

# Research on the Characteristics of Spatial Concentration of Banking Industry in Guangdong Province Based on Kernel Density Function

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## Abstract

In order to reveal the spatial agglomeration characteristics of different types of banks, this paper uses statistical means such as the average nearest distance and the nuclear density function, combined with economic density, for the five major banks of Guangdong Province in 2009-2018 (state-owned commercial banks, joint-stock banks, foreign banks, cities). The temporal and spatial evolutionary characteristics of spatial agglomeration of commercial banks and rural commercial banks have been empirically analyzed. The results show that: (1) The spatial distribution of the banking industry in Guangdong Province is characterized by a prominent feature of "central-periphery" spatial agglomeration; (2) The spatial distribution patterns and agglomeration characteristics of different types of banks are very different. Among them, state-owned commercial banks, joint-stock banks, foreign-funded banks, and city commercial banks exhibit strong agglomeration characteristics. The spatial distribution curves of bank outlet density based on economic density are all decreasing, while rural commercial banks are general agglomerations, and the spatial distribution is represented by Homogeneity; (3) the degree of spatial agglomeration of different types of banks has increased over time during this period, but there has been a difference in bank classifications. In the final article, the relevant countermeasures and suggestions for the development of various types of banking industry are proposed.

## Keywords

Banking Industry; Kernel Density Function; Spatial Concentration; Guangdong Province.

## 1. INTRODUCTION

The financial industry is an important indicator of the comprehensive strength and economic development level of a country and region. Because it is closely related to the development of the national economy, it has become an important basis for investigating the shaping and reorganization of urban spatial structures in global countries and regions, deeply attracted by academic circles. Explore the complex spatial distribution characteristics of the financial industry on a global scale (Martin, 1999). Including location selection of financial institutions from a global perspective (Mitchell, 2015), characteristics of the spatial system of financial institutions (Bassens, et al, 2010; Marshall, 2004; Clark, et al, 2005), construction and selection of financial institutions and outlets and external influence factors (Dixon, 2012), financial geography model, financial globalization and regional operations (Lecturer, 2012), Spatial Distribution and Agglomeration of Finance (Wójcik, 2000; Arnold, et al, 2001). At the national and regional scales, more attention is paid to the spatial layout of the financial industry within cities, particular attention is paid to the spatial pattern of the financial industry guided by its geography, agglomeration, business districts, and economic and cultural characteristics, as well as its evolutionary characteristics and causes. Based on the basic geographic map and related

statistical yearbooks, the spatial distribution characteristics of Beijing's financial services industry were explored (Hui Liu, 2013), the results show that most of Beijing's financial institutions are located in central areas, and there are spatial differences in financial types. The bank-based network points reveal the spatial distribution pattern of the banking industry in Xuhui District, Shanghai, showing typical central-peripheral structure (Qiankuan Ni, 2017). The reasons for the spatial distribution of bank outlets in Jiangsu Province were analyzed from the aspects of urban built-up area, population, per capita GDP, number of industrial enterprises above designated size, urbanization rate, and the proportion of secondary and tertiary industries (Bingqing Che, 2017).

## 2. DATA SOURCES AND RESEARCH METHODS

### 2.1. Data Sources

In this article, Guangdong Province and its prefecture-level cities are selected as the research area, five major types of banks (state-owned commercial banks, joint-stock banks, foreign banks, urban commercial banks, and rural commercial banks) with more than 10,000 banking outlets as the research object. The relevant bank data comes from the city yearbooks of 2009-2018 and websites of major banks, location location data and related geographic information come from Baidu map. The data is mainly calculated and processed by the GIS method of ArcGIS software.

### 2.2. Research Methods

2.2.1 Average nearest distance. Average nearest distance is used to calibrate the average distance of similar banking outlets, at the same time, according to the ratio  $R$  between the nearest distance ( $d_i$ ) and the expected value ( $d_e$ ) to determine the spatial distribution characteristics of the bank outlets. If the nearest distance between each dot is substantially equal to its average distance, it is uniformly distributed, if there is a cluster of dots or more, the distance between them is much smaller than the average distance, while there is no distribution in the other group and above, it is cluster distribution; When some outlets are more concentrated and others are scattered, they are randomly distributed. The ratio  $R$  can be calculated by:

$$R = d_i/d_e \quad (1)$$

The expected value  $d_e$  can be obtained from the number of network points  $N$  and the area  $A$ :

$$d_e = \frac{1}{2} \sqrt{N/A} \quad (2)$$

When  $R < 1$ , it can be judged as a clustered distribution; when  $R > 1$ , it is a distributed distribution; when  $R = 1$ , it is a random distribution. In this study, the value range of  $R$  is:  $0 \leq R \leq 2.149$ . The corresponding standard deviation  $Z$  is:

$$Z = \frac{d_i/d_e \sqrt{N^2/A}}{0.26136} \quad (3)$$

When the value of  $Z$  is extremely low (strongly agglomerated) or extremely high (strongly dispersed), its significant  $p$ -value will be extremely small. The critical  $Z$  values of 2.58, 1.96, and

1.65 correspond to p-values of 0.01, 0.05, and 0.1, respectively. When  $p < 0.01$ , it shows a strong agglomeration or strong dispersion distribution; when  $0.01 < p < 0.05$ , it is a strong agglomeration (dispersion) distribution;  $0.05 < p < 0.1$ , it is a general agglomeration or general dispersion distribution;  $p > 0.1$ , it is random.

2.2.2 Kernel density function. This function is a typical method in modern non-parametric statistics, and can be applied to research in many fields such as space hotspots. The sample density is estimated based on the dot density in the unit area, and the kernel density in a two-dimensional plane can be calculated by the following formula:

$$\lambda(s) = \sum_{l=1}^n \frac{1}{\pi r^2} \varphi(d_{ls} / r) \quad (4)$$

Among them,  $\lambda(s)$  represents the kernel density in the area,  $r$  is the area bandwidth (function radius),  $n$  is the number of dots, and  $\varphi$  is the weighted value of the distance  $d_{ls}$  between the dots  $l$  and  $s$ .

2.2.3 Buffer method. Using the buffer method to analyze the coverage of the bank, and use the 1000m area around the outlets as the coverage area, and calculate the coverage area  $A_c$  by the buffer method of GIS. The coverage  $R_c$  is expressed as:

$$R_c = A_c / (A_T - A_0) \times 100\% \quad (5)$$

Among them,  $A_T$  is the total area of the study area,  $A_0$  is the area of water areas, wasteland and other areas that are not involved in calculation. The higher the  $R_c$  value, the higher the coverage rate.

### 3. RESULTS AND ANALYSIS

#### 3.1. Spatial Distribution and Clustering Characteristics of Bank Outlets

3.1.1 Prefecture-level city level. Based on the above formulas (1) to (5), the bank outlet layout and clustering characteristics of various prefecture-level cities in Guangdong Province in 2018 were analyzed. The P value and the number of bank outlets indicate that the banking industry in Guangdong Province shows obvious imbalances in spatial distribution. Banking outlets in 7 prefecture-level cities including Shenzhen, Dongguan, Guangzhou, Foshan, Zhongshan, Zhuhai, and Shantou showed strong clustering characteristics, banking outlets in three prefecture-level cities including Jieyang, Chaozhou, and Maoming showed a general cluster. The bank outlets of the two prefecture-level cities in Yangjiang and Heyuan showed a strong dispersion. The remaining branches of Shanwei, Huizhou, Jiangmen, Zhanjiang, Zhaoqing, Yunfu, Qingyuan, Shaoguan, Meizhou and other prefecture-level cities are generally scattered.

**Table 1.** Spatial distribution characteristics of banks in prefecture-level cities in Guangdong Province in 2018

City	Number of banks	Average proximity	R	P value	Distribution characteristics
Shenzhen	2272	186.7	0.16	0.0000	Strong
Dongguan	1397	331.2	0.17	0.0000	Strong
Guangzhou	2477	245.7	0.20	0.0000	Strong
Foshan	1492	322.4	0.33	0.0000	Strong
Zhongshan	657	587.8	0.39	0.0000	Strong
Zhuhai	473	601.3	0.34	0.0000	Strong
Shantou	365	698.2	0.62	0.0000	Strong
Jieyang	297	744.3	0.91	0.0645	General
Chaozhou	162	902.7	0.83	0.0518	General
Shanwei	125	1038.3	1.23	0.0839	General
Huizhou	639	647.4	1.03	0.0844	General
Jiangmen	593	698.3	1.35	0.0767	General
Maoming	373	733.4	0.93	0.0704	General
Zhanjiang	466	703.4	1.02	0.0831	General
Yangjiang	178	1023.4	1.49	0.0322	Upper middle
Zhaoqing	397	805.6	1.06	0.0784	General
Yunfu	180	934.4	1.39	0.0716	General
Qingyuan	336	874.5	1.21	0.0803	General
Shaoguan	268	833.5	1.23	0.0792	General
Meizhou	332	984.2	1.34	0.0788	General
Heyuan	217	948.5	1.73	0.0244	Upper middle

3.1.2 Overall level. Based on the combing of previous research literatures and understanding of the relationship between banks and economic development, the paper analyzes its spatial agglomeration characteristics in combination with economic density. Relied on Guangdong's economic density and geographical location, the prefecture-level cities under its jurisdiction can be divided into core layers and other cities composed of the cities under the jurisdiction of the Pearl River Delta (Guangzhou, Shenzhen, Dongguan, Zhuhai, Foshan and Zhongshan) and the outer layer of other cities. The core layer is not only a common gathering area of Guangdong's economic resources and population, but also an active zone for foreign trade and investment. It undoubtedly has a large number of state-owned commercial banks, joint-stock banks and city commercial banks, and has also attracted a large number of foreign banks. The distribution of owned rural commercial banks is also slightly denser than in other regions, on the external level, the density of outlets of various banks is low, and the corresponding service coverage rate will also decline, showing a typical "central-peripheral" diffusion characteristic.

### 3.2. Temporal Evolution Characteristics and Spatial Density Model of Bank Branch Type Distribution

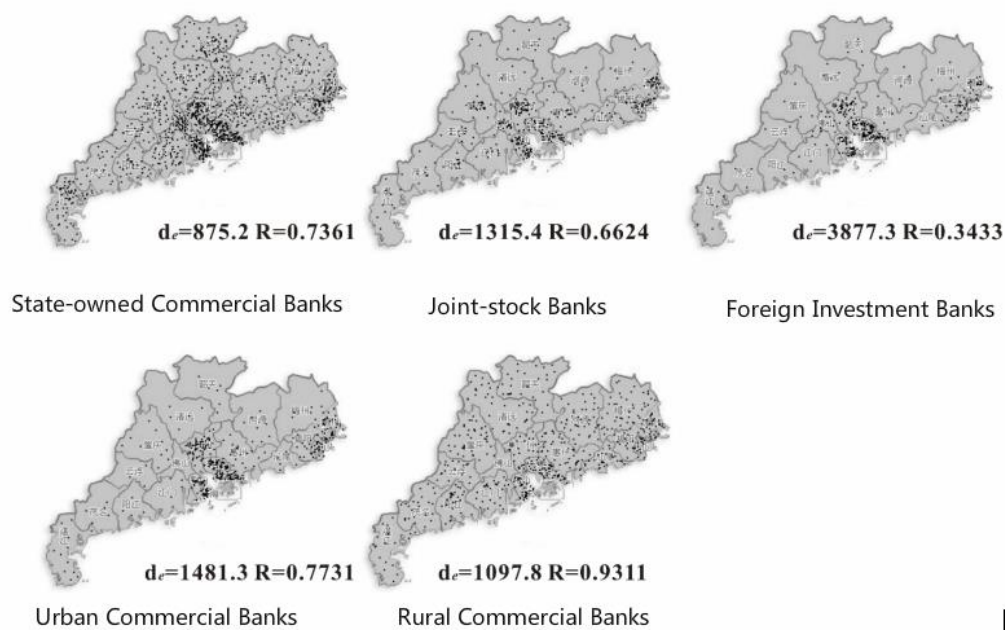
#### 3.2.1 Characteristics of time series evolution of bank branch type distribution

Based on the calculation of the number of outlets and outlet coverage of Guangdong state-owned commercial banks, joint-stock banks, foreign banks, urban commercial banks, and rural commercial banks from 2009 to 2018, the results are shown in Table 2.

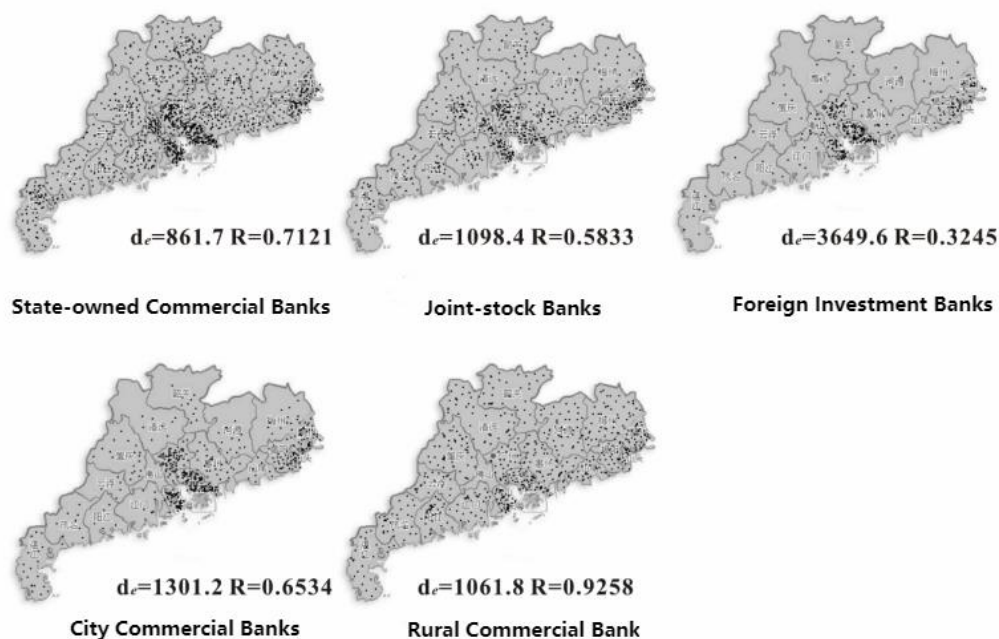
**Table 2.** Distribution of outlets and outlet coverage of major banks in Guangdong Province from 2009 to 2018

Year	State-owned Commercial Banks	Joint-stock Banks	Foreign Banks	Urban Commercial Banks	Rural Commercial Banks
2009	8210	1188	221	358	1920
2012	8337	1201	246	412	1959
2015	8458	1647	261	541	2001
2018	8353	2400	265	607	2071
1000m outlet coverage (%)	27.45	17.41	4.67	14.78	21.09
Distribution characteristics	Intensely concentrated	Intensely concentrated	Intensely concentrated	Intensely concentrated	General concentration

As can be seen from Table 2, the number of branches of state-owned commercial banks, foreign banks and rural commercial banks is relatively stable, due to the country's strict control over financial capital, the proportion of foreign banks is very small. In comparison, the number of outlets of joint-stock banks and city commercial banks has increased significantly. Among them, joint-stock banks have more market competitiveness due to their richer business types. From 1188 outlets in 2009 to 2400 outlets in 2018, the most significant increase during 2015-2018 was 45.72%. Because urban commercial banks can meet local needs, they also have their unique characteristics and have developed rapidly. The following will further apply methods such as average proximity distance and kernel density function to compare and analyze the spatial distribution characteristics of the five major bank outlets based on 2009 and 2018, the results are shown in Figures 1 and 2.



**Figure 1.** The spatial distribution of the five major banking outlets in Guangdong Province in 2009



**Figure 2.** The spatial distribution of the five major types of bank outlets in Guangdong in 2018

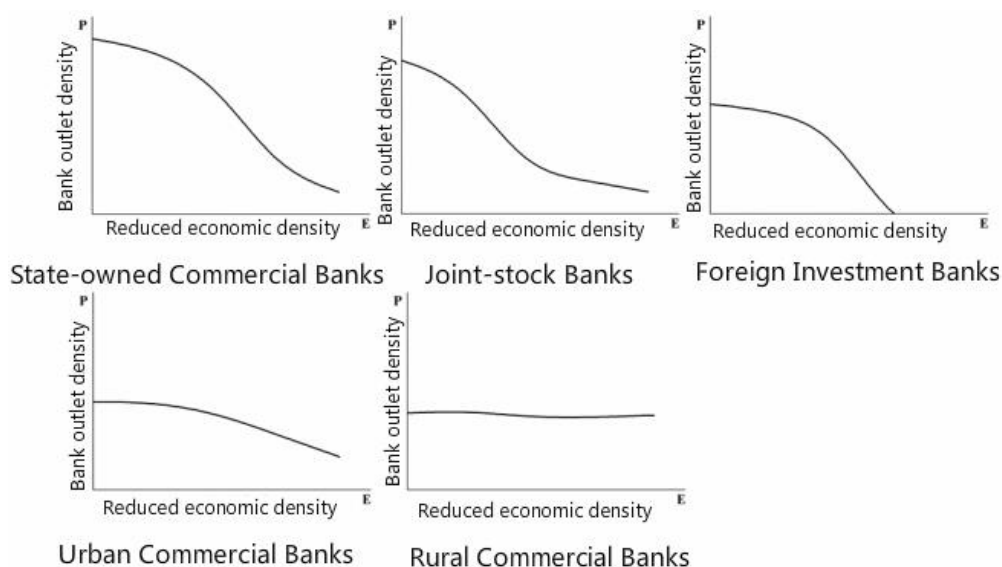
Statistical analysis found that Guangdong Province as a whole: the average proximity of state-owned commercial banks is the smallest, with data for 2009 and 2018 of 875.2m and 861.7 m. The average proximity of joint-stock banks, urban commercial banks, and rural commercial banks all exceeded 1000 m: (1315.4m, 1098.4m), (1481.3m, 1301.2m), and (1097.8m, 1061.8 m). The side shows that its spatial distribution is more dispersed compared to state-owned commercial banks to a certain extent; the average proximity distance of foreign banks is the largest (3877.3m, 3649.6 m). But does not indicate that the spatial distribution of its outlets is extremely scattered. The nuclear density R value results show that, except for rural commercial banks which are generally clustered (0.9311, 0.9258), other state-owned commercial banks (0.7361, 0.7121), joint-stock banks (0.6624, 0.5833), foreign banks (0.3433, 0.3245) and urban commercial banks (0.7331, 0.6534) belong to the characteristics of strong agglomeration, and from the perspective of 2018, the five major banks as a whole showed spatial agglomeration characteristics of foreign banks (0.3245) > joint-stock banks (0.5833) > urban commercial banks (0.6534) > state-owned commercial banks (0.7121) > rural commercial banks (0.9258). In terms of the spatial distribution of bank classification (Figure 2), the five major banks in Guangdong, Shenzhen, Dongguan, Zhuhai, and Shantou have obvious spatial clustering characteristics compared with other cities in Guangdong Province.

In order to improve the accuracy of the calculation, the article further uses the buffer method to examine the spatial clustering characteristics of the five major banks in Guangdong Province in 2018. The results are shown in Table 2. In terms of coverage of 1,000-meter bank outlets, the coverage rates of state-owned commercial banks and rural commercial banks are higher at 1000 m, which are 27.45% and 21.09%, The 1000 m coverage of joint-stock banks, foreign banks and city commercial banks are 17.41%, 4.67% and 14.78%, respectively. It can be seen that (1) the number of state-owned commercial banks is the largest and the coverage is the highest, but their spatial concentration is lower than that of the other three types of banks, the side confirms the general spatial agglomeration of rural commercial banks and the strong agglomeration characteristics of other four types of banks; (2) The characteristics of spatial agglomeration

types of foreign banks> shareholding banks> urban commercial banks> state-owned commercial banks> rural commercial banks.

In terms of time series, according to the specific changes of the absolute value of the nuclear density R value-urban commercial banks (0.1197)> joint-stock banks (0.0791)> state-owned commercial banks (0.0240)> foreign banks (0.0188)> rural commercial banks (0.0053),it shows that the number of outlets of state-owned commercial banks and rural commercial banks did not change much between 2009 and 2018, and their overall spatial pattern remained basically unchanged. The side shows that the market of these two types of banks is basically saturated. Foreign banks have increased to a certain extent and are mainly concentrated in cities around the Pearl River Delta, indicating that the degree of opening up of cities in Guangdong Province and the regional differences have increased. The average nearest distance and R value of city commercial banks and joint-stock banks have shown a significant downward trend. It shows that the operating development and market expansion of these two types of banks have greatly improved during this period. The root cause lies in the diversified characteristics of financial services to better meet people's financial investment needs under the background of sustained economic growth.

3.2.2 Spatial density pattern of bank branch type distribution. In order to further study the spatial pattern of outlet density of different types of banks, this paper will study the regional grid processing. Based on the GIS analysis of the number of bank outlets in the cell grid, calculate the density of outlets in different economic densities of various prefecture-level cities in Guangdong in 2018, analyze the characteristics of the agglomeration and distribution of the banking industry with changes in economic density. From the core layer of Guangdong's economic density to the outer layer, the five types of banks showed different patterns of spatial distribution of outlet density. The results are shown in Figure 3.



**Figure 3.** Distribution of outlet density of five major types of banks as a function of economic density

From Figure 3, we can find that there are obvious differences in the spatial distribution characteristics of different types of banking industry. Among them, the state-owned commercial banks present a typical non-uniform decreasing "S" curve from the core layer to the outer layer. That is, as the economic density decreases, the decline rate of the dot density starts to slow, there is a significant decrease in the middle, and finally the decline rate becomes slower. The

spatial distribution curve of joint-stock banks' outlet density is similar to that of state-owned commercial banks, and the overall decline rate is faster as the economic density decreases; The distribution of foreign banks only exists in the core layer and some outer layers with a slightly higher economic density. When the economic density drops to a certain level, there is no branch distribution of foreign banks. The number of outlets of city commercial banks is small, and they are distributed in the core layer and the outer layer where the economic density is relatively high. Rural commercial banks also exhibit a distribution feature at the core and outer layers, and their homogeneity is very high. It is a slightly fluctuating horizontal linear spatial distribution model. From the above analysis, we can see that the spatial density patterns of different types of banks in Guangdong Province have their own characteristics with changes in economic density. This difference is related to the degree of demand for the regional economic level of various types of banks when expanding their branches.

#### 4. CONCLUSIONS AND SUGGESTIONS

Based on GIS method and kernel density function, this paper conducts an empirical analysis on the spatiotemporal evolution and agglomeration characteristics of five major banks in Guangdong Province (state-owned commercial banks, joint-stock banks, foreign banks, urban commercial banks and rural commercial banks) from 2009 to 2018, and got the following conclusions and recommendations:

There are obvious regional differences in spatial distribution and prominent non-equilibrium characteristics. First of all, at the prefecture-level city scale, bank outlets in 7 prefecture-level cities such as Shenzhen, Dongguan, Guangzhou, Foshan, Zhongshan, Zhuhai, and Shantou present a strong concentration. Banking outlets in three prefecture-level cities including Jieyang, Chaozhou, and Maoming showed a general clustering distribution feature and the bank outlets of the two prefecture-level cities in Yangjiang and Heyuan showed a strong distributed form. The remaining branches of Shanwei, Huizhou, Jiangmen, Zhanjiang, Zhaoqing, Yunfu, Qingyuan, Shaoguan, Meizhou and other prefecture-level cities are generally scattered. Secondly, at the provincial scale, the overall density of bank outlets has gradually shifted from the core layer centered on the cities under the jurisdiction of the Pearl River Delta (Guangzhou, Shenzhen, Dongguan, Zhuhai, Foshan, and Zhongshan) to the outer layer composed of other cities decreasing "central-peripheral" diffusion location characteristics.

Significant differences in spatial distribution and agglomeration characteristics of different types of banks. State-owned commercial banks have the largest number of branches and the widest coverage (27.45%), and their spatial agglomeration characteristics are also obvious, economic density show a more typical inverse "S" curve from the core layer to the outer layer in a non-uniform decreasing space. The number of joint-stock bank outlets ranks second with a high coverage rate (17.41%), which is a strong spatial agglomeration model. The spatial distribution curve of outlet density is similar to that of state-owned commercial banks, but the overall decline rate is faster as the economic density decreases. The distribution of foreign banks is special, with the least number of branches and the lowest distribution coverage (4.67%), but the obvious characteristics of spatial agglomeration, which belongs to a strong core area spatial agglomeration model, when the economic density drops to a certain level, there is no outlet distribution. Urban commercial banks have fewer branches and a more even distribution, and the density of outlets is less affected by the decrease in economic density. The number of outlets of rural commercial banks is equivalent to that of joint-stock banks, but its coverage rate is much higher than that of joint-stock banks (21.09%), with high homogeneity, as a result, its spatial agglomeration characteristics are not very prominent, and it shows a horizontal line spatial distribution pattern that fluctuates slightly with economic density. The following rules are basically followed between each other: foreign banks > joint-stock banks >



urban commercial banks> state-owned commercial banks> spatial concentration of rural commercial banks.

Different banks have different outlet density distribution characteristics with decreasing economic density, reflecting their differences in their attributes and development strategies. The differentiated space model in the banking industry is the result of the industry's long-term development, which has been gradually formed by social, economic, demographic and cultural diversification. At the same time, it also forms a variety of counter-actions, providing practical guidance to the city's social and population development and overall planning. Therefore, in the further development and expansion of the banking industry, on the one hand, we must pay attention to the current economic density, population density, bank outlet density and spatial distribution characteristics of cities. On the other hand, it is also necessary to combine the development planning needs of future financial markets, the overall service coverage of the city, and the reasonable allocation of financial resources.

The spatiotemporal evolution of bank types indicates that the market for state-owned commercial banks and rural commercial banks is basically saturated. City commercial banks and joint-stock banks have strengthened their concentration level due to the diversified characteristics of financial services to better meet the needs of people's financial investment in the context of sustained economic growth. Due to the strengthening of the opening of the core zone to foreign banks, the degree of aggregation of their branches has been relatively obvious.

Suggestions: Under the current situation, Guangdong's state-owned commercial banks and joint-stock banks still dominate the banking industry. For cities with good economic development, their spatial layout structure is also relatively complete. They should actively guide their network expansion in secondary cities, and promote innovation and service coverage of their financial services. For foreign banks, based on their healthy development challenges and opportunities, they should actively attract and encourage them to set up operating institutions in Guangdong Province, increase the market coverage of its outlets, and moderately increase the intensity of competition in the financial market, while promoting healthy competition in the domestic banking industry. For urban commercial banks and rural commercial banks, their performance improvement is also of great significance to the development of the province's economic and financial markets. Need to further explore its own market positioning, through its own spatial layout has the advantage of high service coverage, and target specific populations as the direction, eventually, it will develop into a modern bank and enhance its position in Guangdong's financial and economic development.

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