Analysis and Research on Synergistic Effect of Regional Financial Financing Tolerance and Regional Economic Development from the Perspective of Coupling

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ABSTRACT
Many studies have shown that regional financial development has a promoting effect on the regional economy, but the literature describing the specific correlation between the two and whether there is a synergistic effect is relatively vague. The innovation of this paper is based on the weighted analysis of AHP and CVM by constructing two systems of regional financial financing tolerance and regional economic development and constructing a collaborative system for empirical analysis based on the relevant panel data of Shenzhen City, China. The conclusion shows a stable synergy between regional financial financing tolerance and local, regional economy: the collaborative degree of the constructed collaborative system is always positive. Although it has fluctuated in the past decade, it is still at a relatively stable level. In addition, the development of regional financial financing capacity has a positive effect on the regional economy, and the development of the regional economy will also promote the financing tolerance of regional finance to a certain extent. There is a stable synergistic effect between the two, and there is also an internal driving force for mutual promotion between regional finance and regional economic subsystems. Different regions can mobilize financial resources to stimulate economic growth according to their characteristics or use economic growth to feedback the financial industry to form a virtuous circle within the region.

Keywords: *Regional finance; financing tolerance; regional economic development; synergies*

1.INTRODUCTION

Since 1978, China's financial market system construction has experienced four stages of slow recovery, formation, improvement, and further opening up[1]. The construction of the modern financial market system has achieved phased results. As the economy enters the stage of high-quality development, the main contradiction in the financial field has changed from the contradiction between the demand for economic growth and the limited capital stock to the contradiction between the demand for financial services and the lack of effective financial supply and the imbalance of supply structure[2]. The establishment of the Beijing Stock Exchange in September 2021 is one of the measures taken by the Chinese government to solve this contradiction, which means that China will continue to support the innovation and development of small and medium-sized enterprises, deepen the reform of the New Third Board and improve the efficiency of financial supply. History and practice show an important link between financial development and economic growth, and existing studies have fully demonstrated the specific links.

The research on financial development and economic growth in developed countries started relatively early. Goldsmith[3], or the first time, it is found through empirical analysis that there is synchronization between financial development and economic growth. King and Levine[3]. Through a large number of data, it is concluded that there is a positive correlation between financial agglomeration and economic growth, and the mechanism of its impact on economic growth is demonstrated. In recent years, many

scholars have studied and analyzed China's financial market characteristics: Zhuang Yumin and others[4]. By analyzing the panel data of 31 provinces in China from 2008 to 2016 through the general equilibrium model. It is found that financial development can alleviate information asymmetry, improve the conversion rate of savings to investment, reduce the financing cost of external finance in the R & D sector, and promote enterprises to increase R & D investment, thereby promoting further economic growth. He Ying et al.[1] through the empirical analysis of interest rate level and financial market openness in China and the United States, it is concluded that the interest rate level of China's financial market openness is not enough to reflect the supply and demand of financial market funds and does not have a good transmission effect. It is found that the imbalance of regional financial development is still prominent. Deng

The above research results verify the positive effect of financial development on regional economic growth and analyze the current situation of China's financial market scale, structure, supply, and demand from a macro perspective. However, there is still a blank in the study of the specific measurement of regional financial financing tolerance and the reaction of regional economic development to regional finance, that is, whether there is a synergistic effect between regional financial financing tolerance and regional economy, and whether there is an internal driving force for mutual promotion if they are regarded as a hybrid system. This paper will focus on this problem and innovatively put the two into the perspective of coupling to build a collaborative model: from the perspective of system analysis, this paper selects five order parameters representing regional financial financing tolerance, which reflect the regional financial scale, financial efficiency, financial depth, and risk controllability, and ten order parameters representing regional economic subsystem, which reflect the economic structure, economic aggregate, economic efficiency, and economic benefit, to construct the model of regional financial financing tolerance and regional economic coordinated development, and determine the measurement method of coordination level. Thus, the model is applied to the research on the coordinated development of Shenzhen's regional financial financing and regional economy to explore its internal driving force.

2. REGIONAL FINANCIAL FINANCING TOLERANCE AND REGIONAL ECONOMIC DEVELOPMENT ORDER PARAMETER SELECTION

2.1 Regional financial financing tolerance

Considering the availability of data and the characteristics of the financial market structure dominated by the Bank of China, Liang Jingshu et al.[5]Research experience. The three dimensions of scale, efficiency, and depth are selected as the regional financial development level measurement indexes. Using Theil index[5]And regional financial industry added value of the national financial industry added value of the proportion of regional financial development scale, The conversion rate of regional savings and investment is used to measure the efficiency of regional financial development, and the loan amount of regional financial institutions is used to measure the financial depth[3]. Ma et al. [8].To evaluate the index system of high-quality regional economic development in China, the asset-liability ratio of enterprises above scale and government debt is used to measure the controllability of financial risks. Relevant references obtain the positive and negative correlation of indicators. In summary, the indicators constructed in this paper are shown in Table 1, Type refers to positive(+) and negative(-) correlation between variables.

Table 1 Order parameter of regional financial financing tolerance

Indicator code	First-grade indexes	Second index	Unit	Type
X1	financial scale	Regional financial industry added value / national financial industry added value	%	+
X2	financial efficiency	The conversion rate of regional savings investment	%	+
X3	finance width	Loan amount of regional financial institutions	CNY	+
X4	Risk controllability	The asset-liability ratio of enterprises above scale	%	+
X5		Government annual total expenditure	CNY	+

2.2 Regional economic development

As China's economy is shifting from extensive to intensive, the evaluation of the level of economic

development should shift from simply focusing on the ' quantity ' of economic growth to emphasizing the improvement of the quality and efficiency of economic growth. Many scholars have made a reasonable attempt to study the quality indicators of regional economic growth. This paper refers to the relevant indicators adopted by Ma et al.[8]in the research on the evaluation index system and measurement of the high-quality development of China's regional economy. The traditional pursuit of quantity and scale expansion is reflected in the quality of structural optimization, efficiency improvement, welfare distribution improvement, and environmental cost reduction. Evaluation index of regional economic development combined with Chen Changshi [5], Xie Jun and others[7].Positive(+) and negative(-) reference, index construction see Table 2.

Table 2 Order parameters of regional economic development

Indicator code	First-grade indexes	Second index	Unit	Type
X6	Economic structure	First industrial output	CNY	+
X7		Second industrial output	CNY	+
X8		The output of the tertiary industry	CNY	+
X9	Total supply and demand	GDP	CNY	+
X10		Net population inflow (outflow) at year-end	CNY	+
X11		The total volume of import and export trade	CNY	+
X12	Economic efficiency	Innovation input (R & D input intensity)	CNY	+
X13		Labour productivity (GDP / employed population)	CNY / person	+
X14	Economic benefit	per capita GDP	CNY	+
X15		Urban per-capita disposable income	CNY	+
X16		Residents price consumption index	%	+
X17		Local fiscal revenue	CNY	+

3. WEIGHTED ANALYSIS BASED ON AHP AND CVM

3.1 AHP model construction

The analytic hierarchy process, referred to as AHP, is a process that combines qualitative and quantitative decision-making and makes decision-making hierarchical and quantitative. The analytic hierarchy process (AHP) is used first to establish the hierarchical structure model and divide the problems that need to be decided into three levels. The first level is the target level, followed by the criterion level, and the last is the scheme level.

STEP1: Creating a judgment matrix In the second layer of the analytic hierarchy process, the criterion layer B, the relative importance between n elements is compared to obtain a pairwise comparison judgment matrix, as shown in (1), where $b_{ii}=1$, $b_{ij}=\frac{1}{b_{ji}}$.

According to Formula (1), the eigenvalue of matrix B is solved by the eigenvalue method. As shown in Equation (2), $\lambda_{\max}$ is the maximum eigenvalue of B, ω is the eigenvector of the matrix, and is obtained by calculation, namely, the weight vector, which is objectively weighted.

$$B=\begin{pmatrix} b_{11} & \cdots & b_{1n} \\ \vdots & \ddots & \vdots \\ b_{n1} & \cdots & b_{nn} \end{pmatrix} \quad (1)$$

$$B\omega=\lambda_{\max}\omega \quad (2)$$

STEP2: Consistency testing This step is used to test the consistency of the judgment matrix established in step 2, such as formula (3) formula (4). In formula (3), C_I is the consistency index, and in formula (4), C_R is the consistency ratio. When $C_R \geq 0.1$ the above judgment matrix needs to be corrected; when $C_R \leq 0.1$ it is proved that the above judgment matrix is correct,

that is, the results of the judgment matrix conform to the consistency test.

$$C_I = \frac{\lambda_{\max} - n}{n-1} \tag{3}$$

$$C_R = \frac{C_I}{R_I} \tag{4}$$

3.2 Construction of coefficient of variation model

The weight coefficient of each index of regional coordinated development is determined by the variation coefficient method, and then these data are standardized. Finally, the comprehensive score of regional coordinated development is determined by the weighted average method.

The coefficient of variation of each index is calculated by the formula (5). In formula (5): v_i denotes the coefficient of variation of the item index. α_i represents the standard deviation of the index of the item; $\overline{x_i}$ represents the mean value of the item index. The weight of each index is calculated by the formula (6). In formula (6): w_i denotes the weight of the index. Finally, the data of each index in the model are standardized by the Z-score standardization method and calculated by the formula (7). In formula (7): z_{ij} represents the value of each index variable after standardization of each index data; x_{ij} represents the actual measurement value of each index; σ_i represents the standard deviation of the index of the fourth item; $\overline{x_i}$ denotes the mean value of the index. In addition, after standardizing the indicators, negative numbers need to be added before each indicator.

Finally, each index is multiplied by the weight after standardization, and the comprehensive score of regional coordinated development can be obtained by calculating the sum of each index.(The formula subscripts are readable in word documents, and problems with the conference review system may result in garbled codes.)

$$v_i = \frac{\alpha_i}{x_i} \tag{5}$$

$$w_i = \frac{v_i}{\sum_{i=1}^{n} v_i} \tag{6}$$

$$z_{ij} = \frac{x_{ij} - \overline{x_i}}{\sigma_i} \tag{7}$$

3.3 Weight coupling calculation

Coupling is an index used to describe the degree of interaction between two or more different subsystems. Although coupling degree can reflect the development of two different subsystems to a certain extent, it has some limitations to describe the mutual influence between subsystems. That is, it cannot effectively reflect the level of coordinated development between subsystems. We can solve this problem by introducing a coordination degree to express the coordination degree between subsystems.

The coupling degree of the system is calculated by Formula (8), the coordination degree of the subsystems is calculated by Formula (9), and the comprehensive coordination index is calculated by Formula (10). In the following formula, the system coupling degree $C \in [0,1]$, the synergy degree $D \in [0,1]$, M is the comprehensive harmonic index, α and β are the undetermined coefficients of the two subsystems in the regional coordinated development (the undetermined coefficients in this study are set to $\alpha = 0.5, \beta = 0.5$), and q is the number of subsystems included in the total system.

$$C = q \times \left[\left(G_S \times G_H \right) / \left(G_S + G_H \right)^q \right]^{1/q} \tag{8}$$

$$D = \left(C \times M \right)^{1/n} \tag{9}$$

$$M = \alpha G_S + \beta G_H \tag{10}$$

The coupling degree is obtained through the above calculation, and if $C \in (0.60, 0.80]$, it is moderate coupling; if $C \in (0.80, 0.90]$, it is good coupling, $C > 0.90$ is high-quality coupling.

4. ESTABLISHMENT OF THE COLLABORATIVE MODEL

4.1 Subsystem

Regional economic development is the synergy and cooperation of various factors, and each factor needs to maintain its internal good condition and operation, can be regarded as a subsystem; regional financial financing tolerance can be seen as another subsystem. In addition, different subsystems need to work together and interact with each other to work together on the overall system of regional coordination. Thus, the regional collaborative system is a hybrid system with multiple subsystems. The synergy degree of the composite system is an important tool to measure the synergy effect of the hybrid system. The commonly used synergy model for the composite system mainly includes the proposed synergy model and coupling model of the hybrid system.

It is necessary to study the subsystem of the composite system first. If the composite system S represents the regional collaborative development system, it is assumed that it consists of N subsystems and S_n represents the nth subsystem. Each subsystem generates a synergistic effect through mutual coordination and interaction, and the overall effect of the synergistic effect should be greater than the sum of the effects of each subsystem. The formula can be expressed as $E(S_n) > \sum_{n=1}^{N} E(S_n)$, and the relationship between the hybrid system and the subsystem of the system can be expressed as $S = f(S_1, S_2, S_3 \cdots S_n)$, where f represents the composite factor.

Suppose that subsystem S_n has n order parameter components, then its order parameter can be expressed as $G(S_n) = \{g_{1n}, g_{2n}, g_{3n}, \cdots, g_{kn}\}$ where $n \in [1, N]$ $g_{in} \in [D_{in}, U_{in}]$, $i \in [1, nk]$ D_{in} denotes the lower limit of g_{in}, U_{in} denotes the upper limit of g_{in}.

The system studied in this paper includes two subsystems: regional financial financing tolerance and regional economic development $n = 2$. Because the order parameter component has positive and negative effects, the order degree of the order parameter component g_{in} can be calculated by the formula (11). The formula (11) shows that the value of v_{in} is between $[0,1]$, and the closer v_{in} is to 1, the better the order is. The order degree of a subsystem S_n can be calculated by the formula (12). According to formula (12), $G(S_n) \in [0,1]$, λ is the weighted coefficient of each order parameter component in the subsystem. The closer the value $G(S_n)$ is to 1, the higher the order degree of the subsystem, and the better the development level of the subsystem.

$$v_{in} = \begin{cases} \dfrac{g_{in} - D_{in}}{U_{in} - D_{in}} \\ \dfrac{U_{in} - g_{in}}{U_{in} - D_{in}} \end{cases} \tag{11}$$

$$G(S_n) = \sum_{i=1}^{nk} \lambda_i v_{in}, \lambda_i \geq 0 \tag{12}$$

4.2 Collaborative system

After constructing two subsystems, a collaborative system is introduced. Before constructing the collaborative system, the concept of capacity coupling in physics can be used for reference, and the comprehensive coordination system T can be introduced. Based on this, the collaborative model of the composite regional coordinated development system in this study can be constructed and calculated by Formula (13).

Formula (13), C is calculated by Formula (14) and is T calculated by Formula (15), where ω_n represents the weight coefficient of each subsystem in the total system.

$$S_{yn} = \sqrt{C \times T} \tag{13}$$

$$C = \sqrt[n]{\frac{\prod_{N}^{n=1} G(S_n)}{\prod_{N}^{n_1, n_2} \left[G(S_{n1}) + G(S_{n2}) \right]}} \tag{14}$$

$$T = \sum_{N}^{n=1} \omega_n G(S_n) \tag{15}$$

5. ANALYSIS AND RESEARCH ON THE SYNERGISTIC EFFECT OF REGIONAL FINANCIAL FINANCING TOLERANCE AND REGIONAL ECONOMIC DEVELOPMENT FROM THE PERSPECTIVE OF COUPLING

5.1 Research Object and Data Collection

The index data of regional financial financing tolerance and the order parameter of Shenzhen's

regional economic development system are derived from the Shenzhen Statistical Yearbook from 2011 to 2020 and the statistical bulletin of national economic and social development in the corresponding years. The specific index data are standardized and shown in Figure 1.

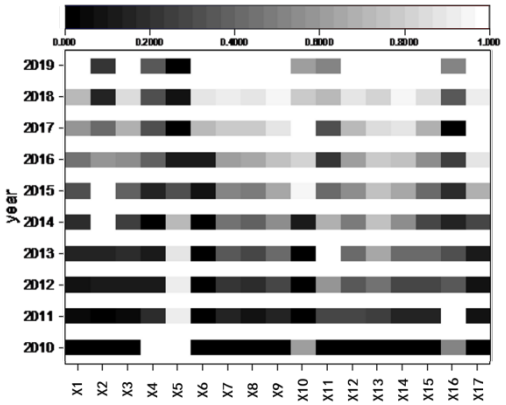

Figure 1 Standardized data heatmap

5.2 Determine the index weight

Based on standardizing the evaluation index of the coordinated development of regional financial financing tolerance and regional economic development in Shenzhen, to determine the weight more accurately, this study uses a combination of subjective and objective methods to determine the index weight of the coordinated system of regional financial financing tolerance and regional economic development. Firstly, the AHP method and the CVM variation coefficient method are used to calculate the index weight, respectively, and then the weight combination method is used to calculate the weight combination of the two methods. The calculation results are shown in Table 3:

Table 3 Results of combined weights

System layer	Targets	Indicator weights	Weight		
			AHP	CVM	AHP-CVM
S_1	X1	0.557	0.245	0.387	0.557
	X2	0.205	0.504	0.069	0.205
	X3	0.148	0.102	0.245	0.148
	X4	0.017	0.102	0.028	0.017
	X5	0.073	0.046	0.270	0.073
S_2	X6	0.045	0.014	0.181	0.045
	X7	0.076	0.065	0.066	0.076
	X8	0.132	0.078	0.094	0.132
	X9	0.172	0.162	0.060	0.172
	X10	0.049	0.016	0.168	0.049
	X11	0.024	0.037	0.037	0.024
	X12	0.051	0.021	0.138	0.051
	X13	0.016	0.058	0.015	0.016
	X14	0.181	0.171	0.060	0.181
	X15	0.162	0.171	0.053	0.162
	X16	0.008	0.171	0.003	0.008
	X17	0.083	0.037	0.125	0.083

5.3 Synergetic Model Calculation

The composite system synergy degree of regional financial financing tolerance and regional economic development reflects the comprehensive coordination degree of regional finance and regional economy, i.e.

$$U_{(1)} = sig(\cdot)\sqrt{\left|U_1(t)-U_1(t-1)\right|\cdot\left|U_2(t)-U_2(t-1)\right|} \quad (16)$$

$$sig(\cdot)=\begin{cases}1, U_1(t)-U_1(t-1)\geq 0, U_2(t)-U_2(t-1)\geq 0\\ -1, others\end{cases} \quad (17)$$

$U_1(t)$ refers to the orderly contribution of the regional financing tolerance subsystem at time t. $U_2(t)$ is the orderly contribution of the regional economic

subsystem at time t, and $U(t) \in [-1,1]$. When $U(t)$ tends to 1, it indicates that the greater the degree of regional financing tolerance and regional economic synergy is, the more effectively coordinated development between the regional financing tolerance system and the regional economic system or between the internal factors is. The smaller $U(t)$ is, the smaller the synergy between the two systems is, and the disorderly development between regional logistics and regional economic systems is.

The synergy degree of Shenzhen regional financing tolerance and regional economic development composite system is obtained through calculation. $y1$ is the order degree curve of the regional financial financing tolerance system, $y2$ is the order degree curve of the regional economic system, $y3$ is the order degree curve of a composite system. The changes from 2010 to 2019 are shown in Figure 2.

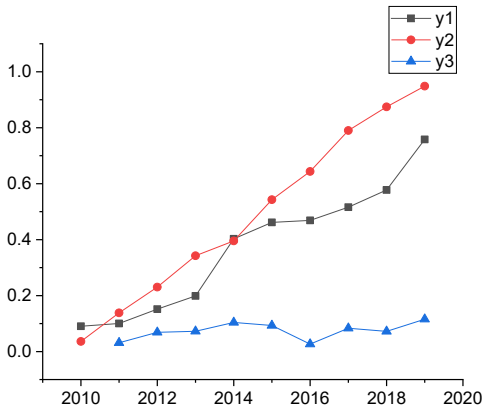

Fig 2 Composite system and subsystem order degree

5.4 Combination and result analysis

5.4.1 Order Degree Analysis of Subsystem

It can be seen from Figure 2 that the order degree of the regional financial financing tolerance subsystem and the regional economic subsystem in Shenzhen shows an overall upward trend. The order degree of regional financial financing tolerance system increased from 0.090 in 2010 to 0.758 in 2019, and the order degree of regional economic subsystem increased from 0.036 in 2010 to 0.949 in 2019. From 2013 to 2014, the regional financial financing tolerance subsystem increased greatly, indicating that the contribution of the two subsystems to the hybrid system is increasing.

By comparing the order degrees of the two subsystems, it can be seen that during 2010 – 2019, the order degree of the regional economic system was higher than that of the regional financial financing tolerance system as a whole, indicating that the regional economy was ahead of the regional financial financing tolerance, which had a great role in promoting the regional financial financing tolerance. The growth rate was also significantly higher than that of the regional financial financing tolerance system.

5.4.2 Synergy analysis of composite system

It can be seen from Figure 2 that the synergy between regional financial financing capacity and regional economic development in Shenzhen presents an alternating M-shaped development trend, which is generally in a low-level system state. The overall change of coordination degree of a composite system can be divided into three stages:

The first stage: from 2010 to 2014, the regional economic system developed steadily, and the order degree of the regional financial financing subsystem showed a steady and low growth after a short stagnation stage and a substantial growth from 2013 to 2014. In 2011, the regional economic subsystem reversed the order degree and continued to be higher than the regional financial financing subsystem. At this time, the synergy degree of the composite system maintained a relatively stable state. That is, the synergy degree of the two systems was relatively stable.

The second stage: from 2014 to 2016, the order degree of the regional economic subsystem has accelerated, while the speed of the regional financial financing subsystem has slowed down, resulting in a significant decline in the order degree of the hybrid system, but it is still positive, indicating that although the synergy degree has declined, it is still in a synergistic state.

The third stage: from 2016 to 2019, the order degree of the regional financial financing subsystem accelerated, while the regional economic subsystem still maintained a stable growth rate, making the hybrid system slightly backward and stabilized compared with 2018, with a good development trend.

6. CONCLUSION

(1) There is a stable synergy between regional financial financing tolerance and local regional economy. The synergy degree of the collaborative system constructed in Shenzhen is always positive. Although it has fluctuated in the past ten years, it is still at a relatively stable level.

(2) The development of regional financial financing capacity has a positive effect on the regional economy, and the development of the regional economy will also promote the financing tolerance of regional finance to a certain extent. In the subsystem research, when the regional financial financing tolerance enhances, the regional economy generally maintains the growth tendency. When regional finance accelerates the development, the regional economy also maintains a

stable rapid growth.

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