

Research Article

Between morphology and function: How syntactic centers of the Beijing city are defined

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Abstract

The application of big data provides a new angle of view on investigating whether, and if so, how to define the urban center through analyzing urban spatial morphology intrinsically interacts with its functions. This article, using empirical research of the Beijing city, first seeking to explore spatial configuration—the complex relation between any pair of individual spaces regarding other contextual spaces – of urban network collected from Baidu. And then, focusing on conducting a statistical correlation between the configurational patterns of urban network and the aggregation patterns of functions. Based on the different patterns of aggregation or dispersion of those functions we discussed, as well as the multi-scale syntactic location choice underlying those patterns, it then can be identified four types of centers in the Beijing city, which may be called active center, ordinary center, brand centers and specified center, as well as the extent to which spatial layout influences functional distribution.

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1. Introduction

Urban centers have been usually defined in terms of population density, land use, social activity, movement intensity, telecommunication, and even block size. For example, a new functional method for identifying the limits of English town centercenters, combining GIS analysis of land use and demography with reviews of informed opinion, has been established by Professor Batty and his colleagues (Batty et al., 1998). However, what they had not elaborated was that the term of ‘center’ applied to settlements has both functional and morphological dimensions, which are inseparable. Theoretically, this can be arguably embodied as a distinctive concentration and mixture of activities in a certain area, spatially a certain position for that area in the settlement as a whole (Hillier, 1999).

From the perspective of space, the relation between morphology and function comprises two main aspects. One is dealing with spatial or geographic distribution patterns of socio-economic activities, as well as their functional relationships and the mechanisms of generating those relations and patterns, in spite of that the socio-economic activities can be measured by land uses, demographic features, creative industries, employment rates, informational

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intensities, or even traffic data (Burgess, 1925; Gordon, Richardson & Wong, 1986; Hoyt, 1933; Harris & Ullman, 1945; Hall, 2004; Hall & Pathy, 2006; Klootsterman & Lambregts, 2001; Porter, 1998; Long & Liu, 2015; Scheffler, Schirru & Lehmann, 2012). Another is seeking to investigate physical forms and the morphological mechanism underlying functional transformation, although the morphological features can be interpreted as block sizes, building densities, spatial forms, sight lines, frontage patterns, physical connections, or even topological relations (Duany & Emily, 2002; DPZ, 1999; Duany & Emily, 2002; Freeman, 1979; Hillier, 1973; Kier, 1977; Kostof, 1992; Katz, 1994; Lynch, 1961, 1984; Parolek, Parolek, & Crawford, 2008; Marshall, 2011; Rossi, 1984; Sabidussi, 1966). The first approach more focuses on the patterning of functions usually represented by land uses or traffic movements; the second approach gives more emphases on physical form and human behavior. However, both these two perspectives have no clear boundaries. To a large extent, spatial distribution mainly explored by the first approach relates to, or is involved in, spatial making primarily investigated by the second approach. Their relationship has not been fully elaborated.

In addition, in the community of GIS, numerous methods have been implemented for integrating spatial data sets aggregated from different mapping agencies or professional geodata providers (Yuan, Zheng, & Xie, 2012; Yang & Zhang, 2015; Yang, Zhang, & Lu, 2014). For example, Scheffler (2012) integrated the Points of Interest (POI)¹ from different VGI platforms to enrich OSM POIs based on a geo filter and string matching. As the public data of POI captured from the website of Baidu² 2012 offers a way of exploring urban functions at finer scale. This paper, by conducting a pilot study of the city of Beijing, seeks to investigate how urban functions (e.g. business, public service, parking and etc.) represented by the POIs are distributed across the Beijing city, and how far this relate to spatial morphology of Beijing. Further, to define the urban centers by clarifying configurational rules underlying the distribution phenomenon of the functions represented by the POIs of Beijing.

2. Methodology

Based on the intention, in this paper, space syntax was used to describe the urban spatial structure, and POIs were used to define the urban functions. The central idea of space syntax is spatial configuration, defined as the complex relation between any pair of individual spaces regarding other contextual spaces. It can be treated to play a key role in bridging physical form with function, in that space is not simply an inert background of human behaviors, but an intrinsic feature of functional arrangement (Hillier & Hanson, 1984; Hillier, 1996; Hillier & Iida, 2005). Therefore, investigating the mechanism of relating spatial configuration to urban functions will help us to give a better understanding of the optimization of urban structure.

Space syntax has developed several variables to measure spatial configuration of urban network. The most widely-used variables are choice calculating how often distance-minimizing routes between every pair of spaces pass through each space up to a certain radius, and total depth measuring how close each space is to all other spaces up to a certain radius (Hillier, Penn, Hanson, Grajewski, & Xu, 1993; Yang & Hillier, 2007; Hillier, 2009; Hillier, Turner, Yang & Park, 2010). The most recent variable is a ratio of choice and total depth – called syntactic efficiency in this article—with an aim of getting rid of the effect of system size (Hillier, Yang, & Turner, 2012).

As for POIs, taking Beijing as an example, the paper is based on a multivariate data comprising of 649,359 POIs in total, which is obtained mainly via data mining techniques. As maps are a basic way to describe urban form, which mainly consists of streets and buildings, and the POIs data can describe the basic information of each building's function. Thus, the POIs data may, to a certain extent, show the distribution pattern of urban functional zones.

Based on the space syntax and POIs, this paper firstly represents the syntactic feature of the Beijing city; And then, the configurational feature of each type of function is investigated; Finally, the paper focused on the normalized choice developed to get rid of the effect of system size.

In order to represent the syntactic feature of the Beijing city, a new method was proposed. First, a regular grid with 300 m by 300 m cells, which was defined by the block scale in Beijing, was applied to cover the Beijing city, and this provided a uniform spatial reference by which the syntactic and functional values can be assigned to each cell and then those two types of values can be compared with each other. Second, the road network of the Beijing city – downloaded from the website of

¹A point of interest, or POI, is a specific point location that someone may find useful or interesting. The term is widely used in cartography, especially in electronic variants including GIS, and GPS navigation software.

²Baidu, incorporated on January 18, 2000, is a Chinese web services company headquartered in the Baidu Campus in Haidian District in Beijing.

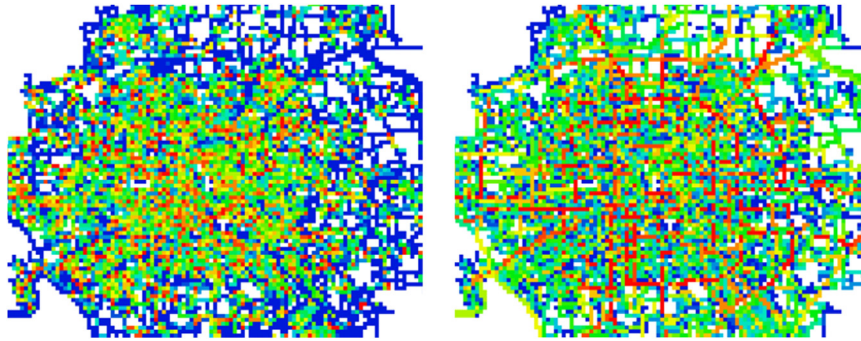


Fig. 1. The local syntactic efficiency pattern generated at the radius of 1 km (left) and the global pattern produced at the radius of 50 km (right).

Baidu – was simplified by using the tools of the GIS and then processed by the DepthMap to get syntactic values measuring morphological features. The mean of the syntactic values of all the segments locating within and intersecting with each cell boundary was calculated and then assigned back to the cell. Therefore, all the cells were colored according to the mean values, and lower values denoted by blue and higher values illustrated by red. In this way, the syntactic feature of the Beijing city was represented by those colored cells.

Another method was adopted in this paper to investigate the configurational feature of each type of function we examined at both global and local scales, and this helped us to understand spatial mechanism for allocating each type of function across the Beijing city. It was conducted in the following way. A 60 m-radius of buffer zone was produced for each POIs for the reason that 60 m-radius can relate each POIs to its closest segments; the mean of syntactic values of the segments within and intersecting with the buffer zone was calculated and then assigned back to the POI. Thus, the syntactic feature of the certain type of function – say that of catering – was examined by averaging the syntactic values of that type of function. Then, the scatter gram of the syntactic values at global and local radii – the local values on the horizontal axis and the global values on the vertical axis – was plotted to explore how each type of function chose its location according to the global and local scales of spatial configurations. As the radius of the processed map of the Beijing city is around 50 km, the radius of 50 km was selected to represent global scale; and as many Beijing communities usually have a radius of 1 km, this radius was then used to denote local scale.

In addition, this paper focused on the normalized choice developed to get rid of the effect of system size (Hillier et al., 2012) because it can be applied to make a comparison among the different sized sub-systems picked out by a fixed radius. This variable is computed by dividing choice by total depth, in which the choice calculates how often distance-minimizing routes between every pair of spaces pass through each space up to a certain radius, and total depth measures how close each space is to all other spaces up to a certain radius. In terms of interpretation, total depth can be treated as the kind of cost in that a person need to overcome all the possible distances to go to a certain destination from the surrounding places; and meanwhile, choice can be considered of as the kind of benefit in that a person living at one place need not go to other places, but can be encountered or watched by all others coming from the surrounding places. Therefore, the normalized choice can also be explained as a kind of syntactic efficiency, a ratio of cost and benefit (Hillier et al., 2012). The following will examine such syntactic efficiency of the Beijing city at both global and local radii.

3. Morphological features of the Beijing city

The different patterns of syntactic efficiency at global and local radii were captured. As Fig. 1 illustrated, the spaces with higher local efficiency – denoted by red cells – were discretely scattered across the whole Beijing, but the spaces with higher global efficiency – also represented by red cells – aggregated to form a kind of structure with stronger rings and radials. This suggests two kinds of models by which the spatial centers with higher syntactic efficiency, called *the efficient centers* here, are located at different scales. The local efficient centers are more discretely distributed across the city; and by contrast, the global efficient centers are more continuously allocated to generate the whole structure.

On reflection. When we observed the locally efficient pattern (Fig. 1 Left), more red, orange and yellow cells concentrated on the central district bounded by the 3rd Ring Road,³ and meanwhile, much fewer dark blue cells were found within the 3rd Ring Road. This demonstrates that the central district comprises more local efficient centers that are relatively better connected, compared to those located at the city edge. To large extent, this corresponds to the fact that the central district within the 3rd Ring Road has much more locally buzz areas than the edge district.

However, as we looked into the globally efficient pattern (Fig. 1 right), the higher efficient cells (the warmer ones), forming the kind of network, were more evenly extended across the whole city; and the ring structure was stronger than the radial structure, in that for example the radial line to the southeast faded away. In addition, the part of the ring structure to the east was clearer, as the 3rd and 4th Eastern Ring Roads were picked out by the red cells. In particular, the 3rd Eastern Ring Road has the highest global efficiency value and the 4th Eastern Ring Road has the second highest value. This seems to correspond to the Beijing CBD located around the 3rd and 4th Eastern Ring Roads. In other words, this at least demonstrates that the Beijing CBD has the highest syntactic efficiency at the global scale.

4. The multi-scale interaction between function and spatial configuration

4.1. The syntactic implication of the different functions

Then, how do those functional facilities choose their locations with respects to their surrounding structures? A buffer zone with a radius of 60 m of each POI was generated and then the syntactic efficiency (normalized choice) values of all the segments within and intersecting with the buffer zone were averaged. For each type of function, the mean of all the POIs denoting that type was calculated, and the scatter gram was produced to plot the syntactic efficiency at 1 km on the vertical axis against that at 50 km.

The primary analysis shows two cluster groups and three outliers, as Fig. 2 displays. The first cluster group, comprising commerce, catering, ATM, entertainment, hotel and public facility, seems to be globally and locally efficient. All of them are profit-oriented facilities, except public facility. Among them, ATM, commerce and catering, as major profit-oriented facilities, have higher global efficiency; and whilst, public facilities have the highest local efficiency. This suggests that the profit-oriented facilities are in general closer to the main structure of the Beijing city (though they are also located at local centers), and public facility seeks to situate at the most localized centers (though it is also placed near the main structure).

The second cluster group, consisting of public institution, public parking, education, business office and cultural facility, appears moderately efficient. All of them belong to public service, except business office. Among them, business office has the highest global efficiency, but the lowest local efficiency; and education has the lowest global value. To some extent, this implies two points. First, the public-service-oriented functions need not necessarily to be placed at the main structure of the Beijing city. Second, business office, as one specific type of profit-oriented function, needs to be relatively closer to the main structure, but not necessarily position on the local center.

However, the three outliers, namely industry, tourist spot and highway service facility seem to have much lower local efficiency, which suggests that they lack of well-structured surrounding areas. Highway service facility has the highest global efficiency, and tourist spot has the second highest global one. This demonstrates that both of them are woven into the main structure of the whole city. However, industry has the lowest global efficiency, and this confirms that industries, as the spatially independent places, are placed outside the main structure.

In general, it can be suggested that each type of function chooses its location according to the degree to which it needs to take advantage of a combination of global and local efficiency of urban structure. This can be called *the multi-scale syntactic location choice*.

³Beijing's urban transport is dependent upon the five "ring roads" that concentrically surround the city, with the Forbidden City area marked as the geographical center for the ring roads. The ring roads appear more rectangular than ring-shaped. There is no official "1st Ring Road". The 2nd Ring Road is located in the inner city. Ring roads tend to resemble expressways progressively as they extend outwards, with the 5th and 6th Ring Roads being full-standard national expressways, linked to other roads only by interchanges. Expressways to other regions of China are generally accessible from the 3rd Ring Road outward.

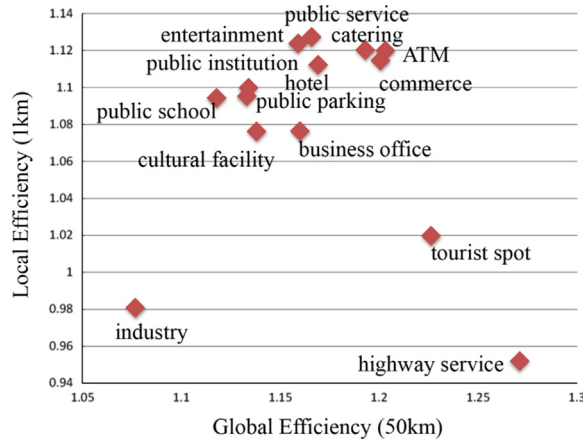


Fig. 2. The local and global syntactic efficiency values of different functions in the Beijing city.

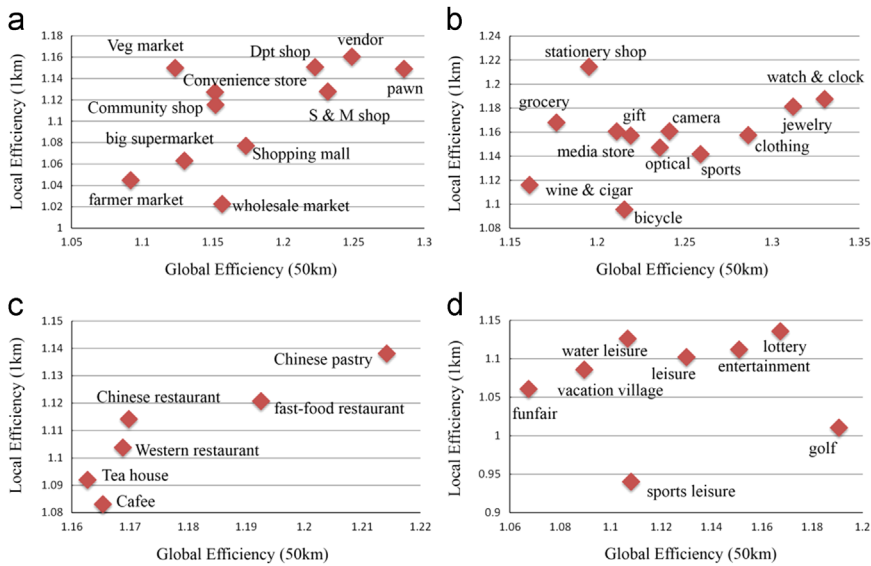


Fig. 3. The local and global syntactic efficiency values of commercial types (a), small and medium shops (b), catering facilities (c) and entertainment facilities (d).

4.2. An intricate combination of multi-scaled syntactic efficiencies

Then we move to investigate subtypes of those functions we examined before, in order to explore what kind of factors are involved in the multi-scale syntactic location choice. For example, the commerce group comprises pawn store, street vendor, department store, small and medium shop, vegetable market, convenience store, community shop, shopping mall, large supermarket, farmer market and wholesale market. The primary analysis demonstrates that several non-spatial factors affect the way by which each function chooses the location with the different degrees of syntactic efficiencies at global and local scales.

First, business size seems to influence the combination of global and local syntactic efficiencies, and this was mainly revealed by the case of commercial facilities. Fig. 3a shows the syntactic efficiency values of subtypes of commerce. Many small and medium sized commercial facilities, such as pawn store, street vendor, department store and small and medium shop, gain higher efficiency values at both global and local radii. The small commercial facilities targeting community market, such as vegetable market, convenience store and community shop, still have higher local efficiency values, though their global efficiency values are not high. This suggests that those facilities make use of spatial advantage of local centers.

By contrast, large commercial facilities have medium or low efficiency values. Shopping mall gains medium values at global and local radii; wholesale market has the lowest local values; large supermarket and farmer market have lower global and local values. The above analysis suggests three points: smaller commercial facilities are, higher syntactic efficiency they gain, and at least higher local efficient place they need to occupy; larger commercial facilities are, less they reckon on syntactic efficiency, and more they rely on business size; the medium sized commercial facilities also need to take certain advantages of both global and local efficient places.

Second, consumer preferences impact on the combination of global and local syntactic efficiencies. Fig. 3b further shows subtypes of small and medium shop, though all of them on average have higher local and global efficiency values compared to large commercial facilities. For example, Watch & Clock store, Jewelry and Clothing shops seem to occupy more globally efficient places that are perhaps closer to the main structure of the Beijing city. Stationery shop and grocery gain higher local efficiency, but lower global efficiency. Wine & Cigarette and Bicycle have the lower efficiency values at global and local radii. Compared to Watch & Clock store, Jewelry and Clothing shops, Stationery shop and grocery seek to attract community consumers and thus they usually have to choose community centers. And Wine & Cigarette and Bicycle targeting specific group of consumers need not make full use of those highly efficient spaces.

Fig. 3c displays different types of catering. Chinese pastry shop has the highest global and local efficiency values, which may be relate to the fact that Beijing local people (and the northerners) prefer food made from flour. Fast-food restaurants also locate at the more globally and locally efficient places usually passed by commuters. Chinese restaurants have higher efficiency values than western restaurants, and tea houses and café gain lower values than those restaurants. This may be due to the fact that the western restaurants in Beijing mainly target high-incoming people or those who prefer the western foods, and meanwhile, tea house and café in Beijing are usually quiet places for drinking or business talking. Bearing in mind, the above comparisons took account of relative values among the caterings, and in fact all subtypes of catering have higher efficiency values compared to other functions.

Fig. 3d shows subtypes of entertainment facilities. Most entertainment facilities, except golf playgrounds and sports leisure facilities, have higher efficiency values; and meanwhile, lotteries have the higher global efficiency values, but funfairs have lower global values. This suggests that most entertainment facilities occupy the local centers to attract local consumers, but some facilities funfairs seek to target specific consumers such as children and so need not take full advantage of globally efficient spaces. In addition, golf playgrounds are located at the globally efficient places, but sports leisure facilities are compatible with the places with low syntactic efficiency. Perhaps this may relate to the fact that the golf playgrounds attract high-incoming groups and the sports leisure facilities target sports fans.

Although the public-service-oriented facilities on average have lower global efficiency values than the profit-oriented ones, their location choices regarding multi-scale syntactic efficiency are also affected by the consumer preferences. As Fig. 4a shows, post office, hospital, public toilet, public parking, small public service and haircut are located at the spaces with higher global and local efficiency values. This implies that those facilities usually choose the places locating the intersections between the main structure and local neighbourhoods and thus offer the services to the people within and outside local communities. By contrast, laundries and community clinics are placed at the local centers, with higher local values and lower global values. This is partly due to that those facilities seek to serve to the locals rather than all the citizens; and auto service and repair centers and parks are closer to the main structure and farer away from the local centers, and this relates to their consumers come from anywhere of the Beijing city. In addition, bookstores have the lowest global efficiency values and moderate local values. This suggests that the bookstores in Beijing more function as the attractors to the people who are keen on reading and thus need not make full use of spatial configuration, either globally or locally.

Third, cultural or brand assets also play a role in choosing locations with the different degrees of syntactic efficiency. Fig. 4b shows different subtypes of tourist spot. Natural attractions have higher global values, but the lowest local values; and all the artificial attractions, though with higher local values, vary with global values. In particular, Chinese temples are located at globally inefficient places, but churches are situated at globally efficient spaces. This reflects that the difference in the Chinese and western religious cultures, that is, that Chinese temples often seek a rural place to avoid urban lives, but churches prefer urbanised environment. Fig. 4c demonstrates different subtypes of Chinese restaurants. Beijing cuisine restaurants have the highest local values, and this only corresponds to the food taste of Beijing locals. Compared to the average values of all the restaurants, those with higher global values, such as Jiangsu cuisine restaurants, seem to be luxury ones, and those with higher local values, such as Sichuan cuisine restaurants, have impacted on the Beijing catering market and culture at the early stage.

And Fig. 4d shows different subtypes of hotel. Luxury hotels (e.g. four and five star ones) occupy the more globally efficient places, but cheap hotels (e.g. hostel, as well as one, two and three star hotels) are situated at more

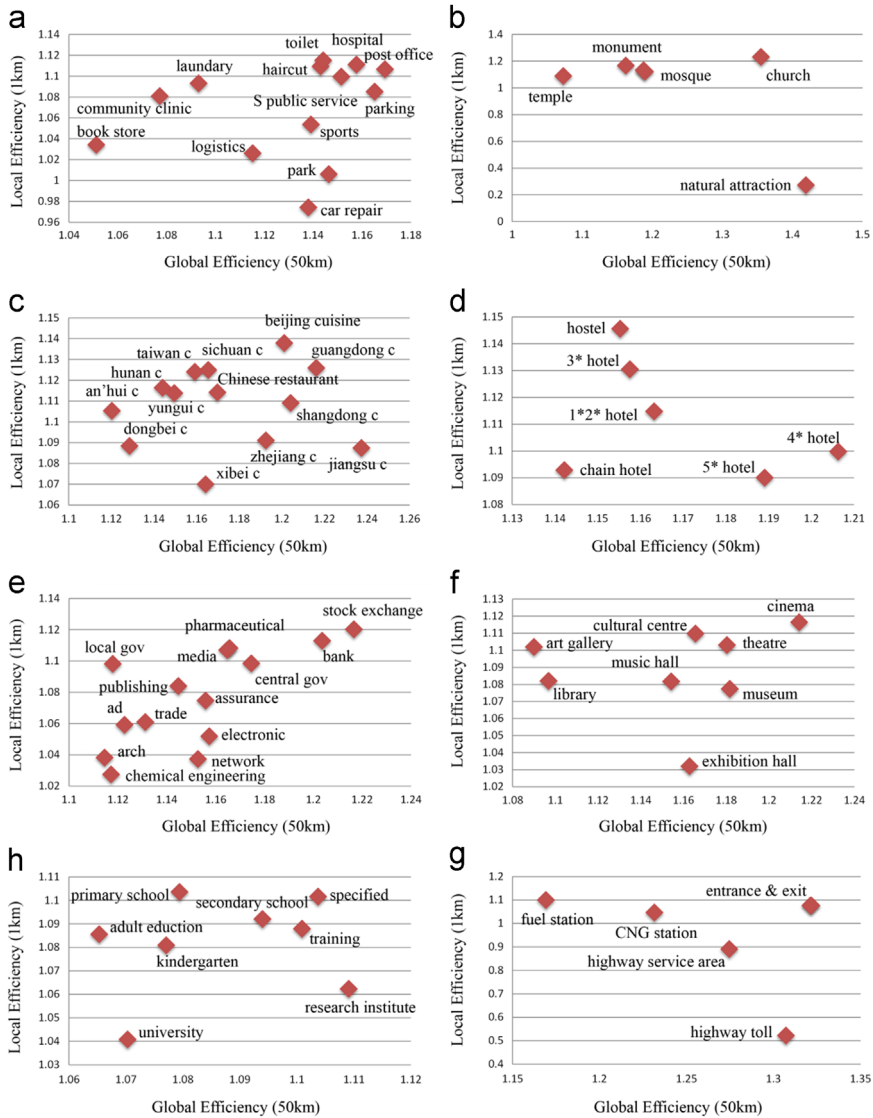


Fig. 4. The local and global syntactic efficiency values of public facilities (a), tourist spots (b), Chinese restaurants (c), hotels (d), business offices (e), cultural facilities (f), education facilities (g) and highway service facilities (h).

locally efficient spaces. This reflects the spatial values of the different branded hotels. In addition, chain hotels seem to choose the locations with lower values at global and local radii, and this suggests this kind of hotel reckons on the chain culture, rather than spatial location.

Fourth, business operation modes also influence the location choice regarding syntactic efficiency. Fig. 4e displays different subtypes of business offices and public institutions. Banks and stock exchanges occupy the most efficient places at global and local radii; pharmaceutical, media, insurance and publishing companies have relatively higher global and local values; advertisement and trading companies have the moderate values, and architectural and chemical engineering companies have the lowest values. This suggests that the companies offering high end services need to take full advantages of local and global places. In addition, electronic and network companies, as high-tech companies, have lower local values, but moderate global ones. Perhaps this may relate to the virtual services those companies usually provide and the real space may not become their focus.

And both central and Beijing local government administration institutions have almost the same local values, but the former has much higher global values. This can relate to the fact that the central government administration

institutions also play a role in demonstrating the national image of Beijing by arranging those buildings along the main roads, but the local administration institutions more concentrate on the local affairs.

Fig. 4f shows different cultural facilities. Cinemas have the highest values, both global and local, and this relates to its full market operation policy. Culture centers, theatres, museums and music halls, partly funded by the governments, have moderate global and local values. Exhibition halls seem to keep a distance from the locally efficient places, but art galleries and libraries concentrate on the local centers rather than the main roads. To some extent, more market operations they adopt, more efficient places (both globally and locally) they choose.

Fig. 4g shows different education and research institutes. Universities have lower global and local values; secondary schools, specialised secondary schools and training centers have higher global and local values. Primary schools, kindergartens and adult educations are placed at the locally efficient spaces, which usually function as local centers; research institutes are situated at the globally efficient places. It seems that the different ways of education or research impact on their location choices.

Fig. 4h displays highway service facilities. In spite of the fact that they all have higher global efficiency values (above 1.15), toll gates as well as entrance and exit ramps take full advantage of global efficiencies of the highway system, and those ramps also relate to their local surroundings that offer better connections to the highway. The fuel and gas stations have higher local values and this suggests that they also service as local centers; and highway service areas where drivers and passengers can rest, eat, or refuel without exiting on to secondary roads have moderate efficiency values. The location choices of those facilities are shaped by the way of operating highway system.

4.3. The function of spatial configuration

Are the spatial distribution patterns of those different functions affected by the spatial configurations of the Beijing city? Based on the grid with 300 m by 300 m cells, the correlation between functional density (measured by the number of the POIs enveloped within each cell) and syntactic efficiency (gauged by normalized choice) was conducted respectively. The *R*-square of the correlation between functional density and normalized choice at 1 km is called *local correlation* in the section, and the *R*-square of the correlation between functional density and normalized choice at 50 km is named *global correlation*. Fig. 5 shows the scatter grams plotting the global correlation (on the vertical axis) against the local correlation (on the horizontal axis). The *R*-square above 0.5 suggests that the kind of relationship is identified between functional distribution and spatial configuration.

On one hand, the spatial distribution of the profit-oriented functions – except tourist spot – seems to be influenced by spatial configuration (Fig. 5 left). Both commerce and catering are affected by global and local spatial configurations, although commerce is more shaped by global configuration and catering is more determined by local configuration. However, business office and industry are more influenced by global configuration and entertainment affected by local configuration. This may be due to the following reasons. The business office and industry areas need to be globally accessed in an easy way, but they are not necessarily accessed by the surrounding areas. And meanwhile, the entertainment facilities are usually used by the locals.

On the other hand, the spatial distribution of some public-service-oriented functions is also shaped by spatial configuration at different scales regarding the functional typology (Fig. 5 left). Public institution is moderately affected by both global and local configurations; public parking and public services are influenced by local configuration rather than global one; highway service facility is determined by global configuration rather than local one; cultural and education facilities are not shaped by those two configurations.

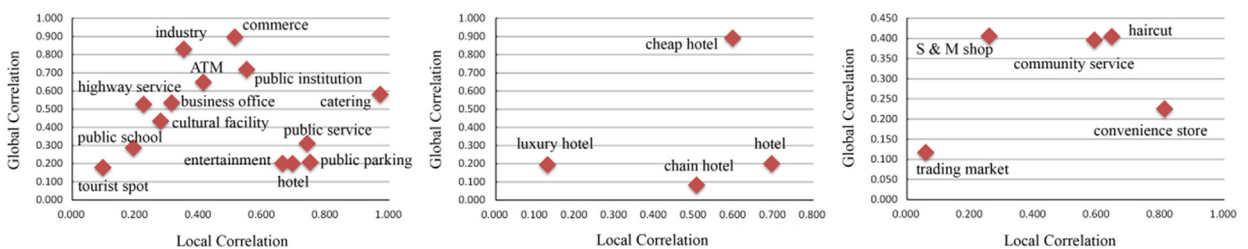


Fig. 5. The local and global correlations for all the functions (left), hotels (middle) and some commercial and public service facilities (right).

In addition, the relationship between spatial configuration and the spatial distribution of some subtypes of functions also varies. Fig. 5 middle shows the global and local correlations of different types of hotel. On average, the spatial distribution pattern of hotel is mainly shaped by local configuration. However, cheap hotel (including hostel, as well as 1 and 2 star hotels) is affected by both global and local configurations, chain hotel (including 3 star hotel) influenced by local layout, and luxury hotel (including 4 and 5 star hotels) has no relationship with spatial configuration. More famous and expensive the hotels are, less they reckon on spatial factor.

Fig. 5 right demonstrates the scenario of certain subtypes of commercial and public facilities. Convenience stores as small commercial facilities, and community service and haircut as small public facilities, are mainly shaped by local configuration; department shops as moderate commercial facilities have a weak relationship with global configuration; and trading markets as big commercial facilities have no relationship with spatial configuration. This suggests that small scale facilities tend to take advantage of spatial layout, but even large commercial facilities can make use of their brands or development volumes to attract users.

5. Discussion and limitation

Based on the different patterns of aggregation or dispersion of those functions we discussed, as well as the multi-scale syntactic location choice underlying those patterns, it then can be argued that the four types of centers in the Beijing city can be identified by the degree to which the locations gain syntactic efficiency, as well as the extent to which spatial layout influences functional distribution., the first one is *active center*, which means the aggregation of those types of functions such as small and medium shops and catering on average occupy highly efficient spaces at global and local scales, and their spatial distributions are also shaped by spatial configuration. The second one can be named *ordinary center*, that means the cluster of those functions such as Some facilities, such as chain hotel, which don't need occupy the efficient spaces, but their spatial distribution patterns are still affected by spatial configuration to some extent. The third one may be named *brand centers*, which means Some facilities like luxury hotels are situated at highly efficient spaces at either global or local scale, but their spatial distribution patterns have no relationship with spatial configuration. in fact, they mainly attract users by their brand or culture effect. And the forth one may be called *specified center*. Some functional aggregation like trading markets are placed at the less efficient spaces at different scales, and spatial forms have no impact on their distribution pattern. this kind of center doesn't rely on its spatial configuration, but on its scale of attraction or volume. In addition, the government institutions occupy the moderately efficient places and their spatial distributions are also fairly influenced by spatial configuration. Thus, those government institutions seem to close to the active centers, and this also implies the political character of Beijing as the capital city. (Fig. 6)

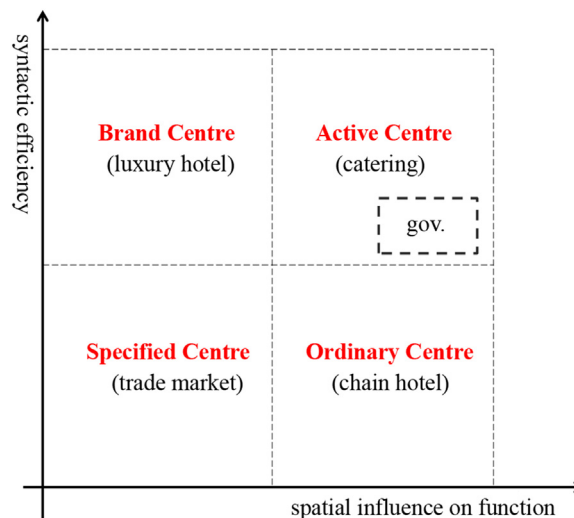


Fig. 6. The centrality system of the Beijing city.

This paper argues that different functional aggregation, dispersion, mixture or centrality results from the differently structured layouts and meanwhile seeks the differently valued locations at different radii. This needs to be further investigated by conducting more case studies in the light of big data.

At the end, it should be alerted that the calculation of averaging those syntactic and/or functional values of all the POIs within 300 m × 300 m cells may eliminate the differences of those individual values of those POIs themselves. Thus, the correlation result cannot be interpreted at the level of individual POI.

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