



Coupling and Coordination Analysis of Incubator and Regional Economy

HUANG Shan^{[a],*}; HUANG Juxia^[b]

^[a]Department of Technology Economics and Management, School of Business and Administration, South China University of Technology, Guangzhou, China.

^[b]Guangzhou Futures Co., Ltd, Guangzhou, China.

*Corresponding author.

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Abstract

Incubators, as a policy tool to enhance regional innovation capabilities and revitalize the regional economy, are worthy of attention in terms of regional development. It is important to understand the coupling and coordination between them. Based on the theoretical analysis of the interaction mechanism between them, this paper introduces the comprehensive index system of subsystems and constructs a coupling coordination model to carry out the development level of incubators and regional economic in 31 provinces regions in China from 2008 to 2014. The research results show that the two systems are significantly related, and the level of coupling and coordination in whole regions is steadily rising. The spatial distribution pattern of the coupling coordination degree is “pyramid”. The synchronous development of the incubator and the regional economy is not realized in most areas. The government should consider improving the incubator efficiency and regional economic development strength in improving regional economic efficiency and regional innovation capability, so as to achieve coordinated and sustainable development of them.

Key words:Incubator; Regional economy; Coupled coordination analysis; Spatiotemporal evolution

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INTRODUCTION

In the 1950s, in order to reduce the entrepreneurial risk of small and medium-sized enterprises, especially high-tech enterprises, and to improve the survival rate of innovative and entrepreneurial enterprises, the world's first technology business incubator was born in the United States. Since then, the technology business incubator has been widely recognized and widely promoted and applied worldwide as a universal tool to promote technological innovation and entrepreneurship. The technology business incubator has experienced 30 years of development in China, and it has made great contributions to enhancing regional innovation capability and revitalizing regional economic development. More and more countries and regions regard it as a regional economic transformation and upgrading and then looking for an important starting point for the economic development of new growth points, and has devoted more resources to the creation and development of incubators. Although Chinese technology business incubators have formed a nationwide and regional incubator network, due to the unbalanced allocation of innovation factors and resource endowments, Chinese incubators and regional economies are still prominent unbalanced development in 31 provinces regions across the country.

In recent years, most of the literature has focused on the emerging economies of technology business incubators themselves. Smilor (1987) divided the incubators into four types: commercial innovation incubators, university incubators, independent private incubators, and company owned incubators, depending on the source of investment in the incubator; Siegel et al. (2003) used the regression model of negative binomial regression and two-step binomial regression to evaluate the Incubation performance under the premise of setting the incubator as a dummy variable; Li (2003) evaluated the Incubation performance based on the internal effectiveness of the incubator, the ability of the incubator resources integration

and the quantitative analysis of the internal and external environment.

Most of the above documents are considered from the microcosmic level of the incubator, and some literatures have qualitatively studied the function and location of the incubator from the macro perspective of the regional economy. Rothschild (2005) validated the function and role of the Israeli incubator based on interviews; Zhang (2005) believe that the core of the functions of the technology business incubator is to cultivate regional innovation ability. Zhang (2010) discussed the important position of the incubator in the construction of regional innovation capability system from the perspective of incubator as an intermediary service platform and innovation agglomeration space.

The above studies validate the role of incubators in promoting regional economies, and little literatures used statistical methods such as regression analysis and correlation analysis to verify the correlation or causal relationship between the incubator and the regional economic. Xu (2010) discusses and deduces the mechanism of the incubator to promote regional economic development based on statistical data of relevant indicators in the incubator time series; Zhu (2014) evaluated the performance of incubators in different regions based on the SFA method and verified its impact on regional economic convergence; These studies do not reveal the complex interactions between incubators and regional economies.

Coupling originates from physics and is a phenomenon in which two or more systems interact with each other through various interactions (Li,Zhou,2012) . This interaction between the various parts of each system is very complex and dynamic changes over time. As one of the methods for measuring interaction effects, coupling is now widely used in economic management research (ZiTang,2015) .A large number of scholars have studied the coupling and coordination relationship between technology investment (Zeng & Liu, 2013), technological innovation (Liu & Wang, 2015), industrial upgrading (Mu & Liu, 2018), R&D (Wu, 2016) and regional economy. Incubator as the important carriers of technological innovation, technology investment and industrial upgrading have become an important starting point for promoting regional economic growth. These studies reveal a coupling interaction between the incubator and the regional economy. Understanding the coupling relationship between the incubator and the regional economy has an important influence in the field of innovation and entrepreneurship. At present, there is no suitable index system for measuring the coupling relationship between them. For a more in-depth and accurate understanding of the relationship between them, this study builds a comprehensive indicator system between the incubator and the regional economy, adopted in 2008-2014Panel data of 31 provinces regions in China,

using the coupling coordination model to evaluate the degree of coupling and coordination between the two subsystems. This study contributes to: (a) clarifying the interaction logic between the incubator and the regional economy; (b)the changing trend between the national incubator and the regional economic; (c)providing a reference for macroeconomic decision-making by government departments.

1. COUPLING COORDINATION MECHANISM

As shown in Figure 1, the incubator promotes regional economic development based on economies of scale and external economy. The regional economy affects the development of incubators as a provider of development conditions and space carriers. The interaction between the incubator and the regional economy is mainly achieved through the promotion mechanism of the incubator to the regional economic development and the pulling mechanism of the regional economy on the development of the incubator.

1.1. The Mechanism of the Incubator to Promote Regional Economic Development

According to Jacobs' externality theory, the technology enterprise incubator creates a competitive and complementary externality in incubator cluster or the cluster of incubating enterprise created in the region, which is conducive to the growth of the incubating enterprises and the simultaneous development of neighboring enterprises or incubators, thus promote regional technological innovation, industrial upgrading and economic development; According to the core-periphery theory, the incubator acts as a core area for all kinds of essential entrepreneurial elements, such as agglomeration of talents, technology, knowledge and capital, to drive the peripheral areas and form a radiation effect on the development of the regional economy.

The incubator is mainly based on the interaction mechanism of the aggregation and diffusion of innovation elements, promotes regional economic development through economies of scale and external economic effects, and injects new vitality and sustainable development innovation power into regional economic development. From the perspective of economies of scale, incubators can promote regional economic growth by cultivating innovative enterprises, nurturing or gathering entrepreneurs, absorbing employment, and generating fiscal revenues; From the perspective of external economic effects, the incubator can achieve a significant improvement in the regional economy through the formation of regional innovation and entrepreneurship environment, opening and optimizing industrial structure, forming an innovation network, and aggregating Venture capital(shown in Figure 1).

1.2. The Pulling Mechanism of Regional Economy on the Development of Incubators

According to the regional development theory, the regional economy is the condition and environmental basis for the survival and development of the incubators in the region. The funding problem penetrates the whole process of the development of the incubator, and the economically developed regions can provide a complete Venture resource support for the incubator construction, helping the incubator to start Innovation and entrepreneurship services. According to the regional innovation theory, the Cobb-Douglas production function shows that technological innovation can promote economic growth, and as an incubator serving the regional economy will provide relevant technical support for its development.

The incubator itself is a regional concept. It has a certain endogenous relationship with the corresponding

regional cities. It will have an impact on the economic development level of the regional cities, and the regional economy as a provider of development conditions and space carriers will drive the development of incubators (Zhu, 2014). Regional resource endowment determines the ability of technology business incubators to provide the underlying conditions for innovation and entrepreneurship in incubating enterprises. According to the regional production factor advantage theory, enterprises in the region improve production efficiency by virtue of the advantages or differences in regional production factors. This study believes that the regional economy mainly affects the development of the technology business incubator through the impact of the environmental foundation, talent resources and innovation and entrepreneurship culture on which the technology business incubator depends (shown in Figure 1).

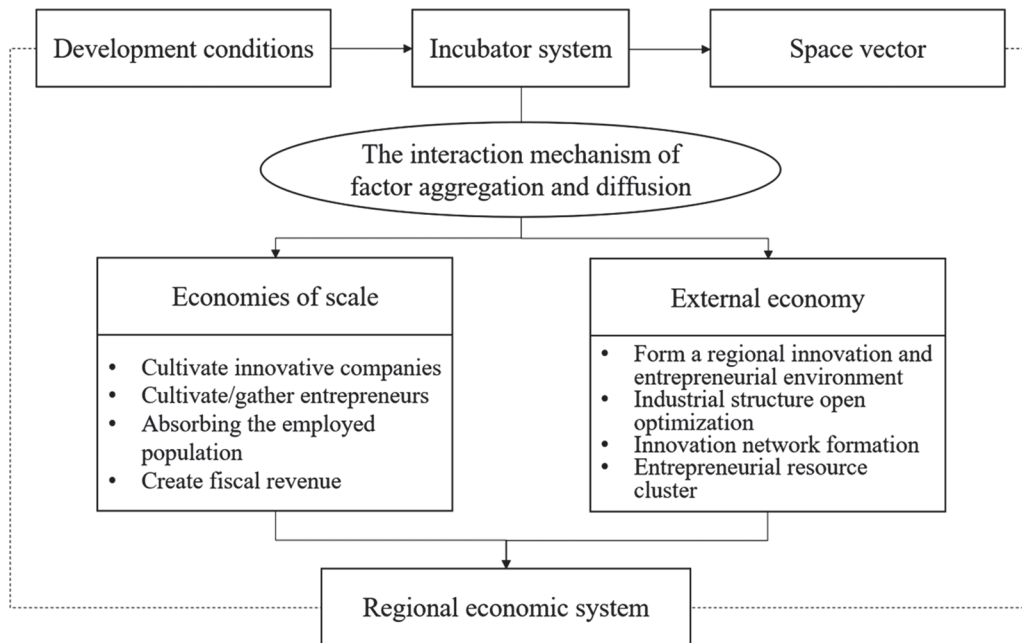


Figure 1
The Interaction Mechanism Between Incubator and Regional Economy

2. METHOD AND DATA

2.1. Index System Construction

This paper constructs a comprehensive evaluation index system of incubator system from the perspective of incubator's behavior and ability. From the perspective of incubator behavior, in order to achieve the measurement of the indicators of the incubator in terms of resource integration or distribution, it should pay attention to the performance evaluation of the behavior process, including the basic hardware conditions of the incubator and the soft power of providing services. From the perspective of incubator capabilities, the key to assessing the incubator's performance is to evaluate the results of the direct or

indirect benefits of the incubator to the enterprise or society, including incubation efficiency and social contribution.

This paper intends to construct a regional economic system evaluation index system from the perspective of economic benefit and social benefit. The comprehensive index of economic development is a direct response to the status quo and growth of regional economic development, which is embodied in the economic foundation and economic structure of the regional economic status quo. The comprehensive index of social benefits is a description of regional culture, science and technology and other environmental aspects, reflecting the input or output effects in the fields of education, technological innovation and entrepreneurship in the process of regional

economic development (shown in Table 1).

2.2. Data Source and Data Processing

According to the China Torch Center Statistical Yearbook, Since the statistical caliber of national incubators from 2008 to 2014 is different from the statistical caliber in 2015, this paper mainly selects national incubator data from 31 provinces regions in 2008-2014. besides, according to the China Statistical Yearbook and the regional Statistical Yearbook, data on economic development of 31 provinces regions in China from 2008 to 2014 were obtained. For some missing data that cannot be queried, this paper uses the trend extrapolation method to assignment. In order to eliminate the effects of dimension and magnitude, the raw data needs to be normalized using formula (1) and (2).

When X_{ij} is a positive indicator:

$$G_{ij} = \frac{(X_{ij} - X_{ijmin})}{(X_{ijmax} - X_{ijmin})} * 0.99 + 0.01, i=1,2; j=1,2, \dots n \quad (1)$$

When X_{ij} is a negative indicator:

$$G_{ij} = \frac{(X_{ijmax} - X_{ij})}{(X_{ijmax} - X_{ijmin})} * 0.99 + 0.01, i=1,2; j=1,2, \dots n \quad (2)$$

Where, X_{ij} represents the i-th sample original value of the j-th index; X_{ijmax} and X_{ijmin} are respectively the corresponding maximum and minimum values of the j-item evaluation index values in the system i.

2.3. Comprehensive Assessment of Incubators and Regional Economies

The comprehensive evaluation value of the development level of the incubator system and the regional economic system:

$$U_i = \sum_{j=1}^p W_{ij} \times G_{ij}, W_{ij} \geq 0, \sum_{j=1}^p W_{ij} = 1, j=1,2, \dots n, i=1,2 \quad (3)$$

where, U_1 represents the comprehensive evaluation value of the development level of the regional economic system, U_2 represents the comprehensive evaluation value of the development level of the incubator system, p represents the number of indicators in each system, G_{ij} is the data after standardization processing, and W_{ij} represents the index j in the subsystem i Corresponding weight.

The information entropy method determines the index weight by analyzing the correlation and information between the indicators. In this study, using the information entropy method to give weights will avoid the deviation caused by subjective influence to some extent.

The steps are as follows (Li et al., 2012):

First, the index weight change: $P_{ij} = \frac{G_{ij}}{\sum_{i=1}^n G_{ij}}$, (4)

Second, calculate the entropy of index j :

$$h_j = -\frac{1}{\ln n} \sum_{i=1}^n P_{ij} \ln P_{ij} (0 \leq h_j \leq 1) \quad (5)$$

Third, calculate the coefficient of variation of the j th indicator: $\varepsilon_j = 1 - h_j$ (6)

Finally, define the weights of the j indicators:

$$W_j = \frac{\varepsilon_j}{\sum_{j=1}^p \varepsilon_j} \quad (7)$$

Where, n and p represent the number of years and the number of corresponding indicators respectively.

Table 1
Incubator and Regional Economic Indicator System and Indicator Weight

Subsystem	Primary indicator	Secondary indicators	Weights	
Incubator subsystem U_1	Basic hardware condition	X_1 Incubation scale / square meter	0.065	
		X_2 Public technology service platform investment / thousand yuan	0.115	
		X_3 Incubation fund preparation scale / thousand yuan	0.115	
	Soft power to provide services	X_4 High quality management personnel /%	0.01	
		X_5 Entrepreneurship instructor state / person	0.065	
		X_6 Incubator total income / thousand yuan	0.08	
		X_7 Incubator service income / thousand yuan	0.08	
	Incubation efficiency	X_8 Number of companies in the incubator/ Number	0.065	
		X_9 Graduation rate in incubating companies /%	0.025	
		X_{10} Accumulated investment in the incubating enterprise / thousand yuan	0.115	
		X_{11} Undertake national science and technology plan projects/ Number	0.045	
		X_{12} Incubator absorbs employment / person	0.065	
		Social Contributions	X_{13} Number of intellectual property owned by the incubator/ Number	0.075
			X_{14} Number of graduated companies/ Number	0.08
Regional economic subsystem U_2	Comprehensive level of economic development	Y_1 Per capita GDP / yuan	0.045	
		Y_2 Per capita consumption level / yuan	0.039	

Subsystem	Primary indicator	Secondary indicators	Weights
		Y ₃ Local per capita fiscal revenue / yuan	0.079
		Y ₄ Per capita import and export trade / US dollar	0.142
		Y ₅ Per capita fixed assets investment / yuan	0.045
		Y ₆ Tertiary industry as a percentage of GDP /%	0.054
		Y ₇ The first and second industries accounted for the proportion of GDP /%	0.054
		Y ₈ Foreign direct investment amount / 100 million yuan	0.083
	Social benefit	Y ₉ Number of employed people at the end of the year/ten thousand person	0.035
		Y ₁₀ Number of college students per 100,000 population/person	0.033
		Y ₁₁ Per capita education expenditure and financial expenditure / yuan	0.055
		Y ₁₂ R&D expenditure / ten thousand yuan	0.084
		Y ₁₃ Number of business units / Number	0.057
		Y ₁₄ Number of intellectual property licenses/pieces	0.112
		Y ₁₅ Number of people engaged in scientific and technological activities/person	0.083

2.4. Constructing a Coupled Coordination Model

$$C = \sqrt{(U_1 \times U_2) / \Pi(U_1 + U_2)^2} \tag{8}$$

$$\begin{cases} D = \sqrt{C \times T} \\ T = \alpha U_1 + \beta U_2 \end{cases} \tag{9}$$

C represents the degree of coupling between the incubator and the regional economic, while U1 and U2 are the comprehensive evaluation values of the development level of the incubator system and the regional economic ,respectively; D is the coupling coordination degree between the incubator and the regional economic. It is a description of the coordination status and development

level between them. T is the comprehensive coordination index of the incubator and the regional economic. This study considers, in their interactive and coordinated development mechanism, the regional economy is in a more prominent position than the incubator . In this paper, the weights of the α and β coefficients are determined to be 0.42 and 0.58, respectively.

The coupling degree (Table 2) of the incubator and the regional economy is divided into three grades and ten categories based on the uniform distribution function method commonly used by scholars.

Table 2
Classification Criteria for the Coupling Degree of Incubator and Regional Economy

sequence	Coupling coordination interval	Coordination level	Types
1	[0.0, 0.1)	Extreme imbalance	dysfunctional decline
2	[0.1, 0.2)	Serious disorder	
3	[0.2, 0.3)	Moderate imbalance	
4	[0.3, 0.4)	Mild disorder	
5	[0.4, 0.5)	On the verge of imbalance	tempered transition
6	[0.5, 0.6)	Reluctant coordination	
7	[0.6, 0.7)	Primary coordination	coordinated upgrade
8	[0.7, 0.8)	Intermediate coordination	
9	[0.8, 0.9)	Good coordination	
10	[0.9, 1.0]	Quality coordination	

3. RESULT

3.1 The Comprehensive Development Level of Incubators and Regional Economy

Based on the comprehensive evaluation value of the incubator development level and the regional economic development level of 31 provinces regions in China from 2008 to 2014,a comprehensive evaluation of the national incubator and the regional economic by means of the mean method. Then, with SPSS software, the evolution trend of the development level of the incubator subsystem and the regional economic subsystem is drawn.

The development level of the incubator subsystem shows (Figure 2), the overall development level of the incubator maintains a steady upward trend, but there are two obvious inflection points in the development process: due to the 2008 financial crisis, the comprehensive evaluation value of the development level of Chinese technology business incubators emerge a slight decline; due to the promulgation of the “Eleventh Five-Year Plan” in 2010, a series of favorable policies have promoted the development of Chinese technology business incubators. With the continuous growth of local financial science and technology investment, and the encouragement of policy

support for “popular innovation, entrepreneurship for all”, these factors have contributed to the steady and rising

trend of the development of China’s technology business incubators after 2010.

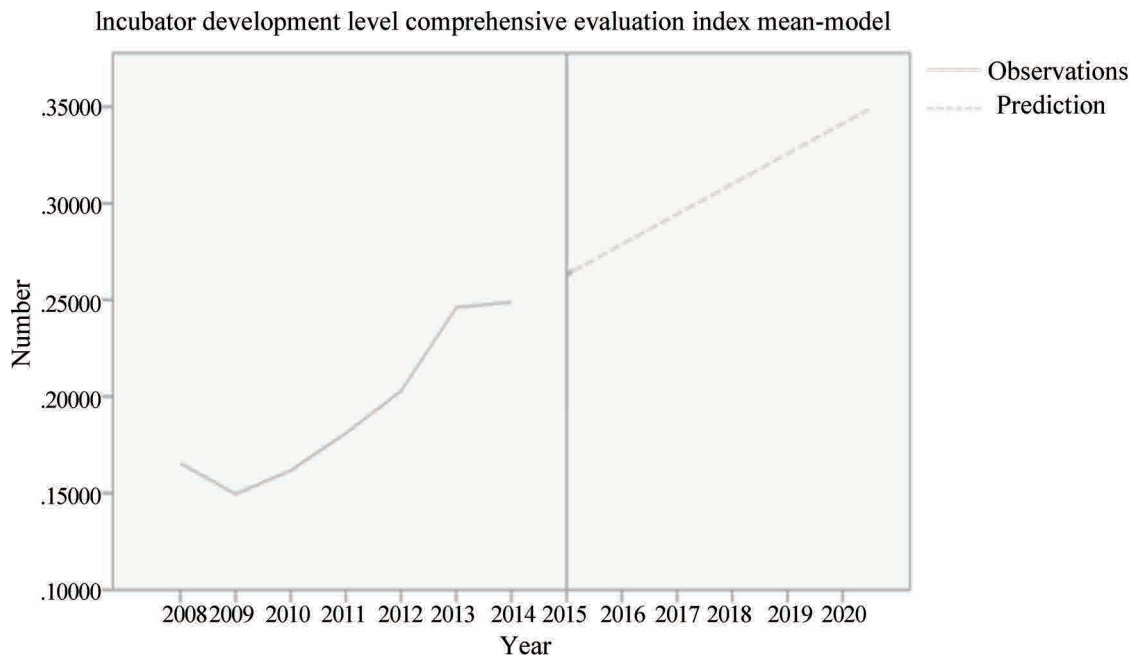


Figure 2
The Average Development Level of Incubator Subsystem

The regional economic subsystem shows (Figure 3), From 2008 to 2014, the comprehensive evaluation index of the national regional economic development level showed an increasing trend, with an average annual growth rate of 2.102%. In the next few years China’s economic development level will continue to develop with a stable and healthy growth rate. The development status is relatively stable. the development level of regional

economic is growing, the annual growth rate is slightly fluctuating, the development is stable, and the regional economy will maintain a stable and good development trend in the future. China’s economic development level is constantly growing, and although the annual growth rate is slightly mobile, it does not affect the trend of the country’s economic development level to a higher level.

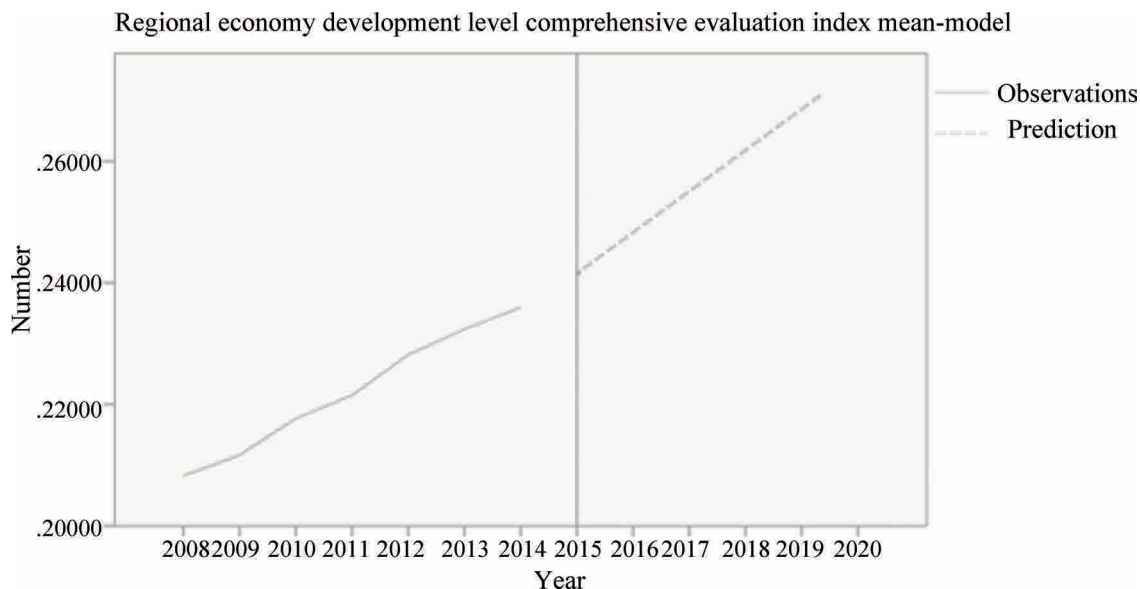


Figure 3
The Average Development Level of Regional Economic Subsystems.

3.2 Coupling Coordination Level of Incubator and Regional Economy

3.2.1 Timing Characteristics

As shown in Figure 4, from 2008 to 2010, the development of the national incubator subsystem lags behind the regional economic subsystem; from 2011 to 2014, the development of the national incubator subsystem is synchronized with the regional economic subsystem. It can be seen that the gap between the national incubator subsystem and the regional economic subsystem is gradually narrowing, reflecting that the entire

large system has undergone a transition from disorder to order, and the benign interactive resonance is gradually realized between the systems. In addition, from 2008 to 2014, the coupling degree of the entire large system is in a high level coupling stage. Due to the fluctuation of the incubator subsystem, the coupling coordination degree between the incubator and the regional economy is slowly increasing. The overall average level of the national incubator and regional economic coupling degree and coupling coordination degree is growing steadily and slowly, and the whole system is in a stable coupling and coordinated development.

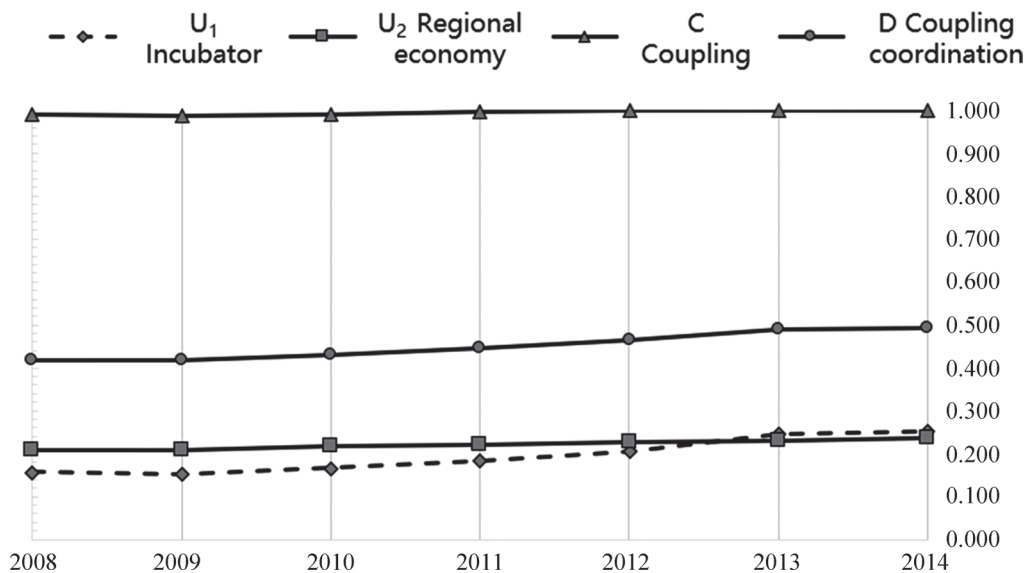


Figure 4
The Average Coupling Coordination Degree of National Incubator and Regional Economy

3.2.2 Spatial Distribution

There is a widespread imbalance between incubators and regional economies in various regions of China. There are significant differences in the development stages of the 31 regions incubators and regional economic systems. The coupling and coordination level of incubators and regional economic systems in various regions of China is pyramidal. In general, the level of system coupling coordination in each region is slowly increasing, but small proportion of corresponding system coupling coordination types is significantly increased.

The national coupling coordination degree is divided into three types: dysfunctional decline, tempered transition, coordinated upgrade. Spatial Geographical Distribution Pattern of Coupling and Coordination Level of China's Technology Business Incubator and Regional Economy as follows:

(a) dysfunctional decline: That is, the degree of coupling and coordination between the incubator and the regional economy is in an unbalanced development state.

As shown in Figure 5, These areas are mainly in the far west and northeastern regions and Yunnan, Guangxi,

Jiangxi, Anhui, Hainan, Chongqing and other places, the coupling coordination degree is below 0.3, the interaction between the incubator and the regional economy is small, and the development stages of the two systems is characterized by the simultaneous development or incubator lag, for these areas with relatively poor economic development, the regional economy has limited ability to drive the incubator.

(b) tempered transition: That is, the degree of coupling and coordination between the incubator and the regional economy has achieved leap-forward growth, and the whole system has reached a transitional period of balanced development and unbalanced development.

As shown in Figure 5, These areas are mainly in the central region and Fujian, Liaoning and other places, the coupling coordination degree is between 0.4 and 0.6, while the development stages of the two systems are mostly characterized by synchronous development or regional economic lag, and the incubator relies on the location advantage of population concentration and convenient transportation, the atmosphere of innovation and entrepreneurship is high, but it has not completely

released the external effects that drive regional economic development.

(3) coordinated upgrade: That is, the degree of coupling and coordination between the incubator and the regional economy reaches a stable state of balanced development.

As shown in Figure 5, These areas are mainly coastal areas (Guangdong, Zhejiang, Jiangsu, Shandong) and the capital Beijing, etc. the coupling coordination degree

is mostly between 0.7-0.8 (Jiangsu province coupling coordination degree is 0.8-0.9), the interaction between incubator and regional economy is great. Among them, Beijing and Guangdong are in the lagging stage of the incubator, while Zhejiang, Jiangsu and Shandong are in the lagging stage of regional economy; these highly coupled and coordinated development areas have not realized the simultaneous development of the them.

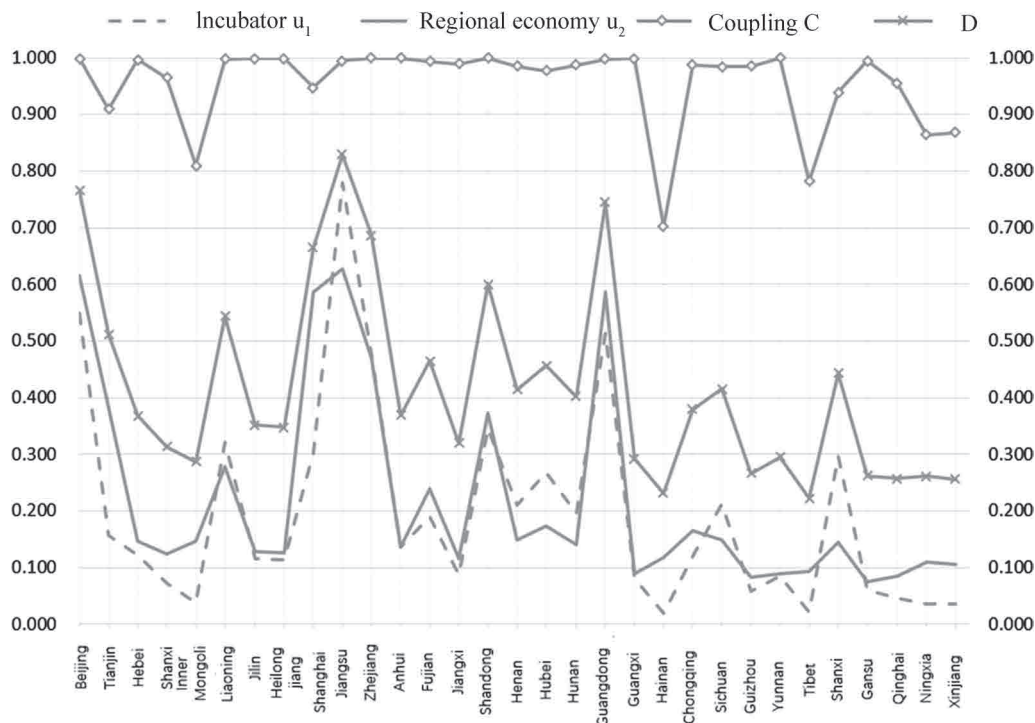


Figure 5 The Coupling Coordination Development Average of National Incubators and Regional Economic Systems

CONCLUSION AND DISCUSSION

Based on the interaction mechanism between incubator and regional economy, the index evaluation system of two major systems is introduced to form a method of coupling coordination model and entropy method. The coupling and coordination of incubators and regional economies in 31 provinces, municipalities and autonomous regions in China from 2008 to 2014 are carried out. Analyze the interaction between incubators and regional economic development. Research indicates:

First of all, at the macro level, the development level of Chinese incubator and regional economic shows a trend of continuous growth. The two systems have synergistic effects of mutual promotion and interaction, and also conform to the interaction mechanism between the incubator system and the regional economic system; Secondly, the overall average level of coupling degree and coupling coordination degree between the national incubator and the regional economy showed a steady and slow growth trend. The whole system was lagging

from the development of the incubator in 2008-2011, and gradually developed to the synchronization of the two systems in 2012-2014. During the development phase, the entire system is in a stable state of coupling and coordinated development.

Then, at the regional level, the “pyramid” phenomenon of the spatial distribution pattern of the coordination degree between the incubator and the regional economic system in China is distinct, showing the distribution characteristics of “high east and low west”, and the areas with high coupling coordination degree show a higher level of economic development. In the eastern coastal areas, the spatial agglomeration state is distinguished; In addition, the coupling coordination degree of the incubator and the regional economy has shown a steady upward trend, but there are significant differences in various regions. In most areas, the incubator and the regional economy have not achieved simultaneous development, except for the systematic coordination of Jiangsu, Beijing, Zhejiang and Guangdong. Leading, system coordination in most other regions has not achieved a qualitative leap.

Among them, Jiangsu, as the leader of the development level of incubators, the development level of regional economic and the coupling and coordination level of the two systems, has never been surpassed in its position. Its experience in incubator construction and regional economic development is worth learning by other regions.

With the rapid development of incubators, its role in enhancing regional economic development is increasingly significant, and the interaction between incubation efficiency and economic development level is the key factor to achieve simultaneous and sustainable development between regional economy and incubator. When formulating relevant policies to support the development of incubators, local governments should pay more attention to the impact of incubation efficiency. When improving the survival rate of incubating enterprises, local governments should pay more attention to the effective use of incubators for social limited resources, thereby enhancing regional innovation capability and regional economic benefits, the healthy and coordinated development of the incubator and the regional economy will be realized.

The results of this paper are objective and reliable, and help to understand the interactive relationship between incubators and regional economic. According to the innovation-driven development strategy proposed in the "13th Five-Year" Plan and the basic connotation of transforming the economic development mode, the relationship between the incubator and the regional economy should be adjusted: (a) Taking advantage of the positive effects of government system and policy support, the construction of Chinese incubator innovation system is guided by regional characteristic economy, avoiding the spread and deepening of the Matthew effect of "strong and strong, weak and weak" among different regions; (b) Enhance the interactive participation of the "government-market-society" multi-agents in the "incubator innovation system-regional economic system" construction process by stimulating the operational mechanism compatible with competition, and enhance the incubation efficiency of the incubator and the development benefits of the regional economy; (c) Improve the imbalance of regional economic development, unreasonable layout, resource resetting or waste etc. of incubators, guide regional role positioning, exert resource advantages, form complementary advantages, and achieve coordinated development in the eastern, western and central regions.

This paper does not identify the factors that affect the level of coupling and coordination between the two systems. It is necessary for relevant government departments and policy makers to pay more attention to detecting the coupling factors affecting the coupling degree between the incubator and the regional economy, and to understand the coupling factor between the incubator and the regional economy. In further research in the future, a system dynamics model can be introduced

to develop dynamic simulations of the incubator and the regional economic system, and then to identify the impact factors in the interaction between the two systems.

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