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Facing the Post-Industrial Age, How to Choose the South Jiangsu Region?

Yingying Li[1]

[1] School of Economics and Management, Nanjing University of Aeronautics and Astronautics, Nanjing, China

Correspondence: Yingying Li, School of Economics and Management, Nanjing University of Aeronautics and Astronautics, Nanjing, Jiangsu Province, China. E-mail:18851879335@163.com

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Abstract

Based on the composite system collaboration model, this paper selects three representative elements that can reflect the innovation input and innovation benefit in south Jiangsu province, namely innovation resources, innovation environment and innovation benefit, and calculates the overall synergy degree of the regional innovation system with five cities in south Jiangsu province as the whole. It can be concluded from the analysis that the order degree of collaborative innovation in Suzhou is the highest, followed by that in Nanjing and Wuxi, Changzhou and Zhenjiang, the order degree of regional collaborative innovation is at the end of the five cities in southern Jiangsu. Due to the differences in the ability and level of collaborative innovation among different cities, as well as the problems in resource sharing and collaborative innovation among different cities, the overall level of the collaborative degree of regional innovation system in southern Jiangsu is not high. On the basis of this empirical analysis, this paper puts forward some scientific and targeted Suggestions for improving the overall coordination degree of regional innovation system in southern Jiangsu and building a higher level of southern Jiangsu modernization demonstration area.

Keywords: southern Jiangsu, collaborative innovation, degree of order, degree of collaboration

1. Introduction

The development of economy follows certain law. After experiencing the stage of rapid economic growth, China's economic development has gradually entered the new normal and entered the stage of high-quality development. In a long period of development, the post-industrialization stage will be the normal development of most developed provinces in China. It is mentioned in the planning of the south Jiangsu modernization demonstration zone that by 2020, on the basis of completing the building of a moderately prosperous society in all respects, regional modernization will be basically realized and the zone will become a national modernization demonstration zone. Some experts said that with the development of economy, southern Jiangsu will face the challenge of post-industrialization in the future. The best way to meet and face the post-industrialization is that southern Jiangsu should develop cooperatively and innovatively. The concept of "collaborative innovation" was first proposed by President Hu at the centennial celebration of Tsinghua university. At the 18th national congress of the communist party of China, President Hu once again pointed out that coordination and innovation are another development based on the capacity of original innovation, integrated innovation and re-innovation, and we need to pay more attention to collaborative innovation. As an active economic unit in economic development, the region is playing an increasingly prominent role in economic development. Within a region, the flow and sharing of resources, innovation ability and achievements among economic units often produce the effect of 1+1>2, which promotes the economic development of the whole region. As an important strategic development region of Jiangsu province, southern Jiangsu plays an important role in the economic development of Jiangsu province and the whole of China. Improving the ability of regional collaborative innovation in southern Jiangsu is not only conducive to improving the ability of regional collaborative innovation, but also has important reference significance for national development and regional construction.

2. Literature Review

With the importance of regional economy becoming more and more prominent, people's research on regional cooperation, regional integration and other related content is getting more and more in-depth, especially the research on the collaborative development. Understanding of the regional collaborative innovation is not the

same, in this article, we adopt the professor Lin of Guangxi University in the definition of regional collaborative innovation, namely the regional collaborative innovation refers to a variety of knowledge resources and elements in the area between the free flow of elements of mutual fusion and use of the development of production technology in the area of innovation, resulting in the entire region's economic development.

Koschatzky and Gundrum (1997) recorded the research overview of ISI's "innovation services and regional development department" (IR) from the perspective of new technology companies, and proposed that regional systems should be interconnected for coordinated development to promote regional economy. Knut Koschatzky, Rolf Sternberg (2000) studied and proved that the spatial scope of innovation connection is largely determined by the size, type of partners, R&D intensity and the industry of manufacturing enterprises for analysis. At the same time, it is pointed out that large enterprises are more willing to participate in regional collaborative innovation than small enterprises. Compared with the innovation system in the peripheral region, the innovation system in the central region will pay more attention to the innovation of production process, and the innovation system in the central region will pay more attention to the innovation of products.This difference has important reference significance for the government to make policy. Guadalupe serrano-domingo (2007) concluded through empirical analysis of regional innovation in Spain that knowledge spillover in adjacent regions has an important impact on local innovation ability. Roberto m. samaniego (2013) used country industry data to reveal the relationship between knowledge spillover and innovation activities as well as the life and death of enterprises. This result is very convincing for the calculation of financial development, the size of labor market and other institutional factors.

Long (2004), a domestic scholar, first proposed the concept of cross-administrative region innovation system, proposed the basic framework of cross-administrative region innovation system construction, and put forward several policy Suggestions for cross-administrative region innovation system construction. Wang (2006) made a comparative analysis of the innovation capacity of the Yangtze river delta region, and proposed to actively utilize the internal and external resources of the region, build an open regional innovation system coordinated with the surrounding areas according to the local reality, and promote the better economic development of the region. Deng, et al. (2014), based on the theory of complex system and dissipative structure and from the perspective of system order and disorder, proposed a regional collaborative innovation measurement method based on coordination degree -- management entropy to test the innovation ability of provinces in China. Chen fang et al. (2015) believe that the collaborative innovation of emerging industries is a complex process in which the internal evolutionary driving force and external environment of the innovation subjects in the industrial system intermingle and influence each other. With the development of the industry, the collaborative innovation is in a continuous evolutionary process, and the degree of collaborative innovation among the innovation subjects is gradually deepened. Jiang (2016) believes that collaborative innovation is an important way to get beyond its own elements. Huang et al. (2017) proposed the proposal of building a "regional collaborative innovation and entrepreneurship circle" with "Cheng-De-Mian" as the core "in the comprehensive capacity evaluation of regional innovation and its spatial structure evolution analysis".

A review of the literature at home and abroad shows that the research on collaborative innovation is still in the preliminary stage, there is no clear and unified standard to measure the ability of collaborative innovation, and the research on collaborative innovation is relatively simple. On the basis of previous studies and from the perspective of collaborative innovation, this paper puts forward the index system of regional collaborative innovation capability according to the actual situation of five cities in southern Jiangsu province, measures the degree of order of collaborative innovation of each city and the overall degree of regional collaboration, analyzes the results, and puts forward corresponding Suggestions scientifically.

3. The Construction and Empirical Analysis of Regional Collaborative Innovation Capability Model

3.1 Model Design

Based on this paper, the collaborative innovation ability of five major cities in southern Jiangsu is studied, which needs to be studied as a whole, namely, composite system. Therefore, this paper selects the collaborative degree model of the composite system for analysis. The southern part of Jiangsu is regarded as a complex system, which consists of Nanjing, Suzhou, Wuxi, Changzhou and Zhenjiang as subsystems. The order degree and change trend of each subsystem are found through the evaluation. Finally, the overall synergy degree of the innovation system is calculated.

The composite system can be used as $S=\{S_1, S_2, \cdots\cdots S_n\}$, indicates that S_k is kth the subsystem of the composite system S, where k=1，2…… n,, and $S_k=\{S_{k1}, S_{k2}, \cdots\cdots S_{kn}\}$, that is, each subsystem S_k consists of several ordered quantities. In this paper, composite system S refers to the collaborative whole composed of five cities in southern

Jiangsu province, namely, the regional collaborative innovation composite system composed of Nanjing, Suzhou, Wuxi, Changzhou and Zhenjiang. S_k refers to the sub-regional innovation system of Nanjing, Suzhou, Wuxi, Changzhou and Zhenjiang. For the subregional innovation system S_k ， $k\in(1,5)$, $e_k=(e_{k1},e_{k2},\ldots\ldots e_{kn})$, where n>, 1, and $\beta_{ki}<e_{ki}<\alpha_{ki}$, i=1,2……n,, α, and β represent the maximum and minimum order parameters of a system in a stable state, respectively. Because the order parameters with different properties have different influences on the synergy effect, the order parameters can be divided into positive and negative ones. The order parameters that have a positive effect on the degree of order are denoted as "+", and the order parameters that have a negative effect on the degree of order are denoted as "-". The value of ekl1 is positively correlated with the degree of order of the system, and the larger the value is, the stronger the positive effect on the degree of order will be. The value of e_{kj} is negatively correlated with the degree of order, and the larger the value is, the stronger the negative effect on the degree of order will be; on the contrary, the smaller the value is, the more favorable it will be for the positive index of the degree of order.

$$Uk(ek1)=\begin{cases}\dfrac{eki-\beta ki}{\sigma ki-\beta ki}, & i\in[1,l1]\\ \dfrac{\beta ki-eki}{\sigma ki-\beta ki}, & i\in[l1+1,j]\end{cases} \tag{1}$$

For the above formula, $Uk(ek1)\in[0,1]$. Since the order degree of each innovation is greater than zero, the above formula is modified as follows.

$$Uk(ek1)\begin{cases}\dfrac{eki-\beta ki}{\sigma ki-\beta ki}\times 0.6+0.4, & i\in[1,l1]\\ \dfrac{\beta ki-eki}{\sigma ki-\beta ki}\times 0.6+0.4, & i\in[l1+1,j]\end{cases} \tag{2}$$

Ordered degree for subsystems, is expressed as: $u(e_k)=\sum_{i=1}^{j} w_i u_i(e_{ki})$. $w_i\geq 0$, and $u(e_k)\in[0.4,1]$. The formula shows that $u(e_k)$, $u(e_k)$value, the greater the order parameter pair e_k , S_k innovation system show that the degree of order the higher the contribution degree of [13] .

Coordination degree of composite system:

Assuming a subsystem of Si in the degree of order of t0 time for$u_k^0(e_k)$,, in the degree of order of the t1 time for$u_k^1(e_k)$, assuming compound innovation system from the initial time to evolve into the t1 t0, the order parameter of the degree of order of the subsystems of the respectively$u_k^0(e_k)$,$u_k^1(e_k)$,k=1,2,3,……n,, it is said that the collaborative degree of compound innovation in the t0-t1 period is defined as:

$$DSG=\theta\sum_{k}^{m}\eta_t\left[\left|u_k^1(e_k)-u_k^0(e_k)\right|\right], \tag{3}$$

And one of the $\theta=\frac{\min[u_k^1(e_k)-u_k^0(e_k)\neq 0]}{|\min[u_k^1(e_k)-u_k^0(e_k)\neq 0|}$,k=1,2,……m， composite regional innovation system as a whole collaborative DSG ∈ (1, 1), the greater the value of income from DSG, show that the composite regional innovation system of the whole synergy degree is higher.

3.2 Design of Index Evaluation System

Based on the comprehensive literature at home and abroad, scientific, accurate and data availability and other reasons, combined with the actual situation of innovation development in south Jiangsu , this paper will establish the indicators of evaluation system of regional collaborative innovation ability in south Jiangsu from three aspects of innovation resources, innovation environment and innovation benefits. The following table:

Table 1. Index system of regional collaborative innovation capacity in southern Jiangsu province

System elements	The child elements	the direction of affect	
Regional collaborative innovation capability	Innovation resource	Total expenditure of R&D internal expenditure of industrial enterprises above the scale (tenthousand yuan)	+
		Industrial enterprises above the scale have R&D activity enterprises (number)	+
		Proportion of R&D activities (%)	+
		Number of industrial science and technology activities above the scale (person)	+
		Employees (persons) of non-private institutions in cities and towns of the whole city	+
		Expenditures for industrial technical renovation above the scale (ten thousand yuan)	+
		Total amount of patent authorization (pieces)	+
		Number of universities (units)	+
		Education expenditure budget (ten thousand yuan)	+
		Budget for science and technology expenditure (ten thousand yuan)	+
		Government funding for science and technology ($10,000)	+
	Innovation environment	Per capita consumption expenditure of urban residents (yuan/person)	+
		Balance of loans from financial institutions (100 million yuan)	+
		Actual use of foreign capital (ten thousand us dollars)	+
		Domestic technical outlays for industrial purchase above the scale (ten thousand yuan)	+
		Number of ordinary higher education graduates (person)	+
		Expenditure on research and experimental development accounts for % of GDP	+
		GDP ($100 million)	+
	Innovation performance	Economic growth rate (%)	+
		Added value of the tertiary industry (hundred million yuan)	+
		Tertiary industry growth rate (%)	+
		Per capita disposable income of urban residents (yuan/person)	+
		Registered urban unemployment rate (%)	-
		Sales of new products increased (%)	+

3.3 Calculation and Evaluation of Synergy Degree of Five Cities in Southern Jiangsu Province

According to the regional innovation synergy model established above, this paper obtained the relevant data from 2012 to 2016 by inquiring the statistical yearbook of Jiangsu province in relevant years, the statistical yearbook of Jiangsu province in science and technology and the statistical yearbook of each city, and calculated the order degree of each subsystem in the five cities in southern Jiangsu and the overall innovation synergy degree in southern Jiangsu.

3.3.1 Data Processing and Order Measurement

Due to the inconsistency of measurement units of the original data, it is necessary to ensure the scientificity and preciseness of the measurement results. Firstly, Matlab14 software was used to standardize the original data and eliminate the dimensional influence. Based on 2012, the order degree of Nanjing, Suzhou , Wuxi, Changzhou and Zhenjiang was calculated. Firstly, the order parameters of each subsystem are calculated.The following table shows the order parameters of Nanjing, Suzhou , Wuxi, Changzhou and Zhenjiang .

Table 2. Ordinal parameter scale of Nanjing, Suzhou , Wuxi, Changzhou and Zhenjiang

region	Order parameter	Upper limit	lower limit	2012	2013	2014	2015	2016
	resource(e11)	1	0.4	0.64	0.64	0.64	0.65	0.65
Nanjing(e_1)	environment(e12)	1	0.4	0.62	0.65	0.65	0.67	0.76
	performance(e13)	1	0.4	0.55	0.60	0.43	0.45	0.50
	resource(e21)	1	0.4	0.59	0.72	0.77	0.80	0.92
Suzhou (e_2)	environment(e22)	1	0.4	0.77	0.77	0.78	0.77	0.80
	performance(e23)	1	0.4	0.52	0.50	0.47	0.46	0.47
	resource(e31)	1	0.4	0.66	0.70	0.72	0.75	0.79
Wuxi(e_3)	environmentv(e32)	1	0.4	0.62	0.65	0.62	0.63	0.70
	performance(e33)	1	0.4	0.47	0.46	0.47	0.42	0.45
	resource(e41)	1	0.4	0.57	0.58	0.58	0.59	0.62
Changzhou(e_4)	environment(e42)	1	0.4	0.52	0.58	0.56	0.57	0.61
	performance(e43)	1	0.4	0.52	0.51	0.52	0.50	0.48
	resource(e51)	1	0.4	0.44	0.44	0.53	0.58	0.59
Zhenjiang (e_5)	environment(e52)	1	0.4	0.40	0.45	0.43	0.45	0.51
	performance(e53)	1	0.4	0.49	0.49	0.48	0.48	0.49

According to the values of the order parameters in the above table, the geometric average method is used to calculate the order degree of each city.

Table 3. Order degree of collaborative innovation in Nanjing

year	[u(e11),u(e12),u(e13)]	Geometric mean method
2012	(0.64,0.62,0.55)	0.60
2013	(0.64,0.65,0.60)	0.63
2014	(0.64,0.65,0.43)	0.57
2015	(0.65,0.67,0.45)	0.59
2016	(0.65,0.76,0.50)	0.64

As can be seen from the above table, in general, the order degree of Nanjing is relatively high, above 0.5, especially in 2012, 2013 and 2016, above 0.60.In general, collaborative innovation in Nanjing is orderly on the whole. Z shows an upward trend during the observation period. In recent years, the improvement of innovation resources, innovation environment and investment intensity have been strengthened. At the same time, the enhancement of innovation investment has also achieved considerable results, and the innovation benefits have increased from 0.43 to 0.50 in response. The above table also shows the overall characteristics of the current economic and technological development of Nanjing.

Table 4. Order degree of Suzhou collaborative innovation

year	[u(e11),u(e12),u(e13)]	Geometric mean method
2012	(0.59,0.77,0.52)	0.63
2013	(0.72,0.77,0.50)	0.66
2014	(0.77,0.78,0.47)	0.67
2015	(0.80,0.77,0.46)	0.68
2016	(0.92,0.80,0.47)	0.73

From the table of the order degree of Suzhou 's collaborative innovation, we can see that the order degree of Suzhou is at the highest level among the five cities in southern Jiangsu .From 2012 to 2016, the degree of order of year above 0.60, and belongs to the state of orderly rise, even in 2016 reached 0.73, Suzhou on the innovation has been at the high level of Jiangsu province, at the same time, collaborative innovation system has always been in its stage, constantly optimize the internal structure of the continuous optimization is more advantageous to the resources reasonable use, also bring better benefit.

Table 5. Order degree of collaborative innovation in Wuxi city

year	[u(e11),u(e12),u(e13)]	Geometric mean method
2012	(0.66,0.62,0.47)	0.58
2013	(0.70,0.65,0.46)	0.60
2014	(0.72,0.62,0.47)	0.60
2015	(0.75,0.62,0.47)	0.60
2016	(0.79,0.70,0.45)	0.65

As can be seen from the degree of innovation collaborative order in Wuxi, the degree of innovation collaborative order in Wuxi is at a medium level among the five cities in southern Jiangsu, generally lower than that in Suzhou and Nanjing. From 2012 to 2016, the degree of order of collaborative innovation in each year reached more than 0.55.From the perspective of specific subsystems, both the order parameters of Wuxi's innovation resources and the innovation environment score higher, but compared with other cities, the innovation benefits brought by the innovation resources and the innovation environment are lower. It shows that the internal optimization is still needed for its innovative collaborative system .It is necessary to make better use of the invested resources and the innovation environment to obtain better innovation benefits.

Table 6. Order degree of collaborative innovation in Changzhou city

year	[u(e11),u(e12),u(e13)]	Geometric mean method
2012	(0.57,0.52,0.52)	0.54
2013	(0.58,0.58,0.51)	0.56
2014	(0.58,0.56,0.52)	0.55
2015	(0.59,0.57,0.50)	0.55
2016	(0.62,0.61,0.48)	0.57

From the table of the order degree of collaborative innovation in changzhou, it can be seen that the order degree is generally on the rise, but it is on the back of the five cities in southern Jiangsu .Compared with Suzhou , Nanjing and Wuxi, the order parameter scores of the two subsystems of innovation resources and innovation environment are lower, but their innovation benefits are higher than those of other cities.It can be seen that the internal optimization of its collaborative innovation system is very high and the resource conversion rate is high.

Table 7. Order degree of collaborative innovation in Zhenjiang city

year	[u(e11),u(e12),u(e13)]	Geometric mean method
2012	(0.44,0.40,0.49)	0.44
2013	(0.44,0.45,0.49,)	0.46
2014	(0.53,0.43,0.48)	0.48
2015	(0.58,0.45,0.48)	0.50
2016	(0.59,0.51,0.49)	0.53

From the perspective of the order degree of Zhenjiang's collaborative innovation, the order degree of Zhenjiang's collaborative innovation is at the lowest level among the five cities in southern Jiangsu province. The order parameters of each subsystem are at a low level. Zhenjiang's collaborative innovation system is at a low level in southern Jiangsu province. However, it can be seen from its increasing status year by year that the orderly trend of regional collaborative innovation system in Zhenjiang still needs to be further strengthened in terms of great potential improvement, innovation input and internal optimization, and rational utilization of resources.

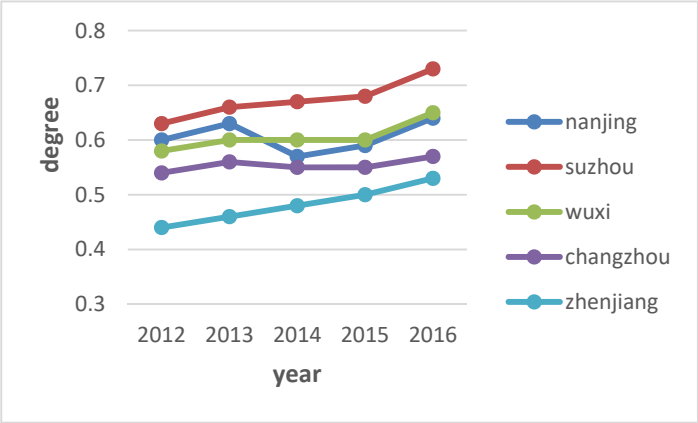

Figure 1. Broken line diagram of order degree of five cities in southern Jiangsu province

The order degree of each year of the five cities is reflected in a comprehensive line chart, which can be obtained on the chart. On the whole, it is in the state of coordinated development, but in some years, the development is not coordinated.

3.4 Calculation of the Overall Regional Synergy in Southern Jiangsu

In order to calculate the overall regional synergy, 2012 was taken as the base period to calculate the weight coefficients of each subsystem by the proportion of GDP of each city in the total regional GDP, and then the overall regional synergy innovation synergy (DGS) of southern Jiangsu was calculated. When calculating the weighting coefficient prime minister,$\eta_i=\frac{GDPi}{\sum_{i=1}^{5} GDPi}$. The formula of η_i is the weight coefficient of the i city, i= Nanjing, Suzhou , Wuxi, Changzhou, Zhenjiang.

Table 8. Weight coefficients of cities in the regional collaborative innovation system in southern Jiangsu province

year	Nanjingη_1	Suzhou η_2	Wuxiη_3	Changzhouη_4	Zhenjiang η_5
2012	0.22	0.36	0.23	0.12	0.08
2013	0.22	0.36	0.22	0.12	0.08
2014	0.23	0.35	0.21	0.13	0.08
2015	0.23	0.35	0.21	0.13	0.08
2016	0.23	0.35	0.21	0.13	0.09

According to formula (3), DSG of the overall synergy degree in southern Jiangsu is calculated

Table 9. Synergy degree DSG of regional collaborative innovation system in southern Jiangsu Province

year	The degree of synergy of geometric mean method
2013	0,0260
2014	0.0300
2015	0.0308
2016	0.0717

As can be seen from the table, DGS calculated in 2012 as the foundation period are all positive values, so the south Jiangsu regional collaborative innovation system as a whole is in a collaborative state. In 2013, the degree of synergy was 0,026, lower than 0.03 and in a low degree of synergy. The degree of synergy in 2014 and 2015

is between 0.03 and 0.05, which is a general state of synergy. In 2016, the degree of synergy is 0.717, which is a highly collaborative state.

3.5 Analysis of Calculation Results

It can be seen from the above analysis that the five cities in southern Jiangsu are basically in an orderly state through the calculation of the degree of order. Among them, the order degrees are in the order of Suzhou, Nanjing, Wuxi, Changzhou and Zhenjiang. Although Nanjing, Suzhou, Wuxi, Changzhou and Zhenjiang have little difference in geographical location, they are different as subsystems. This difference is mainly manifested in two aspects. The first is the difference in order degree of each city. As can be seen intuitively from figure 1, the difference between Suzhou, the city with the first degree of order, and Zhenjiang, the city at the end of the degree of order, is the most significant, with a difference of about 0.2, and there are also differences in the degree of order between other cities. Second, the subsystems themselves differ from year to year. Although there is an upward trend on the whole, there is a significant downward trend in the middle. In particular, the decline of Nanjing was relatively obvious in 2014, which was mainly caused by the decline in innovation performance of Nanjing in 2014.

Suzhou, Nanjing and Wuxi have a high degree of order in the acquisition of innovation resources, which leads to a higher innovation performance. Suzhou has a good industrial foundation and high investment in scientific research and innovation, especially the establishment of Suzhou industrial park, which plays a positive role in promoting the economy of Suzhou .Nanotechnology and biopharmaceuticals are the leading and key industries in Suzhou .As the capital city of Jiangsu province, Nanjing has a long history, and its education resources are the most abundant in the province. The great number of colleges and universities is an important source of talents. Especially in recent years, Huawei and other enterprises have settled in Nanjing, which is particularly important for the development of Nanjing's software and intelligent manufacturing industry. Nanjing's talent introduction program also brings fresh vitality to the development of Nanjing. Compared with other cities, Changzhou and Zhenjiang are at a disadvantage in innovation resources, environment and performance. Firstly, in terms of education resources, there are relatively few universities and scientific research institutes, and the number of R&D personnel is also small, which limits the development of innovation ability. Secondly, the industrial foundation of the two cities is relatively weak, and their innovation performance shows a low degree of order. The total number of innovation subjects is not ideal, the industrial structure adjustment is slow, and the ability of collaborative innovation needs to be further improved.

4. Conclusion

Based on the calculation results of the degree of order and the degree of coordination of collaborative innovation in five cities in southern Jiangsu province, some Suggestions are put forward to build the modernization demonstration area with high degree of coordination in southern Jiangsu province. First, we need to improve the resource sharing mechanism in southern Jiangsu. Take southern Jiangsu region as an integrated system of coordinated development, enhance the soft power and enhance the sharing of resources within the region. Due to the differences in resource advantages of different cities, the city needs to transfer the innovative elements such as human resources from Nanjing to Changzhou and Zhenjiang regions by constructing the resource sharing platform and mechanism within the region. Second, strengthen regional synergy and linkage and optimize regional spatial structure. In the future, we should build an infrastructure network for connectivity, jointly expand the spatial structure of regional development, rationally divide industries, reduce homogenous competition, gradually realize the characteristics of our own industries, strengthen coordination and linkage with urban agglomerations in the Yangtze river delta, and participate in international competition. In order to promote the new industrialization, the most important thing is the quality index. We should try to solve the deep integration of Internet, big data and artificial intelligence into the real economy [14]. Third, strengthen the regional government, universities and enterprises, and other aspects of multi-level collaborative innovation. The government should formulate active and open development policies, and universities and research institutions should strengthen cooperation with enterprises to better transform research results into products. The government should increase investment in scientific research, increase the rate of technological self-sufficiency in the region, and master more core technologies and technologies. At the same time, the innovation environment in the region should be optimized to improve the supporting environment of finance, network and technology.

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