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A STUDY OF URBAN DENSITY IN SHENZHEN:

The relationship between street morphology, building density and land use

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Abstract

China's modern urbanization since 1980s has been characterized with high density of urban development. While dense development is commonly accepted as an urban policy to guide the planning and building of cities, density has seldom been fully addressed and understood in urban study, let alone the appropriate ways for defining urban density from the point of view of designing cities. Most research of urban density focused on the characterizations of human occupation of land and the characterizations of concentration of social, economic, and cultural activities, whereas little attention has been paid to the density of the physical fabric of streets. However, street networks, as the key infrastructure of cities, provide the framework for cities to function and for shared urban life to develop. A fundamental question of urban density is how the density of the physical structure of cities supports the other kinds of density.

This study combines space syntax with some newly developed methods for measuring density to analyze the spatial distribution of urban density in Shenzhen, China. The main objective is to investigate to what extent the physical fabric of streets influences the degree of urban density. Measures of street morphology are correlated to measures of building and development density for the main urban area of Shenzhen which covers about 100 km2. The analysis proceeds at two levels. From the macro point of view, it examines the urban density at the areal level by dividing the study area into 10 areas as well as 50 quarters. At the micro level, the same study area is scrutinized in details as evenly distributed 400m x 400m cells to isolate variations in density with respect to different types of land use. The results reveal that configurational measure of street network is a powerful indicator at quantifying the difference of development density between areas and between smaller grid cells. This is particularly the case when land use composition is taken into consideration: the higher the degree of function mix, the more dependent of building density on spatial accessibility of streets in its surroundings.

Keywords: *urban density, street morphology, Shenzhen, land use.*

Theme: *Urban Space and Social, Economic and Cultural Phenomena*

1. The Problem of Urban Density

China's modern urbanization since 1980s has been characterized with high density of urban development. While dense development is commonly accepted as an urban policy to guide the planning and building of cities, density has seldom been fully addressed and understood in urban study, let alone the appropriate ways for defining the distribution of density from the point of view of designing cities. Most research on density focused on the characterizations of human occupation of land and the characterizations of concentration of social, economic, and cultural activities. Whereas planning is more concerned with the spatial distribution of population, land use, investments and resources of different kinds, little attention has been paid to the study of the third kind of density, the density of the physical fabric of streets (Peponis, et al. 2007). Tang and Fu (2003), Zhou and Zou (2004), for example, proposed a zoning model of density distribution based on location theory of urban economics. In such model, the physical fabric of streets is addressed with transportation issues as a background rather than as a framework for cities to function and for shared urban life to develop.

It has been argued that built form of cities has a relation to urban density. Siksna (1997) measured the metric properties of street morphology of urban centers in Australian and US cities, and revealed that centers require and even generate dense street patterns. Hillier (1999) brought the metric properties of centers into the topological model of space syntax, and addressed the questions of density in a quantitative way by explaining the centrality process in the formation and location of centers and sub-centers that is driven by movement economy. Since then metric properties have been increasingly brought into the mainstream of space syntax research (Hillier & Iida, 2005). Peponis, et al. (2007) broadened the scope of density and measured the density of street connectivity both in metric and syntactic terms for a sample of 25 urban areas in the Atlanta metropolis. Their findings revealed that the density of street co-vary with other kinds of density (population, development and parcel densities). Mashhoodi and Berghauser Pont (2011) combined space syntax with Spacematrix and the Mixed Use Index proposed by Hoek (2008), and investigated the statistical relationship between the degree of mix of functions, density and integration in the southern part of Rotterdam. Van Nes, et al. (2012) applied these models to diagnose the spatial and socio-economic conditions of Rotterdam and to test effects of a new bridge connecting Rotterdam North and South.

Although space syntax based research has shown measures of street configuration interact with some conventional measures of urban density, the relationship was either examined on rather large urban scale between areas (Peponis, et. al. 2007); or measures of urban density were defined as accessible density, i.e., total building area researchable within a certain radius, rather than areal density of a land unit (Mashhoodi and Berghauser Pont, 2011). However, these studies do provide sufficient methods and conceptual frameworks that would allow us to investigate the interrelationship between different kinds of density in a rather comprehensive way.

This study combines space syntax with the mixed use index and examines the spatial distribution pattern of development density in Shenzhen, China. Measures of street morphology are correlated to measures of building density derived from different scales of land use unit. The purpose of study is not only to see whether there are co-variations between different kinds of density, but also to see how far the building density can be accounted by the configurational properties of street and how they are related to each other with respect to particular land uses.

2. The Sample Data and Methods

The study area covers the main city of Shenzhen Special Economic Zone, with a total land area close to 100 square kilometers. There are areas developed in 1980s and 1990s such as Luohu District in the east, when Shenzhen had its 1st stage booming of urban growth; CBD areas developed after late 1990s such as Futian District in the center; and former “fringe” areas such as Nanshan District, which as absorbed into the main urban fabric and has witnessed significant development in the 21st century. Thus, the study area represents a cross section of urban growth in Shenzhen’s main built area.

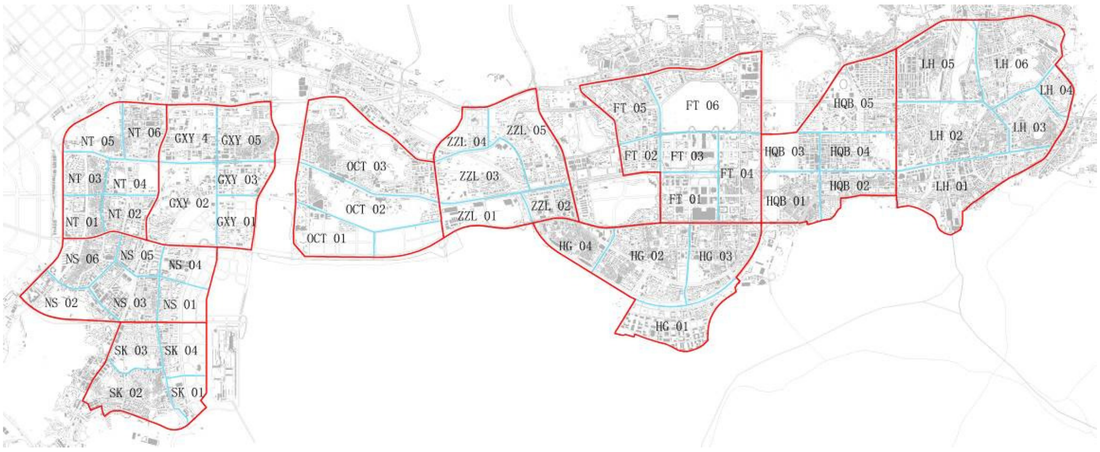


Figure 1 The study area and the division of 10 areas and 50 sub-areas for macro level analysis

The land use data as well the density of buildings were derived from the Building Information Survey Data-base developed by Shenzhen Planning and Land Research Center. The study examined the distribution of building density at two levels. At the macro level, we adapt the scheme used by Peponis et al. in their study in Atlanta metropolis (2007). A set of 3km x 3km grids was initially placed over the whole study area. However, in order to include in the analysis only complete urban blocks, the 9 square kilometers unit was deformed into a polygon of urban land fully surrounded by road lines. As a result, 10 areas were created from such exercise, some areas contain considerably more than the original 9 square kilometers, whereas some are less. The 10 areas were further divided into 50 smaller sub-areas, following the similar logic as mentioned above. The division of the 10 areas and the 50 sub-areas are shown in Figure 1.

The microscopic analysis adopts the method used by Van Nes, et al. (2012), where a 400m x 400m fishnet was placed over the whole study area in order to capture a finer grain of variations of building density. In case the 400m x 400m cells cutting through buildings, a GIS tool was developed to assign building floor area to a cell in proportion to the area of building footprint falling into that cell.

Morphological properties of street network were analyzed with space syntax methods. With emphasis on topo-geometric properties, space syntax methodology and its associated computer program Depthmap allow us to measure the “configured” density of streets at various city scales, instead of mere static density, i.e. length of streets per square kilometer. There is however an issue about the resolution of spatial modeling, i.e. what spaces should be included in the spatial model? Should we only model vehicular routes, or should we also include pedestrian spaces as well as private spaces in real estate developments? A pilot study in Shekou was carried out to test which spatial model was more appropriate. It turned out that a spatial model for public accessible spaces correlated best with the density of buildings in Shekou (Fan, 2012). This scheme was then applied to the present study.

Thus, 4 kinds of measures of density were derived from the sample data. First, the density of streets, street blocks, and plots per unit area of urban layout (Figure 3). Second, the configurational density of street network as measured according to the topo-geometric properties of space syntax. Third, the density of different categories of buildings in terms of floor space area per land unit (Figure 4 &5). Fourth, the density of mixed land use measured according to the degree of function composition, i.e. percentage of different categories of buildings based on the concept of Mixed Use Index (Hoek, 2008).

While the macro level analysis mainly focuses on the relationship between street morphology and development density of buildings, the micro level analysis adds the dimension of land use composition to the review of such relationship by taking account the degree of function mix of each land unit. Questions examined in this study are: are the different aspects of urban density co-varied, and how are they associated at different city scales? Which is the most significant spatial factor that supported the density of buildings across different city scales? What is the relationship between street morphology, building density and land use composition?

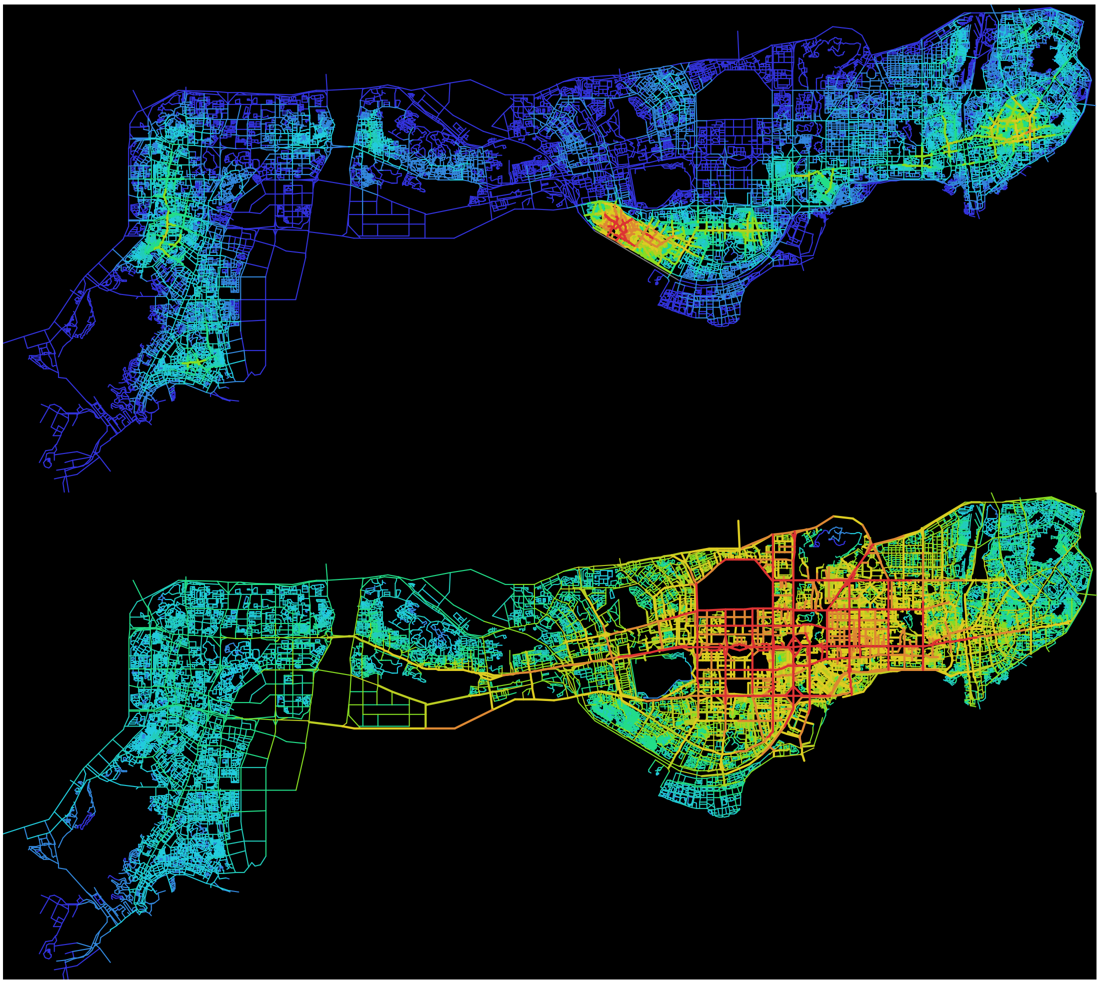


Figure 2 Local (radius 1000m) and global (radius n) accessibility of street segments in Shenzhen

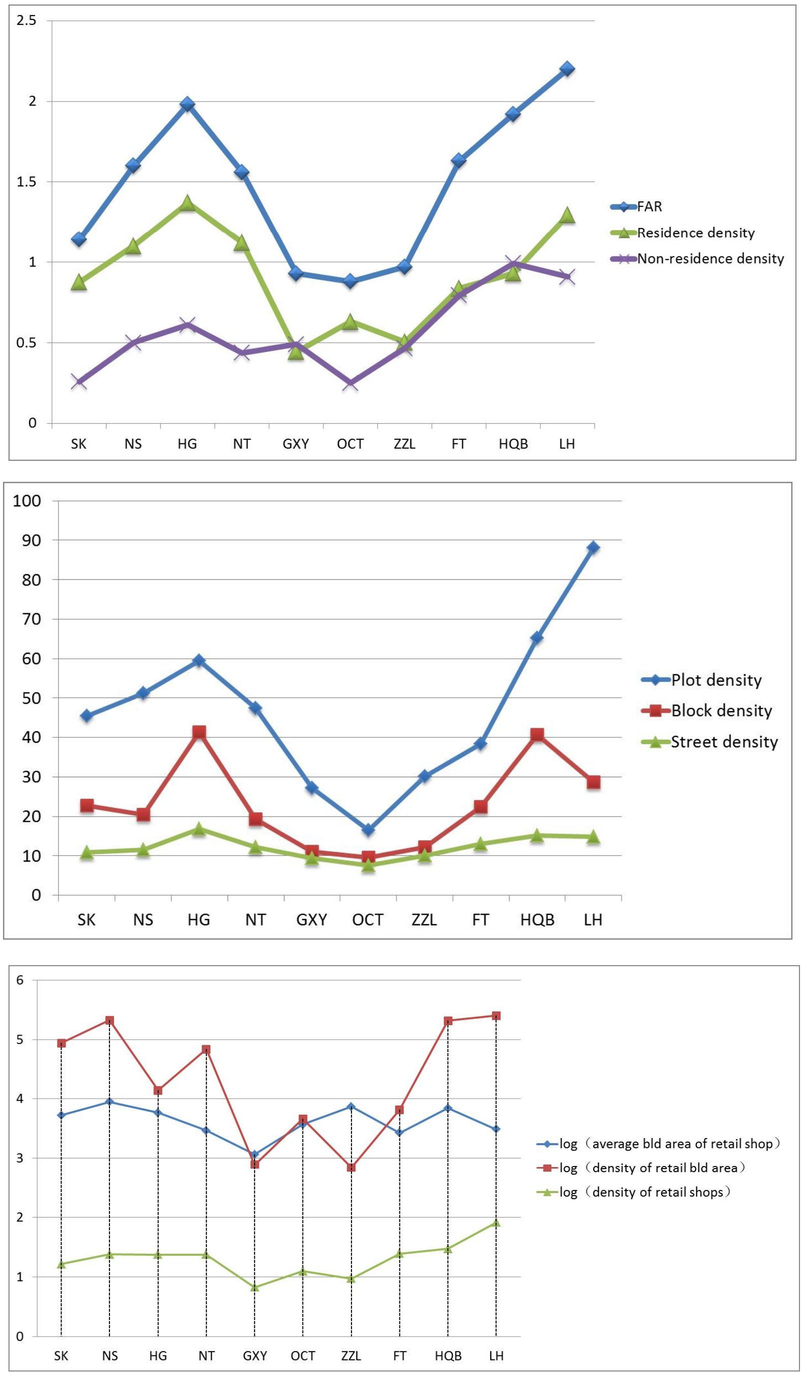


Figure 3 (a) Measures of street, block, and plot density (top left); (b) Building density (top right); and (c) Retail density (bottom left) for the 10 areas in Shenzhen

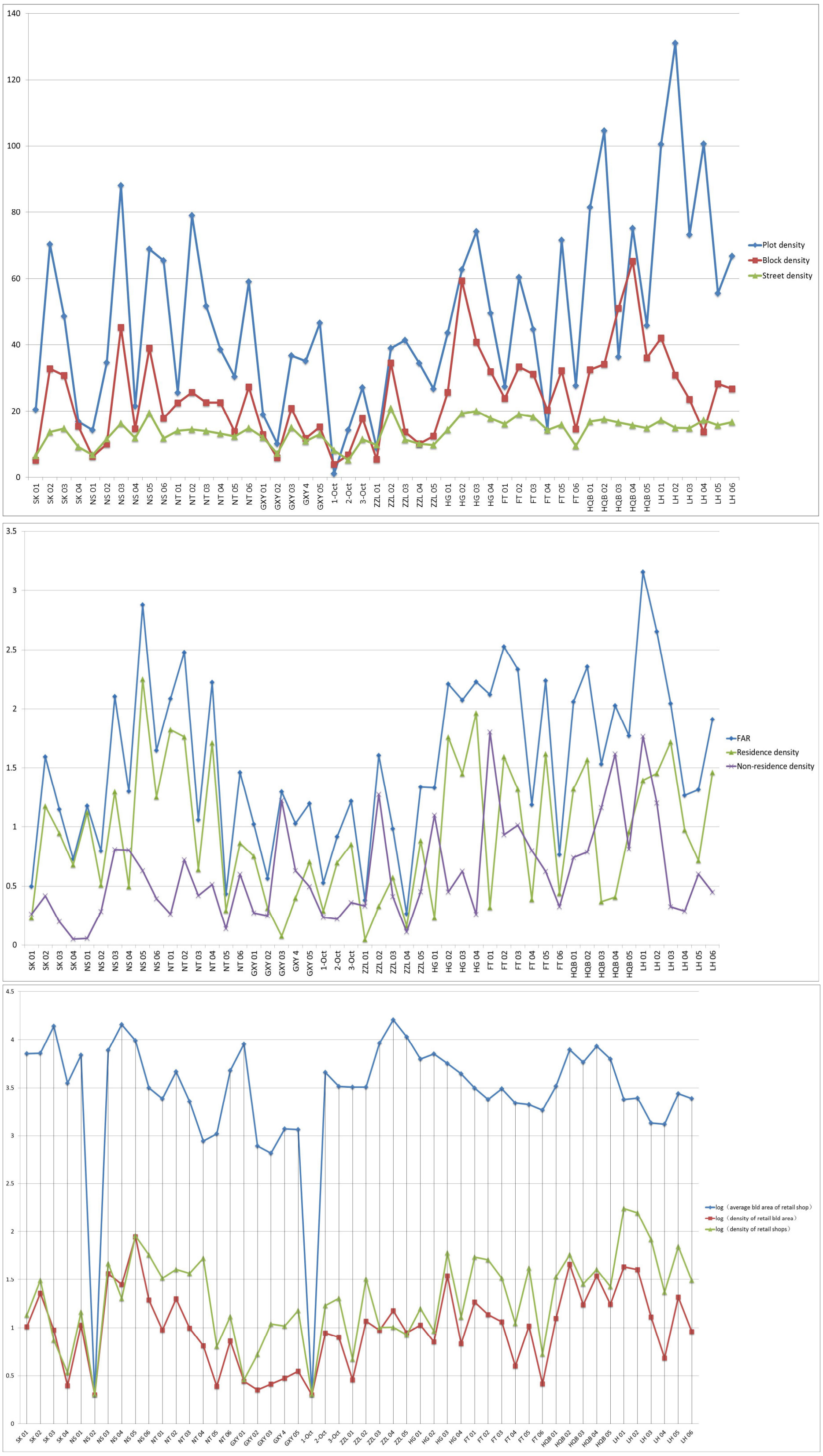


Figure 4 (a) Measures of street, block, and plot density (top); (b) Building density (middle); and (c) Retail density (bottom) for the 50 sub-areas in Shenzhen

3. Street Morphology and Urban Density: a macroscopic review

The macro level analysis examined the relationship between different aspects of urban density in terms of the mean values of each land unit (i.e. 10 areas or 50 sub-areas).

Street morphology and plot density

Table 1 shows the linear regression results between morphological properties of street and plot density for the sample data. At the level of 10 areas, almost all morphological properties except global integration measure correlated strongly and significantly with plot density. The highest value was given by the mean choice value at radius 2000m (r2 = 0.817), followed by radius 1000m choice value (r2 = 0.729). Street density (length of streets per square kilometer) also produced a strong correlation, but to a lesser degree.

Table 1 Correlations between measures of street morphology and plot density for areas and sub-areas in Shenzhen (Correlation coefficient r2)

	Block density	Street density	Int_1000	Int_2000	Int_Rn	Ch_1000	Ch_2000	Ch_Rn	TSL_1000	TSL_2000
10 areas	0.584	0.695	0.692	0.654	0. 001	0.729	0.817	-0.308	0.579	0.578
50 sub-areas	0.390	0.411	0.392	0.310	-0.024	0.484	0.509	-0.070	0.306	0.233

The statistical results here are very similar to those observed in the study of urban density in Atlanta metropolis. In both cases, the density of public network of street is in proportion to the density of ownership properties, which is to the intensification of land subdivision. This phenomenon, as argued by Peponis, et al. (2007), is a fundamental theorem of urban density, arising from the interplay of social principles and the geometrical constraints that drive land subdivision. Although in the present study the sample areas were selected from a continuously connected urban system, instead of discrete areas distant from each other as in Atlanta, the results still seem to lend support the social logic of city form, where greater land subdivision requires more street length in order to be independently accessible from public system.

Another story told by Table 1 is that the configurational density of street correlates better with plot density than street density (length of street per square kilometer). This is also held true when the 10 large areas are subdivided into 50 sub-areas, although the strength of correlation decreased quite significantly (r2 = 0.509 vs. 0.411 for Choice measure at radius 2000m and street density in the third row of table 1). It is also noted that when the space syntax analysis approaches to larger radius, correlations produced by syntactic variables such as integration and choice goes down sharply until to an insignificantly level at the global scale, meaning that plot density co-varies with street morphology only at local and medium scales of urban network.

Street morphology and building density

The building survey data has total floor square meters of individual buildings, and properties of building types for the area under study. Based on this information, we calculate the density of buildings of different categories in terms of FAR (Floor Area Ratio), which is the most important indicator of land use intensification in China’s urban planning system. Table 2 & 3 show the correlation coefficients between building density and street morphology for the 10 areas and the 50 sub-areas, respectively.

As shown in Table 2, both street density and syntactic properties correlate strongly with FAR. While the density of street length per square kilometer gives the highest correlation value (r2 =

0.863), the choice measure at radius 3000m produced an almost equally strong relationship with r2 = 0.853. A comparable level of strength of correlation can be found when the density of building is differentiated as residential and non-residential types. In this case, syntactic properties of street perform slightly better than street density.

Table 2 Correlations between measures of street morphology and building density (floor space area per square m) for 10 areas (Correlation coefficient r2)

	Street density	Int_1000	Int_2500	Int_Rn	Ch_1000	Ch_2500	Ch_3000	Ch_Rn	TSL_1000	TSL_2500
FAR	0.863	0.723	0.763	0.047	0.700	0.788	0.853	-0.180	0.673	0.724
Residential density	0.636	0.558	0.463	-0.030	0.651	0.624	0.568	-0.597	0.462	0.409
Non-residential density	0.558	0.437	0.622	0.393	0.313	0.525	0.624	0.031	0.474	0.636

Table 3 Correlations between measures of street morphology and building density (floor space area per square m) for 50 sub-areas (Correlation coefficient r2)

	Street density	Int_1000	Int_2500	Int_Rn	Ch_1000	Ch_2500	Ch_3000	Ch_Rn	TSL_1000	TSL_2500
FAR	0.531	0.626	0.461	0.008	0.570	0.532	0.469	-0.008	0.572	0.418
Residential density	0.256	0.258	0.168	-0.038	0.301	0.245	0.205	-0.076	0.202	0.134
Non-residential density	0.295	0.412	0.352	0.162	0.269	0.265	0.287	0.033	0.444	0.360

When the study area is further divided into 50 sub-areas, we find that the configuraitonal density of street outperforms street density in correlation both with FAR and the density of different categories of building, as shown in Table 3. The highest correlation is between integration at radius 1000m and FAR (r2 = 0.626). Meanwhile, morphological properties of street in general have a stronger relationship with non-residential building density than with residential density. However, such relationship decreases significantly as the analysis using large radius syntactic measures, a similar trend as found in previous section analysis. Moreover, it is also found that the density of residential buildings is negatively correlated with global accessibility of street, while the relationship is reversed for non-residential buildings. This observation is held both for the 10 large areas and their 50 sub-areas. It seems to indicate that, from a macro point of view, residential buildings appear to have different pattern of density distribution. Dense residential development tends to locate itself in globally less accessible areas in Shenzhen. While this may reflect the location preference of residential planning, it probably also arises from the fragmentation of residential development and broken layout form associated with such development in recent decades.

Street morphology and retail density

We have retail shop data derived from an urban block level data-base developed at CDI (China Development Institute) for the Commercial Network Survey of Shenzhen in 2010. However, the data only include shops with building floor area over 500 square meters. Two types of retail density are calculated for the area under study, retail area per square kilometer and number of retail shops per square kilometer.

The 10 large areas display characteristic pattern of shop distribution. The highest density in terms of shopping area per square kilometer is Luohu, the old city of Shenzhen, followed by Nanshan and Huaqiangbei with an almost equal value. These 3 areas also have the highest density of shops per square kilometer. This is not a surprise as the main commercial centers of

Shenzhen are situated in these areas. The lowest density of shops is found in High Tech Park and residential areas for rich classes such as Zhuzilin and OCT (Oversea China Town).

Table 4 shows results of the linear correlation analysis between retail density and street morphology for the 10 large areas. Syntactic properties of street network in general correlate better than street density. The Choice measure at radius 2000m gives the strongest relationship with retail density both in terms of building area and number of shops (r2 = 0.495 and 0.491, respectively). As expected, the strength of correlation decreases when the analysis is carried out at a finer scale for 50 sub-areas. However, what is more obvious is the fact that syntactic properties perform much better that street density in the correlation analysis (Table 5). Again, we find correlation between syntactic measures and retail density decreases to a very weak, if not insignificant, level at the global radius. The fact that choice measure at radius 2000m is an indicator of retail density appears to be in line with another study of us, although in that study we examine the proportion of retails clustering around top accessible spaces at the level of street segment and use POI (Point Of Interest) data from Baidu.com instead of shops with an area over 500 square meters (Shi, 2013).

Table 4 Correlations between measures of street morphology and retail density for 10 areas (Correlation coefficient r2)

	Street density	Int_R1000	Int_R2000	Int_Rn	Ch_R1000	Ch_R2000	Ch_Rn
Retail area / km^2	0.185	0.321	0.350	-0.056	0.395	0.495	-0.198
Number of shops / km^2	0.326	0.286	0.294	-0.001	0.446	0.491	-0.197

Table 5 Correlations between measures of street morphology and retail density for 50 sub-areas (Correlation coefficient r2)

	Street density	Int_R1000	Int_R2000	Int_Rn	Ch_R1000	Ch_R2000	Ch_Rn
Retail area / km^2	0.169	0.332	0.288	-0.0004	0.320	0.319	-0.002
Number of shops / km^2	0.131	0.339	0.335	-0.0003	0.428	0.446	-0.010

4. Street Morphology, Building Density (in terms of FAR) and Land use Composition – a microscopic review

The micro level analysis is based on a set of 400m x 400m grids covering the area under study. For each of these cells, 3 kinds of data are computed.

(1) Spatial accessibility is derived from segment analysis of space syntax by assigning the highest syntactic value of street segment that intercepts a cell (Figure 5a).

(2) Building density is measured in terms of FAR (floor area ratio), which was computed by dividing building area contained by a cell over 160,000 square meters, i.e., land area of a cell (Figure 5b).

(3) Land use composition is derived according to the concept of Mixed Use Index (Hoek, 2008), which measures the degree of mix of 3 functions (housing, working and amenity) based on the percentage of building area for each of the functions. Seven types of land use composition were categorized in this study (Figure 5c).

Mono-H: housing exceeds 80% of building area of a cell and no other function is more than 10% of total building area;

Mono-W: working exceeds 80% of total building area of a cell and no other function is more than 10% of building area;

Mono-A: amenity exceeds 80% of total building area of a cell and no other function is more than 10% of building area;

H-A: both housing and amenity are over 10% of building area of a cell and working is less than 10% of building area;

H-W: both housing and working are over 10% of building area of a cell and amenity is less than 10% of building area;

W-A: both working and amenity are over 10% of building area of a cell and housing is less than 10% of building area;

H-W-A: all 3 functions are over 10% of building area of a cell.

In this section, we first examine whether land use types have any spatial patterns of distribution, and then investigate to what extend building density (FAR) co-varies with street configuration in terms of different types of land use composition.

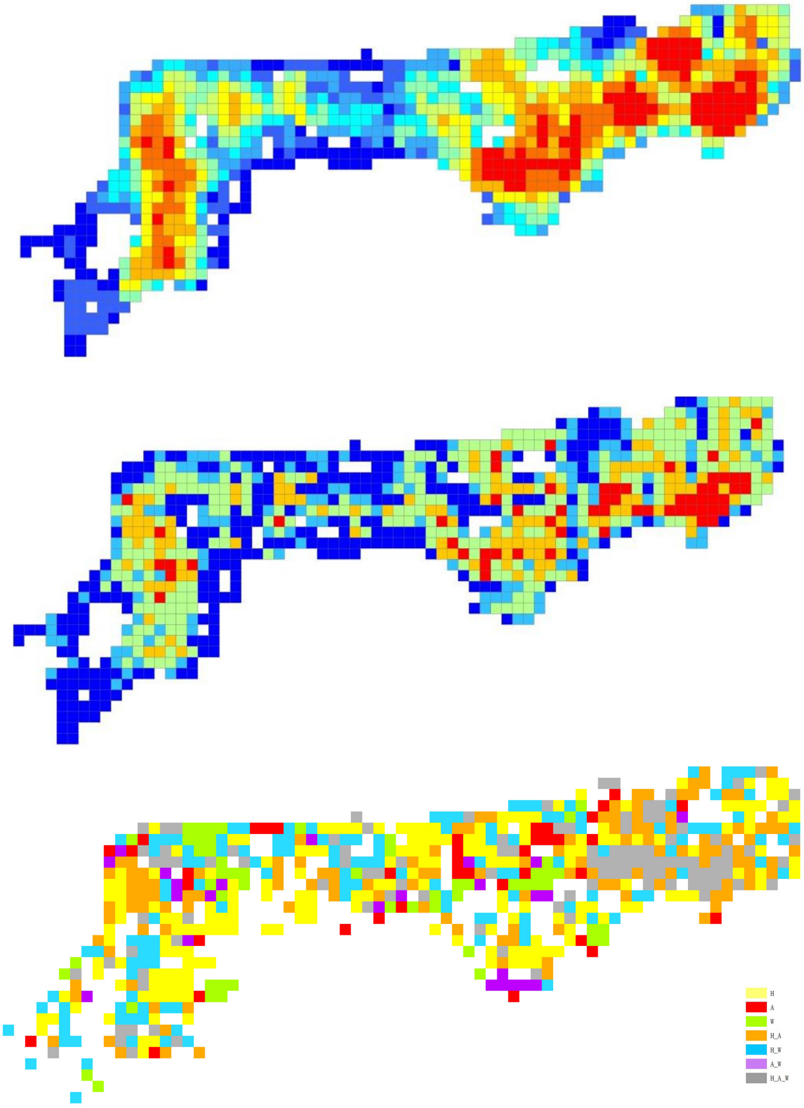


Figure 5 Distribution of (a) Integration values at radius 1000m (top); (b) FAR values (middle); and (c) Land use types (bottom) for the 400m x 400m cells in Shenzhen

Street accessibility and land use composition

In order to assess relationship between street accessibility and land use types, we simply count the occurrence of each of the 7 land use types that lies on highly accessible street segments. Figure 6 shows the percentage of each land use type collected by top 10%, 20% and 30% integrated street segments, respectively. The triple mix use (H-A-W) has the highest concentration rate (57.5% against the integration structure at radius 1000m). Mono-H has the lowest rate of concentration, although it shows a rather even distribution at different scales of radius. Meanwhile, it is found that concentration of land use types varies considerably with different scales of accessibility. This is reflected by the fact that a mixture with housing (H-A, H-W, H-A-W) has a higher rate of percentage collected by top 30% accessible streets at a low or medium radii (R1000m and R2000m), while land use dominated by amenity (Mono-A) or working (Mono-W) has a much higher level of concentration at global scale. This suggests that different types of land use and different degree of land use composition prefer to different scales of accessibility.

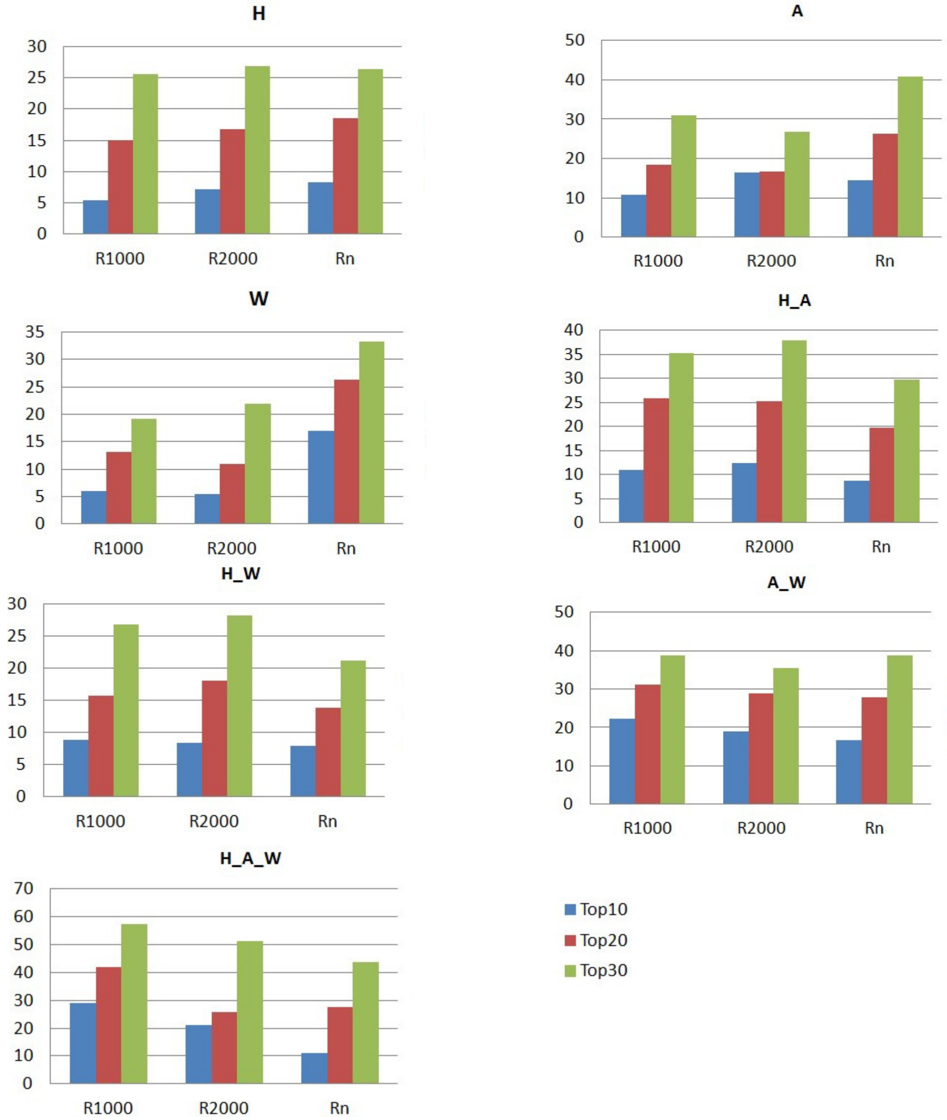


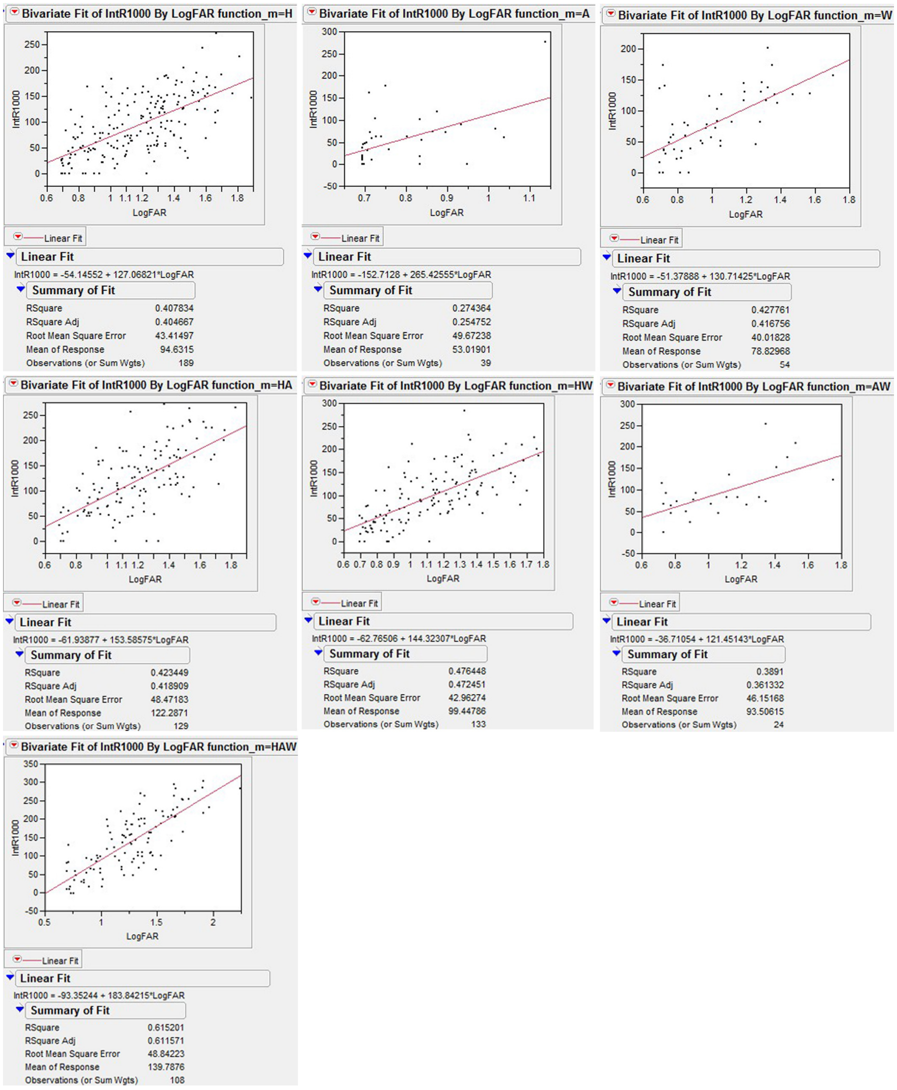
Figure 6 Percentages of land use types collected by top accessible streets

Street accessibility, building density, and land use composition

Table 6 shows the linear regression analysis between building density measured in FAR and integration values from local to global scales for all cells under study. The highest correlation is given by radius 1000m (r2 = 0.511). This is a highly significant and remarkable value, considering the rather huge sample size (845 cells in total). It means that the spatial condition of street in itself could account for more than 50% of the variation in the density of building area between 400m x 400m cells. Even at a rather larger radius of 4000m, integration value displays a moderate correlation with FAR (r2 = 0.275). Again as expected, the relationship diminishes at the global radius (r2 = 0.086), a similar trend as observed in the macro level analysis in previous section.

Table 6 Correlations between FAR and different scale accessibility for 400m x 400m cells (Correlation coefficient r2)

	Int_1000	Int_2000	Int_4000	Int_Rn
FAR	0.511	0.423	0.275	0.086



```
Linear Fit
IntR1000 = -54.14552 + 127.06821*LogFAR
Summary of Fit
RSquare                       0.407834
RSquare Adj                   0.404667
Root Mean Square Error        43.41497
Mean of Response               94.6315
Observations (or Sum Wgts)         189
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```
Linear Fit
IntR1000 = -152.7128 + 265.42555*LogFAR
Summary of Fit
RSquare                       0.274364
RSquare Adj                   0.254752
Root Mean Square Error        49.67238
Mean of Response              53.01901
Observations (or Sum Wgts)          39
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```
Linear Fit
IntR1000 = -51.37888 + 130.71425*LogFAR
Summary of Fit
RSquare                       0.427761
RSquare Adj                   0.416756
Root Mean Square Error        40.01828
Mean of Response              78.82968
Observations (or Sum Wgts)          54
```

```
Linear Fit
IntR1000 = -61.93877 + 153.58575*LogFAR
Summary of Fit
RSquare                       0.423449
RSquare Adj                   0.418909
Root Mean Square Error        48.47183
Mean of Response              122.2871
Observations (or Sum Wgts)         129
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```
Linear Fit
IntR1000 = -62.76506 + 144.32307*LogFAR
Summary of Fit
RSquare                       0.476448
RSquare Adj                   0.472451
Root Mean Square Error        42.96274
Mean of Response              99.44786
Observations (or Sum Wgts)         133
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```
Linear Fit
IntR1000 = -36.71054 + 121.45143*LogFAR
Summary of Fit
RSquare                         0.3891
RSquare Adj                   0.361332
Root Mean Square Error        46.15168
Mean of Response              93.50615
Observations (or Sum Wgts)          24
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```
Linear Fit
IntR1000 = -93.35244 + 183.84215*LogFAR
Summary of Fit
RSquare                       0.615201
RSquare Adj                   0.611571
Root Mean Square Error        48.84223
Mean of Response              139.7876
Observations (or Sum Wgts)         108
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Figure 7 Scatterplots between accessibility and FAR grouped according to land use types

It has been argued that land use is an important factor influencing FAR in urban planning and development (Tang and Fu, 2003). We then split the cells into subsets according to the 7 types of land use composition and redo the correlation analysis with grouping of land use. Figure 7 shows their scatterplots, with integration value at Radius 1000m on horizontal axis and FAR on vertical axis. All the subsets except the triple mixed land use (H-W-A) produce a less strong correlation than the sample as a whole. The lowest value and the highest value are given by Mono-A and H-W-A r2 = 0.303 and 0.597, respectively. Moreover, a mixed of housing with another function displays a rather stronger correlation (r2 = 0.444 and 0.464 for H-W and H-A) than mono-function subsets.

In order to further control the effect of each function in the analysis, we re-group the cells into 9 subsets according percentages of building area taken up by individual function. For example, cells containing housing land use less than 10% of its total building area are banded as subset 1, more than 10% but less than 20% as subset 2, and over 80% as subset 9. Correlation between accessibility and FAR are then regressed for cells in each subset. The same exercise is repeated for the other two functions.

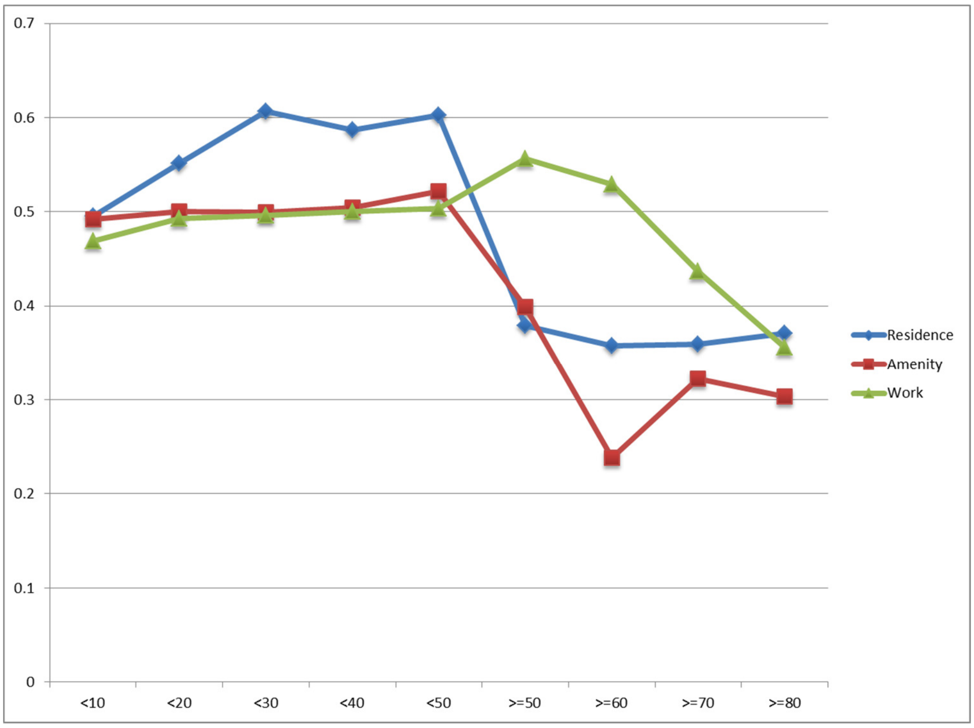

Figure 8 Correlations between accessibility and FAR controlled for cells with different percentages of building area taken up by individual functions

Statistical results of above analysis are displayed in Figure 8, with percentages of building area of a function plotted horizontally and correlation coefficients (r2) plotted vertically. First, there seems to be a critical point at which association between accessibility and FAR is the strongest with respect to individual land use. This happens when a function consumes about 50% of the total building area of a 400m x 400m cell. As the percentage exceeds 50%, correlation between accessibility and FAR shows a quite dramatic change and decreases continuously. For example, the correlation coefficient (r2) with respect to housing drops sharply from 0.60 to 0.38, although this is less remarkable with respect to amenity. Second, when the percentage of housing function is controlled, co-variation between FAR and accessibility is the highest (blue line in Figure 8) with r2 = 0.60 at the point of 50% for all subsets of statistical analysis. When it comes to amenity, the relationship is the weakest with r2 = 0.23 at the point of 60% (red line in Figure

8). This means that when housing is well mixed with other functions, higher building density prefers to locations with better accessibility. Third, as the percentage of building area of a function increases, the relationship between accessibility and FAR behaves differently with respect to individual land use. Before reaching the critical 50% point, housing produces a stronger correlation between accessibility and FAR (with the highest r2 = 0.60 at the point of 50%) than working and amenity, while the latter two functions display an almost identical correlation trend. From 60% and upward, such relationship appears to be reversed as correlation between accessibility and FAR is higher with respect to working than with respect to housing.

What can be inferred from these results is that interdependence between accessibility and building density is more or less related to the degree of function mix of a land unit, the higher degree of mixed use the stronger association between accessibility and FAR. Moreover, FAR of urban land is more dependent on spatial accessibility when housing comprises a certain percentage but not dominates land use, the more accessible from public system the higher building density in that land unit. However, this is unlikely to be the case when a single function dominates land use (i.e. over 80% of total building area).

5. Discussion

The study examined the spatial distribution of urban density in the main city of Shenzhen. The analysis proceeded at two levels, a macro review focusing on interaction between street morphology and development density based on area difference, and a micro review getting inside area to further investigate such relationship with respect to land use composition at a finer scale of 400m x 400m grids.

The results reported in this study suggest that street morphology correlates strongly with measures of urban density across different scales of land size. The study also reveals that configurational density of street network is not only a better indicator to clarify the area difference of urban density than conventional street density measured as length of streets per square kilometer, but also allows us to grasp a finer grain variation of building density within areas. For example, the integration measure (at radius 1000m) in itself could account for more than 50% of the building density within 400m x 400m cells. This is particularly the case when land use composition is taken into consideration: the higher the degree of function mix, the more dependent of building density on spatial accessibility of streets in its surroundings. Such relationship is even more prominent when housing is well mixed with other functions. On the other hand, however, interaction between different kinds of urban density in Shenzhen seems to be leveraged by scales of the city, as it is more related to local scales of spatial accessibility but diminishes at the global level.

These findings suggest that measures of street morphology not only describe properties of the city as a physical object, but also properties of the street network as a framework within which other kinds of urban density develop and vary from one place from another. However, due to availability of data and limitation of research tools, the results of this study are hypothetical rather than conclusive, and constitute only a background for addressing future research questions. One question to be pursued is whether cities have different profiles regarding the relationship between different types of urban density. To do this we need expand the study into other urban areas in Shenzhen metropolitan region as well as other cities. To pursue questions future, we also need to refine our methods and research tools. So far the relationship between street morphology, building density and land use is addressed on a basis of evenly distributed 400m x 400m grids instead of urban blocks. Whether the size of urban blocks has an effect on distribution of density needs to be tested in future. We also need to address a familiar syntactic phenomenon, the organization of urban land by street rather than by land unit. To test this we need to sort the data not by land unit, but rather by street segment, and to study the ways that variation of building density is accommodated by the configurational situation of individual street segments in their surroundings.

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