Chapter 8
Identifying and Evaluating Urban Centers for the Whole China Using Open Data

Yaotian Ma and Ying Long

Abstract The urban center is the core component of urban structure. Its identification and evaluation have long been a concern of the urban planning discipline. However, the central city areas (urban centers) have never been well delineated for the China city system, leading few urban studies on urban centers due to data unavailability. To address this gap and based on reviewing existing identification methods of the urban center, this chapter proposes a novel approach for identifying urban centers using increasingly ubiquitous open data points of interest (POIs) and evaluating the identified nationwide urban centers using various types of open data from four dimensions, respectively. These dimensions range from scale, morphology, function, to vitality aspects, thus providing opportunities for exploring the overall development characteristics of nationwide urban centers. We hope this chapter may shed light on future urban studies on urban centers of China.

Keywords Urban center • Open data • Point of interest • Road network • Urban form

8.1 Introduction

The urban center, as the core space in a city, is a product of a highly developed service industry economy and an important research direction of the urban planning discipline. After experiencing decades of rapid urbanization, China's urban centers have shown obvious differences from general urban areas in many aspects. Therefore, scientifically defining the scope of urban centers and comprehensively describing their development status in terms of scale, morphology, function, and vitality are of great significance and value. Despite the obvious importance, the urban centers have never been well delineated for the China city system. This is mainly because of the difficulty of collecting data on a national scope. However, despite the lack of studies on a wide scale, in the past few decades, domestic and

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foreign scholars have conducted various research on the identification methods of urban centers aiming at a single or a couple of cities.

Foreign traditional center identification methods include the assumption boundary method, population density determinative method, and building density determinative method. The assumption boundary method is a method with high subjectivity and is based mainly on residents' psychological cognitions about the urban center, while the population density determinative and building density determinative methods are mainly defined by quantitative indicators. The population density determinative method takes the block as the basic unit and sets the threshold of block population density with the block exceeding this density being identified as a center block. Similarly, the building density determinative method also takes the block as the basic unit; however, in contrast with the population density determinative method, the building density determinative method judges whether the land belongs to the center area through setting the threshold of building density. These two methods are relatively objective compared with the assumption boundary method, but there still exists the possibility of confusion; for example, the population density determinative method may wrongly regard some densely populated areas in the surrounding areas as the urban center, while the building density determinative method only considers building density but neglects building function, which may lead to the possibility of placing some areas of high-rise residential blocks into the scope of the urban center.

With further understanding of urban centers and progress of data acquisition methods, recent center identification methods have made some improvements over conventional methods in recent years, but still remain the two basic threads, subjective cognition and objective quantification. The identification method based on subjective cognition is represented by the identification method of using user-generated content. After collecting massive amounts of user-uploaded Flickr photos, Hollenstein and other researchers then recognize the photo tags. Their next step is to calculate the location which has the highest density of Flickr photos and define it as the scope of the urban center in the users'subjective cognition (Hollenstein and Purves 2010). In addition, there are also a number of other researches such as the study by Montello in which subjects have been asked to indicate whether locations are found in a particular region and to delineate such regions on a map (Montello et al. 2003). In the identification method based on objective quantification, Speck believes that an urban center is the place where people pursue social, economic, political, and cultural life. Therefore, it can be defined from three perspectives: population, activities, and physical characteristics (Speck 2012). Based on Speck's research direction and many other related studies of New Urbanism (see especially Gupta and Terzano 2008), Malizia and other researchers further propose a more detailed urban center identification indicator system which includes nine indicators: compactness, connectivity, mixed-use (diversity) degree, etc. Furthermore, 65 representative urban centers in the United States have been defined and described using the indicators above (Malizia and Song 2015).

The study of urban center identification started relatively late in China, among which the most representative research is the "Public Service Facility Index Method" proposed by Junyan Yang. Yang and other researchers have drawn lessons from the

Murphy Index Method used for identifying the boundaries of urban central business districts (CBDs) in traditional studies and put forward their methods using the similar computing techniques. According to the investigation results of the typical urban status quo, they first determine the threshold of the public service facility index in urban centers and then place the urban region whose index is higher than the cutoff value into the scope of the urban center (Yang and Shi 2014).

The reviews above prove that there are two basic methods, subjective cognition and objective quantification, adopted in existing studies on identifying urban centers. Despite their strengths and weaknesses, both methods are limited by the enormous workload of basic data acquisition and processing, so it is difficult to apply for a large geographical area, e.g., a whole country with hundreds of cities. Consequently, the identification and further measurement of urban centers mainly take single city or some sample cities as research objects and substantially concentrate on the research of metropolitan centers.

Based on existing research results, this chapter focuses on innovating the research paradigm in this field with the aim of remedying excessively complex identification methods and the deficiencies of the wide-scale holistic approach currently in use. In this era of data explosion, our research has advanced from a traditional small data template to one employing big data. Big data and open data provide opportunities for innovation in research, so that we can conduct wide-scale, and even nationwide, analysis. Long and Shen (2015) have experimented with a number of valuable approaches in using big data to carry out nationwide urban studies, such as mapping built-up urban areas for all Chinese cities at the parcel/block level, simulating urban expansion at the parcel level for all cities in China, evaluating urban growth boundaries for 300 Chinese cities, and estimating population exposure to PM2.5. After years of practice, they further proposed the "big model" paradigm, the nature of which is the establishment of relatively detailed urban region analysis and simulation models of a large geographic area capable of taking both wide-scale scope and detailed research unit into account. The research has referenced the fundamental concept of big model in that it has extended the research scope of urban center identification and measurement to the whole of China while focusing the research scope to certain points, thus avoiding the limit of the single urban area study and simultaneously carrying out studies of cities nationwide, so as to explore the general development law of urban centers in China.

8.2 Data and Methods

8.2.1 Data

This study takes 287 Chinese cities at the prefecture level or above as the research object and mainly focuses on their urban centers. The basic data used include:

1. Points of interest (POIs) from all the 287 cities' urban centers gathered from the Baidu maps in 2014. The characteristics of this data are that it is huge in quantity, which is up to 419,052 in total and covers the whole country, and it is

detailed enough to identify urban function points. Its type includes enterprises, life services, leisure and entertainment, as well as many other urban functions. It not only meets the requirements of the big model paradigm but also directly reflects the spatial distribution of urban functions. As a result, it can be used as the basic data source to identify urban centers.
2. Detailed road networks of all the 287 cities' urban centers. The road networks mainly contain three kinds of urban roads which are arterial road, minor arterial road, and branches. And the total length of all types of roads is 6904 km.
3. Microblog check-in records for all the 287 cities' urban centers. By using intersect analysis function of ArcGIS, we finally got a total of 836,473 microblog check-in records which contain the specific location and check-in time in the urban centers above.
4. City boundaries of all the 287 cities including the city names and the administrative level.

8.2.2 *Methods*

8.2.2.1 Exploring New Methods Based on Big Data to Identify Urban Centers

This study is based on the defined urban center range of Nanjing in the existing research performed by Junyan Yang. We test different center identification methods based on POI dot density distribution and compare their degree of fit with the existing scope of urban centers. Ultimately, the most reasonable method of identifying urban centers is to select POI material in Chinese cities' center group of built-up areas from the 2014 data and then use ArcGIS classification method (Jenks) to conduct clustering analysis of the dot density of interest points. When the grouping number of POI dot density is eight and the search radius and output cell size are 1000 m and 20 units, respectively, the highest level of the POI dot density distribution area is most consistent with the scope of the urban center in existing research. Therefore, this method is used as the identification method of urban centers and applied to the promotion and calculation of other cities.

After applying the identification method above to the 287 aforementioned cities and carrying out calculations of the scope of each city's urban center on ArcGIS, we then regard the street block as the unit and carry out artificial detail processing on obtained tentative center ranges to further clarify the precise boundary of each urban center, combined with the boundaries of urban internal roads and river systems.

8.2.2.2 Evaluating Nationwide Urban Centers from Four Dimensions

On basis of identifying the scope of urban centers nationwide, we extracted road network data and microblog check-in data and other data from each urban center. We also used the proportion of the total urban area (%) occupied by the urban center to represent the center's scale, road network length in the unit area (km/km^2) to represent the center's morphology, POI dot density (each dot/km^2) inside the center to represent the center's function, and microblog check-in frequency density (person-time/km^2) to represent the vitality of urban center. We then described the general law of national urban center development by again utilizing ArcGIS and other software to further evaluate the scale, morphology, function, and vitality of urban centers throughout China.

During the evaluation of four dimensions, scale, morphology, function, and vitality, the methods used are as follows:

ArcGIS classification method (Jenks)
We can obtain the distribution patterns of scale, morphology, function, and vitality for urban centers mainly by using Jenks' analytical method of ArcGIS. The Jenks method can group the similar values of input data in the most appropriate way to minimize the differences within groups and maximize the differences between groups to ultimately form the appropriate data grouping.

Zipf rank-size rule
The hierarchical system patterns of scale, morphology, function, and vitality in urban centers are mainly studied by means of the Zipf rank-size rule. This rank-size rule investigates the scale distribution law of urban systems in one region from the relationship between urban scale and urban scale ranking, which is helpful in indicating the rank-size distribution of a research object and its differences. The formula of the Zipf rank-size rule is $P(r) = P_1 r^{-q}$, and simultaneously taking the logarithm on both sides, we can get:

$$\ln P(r) = \ln P_1 - q \ln(r)$$

In the formula, r is the serial number of cities, Pr represents the indices (scale, functional density, vitality density, and road network density) of the urban center whose serial number is r, P_1 denotes the indices (scale, functional density, vitality density, and road network density) of the primate city, and q is the dimensionality of Zipf. When $q < 1$, it indicates that each developmental level of urban centers nationwide is rather concentrated with small-scale differences and it has a greater number of cities with medium rank-size. When $q > 1$, it indicates that the distribution of each developmental level of national urban centers is dispersive and the scale difference is large.

Quadrifid graph analytical method
The development status of scale, morphology, function, and vitality in urban centers throughout China is mainly analyzed through the quadrifid graph model. Quadrifid graph models take scatter diagrams as a basis and are mainly used for evaluating one certain thing from two dimensions. It regards the average value of the two dimensions evaluated as an identification line to divide the scatter diagram into four regions and to conduct classification analysis of evaluated items. This analysis plots two of the variables of functional density, vitality density, and road network density of urban centers, which are respectively placed at the horizontal and

vertical axes of the coordinate system to create a scatter diagram. Next, according to the classification rules of a quadrifid graph, the average values of center road network density (7.35 km/km^2), center function density (1080 pcs/km^2), and center vitality density (1743 person-time/km^2) are used to divide the scattered points representing the 287 urban centers into four parts and to further obtain the development state features of these urban centers.

Spatial autocorrelation analytical method

The spatial agglomeration features of scale, morphology, function, and vitality in nationwide urban centers are mainly analyzed through the spatial autocorrelation method. Spatial autocorrelation analysis includes two aspects: global spatial autocorrelation and local spatial autocorrelation. Global spatial autocorrelation mainly checks the overall trend of spatial correlation throughout the whole study area, which is measured by using Moran's I index, and the formula is as follows:

$$I = \frac{\sum_{n}^{i=1}\sum_{n}^{j=1} W_{ij}\left(x_i - \bar{x}\right)\left(x_j - \bar{x}\right)}{S^2 \sum_{n}^{i=1}\sum_{n}^{j=1} W_{ij}}$$

In the formula, I is Moran's I index, n is the number of research objects, x_i and x_j represent the attribute values of region units i and j, W_{ij} is spatial weight matrix, S^2 is the observation value variance, and x^{-} is the average value of observation. The value of I ranges from −1 to 1, and when $I > 0$, there is a positive spatial autocorrelation, which appears as an agglomeration pattern in space; the higher the value, the larger the agglomeration degree will be. When $I < 0$, the spatial autocorrelation is negative, and the smaller the value is, the stronger the negative correlation will be. If $I = 0$ then the space is not relevant.

The overall spatial autocorrelation can reflect the distribution pattern of the research object in regional space, but it has no access to the location of the research object's assembling area. Therefore, this study additionally adopts a local hot spot analysis tool (Getis-Ord General G) of ArcGIS to explore the cold-hot spots' agglomeration of the scale, morphology, function, and vitality in the urban center. Its formula is as follows:

$$G^* = \frac{\sum_{n}^{j=1} W_{ij}x_j - \bar{X}\sum_{n}^{j=1} W_{ij}}{S\sqrt{\left[n\sum_{n}^{j=1} W_{ij}^2 - \left(\sum_{n}^{j=1} W_{ij}\right)^2\right] / \left(n-1\right)}}$$

In the formula, x_j represents the attribute value of region j, S signifies the standard deviation of the regional observation value x, W_{ij} indicates the spatial weight between region i and region j, and n is the total region quantity.

8.3 Scale, Morphology, Function, and Vitality in Nationwide Urban Centers

8.3.1 The Distribution Pattern of Scale, Morphology, Function, and Vitality in Nationwide Urban Centers

It can be seen from the results of the Jenks analysis that the distribution patterns of scale, morphology, function, and vitality of nationwide city centers have shown a descending trend from east to west and south to north, but specific features vary. In the distribution pattern of scale in urban centers, the proportion that urban center areas occupy of the total urban area is generally high in Northern China and the Yangtze River Delta region. In other regions, especially in Northeast and Southwest China, the proportion that urban center area occupies of the total urban area is relatively small (Fig. 8.1). In the distribution pattern of morphology in urban centers, the coastal areas have a generally higher road network density than the inland areas. The city centers with lower road network density are mostly located in Northeast, Northwest, and Southwest China (Fig. 8.2). In the distribution pattern of function in urban centers, China's southeast coastal areas have a generally higher function density. Additionally, in the Yangtze River Delta region and Pearl River Delta region, especially the Chengdu-Chongqing area, there formed an obvious urban clustering area with high functional density centers. However, the advantages of function density in the Beijing-Tianjin-Hebei region are not prominent (Fig. 8.3). In the distribution pattern of vitality in urban centers, the Beijing-Tianjin-Hebei region, the Yangtze River Delta sector, and Chengdu-Chongqing area have formed urban clusters with high vitality density centers, while in the Pearl River Delta region, which has a fairly high functional density, the advantages of vitality density in urban centers are not prominent (Fig. 8.4).

Comprehensively speaking, the distribution patterns of scale, morphology, function, and vitality in nationwide urban centers all present obvious geographical differences. Two different basic geographic patterns have been formed between the three main urban agglomerations and inland areas of Northeast, Northwest, and Southwest China and between major prefecture-level cities and general prefecture-level cities in each province. Among them, the degree of similarity between the distribution patterns of function and morphology in nationwide urban centers is rather high as the southeast and southern coastal cities have more apparent density and morphology advantages. Nevertheless, in the distribution pattern of urban centers' scale and vitality, the main large scale and high-density concentration areas appear in the Beijing-Tianjin-Hebei region and Yangtze River Delta region, while the southern coastal cities do not present obvious advantages. In addition, except for the three traditional urban agglomerations, the Chengdu-Chongqing region forms clustering areas of high value in all of the distribution patterns above except the scale pattern, indicating that although the Chengdu-Chongqing area is still lagging behind the three traditional urban agglomerations in the aspect of comprehensive competitiveness,

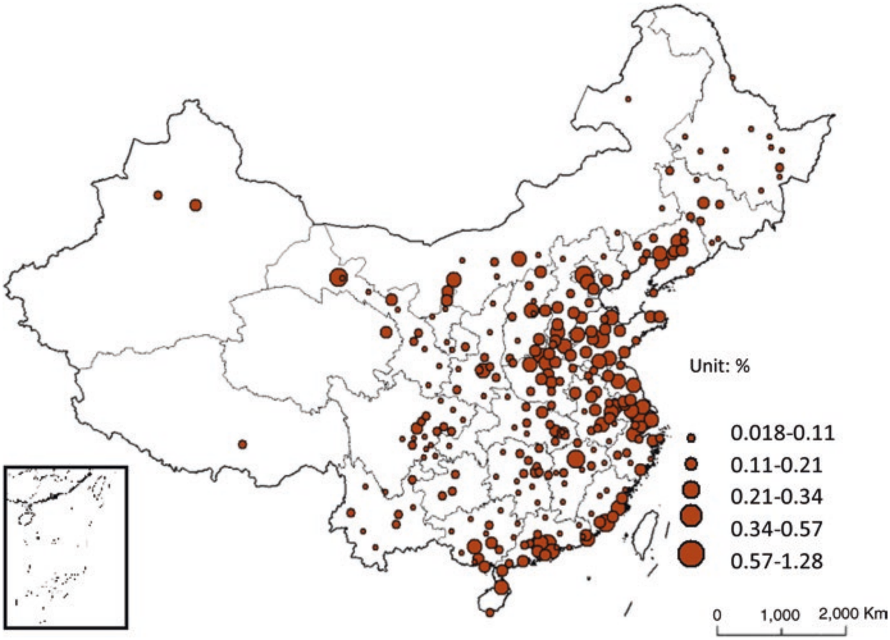


Fig. 8.1 Scale distribution pattern of nationwide urban centers

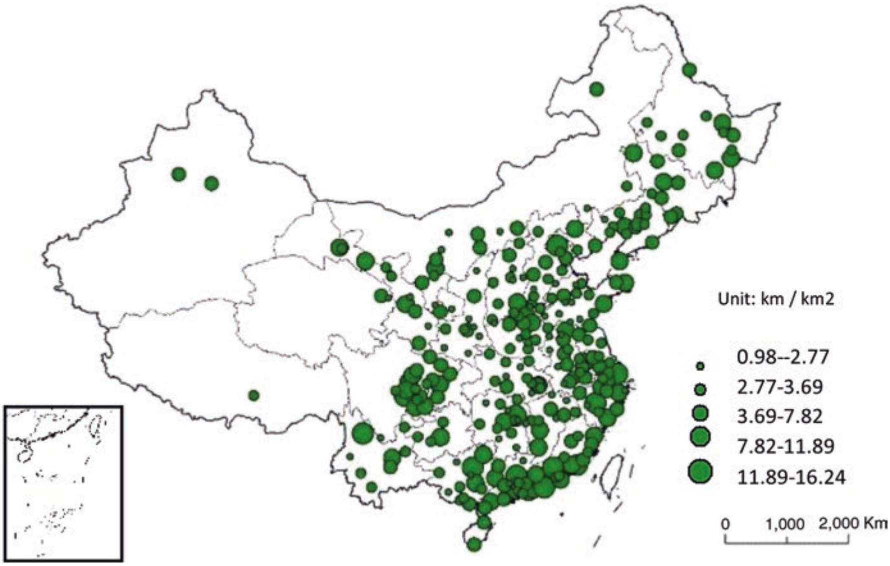


Fig. 8.2 Morphology distribution pattern of nationwide urban centers

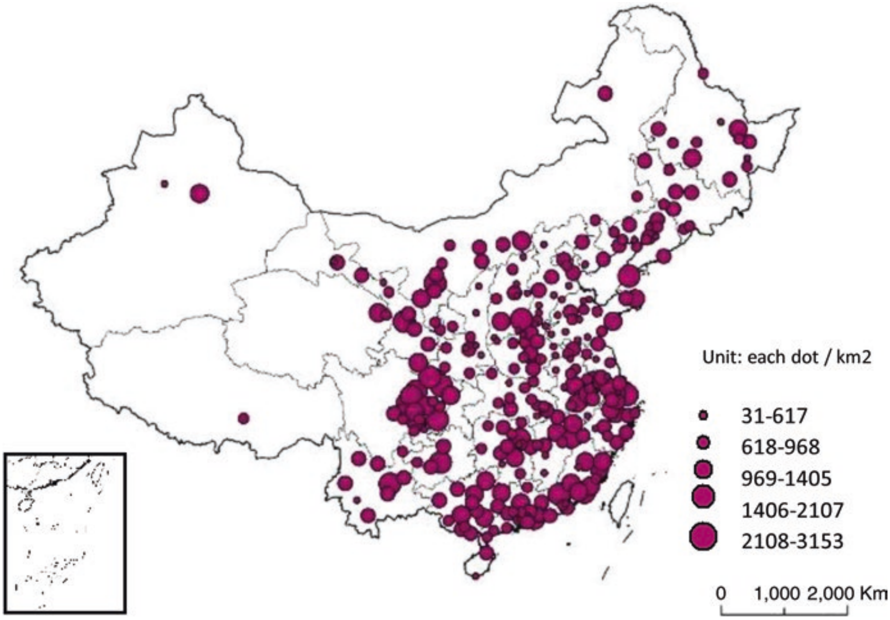


Fig. 8.3 Function distribution pattern of nationwide urban centers

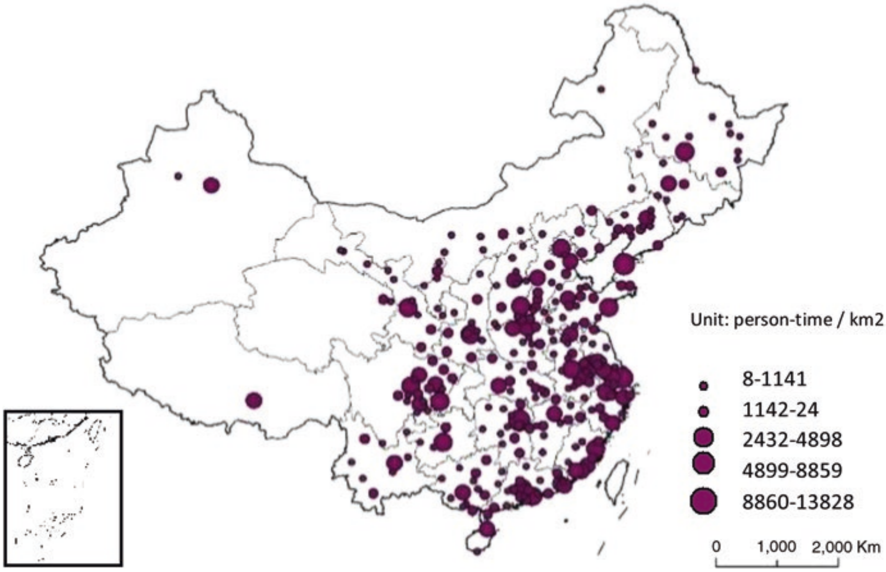


Fig. 8.4 Vitality distribution diagram of nationwide urban centers

the strength of each urban center in the Chengdu-Chongqing area should not be underestimated, especially when it comes to the density of function and validity in urban centers there.

8.3.2 The Hierarchical System Pattern of Scale, Morphology, Function, and Vitality in Nationwide Urban Centers

It can be seen from the *q* value calculated by the rank-size rule that the hierarchical system pattern of scale, morphology, function, and vitality varies a lot. In this system pattern of scale and vitality density, *q* values which are bigger than 0.5 and less than 1.0 belong to a weak equilibrium distribution (Figs. 8.5 and 8.8). Therefore, the scale and vitality density in nationwide urban centers all have large differences in distribution, which are embodied in the large differences between top-ranked cities and low-ranked cities in center scale and vitality density (same with primate and other cities). In the hierarchical system pattern of function and morphology, all *q* values are less than 0.5 and belong to the strong equilibrium distribution (Figs. 8.6 and 8.7). Therefore, the distribution of function and morphology in Chinese urban centers is relatively balanced. The specific manifestation is that the differences of function and morphology of urban centers among top-ranked and low-ranked cities are relatively small (Fig. 8.8).

Summing up the above analysis, we can infer that the hierarchical system pattern of function and morphology in urban centers in China is rather balanced. However, in the aspect of hierarchical system pattern of vitality and scale, the primate city enjoys a strong monopoly. That is to say, there exists a wide gap of vitality among urban centers, and although some urban centers also have relatively intensive functions, their vitality still lags behind those top-ranking centers. The differences among centers are not mainly reflected in function, morphology, and other infrastructure conditions but more in the aspect of scale and vitality.

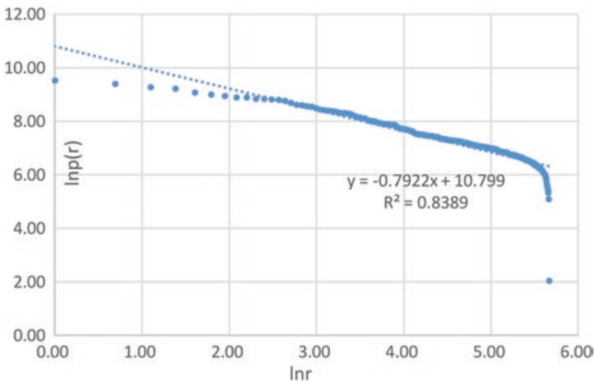


Fig. 8.5 ln-ln plot of the scale of nationwide urban centers

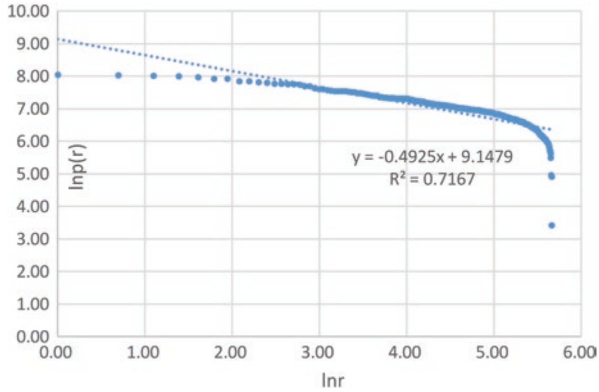


Fig. 8.6 ln-ln plot of the morphology of nationwide urban centers

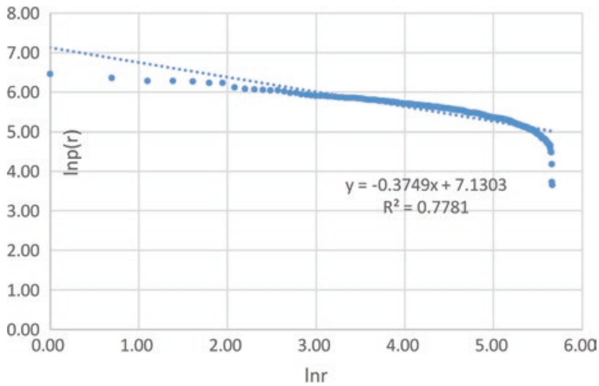


Fig. 8.7 ln-ln plot of the function of nationwide urban centers

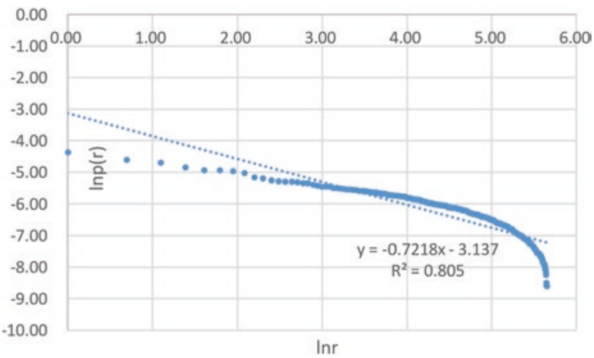


Fig. 8.8 ln-ln plot of the vitality of nationwide urban centers

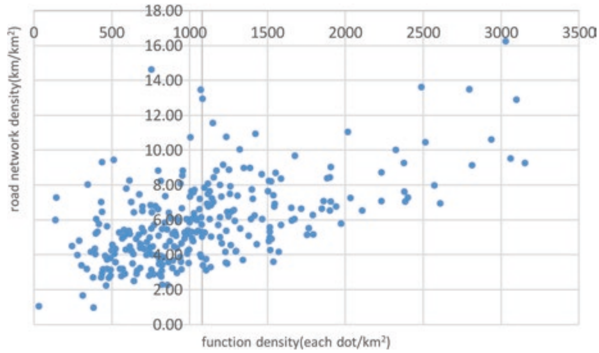


Fig. 8.9 Quadrifid graph of functional density-road network density of nationwide urban centers

8.3.3 The Development Status Features of Morphology, Function, and Vitality in Nationwide Urban Centers

8.3.3.1 The Development Status of Function: Morphology in Nationwide Urban Centers

After conducting a quadrifid graph analysis of the function and morphology of nationwide urban centers, the average value of center functional density and road network density divides the coordinate system into four quadrants (Fig. 8.9): the first quadrant (high functional density-high road network density), the second quadrant (low functional density-high road network density), the third quadrant (low functional density-low road network density), and the fourth quadrant (high functional density-low road network density). The cities belonging to the quadrant of high functional density-high road network density include Shenzhen, Shanghai, and 81 other cities, mostly located in southeast coastal areas and accounting for 28% of total cities (Fig. 8.10). The cities belonging to high functional density-low road network density quadrant include Nanning, Quanzhou, and other 34 cities, which are dispersed throughout the inland provinces. The cities in the quadrant of low functional density-high road network density include Lijiang, Yibin, and other 45 cities, while the cities belonging to the quadrant of low functional density-low road network density include Ordos, Zhanjiang, and other 127 cities, accounting for the highest proportion (44%) among these four types of cities and are spatially concentrated in Central and Western China. As a whole, 287 urban centers in China are mainly of “high functional density-high road network density” and “low functional density-low road network density” status, with “low functional density-low road network density” leading the way. This indicates that the polarization phenomenon in urban centers’ function and morphology is quite serious and there are still a large number of cities remaining in “double low” status.

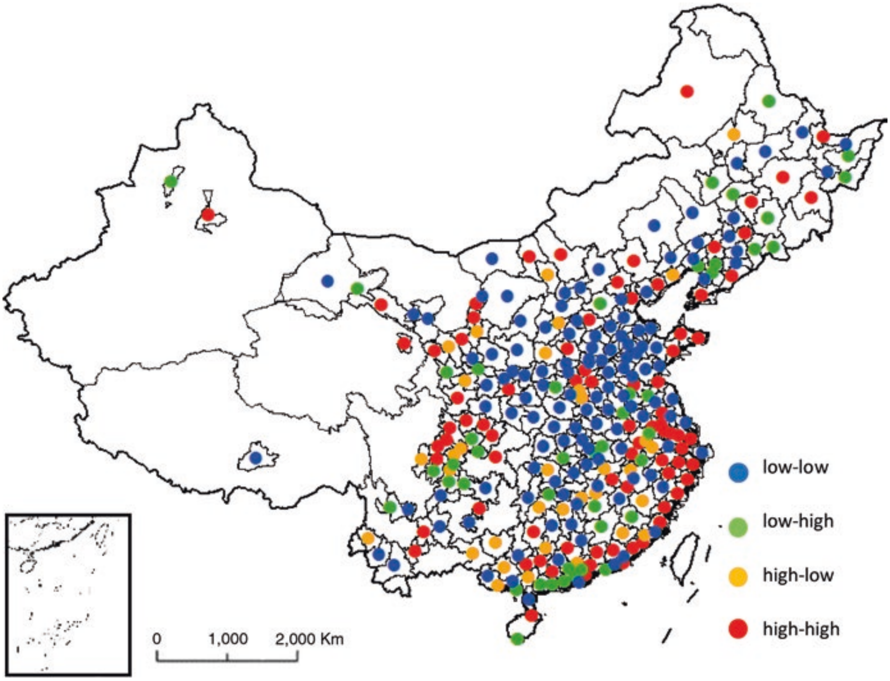
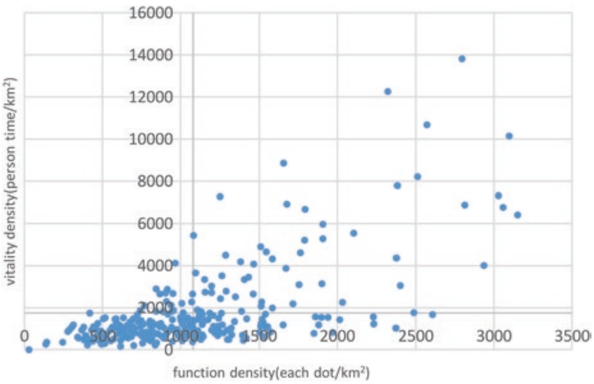


Fig. 8.10 Distribution of functional density-road network density of nationwide urban centers

Fig. 8.11 Quadrifid graph of functional density-vitality density of nationwide urban centers



8.3.3.2 The Development Status of Function: Vitality in Nationwide Urban Centers

After conducting a quadrifid graph analysis of the function and vitality of nationwide urban centers, the average value of center functional density and vitality density divides the coordinate system into four quadrants (Fig. 8.11): the first quadrant (high functional density-high vitality density), the second quadrant (low functional density-high vitality density), the third quadrant (low functional density-low vitality density), and the fourth quadrant (high functional density-low vitality density). The cities belonging to the quadrant of high functional density-high vitality density encompass Shanghai, Dalian, and other 55 cities, accounting for 19% of total cities. Most first quadrant cities are located in the three major urban agglomerations including the Yangtze River Delta region, Beijing-Tianjin-Hebei region, and Chengdu-Chongqing area (Fig. 8.12). The cities belonging to the quadrant of high functional density-low vitality density cover Yinchuan, Hulun Buir, and other 60 cities. The cities belonging to the quadrant of low functional density-high vitality density comprise Lhasa, Lijiang, and other 19 cities, which are widely dispersed and mostly developed tourism cities. Fourth quadrant cities (low functional density-low vitality density) include Handan, Panjin, and other 153 cities, accounting for the highest proportion (53%) of these four types of cities, which are spatially concentrated in Central, Western, and Northeast China. As a whole, 287 prefecture-level and above urban centers in China are of two main types "high functional density-low vitality density" and "low functional density-low vitality density," the latter one being particularly dominant. This indicates that a large number of urban centers feature high functional density but lack vitality and there are still a large proportion of cities which remain in the "double low" status of vitality and function density.

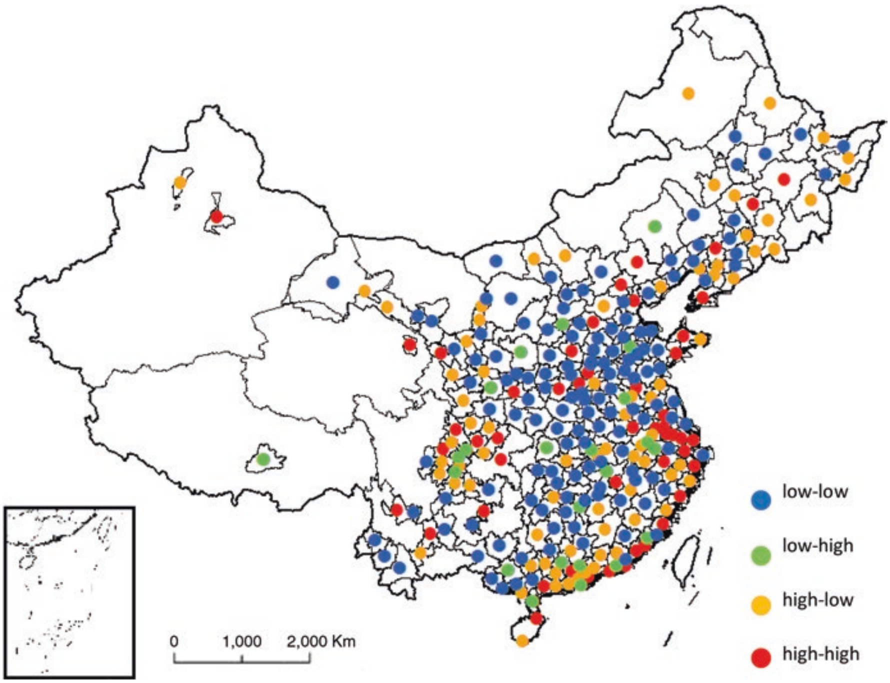


Fig. 8.12 Distribution of functional density-vitality density of nationwide urban centers

8.3.3.3 The Development Status of Morphology: Vitality in Nationwide Urban Centers

After conducting a quadrifid graph analysis of the morphology-vitality of nationwide urban centers, the average value of road network density and vitality density divides the coordinate system into four quadrants (Fig. 8.13): the first quadrant (high road network density-high vitality density), the second quadrant (low road network density-high vitality density), the third quadrant (low road network density-low vitality density), and the fourth quadrant (high road network density-low vitality density). The cities belonging to the quadrant of high road network density-high vitality density encompass Shanghai, Dalian, Nanjing, and other 74 cities, which are widely dispersed and account for 26% of total cities (Fig. 8.14). The cities belonging to the quadrant of high road network density-low vitality density include Leshan, Jixi, and other 75 cities. The cities belonging to the quadrant of low road network density-high vitality density contain Guangzhou, Taiyuan, and other 23 cities, including Guangzhou, Taiyuan, Nanning, Lhasa, Wuhan, and a plurality of provincial capitals. The cities belonging to the quadrant of low road network density-low vitality density cover Xinyang, Ya'an, and other 138 cities, accounting for the highest proportion (48%) of these four types of cities which are spatially concentrated in Central and Western China. As a whole, 287 prefecture-level and above urban centers in China are mainly "high road network density-low vitality density" and "low road network density-low vitality density," with the latter remaining dominant. This indicates that a large number of urban centers exhibit high road network density but still lack vitality and there are a large proportion of cities which are in the "double low" status of vitality and network density.

Based on the above analysis, we can find that a large number of urban centers present the "double low" development status of low road network density-low functional density, low functional density-low vitality density, and low road network density-low vitality density in China's urban centers. The cities of "double high" status account for a small proportion, and most of these are located along coastal areas or in the three major urban agglomerations. In addition to universal "double

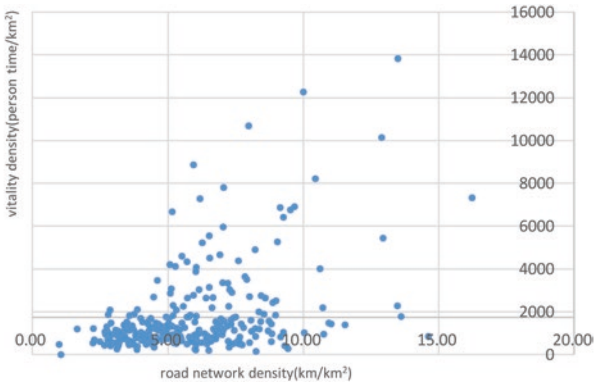


Fig. 8.13 Quadrifid graph of road network density-vitality density of nationwide urban centers

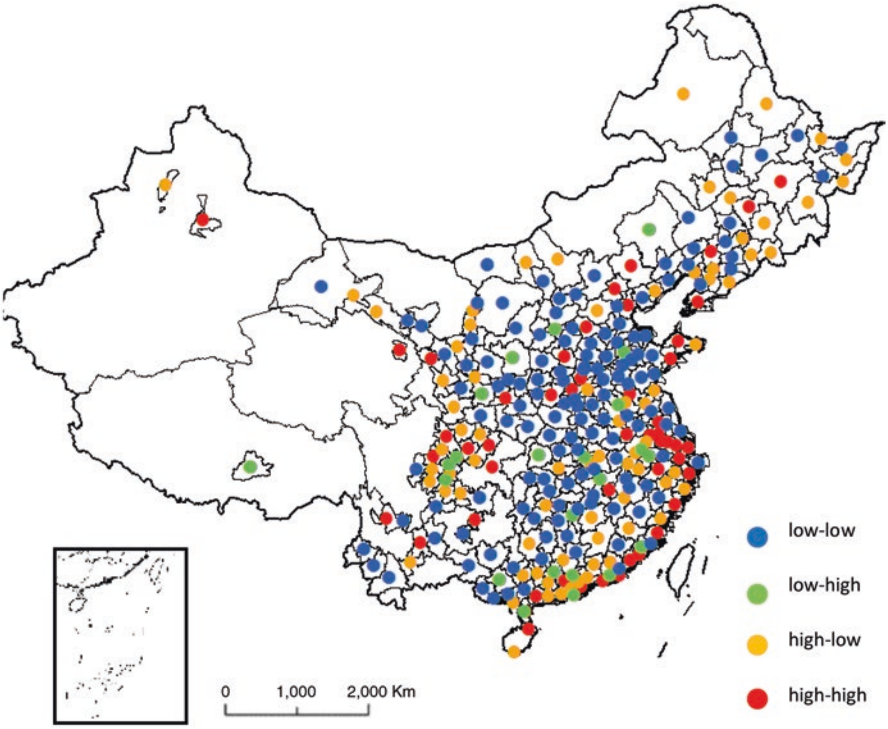


Fig. 8.14 Distribution of road network density-vitality density of nationwide urban centers

low" status, what is particularly noteworthy is that plenty of urban centers suffer from the serious problem of low vitality density. Although these cities possess high road network density or high functional density, their vitality density remains low, which does not seem to match the condition of high road network density and high functional density.

8.3.4 The Spatial Agglomeration Features of Scale, Morphology, Function, and Vitality in Nationwide Urban Centers

8.3.4.1 The Overall Spatial Agglomeration Features of Scale, Morphology, Function, and Vitality in Nationwide Urban Centers

To discuss the overall agglomeration pattern features of scale, morphology, function, and vitality in nationwide urban centers, this chapter calculates the Moran's I index (Table 8.1) through ArcGIS. From this table, we can see that all of the Moran's I index values are positive ($p \leq 0.01$), indicating that the scale, morphology,

Table 8.1 Moran's I index of nationwide urban centers

Type of index	Moran's I index	Z test value	Significance level
Center scale	0.26	14.56	0.01
Center road network density	0.094	5.33	0.01
Center functional density	0.21	11.79	0.01
Center vitality density	0.27	14.59	0.01

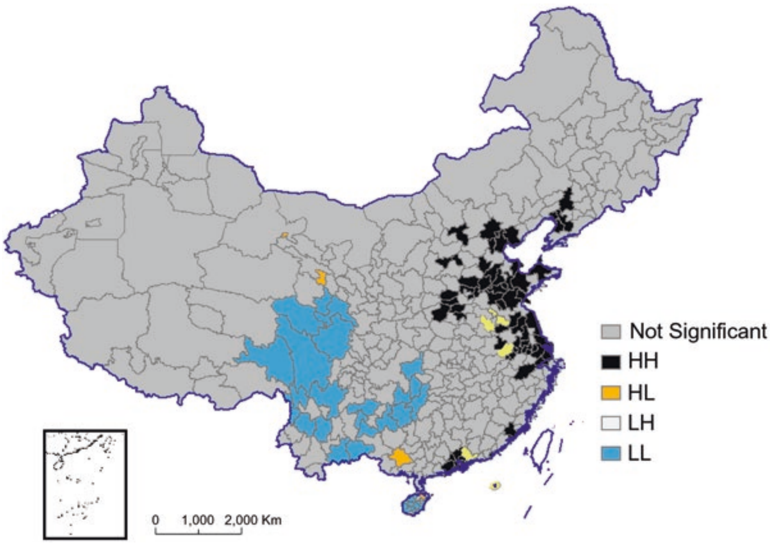


Fig. 8.15 Cold-hot agglomeration pattern of scale of nationwide urban centers

function, and vitality in nationwide urban centers are all positively correlated to space and the cities with high indicators tend to agglomerate in space. However, by comparing specific index values, it can be found that the cities with large center scale and high vitality density present more significant agglomerations in space.

8.3.4.2 The Partial Spatial Agglomeration Features of Scale, Morphology, Function, and Vitality in Nationwide Urban Centers

Through local spatial autocorrelation, we further identify the agglomeration pattern of cold-hot spots in nationwide urban centers. As for the partial spatial agglomeration features of urban centers' scale, there appears to be a high-value agglomeration area in the Beijing-Tianjin-Hebei region and North China, while there is a low-value agglomeration in the Chengdu-Chongqing region (Fig. 8.15).

As for the density of morphology in nationwide urban centers, there appears to be a high-value agglomeration area in the Yangtze River Delta and Pearl River Delta

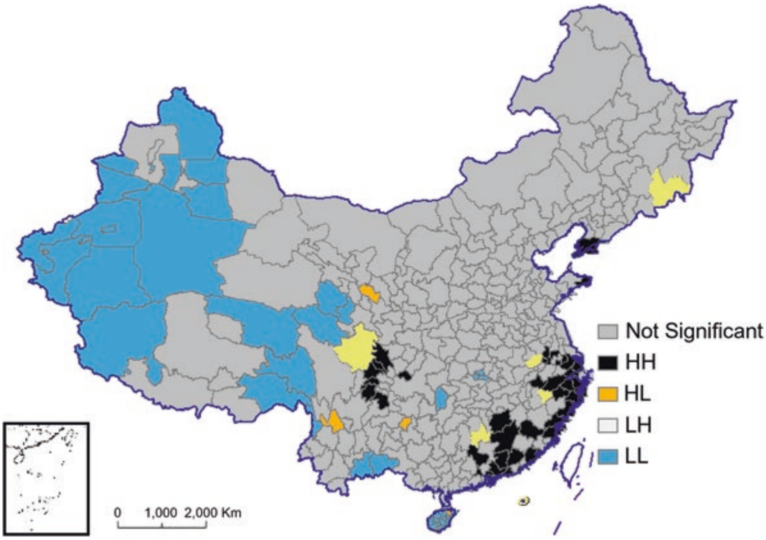


Fig. 8.16 Cold-hot agglomeration pattern of morphology of nationwide urban centers

regions, as well as the Chengdu-Chongqing area, while this phenomenon does not occur in the Beijing-Tianjin-Hebei urban agglomeration. The high-value areas in low value mainly appear in the provincial capital of Western China, while low-value clustering areas mainly appear in Western China outside the provincial capital (Fig. 8.16).

For the partial spatial agglomeration features of function in urban centers, there appears to be a high-value agglomeration area in the Yangtze River Delta and Pearl River Delta regions, as well as the Chengdu-Chongqing area, while this phenomenon does not occur in the Beijing-Tianjin-Hebei urban agglomeration. The high-value areas in low value mainly appear in the provincial capitals of Central and Southwest China, as well as some other regions. The low-value agglomeration areas occur in the outlying regions of Xinjiang and Tibet (Fig. 8.17).

When comparing the partial spatial agglomeration features of vitality in nationwide urban centers with the previous three features, the scope of agglomeration areas of both high and low value has been sharply reduced. The low-value areas in high value and high-value areas in low value have also been reduced. In addition, the high-value agglomeration regions mainly appear in the Yangtze River Delta region and the southeast coastal cities, while low-value agglomeration regions are not conspicuous (Fig. 8.18).

Taken together with global and local spatial agglomeration patterns, nationwide urban centers present obvious agglomerations with respect to scale distribution and functional distribution. High-value agglomeration areas of various indicators mostly appear in the three major urban agglomerations and southeast coastal areas, while low-value agglomeration areas are mainly concentrated in the western region. The high-value areas in low value mostly are located in the provincial capitals of each province.

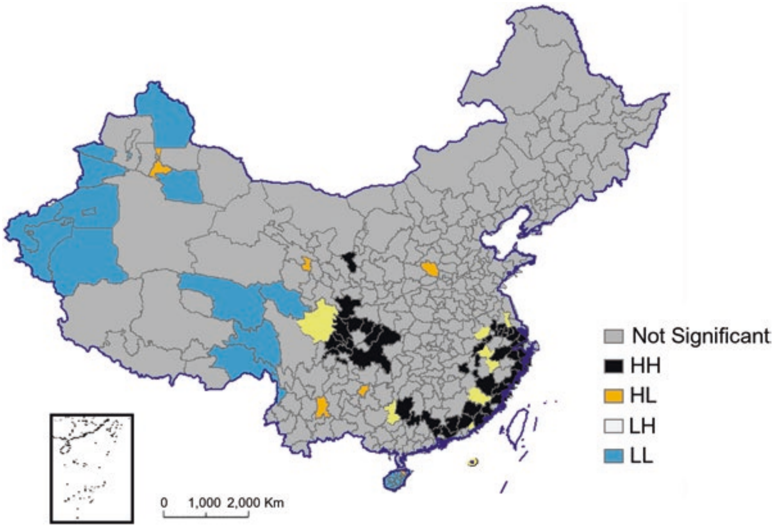


Fig. 8.17 Cold-hot agglomeration pattern of function of nationwide urban centers

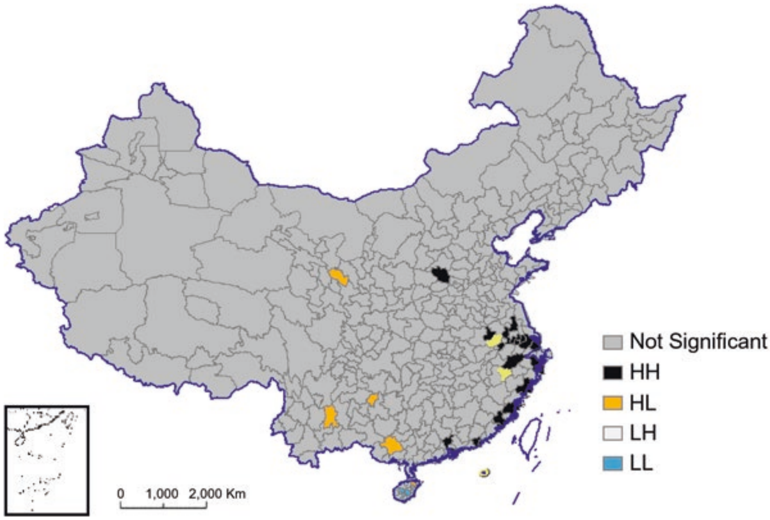


Fig. 8.18 Cold-hot agglomeration pattern of vitality of nationwide urban centers

8.4 Conclusion and Discussion

Considering being lacking of an urban center study for a whole country, this chapter proposes a novel approach for identifying urban centers using increasingly ubiquitous open data points of interest (POIs) and evaluating the identified nationwide urban centers using various types of open data from four dimensions, respectively. These dimensions range from scale, morphology, function, to vitality aspects, thus providing opportunities in an attempt to summarize the regularities and features of the development in nationwide urban centers. The research reveals that:

1. Regarding the distribution patterns of scale, morphology, function, and vitality, nationwide urban centers all present a declining trend from east to west and from south to north. In addition, two different basic geographic patterns have formed between the three main urban agglomerations and inland areas, as well as between those major prefecture-level cities and the general prefecture-level cities in each province. However, the specific distribution patterns of these four dimensions also differ from each other to some extent. Among them, the distribution patterns of scale and vitality in nationwide urban centers are rather similar, with the main high-value regions existing in the Yangtze River Delta region and Beijing-Tianjin-Hebei region. Additionally, the degree of similarity between the distribution patterns of function and morphology in nationwide urban centers is rather high, showing that the southeast and southern coastal cities have more apparent density advantages.
2. Regarding the hierarchical system patterns, the features of scale, morphology, function, and vitality in nationwide urban centers vary. In the hierarchical system pattern of scale and vitality in nationwide urban centers, there is a big difference between the primate city and other cities. In contrast, in the hierarchical system of function and morphology in nationwide urban centers, the differences between the primate city and other cities are relatively small, and the distribution is more balanced as well.
3. Regarding the features of the development status, a large proportion of urban centers present a "double low" development status such as "low functional density-low vitality density," and cities with a "double high" development status only account for a small portion. In addition to the common "double low" status, a multitude of urban centers also have the problem of low vitality. Although these cities possess the condition of high road network density or high functional density, the vitality density remains in low-value status, which does not match the condition of high road network density and high functional density.
4. Regarding the features of spatial agglomeration, there are obvious positive spatial correlations on scales, function, vitality, and morphology distribution which show that urban centers with a higher (or lower) index tend to agglomerate in space. Among them, cities with large (or small) center scale and high (or low) center vitality density present a more significant agglomeration in space.

Although this chapter identifies the nationwide urban centers innovatively and evaluates the development features of urban centers along four dimensions based on the identification results, the research can be extended via various avenues. On one hand, we will explore the influencing factors of the development features in nationwide urban centers in the close future. On the other hand, we will make a more in-depth description of the development features, thus gaining more knowledge on the formation of urban centers. Considering urban centers will play an even more crucial role in the future development of cities, it is of great importance to conduct these mentioned continuing studies of the urban centers from the quantitative perspective and the national scale.

References

Gupta, P. K., & Terzano, K. (2008). *Creating great town centers and urban villages [M]*. Washington, DC: Urban Land Institute.

Hollenstein, L., & Purves, R. (2010). Exploring place through user-generated content: Using Flickr tags to describe city cores [J]. *Journal of Spatial Information Science, 2010*(1), 21–48.

Long, Y., & Shen, Z. (2015). Big models: From Beijing to the whole China [M]. In *Geospatial analysis to support urban planning in Beijing* (pp. 255–272). Switzerland: Springer.

Malizia, E., & Song, Y. (2015). Does downtown office property perform better in live–work–play centers? [J]. *Journal of Urbanism: International Research on Place making and Urban Sustainability, 9*, 1–16.

Montello, D. R., Goodchild, M. F., Gottsegen, J., et al. (2003). Where's downtown? Behavioral methods for determining referents of vague spatial queries [J]. *Spatial Cognition & Computation, 3*(2–3), 185–204.

Speck, J. (2012). *Walkable city [J]*. New York: Farrar, Straus and Giroux.

Yang, J., & Shi, B. (2014). Research on the quantitative definition method of Urban Center boundaries [J]. *Journal of Human Settlements in West China, 29*(6), 17–21. (in Chinese with English abstract).