

Collaborative Effect of Innovation System in Guangdong-Hong Kong-Macao Greater Bay Area and Jiangmen Countermeasures

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Abstract—The Guangdong-Hong Kong-Macao greater bay area is one of the most open and economically dynamic areas in China and plays an important strategic role in the overall national development. Whether it can become a world-class bay area and a world-class city cluster depends on the collaborative innovation ability of the region. Innovation is the fundamental driving force for the sustainable development of regional economy. The formation of innovation system is also a shortcut to improve the ability of independent innovation. This paper takes the innovation system of the Guangdong-Hong Kong-Macao greater bay area as the research object, constructs the evaluation index system of the synergy effect of the innovation system of the Guangdong-Hong Kong-Macao greater bay area, and measures and evaluates the synergy degree of each regional subsystem in the greater bay area, among which, Hong Kong is the highest and Jiangmen is the lowest. Therefore, this paper focuses on the analysis of the coordination obstacles and level differences in Jiangmen, and puts forward countermeasures and suggestions to promote the innovative development of Jiangmen based on the existing problems and their causes, in an attempt to provide some experience for the innovative development of the Guangdong-Hong Kong-Macao greater bay area.

Keywords—Guangdong-Hong Kong-Macao greater bay area; regional innovation system; synergistic effect

I. INTRODUCTION

Innovation capability is an important pillar of sustainable development of national economy, and regional innovation is the foundation of national innovation. Through regional innovation to drive national innovation, the Guangdong-Hong Kong-Macao greater bay area will become the forerunner of national innovation and development, and innovation and development will also become an important engine of the Guangdong-Hong Kong-Macao greater bay area [1]. However, for the Guangdong-Hong Kong-Macao greater bay area, to achieve better development, it is not enough to improve the innovation ability of one city or several cities. For the innovation and development of the greater bay area, simply integrating and summing up the innovation resources in the greater bay area cannot achieve the most efficient development and utilization of the innovation resources in the greater bay area. Therefore, it is extremely necessary to improve the degree

of collaborative innovation in the whole region and form a complete innovation system mechanism to improve the overall innovation capacity of the greater bay area.

Jiangmen is a famous hometown of overseas Chinese in China, located in the west of the Pearl River Delta. It was once one of the economic miracles of Guangdong province, but Jiangmen missed the first golden development period after the reform and opening up, and its economic development lagged behind other cities in the Pearl River Delta. The strategy of Guangdong-Hong Kong-Macao greater bay area is regarded as a significant historical opportunity for Jiangmen's development. How Jiangmen seizes the development opportunities of Guangdong-Hong Kong-Macao greater bay area to catch up is the focus of Jiangmen city.

II. THEORETICAL BASIS

From the perspective of meso-level, the goal of collaborative development of an innovation system is to produce synergistic effect, and the core of the synergistic effect lies in whether the innovation synergy can be formed through self-organization in the system. Regional innovation synergy is different from other regional innovations mainly because of its complex and collective main innovation behavior [2]. Most of the existing literature and research is to study the synergy of innovation from the perspective of enterprises. While this paper mainly studies the regional innovation synergy at the meso level. The synergy theory and method are used to analyze the motivation of regional innovation synergy development, and the mechanism of synergy effect generated by subject behavior is studied, which is the theoretical framework of this paper.

A. The Concept of Regional Innovation Synergy

Innovation synergy refers to the process in which each innovation element forms a collective synergetic effect that cannot be generated by individual innovation elements under the nonlinear interaction. The research in this paper assumes that the innovation environment in the region remains unchanged, and focuses on the innovation synergy between regions.

The results of regional innovation synergy can be expressed by whether the synergy effect is formed or not. In order to

accurately analyze the connotation of regional innovation synergy, two concepts are clarified here: degree of synergy and cooperative surplus.

1) *Degree of Synergy* In the process of the system changing from disorder to order, the degree of order and harmony among subsystems is called the degree of synergy, which also reflects the nature of the system synergy [3].

The synergistic effect is a function of the degree of synergy, that is, $Y = f(x)$, where the degree of synergy is represented by x and the synergistic effect Y is represented. The synergistic effect (Y) and the degree of synergy $f(x)$ appear to be positively correlated.

2) *Cooperative surplus* Synergistic effect is the result produced by regional innovation actors through various synergistic behaviors in the innovation system, that is, “ $1 + 1 + \Delta V > 2$ ” is realized, where ΔV is the synergistic surplus [4].

B. The Mechanism of Regional Innovation Synergy

- The mechanism of synergy is the synergy between the specific attributes of each resource element, that is, the matching or complementarity between the element attributes produces a strong mutual relationship of coordination and synchronization, which produces the order parameter that governs the development of the system, thus governing the system. The orderly development makes the overall function of the system the strongest and produces synergies.
- This kind of nonlinear complex combination embodied in the regional innovation synergy process not only reflects the importance of the characteristics of the elements themselves, but also utilizes the unique combination relationship between the elements to form the optimal combination relationship. This kind of complex nonlinear relation combination is the essence of synergistic effect.
- Regional innovation system synergy is the process of interaction between regional factors. The method to achieve synergies is not unique, but it cannot be achieved by relying on a single factor. Innovation resources must be integrated to form an optimal combination to drive the overall progress of the system through interaction.

III. EVALUATION INDEX CONSTRUCTION OF COLLABORATIVE EFFECT OF INNOVATION SYSTEM IN GUANGDONG-HONG KONG-MACAO GREATER BAY AREA

A. System Effect Evaluation System of Regional Innovation System

Based on the feasibility, objectivity and scientific nature of the basic principles of establishing indexes, combining the China Regional Innovation Capability Report and other

scholars research of evaluation system, evaluation system of this paper is mainly divided into clear knowledge creation, knowledge acquisition, knowledge application and innovation environment, innovation performance five criteria (level indicators), are shown in Table I. The indicator system set in this paper contains 17 secondary indicators. The main source of secondary indicator data is the statistical yearbook of each city.

B. Evaluation method

In this paper, the measurement method of synergy degree is as follows:

First, the innovation system $S = \{S_1, S_2, \dots, S_k\}$, where S_i is the i -th regional subsystem compounded into S , $i = 1, 2, \dots, k$, and $S_i = \{S_{i1}, S_{i2}, \dots, S_{ik}\}$, that is, S_i is calculated from the elements of several subsystems.

TABLE I. SYSTEM EFFECT EVALUATION INDEX OF REGIONAL INNOVATION SYSTEM

	Level Indicators	Secondary indicators
Regional subsystem	Knowledge creation C_{i1}	Government investment in science and technology Number of patents granted Number of research papers
	Knowledge acquisition C_{i2}	Growth rate of invention patent applications Foreign direct investment
	Knowledge application C_{i3}	Investment in research and development of industrial enterprises above a certain scale Patent applications per 10,000 people Output value of high-tech industries
	Innovation environment C_{i4}	Number of computers per 10,000 people Household consumption level Years of education per capita Number of high-tech enterprises Per capita GDP
	Innovation performance C_{i5}	High-tech output as a percentage of GDP Merchandise export value Per capita income Employment in high-tech industries accounts for the proportion of employed people

TABLE II. CLASSIFICATION TABLE OF SYNERGY DEGREE OF REGIONAL INNOVATION SYSTEM

Level range	[0,0.4]	(0.4,0.5]	(0.5,0.6]	(0.6,0.7]
Collaborative evaluation	Extremely uncooperative	Un-coordinated	Mild uncoordinated	Weak synergy
Level range	(0.7,0.8]	(0.8,0.9]	(0.9,1.0]	
Collaborative evaluation	The basic collaborative	Good collaboration	Highly collaborative	

The following formula is defined as the system order degree of the order parameter c_{ij} of the sub-regional innovation system S_i :

$$\mu_i(c_{ij}) = \begin{cases} \frac{c_{ij}-\beta_{ij}}{\alpha_{ij}-\beta_{ij}}, & j \in [1, l_1] \\ \frac{\alpha_{ij}-c_{ij}}{\alpha_{ij}-\beta_{ij}}, & j \in [l_1 + 1, n] \end{cases} \quad (1)$$

$\mu_i(c_{ij})$ is a value between 0-1, where α_{ij} and β_{ij} are the upper and lower limits of the order parameter c_{ij} at the critical point when the system is stable. The larger the value of $\mu_i(c_{ij})$, the greater the effect of c_{ij} on the order of the sub-region innovation system [5].

When calculating the degree of system order, this paper adopts the geometric average method which is relatively easy to calculate for integration and integration, that is,

$$\mu_i(c_i) = \sqrt[n]{\sum_{j=1}^n \mu_i(c_{ij})} \quad (2)$$

Suppose the initial time is t_0 , and the order degree of each subregional innovation system order parameter is $\mu_i^0(c_i), i = 1, 2, \dots, k$. In the evolution process of the regional innovation system, at a certain time t_1 , if the order degree of each subregional innovation system order parameter at time t_1 is $\mu_i^1(c_i), i = 1, 2, \dots, k$. Then, the overall synergy (W) of the composite regional innovation system in the $t_0 - t_1$ period is defined as:

$$W = \theta \sum_i^k \lambda_i [|\mu_i^1(c_i) - \mu_i^0(c_i)|] \quad (3)$$

Where $\theta = \frac{\min_i[\mu_i^1(c_i) - \mu_i^0(c_i) \neq 0]}{|\min_i[\mu_i^1(c_i) - \mu_i^0(c_i) \neq 0]|}, i = 1, 2, \dots, k \quad (4),$

$$\lambda_i \geq 0, \sum_{i=1}^k \lambda_i = 1, i = 1, 2, \dots, k$$

In this article, $\lambda_i = \frac{GDP_i}{\sum_{i=1}^{11} GDP_i}, i = 1, 2, \dots, 11.$

As an evaluation criterion to judge whether the system is in the process of collaborative development and the degree of collaboration, synergy w is shown in Table II.

IV. EMPIRICAL STUDY ON SYNERGETIC EFFECT OF INNOVATION SYSTEM IN GUANGDONG-HONG KONG-MACAO GREATER BAY AREA

The collaborative degree of innovation systems in the greater bay area is analyzed by using the collaborative degree measurement model of innovation systems in the above formula (3) and the indicator system in Table I. According to the development process of the innovation system in the Guangdong-Hong Kong-Macao greater bay area, the order parameters of the innovation system and its subsystems are determined, and the order degree of the subsystem and the overall synergy degree of the innovation system in the Guangdong-Hong Kong-Macao greater bay area are calculated by using the formulas of (2), (3) and (4).

TABLE III. ORDER PARAMETERS OF JIANGMEN INNOVATION SYSTEM (0-100)

Indicators	2012	2013	2014	2015	2016	2017
Knowledge creation C_{i1}	37.69	40.25	40.87	44.16	47.58	47.49
Knowledge acquisition C_{i2}	44.78	44.96	48.26	48.77	50.87	52.05
Knowledge application C_{i3}	40.32	41.66	44.88	47.02	48.32	52.67
Innovation environment C_{i4}	42.32	42.48	45.14	46.89	49.56	50.68
Innovation performance C_{i5}	43.98	45.42	46.63	49.51	51.09	51.66

TABLE IV. REGIONAL SUBSYSTEM ORDER

	2012	2013	2014	2015	2016	2017
Hong Kong	0.6289	0.6177	0.6109	0.6368	0.6473	0.6568
Macao	0.5205	0.5429	0.5356	0.5625	0.5633	0.5662
Guangzhou	0.5237	0.5115	0.5431	0.5696	0.5941	0.6262
Shenzhen	0.5023	0.5246	0.5455	0.5700	0.5933	0.6217
Zhuhai	0.4337	0.4812	0.4991	0.5338	0.5418	0.5776
Foshan	0.4573	0.4767	0.5002	0.5187	0.5363	0.5757
Huizhou	0.4235	0.4745	0.4653	0.4856	0.5135	0.5236
Dongguan	0.4592	0.4522	0.4955	0.5157	0.5335	0.5722
Zhongshan	0.4621	0.4811	0.4758	0.4938	0.5188	0.5535
Jiangmen	0.4384	0.4340	0.4542	0.4760	0.4952	0.5123
Zhaoqing	0.4331	0.4287	0.4586	0.4739	0.4959	0.5188

TABLE V. INNOVATION SYSTEM SYNERGY OF GUANGDONG-HONG KONG-MACAO GREATER BAY AREA IN 2015-2017

Year	Overall synergy
2015	0.25
2016	0.31
2017	0.58

Due to the limited space of this article, only the calculation results of the order parameters of Jiangmen Innovation System are shown here, as shown in Table III.

See Table IV and V for the subsystem order degree and the overall synergy degree of the innovation system in Guangdong-Hong Kong-Macao greater bay area. It can be seen from Table IV that the order degree of each urban subsystem in Guangdong-Hong Kong-Macao greater bay area is still above medium level. From 2012 to 2017, the order of the regional innovation system has gradually increased, but Hong Kong in 2013, In 2014 and Macao in a special state in 2014, the orderly decline, indicating that Guangdong-Hong Kong-Macao greater bay area as a whole in 2013, 2014 is in a state of non-cooperative development. During the three years from 2015 to 2017, Guangdong, Hong Kong and Macau Bay Area is in a state of coordinated development, so we chose the order of 2015-2017 to calculate the overall synergy of the innovation system in Guangdong, Hong Kong and Macau.

The degree of order in Jiangmen is relatively low, and the subsystem still faces great difficulties in the process from disorder to order. Although it shows a state of coordinated development, it still needs to focus on the power of the orderly process to improve the degree of order in the subsystem city.

From the results in Table V, it can be seen that the synergy degree of the innovation system in Guangdong-Hong Kong-Macao greater bay area has gradually increased from 2015 to 2017, but the overall synergy is still relatively low. According to the level of synergy of Table IV, the innovation system of Guangdong-Hong Kong-Macao greater bay area is still in a state of weak synergy at present, and there is still much room for improvement in the degree of synergy of the innovation system.

V. THE COUNTERMEASURE OF JIANGMEN'S DEVELOPMENT UNDER THE BACKGROUND OF GREATER BAY AREA

A. Actively Expand Opening Up

As an important member of Guangdong-Hong Kong-Macao greater bay area, Jiangmen is at an important juncture where Guangdong-Hong Kong-Macao greater bay area connects the east and the west. Jiangmen should seize opportunities, give full play to the resource advantages of overseas Chinese in Jiangmen and strengthen economic and trade cooperation with countries and regions along "The Belt and Road". It is necessary to build a national platform carrier "overseas Chinese dream garden" to attract the new generation of overseas Chinese to come back for entrepreneurship and innovation.

At present, centering on the general idea of "one hub, two centers and three roads", Jiangmen adheres to the principle of "industry first" and builds a "5+1" major industrial platform. Jiangmen should establish different industrial parks according to regional advantages. By integrating core park resources, Jiangmen should help the layout reconstruction of productivity, promote the overall coordination and interaction of economic and social development in the greater bay area.

The Guangdong-Hong Kong-Macao greater bay area has developed economy and unique port development conditions. It is one of the regional ports with the largest capacity and the best water depth in the world, and the regional port throughput ranks first among all bay areas in the world. According to the needs of national "The Belt and Road" initiative and the essential characteristics of bay area economy, Jiangmen must attach great importance to the development of port economy in the future. The port is one of the core resources of the greater bay area. If Jiangmen does not pay attention to the port, it will restrict the future development of Jiangmen in greater bay area. Jiangmen should learn from the development experience of the international greater bay area and the domestic advanced port resources integration experience, combined with the characteristics of the bay area ports, plan to build one or two excellent hub ports, and enhance the competitiveness and influence of Jiangmen in the economic development of Guangdong-Hong Kong-Macao greater bay area.

B. Build a Cultural Brand in Hometown of Overseas Chinese

2019 is the "year of public cultural undertakings construction". Jiangmen should dig deeper, protect and inherit the culture of overseas Chinese, accelerate the establishment of China (Jiangmen) Overseas Chinese Cultural and Ecological Protection Experimental Zone, and run the Chinese (Jiangmen) Overseas Chinese Carnival in 2019. It is also necessary to implement the overseas Chinese celebrity propaganda and promotion plan, the "Overseas Chinese Culture Roots" project, and continue to apply for the listing of historical sites on the maritime silk road. Polishing cultural cards such as Chen Baisha and Liang Qichao. Develop Xinxiangxian culture and promote the construction of cultural ancestral halls. Implement the Project of Promoting Literary and Art Excellence in Overseas Chinese Hometown and promote the transformation and development of the cultural industry.

C. Strengthen Cooperation and Synergy with Greater Bay Area Urban Agglomerations

Jiangmen should strengthen cooperation with the greater bay area urban agglomerations and actively introduce quality public services from Hong Kong and Macao. It is also necessary to optimize the industrial planning of Da Guang Hai -bay, accelerate the construction of Da Guang Hai -bay harbor industrial zone, and plan major energy projects such as Da Guang Hai -bay LNG receiving station. At the same time, Jiangmen should actively connect and extend the "Guangzhou-Shenzhen-Hong Kong and Macao" science and technology innovation corridor, make solid progress in the construction of advanced equipment manufacturing industrial belt on the west bank of the pearl river, plan to build a high-end industrial agglomeration development zone of Jiangmen-Zhuhai, and build a large bay area science and technology innovation achievements transformation base. And actively integrate into the cultural circle of the Guangdong-Hong Kong-Macao greater bay area to create a significant platform for overseas Chinese cultural exchange with international influence.

Macao and Jiangmen have a long history. Macao enjoys frequent international exchanges, world-class modern services and the advantage of flexible multilateral regional cooperation.

The Macao SAR government and the society have a huge pool of funds to lay a solid foundation for the development of science and technology entrepreneurship. Jiangmen is rich in land resources and has the advantage of continuous development. Jiangmen and Macao explore the inter-regional cooperation model of “enclave”, which can be used as a pilot for inter-city cooperation between Guangdong-Hong Kong-Macao Greater Bay Area, breaking the restrictions of the original administrative region and facilitating administrative licensing, market enforcement and resources. The use of precise docking in other fields provides reliable protection and convenience for the free and orderly flow of land, talents, funds and other elements.

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