How block density and typology affect urban vitality: an exploratory analysis in Shenzhen, China

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ABSTRACT
Recent urban transformations in China have led to critical reflections on the low-quality urban expansion in the previous decades and called for the making of vital and lively urban places. To date, limited research has been devoted to empirically testing the relationship between urban design, urban morphology, and urban vitality in Chinese cities. This paper employs new urban data and analytical methods and explores the relationship between urban morphology and urban vitality using regression models. Shenzhen, one of the largest and fastest growing cities in China, is selected as the case study. The regression analysis focuses on two morphological factors, density and typology, while controlling for the accessibility, functional mix, and size of individual blocks. The presence of small catering businesses is used as a proxy for urban vitality. The analysis suggests that both typology and density matter for urban vitality, with typology playing a more important role. More specifically, “block” and “strip” types tend to show significant positive effects on urban vitality. The implications for urban planning and design practices are discussed.

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Morphological categories; urban vitality; urban design; open data; China

1. Introduction
Jane Jacobs’s (1961) notions about urban vitality and diversity were less of a concern for urban planning and design in China before the 2000s, as the country’s urbanization was largely characterized by rapid and oftentimes low-quality urban expansion. Recent changes have led to critical reflections on the urban expansion in the previous decades and called for the making of vital and lively urban places (Den Hartog, 2010). For example, with rising income levels and increasing demands for liveability, the public starts to pay more attention to the quality of urban space. Place-making therefore becomes a hotly debated issue in China (Campanella, 2012; Ye & Zhuang, 2017). Still, the needs for revitalizing old neighborhoods, factories, and villages become apparent (Lin, 2015), driven by government policies targeting at stricter land use controls, increasing land-related disputes, as well as the restructuring of the Chinese economy. Relatedly, the latest National New-Type Urbanization Plan of China
emphasizes the “people-oriented approach”, quality of life, and urban sustainability (Wang, Hui, Choguill, & Jia, 2015). This transformation requires planners and designers to play a more active role in improving the quality of the built environment and inducing urban vitality. Urban design needs to assure that urban composition not only functions properly but is also pleasing in its appearance (Buchanan, 1988; Madanipour, 1996). In other words, for designers and planners, life in a diverse and multi-functional city should be considered a fundamental requirement rather than a luxury.

This increasing interest in urban design requires a deeper understanding of urban morphology. While the conventional approach to analyzing urban morphology is useful for in-depth studies of individual sites, collecting city-wide information about urban morphology and related urban vitality measures is usually difficult. Many existing attempts to connect urban analytics and design have been less well-received by designers (Ye, Yeh, Zhuang, Van Nes, & Liu, 2017), while Stanilov (2010) and Karimi (2012) have called for new analytical processes that bring together the art and science in urban design. More efforts are therefore needed to empirically explore the link between urban morphology and urban design (Marshall & Caliskan, 2011). Last but not the least, existing studies have largely been developed in cities in traditional market economies, entailing different dynamics between the state, market, and society (De Nadai et al., 2016; Sung, Lee, & Cheon, 2015). A case study in China would not only test design theories developed in other contexts, but may also serve as a “laboratory” to provide nuanced understandings of urbanization in emerging economies (Bertaud, 2012; Wu, 2016).

This study therefore aims to (1) identify typical morphological categories of building density and typology through a city-wide analysis, and subsequently (2) explore the relationship between these morphological categories (e.g., building typology and density) and urban vitality. More specifically, we develop a quantitative approach to urban morphology using open geospatial data and new morphological analytics. Urban vitality is measured based on the presence of small catering businesses. The study focuses on Shenzhen, one of the largest and fastest growing cities in China. This paper hopes to close a gap in the literature and provide useful information for urban design and planning practice in China. Relevant studies are reviewed in the next section, which is followed by a summary of data and methods. The result section identifies morphological categories of building density and typology, and presents a regression analysis of the relationship between morphological categories and the distribution of small catering venues. The paper concludes with implications for planning and design practice as well as avenues for future research.

2. A review of relevant concepts and studies

2.1. Urban morphology, design, and vitality

Urban morphology concerns the physical aspects of the built environment, i.e., key elements such as streets, blocks, plots and buildings as well as the transformative processes that shape these key elements (Larkham & Jones, 1991; Oliveira, 2016). In other words, urban morphology can be regarded as an analytical abstraction of the
form, structure, and evolution of the built environment (Kropf, 2017). As a design effort to analyze, organize, and shape urban form and related functions for lively urban places, urban design is closely related to urban morphology (Rowley, 1994). Although urban design concerns more than morphological aspects, these two fields speak the same language about the essential components of desirable urban form (Hall, 2013). In this regard, an incisive understanding of urban morphology will help producing good urban design (Marshall & Caliskan, 2011).

Urban vitality usually refers to the capacity of a place to induce lively social and economic activities (Jacobs, 1961). We note that it is difficult to capture the rich meanings of urban vitality in specific measures. On the one hand, Wirth’s (1938, p. 9) deemed urbanism a social life supported by the gathering of “size, density and heterogeneity of people”. Urban vitality is socially constructed in the sense that it depends on the gathering of people. On the other hand, as Lefebvre (1968) claimed, the “urban” is the immaterial city life of diversity, vitality and attractiveness, which are in turn dependent on physical entities of urban form, i.e., the built environment. Put differently, urban vitality is a social process that has strong ties with urban form (Lees, 2010; Marcus, 2010; Oliveira, 2013). Therefore, our analysis focuses on how morphological features help creating this kind of diverse and vibrant urban lives.

As an essential goal of urban design, promoting urban vitality from a morphological perspective has been discussed in many design theories. In these discussions, street accessibility, building density and typology, and diversity are frequently highlighted as important physical underpinnings of urban vitality. The density dimension focuses on the compactness and concentration in urban form, such as plot ratio. The typology dimension is related to building coverage and footprints within individual blocks, e.g., point, strip, and block types.

Taking Jacobs’ (1961) view as an example, “the dense concentration of people” requires both street accessibility and building density. “Short blocks” help creating a permeable public realm, improving accessibility, and providing space for interactions and activities. “Mixed-uses” and “buildings of varied age and condition” reflect functional mixture within individual street blocks. Put differently, higher levels of street accessibility, building density, and functional mixture seem to be conducive to vibrant urban lives. Montgomery (1998) emphasized the importance of “development intensity” as a driver of vibrant urban life. Still, highlighting adaptability, human scale, city blocks and permeability in his studies, Montgomery suggested that strip or block typologies tend to foster interactions between buildings and street activities. His other principles regarding “fine grain”, “street contact”, and “mixed-use” also pointed to the importance of accessibility and functional diversity. Similarly, Gehl (1971) argued for high levels of accessibility, density and building coverage in his Copenhagen study. Similar suggestions can be found in New Urbanism design guidelines beyond the European context, which highlight pedestrian-oriented streets, appropriate density, and mixed use (Katz, Scully, & Bressi, 1994). While these principles are intuitive and easy to be implemented in practice, there seems to be a lack of large-scale and quantitative evaluations regarding whether and to what extent the identified factors contribute to urban vitality (Sung et al., 2015). Existing approaches to evaluating these principles are oftentimes qualitative and limited to small scale. This may be due to the difficulty of collecting detailed
quantitative information about urban morphology and related urban vitality measures at the city-scale.

2.2. Small catering businesses as an indicator of urban vitality

Small catering businesses can be reasonably deemed “indicator businesses” for vibrant urban places, although they do not in and by themselves reflect all dimensions of urban vitality. In other words, urban places tend to be more vibrant where small catering businesses flourish. Just as the vitality of a habitat can be evaluated based on “indicator species”, the vitality of an urban place can be gauged via “indicator businesses”. In her work on local streets and urbanism, Zukin (2010) highlighted small catering businesses’ role as an essential element of “authentic” urban life and an indicator of a place’s attractiveness. On the one hand, the survival of small catering businesses depends on pedestrian flows and intensive urban activities, and therefore small catering businesses tend to locate in accessible places with dense and diverse gatherings of people (Philipsen, 2015). On the other hand, places that satisfy small catering services’ locational needs tend to promote encountering, walking, resting, and other leisure activities. Furthermore, unlike fine dining restaurants and department stores that become attraction points, small catering businesses are often too small to (re)shape their surrounding built environment and thus reflect existing urban vitality. By contrast, the locational choices of large catering enterprises are often affected by market and symbolic reasons, making them less appropriate to serve as an indicator of urban vitality. Still, the turnover rate of small catering services is usually higher than their larger counterparts. The distribution of small catering businesses may therefore be seen as an up-to-date reflection of urban vitality. Put differently, the distribution of small catering businesses can be valuable for understanding the social performance of urban form, as the pattern emerges through the actions of self-motivated people, i.e., business owners and the public.

Empirically, several studies have compared urban vitality and the distribution of small catering businesses, suggesting that the latter can be used as a proxy for the former (Joosten & Van Nes, 2005; Van Nes, 2005). However, these studies are often done in a qualitative, manual manner. There still lacks large-scale and systematic studies to quantitatively reveal the relationships between urban vitality and the physical aspects of the built environment. City-wide mapping is usually time-consuming and difficult to be applied extensively. The emergence of new urban data opens new opportunities of gathering large-scale and fine-grained datasets. This transformation contributes alternative data sources for exploring the social performance of urban form and providing recommendations for urban design.

2.3. New urban data for morphological analysis

Many conventional urban morphological analyses focus on small-scale (historical) districts and traditional architecture typologies (Jin, 1993; Whitehand & Gu, 2006; Whitehand, Gu, Whitehand, & Zhang, 2011). Several typo-morphological studies linking urban morphology with urban design are qualitative in general (Chen & Thwaites, 2013; Samuels, 1999). Attempts have also been made from a geographical modelling perspective (Chen & Wang, 2013). However, there still lack actionable and quantitative
insights for urban design practices, thus calling for the introduction of new techniques and methods in urban morphology (Samuels, 2013).

The emerging urban data environment opens new possibilities of quantitative and systematic studies of urban morphology (Liu et al., 2015). With the rapid development in information and communication technologies (ICTs), volunteered geographic data about urban form and function are generated at high spatial and temporal resolutions (Liu et al., 2015). For instance, OpenStreetMap (OSM) provides open information about buildings and street blocks for large geographic areas and with high spatial accuracy (Haklay, 2010). In addition, Points of Interest (PoIs) and check-in data from social media platforms provide new ways of gauging how people feel, like, and use urban places (Cheng, Caverlee, Lee, & Sui, 2011). The new data environment helps to gather information about urban form and function in a relatively automatic, accurate and consistent manner (Batty, 2013). Meanwhile, new morphological tools emerge with the use of GIS in urban design. For example, the combination of GIS and new tools in urban morphology, such as Space Syntax and Spacematrix, helps quantifying design concepts such as accessibility, density, and typology (Berghauser-Pont & Haupt, 2010; Hillier, Penn, Hanson, Grajewski, & Xu, 1993). The integration of new datasets and tools provides a solid foundation for large-scale, in-depth morphological studies (Oliveira & Medeiros, 2016). In addition, there is an increasing scholarly interest in introducing new quantitative thinking into the studies of urban form and urban design. This is reflected in a series of recent studies that apply geo-referenced big data to verify classical urban design theories (De Nadai et al., 2016; Sung et al., 2015). These new methods are design-oriented and thus able to analyze urban form from designers’ viewpoints. This paper therefore can be seen as a response to this rising trend of quantitative analyses in urban design.

3. Data and methods

3.1. Study area

Our analysis focuses on Shenzhen, one of the largest and fastest growing cities in China. When Shenzhen was established as a special economic zone (SEZ) to attract foreign investments in the late 1970s, it was a border town with a small population (Hao, Sliuzas, & Geertman, 2011). The number of residents has since increased by more than forty times, and Shenzhen has become a megacity of 14 million residents (Zacharias & Tang, 2010). Shenzhen is a good window on contemporary urban form in China, as the entire city was built from scratch in the past four decades (Figure 1). The city has accumulated various urban forms that are typical in post-reform China, e.g., urban villages and gated residential neighborhoods (Den Hartog, 2010; Gu, 2001; Keeton, 2011; Liu, He, Wu, & Webster, 2010). This echoes Zhong’s (2013, p. 216) observation that “Shenzhen, as a vanguard in reform and opening up, epitomizes the present and future of the whole country, as vividly articulated in the popular saying, ‘Shenzhen today is the inland areas tomorrow’”.

The urban built-up area has expanded significantly to accommodate the rapid population growth (Figure 1). Shenzhen consists of four inner-city (Luohu, Futian, Yantian, and Nanshan) and two outlying districts (Baoan and Longgang). Luohu and
Futian districts are selected as the sites of analysis for the following reasons. First, these two districts were part of the initial special economic zone and have undergone the longest development process, thus containing most urban morphological categories. Second, geospatial data such as Points of Interest are more readily available in inner-city districts, such as Luohu and Futian, at higher geographical and thematic resolutions. The total size of these two districts is 157 km$^2$, which is well beyond the scope of conventional urban morphological studies.

3.2. Methodology

This study develops a large-scale, quantitative approach to understanding the relationship between urban form and vitality. Our approach involves the following major steps (Figure 2). We will firstly identify typical morphological categories of buildings and
blocks, which are the key independent variables in our analysis. A second step will produce additional urban form measures, such as street accessibility and functional mixture, which will be used as control variables. We then perform a regression analysis with the distribution of small catering businesses as the dependent variable. The units of our analysis are individual street blocks.

3.2.1. Identifying typical morphological categories of buildings

We employ Spacematrix (Berghauser-Pont & Haupt, 2010; Steadman, 2014) to identify typical morphological categories of buildings and blocks. The categorization process focuses on the density and typology of individual blocks, and as discussed, the units of analysis are individual street blocks. The categorization in Spacematrix considers both building density and typology, while many previous studies only reveal one of these two dimensions (Berghauser-Pont & Haupt, 2007; Lozano, 1990). Our analysis uses three Spacematrix measures: floor space index (FSI), ground space index (GSI) and height (L). FSI, more commonly known as floor area ratio or plot ratio, reflects the building density of a block. FSI is calculated as the ratio of gross floor area to building footprint.

\[
FSI_x = \frac{F_x}{A_x}
\]

Where \( F_x \) and \( A_x \) denote the gross floor area (m²) and gross area (m²) of individual street blocks, respectively.

GSI concerns about building typology and reflects the relationship between built and non-built area within individual blocks. GSI is calculated as follows.

\[
GSI_x = \frac{B_x}{A_x}
\]

Where \( B_x \) and \( A_x \) denote the gross building footprint (m²) and gross area (m²) of individual street blocks, respectively.

L is calculated as the ratio of FSI to GSI and indicates the average height of buildings within a block. We note that L is different from a simple average of individual buildings’ number of floors, as it is weighted based on the footprints of individual buildings. Along the density dimension, we classify individual blocks into low-rise, medium-rise, or high-rise based on their L values. Individual blocks with an L value greater than 7 are classified as
high-rise, those with an L-value lower than 3 as low-rise, and the rest as medium-rise. High-rise blocks are usually associated with office buildings and apartment towers, while blocks with low L-values are often characterized by single/two-storey apartments, villas, and primary/secondary schools. This classification of high-, medium-, and low-rise is based on current building regulations in China.

As for building typology, a street block can be categorized as having point, strip, or block buildings based on the corresponding GSI values. More specifically, blocks with GSI scores smaller than 0.2 are categorized as “point”-type, those with a GSI between 0.2 and 0.36 as “strip”-type, and the remaining as “block”-type. While these empirical values are derived based on urban form mapping in the European context (Berghauser-Pont & Haupt, 2010), they are applied here as the definitions of point, strip, and block types are similar in Europe and China (Ye & Zhuang, 2017). “Point”-type blocks often represent large parcels with scattered buildings, such as an urban park with several service and utility buildings. “Strip”-type blocks are usually characterized by rows of apartment buildings as well as other slab-shaped buildings. Built-up areas occupy a significant portion in “block”-type blocks, which can be commonly seen in stadium, exhibition centers, urban villages, and office complexes (See Figure 3 for more examples of individual types in the study area).

Putting the density and building typology dimensions together, we arrive at a three-by-three categorization of street blocks, i.e., a total of nine categories. We note that conventional urban morphological studies may or may not adopt similar definitions, as the morphological classification of building types used in our study is relatively new (Ye & Zhuang, 2017).

3.2.2. Calculating other related morphological elements as control variables

Our analysis will control for street accessibility and functional mixture, which have been highlighted in existing urban design theories as important physical underpinnings of urban vitality (Ye & Van Nes, 2013). In addition, the size of individual blocks included as a control variable.

We employ Space Syntax to assess the accessibility of individual blocks (Griffiths, Jones, Vaughan, & Haklay, 2010; Hillier et al., 1993). More specifically, we use the spatial design network analysis (sDNA) tool to operationalize the Choice concept in Space Syntax. Choice reflects the potentials of “through-movements”, i.e., the potential of individual street segments to be selected by pedestrians or drivers as the path (Al_Sayed, Turner, Hillier, Iida, & Penn, 2014). Following previous empirical studies (Cooper, 2013), the analytical radius in sDNA is set as 800 meters, corresponding to the normal walking distance. The sDNA measure of Choice, or “betweenness” in sDNA’s term, is used to characterize the accessibility of individual streets. As sDNA measures are for individual streets, the accessibility of individual blocks is calculated as the weighted sum of the accessibility of nearby streets. The weights are determined based on three factors: the length of individual street segments ($L_i$), the Euclidian distance between street segments and the block under investigation ($D_i$), and the distance decay factor ($\alpha$).
Where $AC_b$ denotes the accessibility of a block, $AC_s$ is the measure of “Choice” for individual streets that are within 800 meters of the block under investigation, $L_i$ represents the length of individual streets, $D_i$ is the Euclidian distance from street central lines to the block’s edge, and $\alpha$ indicates the distance decay parameter, which is set to 2 according to Ye (2015). Streets with higher $AC_b$ scores are more accessible and tend to be more frequently used by pedestrians, while dead end streets and cul-de-sacs are usually associated with lower $AC_b$ scores (Ye & Van Nes, 2013).

Functional mixture or diversity (Van Den Hoek, 2009) is measured as the composition of urban functions within individual blocks. This composition is approximated based on the floor area of individual functions. Our analysis accounts for four major uses of the urban space, i.e., housing, office, commercial, and public space. Housing...
space includes various buildings for residential use, such as apartments, condominiums, and townhouses. Office space includes offices, workshops, and laboratories. Space for public use covers hospitals, concert halls, museums, and schools. Commercial space in our study mainly includes shopping centers and retail facilities. Our measure of functional mixture applies the Shannon entropy function (Shannon, 1948) and is calculated as follows.

$$MIX = - \sum_{i=1}^{n} P_i \ln P_i$$

Where $P_i$ is the proportion of the $i^{th}$ functional type, i.e., $P_{housing}$, $P_{office}$, $P_{public}$ and $P_{commercial}$ within the total gross floor area of a street block. A larger MIX value suggests higher level of mixed use, and vice versa.

### 3.2.3. A statistical analysis of the relationship between morphological categories and urban vitality

We measure urban vitality based on the number of small catering businesses within individual blocks. A regression model is subsequently constructed to explore the relationship between morphological categories and urban vitality. The regression model helps to assess the extent to which the dependent variable, i.e., the number of small catering businesses, is associated with independent variables, i.e. morphological categories (Neter, Kutner, Nachtsheim, & Wasserman, 1996). A conventional linear regression assumes the dependent variable to be normally distributed. However, this might not be the case for our analysis. The dependent variable, the number of small catering businesses, is count data. As count data can only take non-negative values, they do not necessarily follow a normal distribution. In such case, linear regression cannot be applied (Cameron & Trivedi, 2013). Descriptive statistics also confirm that the dependent variable is over-dispersed as the conditional variance exceeds the conditional mean. We therefore employ a negative binomial regression which is suitable for the analysis of count data (Hilbe, 2011). FSI, GSI, block size, street accessibility, and functional mixture are included as independent variables. A second regression model is performed with FSI and GSI replaced by individual morphological categories. In this second regression, the high-rise block is used as the dropped variable, and the remaining eight morphological categories are represented by dummy variables.

### 3.3. Data

Our analysis synthesizes information from a variety of sources (Figure 4). First, basic datasets regarding building functions, floor area, and footprints are gathered from Shenzhen Planning Bureau. Street networks are obtained from OpenStreetNetwork (OSM) and official road network survey. The quality of OSM data for major cities in China is relatively robust and the dataset has been applied to characterize urban form and function (e.g., Liu & Long, 2016). Second, street blocks are the units of analysis and generated based on street network and land use plans. Due to the tradition of functionalism planning in China, certain street blocks are large “superblocks” containing multiple functions and different morphologies. Therefore, a pre-processing is
performed to divide “superblocks” into individual parcels with similar function and morphological categories (Figure 4). Third, Points-of-Interest data are crawled from the Dianping website, which is the largest Chinese online catalogue for restaurants (i.e., the Chinese equivalent of Yelp). Dianping has categorized all PoIs into twenty-two categories. Our analysis adopts Dianping’s categorization and focuses on four main categories of small catering venues: snack store, fast food, tea house/cafe, and bakery. While we acknowledge that Dianping data do not necessarily account for all existing small catering venues and that there might be mis-categorization of certain businesses, PoIs from Dianping have been proved useful in understanding urban geography of Chinese cities (Yuan et al., 2013). After excluding large catering chains and PoIs located outside the study area, we include 15,532 geotagged PoIs in subsequent analysis.

4. Results

4.1. Overview

The analysis identifies nine typical morphological categories, ranging from low-rise point to high-rise block types (Figure 5). In the upper half of Figure 5, individual blocks are color-coded according to their morphological categories. In the lower half of Figure 5, each point represents a street block, with the same color scheme as the upper half of the figure. Individual points are plotted with their FSI and GSI as coordinates. We also plot the “mean centers” of individual morphological categories by averaging the FSI and GSI measures of all blocks of the same morphological categories. The “mean centers” of individual categories are marked by their corresponding letter codes. Type A (low-rise point), type B (low-rise strip), and type D (mid-rise point) are less common, with 3.8%, 1.1%, and 1.3% of the blocks classified as these categories, respectively. Due to the planning and development policies that favor high density, it is hard to find either low-density or point building types in the centers of Chinese cities. Most type A and type D blocks are urban parks. The other six types are more commonly seen. More specifically, most type C (low-rise block) blocks are exhibition centers and malls.
Street blocks that are classified as type E (mid-rise strip) and type H (high-rise strip) are mostly residential neighborhoods. Type I (high-rise blocks) are usually found in large urban complexes with integrated residential and commercial development. Figure 6 presents specific examples of individual types in the study area.

Our analysis suggests a sizeable presence of category F (mid-rise block), which accounts for 13.2% of all blocks (Figure 6). Under the current building regulations of China, this morphological category of “mid-rise block” cannot be built in the first place and is technically “illegal”, due to sun rights and building interval considerations. Most type F blocks are associated with urban villages (i.e., villages-in-the-city or chengzhong-cun), which emerged when rural villages are spatially encompassed by the expanding urban areas (Hao et al., 2011). The mid-rise block type is widely used in urban villages to increase total floor space. The administrative status and land use rights of these villages often remain ambiguous, thus allowing for constructions that do not necessarily follow building regulations.
4.2. Evaluating the impacts of building density and typology on the distribution of small catering venues

In the upper half of Figure 7, individual blocks are color-coded based on the number of small catering business therein. In the lower half of Figure 7, each point represents a street block, with the same color scheme as the upper half of the figure. Individual
points are plotted with their FSI and GSI as coordinates. We can see that urban vitality tends to increase along with the increases in FSI and GSI. In other words, blocks with more small catering businesses tend to be found in the upper-right corner of this scatterplot.

Our regression results are reported in Table 1. We use regression coefficients (B) and incident rate ratio (Exp(B)) to measure the relative impacts of density (FSI) and typology (GSI) on urban vitality. A larger coefficient or incident rate ratios implies a stronger impact, and vice versa. Our model controls for street accessibility, block size and functional mixture. The coefficients for all independent variables are statistically significant at the 0.01 level. The incident rate ratios of FSI and GSI are 1.050 and 5.455, respectively. In other words, building typology tends to exert greater influence on urban vitality than building density, ceteris paribus. Meanwhile, functional mixture is associated with a larger regression coefficient than street accessibility and block size.

Table 1 also summarizes the association between various morphological categories and urban vitality. As mentioned, the high-rise block is set as the dropped parameter in the second regression. Considering that the high-rise block category is associated with high urban vitality in existing urban design theories, we conjecture that the remaining
categories will show “weaker” effects. Similar to the first regression analysis, street accessibility, block size, and functional mixture are accounted for.

All morphological categories show significant positive effects on urban vitality. While we note that the regression analysis suggests correlation but not causation, the implied causal relationship between morphology and urban vitality is informed by existing urban design theories. As conjectured, the eight morphological categories included in the regression model show significant but weaker effects on urban vitality than the high-rise block type. In other words, these eight morphological categories are associated with lower incident rate ratios (Exp(B)), when compared with the dropper parameter. More specifically, mid-rise block (Exp(B) = 0.610, p < 0.01), high-rise strip (Exp(B) = 0.570, p < 0.01), and mid-rise strip (Exp(B) = 0.464, p < 0.01) are the three morphological categories with relatively larger positive coefficients. It seems that blocks with substantive amount of active urban frontages, i.e., strip or block types, and with sufficient density, i.e., middle or high rise, are more conducive to urban vitality. The strong positive influence of the “block” type is consistent with Carmona’s (2014) observation of “place-shaping continuum”. The “block” type has higher probabilities of providing active urban frontages. Active urban frontages allow for more interfaces between buildings and streets and facilitate the unselfconscious processes of urban adaptation and change, which in turn shape the surrounding built environment. A long-term morphological adaption process such as “space in use” is generated in this context and conducive to urban vitality (Carmona, 2014).

Again, typology tends to exert greater influence on urban vitality than density. For example, the incident rate ratios for morphological types of different density but the same typology do not differ much. More specifically, the incident rate ratios of low-rise-point, mid-rise-point, and high-rise-point are 0.241, 0.250, and 0.315, respectively. By contrast, changes in typology tend to have greater effects on urban vitality. For example, the incident rate ratios are substantially different for mid-rise-point (0.223), mid-rise-strip (0.464) and mid-rise-block (0.610), which have the same category along the density dimension (mid-rise) but differ in typology.
4.3. **Detailed analyses of morphological categories**

To enrich our understanding of the relationship between building density, typology, and the distribution of PoIs, we have a closer look at the four morphological categories with higher incident rate ratios (i.e., with Exp(B) values greater than 0.4). More specifically, we further examine urban vitality in street blocks of high-rise block, mid-rise block, high-rise strip, and mid-rise strip types (**Table 2**). Blocks of the high-rise block type are usually characterized by large indoor shopping malls as well as official and residential towers. This morphological type often has limited entrances, and

<table>
<thead>
<tr>
<th>Building types</th>
<th>Influences</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>high-rise block type</td>
<td>quite high</td>
<td><img src="image1.png" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td>(Exp(B) set as 1)</td>
<td><img src="image2.png" alt="Example" /></td>
</tr>
<tr>
<td>mid-rise block type</td>
<td>relatively high</td>
<td><img src="image3.png" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td>(Exp(B) = 0.610)</td>
<td><img src="image4.png" alt="Example" /></td>
</tr>
<tr>
<td>high-rise strip type</td>
<td>medium</td>
<td><img src="image5.png" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td>(Exp(B) = 0.570)</td>
<td><img src="image6.png" alt="Example" /></td>
</tr>
<tr>
<td>mid-rise strip type</td>
<td>relatively low</td>
<td><img src="image7.png" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td>(Exp(B) = 0.464)</td>
<td><img src="image8.png" alt="Example" /></td>
</tr>
</tbody>
</table>
therefore tends to be closed from the surrounding urban context. In addition, it is
difficult to find enough interacting urban frontages between buildings and streets. It
seems that the high vitality associated with this morphological type is mainly supported
by its high building density (average FSI = 6.8) rather than active street frontages.

By contrast, the mid-rise block type, which is not encouraged by current building
regulations, tends to be more open to the surrounding environment and obtains a
relatively high level of urban vitality. Although this morphological type has a much
lower building density (average FSI = 2.1), blocks of this type are often associated with a
large amount of interacting urban frontages between buildings, streets and residents,
which could in turn induce urban vitality. For example, this type is often characterized
with within-block pedestrian routes, which could facilitate pedestrian activities and
improve the connectivity with the surrounding environment. Furthermore, the high-
rise and mid-rise strip types tend to have significant positive influence on urban vitality.
This may be due to the fact that high-rise strip blocks often have commercial space on
the ground level.

4.4. Summary of results and design implications

While these determinants of urban vitality have been qualitatively discussed in the
existing literature, our analysis moves a step forward and supplements classical urban
design theories with quantitative measures. First, this study measures the effects of
individual morphological elements on urban vitality as well as the weights of different
morphological elements. Such quantitative measures are often missing from the litera-
ture. For instance, most design theories agree that street accessibility and functional
mixture play important roles in inducing urban vitality (Jacobs, 1961; Montgomery,
1998), however it is less clear which morphological elements exert greater influence.
Second, this study helps urban designers to estimate the combined effects of morpho-
logical features and choose assists appropriate design interventions. For instance,
previous studies have found that both increasing building density, e.g., from low-rise
to high-rise, and changing building typology, e.g., from point type to strip type, could
help promoting urban vitality. However, it is still difficult for urban designers to assess
when different features are combined, e.g., whether the high-rise strip type will have
greater positive influence on urban vitality than the middle-rise block type.

Our results could inform urban planning and design practices in Chinese cities as
well as those in emerging economies which are facing similar socioeconomic transitions
and demands for high quality urban space (Keeton, 2011). From an urban planning
perspective, results from this paper shed critical light on many normative post-war
urban planning practices, in which urban density, i.e., plot ratio, is often the most
important factor. Accordingly, a critical review of the current planning practices and
building regulations in China is needed. For example, the current tight controls on sun
right are in fact against design plans that target at high GSI. We could therefore explore
the possibility of having relatively higher GSI in certain areas to help creating attractive
interfaces between buildings and streets. Subsequently, tools such as plot ratio bonus
could be considered to promote selected building typology and active urban frontages.
From the perspective of urban design, “block” or “strip” types should be encouraged
along with high density development in key urban areas, such as town centers and
urban regeneration sites. By the same token, the high-rise point building type may need to be avoided in these areas. Empirical analyses of key morphological elements suggest that it could be necessary to arrange designs carefully to allow for synergies between the positive effects of street accessibility, building types and density, and functional mixture.

5. Conclusions

This paper advances our understanding of the relationship between urban morphology and urban vitality based on emerging urban data and new analytical methods (Liu et al., 2015). This study is a response to the increasing academic interest in introducing new quantitative thinking into urban design. Using Shenzhen as the case study, our study identifies typical morphological categories of building density and typology, and explores the relationship between these morphological categories and urban vitality. The overall interpretation of our regression models is in line with theoretical predictions made by Jacobs (1961) and Montgomery (1998). Although our analysis is exploratory, it moves a step forward and supplements classical urban design theories with quantitative measures. The results suggest that building typology tends to play a more important role than building density in inducing urban vitality. More specifically, “block” and “strip” typologies are associated with significant positive effects on urban vitality, even when the effects of building density are accounted for. Substantive insights from this study can be used for urban planning and design in China and other emerging economies. Moreover, the quantitative weighting of key morphological features could be used to evaluate urban vitality of individual sites and identify appropriate design interventions in an evidence-based manner. For example, a GIS tool can be developed to calculate the morphological features of individual designs and “convert” these features back to a score of “vitality” using the corresponding quantitative weighting.

Our approach has several limitations. First, small catering businesses only represent one specific dimension of urban vitality. Other analyses using different proxies may or may not generate similar results. Further analyses are required to benchmark our analysis with alternative measures of urban vitality. Second, while urban vitality is a reflection, in part, of the intended uses in different times of the day, the current POI dataset lacks a temporal dimension. Information about human-behaviors throughout the day should be included to increase the robustness of the analysis. However, many potential datasets, such as cell phone data, are hard to collect due to privacy issues and may not have the high spatial resolution required in urban morphology and urban design. Third, our analysis does not include information about building age, although (the mixture of) buildings of different ages were highlighted in existing theories. Nevertheless, Shenzhen does not have many “old buildings” as the entire city was built from scratch since the 1980s, and therefore the influence of building age may be less significant than that in Western cities where Jane Jacob developed her theories.

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**Disclosure statement**

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