Coupling Relationship between Commercial Spatial Structure and Population based on the Point Pattern Analysis and Coupling Model: a Case Study in Beijing

WANG Fang[1,2]   ZHEN Maocheng[1,2]   GAO Xiaolu[1]

1．Key Laboratory of Regional Sustainable Development Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China;

2. University of Chinese Academy of Sciences, Beijing 100049, China

wangf741@163.com

Abstract—**On the basis of the locations of all the commercial networks extracted from POI data in Beijing, this paper used the point pattern analysis and the construction of the coupling model to investigate the spatial pattern of different formats of commercial networks in Beijing, and the coupling of commercial networks and population on the scale of housing block. This research takes the central of Beijing city and suburban areas as the study area. The results show that: ① Shopping malls, supermarkets and convenience stores are all spatial agglomeration types. And the clustering districts distribution of different formats of commercial networks varies in Beijing. The gathering areas of most formats of commercial networks distributed mainly within the Fourth Ring Road. ②The L(d) curve shows that shopping malls and convenience stores belongs to the inverted "U" type, which indicates commercial outlets gathered first, and then tended to dispersed within a certain range. The curve of supermarket shows a rising type, indicating that with the increasing distance radius, the convergence degree gradually increased. ③ There are still many mismatches in the coupling relationship between commercial spatial pattern and population on the housing block scale. Senior commercial facilities and common living facilities are both poor in the peri-urban areas. At the same time, there are also some "blind spot" which are low coupled with population in the inner city.**

Keywords-Commercial Spatial Structure; Format; Population Couple; Beijing

I. INTRODUCTION

The rationality of the commercial structure will affect urban agglomeration economies to maximize the benefits; and the coordination of commercial networks and population distribution will affect the convenience of the inhabitants' daily life.

While reviewing the previous literature, issues of urban commercial spatial structure has enjoyed a long tradition of research(JADawson,1980; Ghosh &Graig 1984; Rafael Su árez-Vega ,2012) Meanwhile, some scholars have conducted empirical researches on commercial structure in different cities (Poter, 1981; Lloyd, 1991; Chai, 2008; Wang, 2013). Although the study of commercial spatial structure has formed a series of theories, methods and empirical research, it is still rare based on commercial formats. In addition, existing research about the coupling relationship between commercial networks and population concentrated in cities, Jiedaos, and other macro-scale, very few from the residential block scale to explore coupling between the two.

Nowadays, with changes of the urban spatial structure, Beijing's commercial spatial structure has broken its traditional pattern and some new characters began to emerge. Meanwhile, the spatial distribution of urban population has undergone tremendous changes. Thus, this paper attempts to explore the spatial characteristics of Beijing's different formats of commercial networks, and establish a coupling model to examine its coupling relationship with population distribution from the housing block scale.

II. DATA AND METHODS

A. DATA

According to Baidu POI (Point of Interest) data, we extracted a total of 57,864 commercial point of interest. The commercial networks are divided into 12 categories according to the "Retailing classification" (GB/T18106-2010). This paper stressed on 3 categories, which are closely related to people's daily life, and the number and ratio of these 3 different formats shown in Table 1. Meanwhile, using LocoySpider software, the records of residential blocks listed on website pages were automatically collected and the accuracy of information was crosschecked with data from largest two real estate information websites (www.anjuke.com; www.soufang.com). As a result, a database comprising 8677 residential blocks for 2012 was established.

Table 1.the number and proportion of commercial outlets in Beijing

Type	Number	Ratio
shopping mall	1064	8.2%
supermarket	3867	29.6%
convenience store	8116	62.2%
Total	13047	100%

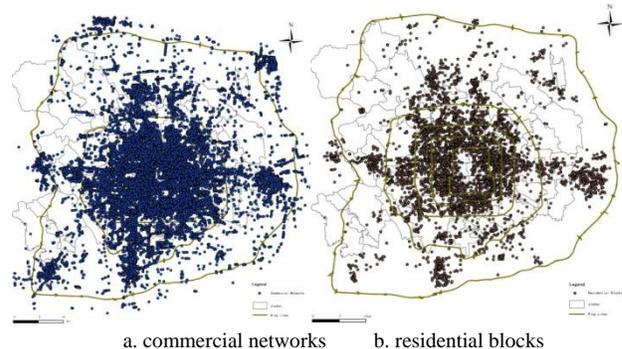a. commercial networks   b. residential blocks

Figure 1. Spatial layout of commercial outlets and residential blocks in Beijing

B. METHODS

1) The coupling model

The coupling relationship between two geographical elements reflects the synergy within the geographical system and the degree of interaction between them.

The housing block is the most basic agglomeration unit, and the commercial configuration around housing blocks has a direct impact on the quality of residents' lives. So we took the housing block as the urban population concentration area; calculated the population weights; and estimated distance from every housing block to nearest commercial outlet, which presents the coupling relationship of commercial networks and the population.

The population weight of housing blocks is estimated according to the method of area weighted interpolation. Assuming that the per capita area of the similar area is uniform, determine the value of a property in the target area based on the percentage of each source area occupied area of the target area(Zhang, 2010; Qi, 2013).In this paper, we took the construction area of respective housing block as the basic weight, and proportioned the corresponding population of the Jiedao based on the basic weight to get the population weights. The coupling model is as follows:

$$C_i = P_* \times \frac{d_{max}}{d_i} = \frac{\frac{A_i}{A_J} \times P_j}{p_{max}} \times \frac{d_{max}}{d_i}$$

Where C_i is the coupling degree of i housing block and commercial networks; P_* is the population weight of i housing block; d_i is the distance from i housing block to the nearest commercial outlet; d_{max} is the largest number of d_i. $A_i / \overline{A_J}$ is the ratio of i housing block construction area and j Jiedao total construction area; p_{max} is largest population weight of housing block in Beijing. So the bigger the C_i is, the higher coupling performance is.

2) Point pattern analysis

In this paper, we used the point pattern analysis to analyze the spatial pattern of commercial networks in Beijing, which included Kernel density estimation Kernel density estimation, Ripley′s K-function, and Nearest Neighbor Distance analysis.

III. ANALYSIS OF THE RESULTS AND DISCUSSION

A. Analysis of commercial spatial pattern

1) The spatial distribution types of commercial networks

Spatial distribution types of commercial networks, directly determines the scale and level of organization of city commercial market competition. Agglomeration of commercial distribution types is conducive to save investment and improve the land utilization rate. However, commercial space distribution is too concentrated prone to the situation of agglomeration diseconomies, and commercial development is too high density will reduce the quality of business environment, affecting the quality of

the environment of the whole city. While the commercial distribution is too scattered will lead to non-economic as well as the city land use efficiency is low.

Based on the spatial distribution of commercial outlets, we used the CrimeStat 3.3 software, through the nearest neighbor distance method to analyze the mutual proximity of the feature point in geographic space.

Table2. Statistical result of nearest neighbor distance analysis

Type	NNI	Z-score
shopping mall	0.42289	−36.013
supermarket	0.48141	−61.6943
convenience store	0.40782	−102.061

It can be seen from table 2 that the 3 types of Beijing city commercial networks, NNI values were less than 1, and the Z-score is less than -2.58, namely spatial cluster is generated from the probability of randomly less than 1%. Therefore, the 3 types of commercial networks are all belong to gathering distribution type.

2) Hot spot analysis of commercial networks

Kernel density of the commercial networks in Beijing was analyzed by arcgis10.0 (KDE), as shown in figure 2.

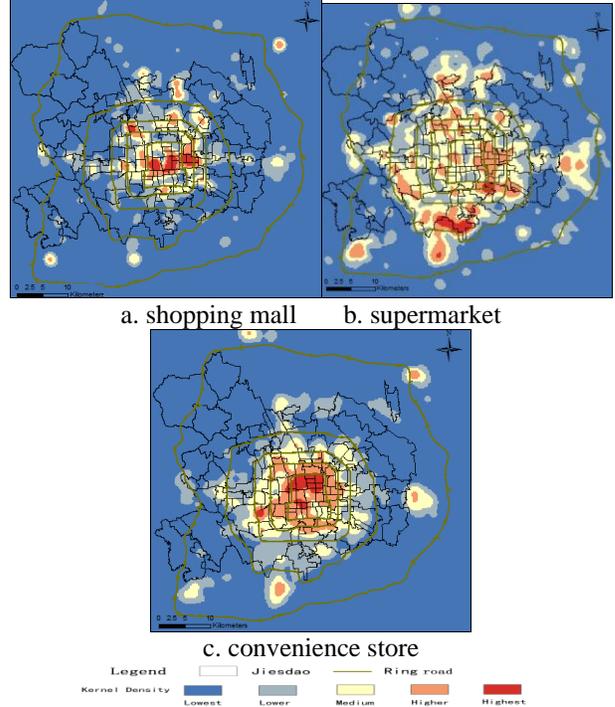a. shopping mall   b. supermarket

c. convenience store

Figure 2. Results of kernel density of the commercial networks

Shopping malls gathering area in Beijing dominated mainly within the 4th ring road, and the gathering area formed an agglomeration belt along the Chang'an Avenue. Xidan, Wangfujing, Chaowai and Zhongguancun formed a obviously cluster; In addition, in the outer space of the central city, Huilongguan, liangxiang, huangcun, Wangjing etc. are also centers of commercial networks concentration area. The distribution of Supermarkets are

more dispersed, mainly gathered in nanyuan, huilongguan, liangxiang, sijiqing, etc.The cluster of convenience stores are mainly located in the 4th ring road, such as Tongzhou, Liangxiang and other large residential area.

3) Commercial networks differentiation pattern

Ripley's L(d) index provides a way to summarize spatial patterns and compare the patterns of different sectors within different temporal dimensions. This paper used the Crimestat3.3 for this analysis.
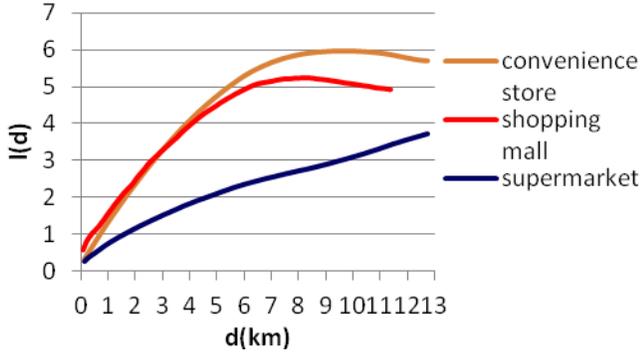

Figure 3. Results of Ripley's K(r) function for the commercial networks

The L(d) curve shows that shopping malls and convenience stores belongs to the inverted "U" type. For the shopping mall, The d value that corresponded to the peak L(d) was 8 km, which suggests that shopping malls in Beijing would most likely aggregate within a distance of 8 km. And for the convenience store, it most likely aggregate within a distance of 9.5km. The curve of supermarket shows a rising type, L (d) has always maintained an upward trend, no peak. Indicating that with the increasing distance radius, the convergence degree gradually increased.

B. Coupling analysis between commercial networks and population

The rapid development of urbanization causes the expansion of urban space, and urban population and spatial development of commercial networks also showed a tendency to expand outward. The coordinated development of commercial networks and population is directly related to the improvement of living standard and optimize urban space layout. Therefore, urban commercial spatial structure can not only achieve the economies of scale; but also adapt to the distribution of population. As can be seen from the above analysis, the commercial networks showed gathering momentum distribution. But it still need further analysis to assess that whether the degree of agglomeration is reasonable and whether it can satisfy the population distribution pattern.

Different commercial formats have different service groups and service radius. Therefore, the coupling degree of shopping malls, supermarkets and convenience stores with population were analyzed. Firstly, we calculated the coupling of each housing block and commercial networks by the coupling model, Secondly, by the kriging interpolation method of arcgis 10.0, we obtained population and different

formats of commercial networks spatial coupling diagram (Figure 4)

a. shopping mall
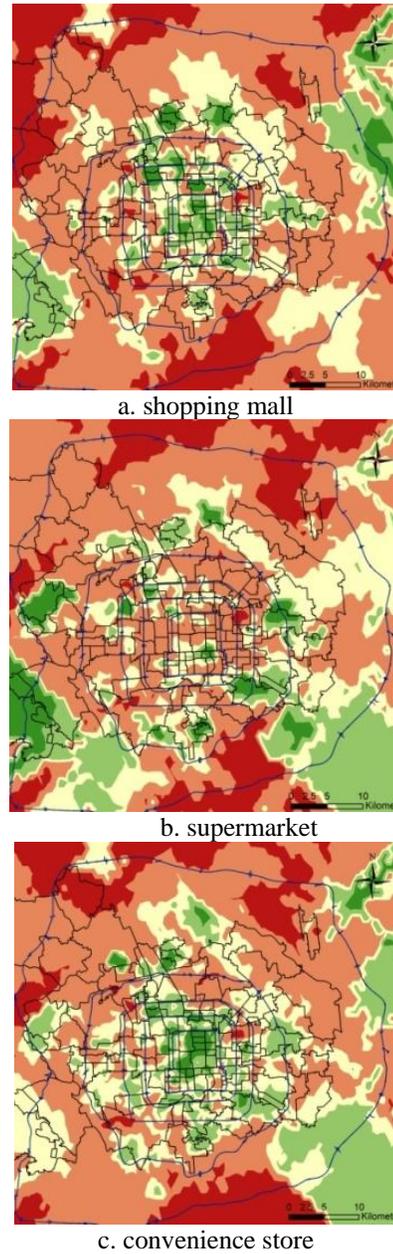

b. supermarket

c. convenience store

Figure 4. The coupling of population and commercial outlets

Overall, from the average coupling degree between population concentration area and commercial networks, the coupling of Beijing convenience store and population was 0.78, the shopping mall was 0.77, and supermarket was 0.50. The coupling degree of supermarket is the worst, which shows that the spatial structure of the supermarkets and population distribution is not reasonable enough. From the perspective of space (figure 4), the high coupling performance of population and market mainly within the 4th ring road, most areas of poor coupling degree distribute outside the 5th ring road, especially in the northwest of Haidian District and the south of the 5th ring road;

meanwhile, some areas within the 4th ring also has some bad coupling region -"blind area", such as Willow Street, Village street, Maizidian street. The strong coupling of population and the convenience store is also within the 4th ring road, weak coupling areas mainly distribute in the outskirts of the city, and "blind spots" within 4th ring are mainly distributed in the same position. While, for the supermarkets, in the spatial distribution the strong coupling areas are more dispersed, mainly in the areas of Zhongguancun, Wangfujing, and Shangdi, etc.

Therefore, it can be seen that the coupling relationship between population and commercial networks exist many mismatch phenomenon in the space, which can affect the comfort and convenience of residents' living standard. In recent years, the expansion of living space in Beijing mainly in the city periphery area, such as Tiantongyuan, Huilongguan, etc. where established some large residential areas. These areas should be equipped with corresponding scale commercial facilities. In addition, from the point of now, the spatial distribution of commercial networks around the city areas is not enough. And, there formed some "blind spots" with poor coupling within the 4th ring road.

The commercial spatial structure should adapt to the changes of distribution population, which is a basic law. But because of the rapid changes of population distribution, the commercial networks and population often cannot match well in space. So in the future, commercial networks planning should be more adapt to the changes of population distribution, guide the commercial networks distribute in the city periphery and the "blind areas", and should integrate the planning of commercial networks and housing blocks and optimize the city spatial structure.

IV. CONCLUSIONS

This research based on the POI data, established a coupling model and used the point pattern analysis to explore the coupling relation between commercial type and population in the residential district scale and analyze the various formats of commercial network spatial pattern in Beijing. And the conclusion can be drawn that:

① The three format of commercial spatial pattern in Beijing are all gathering distribution type. Shopping malls gathering area in Beijing dominated mainly within the 4th ring road, and the gathering area formed an agglomeration belt along the Chang'an Avenue. Xidan, Wangfujing, Chaowai and Zhongguancun formed a obviously cluster; In addition, in the outer space of the central city, Huilongguan, liangxiang, huangcun, Wangjing etc. are also centers of commercial networks concentration area. Supermarkets, convenience stores are mainly concentrated in large residential areas, including the distribution of supermarkets is scattered.

② By Ripley's L (d) statistic analysis, we found that the L(d) curve shows that shopping malls and convenience stores belongs to the inverted "U" type, which indicates commercial outlets gathered first, and then tended to dispersed within a certain range. The curve of supermarket shows a rising type, indicating that with the

increasing distance radius, the convergence degree gradually increased.

③There are still many mismatches in the coupling between commercial spatial pattern and population on the residential block scale. Senior commercial facilities and common living facilities are both poor in the peri-urban areas. At the same time, there are also some "blind spot" which are low coupled with population in the inner city.

REFERENCES

[1] Louise Crewe. Geographies of retailing and consumption. Progress Human Geography, 2000,(2).

[2] Sara L, Malaffety, Ghosh Avijit, Multipurpose shopping and location of retailing firm.Geographical Analysis,1986,(3)。

[3] Rafael Suárez-Vega, Dolores R. Santos-Peñate, Pablo Dorta-González. Location models and GIS tools for retail site location. Applied Geography, 2012,35(2):12-22.

[4] Poter, R.B. Correlates of the functional structure of urban retail areas: an approach employing multivariate ordination. The Professional Geographer, 1981, 3(2):208-215.

[5] Lloyd, W.J. Changing suburban retail patterns in metropolitan Los Angeles. Association of American Geographers, 1991, 3(3):335-344.

[6] Qi Wei, Li Ying, Liu Shenghe et.al. Estimation of urban population at daytime and nighttime and analyses of their spatial pattern: A case study of Haidian District, Beijing. Acta Geographica Sinica, 2013, 68(10):1344-1356. (in Chinese)

[7] Chai Yanwei, Weng Guilan, Shen Jie. A study on commercial structure of Shanghai based on residents'shopping behavior. 2008, 27(4): 897-906. (in Chinese)

[8] Wang De, Li Guangde, Zhu Wei et.al. Establishment and application of consumers' behavior model in Guanqian commercial street, Suzhou. City Planning Review, 2013,37(9):28-33. (in Chinese)