weighted average R<sub>3</sub> integration values for the tenant mix in each shopping complex

When space, size, tenant mix and business performance are considered together, their relationship in individual shopping complexes can be diagrammed by a matrix shown in figure 7. The horizontal axis represents accessibility measured by spatial variables and their interactions, and the vertical axis displays commercial performance evaluated with rent and vacancy rate of shops at the aggregated building level. In short, better business performance seems to be associated not only with buildings that have better spatial accessibility, but also with the degree to which the pattern of tenant mix in a shopping complex is aligned with movement flows drawn by that accessibility. When a positive relationship of spatial configuration and tenant mix is presented in a building, such as in Coastal City and Hai'an Mansion, an enhanced business performance can be observed. When such a relationship is absent or becomes negative, as in the case of Baoli, a decreased level of performance is also observed. It should be noted that the present study does not relate the business performance of a shopping complex to its size or market strategy of tenant mix. It does not mean these are not important factors influencing the performance of shopping; instead, because a discussion of their effects is beyond the scope of this study, these should be addressed by additional research.

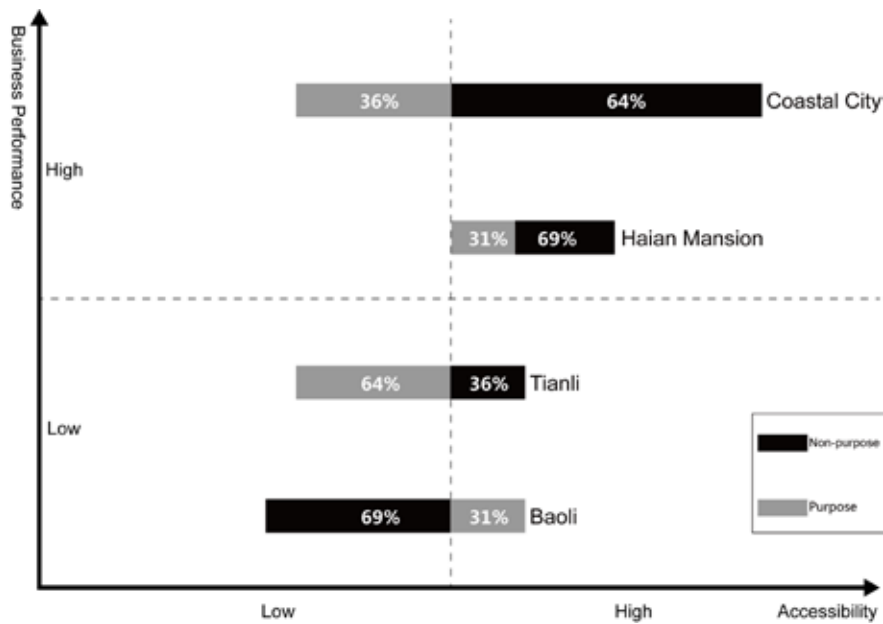


Figure 7 - Relationship between spatial accessibility, tenant mix and business performance at the aggregated building level.

## 6. CONCLUSIONS

The study investigates the effects of spatial patterns on pedestrian movement and clustering of tenant types in the multi-level commercial system that consists of a cluster of buildings in a high-density urban context. The key objective is to better understand the interactions between the socio-economic variables and spatial design parameters of shopping complexes. Although the study reveals that the patterns of pedestrian flow are in the main influenced by the syntactic properties of space, it also points to the importance of interactions between the

syntactic variables and other spatial variables in shaping the pedestrian flows and the clustering of tenant types in the highly complex commercial system.

Nearly two-thirds of the variation in commercial flows distributed in the shopping area can be explained by the interaction of spatial variables. Among these spatial variables, the syntactic variables, namely, accessibility within a few step depths from a space, and the number of other spaces directly linked to that space, have the highest predictive power of movement distribution. A multiplicity of syntactic variables and other local design parameters together contribute to a more robust address of the distribution of movement flows. Particularly noteworthy is the interplay of R<sub>3</sub> integration and location of escalators, which explains 55% of the variation of the dependent variable and has a noticeably stronger effect than that of any of the other variables.

The empirical results lend some supports to the classic shopping mall design principles, i.e., the importance of considering the locations of particular spaces such as functional attractors and vertical connectors when designing the circulation system. On the other hand, however, it is the ways that the local spatial parameters are spatially organized, rather than those parameters per se, are highly important in structuring commercial flow distribution in the multi-level spatial environment. Whether those functional attractors can create artificial pedestrian flows depends on whether they are well integrated with the overall spatial system. Moreover, the integration of space and certain local design parameters such as vertical connectors can somehow counterbalance the floor variations and effectively direct commercial flows onto upper floor levels.

The study also suggests the importance of considering the ways individual commercial buildings are embedded in the overall multi-level system. As indicated by the research findings, an integration of building interiors and urban context, with an alignment of local design parameters, is more likely to result in a shopping interface within which positive interactions between spaces, movements and functions can be activated and developed. These provide useful implications for the strategic design decision to create the vertically effective mixed land use in high-density built environments.

## ACKNOWLEDGEMENT

This research is supported by Graduate Independent Innovation Project (No. 000022070154) of Shenzhen University, and National Natural Science Foundation of China (NSFC, No. 51178269).

## REFERENCES

- Applebaum W. (1968), Guide to Store Location Research with Emphasis on Super Markets, Super Market Institute, Inc. Addison-Wesley, Reading, MA.
- Chang D., Penn P. (1998), Integrated multilevel circulation in dense urban areas: the effect of multiple interacting constraints on the use of complex urban areas, *Environment and Planning B: Planning and Design*, 25: p507–538.
- Fujitani M., Kishimoto T. (2012), A Study about the Pedestrian Distribution in the Commercial Buildings by the Location of Stores and the Structure of the Walking Space. *Proceeding of the 8th International Space Syntax Symposium, Santiago Chile.*
- Hillier B. (1996), *Space is the Machine: a Configurational theory of Architecture*, Cambridge University Press.
- Hillier B., Penn A., Hanson J., Grajewski Z., Xu J. (1993), Natural movement: or, configuration and attraction in urban pedestrian movement, *Environment and Planning B: Planning and Design*, 20: p29-66.
- Kong E.M, Kim Y.O. (2013), Examination of Spatial Characteristics influencing Sales by Tenant Types in Shopping Malls. *Proceeding of the 9th International Space Syntax Symposium, Seoul.*
- Ook Y, Chung J. H, Kong E.M, Shin H., Heo J. (2015), A study on the design methodologies for activating large-scale underground commercial complexes. *Proceeding of the 10th International Space Syntax Symposium, London.*
- Parvin A., Ye A., Jia B. (2008), Effect of visibility on multilevel movement: a study of the high density compact built environment in Hong Kong, *Urban Design International*, Vol.13, pp.169-181.
- Penn, A. (2005), The complexity of the elementary interface: shopping space, *Proceedings of the 5th International Space Syntax Symposium, TU Delft, Netherlands.*
- Ueno J., Nakazawa A., Kishimoto T. (2009), An Analysis of Pedestrian Movement in Multilevel Complex by Space Syntax Theory-In the Case of Shibuya Station. *Proceeding of the 7th International Space Syntax Symposium, Stockholm.*
- Yin Z. Y., Wang H. F., Fu M. L. (2016), A study on cognitive intersections in commercial complexes – a case study of coastal mall in Shenzhen, *Architectural Journal (in Chinese)* 569 (2): 52-55.
- Zhang, L. Z., Zhuang, Y., Dai X. L. (2012), A configurational study of pedestrian flows in multi-level commercial space: Case study Shanghai. *Proceedings of the 8th International Space Syntax Symposium, Santiago Chile.*