Study on the coupled coordination of financial ecological environment and economic growth in the Guangdong-Hong Kong-Macao Greater Bay Area

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Abstract: Based on the background of the economic construction of the Guangdong-Hong Kong-Macao Greater Bay Area in the new era, this paper selects the panel data of 11 cities from 2008 to 2020 to build a financial ecological environment index system and calculate the comprehensive evaluation index. The coupled coordination model and Moran'I index model are used to conduct quantitative research on the relationship between financial ecological environment and economic growth in the Guangdong-Hong Kong-Macao Greater Bay Area, comprehensively evaluate the financial ecological environment and economic growth status in the Guangdong-Hong Kong-Macao Greater Bay Area, and verify the two-way driving relationship between the two. Explore the regional differences and spatial agglomeration phenomenon in the relationship between financial ecological environment and economic growth from the two dimensions of time and space. Finally, it is concluded that the financial ecological environment in the Guangdong-Hong Kong-Macao Greater Bay Area varies significantly and geographically, and there is indeed a significant two-way promotion relationship between the financial ecological environment and the economic growth. The financial ecological environment will not only promote the economic growth of the region, but also have a spatial spillover effect on the surrounding areas.

Key words: Guangdong-Hong Kong-Macao Greater Bay Area, financial ecological environment, economic growth, and spatial agglomeration

1. Research Background

Throughout the global regional economic development, the economic trend of the Bay Area is surging and surging. The financial sectors of the world's three major Bay areas--Tokyo, San Francisco and the New York Bay Area--play a key role in the Bay Area's economic development[1]. Under this background, the study of financial ecological problems of Guangdong area, to explore the financial ecological environment for the regional economic development, open regional economic circulation "blood", optimize the regional economic system financial better coordinated development, more conducive to large bay area integrated resources and optimal allocation, can better and faster construction of financial system, become a large bay area of Guangdong economic development "booster"[2].

2. Selection of the evaluation method

This paper adopts the combination of hierarchical analysis method (AHP) and entropy weight method as index empowerment. Compared with other index empowerment method, entropy weight method is more objective, the mathematical theoretical basis is stronger, and the application of systematic comprehensive evaluation is more widely used[3].

The entropy weight method first determines the weight of each index according to its size, and then according to the entropy weight of each index[4].

The calculation process is performed as follows:

Suppose that m indicators are selected, and n samples.need Xij Represents the j-th index of the i-th sample, and 1 ≤ i ≤ n, 1 ≤ j ≤ m.

Because the index units and orders of magnitude of the five dimensions in the index system differ, all sample data are first standardized to eliminate the impact.

Positive indicator formula:

\[ x_{ij} = \frac{x_{ij} - \min \{x_{1j}, x_{2j}, \ldots, x_{nj}\}}{\max \{x_{1j}, x_{2j}, \ldots, x_{nj}\} - \min \{x_{1j}, x_{2j}, \ldots, x_{nj}\}} \]  \hspace{1cm} (1)

Negative indicator formula:

\[ x_{ij} = \frac{\max \{x_{1j}, x_{2j}, \ldots, x_{nj}\} - x_{ij}}{\max \{x_{1j}, x_{2j}, \ldots, x_{nj}\} - \min \{x_{1j}, x_{2j}, \ldots, x_{nj}\}} \]  \hspace{1cm} (2)

Under the j index, the characteristic proportion of the i evaluation object is pij, Then:
\[ p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} \quad (3) \]

The entropy value of the j-th-term index is calculated as:
\[ e_j = -k \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) \quad (4) \]

among, \( k = \frac{1}{\ln(n)} > 0, 0 \leq e_j \leq 1 \) \( (5) \)

The difference coefficient of the j-th index was calculated as:
\[ d_j = 1 - e_j \quad (6) \]

Calculate the weight, that is, the weight of each index (economic foundation, financial development, government public service, social integrity, social security) as:
\[ w_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \quad (7) \]

Finally, a composite index of all sample data:
\[ U_i = \sum_{j=1}^{n} p_j \cdot w_j \]

### 3. Model construction

#### 3.1 Coupled coordination model

From the perspective of "development" and "coordination", this paper explores the coupling and coordination relationship of financial ecological environment and economic growth systems. "development" and "coordination" should be coordinated in time and space [5].

Establish the coupling model:
\[ C_m = \{(U_i \times U_j \times \wedge U_m)\} / \prod(U_i + U_j) \] \( (8) \)

In this paper, we study the coupling degree of the two systems, and the smaller the difference of the desired sum, the better. Formula (8) becomes: \( m = 2U_i U_j \)

\[ C = \{(U_i \times U_j) / [(U_i + U_j)^2] \}^{k/2} \quad (k \geq 2) \]

Further construct the coupling coordination degree model, overcome the defects of the coupling degree model, and analyze the comprehensive degree of system analysis development and coordination:
\[ T = \alpha U_1 + \beta U_2 \quad (10) \]

In this equation, D is the coupling and coordination degree, T is the comprehensive evaluation index, the weight of financial ecological environment and the weight of economic growth level, and the two are equal in this paper. \( \alpha = \beta = 0.5 \)

The value of D reflects the degree of coupling and coordination, and reflects whether the development and coordination of the two systems are in a benign reciprocal promotion state. The coupling coordination level standard is set as shown in Table 2:

### Table 1 Definition of the coupling degree level

<table>
<thead>
<tr>
<th>degree of coupling</th>
<th>C</th>
<th>0,</th>
<th>0.3</th>
<th>0.5</th>
<th>0.8</th>
<th>1</th>
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<tbody>
<tr>
<td>Coupling level</td>
<td></td>
<td>The lower-level coupling phase</td>
<td>Jie coupling period</td>
<td>Benign coupling period</td>
<td>High-level coupling period</td>
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</table>

<table>
<thead>
<tr>
<th>Negative coupling (disorder development)</th>
<th>Forward coupling (coordinated development)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D price</td>
<td>Developm ent type</td>
</tr>
<tr>
<td>0.0</td>
<td>0 - Extreme disorder</td>
</tr>
<tr>
<td>0.4</td>
<td>On the verge of dysregulati on</td>
</tr>
<tr>
<td>0.4</td>
<td>9</td>
</tr>
<tr>
<td>0.1</td>
<td>major maladjust ment</td>
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<tr>
<td>0.2</td>
<td>Moderate dysregulati on</td>
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<tr>
<td>0.5</td>
<td>Unusually dysregulat ed</td>
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<td>0.5</td>
<td>9</td>
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<tr>
<td>0.3</td>
<td>Mild dysregulati on</td>
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<tr>
<td>0.9</td>
<td>Transitional reconciliation zone</td>
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</table>

<table>
<thead>
<tr>
<th>Disorder recession area</th>
<th>Transitional reconciliation zone</th>
<th>Coordinated development zone</th>
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</thead>
<tbody>
<tr>
<td>0.3</td>
<td>0.9-</td>
<td>0.91</td>
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<td>0.9</td>
<td>0.9-</td>
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Table 2 Coupled coordination level standard
3.2 The Moran’I exponential model

This paper continues to introduce the global Moran’I index and the local Moran’I index to describe the spatial characteristics of the interaction between the financial ecological environment and economic growth in the Bay Area.

The global Moran’I index adopts the attribute value for all adjacent objects in the region, the i-th observation of n region cells is recorded as, and the mean of the observed variable in n units is recorded as \( \bar{x} \).

\[
I = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{S^2 \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}} \quad ( -1 \leq I \leq 1 ) \tag{12}
\]

Local Moran’I index (LISA) values reflect the degree of similarity of the spatial agglomeration effect in each region.

\[
I_i = \frac{(x_i - \bar{x})}{S} \sum_{j=1}^{n} w_{ij} (x_j - \bar{x}) \quad ( -1 \leq I_i < 1 ) \tag{13}
\]

\[
\sum_{i=1}^{n} I_i = nI \tag{14}
\]

\( x_i \), (13) and (14), is the coupling coordination of the Bay Area. \( I \) is the security Moran’I index and is the local Moran’I index. When representing a high degree of system coupling, \( I_i > 0 \) (\( I > 0 \))

There is a positive spatial correlation, spatial agglomeration and spatial dispersion between regions, and there is no spatial auto correlation. \( I < 0 \) (\( I < 0 \))

\( I = 0 \) (\( I = 0 \)) \( w_{ij} \) As the spatial weight matrix, generally speaking, the specific calculation rules are as follows:

\[
W_{ij} = \begin{cases} 
1, & \text{when area } i \text{ is adjacent to } j \\
0, & \text{other}
\end{cases}
\]

In this paper, considering that the geographical adjacency matrix has some limitations, the spatial distance weight matrix is selected, and the main diagonal value is 0, and the non-main diagonal value is \( 1 / d^2 \), And d represents the two geographically centered location distances.

\[
Z = \frac{1 - E(I)}{\sqrt{VAR(I)}} \quad \text{Final Moran’I } Z \text{ test: The } P \text{ value was calculated based on the } Z \text{ value and the significance of Moran’I index was judged according to the } P \text{ value result.}
\]

4. Selection of indicators and data processing

The composite index of the two systems was first calculated. Standardize the GDP, GDP per capita and GDP, the growth rate, and then make the three the arithmetic average of the economic growth index. The second and third-level factors are averaged step by step to obtain the first-level standardized factor, and the first-level factor is multiplied by the weight and the sum result is the financial ecological environment composite index.

\[
U_1 = \sum_{j=1}^{n} Z_{yj} W_j \tag{15}
\]

\[
U_2 = \frac{u_1 + u_2 + u_3}{3} \tag{16}
\]

In formula, (16), it is the comprehensive evaluation index of the economic growth, the standardized value of the first-level factor, and the weight of the first-level factor index, which are the total GDP, per capita GDP and GDP growth rate respectively.

5. Empirical analysis

5.1 Comprehensive evaluation index analysis

Firstly, from the five dimensions of financial ecological environment, the evaluation index of the five dimensions of financial ecological environment in the Guangdong-Hong Kong-Macao Greater Bay Area over the years is calculated, and the comprehensive evaluation index of financial ecological environment is finally calculated. The economic growth index is obtained from the arithmetic average of standardized GDP, per capita GDP and GDP growth rate. Financial ecological environment evaluation index and economic growth index are shown in Table 3.

<table>
<thead>
<tr>
<th>Year</th>
<th>Area</th>
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</table>
1. The comprehensive index of financial ecological environment and economic growth in all regions is generally on the rise. As can be seen from the above table, affected by the global economic crisis in 2008, the regional economy fell significantly. In 2009, the regional economic growth index decreased significantly, but then with the economic recovery, the economic growth index increased. Taking Shenzhen and Guangzhou as an example, in 2019, compared with 2008, Shenzhen's economic growth index increased by 70.27%, while Guangzhou increased by about 55.86%. Different from the economic development situation, the development of financial ecological environment is relatively gentle, with an average growth rate of 12.9% in 12 years, and the impact of the global economic crisis is not obvious. In 2009, the average financial ecological environment index did not decline, but increased by 0.01, indicating that the financial ecological environment is relatively stable. Thanks to the global economic stability, the regional financial ecological environment index and the comprehensive economic growth index in the Guangdong-Hong Kong-Macao Greater Bay Area have grown steadily since 2009.
2. The comprehensive index of financial ecological environment varies greatly among cities in different regions.

The financial ecological composite index shows obvious differences among regions in the Greater Bay Area. There is no doubt that Hong Kong has topped the Guangdong-Hong Kong-Macao Greater Bay Area, all above 0.8. Shenzhen second, Guangzhou third, Macao fourth. The composite index of the other seven cities was all at 0.15 or below, with Dongguan and Foshan among the top of the rest.

3. There are many factors affecting the comprehensive ecological index of financial environment in each region. From the perspective of economic foundation, financial development level and social integrity level, the indexes of China, Guangzhou, Shenzhen, Hong Kong and Macao in the 11 cities are all higher than those of other inland cities in Guangdong. In particular, the economic foundation of Zhongshan, Jiangmen and Zhaoqing is relatively backward. Compared with the economic foundation and social integrity level, Guangzhou, Foshan, and Dongguan do not show the level of financial development commensurate with their economic development. Hong Kong has a prominent level of financial development, while Shenzhen, Guangzhou, Foshan, and Macao have a prominent level of economic development. Relatively speaking, the level of social integrity development in each region is higher than the level of economic development and financial development, so the development focus of each region should still be in the economic and financial fields.

5.2 Coupled coordination analysis

According to the above calculation formula of coupling coordination degree, the comprehensive index and coupling coordination degree of financial ecological environment and economic growth from 2008 to 2020 are calculated, on which the type and level of financial ecological environment and economic growth in Guangdong-Hong Kong-Macao Greater Bay Area are determined. The results are shown in Figure 1 below:

![Figure 1 coupling coordination of the Guangdong-Hong Kong-Macao Greater Bay Area from 2008 to 2020](image)

1. The coupling and coordination degree of financial ecological environment and economic growth in all regions has been significantly improved over the past decade, the degree of coupling and coordination has been significantly improved after more than ten years of development, and the types of stages continue to develop to a better stage. The coupling level of Hong Kong and Macao increased from good coordination to high quality coupling, but in 2020, the coupling coordination was reduced to 0.35; the coupling level of financial ecology and economic growth in Shenzhen and Guangzhou increased from intermediate coordination to good coordination; Zhuhai, Foshan, Zhongshan and Jiangmen increased from low coordination; Dongguan and Zhaoqing increased from weak coordination to primary coordination.

2. The coupling and coordination of financial ecological environment and economic growth in different regions is no doubt that Hong Kong has topped the Guangdong-Hong Kong-Macao Greater Bay Area, all above 0.8. Shenzhen second, Guangzhou third, Macao fourth. The composite index of the other seven cities was all at 0.15 or below, with Dongguan and Foshan among the top of the rest.

5.3 The Moran's I index analysis of the coupled coordination degree

The above results show that the regions with high coupling and coordination of the system are concentrated, mainly in the eastern and southern regions of Guangdong. The lower regions are concentrated in the western region, and it is speculated that there may be a coupled and coordinated spatial correlation between the regions. To further reveal the interaction mechanism, the global and local Moran's I index method was used to analyze the coupling coordination of each region and draw the scatter plot of Moran's I index.

5.3.1 Global Moran's I Index Analysis

The coupling coordination of financial ecological environment and economic growth global Moran's I value is 0.082 and P value is 0.194. Obviously, there is spatial non-equilibrium and correlation in the coupling coordination degree, and this spatial correlation shows a strong positive relationship. Typical coupling coordination zones are HH and LL, with two cities in the first quadrant, two cities in the second quadrant, 5 cities...
in the third quadrant and the other two cities in the fourth quadrant.

5.3.2 Local Moran's I index analysis

In order to further measure the spatial correlation and difference of financial ecological environment and economic growth in the Guangdong-Hong Kong-Macao Greater Bay Area, the Moran scatter plot is used for analysis. The trend line in the figure shows the strength of spatial correlation, the abscissa is the mean of the coupling coordination, the ordinate is the spatial lag value, and the four quadrants in the study area represent four spatial correlation patterns. HH and LL quadrants represent the region belonging to spatial positive correlation, while LH and HL represent spatial negative correlation. In view of the length, here is only a scatter plot of the Moran index for the five years.

![Moran's I scatter plot of the coupling and coordination degree between financial ecological environment and economic growth in the Guangdong-Hong Kong-Macao Greater Bay Area from 2008 to 2020](image)

<table>
<thead>
<tr>
<th>type</th>
<th>2008</th>
<th>2011</th>
<th>2014</th>
<th>2017</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>High type (H-H)</td>
<td>Shenzhen</td>
<td>Shenzhen</td>
<td>Shenzhen</td>
<td>Shenzhen</td>
<td>Shenzhen</td>
</tr>
<tr>
<td>Low high type</td>
<td>Huizhou</td>
<td>Huizhou</td>
<td>Huizhou</td>
<td>Huizhou</td>
<td>Huizhou</td>
</tr>
<tr>
<td>Low type</td>
<td>Zhuhai, Foshan, Jiangmen, Zhaoqin, Zhongshan</td>
<td>Zhuhai, Foshan, Jiangmen, Zhaoqin, Zhongshan</td>
<td>Zhuhai, Foshan, Jiangmen, Zhaoqin, Zhongshan</td>
<td>Zhuhai, Foshan, Jiangmen, Zhaoqin, Zhongshan</td>
<td>Zhuhai, Foshan, Jiangmen, Zhaoqin, Zhongshan, Macao</td>
</tr>
<tr>
<td>High low type</td>
<td>Guangzhou, Macao</td>
<td>Guangzhou, Macao</td>
<td>Guangzhou, Macao</td>
<td>Guangzhou, Macao</td>
<td>Guangzhou, Macao</td>
</tr>
</tbody>
</table>

The spatial agglomeration effect of the coupling and coordination between financial ecological environment and economic growth in the Guangdong-Hong Kong-Macao greater bay area shows a trend of weakening first,
and then strengthening. Through comparison, it is found that: (1) Shenzhen and Hong Kong are located in the first quadrant for a long time, Located in the central and southern parts of the Pearl River Delta, it has obvious advantages in its surrounding location, obvious radiation effect on the city, and a relatively high level of financial development. (2) Huizhou and Dongguan have been located in the second quadrant for a long time, and their own financial development level is low, but the financial ecological environment and economic development level of Guangzhou are both good, with certain acquired advantages. (3) Most of the cities located in the third quadrant are Foshan, Zhaoqing, Jiangmen, west of Guangzhou. These cities do not have a high economic development level, and there are no surrounding cities that can play a leading role. In a short time, it can neither become the “main force” nor effectively use the radiation effect of the surrounding financial ecological environment. The high financial development level of Hong Kong and Shenzhen will be passed through the node cities in the central Pearl River Delta such as Huizhou and Dongguan in the Pearl River Delta, to enhance the radiation effect to the surrounding areas, the financial ecological construction level of low and low areas will be gradually improved, and the steady progress of the coordination and integration of the Guangdong-Hong Kong-Macao Greater Bay Area will be realized. (4) Guangzhou is the only city among the 11 cities in the Guangdong-Hong Kong-Macao Greater Bay Area that is always located in the fourth quadrant during the sample period, that is, the level of financial development is high, but the level of surrounding cities is low.

6. Conclusion

On the basis of the research on financial agglomeration and economic growth, this paper systematically analyzes the relationship between financial ecological environment and economic growth by establishing a coupling and coordination model. Finally, through the Moran's I index with coupling and coordination degree, the regional differences of economic growth relationship and financial ecological environment are investigated from the perspective of geographic agglomeration. Through a series of empirical studies and quantitative analysis, the following conclusions are drawn:

(1) The financial ecological environment of the Guangdong-Hong Kong-Macao Greater Bay Area is significantly different and geographically. The calculation results of the Moran Index show that the financial ecological environment development in the Guangdong-Hong Kong-Macao Greater Bay Area is unbalanced, with obvious spatial agglomeration and regional differences.

(2) There is indeed a two-way promotion relationship between the financial ecological environment and economic growth. In general, the higher the development level of the financial ecological environment, it can significantly promote economic growth. Economic growth is also significantly promoting the development of urban financial ecological environment. Although there are significant differences in the coupling and coordination of financial ecological environment and economic growth in different regions, from the dynamic evolution of the coordinated development of financial and economic development in the Guangdong-Hong Kong-Macao Greater Bay Area over the past decade, the coupling and coordination degree has been significantly improved after more than ten years of development, and the stage type has been developing to a better stage.

(3) The financial ecological environment will not only promote the economic growth of the region, but also produce space overflow to the surrounding areas and promote the economic growth of the surrounding areas.

References


