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Complex Power: An Analytical Approach to Measuring the Degree of Urbanity of Urban Building Complexes

Shuchen Xu, Yu Ye, and Leiqing Xu†

Department of Architecture, Tongji University, 1239 Siping Road, 200092 Shanghai, China

Abstract

The importance of designing urban building complexes so that they obtain 'urban' power, rather than become isolated from the surrounding urban context, has been well recognized by both researchers and practitioners. Nevertheless, most current discussions are made from architects' personal experiences and intuition, and lack a quantitative understanding, to which obstacles include an in-depth exploration of the 'urban' power between building complexes and the urban environment. This paper attempts to measure this feature of 'urban', i.e., 'urbanity,' through a new analytical approach derived from the open-data environment. Three measurements that can be easily collected though the Google Maps API and Open Street Map are applied herein to evaluate high or low values of urbanity. Specifically, these are 'metric depth', i.e., the scale of extended public space, 'development density', i.e., density and distribution of point of interests (POIs), and 'type diversity', i.e., diversity of different commercial types. Six cases located in Japan, China and Hong Kong respectively are ranked based on this analytical approach and compared with each other. It shows that Japanese cases, i.e., Osaka Station City and Namba Parks, Osaka, obtained clearly higher values than cases in Shanghai and Hong Kong. On one hand, the insight generated from measuring and explaining 'urban' power would help to assist better implementation of this feature in the design of urban building complexes. On the other hand, this analytical approach can be easily extended to achieve a large-scale measurement and comparison among different urban building complexes, which is also helpful for design practitioners.

Keywords: Urban building complex, Points of Interests (POI), Urban context, Complex power, Urbanity

1. Introduction

1.1. Urban building complexes and Urbanity

Nowadays, urban building complexes have become a typical feature of high-density development, due to their advantages in achieving intensive and multi-functional land use, promoting high-quality public space and enhancing development competitiveness (Wang, 2008). The development of urban building complexes has been the subject of much attention in East Asia, where population density and intensive land use conflicts are prominent features, and because people believe that urban building complexes will be one of the better choices for solving the needs of high-density residential development (Wang et al., 2010). Therefore, a large number of studies about the development of urban building complexes have been made in the past several decades.

The concept of the "urban building complex" is developed from the "building complex". According to Wang and Wang (2014), the urban building complex herein represents a functionally aggregated and land-intensive building with urban functions. An urban building complex usually integrates five core functions: commercial, retail, business office, hotel catering, apartment house and entertainment. In addition to the multi-functional development feature inside the complex, it often connects spatially and structurally with the urban pedestrian network in both horizontal and vertical dimensions, which extends across multi-level building spaces into urban context. This concept leads to the discussion of "the urbanity of the urban building complex" in this paper.

The "urbanity" term used herein does not encompass the same broad meaning as in sociology. Instead, it focuses on the diverse and lively atmosphere generated from good public spatial qualities. The importance of urbanity has been widely discussed. For instance, the European Commission's Green Paper on the Urban Environment (1990) claimed that urbanity (or in their words, 'life in the diverse and multi-functional place', should be considered a fundamental issue, rather than a luxury. Many scholars also emphasize the importance of creating lively, vibrant places rather than soulless developments (Buchanan, 1988; Marcus, 2010).

Nevertheless, the concern of the "urbanity" of the building complex is still rare in current studies. Existing research mainly focuses on functional composition and spatial organization inside the urban building complex. Just as Wang et al. (2010) mentioned, the interior space, and

†Corresponding author: Leiqing Xu
Tel: +86-13901982803; Fax: +86-21-65986707
E-mail: leiqingxu@163.com

the complementarity and symbiotic relationship between the interior functions, are the two main focuses of a study of urban building complexes. This is partly because the functional and spatial presentation of the diversification and multi-level development have been well recognized as main features of urban building complexes by architects and developers. However, in order to make sure the development of the urban building complex could bring more benefits for the public and assistance in place-making, it is necessary to extend the scope of the study to the surrounding environment and adjacent space systems within the urban context (Feng, 2003; Cui et al., 2013).

1.2. Understanding the Degree of Urbanity in an Urban Building Complex

The first step to measuring the urbanity of an urban building complex is to define appropriate measurements for this concept. According to a set of studies between urban form and urbanity (Ye and van Nes, 2014; Ye at al., 2016), the degree of urbanity can be measured based on the integration of three issues – accessibility, density, and diversity. Therefore, if we allow for simplification, 'accessibility' can be measured based on the total length of extended public space from the urban complex itself to surrounding built environment. The 'density' and 'diversity' factors can be measured based on the numbers and commercial types of stores, offices, etc., inside the extended public space.

Then the next question is how to measure 'accessibility', 'density' and 'diversity' from the perspective of the urban building complex. Architects' personal experiences and intuition cannot help too much in this area, and the lack of a quantitative understanding obstructs in-depth exploration in this direction.

1.3. A New Data Environment Brings New Research Possibilities

Recent technological developments have brought the emergence of a new data environment, which includes a large amount of geo-referenced urban data, reflecting both the physical aspects of space and the related functions based on them. In contrast to the past, when most data was hand-picked, expensive to collect, and time-consuming to process, the new data environment, including "big data" and "open data," helps to present physical data regarding urban form and people's experience of it in a new, accurate and consistent way (Batty, 2013). This new data environment enables us not only to study and grasp the spatial characteristics on a macro scale, but also to study and observe on micro scales, which thus can be applied to both urban design and architecture studies (Liu et al., 2015).

The rise of open-access online maps, e.g., Google Maps, Open Street Map (OSM), and their Application Programming Interfaces (APIs) provide great convenience for researchers to access data about building structures and points of interest (POIs), representing functions inside. According to the definition of a geographic information system (GIS), a POI represents anything that can be abstracted as a point, e.g., a house, shop, lavatory or bus station,



Figure 1. An illustration of points of interests (POIs) in urban building complexes.

etc. Each POI contains information such as place name, category, address, latitude and longitude and nearby facilities (Fig. 1).

Therefore, the online map API that provides both floor plans and POIs are important data sources for our study. On one hand, it is an open-accessed data for everyone to make sure it can be edited and updated quickly, which ensures the high accuracy of the information. On the other hand, these data can be easily collected through computer programming, which would help to run large-scale simultaneous comparisons. Based on that, we can attempt to develop an analytical approach that is applicable to the study of urbanity in urban building complexes. Benefiting from the continuous features of POI data in both interior and outside spaces of urban building complexes, our study could integrate the consideration of an urban building complex with its surrounding built environment, in order to measure its degree of urbanity.

Following this introduction, section 2 is the research framework illustrating the research design, information about the research case and data, and explanations of the analytical framework. Section 3 consists of analyses and results of the selected cases. Finally, the discussions and conclusions of this research are illustrated in sections 4 and 5.

2. Research Framework

2.1. Research Design

This study attempts to establish new ground in the following two directions: (1) extending the research focus of urban building complexes from interior spaces to the surrounding urban environment, and (2) applying open data to the measurement of the degree of urbanity in urban building complexes. The open data herein includes floor plans and POIs collected from map APIs.

Specifically, this research assesses high or low values of 'urban power' based on three measurements. The first one is total length of extended public space from the urban building complex to the surrounding environment, the so-called 'metric depth'. The second is the density and distribution of points of interest (POIs) in this extended public space, the so-called 'development density', and diversity of different commercial types in this extended public space, referred to as 'type diversity'. The integration of high or low values of the three measurements would provide a final evaluation of the urbanity of an urban building complex (Fig. 2).

The extensions from urban building complexes to surrounding built environments are usually accomplished through a multi-level pedestrian system, which can be found at the underground, ground, and above-ground floors. In order to simplify this complex system, this study focuses on the underground floor, where most extension space exists[1]. The POIs collected on the ground and above-ground levels will be converted into the focused underground space with a reduction factor to allow three-dimensional consideration in this analysis (Fig. 3). Specifically, the reduction factor herein is calculated following the standard distance-decay model $I \propto 1/d^2$, where I is interaction space (underground level) and d is distance. The calculated results will be shown in round figures to make the results more readable.

2.2. Case Selection

The urban development paradigms of East Asian megacities have plenty of similarities, thus allow in-depth comparable studies among different cities and countries. Osaka

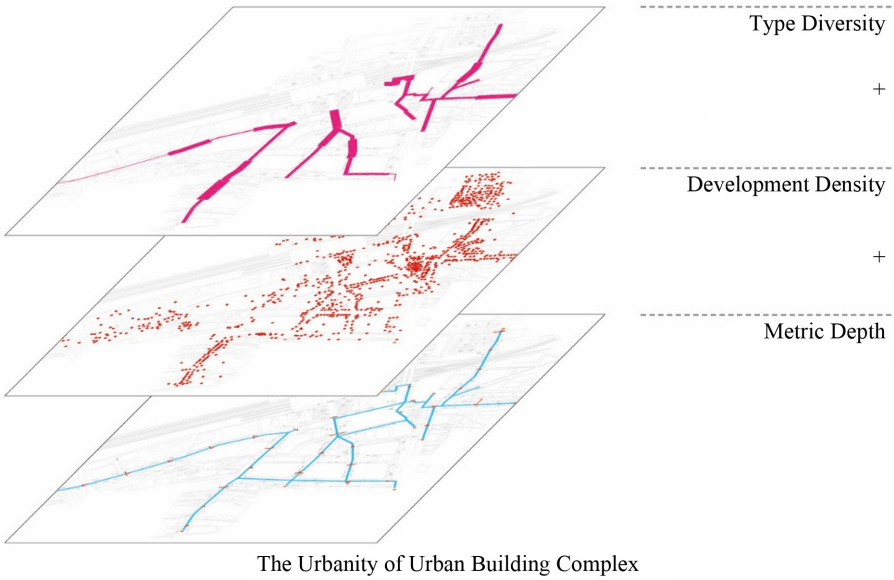


Figure 2. The three measurements of urbanity of urban building complex.

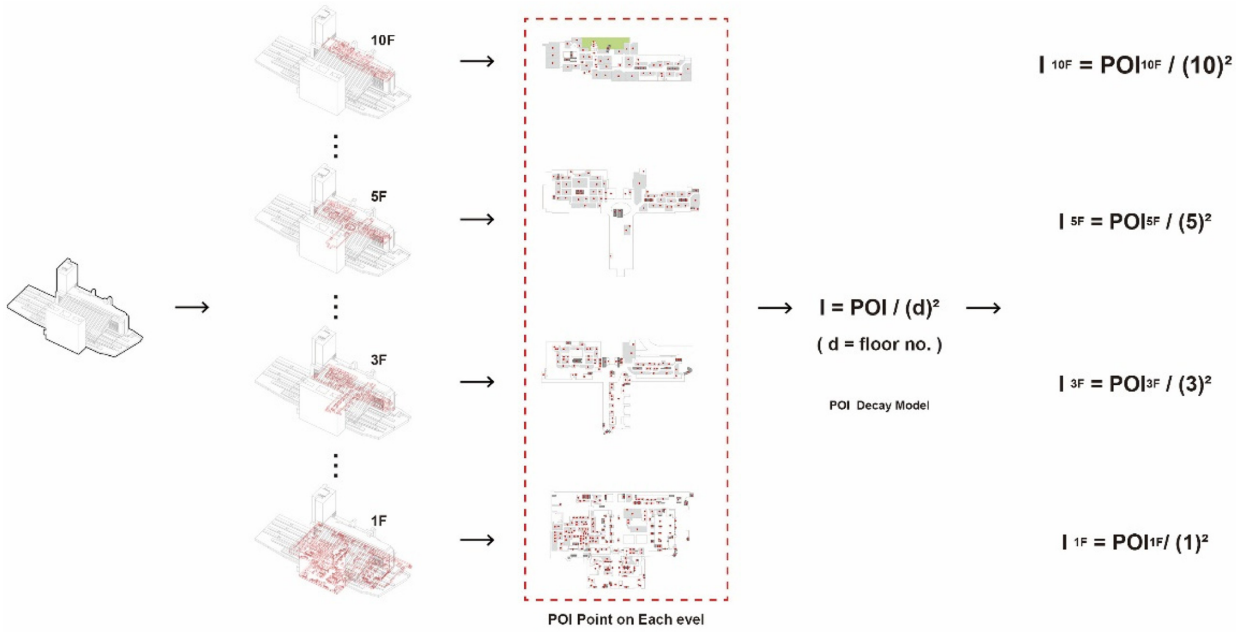


Figure 3. Converting multi-level POIs into the focused underground public space through distance decay model.

(Japan), Hong Kong and Shanghai (China) are the most representative megacities in their countries and regions, which have been chosen as cases. Specifically, the researcher selected urban building complexes located in the respective city centres, . because urban building complexes inside city centres tend to show high or low values of urbanity, while urban building complexes in suburban areas tend to be isolated from their surrounding environments.

In Osaka, Osaka Station City (OSC) and Namba Parks (NP) are selected as research cases. Shatin New Town Plaza (NT) and Langham Place (LP) are chosen in Hong Kong. The Shanghai case is Wujiaochang Wanda Plaza (WD) and Jingan Temple Jiu-Guang Department Store (JG) (Table 1). The six cases above have several similarities supporting comparable studies. First, all of them are located in the centre of the city-level commercial area. Second, all of them are composed of department stores, catering, entertainment, parking spaces, and office towers. Moreover, all six cases have vertical or horizontal transport links with neighbouring rail transit stations and urban areas at multiple levels, presenting the three-dimensional development characteristics of urban building complexes, both in function and space. These features ensure that they are typical cases that can be analysed with the same approach.

2.3. Data Collection

In order to make sure this analytical approach can be extended into other research cases in the future, we choose Google Maps and Open Street Map, two open-source online maps, as the data sources from which to collect the urban building complex floor plans and POIs. Specifically, the floor plans illustrating urban building complexes and commercial facilities are mainly collected by Google Maps. In addition, Yahoo Map Japan is also used as a supplement because it has higher resolution results for underground commercial passageways in Japan. Moreover, Open Street Map provides additional information, such as road network structure, street building forms, etc.

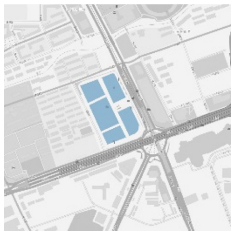
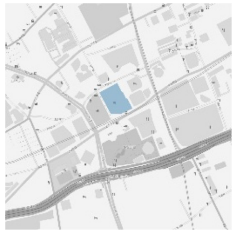
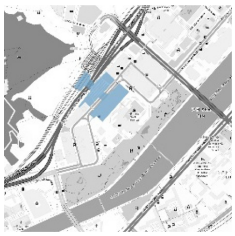
The POIs' geo-references, functions and other information within the research area of the urban building complex cases are collected through *R*, a computer language and environment commonly used for statistical computing and analyses. We use *R* to visit the application programming interface (API) of online maps for collecting detailed information of each POI, which are then illustrated on GIS platform. In detail, the name, functional category, distribution and densities of POIs in surrounding areas of the study cases were collected.

Due to the limitation of national policy, Google Maps cannot be accessed in mainland China. Thus, we selected Amap (Gaode) as the alternative in the case study of Shanghai. The number of POIs in each of the six cases involved in this study has been collected, including interior space, extended space and other space directly connected to the extended space, vertically and horizontally.

2.4. Analytical Approach

A set of analytical rules have been developed in this study to objectively measure the degree of urban building complex cases. All the data needed for these rules can be automatically accessed through the integration of computer programming and open data. By this method, this analytical approach has the potential to be easily applied in

Table 1. The case studies: Six urban building complexes

Urban building complex	Wujiaochang Wanda Plaza	Jingansi Temple Jiu-Guang Department Store	Osaka Station City
City	Shanghai	Shanghai	Osaka
Construction Area (m^2)	400,000	91,613	245,000
Floor No.	25F	9F	28F
Underground Floor No.	2	1	2
Rail Transit Staion No.	1	2	6
Nolli Map			
Urban building complex	**Namba Parks**	**Langham Place**	**Shatin New Town Plaza**
City	Osaka	Hong Kong	Hong Kong
Construction Area (m^2)	297,000	17,000	1,300,000
Floor No.	9F	15F	9F
Underground Floor No.	2	2	1
Rail Transit Line No.	2	1	1
Nolli Map			

many other cases.

This study assumes that the urbanity of the urban building complex should be presented and reflected by how the complex extends its internal functions to the surrounding urban environment. First, the underground space of the case will be abstracted into a basic topological form. In this step, the axis of the underground public space is generated by taking the projection line of the ground contour of the urban building complex on the underground plan as a starting point and extending it outward along the axis. It should be mentioned that the underground space and extended public space of the study cases are often closely related to the spatial and functional boundaries, and cannot be clearly identified. To solve this problem, we define the starting point of the topology axis as the point where the axis meets a significant spatial widening or narrowing, or enters a significant channel-shaped space, starting from the underground projection line of the ground contour. The end of the axis will be defined as a termination point or sudden decrease in the width of public space.

Second, the POI data reflecting the density and diversity of functions inside extended public spaces will be collected. In order to illustrate the reduction factor from the urban building complex towards surrounding areas, we divide the spatial topology axis by 100-meter units into several segments and calculate the POI amount in each segment. The final evaluation of the urbanity of the urban building complex will be given through integrating the high or low values of the three measurements.

3. Analyses and Results

The data of six urban building complexes in Osaka, Hong Kong and Shanghai were compared and analysed as an exploration of mapping this special 'urban power.' The three measurements discussed above are applied and illustrated first. The integrated final results are shown later.

3.1. The Scale of Extended Underground Public Space

As Table 2 and 3 show the metric depths of underground public space of the six study cases are shown below. The number of axes reflect the depth of urban building complexes integrated with the surrounding urban environment. It is clear that Osaka's cases are larger than their counterparts in Hong Kong and Shanghai regarding the maximum, minimum and average values of spatial depth. The number of axes reflects the degree to which the urban building complex extends to the surrounding urban context

Table 2. The extended underground public space among the six cases

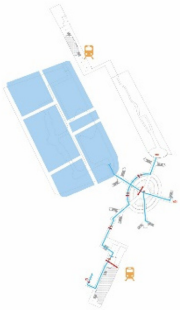
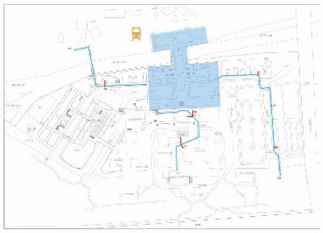
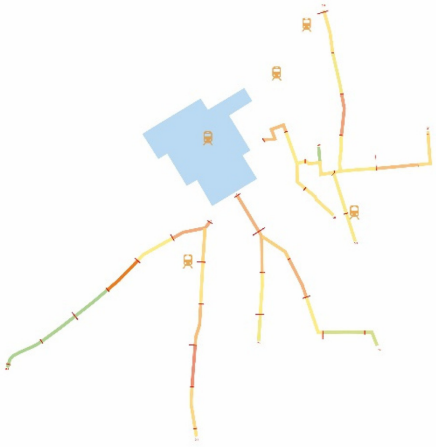
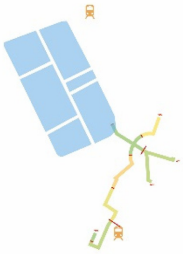
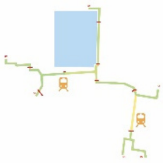
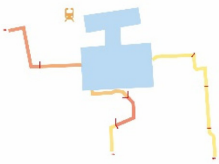
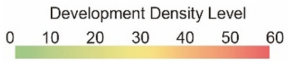
Case	Osaka Station City	Namba Parks
Osaka		
Case	Wujiaochang Wanda Plaza	Jingansi Temple Jiu-Guang Department Store
Shanghai		
Case	Langham Place	Shatin New Town Plaza
Hong Kong		
Legend	Extended Space Axis	Rail Transport Station / Urban Buiding Complex

Table 3. Metric depth of extended underground public space among the six cases

	Case	Axis Amount	Min.	Max.	Mean
Spatial Depth	Osaka Station City	9	342	704	527
	Namba Parks	4	189	795	496
	Langham Palace	3	110	210	160
	Shatin New Town	5	252	372	298
	Wujiaochang Wanda Plaza	6	170	421	239
	Jingan Temple	4	114	396	267

within the region and the possible number of walking paths pedestrians can choose. Obviously, the larger number of paths connotes more choices people can make when they need to go to specific destinations or simply walk around the area. The cases in Shanghai represented a relatively medium size of extended public space, followed by cases in Hong Kong.

Table 4. POI density in the underground extended public space among the six cases

Case	Osaka Station City	Namba Parks
Osaka		
Case	Wujiaochang Wanda Plaza	Jingansi Temple Jiu-Guang Department Store
Shanghai		
Case	Langham Place	Shatin New Town Plaza
Hong Kong		
Legend		 Rail Transport Station  Urban Buiding Complex

3.2 Density and Distribution of POIs in the Extended Public Space

Table 4 shows the density of POIs on different axes in the underground extended space of the urban building complexes. The POI density herein reflects the amount and distribution of functional spaces that can be used by pedestrians in these extended spaces. In Osaka's urban building complex and the underground public space extending from it, the highest density of POIs in total and per segment can be found, which is due to the close connection of the surrounding urban environment with the urban building complex.

Table 5 shows the reduction rate of POIs in the underground extended public space among different cases. It is apparent that Osaka Station City and Namba Parks not only have highest density but also have lower reduction rates, compared with the other cases in Hong Kong and Shanghai. Although the general underground extended spaces of Hong Kong are typically the smallest, they tend to obtain relatively higher average number per segment, due to the city's strongly vertical development feature. The two cases in Shanghai reported the fastest reduction rate of POIs.

3.3. Diversity of Different Commercial Types

The diversity herein is evaluated based on the mixture of different commercial types. Considering the fact that most urban functions inside extended public spaces are either retail stores or restaurants, we define the high value of density as the co-representive of retail and dining functions with different building scales. The low value indicates only one main function, or indicates that no POIs can be found. The rest is indicated by medium values. As shown in Table 6, a wider axis segment represents higher diversity in the extended public space. The general trend is similar with the analysis of the density issue. The Osaka cases show highest diversity, followed by Hong Kong and Shanghai, respectively.

4. Discussion: Integrating the Three Measurements

From the perspective of metric depth, i.e., the scale of extended public space, urban building complexes in Osaka tend to demonstrate the largest underground extended public spaces, from the urban building complex itself to surrounding built environment. Meanwhile, Osaka's case shows a stronger connection with metros and other urban infrastructures. The Shanghai cases rank second, and followed by the Hong Kong cases.

From the perspective of development density, i.e., density and distribution of POIs inside the extended public space, Osaka Station City and Namba Parks have much higher POI density compared with other cases in Shanghai and Hong Kong. Meanwhile, the distribution of POIs tends to show a relatively lower reducing ratio. This feature lends a positive value to the urbanity, publicness and pedestrian quality of the urban building complex. Hong Kong cases benefiting from their high-density development strategy thus report higher POI density and lower reducing rates than cases in Shanghai. In other words, many extended public spaces in Shanghai cases are developed as pedestrian tunnels, rather than as attractive urban spaces. There is a lack of enough POIs, e.g., retail stores, cafes, etc., to provide urban functions and support diverse activities.

From the perspective of type diversity, i.e., the diversity of POIs inside the extended public space, the situation is quite similar. Various commercial types and scales can be observed inside the extended underground public spaces of the Osaka cases, from large supermarkets, to medium-size retail stores to small cafes. A relatively high diversity of POIs can also be founded in Hong Kong cases. In turn, diverse functional types are relatively lacking in the Shanghai cases. There are many public interfaces without appro-

Table 5. The reduction factor of POI density in the Underground Extended Public Space

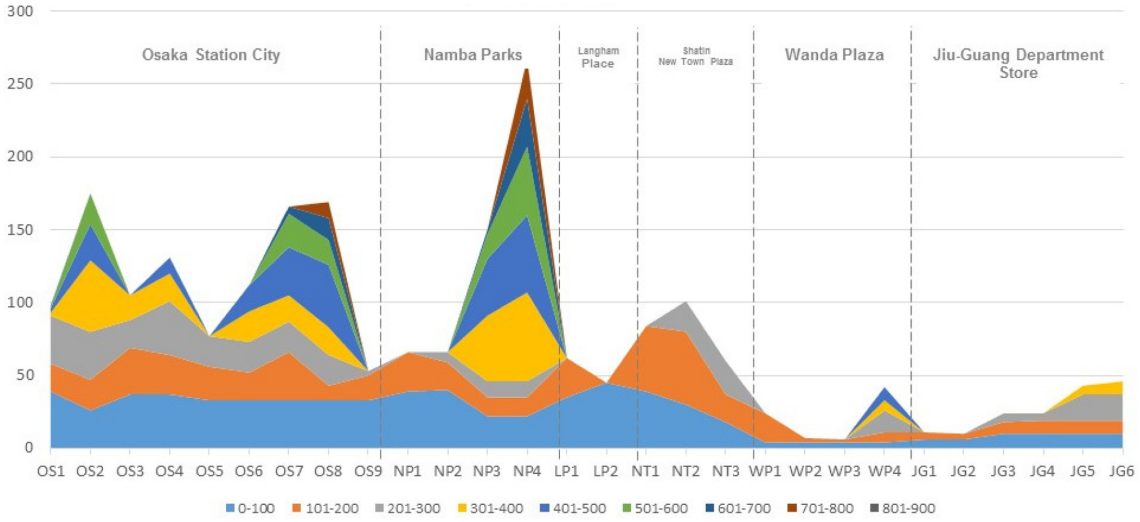
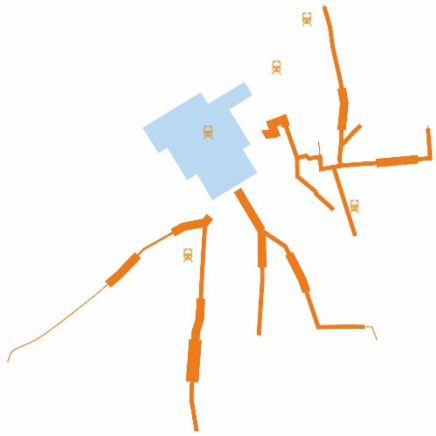
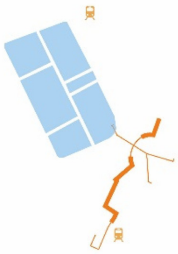


Table 6. Type diversity of POIs among the six cases

Case	Osaka Station City	Namba Parks
Osaka		
Case	Wujiaochang Wanda Plaza	Jingansi Temple Jiu-Guang Department Store
Shanghai		
Case	Langham Place	Shatin New Town Plaza
Hong Kong		
Legend	Type Diversity Level (High-Medium- Low)	Rail Transport Station / Urban Buiding Complex

priate functions placed adjacent to them.

Based on the discussions above, we propose a conceptual model integrating all the three measurements together to provide a direct illustration of the degree of urbanity of the urban building complex, including the metric depth into the urban context, development density and functional diversity (Figure 4). In short, the two Osaka cases obtain high values in all the three measurements,

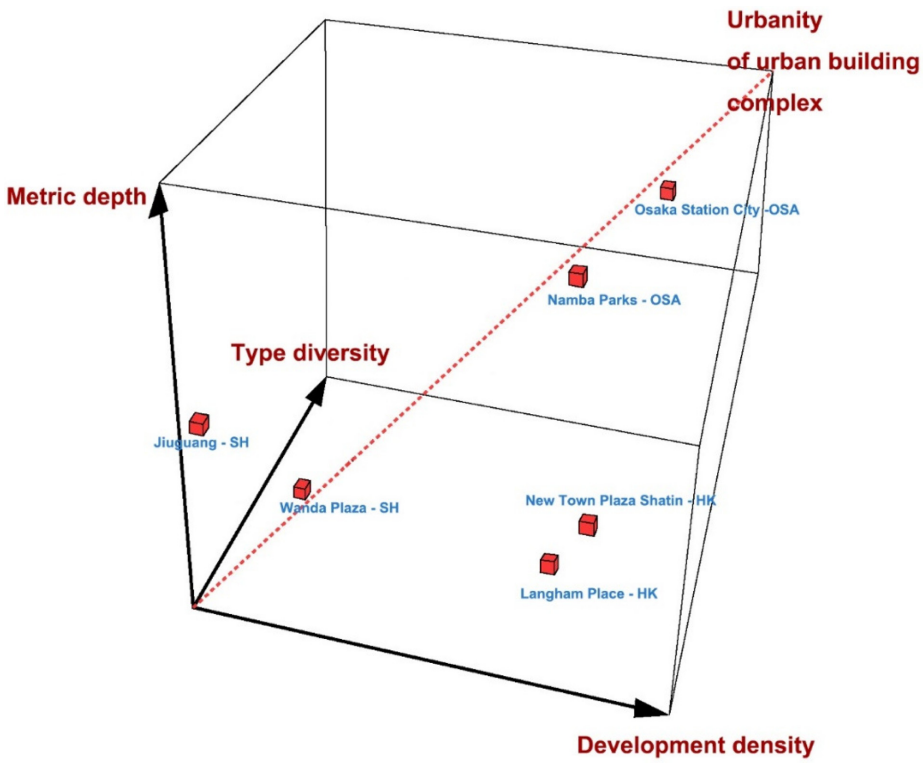


Figure 4. The conceptual model integrating all the three measurements as a direct illustration of the urbanity of the urban building complex.

and thus show the highest degree of urbanity. The degree of urbanity of Hong Kong cases ranks second, reporting relatively high values in density and diversity aspects, but relatively lower values in the scale of extended public space, when compared with the Shanghai cases. In turn, the Shanghai cases reported larger extended public spaces but lower density and diversity, as measured through POI distribution. In other words, the degree of urbanity of urban building complexes in Shanghai cases have the potential to be improved through appropriate design interventions.

5. Conclusions

In short, this study attempts to establish an analytical approach using open data that can be easily collected. Although the research framework can be understood to a certain extent as a simple mapping of existing data, it actually makes some contributions to the study of urban building complexes.

First, the analytical approach established in this paper provides insights for understanding the role of the urban building complex in the urban context, which is an important issue for high-density Asian megacities. Rapid urbanization in the past decades has resulted in the construction of many urban building complexes for these megacities. Nevertheless, the question of whether these urban building complexes are really 'urban' deserves an insightful answer. This workable approach contributes to illustrate the degree of urbanity of urban building complexes, which was previously an unmeasurable sense of "atmosphere" that was usually judged by designers' intuitions. Now it can be utilized as a clear index for assisting the measurement of the "unmeasurable."

Second, this analytical approach can be easily applied into large-scale comparisons among plenty of urban building complexes in many cities, since all the data can be collected through computer programming. In other words, this study is a response to the growing new data environment (open data, and big data with detailed geo-references), which is able to support studies with detailed analyses, but also can be applied at a large scale. The high or low values in the three measurements could be used as a guide for appropriate design interventions.

Nevertheless, there are also several limitations to this study. Many other spatial features that might affect degrees of urbanity, including both physical aspects like the weights of different functions, publicness, and non-physical aspects like real-time pedestrian distribution, etc., are not included in this study. A more comprehensive analysis incorporating these features should be conducted in future research. Additionally, it might be helpful to add the street configurational features between urban building complexes and surrounding environments, which can be

achieved with some newly-developed 3D space syntax tools.

To conclude, emerging new data have already brought new quantitative possibilities to the design of urban building complex. There is an increasing scholarly interest in introducing new quantitative thinking into the previously qualitative and intuition-based fields with an urban viewpoint, which thus helps to measure the 'unmeasurables' (Ewing and Clemente, 2013). The work focusing on the building complex's urban power illustrates a good response to this trend. It presents at least an attempt to combine science and design thinking to improve the design of more attractive urban building complexes.

Acknowledgements

We want to express our thanks for Prof. Zhendong WANG's kind help and guidance on this paper. The study is supported by the National Natural Science Foundation of China (NSFC) (Grant No. 51378355 and 51178318).

Notes

This study focuses on the underground floors due to two reasons. On one hand, it is hard to identify a clear and reasonable analytical area if by using the ground level as the research focus. On the other hand, most above-ground level public space usually is not systematic enough to support a continuous analysis.

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