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The Spatial Performance of Multi-Level Shopping Clusters A Case Study of Nanshan Commercial Cultural District

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Abstract

With the intensification of urban development in Chinese cities, mixed land use in urban centers extends vertically into 3-D and expands its scale from a single building to commercial clusters. The multi-level pedestrian system in city centers 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, within which pedestrian flows are guided and shopping facilities are arranged. This paper uses spatial configuration analysis of space syntax to examine the impacts of spatial patterns on movement distribution and the business performance of tenant mix in the multi-level commercial system of the Nanshan Commercial Cultural District in Shenzhen, China. The key objective is to better understand the interactions between the socio-economic variables and spatial design parameters of a shopping complex. The research findings point to the importance of multiplicity between syntactic variables and other spatial variables in influencing the pedestrian flows, business performance and tenant mix in highly complex commercial systems. Particularly noteworthy is the relationship between spatial accessibility measures and the location of escalators, and the ways in which individual commercial buildings are embedded into the overall spatial system. The study suggests that this may lead to the preliminary identification of the spatial qualities of effective vertical extensions of mixed land use in a high-density urban settings.

Keywords: Multi-Level, Commercial complex, Movement, Tenant mix, Spatial pattern

1. Introduction

Contemporary urban development in China is characterized by high density and mixed land-use. In big cities like Shenzhen, Beijing and Shanghai, high land values drive the design of commercial buildings toward the configuration of a multi-level spatial complex, with the podium devoted to retail activities and the high-rise tower to office, hotel or apartments, not only for the purpose of maximizing floor area ratio (FAR), but also for fine-tuning tenant mix on the supply side for a competing market. These mixed-use complexes usually have large circulation areas, including multi-level entrances and complicated vertical transitions between floor levels. In urban centers where shopping demand is very high, intensified mixed land use extends not only into 3-D, but also expands its scale from single buildings to commercial clusters (Fig. 1).

Early multi-level pedestrian systems often used footbridges as overpasses of traffic-congested streets. With increasing investment in commercial complexes, the multi-level system in urban centers has also changed its role from isolating pedestrians and traffic to organizing

spaces and functions for retailing and public activities. Transit nodes, street sidewalks, footbridges, platforms, squares, building entrances, atriums, and corridors are interconnected, both horizontally and vertically, into a continuous system defined as “multi-level commercial space”, upon which pedestrian flows are guided and a variety of commercial facilities are interfaced.

The complexity of multi-level commercial space makes it hard for users to understand its spatial structure intuitively. It is also difficult for designers to evaluate the spatial layout of their design for the purpose of achieving a balanced configuration of accessibility and functional arrangement. These difficulties are even more pronounced in the highly-intensified commercial areas where shopping complexes concentrate into clusters. It is not only individual buildings, but their inter-relationship that matters. Each building functions both as an attractor and as a distributor of commercial flows to neighboring buildings. Such interdependency creates opportunities, of which commercial facilities may take advantage to develop their competitive positions.

However, little is known about the strategic architectural decisions that result in particular spatial patterns of such high-density multi-level spaces; these patterns may have social and economic consequences. In this study, we apply space syntax methods and investigate the effect of

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Figure 1. Shopping cluster formed by multiple commercial buildings.

spatial layout organization in the multi-level commercial space that is formed by a cluster of buildings in Shenzhen, China. The study extends from a pilot research project conducted in conjunction with Space Syntax Ltd. in May 2013, which was reported in Yin et al. (2016). In the present study, we expand the scope of research, not only to a larger urban context integrated with multiple commercial complexes, but also to wider questions. Rather than asking whether syntactic variables have a significant impact on the distribution of movement flows, we ask whether the interactions between syntactic variables and other design parameters would contribute to more robustly addressing the patterns of movement, and whether the configuration of these parameters can be related to business patterns of shopping.

2. Space Syntax Research of Multi-level Commercial Space

Space syntax is a set of computer-based techniques for the modeling and analysis of building and urban layouts as systems of spatial relations. Underpinning the method is a theory about the configuration of built space as an interface of social co-presence, awareness and movement (Hillier & Hanson, 1984; Hillier 1989). Previous empirical studies of space syntax have established that connectivity of spatial networks influences different kinds of behaviors and cognitive processes in building and urban layouts. More specifically, movement flows tend to be more biased

towards better-accessible spaces, measured in terms of spatial integration (Hillier et al, 1993; Hillier 1996; Peponis et al, 1990; Peponis et al, 1997).

Chang and Penn (1998) applied the space syntax method to investigate the multi-level spatial system of an urban area in London. They found in the illegible multi-level setting, pedestrian movement is less predictable from an integration-measurement standpoint, 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 shaping 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). Given the prominence of urban design parameters like metro stations, level variations, and the location and type of vertical transitions that are characteristic to the site, they developed an integrated model on movement patterns, including both spatial integration measures, 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).

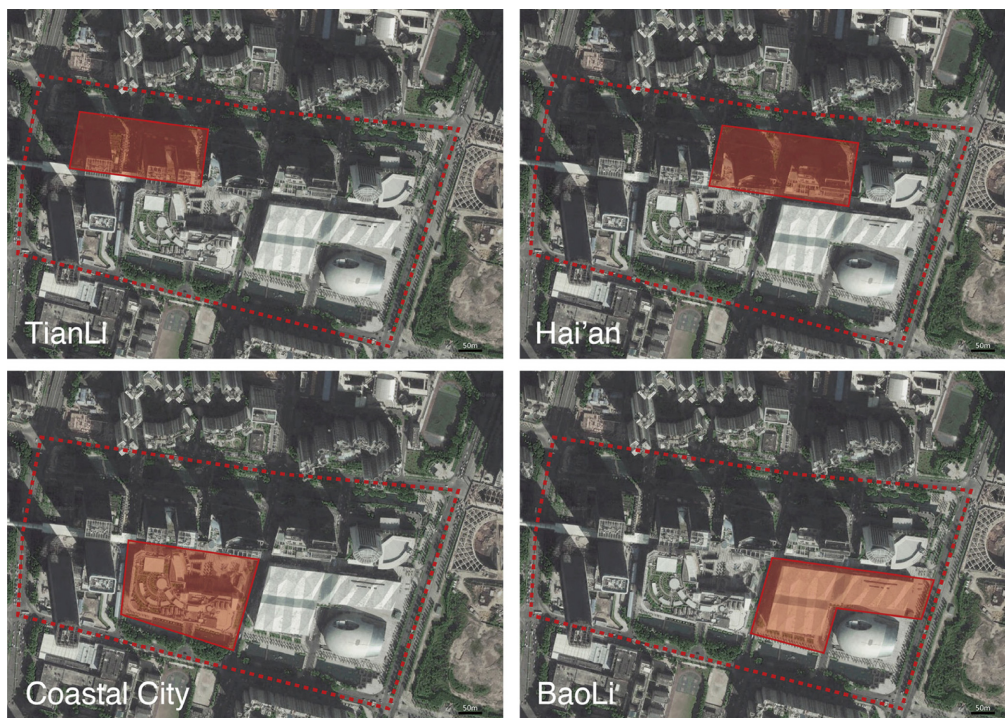


Figure 2. The site of study area, showing locations of the four commercial complexes.

Table 1. Building profile of the constituent shopping complexes in NCCD

	TianLi	Hai'an Mansion	Coastal City	BaoLi
Location in the site	Northwest	Northeast	Southwest	Southeast
Year open	2010	2007	2007	2007
Height (level)	4+33	3+32	5	4
Plot area (?)	39,000	13,000	36,000	54,000
Total floor area (?)	250,000	85,000	120,000	150,000
Rentable shop area	35,200	21,400	60,600	37,360
Parking lot	499	2000	1500	980
Entrance location	1F, 2F	1F, 2F	1F, 2F	1F, 2F, 3F
Mix use type	Commercial + Office	Commercial + Office	Commercial	Commercial + Culture

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. 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.

3. Case Description

Nanshan Commercial Cultural District (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 center of the metropolitan area. The site is demarcated with two main thoroughfares along the west and east edges. To the east is the newly developed Houhai CBD, which contains a number of mixed-use skyscrapers under construction. The portion of NCCD examined in the study consists of 4 buildings: Coastal City, BaoLi Culture Square, TianLi, and Hai'an Mansion. The former 2 buildings are shopping complexes, and the latter ones are a mixture of shops in podia with offices and hotels in high-rise towers. Fig. 2 shows the location of these buildings, and Table 1 summarizes their characteristics.

The street pattern of the site is characterized by a small grid size, contrary to the super-grid structure sounding the site. In order to accommodate large retail complexes and separate vehicles from pedestrians, a huge elevated plat-

form is created along the central axis of the area, running from east and west. This also helps bring pedestrian flows from mixed-use residential areas in the west to the upper level of the site (Fig. 1). To the east of the platform runs the recently built No. 2 metro line, with a station that is partially implemented. Vertical connectors such as escalators, staircases and lifts are deployed in multiple locations, linking the elevated platform with its surrounding streets. All the 4 commercial buildings are designed in a similar layout fashion to that of shopping malls (Maitland, 1985 & 1990; Northen & Haskoll, 1977), with one or more spacious atriums, double-to-quadruple-height circulation

spaces, and wide corridors formed into various shapes from case to case. They are connected seamlessly as a continuous spatial system above the street level via the large elevated platform. The numerous building entrances that are located on both the street level and upper floors accentuate the concept of “the second ground floor”, which the design of the elevated platform intends to achieve. 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 (Fig. 3). In comparison, the number of staircases is much lower. They are predominantly used for evacuation purp-

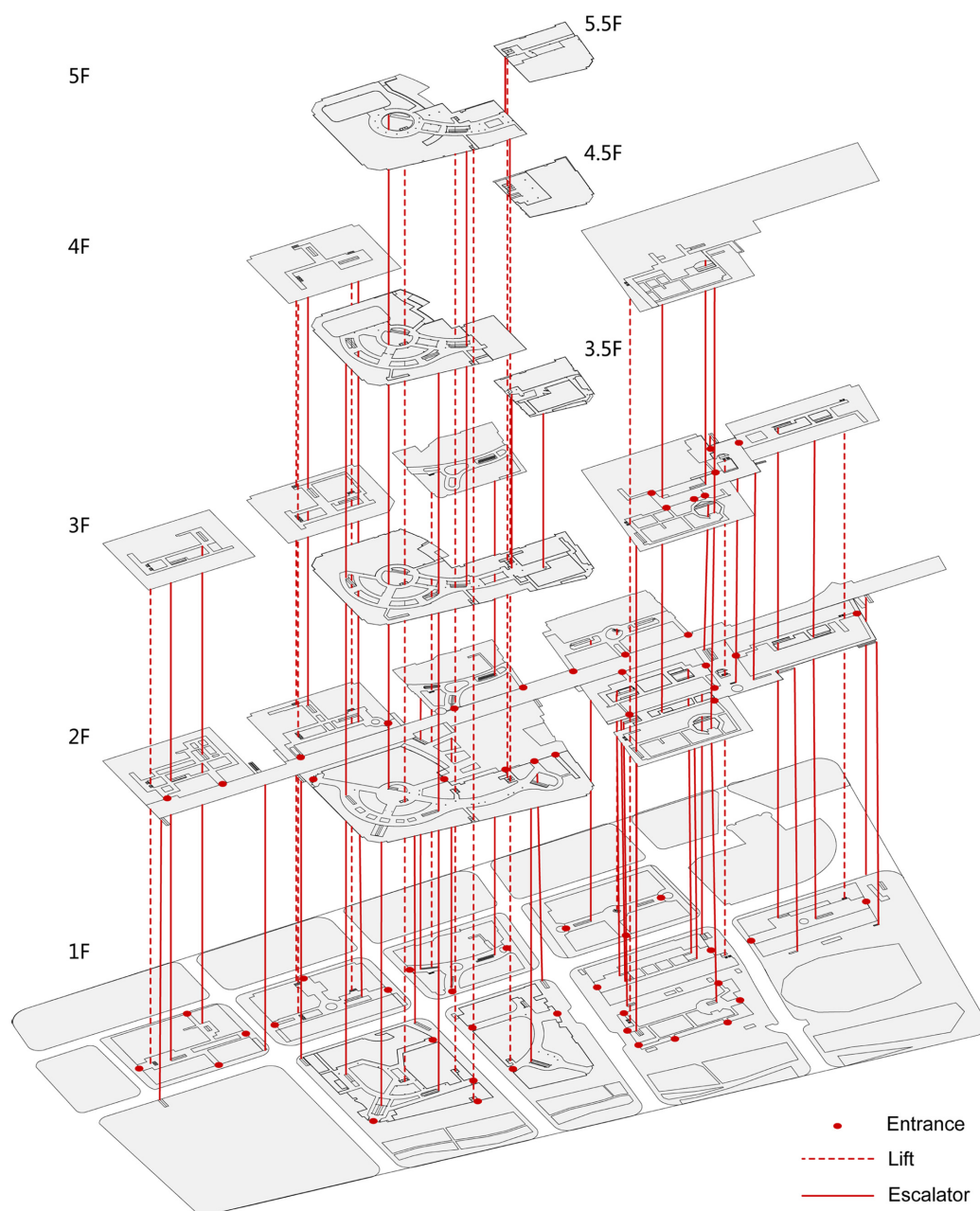


Figure 3. Locations of vertical transitions and entrances in the study area.

oses, and thus recede from the main circulation areas of building interiors.

The overall spatial system of NCCD is highly complicated. Transit nodes, street sidewalks, squares, building entrances, atriums, and interior circulations within the site are all interconnected with each other, both horizontally and vertically, into a multi-level spatial complex. Although varied in size and commercial marketing strategy, all the 4 shopping complexes 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 numbers of shoppers and rising rental prices.

4. Methods

The study applies the axial model of space syntax to analyze the spatial configuration of NCCD in terms of a minimum set of longest lines that covers all public spaces, excluding shop interiors. Axial lines of individual floors are linked together at locations of vertical transition (Fig. 4). Staircases are modeled 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.

The configuration of the axial map is measured in terms of the number of depths or directional changes needed to move from a linear space to other spaces. The *connectivity* measure describes how many other linear spaces are directly connected to a space. The *integration* measure quantifies the mean depth, i.e., relative accessibility, needed of a linear space to access every other space within a radius, which specifies the maximum scope of topological changes to be reached by that space. Radius 3 (R3) integration and radius n (Rn, without radius limit) are used as accessibility indicators for local and global levels, given the different topological distances involved in computation.

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. Fig. 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. Shops are categorized into 8 tenant types: retail store, catering, costume, jewelry, educational service, cosmetic, electrical appliance, and entertainment. Locations of each type of shop 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 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.

5. Modeling the Distribution of Pedestrian Flows

5.1. Independent 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). In order to assess their impacts on pedestrian flows, we apply a simple summary statistic of movement data with respect to those parameters. A quick review suggests such effects do exist. These effects are accounted by measuring the step depth away from these spatial parameters. The following summarizes all the independent spatial variables adopted in the study.

Syntactic variables: connectivity, R3 and Rn integrations, describing the degree of connectivity that a space is linked locally and globally in the spatial system.

Vertical transition variables: including 2 variables, step depth from escalators (SDE) and step depth 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), given the fact that pedestrian flows are significantly higher on the platform, and level (L) measured in floor numbers.

5.2. Preliminary Bivariate Correlations

Preliminary linear regressions between the density of movement flows and each independent variable are provided in Table 2. Syntactic variables produce moderate to

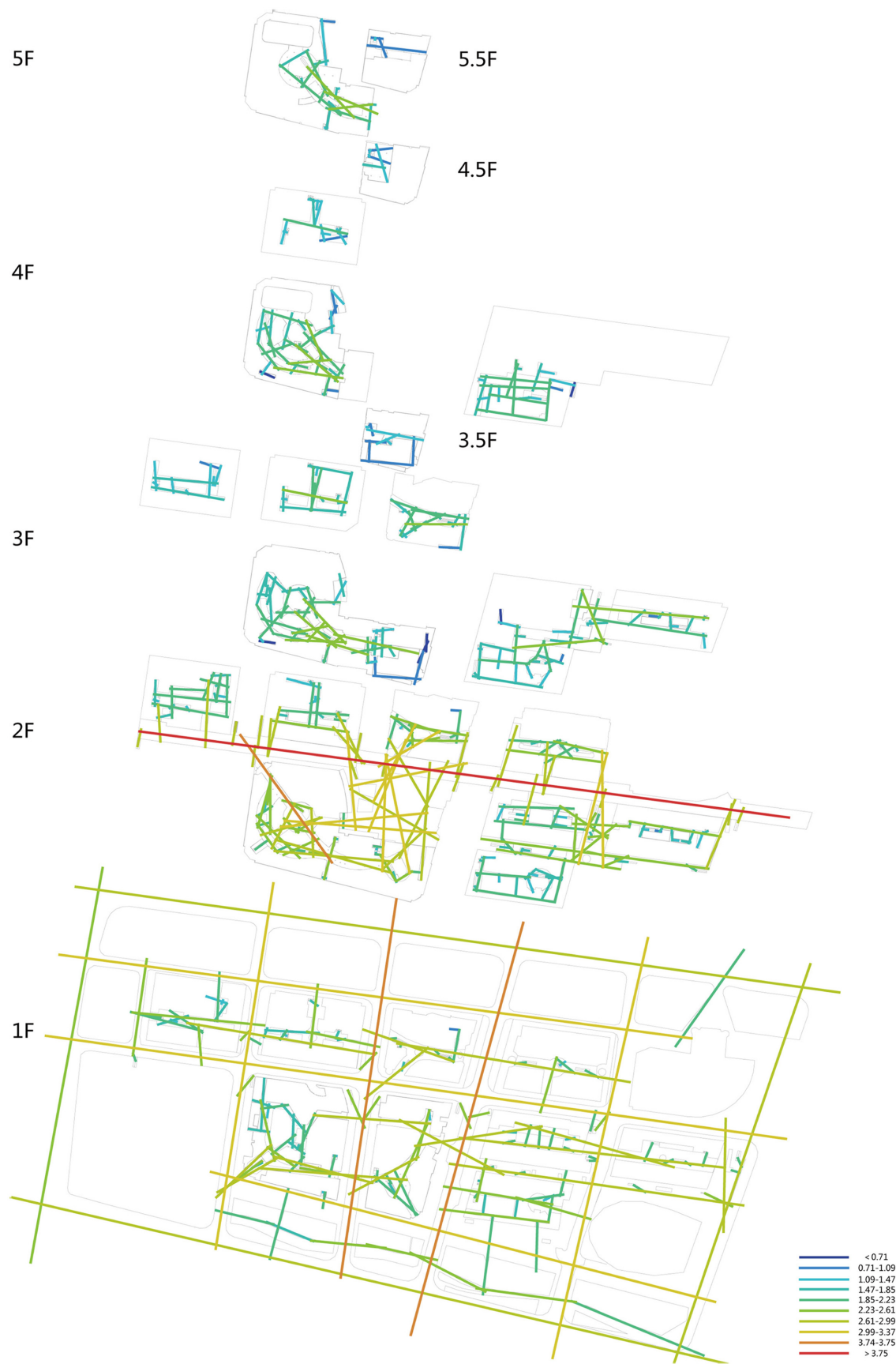


Figure 4. R3 integration of the multi-level commercial system, red to blue lines showing value from high to low.

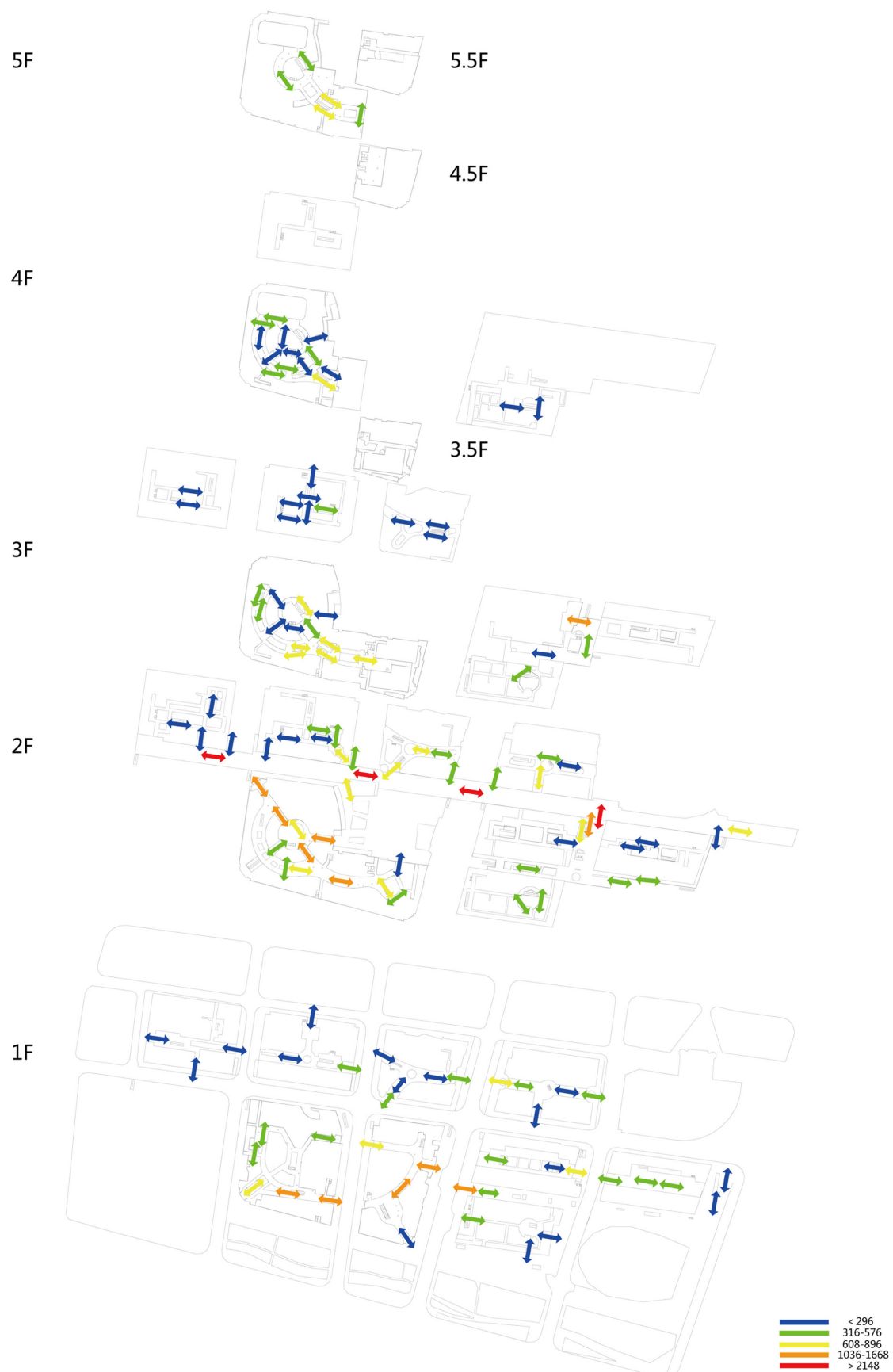


Figure 5. Location and density of observed pedestrian flows in the study area.

Table 2. Bivariate correlation coefficients of movement flows (in square root) and spatial variables

	Connectivity	R3 Integration	Rn Integration	SDP	SDE	SDL	SDFA	L
R ²	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

relatively strong correlations with the square root of movement, and their coefficients are all significant. The strongest correlation is given by R3 integration, with an $R^2 = 0.49$, indicating that nearly half of movement variations in the shopping area can be explained by this single variable. Following are measures of Connectivity and Rn 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. As expected, they are all negatively correlated with the dependent variable. However, only three out of five are found to be 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 R3 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.

5.3. Multivariate Correlation Analysis

This section reports statistical results derived from multiple regression 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, R3 and Rn integrations. Each block of variables is added step-wise into the multiple regression analyses in order to foreground any model variations.

Table 3 summarizes the statistical results of each multiple regression model. Along with the models' R^2 value, the study reports beta coefficients of the regression equation, significance values, standardized beta coefficients, Variance Inflation Factors (VIF), and DW statistics. Standardized Beta coefficients constitute a means by which to evaluate the predictive power of each of the independent variables in explaining movement distribution. These coefficients are measured in standard deviations (using z-scores transformation) rather than the units of variables. Variance Inflation Factors and DW values, on the other hand, are used to evaluate collinearity among the independent variables, and autocorrelation of the regression residuals, respectively. As rule of thumb, VIF values greater than 4 are indicative of severe collinearity among the explanatory variables, and DW values between 1 and 3 and close to 2 suggest no severe autocorrelation of resi-

Table 3. Effect tests for multivariate regressions, estimating square root movement flows

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
R3 Integration									9.557	5.586	0.472	2.648
Rn Integration									-	-	-	-
N = 134												
R ²			0.245				0.245				0.655	
R ² adjusted			0.233				0.233				0.642	
DW statistics			1.348				1.348				1.894	

Note: all presented coefficients are significant at $p < 0.01$.

duals among the explanatory variables.

When only those variables in the first block (including functional attractor variables and level variation variables) 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 R3 integration, in conjunction with SDE, DFA and SDF, results in a correlation coefficient (R^2) of 0.64. In other words, nearly two-thirds of the variation in commercial flows distributed in the shopping area can be explained by the independent variables used in this study.

As expected, given the results of bivariate analysis, the R3 integration is the variable that has the strongest impact on the distribution of movement in the shopping area (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 neighbors. 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. Residual analysis indicates a fairly random pattern of distribution, with a DW statistic value of 1.89 suggesting no significant autocorrelation presented in the multivariate regression model.

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, in spite of the inclusion of other variables, 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 R3 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. Due to the large amount of commercial flows in the shopping area, the time spent waiting for lifts is rather long, which keeps customers from using them for vertical transitions. 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 inverse to positive, which is contrary to the *a 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 R3 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. With many vertical transitional spaces linking the large elevated platform and streets in multiple locations, and the numerous building entrances opened toward it, 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, 2007; 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 somehow counterbalance the floor level changes and effectively direct commercial flows onto upper floor levels.

6. Business Performance of Tenant Mix

In light of the regression analyses presented above, the next question we ask is whether the impact of those spatial variables on movement distribution is somehow related to the clustering 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 at the aggregated building level in terms of rent and vacancy rate. It is established that 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 by their available rentable 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 the syntactic and other spatial variables contributes to more robustly address the distribution of movement flows.

We define the axial lines whose R3 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 (Fig. 6). 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 4, 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 R3 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 R3 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 (17 out of 20) and Hai'an Mansion (12 out of 14) 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.

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

Table 4. Syntactic properties of individual commercial buildings, and the percentages of their vertical transitional spaces and entrances located on the core structure

	The System	CC	BL	HAM	TL
Connectivity	4.31	4.62	3.58	4.85	3.68
R3 Integration	1.92	1.87	1.75	2.10	1.76
Rn 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

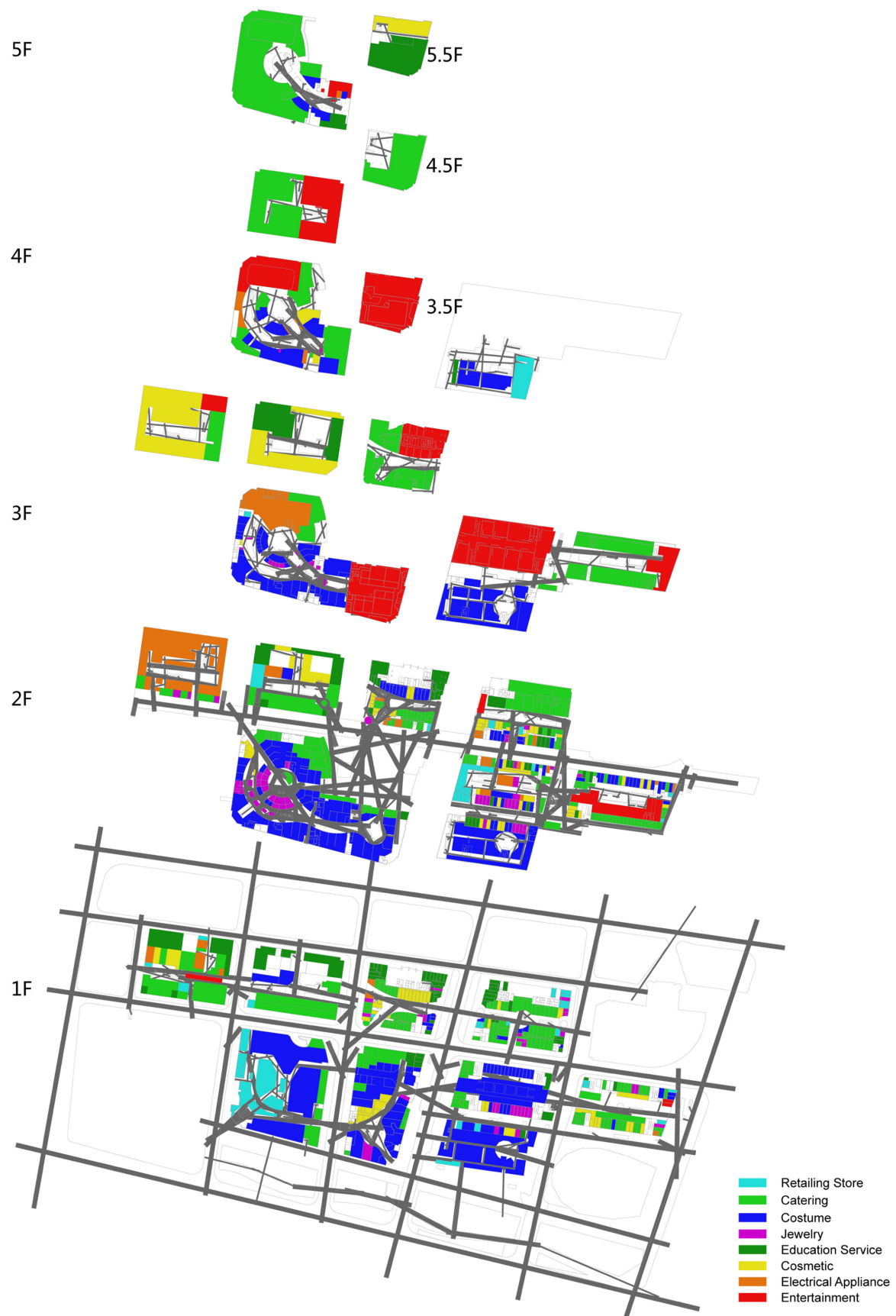


Figure 6. Distribution of tenant types against the top 30% of R3 integration lines (in bold).

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 a categorization of 8 commercial types: retail store, catering, costume, jewelry, 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. A major 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 (Fig. 7).

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, jewelry and retail stores in general tend to be more closely related to the core structure of R3 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.

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. This is done in two steps. First, each

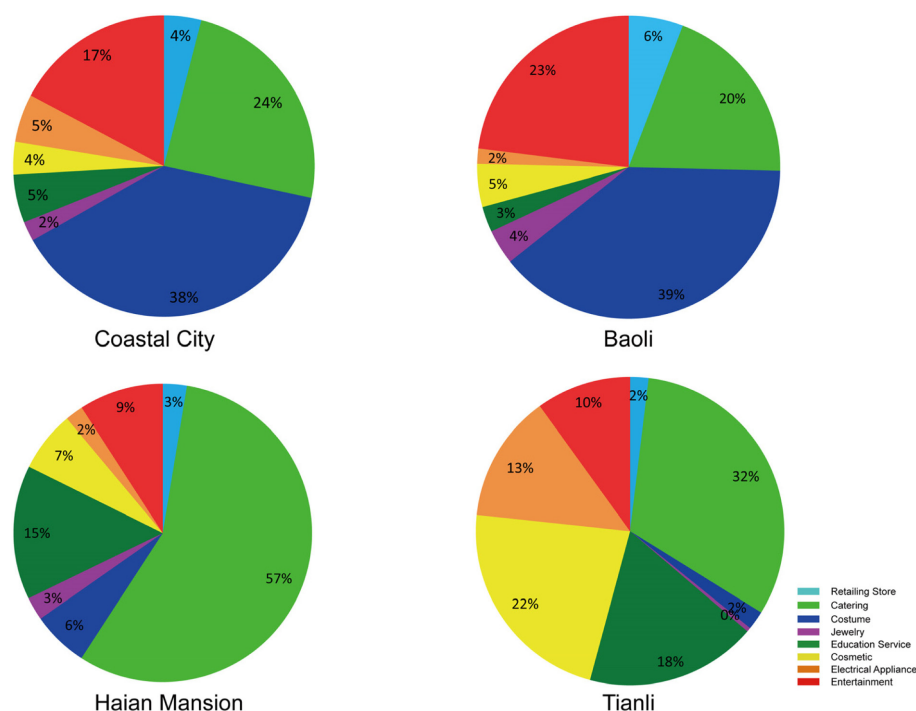


Figure 7. Statistics of tenant mix measured in percentages of shop area for individual buildings.

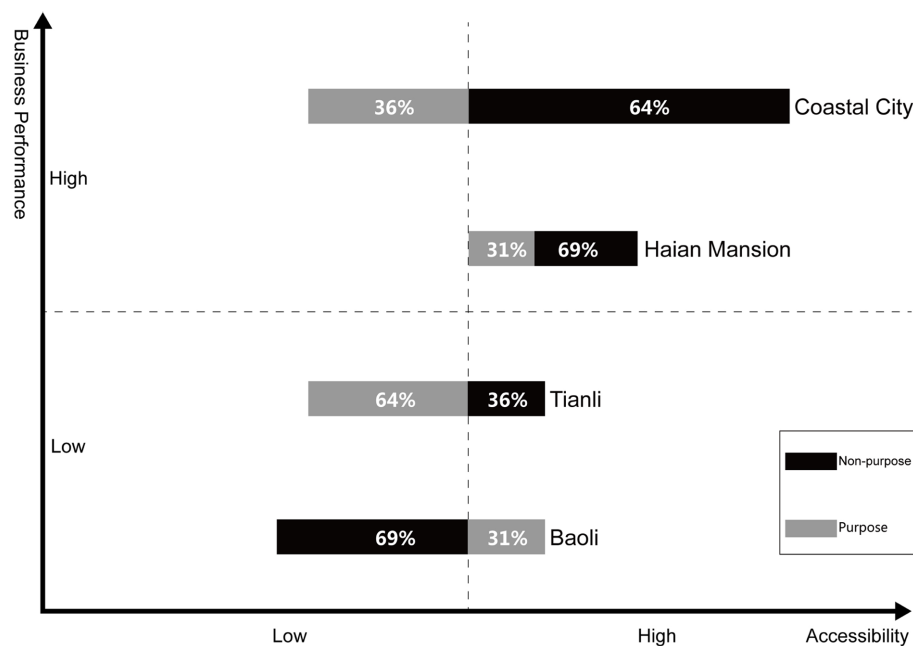
Table 5. Weighted average R3 integration values for the tenant mix in each shopping complex

	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

shop is assigned to the R3 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 (Table 5). 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 jewelry, 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.

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 Fig. 8. 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 8.** Relationship between spatial accessibility, tenant mix and business performance at the aggregated building level.

7. Conclusion

The study investigates the effects of spatial patterns on pedestrian movement and business performance of tenant mix 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.

Modern shopping mall design is generally based on the premise of the classic “gravity model,” so as to create artificial flows of pedestrian movement between the large competing stores that work as “magnets” or “anchors,” spaced between small cellular stores. The aim is to reproduce the by-product effect that occurs naturally on urban streets. Therefore, the placement of magnets, the location of entrances, the layout of the center, the use of escalators to streamline pedestrian flows, and the allocation of tenant types with respect to level variations are all important considerations in shopping-mall dynamics. The concept of the magnet “polar forces” of “anchor” and “pull” is so influential that there seems to be little challenge to the way the spatial structure of the shopping mall supposedly works.

The study reveals that, in spite of the many influencing factors in the complex multi-level spatial system, pedestrian flows are in the main shaped by the spatial structure of the multi-level system. What is of more importance is the interplay between syntactic variables and local spatial parameters, in particular the spatial integration and location of escalators, which contributes to a powerful explanation of patterns of movement distribution. The study also reveals the spatial pattern of the multi-level commercial system has certain effects on the economic performance of tenant mix at the aggregate building level, in the sense that the alignment of spatial characteristics with tenant mix in a shopping complex may result in a higher rent and lower vacancy rate.

By highlighting the interactions between socio-economic variables and spatial design parameters of shopping complex, the study provides useful implications for the strategic architectural decisions that may result in spatial patterns of effectively functioning multi-level commercial space. As indicated by the research findings, an integration of building interiors and urban context, with an alignment of the local design parameters to that integration, is more likely to result in a shopping interface within which positive interactions between spaces, movements and functions can be activated and developed. The study suggests this may be an important spatial quality of an effective vertical extension of mixed land use in high-density urban settings.

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