Study on Spatial Distribution of Fresh Supermarket Based on Street View Data

Abstract: People's demand for fresh agricultural products of fruits and vegetables is absolute, and the demand for fruits and vegetables is also continuous and regular. The outbreak of COVID-19 has increased people's requirements for food safety. At the same time, the emergence of the digital economy has gradually increased the number of take-out shopping methods that reduce contact with people. Based on open data such as Baidu map and Dianping combined with field research, this paper analyzes the distribution and use of fresh supermarket before and after the epidemic. The results showed that the epidemic further reduced the service radius of fresh supermarkets and reduced the accessibility of the roads where the stores were located. However, regional fresh markets with different online degrees have different degrees of change. Under the influence of the epidemic, fresh markets that are easier to reach and have distribution services have developed more strongly, thus distinguishing the distribution pattern of fresh stores in different regions. To a certain extent, Internet services have given stores stronger stability, and areas with perfect online development have been developed after the epidemic, and store location distribution is more closely related to geographical factors.

Key words: Fresh supermarket; Space Syntax; Space law; Accessibility

1 Research Background

In daily life, the fresh market, as an indispensable commercial type, provides people with fresh fruits and vegetables necessary for life. Under the impact of the epidemic, the importance of fresh markets has further increased, while take-out shopping methods that reduce human contact have gradually increased. During the pandemic, the daily necessities provided by the fresh market are relatively less affected; As a product supply business that must be consumed, fresh supermarket is closely related to the social economy, and the evolution of this business form can reflect the economic behavior pattern under the new purchasing environment.

At present, the use of big data for commercial spatial analysis has gradually become a new trend in commercial quantitative research. The public-oriented commercial institution point of interest (POI) data contains the spatial information of retail store location and the attribute information of business type, which is characterized by large data volume and strong real-time performance. It can improve the objectivity and accuracy of the hot spot identification of the commercial center and the analysis of the characteristics of the retail agglomeration area. With the development of information technology, the spatial analysis of commercial agglomeration by big data has gradually become a new trend of commercial quantitative research, providing more accurate judgment criteria and comprehensive technical support for urban planning and governance.

Most studies on open network data analyze the urban spatial structure through the overall business composition and apply it to urban assessment and guide urban design. For example, Zheng Xiaowei (2017) analyzed the urban and community-level service industry based on open data. The urban center system determined in the overall urban planning should be identified, and the main business forms and spatial agglomeration degree of various urban center service industries should be clarified to guide urban design [2]. On the block scale, the factors that affect the vitality of the site are judged by the quantitative evaluation of the component elements in the local area. For example, Zhao Nannan et al. found the influencing factors that affect the vitality of the commercial street of Binjiang Road through the analysis of the Dianping data [3]. Some scholars also analyze the composition of regional formats based on open data to know relevant designs. For example, Professor Sheng Qiang conducted regional potential evaluation through open data and applied it to the quantitative evaluation and comparison of different schemes [4]. Tan Xin obtained the data and attribute information of restaurants in the main urban area of Beijing and analyzed the influencing factors according to the Sixth National Population Census, Beijing Statistical Yearbook, Beijing Master Plan, Beijing Municipal Commission of Tourism Development, basic Geographic Information Network, Baidu Map, Dianping, Fantong, etc. [5]. Jiao Yao et al. obtained the business distribution of Guangzhou through Baidu map POI, and analyzed the relationship between urban land expansion, real estate expansion and commercial business space [6]. Yan Longxu obtained and distinguished the locations of catering shops and online shops under Shanghai's inner ring Road through open data such as Ele. me and Dianping, and summarized the distribution characteristics of the two [7]. Xia Lingjun et al. obtained the catering data of 355 cities in China through Dianping data and analyzed its distribution pattern, characteristics and influencing factors [8]. Wu Jianxun et al. obtained the location data of catering shops in Nanning through the open data of AmAP and analyzed the distribution and evolution of catering space [9].

Theoretically, Space Syntax theory holds that the topology of street network determines the state of motion distribution, while commercial functions are directly dependent on traffic flow [10]. For example, Shengqiang's team also found that the overall business distribution topology was obvious in many cases in Jilin and Beijing [11,12]. Through the correlation between the composition ratio of housing service facilities and syntactic parameters, Zhu Xuhuan obtained the business formation and layout rules of typical residential areas where commerce meets residents' needs [13]. In addition, the distribution law of a certain type of business is studied. For example, Tao Wei et al. explored the spatial layout law of the hotel industry from three perspectives, including the urban road network form [14]. Most studies on fresh supermarkets focus on the sales model or distribution law of certain fresh supermarkets. For example, Wang Lei et al. found the effectiveness of the hybrid innovative sales model through the case analysis of Metro Fresh supermarket [15]. As well as Wang Yun's analysis of the distribution of S fresh supermarket, the optimal site selection scheme was obtained [16]. Xiang Persisted et al. obtained the influencing factors by constructing the structural model of customer satisfaction of Hema Fresh Food [17]. On the whole, there are few researches on the distribution law of fresh supermarket at the block level by using Space Syntax.

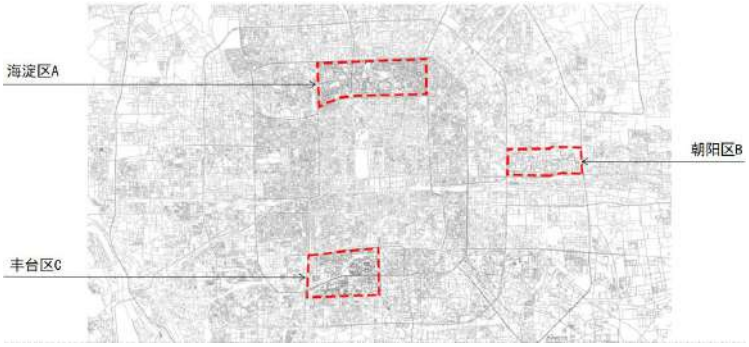
In the study on the impact of the epidemic on industrial distribution, before the epidemic, domestic and foreign studies were carried out on the impact of various epidemics and treatment measures on the economy, including the impact of the epidemic on the market economy [18, 19] and the impact on the hotel and catering industries [20]. In the existing studies related to COVID-19, most scholars believe that COVID-19 has caused a serious negative impact on China's macro economy, but also triggered structural changes in the industry [21]. In the recent studies, Wang Yangjie et al. also proposed that the epidemic will promote the development of industry digitalization [22, 23]. In terms of the development of fresh e-commerce, the impact of product supply, logistics distribution and other aspects has been mostly analyzed [24, 25], while there are few studies on the actual distribution of business formats after the epidemic.

Based on the above background, this study, based on open network data, applied Space Syntax to study the distribution and evolution rules of fresh supermarkets in three regions of Beijing during the epidemic period, and tried to analyze the change rules and influencing factors of fresh supermarkets under the influence of the epidemic.

2. Research Data And Methods

2.1 Research Object And Technical Route

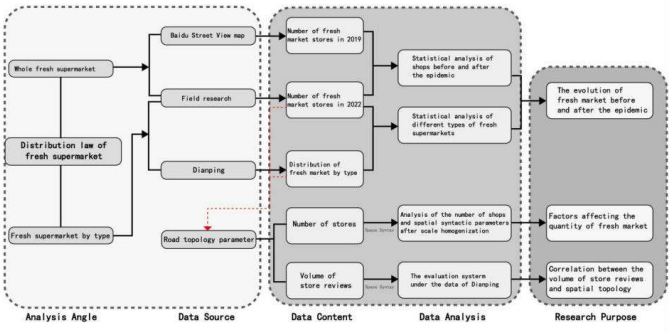
The fresh market in three regions of Beijing is selected as the research object in the research area (FIG. 1). After comparing and screening the surrounding environment, road network characteristics, permanent population and other data, three similar plots located in Haidian District, Fengtai District and Chaoyang District of Beijing are finally selected. Since the constituency does not cover the whole district, the plots within the research scope are named A, B and C respectively.



Figures 1. Study area diagram

The data of fresh supermarket in three regions are studied in multiple dimensions, which can be divided into two perspectives: the whole fresh supermarket and the sub-type fresh supermarket. For the overall analysis of fresh supermarkets, Baidu map and Baidu Street View map data were used to obtain the number and location of fresh supermarkets in 2019 and 2023. The changes in the number

and distribution of fresh supermarkets before and after the epidemic were obtained through statistical analysis and Space Syntax analysis, and the correlation between their distribution and surrounding influencing factors was also analyzed. The factors affecting the quantity of fresh market are analyzed. According to the information of stores on Dianping and Meituan, the fresh supermarket is divided into offline stores and online stores. Through the regression relationship of Dianping data and Space Syntax parameters, the difference between the distribution of the fresh supermarket in store mode and the fresh supermarket in store plus distribution is analyzed.



Figures 2 Technology roadmap

2.2 Data Processing Method And Model Independent Variable Selection

2.3.1 Analysis Of Changes In The Quantity Of Fresh Market

The subjects were selected as markets, supermarkets, vegetable shops and other stores that provide daily food. In the analysis of changes in the fresh market in 2019 and 2023, the market in 2019 was obtained by the street view pictures provided by the Baidu Map time machine, and the market in 2023 was obtained by the POI capture and proofread combined with field research (Figure 4). In the comparison of the period before and after the epidemic, the changes in the overall number of fresh market were divided into three conditions: new (no stores in 2019, no stores in 2023), stable (no stores in 2019, no stores in 2023), and disappeared (no stores in 2019, no stores in 2023).

2.3.2 Selection Of Influencing Factors Of Fresh Market Distribution

The Integration of Space Syntax refers to the shortest topological distance between a certain street segment and all other street segments within a certain geometric distance, which measures the spatial potential of reaching a certain street. Choice is the number of times a certain street segment is crossed by the shortest topological path of any two other streets within a certain geometric distance, which measures the spatial potential of crossing the street [1]. On the basis of these two indicators, Bill Hillier et al proposed standardized Angle selection (NACH) and standardized Angle integration (NAIN), aiming to further eliminate the influence of the number of line segments on the analysis, so as to realize the comparison of spatial systems with different scales and complexity. On the basis of the four types of

parameters, five different distance radii representing walking, non-motor vehicle and motor vehicle were selected for analysis, namely 750m and 1000m for walkers, 2000m and 3000m for non-motor vehicles and 5000m for motor vehicles, and the syntactic parameters were analyzed respectively.

Fresh supermarkets are generally located near living areas, and their main consumers come from surrounding residents. Therefore, the number of residents in mobile signaling data is selected as the population influencing factor. For road factors, parameters such as degree of selection and degree of integration in Space Syntax are selected. At the street level, the number of shops is correlated with population and road through the homogenization process of street summing.

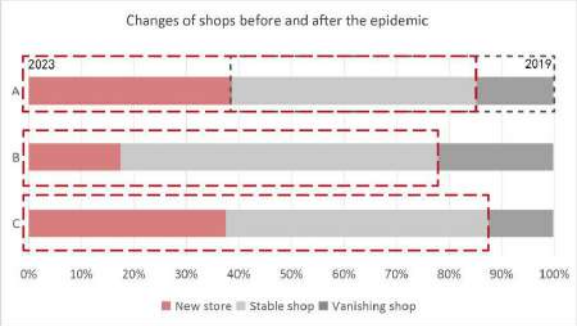
2.3.3 Classification Fresh Market Data Processing

The fresh market is divided into two types. According to the store information on Dianping and Meituan, the fresh supermarket is divided into offline stores that only rely on customers' offline purchase, and online stores with review and delivery services on Dianping, Meituan and other online stores.

3 Analysis Of Changes In Fresh Market

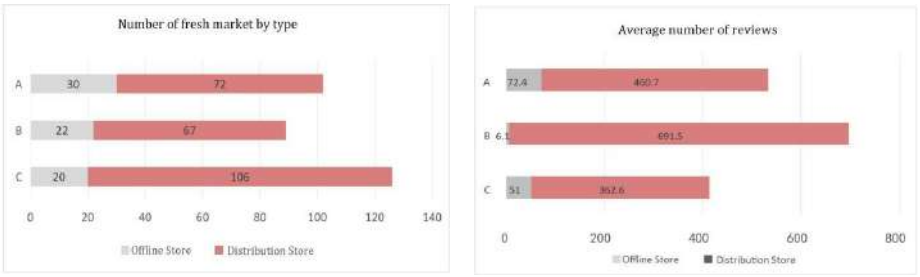
3.1 The Number And Online Presence Of Fresh Supermarkets Before And After The Epidemic

The distribution location of fresh supermarket in the region is obtained according to Baidu map (Figure 5), and the information of fresh supermarket is corrected through Baidu Street View map and POI data. Among the data in 2023, there were 132 effective fresh supermarkets in region A, 60 were added after the epidemic, 72 remained stable, and 23 disappeared. There are 126 effective fresh supermarkets in region B, 30 new after the epidemic, 104 stable, and 38 disappeared; There are 115 effective fresh supermarkets in area C, 54 new after the epidemic, 72 stable, and 18 disappeared.



Figures 3 Changes in the quantity of fresh market

Through Dianping and Meituan Distribution, fresh supermarkets in the region are further classified into online and offline types. Among them, online market refers to stores with a large number of comments on the cable. Citizens can obtain their location from Dianping software and understand the comment information such as product quality and service, and have distribution services. The offline market requires citizens to buy offline, and some markets have review services, but they do not have delivery services.



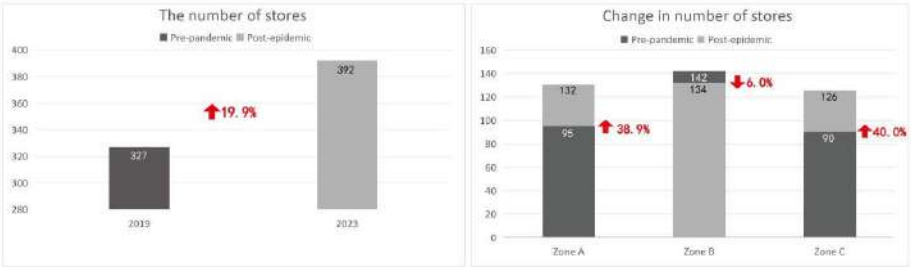
Figures 4 Number of stores in the three regions (left) and number of comments by type (right)

According to the proportion, the number of two types of supermarkets in the three regions is similar. When analyzing the volume of reviews, the volume of reviews of online stores is much higher than that of offline stores. In the comparison of the number of comments in the three regions, the average number of comments in the B region is much higher than that in the AC region, which further indicates that under the influence of the overall business atmosphere in the Chaoyang region, the fresh supermarkets in the region show strong information characteristics.

In the analysis of stores by type and the average number of reviews, the stores with delivery service in the three regions all showed a higher number of reviews. Based on the comparison of the comment rate and the average number of comments, relatively speaking, region B has a relatively concentrated online fresh market, and the online market has a considerable number of consumer audiences. The proportion of online stores in AC region is less, and consumer groups tend to choose offline purchases.

3.2 Changes In The Number And Distribution Of Fresh Supermarkets Before And After The Epidemic

Based on the overall number of fresh markets in the three regions and the online situation, the change of the number and the average distance between stores before and after the epidemic were analyzed.



Figures 5 Changes in the quantity of fresh market before and after the epidemic

For the whole study area, the number of fresh supermarkets increased significantly after the epidemic. For the fresh market in each region, the number of fresh market in AC region increased significantly, while the number in B region decreased slightly. For the average store spacing, the average store spacing in AC region decreased during the epidemic period, while it increased slightly in B region.

Figures 6 Changes in average store spacing

Under the influence of the epidemic, the quantity distribution of the fresh market has changed, and the overall trend is growing. At the same time, its distribution position also changed. This paper used Space Syntax software to position the market before and after the epidemic, and calculated its walking accessibility and vehicle accessibility respectively. The accessibility changes within the whole region were compared with the accessibility changes in each sub-region, so as to judge the distribution trend.

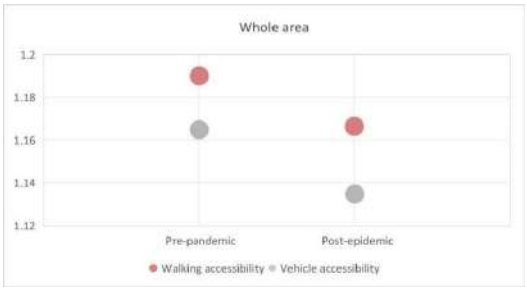


Figure 7 Changes in accessibility before and after the epidemic

Figures 8 Total number of reviews of stores in the three regions (left) and average number of reviews by type (right)

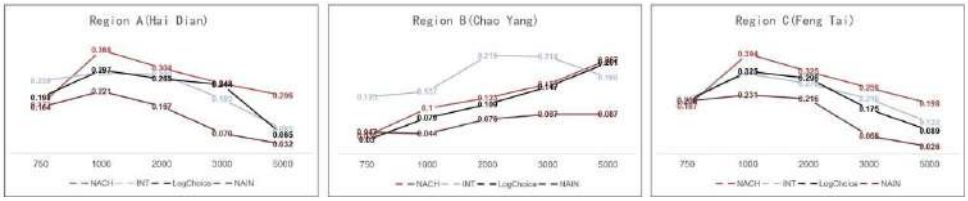
According to the analysis of the above figure, the walking accessibility and motor vehicle accessibility of the fresh market both show a downward trend; In the comparison of the three regions, the accessibility of shops in the three regions decreased, but to different degrees. The distribution accessibility of region B was lower than that of AC, but the accessibility changed little under the influence of the epidemic, and even the accessibility of motor vehicles was slightly improved.

The results showed that the total number of fresh market increased when people reduced long-distance shopping after the epidemic. But the impact varies in different regions. The obvious increase in the number of markets in AC region reflects the further increase in the demand for fresh markets under the epidemic situation. However, judging from the stable or even reduced number of stores in B region, the growth of the fresh market is limited to a certain extent. The average distance between stores in the three regions is also related to the quantity change, and the distribution radius of AC fresh market is further reduced, and finally reaches the same as that of region B. At the same time, this change may also be related to the degree of regional market online, the high-line B region showed stronger stability during the epidemic, while the AC region with a lower degree of network distribution service had a greater impact. In addition, under the impact of the epidemic, the distribution of shops has further reduced the requirements for road accessibility, and shops located in hard-to-reach back streets and alleys have become relatively more "safe" shopping choices.

4 Factors Affecting The Distribution Of Fresh Market

4.1 Distribution Law Of Fresh Market Quantity After Epidemic

The distribution of the fresh market is often related to road accessibility. When Space Syntax parameters are applied to analyze the distribution of the number of shops and the number of comments, in order to eliminate the interference of accidental factors in the space and reduce the numerical differences of adjacent space units, the number of shops within a 500M radius along the street is added up, and the parameters of integration degree and selection degree in Space Syntax are selected. Then the correlation analysis is made with the syntactic parameters in five different radii.



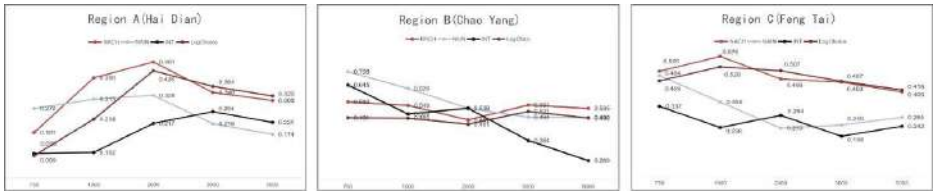
Figures. 9. Three-region regression analysis in 2023

In the analysis of the correlation between the number of fresh supermarkets and the urban topological structure, AC region has the highest correlation with the traversability parameter of 1000m radius, which indicates that supermarkets are greatly affected by the accessibility potential, and the number of supermarkets is significantly affected by the walking flow. However, the correlation between the number of fresh supermarkets and the pedestrian flow in area B is not strong, and the highest correlation is the travel degree parameter of the radius of 5000 meters. This phenomenon may be caused by the influence of the concentration of business districts in Chaoyang District, which makes the fresh supermarkets in this area have more characteristics of urban commerce.

Overall, when there is a high correlation between the number of fresh markets and road influencing factors, walking flow is often the decisive factor. In the case of the same radius, the traversal parameter correlation tends to have a higher correlation, which proves that the fresh market tends to be distributed on streets that are easier to cross. They tend to be on streets that are easier to cross.

4.2 Distribution Law Of Online Fresh Market

Since the online degree of shops in the three regions is different, the number of shop comments is taken as the research object to further explore the relationship between online shop sales and road topology.



Figures. 10 Correlation between review volume and accessibility in the three regions

On the whole, the number of shop reviews in region A is highly correlated with the selectivity parameter, indicating that shops distributed on roads with high travel are more likely to be patronized by customers. The peak values of integration parameters are all at R2000m, indicating that their distribution is more susceptible to the influence of non-motor vehicle flow. The number of shop comments in area B is highly correlated with the parameters of the integration degree system, indicating that shops are greatly affected by the accessibility potential, and the peaks of the integration degree parameters are all at R750m, indicating that their distribution is more susceptible to the influence of walking traffic. The number of shop comments in area C is highly correlated with the selectivity parameter, indicating that shops are greatly affected by the degree of travel, while the peaks of the integration parameter are all at R1000m, indicating that their distribution is more susceptible to the influence of walking traffic.

According to the parameter analysis of the three regions with the highest correlation, the stores in AC region are more inclined to be distributed in the area with high intensity of pedestrian traffic, while the stores in B region are distributed in the area with high degree of road aggregation. Among them, the regularity of store distribution in area B is relatively weak, which may be related to the high degree of online. The correlation between the number of fresh markets and the number of reviews and the urban topological structure is confirmed, while in the area with the gradual improvement of online development, the store location is to a certain extent free from the influence of geographical factors, which is also verified in area B.

5 Conclusion and discussion

The results showed that: in terms of the overall fresh market, the epidemic increased the number of fresh supermarkets and further reduced the service radius, and the service radius after the epidemic was about 350M. At the same time, the accessibility of store distribution was reduced, and stores located on remote roads were more easily selected by customers. In the comparison between regions, the regions with a relatively high proportion of online stores were less affected, and the number of stores in the region did not change significantly before and after the epidemic, and the business format was more resilient, while the number of fresh supermarkets in the regions with a low proportion of online stores increased significantly after the epidemic.

In the analysis of market and road accessibility after the epidemic, the regions with more online markets are correlated with the degree of road integration, and the market is concentrated in the regions with more dense roads, while the regional market distribution with more offline markets is correlated with the degree of road travel, and is more dependent on the intensity of road traffic flow. The number of shops in the two types of areas is greatly affected by the demand for short-distance travel. In the comparison of the correlation between the number of online fresh market reviews and accessibility, the stores with higher review volume were distributed in the sections with better accessibility and were more affected by geographical factors.

Therefore, the epidemic may have the following impacts on the distribution of fresh markets: In terms of the quantity change and distribution law, the number of fresh markets increased, and the relative distance between markets decreased, which proved that the demand for fresh products by surrounding residents further increased, and they were more inclined to reach the purchase demand in a small range. After the epidemic, the geographical location of the newly added markets tended to be far away from the area where people and vehicles gathered. The distribution characteristics of different regions showed similar accessibility in small-radius road distribution, which indicated that the construction purpose of fresh market was similar to that of nearby communities and easy to walk during the epidemic period. In terms of online service and distribution service stores, because online delivery service can ignore the impact of the actual geographical factors of the market on consumers, the fresh market is less affected under the epidemic situation, and the number of regional stores with a high degree of online service can provide distribution services changes less. However, in areas with insufficient online access, people often choose to buy consumer goods in nearby fresh markets under the impact of the epidemic, and the demand for smaller markets increases, resulting in an increase in the number of fresh markets. In short, under the impact of the epidemic, more accessible store locations and contactless delivery services have been stronger development, and therefore affect the distribution pattern of these fresh stores in the region.

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