

Research on Measurement and Improvement Path of Collaborative Innovation Capability in the Yangtze River Delta Region

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Abstract: The development of the Yangtze River Delta region has entered a new stage. Regional collaborative innovation is an important way to further promote the regional integration of the Yangtze River Delta and an important part of the construction of the Yangtze River Delta urban agglomeration. In this paper, using the composite system synergy model, 16 representative indicators are selected to measure the orderly degree and overall synergy of the collaborative innovation of the subsystems in the Yangtze River Delta region from 2013 to 2017. The research shows that Jiangsu Province has the highest level of order. Shanghai is second, Zhejiang is third, and Anhui is the weakest. The overall situation is in a low degree of coordination. Based on this, this paper combines the economic characteristics of each province, and proposes to enhance regional collaborative innovation from the perspectives of geographical advantages and industrial upgrading.

1. Introduction

In the current era, the market economy is developing at a high speed, the digitalization process and the revolution are accelerating, and the traditional market economy structure is beginning to shift to an ecosystem-based environment, and the market demands for collaborative innovation is increasing. With the reform and development of the national economic system, the provinces and cities in the Yangtze River Delta have firmly grasped the opportunity of the country to implement the innovation strategy and promote the transformation and upgrading of the real economy, build industrial parks, develop the enclave economy, and jointly expand the market and development space. To achieve benefit sharing, there are now more than 100 national-level parks in the Yangtze River Delta. However, the unbalanced development pattern of regional innovation and the closed operation of the three provinces and one city still exists: The proportion of state-owned enterprises and foreign-funded enterprises in Shanghai and Jiangsu is too high, and there is no leading enterprise in the field of scientific and technological innovation. Anhui Province is more to undertake the industrial transfer of Jiangsu, Zhejiang and Shanghai. The development of the three provinces and one city is “unevenly hot and cold”, and the coordination is too difficult. Accelerating regional coordinated development is imminent.

In view of this, we will focus on The measurement of collaborative innovation capability in the Yangtze River Delta region, how to break through the inter-provincial boundaries with strong coupling innovation, form an innovative regional group beyond the administrative boundary, and realize the transformation of the Yangtze River Delta from the traditional industrial cluster development path to the regional innovation-based spillover path. The upgrade is important.

2. Establishment of composite system synergy model

2.1 Model setting

Constructing the Yangtze River Delta Innovation Composite System $R = \{R_1, R_2, R_3, R_4\}$, Where $R_1 - R_4$ represented separately: knowledge creation and diffusion subsystem, technology innovation and

application subsystem, innovation environment and culture subsystem, industry output and performance subsystem. And subsystem $R_k = \{R_{i1}, R_{i2}, \dots, R_{in}\}$, representing each subsystem consisting of several order parameters. Because the positive and negative indicators of the order parameters are divided, in order to eliminate the influence, the following model is constructed. If the value taken, the stronger the negative trend of the system and the lower the degree of order, in order to eliminate the influence of positive and negative indicators, the following model is constructed, $\mu_i(R_{ik})$ indicates the degree of order in the system R_i and R_{ik} :

$$\mu_i(R_{ik}) = \begin{cases} \frac{R_{ik} - \alpha_{ik}}{\beta_{ik} - \alpha_{ik}}, k \in [1, \dots, m] \\ \frac{\beta_{ik} - R_{ik}}{\beta_{ik} - \alpha_{ik}}, k \in [m+1, n] \end{cases} \quad (1)$$

$$\mu_i(R_i) = \sum_{j=1}^n \omega_j \mu_i(R_{ik}), \omega_j \geq 0, \sum_{j=1}^n \omega_j = 1 \quad (2)$$

Known by formula (2), $\mu_i(R_i) \in [0, 1]$, the greater the value, the higher order of the sub-innovation system R_i , on the contrary, the lower. The synergy of the composite system in the Yangtze River Delta region is as follows:

$$DGS = \theta \sum_i^n \eta_i [|\mu_i'(R_i) - \mu_i^0(R_i)|] \eta_i \geq 0 \quad (3)$$

Where $DGS \in [-1, 1]$, the larger the value, the higher the overall synergy of the composite system. Staged as follows: $DGS \in [-1, 0]$ is not synergistic, $DGS \in (0, 0.3]$ is low synergy, $DGS \in (0.3, 0.5]$ is moderate synergy, $DGS \in (0.5, 0.8]$ is highly synergistic, $DGS \in (0.8, 1]$ is extreme synergy.

2.2 Index system framework construction

Based on the establishment of the Yangtze River Delta Innovation Composite System, this paper gradually optimizes and screens relevant indicators to build a systematic framework for the evaluation of the collaborative innovation capability of the Yangtze River Delta region (Table 1).

Table. 1 System Framework

Total system	Subsystem/weight	Element
Yangtze River Delta Collaborative Development System	Knowledge creation and diffusion subsystem(0.26)	Effective invention patent (piece)
		Government R&D expenditure (100 million)
		R&D personnel
		Number of scientific papers published (parts)
	Technology Innovation and Application Subsystem(0.25)	High-tech industry investment (100 million)
		Conversion rate of scientific and technological achievements
		High-tech industry new product development projects
		Science and technology funding (100 million)
	Innovation Environment and Culture Subsystem(0.26)	Financial Technology Grant (100 million)
		Per capita consumption expenditure of residents' lives (yuan)
		Compulsory teaching per capita education funding (yuan)
		University degree (%)
	Industrial output and performance subsystem(0.3)	High-tech industry new product sales (100 million)
		Residents' disposable income (yuan)
		Economic growth rate (%)
		The proportion of high-tech total output value to GDP (%)

3. Composite system synergy measurement and evaluation

3.1 Regional subsystem order measure

The core of this paper is the collaborative innovation development in the Yangtze River Delta region. Therefore, the 2013-2017 statistics of Jiangsu, Zhejiang, Anhui and Anhui provinces will be selected as samples. The original data is subjected to standard deviation method (Z-Score) non-dimensional processing by SPSS to eliminate the interference of different units. At the same time, the entropy method is used to calculate the weight of each order parameter and subsystem, and the corresponding data is substituted into formula (1) Obtain the order parameters of collaborative innovation in each province. The results are shown in Tables (2)-(5).

Table. 2 Jiangsu Collaborative Innovation System Order Parameters

Order parameter/year	Upper limit	Lower limit	2013	2014	2015	2016	2017
Knowledge creation and diffusion subsystem	100	0	65.21	66.79	71.55	74.78	78.46
Technology Innovation and Application Subsystem	100	0	69.39	72.50	68.89	72.00	78.89
Innovation Environment and Culture Subsystem	100	0	41.48	43.57	47.18	54.36	55.17
Industrial output and performance subsystem	100	0	59.23	65.25	80.88	86.22	92.37

Table. 3 Zhejiang Collaborative Innovation System Order Parameters

Order parameter/year	Upper limit	Lower limit	2013	2014	2015	2016	2017
Knowledge creation and diffusion subsystem	100	0	32.63	34.28	39.77	41.79	43.10
Technology Innovation and Application Subsystem	100	0	32.32	34.19	36.47	43.01	49.33
Innovation Environment and Culture Subsystem	100	0	33.77	37.30	40.23	43.57	46.97
Industrial output and performance subsystem	100	0	29.37	34.64	38.35	41.85	42.66

Table. 4 Shanghai Collaborative Innovation System Order Parameters

Order parameter/year	Upper limit	Lower limit	2013	2014	2015	2016	2017
Knowledge creation and diffusion subsystem	100	0	45.97	48.81	51.47	52.08	55.79
Technology Innovation and Application Subsystem	100	0	42.12	45.28	44.35	46.59	47.03
Innovation Environment and Culture Subsystem	100	0	53.46	60.09	66.42	71.78	78.88
Industrial output and performance subsystem	100	0	28.45	35.85	34.64	35.10	36.81

Table. 5 Anhui Collaborative Innovation System Order Parameters

Order parameter/year	Upper limit	Lower limit	2013	2014	2015	2016	2017
Knowledge creation and diffusion subsystem	100	0	14.9 2	16.2 3	17.0 6	18.6 2	19.9 9
Technology Innovation and Application Subsystem	100	0	20.5 3	20.2 7	19.4 9	21.3 7	23.8 5
Innovation Environment and Culture Subsystem	100	0	19.2 3	21.7 5	24.4 7	27.1 4	29.0 8
Industrial output and performance subsystem	100	0	21.6 6	34.7 7	25.7 9	29.6 5	34.0 6

The above data shows the changes of the order parameters of the provincial subsystems. It can be seen from the analysis that the knowledge creation and diffusion subsystem contributes the most to the order degree, the innovation environment and the technology application subsystem are the second, and the output and performance subsystems are the most. Poor, this result matches the

current national policy. First of all, the state vigorously promotes the development strategy of “mass entrepreneurship, innovation” and promotes cooperation between industry, academia and research, and the knowledge creation capacity of each province is greatly enhanced. At the same time, the state pays attention to the creation of a good innovation environment and the improvement of the ability to transform innovation results, making these two subsystems the contribution of innovation and synergy has increased; while China is currently in the stage of vigorous development and innovation investment, and the output performance is not reasonable. Anhui Province is slightly different. Because it has not been deeply integrated into the industrial development of the Yangtze River Delta region, innovation investment is not good. However, as an industrial production area in the Yangtze River Delta region, innovation performance has contributed the most to the orderly degree.

3.2 Three provinces and one city order measure

According to the order parameters and corresponding weights of the three provinces and one city, the linear weighting method is used to calculate the order of the collaborative innovation system. The results are shown in Table 6:

Table. 6 Collaborative innovation system order

Year/Area	Jiangsu	Zhejiang	Anhu	Shanghai
2013	58.71	32.10	18.99	42.92
2014	61.83	35.13	22.94	47.88
2015	66.70	38.74	21.60	49.71
2016	71.41	42.57	24.06	51.92
2017	75.71	45.56	26.56	55.24

The data in Table 6 clearly shows the trend of the orderly degree of collaborative innovation systems in the three provinces and one city in the past five years: The orderliness of the provinces are improving steadily, and the cooperation ability among the subsystems is strengthening year by year, which is basically in an orderly state, which reflects the effective implementation of the national innovation-driven development strategy. Among them, Jiangsu Province's collaborative innovation system has the highest level of order, followed by Shanghai, Zhejiang, and Anhui.

Jiangsu Province holds the most advanced science and technology in electronics and communication equipment, Internet of Things, software and animation games. The economically developed cities of southern Jiangsu such as Nanjing, Suzhou and Wuxi are in the hope of helping the cities of northern Jiangsu with a slightly slower development rate. Its collaborative innovation order has been more than 50% for five years, and it is generally orderly, with a large increase, and its innovation capability has reached the highest ranks in the country.

The order of Shanghai is second only to Jiangsu, as a financial center in China, its financing potential is huge. It is a characteristic base of software parks, data services and internet finance. It is a national front-end in terms of market level and policy support. However, if the strength of the Yangtze River Delta region cannot be further enhanced, it will be difficult for Shanghai's economy to develop in a higher direction. And in recent years, the development of Zhejiang Province is like a broken bamboo. The rise of e-commerce, the convening of the G20 summit and the development of big data cloud computing have greatly improved the orderly degree. The growth rate has been 41.9% in 5 years. Do a good job in policy orientation, and the orderly improvement in Zhejiang Province is just around the corner.

In contrast, the orderly degree of regional collaborative innovation system in Anhui Province is relatively low. In 2015, there was a small decline in orderly degree. In 2016, it began to accelerate again. It can be seen that Anhui is in the period of economic adjustment and transformation. Pulling down the source of the coordinated innovation and order of Anhui Province, opening the breakthrough of the process of improving the orderly process, and promoting the orderly trend of Anhui's innovation system. In the long run, Anhui Province has a superior geographical position and

accurate industrial positioning. When new opportunities come, Anhui's collaborative innovation capability will be greatly enhanced.

3.3 Overall synergy measure in the Yangtze River Delta region

According to the formula (3), the overall degree of synergy DGS of the long triangle region is calculated as follows.

Table. 7 Yangtze River Delta Composite System Synergy

Year/Area	η				DGS
	Jiangsu	Zhejiang	Anhu	Shanghai	
2013	0.43	0.27	0.14	0.16	-
2014	0.43	0.27	0.14	0.16	0.0350
2015	0.44	0.27	0.14	0.15	0.0669
2016	0.44	0.26	0.14	0.16	0.1046
2017	0.44	0.26	0.14	0.16	0.1401

Through the analysis of the data in Table 7, it is found that the collaborative innovation of the Yangtze River Delta region is generally in a low degree of synergy. Although it has been rapidly improved in recent years, there is still much room for improvement. To achieve synergy innovation in the three provinces and one city, there are still many problem.

4. Conclusion

With the development and changes of the global economic situation, the development model of regional economy in China's economic development needs to be changed. Through the analysis of the data results, this paper deeply considers the economic characteristics of the provinces in the Yangtze River Delta and proposes the corresponding suggestions for enhancing the degree of synergy.

(1). Make full use of geographical proximity to enhance cooperation and exchange between regions. The Yangtze River Delta region has natural geographical advantages, convenient transportation, and industrial agglomeration. In order to enhance regional collaborative innovation and development, it is necessary to integrate enterprise clusters in 26 cities, analyze the development status and dilemma of similar enterprises, seek the best opportunities, and jointly develop the market. Trade with other parts of the country and foreign countries in a way that helps the regional enterprises with weaker voices to stand in the market. At the same time, we will relax restrictions on talents and other aspects, enhance the stickiness of talents, attract outstanding scientific and technical personnel and management talents, and establish an innovative talent pool.

(2). Cultivate competitive companies and implement a gradient development strategy. The Yangtze River Delta region needs to maintain its leading position in the future market competition. It requires government policy support and the need to cultivate truly competitive enterprises. All governments must launch special funds for independent innovation and high-tech industry development. Help companies expand financing channels and encourage enterprises of all types to carry out technological innovation in their development areas, depending on the region. Advantages achieve a rational division of labor in the industrial chain, implement an industrial gradient development strategy, and promote higher-level exchanges and cooperation between enterprises.

(3). Technologies such as electronic communication and Internet of Things in Jiangsu Province, e-commerce in Zhejiang Province, and the rapid development of Internet finance in Shanghai and the layout of emerging enterprises in Anhui Province have promoted the further development of the Yangtze River Delta regional economy. The three provinces and one city should work together to enhance regional synergy, seize opportunities, and strive to build the Yangtze River Delta into a veritable "world-class urban agglomeration with global influence."

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