Study on the spatial distribution characteristics and spatial symbiosis of living supermarkets based on GIS

Sheng Ye, Zong He¹, Jing Li and Yang Chen
Chongqing Geomatics and Remote Sensing Center, Chongqing, 401121, China

¹Email:1061532041@qq.com

Abstract. By using the POI data of Gaode, we screened out the life supermarket system, and studied the spatial distribution characteristics of life supermarket system and its spatial symbiosis with the surrounding residential areas. The analysis found that: ① The spatial distribution pattern of Chongqing's main city supermarkets is consistent with the "multi-center group" urban structure. The development of supermarkets in the main urban area presents the "Matthew Effect", and it still faces several major business districts within the inner ring and its surroundings. Centralized, another university town relies on stable student group demand, showing a new growth direction; ② Convenience stores have relatively homogeneous clustering characteristics, are mainly developed on more mature commercial areas, and have achieved rapid growth in recent years increased by 1.2 times; ③ The overall distribution of imported merchandise stores in the main urban area is small clusters, and the concentration degree in the GuanYinqiao area is the most prominent. Compared with other types, the concentration degree is higher in the Haier Road area near the bonded port area; ④ Living areas with a high degree of compounding of the living supermarket system around the community are mainly distributed within the inner ring and have a high degree of spatial fit with the major business districts. Outside the inner ring, they are mainly distributed in the north of Beibei City, Beibei Old City, Yudong, and Lianglu.

1. Introduction
With the economic globalization and informatization, the size of cities has been continuously expanded; he industrial structure has been continuously adjusted and upgraded, and the proportion of business services has increased rapidly, gradually becoming the main driving force for urban economic growth. Commercial space is an important part of urban space. The rational layout of commercial space can not only correctly guide population flow and reduce urban traffic congestion, but also improve the quality of life of urban residents, which is the basis for high-quality urban development. Foreign scholars' research on commercial space began in the 1920s, and has developed into a more mature theoretical system. Classical theories such as central land theory and land rent theory have emerged. In different historical periods, the neoclassical school, spatial analysis school, and behavior school of commercial space research have been correspondingly born abroad. Foreign scholars' research involves the spatial characteristics of commercial retail activities, retail location choices, consumer behavior, etc. After the introduction of measurement methods, scholars began to conduct spatial analysis of commercial forms in specific regions [1]-[5]. The domestic scholars' research on commercial space started in the 1980s. The research relied mainly on the theoretical
system of foreign scholars. The research mainly focuses on commercial space structure, format layout, image factors, etc. The research area is mainly in Beijing, Shanghai and other cities [6]-[14].

In terms of commercial space research, scholars at home and abroad have done more research on theories, models, and empirical studies in big cities. However, the research on the specific micro-location of living supermarkets in urban commerce and their spatial symbiosis has rarely been found. This article takes the living supermarkets in Chongqing's main urban area as the research object, and uses the Internet big data resources to study the spatial distribution characteristics of living supermarkets and their symbiotic relationships, to provide a reference for major decision-making such as urban commercial space planning and layout.

2. Data sources and research methods

2.1. Data sources

Through pathon crawler technology, Gao De POI data of May 2019 and July 2014 in Chongqing's main urban area were obtained, of which 470,733 in May 2019 and 280,476 in July 2014. After obtaining the crawled data, it was first cleaned, mainly dealing with data duplication and missing data attributes. Then, the POI data in the study area were spatialized based on its latitude and longitude coordinate information. Finally, the spatialization was performed. The POI data are transformed into coordinate projections and unified into the 2000 national geodetic coordinate system.

2.2. Research methods

The spatial density analysis of geographic information calculates the data aggregation status of the entire area according to the input point feature data set, thereby generating a continuous density surface. Kernel density estimation (KDE) is a spatial density analysis method based on a data density function clustering algorithm. During the analysis process, give high weights to those close to the center and low weights to those far from the center, and its equation is defined as:

$$\int h(x) = \frac{1}{nh^d} \sum_{i=1}^{n} K\left(\frac{x-x_i}{h}\right) \tag{1}$$

Where, $K\left(\frac{x-x_i}{h}\right)$ representing the form of a kernel function, usually a symmetrical single-peak probability density function; $h$ is the bandwidth, which is a free parameter that defines the amount of smoothing; $d$ is the dimension of the data; $n$ is a function of the point i within the bandwidth. This paper uses the kernel density estimation method to analyze the traffic congestion points within the inner ring of Chongqing's main urban area.

3. Spatial distribution characteristics of living supermarkets

Life supermarket is a system that cannot be simply attributed to a certain type of supermarket, including mall supermarkets, convenience stores and so on. Starting from the data, the basic objects for researching the life supermarket system are selected, and the POI of Gaode Map as of May 2019 is used for object extraction. In the process of object extraction, the following three considerations were mainly made: First, consider the typical POI that meets the shopping needs of citizens in daily life. The two categories of “convenience store” are specifically selected as “supermarket” and “convenience store”; the second is to consider the types that cannot be easily obtained from POI data, and extract them based on the POI name keywords, spatial proximity and other conditions, screening out “shopping malls supermarkets, 24-hour convenience stores and import stores; the third is to duplicate and overlap each category to ensure independence. Finally, the five basic categories of shopping malls, supermarkets, independent supermarkets, 24-hour convenience stores, general convenience stores, and imported merchandise stores were identified. A shopping mall supermarket is
a supermarket located inside a large shopping mall. Independent supermarkets are relatively independent of supermarkets in terms of space.

3.1. Supermarket (Including mall supermarket, independent supermarket)

3.1.1. Overall situation. The spatial distribution pattern of Chongqing's main city supermarket matches the "multi-center group" urban structure (Figure 1). The high-density area of the supermarket in the main urban area is mainly located around the core business circle within the inner ring, showing a clustering trend; scattered outside the inner ring, and the local area extends along the traffic corridor, reflecting the expansion in the development process. Judging from the quantity, among the streets in the main city, Yuping Road in Shapingba District has the highest density of 12 supermarkets per km² and among the towns in the main city, Jiulong Town in Jiulongpo District has the highest density, with 4 supermarkets per km². The development of supermarkets in the main urban area presents the "Matthew Effect", which is still concentrated in several major business districts within the inner ring and its surroundings (Figure 2). Besides the university town relies on the stable demand of student groups and presents a new growth direction. The growth rate from 2014 to 2019 is about 33%, and the increase is mainly in Nanping, Guanyin Bridge, Yangjiaping, Three Gorges Plaza, and University Town.

![Figure 1](image1.png) ![Figure 2](image2.png)

Figure 1. POI nuclear density map of Chongqing main city supermarket in May 2019.  
Figure 2. POI nuclear density analysis chart of the main city department store.

3.1.2. Supermarket. Shopping malls and supermarkets are highly concentrated in the five traditional commercial districts of Chongqing's main city, and another "two-way" area has emerged. Compared to other types, it is mainly distributed in six "points", including several commercial districts such as Guanyin Bridge, Nanping, Jiefangbei, Yangjiaping, and Three Gorges Plaza, as well as two road areas with a relatively long distance. To some extent, it reflects the unstable state of the mall and supermarket layout during the rapid development process, which indicates that a vacuum zone of mall and supermarket services has emerged between the traditional commercial circle cluster and the two enclaves. The Jiefangbei street in Yuzhong District has the highest density of the malls in the main urban area, with 5 malls per km². The growth rate of the mall and supermarket data from 2014 to 2019 is about 10%.

3.1.3. Independent supermarket. Independent supermarkets in the main urban areas are related to the distribution of residential quarters, with a relatively wide distribution range. The high-density areas are
mainly in Dayangshi, Nanping, Shapingba, Beibei Old City, Yuzhong Peninsula, and the inner ring area north of Jialing River (Figure 3). However, the clustering degree of each film is not uniform. The southern subcenters such as Nanping, Daping, Yangjiaping, and Shapingba have higher clustering degrees than the northern filming areas. Xiaolongkan Street in Shapingba District has the highest density of independent supermarkets in the main urban area, with 11 independent supermarkets per km². In the past three years, the growth rate has been three times that of shopping malls and supermarkets, and the increase has been distributed in diverse urban areas. The growth rate of the number of independent supermarkets from 2014 to 2019 is about 35%, which is accentuated by the increase of Three Gorges Square, Longtou Temple, Yangjiaping, University Town, and Tea Garden.

![Figure 3. POI nuclear density analysis chart of independent supermarket in main city.](image1)

![Figure 4. POI nuclear density analysis chart of convenience stores in the main city.](image2)

3.2. Convenience store

3.2.1. Overall situation. Compared with supermarkets, convenience stores have relatively homogeneous cluster characteristics. Convenience stores in the main urban area are mainly concentrated within the inner ring. The larger agglomeration areas include the surrounding areas of Guanyin Bridge to Longxi, Nanping, Shapingba, and Lianglu to Huixing. Among streets of the main city, Xiaolongkan Street in Shapingba District has the highest density, reaching 66 convenience stores per km², and Nanping District in the south bank district of the main city has the highest density, reaching 16 convenience stores per km² (Figure 4). Convenience stores are mainly relying on the development of more mature commercial areas, and have achieved rapid growth in recent years. From 2014 to 2019, the number of convenience stores in the main urban area increased by about 1.2 times, and the increase was mainly in Nanping, Yang Jiaping, Guan Yinqiao, Sha Pingba, Jie Fangbei, Beibei Old City and other places.

3.2.2. General Convenience Store. Convenience stores in the main urban areas are relatively widely distributed, and the degree of agglomeration appears to be "heavy in the north." It is contrary to the trend of independent supermarkets "heavy in the south and light in the north", and may be related to the complementarity of service functions of the two types of supermarkets (Figure 5). Convenience stores in the main urban areas are relatively concentrated in the two roads-Huixing, the north of the Jialing River to the inner ring area, Nanping and Shapingba, and the two road areas are the most prominent. Xiaolongkan Street in Shapingba District has the highest density of general convenience stores in the main urban area, with 66 general convenience stores per km². Convenience stores in the
main urban areas are growing at a faster rate, similar to the incremental distribution of independent supermarkets in diverse urban areas. From 2014 to 2019, the growth rate of general convenience stores in the main urban area was about 114%, and the increase was mainly in Nanping, Beibei Old Town, Yangjiaping, Guanyinqiao, Three Gorges Plaza, and Huixing.

3.2.3. 24-hour convenience store. 24-hour convenience stores in the main urban area are mainly concentrated in commercial areas within the inner ring, with the highest concentration of Guanyin Bridge-Longtou Temple and Nanping. The 24-hour convenience store in the main city area is mainly adjacent to the development of commercial areas, and also includes Dashiba, Ranjiaba, and Wulidian(Figure 6). Convenience stores in the main urban area have the highest density of Tuwan Street in Shapingba District, which is 9 per km². Convenience stores in the main urban area are growing at a rapid rate, increasing by 2.6 times, about twice the growth rate of ordinary convenience stores. Besides to the concentration of traditional shopping areas, the increase in Daping and Dashiba-Ranjiaba areas is also prominent. From 2014 to 2019, the number of 24-hour convenience stores increased by about 259%, and the increase is mainly in Guanyinqiao, Yangjiaping, Daping, Nanping, Dashiba, and Three Gorges Plaza.

3.3. Import Merchandise Store
In the main urban area, imported goods stores are generally distributed in small clusters, and the concentration degree in the Guanyinqiao area is the most prominent(Figure 7). In addition, the concentration of haier road is also high.Compared with the distribution of convenience stores and other types, the main city's imported goods stores are more concentrated. Although the concentration of imported merchandise stores in the main urban area is most prominent in the Guanyinqiao area, according to street statistics, the density of Jiefangbei Street in Yuzhong District is the highest, at 4 per km².
4. Symbiotic relationship of living supermarket space

The differences in environmental factors such as business, facilities, and transportation around the living supermarket show different environmental symbiosis characteristics, and the possibility of residents' consumption choices is high or low, which in turn leads to deeper service level differences. In other words, due to differences in the surrounding symbiotic environment, life supermarkets have different levels of inherent service capabilities. This community characteristic of differentiated service levels has become an invisible force, which subtly affects the living convenience and even the living mode of the settlements in the area. This article attempts to analyze the environmental symbiosis relationship from the spatial entity of the living supermarket and analyze the spatial information in a specific range around it. The determination of the spatial analysis scale mainly includes the following two considerations: (1) Considering the actual support conditions of the data, choose a buffer analysis method, and analyze the distance based on a 10-minute walking distance and about 500 meters; (2) For large shopping malls and supermarkets, the buffer radius is 530 meters.

4.1. Symbiosis environment around living supermarkets in the main city

The types of POI with the largest number of extended spaces in living supermarkets are "shopping service (accounting for 28.2%)", "food service (accounting for 22.31%)", "living service places (such as courier companies, appliance repair points, graphic printing etc. accounting for 17.37%), "Company (accounting for 9.84%)." It can be seen that half of the POI facilities in the symbiotic environment around the living supermarket are either "shopping services" or "catering services"(Figure 8).

4.2. Comparison of the POI type complex degree and low type complex degree in the extended space of the living supermarket in the main urban area

The natural breakpoint method is used to classify the POI type compound degree of the extended space of various types of living supermarkets into three levels: high, medium and low(Figure 9). The POI type of living supermarket extended space has a high degree of compounding, that is, there are relatively many types of facilities in the surrounding symbiosis environment; the POI type of living supermarket extended space has a low degree of compounding, that is, relatively few types of facilities in the surrounding symbiotic environment. Comparing the two cases with high POI type and low type combination, it was found that within the range of high type combination, "accommodation services", "sports leisure", "financial insurance" and other service leisure type facilities accounted for a slightly higher proportion; types of public infrastructure services such as "medical care", "transportation
facilities", "automobile services", and "car maintenance" accounted for a slightly higher proportion within the low-complexity range.

Figure 8. Proportion of various types of POI in the extended space of life supermarkets in the main urban area.

4.3. Relationship between POI Type Complexity of Living Supermarket Extension Space in Main Urban Districts and Residential Quarters

There are many types of supermarkets around the community, mainly located in Runjiaba, Jiazhou, Huangnilb, Guanyin bridge, Jiefangbei, Shiqiao pu, Yangjiaping, Daping and so on (Figure 10). The POI type composite degree of the extension space of the life supermarket of the Auto Expo Center has collapsed; the overall POI type degree of the extension space of the living supermarkets in new urban areas such as university towns, tea gardens, etc. is not high as a whole; The POI type composite degree of the extension space of living supermarkets in the popular area of homeownership is also at a low value. It is worth noting that after more than ten years of development of the Dazhulin Plate, the POI type combination degree of the extension space of living supermarkets is relatively high and has reached the median value. In addition, it was noticed that the composite degree value in the living supermarket had a significant collapse in the Yuanyang area.

5. Conclusion outlook

Based on collecting POI data (2014 and 2019 editions) of Gaode in the main urban area of Chongqing, this article extracts a lifestyle supermarket system (including mall supermarkets, independent supermarkets, general convenience stores, 24-hour convenience stores, and imported merchandise stores). Using GIS technology, a detailed analysis of the spatial distribution characteristics of the living supermarket system was conducted. At the same time, the spatial symbiotic relationship between the living supermarket and the surrounding residential quarters was studied. Through analysis, it is found that different types of living supermarkets have different spatial distribution characteristics due to the difference in service objects and service levels. For example, supermarkets and other areas are closer to business districts, and convenience stores are closer to residential. The areas with a high degree of complexity of the living supermarket system around the residential area are mainly distributed within the inner ring and have a high degree of spatial fit with the major business districts. Outside the inner ring, they are mainly located in the north of Beibei City, Beibei Old City,
Bananyudong, Yubei Two-way and other areas. This article analyzes its spatial distribution characteristics and the spatial symbiosis relationship with residential quarters from the static perspective of living supermarkets. In the next research, you can try to add the consumption data of living supermarkets and the trajectory data of living trips to analyze the spatial dynamics, may dig more deep-seated laws.

**Figure 9.** Comparison chart of the situation where the type of POI of the supermarket extended space is high and the type is low.

**Figure 10.** Types of residential quarters in the main urban area based on the POI type of the extended supermarket space.
References

[1] Huff D L 1963 A probability analysis of shopping center trade areas[J] Land economics 53 81-89
[2] Dawson J A, Dennislord J 1985 Shopping Center Development: Policies and Prospects[M] London & Sydney: Croom Helm
[3] Jones K, Simmons J 1993 Location, Location: Analyzing the Retailing Environment[M] Canada: Nelson
[4] Zhou Wei, Zhang Qin 2012 Spatial Planning and Management Policy of British Retail Industry and Its Evolution [J] Modern Urban Studies 10 67-71
[5] Yang Ying 2000 Research Progress on Commercial Spatial Theories in Western Countries since the 1920s [J] Tropical Geography 1 62-66
[6] Wu Yuwen 1988 Discussion on the Location of Retail Commercial Enterprises in Guangzhou City [J] Geographical Science 3 201-208
[7] Yu Wei, Wang Enru, Song Jinping 1984 Research on the Development Trend and Characteristics of Beijing Retail Space since 1984 [J] Acta Geographica Sinica 8 1098-1108
[8] He Yongda, Zhao Zhitian 2012 An Empirical Analysis on the Spatial Distribution Characteristics and Dynamic Mechanism of China's Retail Industry [J] Economic geography 1 1971-1976
[9] Zhu Wei, Wang De 2011 Simulation of retail space structure based on multi-agent [J] Acta Geographica Sinica 6 796-804
[10] Zhang Guoxin, Hu Xuezhi 2011 Research on the Impact of Retail Site Selection on Its Competitiveness [J] Modern Urban Studies 12 73-78
[11] Ji Haowei, Zhao Yuan 2010 A Study on the Spatial Distribution of Urban Hypermarkets in Nanjing [J] Economic geography 5 756-760
[12] Yu Wei, Yang Shuai, Song Jinping et al 2012 Research on Beijing's Commercial Suburbanization under the Background of Functional Decomposition [J] Geographical Research 1 123-134
[13] Zhang Shilei, Bi Zhongde, Yang Zhiyi et al 2011 Analysis of the Evolution Process and Driving Factors of the Benchmark Land Price of Commercial Land in Changchun [J] Geographical Science 7 823-828
[14] Li Qiang, Wang Shijun, Mei Lin 2013 Research on the Spatial Evolution Process and Mechanism of Large-scale Supermarkets in Changchun City Center [J] Geographical Science 5 553-560