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Can Higher Education, Economic Growth and Innovation Ability Improve Each Other?

Haiying Xu [1], Wei-Ling Hsu [1,*], Teen-Hang Meen [2] and Ju Hua Zhu [3]

1 School of Urban and Environmental Science, Huaiyin Normal University, Huai'an 223300, China; sqxhy@126.com
2 Department of Electronic Engineering, National Formosa University, Yunlin 632, Taiwan; thmeen@nfu.edu.tw
3 Department of Civil, Environmental and Architectural Engineering, Korea University, Seoul 02841, Korea; khjoo1214@gmail.com
* Correspondence: quartback@hotmail.com

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Abstract: This study argues that the coupling between higher education, economic growth, and innovation ability is of great significance for regional sustainable development. Through the experience of Jiangsu Province in China, this study establishes a coupling coordination evaluation index system and applies the coupling coordination model to evaluate interactive relationships among the three. It finds that during 2007–2017, the level of coupling of 13 prefecture-level cities in Jiangsu was increasing over time, which fully verified the previous scholars' view that the three can improve each other over a long period. However, this study finds that there are obvious differences within Jiangsu. Inadequate investment in higher education has become a crucial constraint on sustainable economic growth in northern and central Jiangsu, which are backward regions of Jiangsu. By contrast, in southern Jiangsu, which is the advanced region of Jiangsu, although the resources of higher education are abundant the growth of innovation ability cannot support sustained economic growth well. Thus, the quality of higher education should be improved to meet the needs of the innovation-based economy. Accordingly, cross-regional cooperation and balanced investment in higher education are the keys to practicing a balanced and sustained regional development. The results of this study's coupling coordination analysis and evaluation can serve as a reference for governments in enhancing regional sustainable development.

Keywords: higher education; innovation ability; economic growth; coupling coordination; Jiangsu province

1. Introduction

Since the emergence of the knowledge economy in the 1990s, knowledge has become a crucial resource for regional development. Innovation through accumulating knowledge has been a critical factor in sustainable regional development. Since 2000, human development is facing more serious problems, including resource problems, environmental problems, and ecological problems, which have led to global thinking about sustainable economic growth models. Whether education development can meet the ever-changing needs has become an important topic of common concern in many fields. The 2015 United Nations Sustainable Development Summit passed the 2030 Agenda for Sustainable Development [1]. The aim of Goal 4 is to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. This indicates the urgency of incorporating sustainable development education at all levels [2].

In this era of globalization, governments worldwide focus on sustainable development education, which is likely to result in sustainable economic development. Many countries employ the service economy concept to stimulate economic growth. Furthermore, education is a form of investment in human resources. Higher education increases a nation's gross national income [3]. Regions and organizations accentuate competitiveness in higher education because it enhances welfare and economic performance [4,5]. Organizations, cities, regions, and countries apply different approaches to manage and incorporate intellectual capital; however, the choice of approach is the decisive factor for success [6]. A substantive body of literature indicates that the global movement toward a highly qualified workforce can be a powerful boost, enhancing knowledge transfer, international cooperation, and innovation [7,8]. This influences the reputation, competitiveness, and wealth of countries and encourages them to pay attention to quality of life and contributions to a sustainable and balanced society [9].

Therefore, in the past 20 years, the enrollment scale of universities has been expanding, especially in developing countries. However, empirical research has found that the development of higher education does not necessarily bring about innovation, thus bringing about positive effects on economic growth. The relationships between these three indices are complex. Therefore, the coordinated development among higher education, economic growth, and innovation ability critically determines whether sustainable development in a region is possible.

The sustainability of China's economic miracle is in question. As is possible for some developing nations, China stands at a critical juncture between its catch-up phase that relies on technological adaptation and the phase that springs from its capacity for knowledge generation and technological innovation [10]. Currently, China's economic development is undergoing a critical period of reform, and the economy is driven by innovation instead of conventional input and investment. Regional innovation has become a crucial driving force of regional economic growth. Improved innovation relies on developing higher education and requires the support of materials provided by economic growth. Accordingly, economic growth, higher education, and innovation ability are interdependent, and the relationships among these indices have been studied by Chinese researchers.

Jiangsu, a major economic province of China, relies heavily on exports for economic development. With the recent decline in global trade, uncertainty in the external environment of the export-oriented economy of Jiangsu has increased, which inhibits its sustainable development. Therefore, during the 13th Five-Year Plan for the National Economic and Social Development of China, the Jiangsu government decided to implement strategies facilitating innovation and technological and human resource advancement to stimulate sustainable and efficient development through innovation. This study investigates whether interactions between higher education, economic development, and technological innovation were facilitated in Jiangsu, and examines the factors inhibiting sustainable development in the province. In addition, there is a very obvious difference in the level of economic development within this region. Is there any difference in the interactive relationships among the three? Which key factors restrict the sustainable development of this region? These are all the problems that need to be solved in this paper.

The purpose of this paper is to examine the relationships among higher education, economic growth, and the innovation ability in the region. The concepts of coupling and coordination applied in this paper emphasize interactive and dynamic relationships among the three. Meanwhile, this study focuses on significant differences within the research region, aiming to find the factors that restrict the sustainable development of different regions.

To achieve this goal, this paper establishes a coupling coordination evaluation index system, applies the capacitive coupling coefficient model to present a dynamic relation of interdependence and coordinative development under the interaction between the subsystems, and subsequently employs a physics-based capacitive coupling coefficient model to verify the validity of three subsystems, namely higher education, innovation ability, and regional economy. The present study selected Jiangsu—an indicative, economically developed region of China—as the empirical research area. This selection is made so as to provide beneficial advice for solving the problem of sustainable development in Jiangsu. This study also has significant implications for all developed provinces in Eastern China. The data in this paper are collected from official statistical reports and statistics yearbooks.

The remainder of this paper is organized into four sections. Section 2 presents the theoretical background; Section 3 details the study materials and methods; Section 4 discusses the coupling coordination between economic growth, higher education, and innovation ability in Jiangsu's 13 prefecture-level municipalities; and Section 5 provides conclusions, suggestions for future research, and regional development countermeasures from the coupling coordination analysis. The results of the coupling coordination analysis and evaluation of this study can provide a reference for governments to enhance regional economies.

2. Theoretical Backgrounds

Nowadays, the world is facing more serious environmental, resource, and ecological problems, and human beings have a deeper understanding of economic development. The sustainability of a regional economy refers to the ability of this region to grow continuously by fostering a proper limit of population and economic activities without exhausting resources or degrading the environment [11]. Therefore, the indicators of sustained regional economic growth include economic scale, industrial upgrading, and welfare improvement. For a long time, scholars from various countries have been paying attention to the motive force of sustained regional economic growth. In a knowledge economy, innovation is vital for regional socioeconomic development [12–24]. According to the innovation theory proposed by Harvard University professor Joseph Alois Schumpeter [25], innovation ability and regional economic development promote and restrain each other.

In the era of the knowledge-based economy, most countries have continuously increased investment in research and development funds to maintain rapid economic growth. In early research, scholars found that areas with sustained economic growth in the United States often have continuous investment in research and development activities [26]. In China, State-level High-tech Industry Development Zones (SHIDZ) are a critical driver of economic growth. Every year, the Chinese government invests a large amount of R&D funds in SHIDZ. From actual observations, continuous government investment in R&D funds can enhance the innovation ability of enterprises in science parks and have a positive impact on regional industrial upgrading [27,28]. Coad et al., have constructed a large number of models to demonstrate the important role of innovation investment in regional sustainable economic growth, corporate competitiveness, and industrial upgrading [29]. Although there is a positive relationship between innovation and sustained economic growth, actual observations show that there is no direct relationship between innovation input and sustained economic growth, and innovation output is more directly related to economic growth. For example, with the same innovation investment, the results of economic growth may be different in different regions. The actual impact of innovation input also depends on the absorptive capacity of different regions for innovation [30]. According to Xiong (2020), the relationships between innovation and economic grown are complex, and social filters play important role in innovation and economic growth in different regions [31]. Some researchers have conducted empirical research based on regional innovation theory. For example, one researcher examined the coupling coordination of innovation ability and economic growth in the Yangtze River Economic Belt and its upstream provinces. The results revealed a strong connection between the region's innovation ability and economic growth. In most provinces within the Yangtze River Economic Belt, the two indicators were more than marginally coordinated, whereas those in the four upstream provinces exhibited imbalanced development, with two provinces being highly coordinated and the remaining two being slightly coordinated [32,33]. Therefore, this paper contributes to analyze the relationship between innovation and economic growth from the spatial and temporal perspective in order to gain policy implications for different regions. We selected economic scale, economic structure, and quality of the economy as indicators of an economic growth system, and chose innovation input and output as indicators of innovation ability.

In terms of the relationship between higher education and innovation ability, researchers generally consider the two indicators to be related. Higher education provides the two core elements required for reformation: talent and innovation [22,23]. Human capital formation is a fundamental element of economic growth and innovation [13]. Higher education has undertaken the tasks of personnel training and scientific research. Therefore, universities and research centers are a source of innovation information and important providers of innovative talents. In addition, the development of innovative economy has put forward new requirements for talent training. Rusyf Balci (2019), after analyzing the innovation-based development in Turkey, has proposed that the talent training of universities must meet the development requirements of innovation [34]. These institutions must change from rote teaching methods to analytical learning. It is generally believed that there is a positive relationship between the development of higher education and innovation capacity, so almost all countries attach great importance to the development of higher education. But can higher education definitely improve the efficiency of corporate innovation? Kim (2019) studied the innovation efficiency of the Korean logistics industry, and reached a very interesting conclusion: universities and research institutions are not the most critical factor in improving the innovation efficiency of enterprises [35]. However, if it is completely separated from the innovation information of universities and research institutions, the innovation efficiency of enterprises will also decline. It can be seen that the concept of taking the enterprise as the subject of innovation cannot be ignored.

How should higher education be developed to meet the needs of innovative economic growth? According to Urbano (2014), higher education plays a great value role in creating synergies between actors of the innovation ecosystem that strengthen social and economic growth [14]. To achieve economic growth, interactions between participants in the innovation ecosystem are necessary. Factors affecting the establishment of new enterprises include received messages, human resource training by universities and research institutions, funds, markets, clients, and business opportunities relative to clients and suppliers [16]. Through such interactions, an education plan concerning entrepreneurship and the cultivation of creative and innovative professionals supported by research institutes such as universities provide the opportunity to generate knowledge and an economic network [17]. In addition, knowledge transfer between academia and industry is a major driver of innovation and economic growth because it encourages the commercialization of new scientific knowledge within an enterprise [10,12–18,27,28,36]. Bloedon and Stokes defined the concept of knowledge transfer as a procedure through which the production or knowledge of a useful item within an organizational environment becomes applicable in another organizational environment [19]. Knowledge generation and transfer abilities in academia are crucial factors; in particular, higher education and public research institutes are considered sources of proven science and knowledge [20]. Kruss (2015) also particularly emphasized that universities and research institutions should improve their ability to interact with other participants as a talent supply and engage in research and development activities [37]. It requires a clearer strategy, structures, and mechanism for communicating with firms, sectoral intermediaries, government, and other knowledge producers.

Since the 2000s, most countries accepted the discourse of the global knowledge economy, giving more emphasis to issues of industry-led economy, technological progress, and innovation. In this situation, many countries have increased the enrollment scale of universities, and so is China. But research exploring the relationship between higher education and sustainable economic growth is still very scarce [38]. Regarding higher education and economic development, researchers have proposed theories including the new economic growth theory, endogenous growth theory, human capital theory, and triple helix theory [10]. How much does the development of higher education contribute to sustained economic growth? In response to this problem, Ca (2006) has proposed the opposite view, that the interaction between higher education and economic growth is very limited [39]. To conduct empirical research on the relationship between provincial or national higher education and economic growth, the following methods have been employed in research: a vector autoregression model, the Johansen cointegration test, the Granger causality test, impulse response functions, variance decomposition, and a coupling coordination model. The following are crucial findings: in the short term, higher education investment is not an essential factor of economic growth. However, in the long term, higher education investment in China's eastern, central, and western regions has a bilateral and causal relationship with economic growth; it has a strong relationship in the eastern regions and a weak one in the central and western regions [21]. Furthermore, investment in higher education and human resources positively influences economic growth, which is a motivator of higher education reforms. Socioeconomic transformation is the premise of higher education transformation, which is in turn a driver and guarantor of socioeconomic transformation.

On the whole, research on higher education, innovation ability, and economic relations has increased considerably; however, in terms of research results, most studies have focused on the relationship between two of the three indicators instead of all three indicators. Few researchers have explored the coupling coordination of higher education, innovation ability, and economic growth. Zhao Ran analyzed these indicators along with spatial evolution [40]. Zhou Yuanyuan applied measurement methods including panel data cointegration analysis and a causality test, and discovered that economic growth in the Pan Yangtze River Delta Region mainly relies on investment. In addition, regional technological innovation, higher education quality, and higher education development are influential factors for boosting economic growth [41]. The two aforementioned studies are useful references for the present study.

3. Materials and Methods

3.1. Study Area

Jiangsu is located in the eastern coastal area of China with 13 prefecture-level cities (Figure 1). Generally, Jiangsu is divided into three districts: Southern Jiangsu (encompassing Nanjing, Zhenjiang, Suzhou, Wuxi, and Changzhou), Central Jiangsu (encompassing Yangzhou, Taizhou, and Nantong), and Northern Jiangsu (encompassing Xuzhou, Huai'an, Lianyungang, Yancheng, and Suqian). Jiangsu has a robust economy. In 2019, Jiangsu achieved a gross regional product of 9963.15 billion Chinese Yuan (CNY) and was the second most economically advanced province in China, second only to Guangdong. However, the three Jiangsu districts have differences in economic development, with Southern Jiangsu being the most economically advanced and the other two districts being relatively disadvantaged in terms of economic development. Coordinated regional development is crucial to sustainable development in Jiangsu. Moreover, Jiangsu has an advanced education system featuring the most general universities of all provinces. Therefore, Jiangsu has an advantage in terms of innovation-based economy.

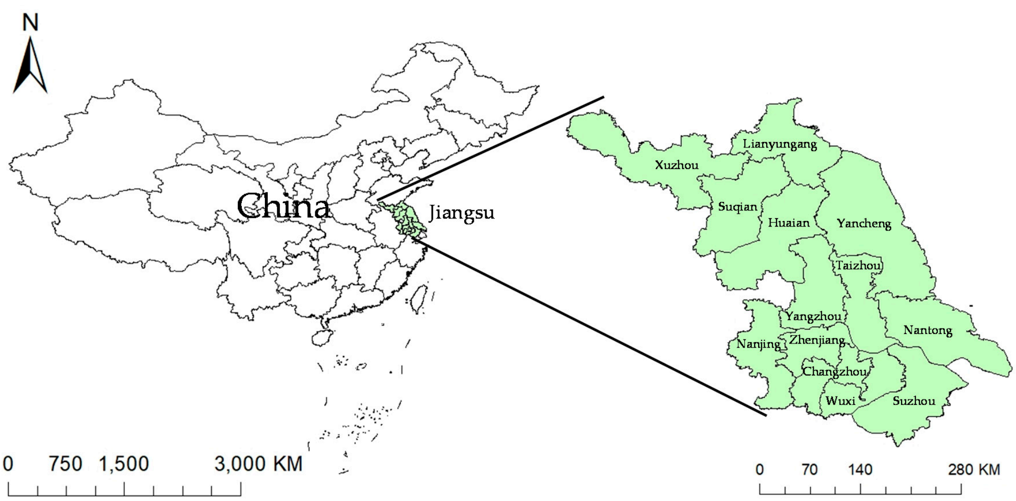


Figure 1. Location and administrative areas of the study.

3.2. Establishment of the Index System and Data Source

Higher education, innovation ability, and economic growth are influenced by various complex factors; therefore, to comprehensively reveal the interaction between them, in the present study, research was conducted in accordance with the features of the three subsystems. Indices were selected to establish for economic growth, higher education, and innovation ability (Table 1) by following the principles of scientific endeavor, representativeness, comparability, and availability.

Table 1. Coupling coordination evaluation index system concerning economic growth, higher education, and innovation ability.

Coupling System	First-Level Index	Second-Level Index	Unit	Weight
Economic growth subsystem S1	Economic scale	Gross regional product	Hundred million CNY	0.2144
		Total retail sales of consumer goods	Hundred million CNY	0.2050
	Economic structure	Percentage of GDP of the tertiary industry	%	0.1518
		Tertiary industry employees as a percentage of the total employees	%	0.1134
	Quality of economy	Disposable income per capita of town residents	CNY	0.1372
		Regional GDP per capita	CNY/person	0.1782
Higher education subsystem S2	Education scale	Numbers of colleges and universities	—	0.1622
		Numbers of full-time teachers in colleges and universities	People	0.1948
		Numbers of college and university students	People	0.2054
		Numbers of college and university enrollments	People	0.1811
		Numbers of college and university graduates	People	0.1974
	Quality of education	Teacher–student ratio in colleges and universities	%	0.0591
Innovation ability subsystem S3	Innovation input	Numbers of above-scale industrial enterprises with R&D activities	—	0.1623
		R&D expenditure of above-scale industrial enterprises	Ten thousand CNY	0.2408
		R&D expenditure as a percentage of GDP	%	0.0674
		Number of R&D staff	People	0.1550
	Innovation output	Patent applications	Pieces	0.1811
		Output values of new products	Ten thousand CNY	0.1934

The index system was divided into three subsystems: economic growth, higher education, and innovation ability. Three first-level indices—economic scale, economic structure, and economic quality—were established in the economic growth subsystem, with six second-level indices defined under them. In the higher education subsystem, two first-level indices—education scale and education quality—were established, and six second-level indices were defined under them. In the innovation ability subsystem, two first-level indices—innovation input and output—were established, with six second-level indices under them.

The data employed in the quantitative analysis were the 18 indices of the 13 prefecture-level cities in Jiangsu, China from 2007 to 2017. Most data were collected from the statistical yearbook of each prefecture-level city and the Jiangsu Statistical Yearbook. Most data in the higher education subsystems were gathered from the China City Statistical Yearbook, and most data on research and development (R&D) expenditure as a percentage of gross domestic product were obtained from the statistical communiqué of each prefecture-level city. An interpolation method based on data from consecutive years was adopted to replace the missing data.

3.3. Index Weight Verification

In the present study, entropy was applied to verify the index weights according to the following procedure. The origin index value of the 18 indices in the coupling coordination system was assumed to be X.

(1) Index standardization

Data standardization was required before weight verification because of the different units in each index. Let $\alpha = max\ (X)$ and $\beta = min\ (X)$. To simplify the calculation and operation, data were converted into forward pointers. X^* is the standardized index value, and its equation is as follows:

$$X^* = [(X - \beta)/(\alpha - \beta)] \times 0.9 + 0.1 \tag{1}$$

(2) The weights (P) of each index were calculated for different prefecture-level cities and years, with α as the total number of prefecture-level cities and β as the number of prefecture-level cities in different years:

$$P = \frac{X^*}{\Sigma_a \Sigma_b X^*} \tag{2}$$

(3) The entropy (e) of each index was calculated using the following equation:

$$e = \frac{\Sigma_a \Sigma_b X^* 1n X^*}{k}, k = 1n\text{ab} \tag{3}$$

(4) The weight w_j of each index was calculated with j as the number of indices and $1 - e$ as the variation coefficients:

$$w_j = \frac{1 - e}{\Sigma_j (1 - e)} \tag{4}$$

3.4. Coefficient Model of the Subsystems

Higher education, innovation ability, and economic growth are three different yet mutually interactive subsystems; hence, the contribution of the order parameters in each subsystem could be calculated through the weighted summary method using the following equation:

$$S_\lambda = \Sigma_j w_j X^* \tag{5}$$

where S_λ indicates the degree of contributions from each subsystem to the main system; λ = 1, 2, 3, j are the numbers of indices concerning each subsystem; w_j suggests the weight value of each order parameter; X^* is the standardized value of each index; and S1, S2, and S3 represent economic growth, higher education, and innovation ability subsystems, respectively.

3.5. Coupling Function

The three subsystems were coupled by applying the capacitive coupling coefficient model used in physics to present a dynamic relationship of interdependence and coordinative development from the positive interaction among the subsystems and establish coupling function C_{xy}:

$$C_{xy} = \frac{2\sqrt{S_x S_y}}{S_x + S_y} \tag{6}$$

where x, y = 1, 2, and 3; $x \neq y$. C_{xy} indicates the level of coupling for systems x and y; the level was between 0 and 1. A high C value suggested a high level of coupling between the two subsystems. The levels of coupling were categorized based on C values, and the standards defined by the present study are presented in Table 2.

Table 2. Levels of coupling.

C Value	Levels of Coupling
0 ≤ C ≤ 0.4	Uncoupled
0.4 < C ≤ 0.6	Slightly coupled
0.6 < C ≤ 0.8	Moderately coupled
0.8 < C ≤ 1	Highly coupled

3.6. Coupling Coordination Model

The coupling function can only determine the level of connection among subsystems but cannot decide their level of coordination; accordingly, the coupling coordination function was employed to examine the level of coordination among subsystems and analyze the level of coordinated development and stages of development for each region. The equations are as follows:

$$D_{xy} = \sqrt{C_{xy} \times T_{xy}} \quad (7)$$

$$T_{xy} = \alpha S_x + \beta S_y \quad (8)$$

where D_{xy} indicates the level of coupling coordination of systems x and y; T_{xy} reflects the comprehensive evaluation indices of the overall synergy effects concerning systems x and y; and a high D value suggests improved coordination among the subsystems. Furthermore, α and β are coefficients to be determined; thus, $\alpha + \beta = 1$, and let $\alpha = \beta = 0.5$ because the coordinated development of economic growth, innovation ability, and higher education has equal importance.

Evaluations were conducted from the classification standard of the coupling coordination value proposed by Zhao Ran [10], as displayed in Table 3.

Table 3. Levels of coupling coordination for economic growth, higher education, and innovation ability.

Coupling Coordination (D)	Levels of Coupling	Relationships between S_1, S_2, and S_3	Grading
0 < D ≤ 0.4	Slightly coordinated C	S1−S2 > 0.1	Slightly coordinated–higher education backwardness, Ca
		S2−S1 > 0.1	Slightly coordinated–economic growth backwardness, Cb
		0 ≤|S1−S2|≤ 0.1	Slightly coordinated–synchronized development in higher education and economic growth, Cc
		S1−S3 > 0.1	Slightly coordinated–innovation ability backwardness, Cd
		S3−S1 > 0.1	Slightly coordinated–economic growth backwardness, Ce
		0 ≤ |S1−S3| ≤ 0.1	Slightly coordinated–synchronized development in innovation ability and economic growth, Cf
		S2−S3 > 0.1	Slightly coordinated–innovation ability backwardness, Cg
		S3−S2 > 0.1	Slightly coordinated–higher education backwardness, Ch
		0 ≤ |S2−S3| ≤ 0.1	Slightly coordinated–synchronized development in higher education and innovation ability, Ci
0.4 < D ≤ 0.5	Moderately coordinated B	S1−S2 > 0.1	Moderately coordinated–higher education backwardness, Ba
		S2−S1 > 0.1	Moderately coordinated–economic growth backwardness, Bb
		0 ≤ |S1−S2 |≤ 0.1	Moderately coordinated–synchronized development in higher education and economic growth, Bc
		S1−S3 > 0.1	Moderately coordinated–innovation ability backwardness, Bd
		S3−S1 > 0.1	Moderately coordinated–economic growth backwardness, Be
		0 ≤ |S1−S3| ≤ 0.1	Moderately coordinated–synchronized development in innovation ability and economic growth, Bf
		S2−S3 > 0.1	Moderately coordinated–innovation ability backwardness, Bg
		S3−S2 > 0.1	Moderately coordinated–higher education backwardness, Bh
		0 ≤ |S2−S3| ≤ 0.1	Moderately coordinated–synchronized development in higher education and innovation ability, Bi
0.5 < D ≤ 0.8	Highly coordinated A	S1−S2 > 0.1	Highly coordinated–higher education backwardness, Aa
		S2−S1 > 0.1	Highly coordinated–economic growth backwardness, Ab
		0 ≤ |S1−S2| ≤ 0.1	Highly coordinated–synchronized development in higher education and economic growth, Ac
		S1−S3 > 0.1	Highly coordinated–innovation ability backwardness, Ad
		S3−S1 > 0.1	Highly coordinated–economic growth backwardness, Ae
		0 ≤ |S1−S3| ≤ 0.1	Highly coordinated–synchronized development in innovation ability and economic growth, Af
		S2−S3 > 0.1	Highly coordinated–innovation ability backwardness, Ag
		S3−S2 > 0.1	Highly coordinated–higher education backwardness, Ah
		0 ≤ |S2−S3| ≤ 0.1	Highly coordinated–synchronized development in higher education and innovation ability, Ai
0.8 < D < 1	Exceedingly coordinated S	S1−S2 > 0.1	Exceedingly coordinated–higher education backwardness, Sa
		S2−S1 > 0.1	Exceedingly coordinated–economic growth backwardness, Sb
		0 ≤ |S1−S2| ≤ 0.1	Exceedingly coordinated–synchronized development in higher education and economic growth, Sc
		S1−S3 > 0.1	Exceedingly coordinated–innovation ability backwardness, Sd
		S3−S1 > 0.1	Exceedingly coordinated–economic growth backwardness, Se
		0 ≤ |S1−S3| ≤ 0.1	Exceedingly coordinated–synchronized development in innovation ability and economic growth, Sf
		S2−S3 > 0.1	Exceedingly coordinated–innovation ability backwardness, Sg
		S3−S2 > 0.1	Exceedingly coordinated–higher education backwardness, Sh
		0 ≤ |S2−S3| ≤ 0.1	Exceedingly coordinated–synchronized development in higher education and innovation ability, Si

4. Results and Discussion

4.1. Coupling Level Analysis

The level of coupling obtained from Equation (6) was applied to calculate the coupling levels of the following subsystem pairs: economic growth–higher education (C_{12}), higher education–innovation ability (C_{23}), and economic growth–innovation ability (C_{13}). The results are presented in Table 4. In general, these aforementioned systems were all highly coupled ($C > 0.8$), which implied that economic growth, higher education, and innovation ability were closely related.

Table 4. Level of coupling among economic growth, higher education, and innovation ability in 13 prefecture-level cities in Jiangsu, China.

Region/Year	Index	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Nanjing	C12	0.957	0.953	0.955	0.970	0.973	0.983	0.993	0.996	0.998	1.000	1.000
	C23	0.893	0.873	0.897	0.909	0.923	0.943	0.973	0.975	0.979	0.984	0.984
	C13	0.983	0.976	0.986	0.981	0.985	0.987	0.994	0.992	0.989	0.989	0.988
Wuxi	C12	0.964	0.956	0.948	0.933	0.908	0.894	0.883	0.869	0.862	0.841	0.823
	C23	0.991	0.989	0.975	0.959	0.932	0.913	0.893	0.896	0.897	0.884	0.877
	C13	0.991	0.989	0.994	0.996	0.998	0.999	1.000	0.998	0.996	0.995	0.993
Xuzhou	C12	0.998	1.000	0.999	0.993	0.989	0.981	0.971	0.960	0.949	0.938	0.927
	C23	0.993	0.994	0.999	1.000	0.998	0.997	0.993	0.995	0.994	0.986	0.990
	C13	0.998	0.995	0.998	0.994	0.997	0.993	0.992	0.982	0.976	0.982	0.968
Changzhou	C12	1.000	0.997	0.990	0.973	0.954	0.945	0.911	0.903	0.882	0.865	0.872
	C23	0.996	0.999	0.997	0.986	0.982	0.980	0.945	0.940	0.929	0.918	0.943
	C13	0.994	0.993	0.998	0.998	0.993	0.991	0.995	0.995	0.992	0.991	0.982
Suzhou	C12	0.985	0.977	0.972	0.961	0.947	0.928	0.916	0.906	0.898	0.886	0.878
	C23	0.999	1.000	0.999	0.990	0.977	0.974	0.954	0.958	0.959	0.944	0.943
	C13	0.979	0.979	0.983	0.990	0.993	0.987	0.993	0.988	0.984	0.988	0.985
Nantong	C12	0.982	0.974	0.967	0.960	0.938	0.919	0.900	0.887	0.872	0.856	0.845
	C23	0.995	0.989	0.984	0.958	0.933	0.939	0.930	0.936	0.927	0.923	0.924
	C13	0.996	0.996	0.997	1.000	1.000	0.998	0.997	0.991	0.990	0.986	0.981
Lianyungang	C12	0.985	0.976	0.968	0.961	0.952	0.937	0.925	0.925	0.909	0.897	0.889
	C23	1.000	1.000	0.999	0.997	0.994	0.988	0.983	0.978	0.973	0.966	0.971
	C13	0.985	0.979	0.980	0.979	0.979	0.978	0.977	0.982	0.979	0.978	0.969
Huaian	C12	0.996	0.994	0.991	0.978	0.969	0.957	0.942	0.928	0.915	0.902	0.895
	C23	0.997	0.996	0.997	0.999	1.000	1.000	0.998	0.995	0.989	0.980	0.980
	C13	0.986	0.981	0.979	0.970	0.970	0.964	0.960	0.958	0.963	0.967	0.963
Yancheng	C12	0.991	0.988	0.980	0.964	0.953	0.938	0.921	0.912	0.894	0.886	0.874
	C23	0.999	0.999	1.000	1.000	0.998	0.997	0.992	0.990	0.985	0.960	0.960
	C13	0.983	0.978	0.976	0.966	0.969	0.959	0.961	0.958	0.955	0.977	0.972
Yangzhou	C12	0.996	0.990	0.980	0.961	0.945	0.930	0.916	0.903	0.884	0.864	0.853
	C23	1.000	0.999	0.995	0.990	0.988	0.982	0.973	0.966	0.947	0.937	0.934
	C13	0.998	0.995	0.995	0.990	0.983	0.981	0.982	0.981	0.985	0.983	0.980
Zhenjiang	C12	0.996	0.991	0.985	0.971	0.950	0.931	0.910	0.901	0.886	0.876	0.871
	C23	1.000	1.000	1.000	0.996	0.990	0.989	0.975	0.944	0.935	0.927	0.957
	C13	0.995	0.994	0.983	0.989	0.984	0.973	0.977	0.993	0.991	0.991	0.972
Taizhou	C12	0.987	0.976	0.971	0.956	0.938	0.919	0.909	0.902	0.886	0.870	0.852
	C23	0.916	0.864	0.827	0.820	0.807	0.836	0.856	0.806	0.846	0.849	0.832
	C13	0.997	0.997	0.998	0.993	0.986	1.000	0.989	0.993	0.991	0.992	0.986
Suqian	C12	0.999	0.993	0.991	0.972	0.960	0.958	0.942	0.981	0.915	0.899	0.885
	C23	1.000	1.000	1.000	0.999	0.998	0.983	0.966	0.993	0.944	0.938	0.952
	C13	0.998	0.994	0.992	0.979	0.975	0.994	0.996	0.997	0.996	0.994	0.983

Economic growth supports the materials required in higher education development, and higher education cultivates innovative professionals to boost economic growth; furthermore, an enhanced regional innovation ability promotes economic development, and economic development provides regional innovation through funding. Each set of two factors (of the three) could mutually promote and develop mutual prosperity.

4.2. Economic Growth–Higher Education Coupling Coordination Analysis

D (level of coupling coordination) was calculated from Equations (6)–(8), and the results are presented in Table 5. Figure 2 displays temporal changes related to the coupling coordination level of higher education and economic growth. From 2007 to 2017, *D* exhibited a rising trend. The level of coupling coordination in all 18 prefecture-level cities increased and covered all four stages, from slightly coordinated to extremely coordinated. In 2007, only Nanjing and Suzhou were highly coordinated, whereas the remaining regions were all slightly and moderately coordinated. In 2014, the *D* for all prefecture-level cities exceeded 0.4 and reached a moderately coordinated level or above. The variation trend of the economic growth–higher education system was stable. For the 13 cities of Jiangsu, Nanjing was in the lead in 2014 in terms of coupling coordination; it reached an extremely coordinated level. In 2017, *D* for Suqian and Lainyungang remained below 0.5, which indicated no improvement in coupling coordination.

Table 5. Coupling coordination of economic growth–higher education in Jiangsu, China.

Region/Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Nanjing	0.720 Ab	0.760 Ab	0.786 Ab	0.824 Sb	0.857 Sb	0.874 Sb	0.881 Sb	0.894 Sb	0.913 Sc	0.930 Sc	0.960 Sc
Wuxi	0.496 Ba	0.514 Aa	0.527 Aa	0.543 Aa	0.556 Aa	0.568 Aa	0.578 Aa	0.589 Aa	0.598 Aa	0.609 Aa	0.621 Aa
Xuzhou	0.431 Bc	0.449 Bc	0.464 Bc	0.482 Bc	0.498 Bc	0.514 Aa	0.529 Aa	0.542 Aa	0.555 Aa	0.569 Aa	0.581 Aa
Changzhou	0.457 Bc	0.480 Bc	0.498 Bc	0.516 Aa	0.525 Aa	0.546 Aa	0.545 Aa	0.554 Aa	0.564 Aa	0.576 Aa	0.604 Aa
Suzhou	0.522 Ac	0.557 Aa	0.579 Aa	0.605 Aa	0.623 Aa	0.640 Aa	0.657 Aa	0.676 Aa	0.690 Aa	0.706 Aa	0.724 Aa
Nantong	0.423 Bc	0.441 Bc	0.453 Ba	0.457 Ba	0.468 Ba	0.483 Ba	0.499 Ba	0.514 Aa	0.527 Aa	0.540 Aa	0.556 Aa
Lianyungang	0.373 Cc	0.383 Cc	0.390 Cc	0.403 Bc	0.410 Bc	0.420 Bc	0.432 Bb	0.433 Bb	0.443 Bb	0.450 Bb	0.459 Bb
Huaian	0.399 Cc	0.414 Bc	0.428 Bc	0.439 Bc	0.447 Ba	0.459 Ba	0.468 Ba	0.477 Ba	0.488 Ba	0.498 Ba	0.505 Aa
Yancheng	0.392 Cc	0.406 Bc	0.416 Bc	0.433 Ba	0.441 Ba	0.452 Ba	0.464 Ba	0.469 Ba	0.482 Ba	0.494 Ba	0.506 Aa
Yangzhou	0.418 Bc	0.433 Bc	0.446 Bc	0.467 Ba	0.483 Ba	0.500 Ba	0.512 Aa	0.520 Aa	0.531 Aa	0.541 Aa	0.555 Aa
Zhenjiang	0.421 Bc	0.438 Bc	0.451 Bc	0.471 Ba	0.491 Ba	0.505 Aa	0.513 Aa	0.522 Aa	0.533 Aa	0.544 Aa	0.553 Aa
Taizhou	0.385 Cc	0.397 Cc	0.409 Bc	0.430 Ba	0.444 Ba	0.458 Ba	0.463 Ba	0.476 Ba	0.489 Ba	0.503 Aa	0.515 Aa
Suqian	0.333 Cc	0.344 Cc	0.355 Cc	0.367 Cc	0.379 Cc	0.378 Cc	0.386 Ca	0.434 Bc	0.403 Ba	0.411 Ba	0.422 Ba

Note: Sc, extremely coordinated synchronized development in higher education and economic growth; Sb, extremely coordinated and economic growth lagging; Aa, highly coordinated higher and education development lagging; Ab, highly coordinated and economic growth lagging; Ac, highly coordinated and synchronized development in higher education and economic growth; Ba, moderately coordinated and higher education development lagging; Bb, moderately coordinated and economic growth lagging; Bc, moderately coordinated and synchronized development in higher education and economic growth; Ca, slightly coordinated and higher education development lagging; Cc, slightly coordinated and synchronized development in higher education and economic growth.

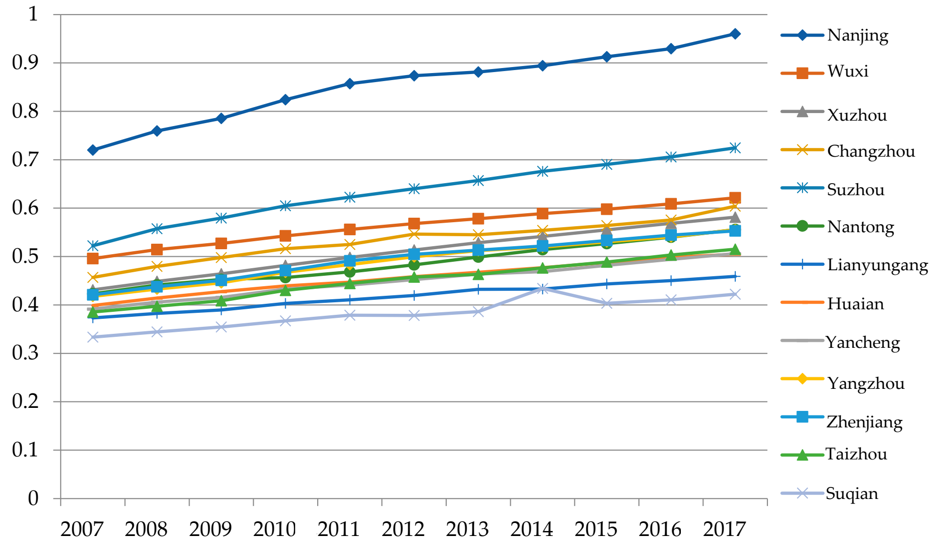


Figure 2. Variations in economic growth–higher education coupling coordination in Jiangsu, China.

The coupling coordination of economic growth–higher education increased; however, it was unclear which of the two subsystems (economic growth or higher education) dominated. Therefore, the coupling coordination of economic growth–higher education was evaluated from Table 3 (Table 5). In 2007, all regions except for Nanjing and Wuxi had synchronized development in higher education and economic growth. The contribution of higher education to the local economy in Nanjing had yet to improve, whereas higher education in Wuxi did not keep pace with economic growth. A decade later, in 2017, Nanjing had synchronized and stable growth in economic growth–higher education development, and the level of coupling coordination in the other cities notably increased too. However, problems were exposed during development; for example, economic development in Lianyungang was slightly faster than that of higher education; however, the remaining cities had backward higher education, which indicated that improving higher education is key for promoting balanced regional development.

4.3. Economic Growth–Innovation Ability Coupling Coordination Analysis

Through the aforementioned method, a line chart (Figure 3) was created based on the coupling coordination values listed in Table 6, and trend variations in economic growth–innovation ability coupling coordination in Jiangsu from 2007 to 2017 were analyzed. Generally, the coupling coordination values rose continuously, and the coupling coordination in all prefecture-level cities in Jiangsu increased. By 2012, the coupling coordination value of all prefecture-level cities exceeded 0.4, indicating moderate coordination and above. Nanjing ranked first in all years. In 2015, Nanjing and Suzhou reached the level of extreme coordination, followed by Wuxi in 2017.

An in-depth analysis revealed that the development of the innovation ability–economic growth system covered four stages: slightly coordinated to extremely coordinated. In 2007, Nanjing and Suzhou had a highly coordinated innovation ability (underdeveloped), and Wuxi had highly coordinated and synchronized development in terms of innovation ability and economic growth. Xuzhou, Changzhou, Taizhou, Nantong, Zhenjiang, and Yangzhou had moderately coordinated synchronized development in innovation ability and economic growth, and Huaian, Yancheng, Lianyungang, and Suqian had slightly coordinated and synchronized development in innovation ability and economic growth. In 2012, coupling coordination in regions excluding Nanjing, Wuxi, and Suzhou increased; however, underdeveloped innovation ability was noted in many regions, including Nanjing, Changzhou, and Suzhou. By 2017, coupling coordination in all regions improved from the situation in 2007. Suqian had moderately coordinated and synchronized development in higher education and economic growth, whereas the innovation ability of other cities lagged behind the economic development. This indicated that innovation ability is a factor for economic growth, whereas economic growth is not the most crucial factor for innovation ability. Therefore, enhancing innovation ability is a major step for promoting regionally balanced development.

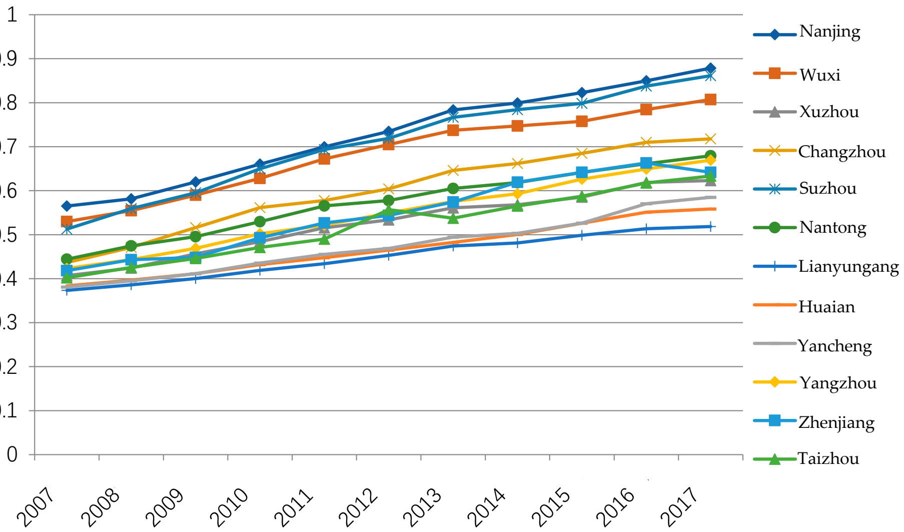


Figure 3. Variations in economic growth–innovation ability coupling coordination in Jiangsu, China.

Table 6. Innovation ability–economic growth coupling coordination in Jiangsu, China.

Region/Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Nanjing	0.565 Ad	0.582 Ad	0.620 Ad	0.660 Ad	0.700 Ad	0.735 Ad	0.783 Ad	0.799 Ad	0.823 Sd	0.850 Sd	0.879 Sd
Wuxi	0.530 Af	0.555 Af	0.590 Af	0.628 Af	0.672 Af	0.705 Af	0.737 Af	0.747 Af	0.758 Af	0.784 Ad	0.807 Sd
Xuzhou	0.407 Bf	0.424 Bf	0.456 Bf	0.484 Bf	0.516 Af	0.534 Af	0.561 Af	0.568 Ad	0.586 Ad	0.619 Ad	0.623 Ad
Changzhou	0.437 Bf	0.471 Bf	0.516 Af	0.562 Af	0.578 Af	0.604 Ad	0.646 Af	0.662 Af	0.685 Ad	0.710 Ad	0.718 Ad
Suzhou	0.513 Ad	0.559 Ad	0.595 Ad	0.650 Ad	0.694 Ad	0.719 Ad	0.767 Ad	0.784 Ad	0.798 Ad	0.838 Sd	0.861 Sd
Nantong	0.444 Bf	0.475 Bf	0.495 Bf	0.530 Af	0.565 Af	0.578 Af	0.605 Af	0.618 Ad	0.642 Ad	0.661 Ad	0.679 Ad
Lianyungang	0.373 Cf	0.386 Cf	0.400 Bf	0.419 Bf	0.434 Bd	0.453 Bd	0.474 Bd	0.481 Ad	0.499 Ad	0.513 Ad	0.519 Ad
Huaian	0.384 Cf	0.397 Cf	0.411 Bf	0.432 Bf	0.448 Bd	0.465 Bd	0.482 Bd	0.501 Ad	0.526 Ad	0.551 Ad	0.558 Ad
Yancheng	0.381 Cf	0.395 Cf	0.411 Bf	0.436 Bd	0.455 Bd	0.469 Bd	0.494 Bd	0.503 Ad	0.526 Ad	0.570 Ad	0.585 Ad
Yangzhou	0.423 Bf	0.443 Bf	0.469 Bf	0.502 Af	0.522 Ad	0.549 Ad	0.576 Ad	0.593 Ad	0.626 Ad	0.649 Ad	0.669 Ad
Zhenjiang	0.418 Bf	0.443 Bf	0.448 Bf	0.493 Bf	0.527 Ad	0.544 Ad	0.574 Ad	0.619 Af	0.642 Ad	0.663 Ad	0.642 Ad
Taizhou	0.402 Bf	0.425 Bf	0.446 Bf	0.471 Bf	0.490 Bf	0.557 Af	0.537 Af	0.565 Af	0.588 Af	0.617 Ad	0.633 Ad
Suqian	0.331 Cf	0.345 Cf	0.356 Cf	0.374 Cf	0.391 Cf	0.415 Bf	0.441 Bf	0.461 Bf	0.479 Bf	0.492 Bf	0.495 Bf

Note: Sd, extremely coordinated and innovation ability lagging; Ad, highly coordinated and innovation ability lagging; Af, highly coordinated synchronized development in innovation ability and economic growth; Bd, moderately coordinated and innovation ability lagging; Bf, moderately coordinated and synchronized development in innovation ability and economic growth; Cf, slightly coordinated and synchronized development of innovation ability and economic growth.

4.4. Higher Education–Innovation Ability Coupling Coordination Analysis

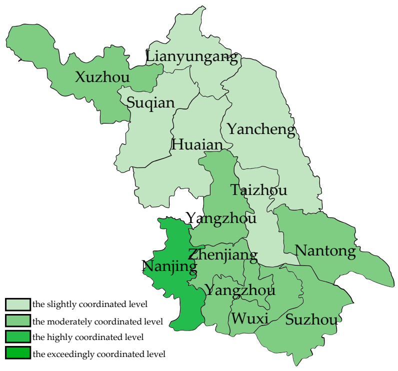
Coupling coordination of higher education–innovation ability increased year-to-year. In 2007, the coupling coordination of the two indicators fluctuated around a certain value; however, Nanjing already had highly coordinated development, with the development of innovation ability being slightly behind that of higher education. Lianyungang, Huaian, Suqian, Yancheng, and Taizhou were slightly coordinated, and the remaining regions were moderately coordinated; in addition, all regions had synchronized development concerning the two indicators. In 2017, coupling coordination in Nanjing was above 0.8; the area underwent extremely coordinated development. Wuxi, Suzhou, Xuzhou, Nantong, and Yangzhou were highly coordinated, and the remaining regions were all moderately coordinated. The accumulation of human resources and technology became the main factors of economic growth, and higher education—through which scientific knowledge is created, integrated, spread, and applied—was highly associated with the two factors. The development of higher education significantly influences the innovation ability of a region and the speed and pattern of regional economic development. Thus, the problem Jiangsu currently faces is imbalanced development in higher education and regional technological innovation ability. Therefore, the present study examined the spatial evolution of higher education–innovation ability coupling coordination in Jiangsu (Table 7).

Table 7. Coupling coordination of higher education–innovation ability in Jiangsu, China.

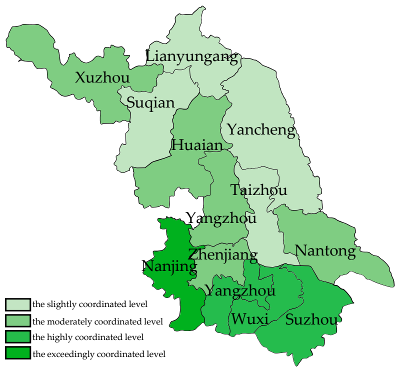
Region/Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Nanjing	0.656 Ag	0.680 Ag	0.722 Ag	0.747 Ag	0.786 Ag	0.806 Sg	0.833 Sg	0.838 Sg	0.847 Sg	0.863 Sg	0.888 Sg
Wuxi	0.463 Bi	0.477 Bi	0.500 Bh	0.520 Ah	0.538 Ah	0.554 Ah	0.572 Ah	0.570 Ah	0.573 Ah	0.580 Ah	0.585 Ah
Xuzhou	0.419 Bi	0.427 Bi	0.449 Bi	0.456 Bi	0.479 Bi	0.483 Bi	0.497 Bi	0.492 Bi	0.497 Bi	0.516 Ai	0.511 Ai
Changzhou	0.432 Bi	0.453 Bi	0.481 Bi	0.500 Bi	0.495 Bi	0.510 Ah	0.519 Ah	0.526 Ah	0.530 Ah	0.539 Ah	0.549 Ah
Suzhou	0.471 Bi	0.502 Ai	0.528 Ai	0.564 Ai	0.587 Ah	0.591 Ah	0.620 Ah	0.626 Ah	0.630 Ah	0.652 Ah	0.664 Ah
Nantong	0.404 Bi	0.422 Bi	0.435 Bi	0.459 Bh	0.472 Bh	0.469 Bh	0.479 Bh	0.482 Bh	0.491 Bh	0.497 Bh	0.504 Ah
Lianyungang	0.342 Ci	0.345 Ci	0.352 Ci	0.364 Ci	0.370 Ci	0.378 Ci	0.388 Ci	0.394 Ci	0.400 Ci	0.405 Bi	0.405 Bi
Huaian	0.367 Ci	0.375 Ci	0.385 Ci	0.388 Ci	0.395 Ci	0.400 Bi	0.405 Bi	0.412 Bi	0.425 Bi	0.438 Bi	0.440 Bi
Yancheng	0.356 Ci	0.365 Ci	0.372 Ci	0.380 Ci	0.389 Ci	0.391 Ci	0.402 Bi	0.405 Bi	0.413 Bi	0.444 Bh	0.449 Bh
Yangzhou	0.405 Bi	0.413 Bi	0.424 Bi	0.436 Bi	0.440 Bi	0.453 Bi	0.465 Bh	0.472 Bh	0.486 Bh	0.492 Bh	0.501 Ah
Zhenjiang	0.400 Bi	0.414 Bi	0.411 Bi	0.437 Bi	0.448 Bi	0.449 Bi	0.461 Bi	0.491 Bh	0.499 Bh	0.510 Ah	0.491 Bh
Taizhou	0.356 Ci	0.356 Ci	0.362 Ci	0.369 Ci	0.371 Ci	0.372 Ch	0.371 Ch	0.378 Ch	0.380 Ch	0.384 Ch	0.385 Ch
Suqian	0.323 Ci	0.326 Ci	0.333 Ci	0.331 Ci	0.338 Ci	0.358 Ci	0.370 Ci	0.418 Bi	0.386 Ch	0.389 Ch	0.385 Ci

Note: Sg, extremely coordinated and innovation ability lagging; Ag, highly coordinated and innovation ability lagging; Ah, highly coordinated and higher education development lagging; Ai, highly coordinated and synchronized development in higher education and innovation ability; Bh, moderately coordinated and higher education lagging; Bi, moderately coordinated and synchronized development in higher education and innovation ability; Ci, slightly coordinated synchronized development in higher education and innovation ability.

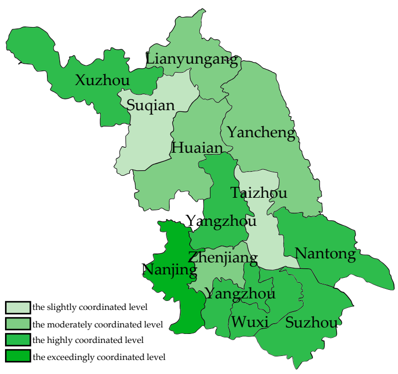
To examine the spatial evolution of higher education–innovation ability coupling coordination, ArcGIS data visualization was applied to statistically analyze coupling coordination, as displayed in Figure 4. On the basis of the spatial distribution, coupling coordination in Southern Jiangsu was generally higher than that in the northern regions; in addition, the results in Southern, Central, and Northern Jiangsu were distributed in a gradient trend. This indicated that Nanjing had the highest level of coupling coordination and reached the level of extreme coordination in 2012. Nanjing, the administrative center of Jiangsu, possesses a rich culture and long history; furthermore, with several Project 985 and 211 colleges and universities in the region, including Nanjing University, Nanjing Normal University, and Hohai University, outstanding talent is cultivated, and this enhances innovation ability. However, other regions such as Huaian, Lianyungang, and Suqian were not highly coordinated in higher education and innovation ability, because these regions have limited educational resources. Hence, improving the quality of higher education and increasing investment in regional innovation and talent are key to achieving balanced development and industrial transformation.



(a) 2007



(b) 2012



(c) 2017

Figure 4. Spatial evolution of higher education–innovation ability coupling coordination in Jiangsu, China.

5. Conclusions and Implications

The coupling coordination evaluation index system established in the present study was divided into three subsystems: economic growth, higher education, and innovation ability. In addition, six first-level and 18 second-level indices were defined. Entropy was applied to verify the index weights, and a coupling function and coupling coordination model were employed to analyze the coupling coordination of the three subsystems in Jiangsu, China to confirm the effectiveness of the evaluation system. From the results, the following conclusions were reached:

1. From 2007 to 2017, the coupling coordination of the 13 prefecture-level cities in Jiangsu increased. This indicated an excellent interaction overall between higher education, economic development, and innovation capacity in Jiangsu, which positively influenced sustainable development in the province.
2. In 2017, economic growth and higher education in Nanjing in 2017 underwent synchronized development and steady increases. The remaining regions also exhibited noticeable increases; however, problems arose during development. The economic growth of Lianyungang fell behind higher education development, and the other regions required improvements in the development of higher education. In summary, higher education resources in Jiangsu are excessively concentrated in the capital, which results in uneven spatial distribution. In particular, higher education resources are insufficient in economically disadvantaged Northern Jiangsu. This impedes innovation-based economic development in the district.
3. In the economic growth–innovation ability system, the coupling coordination of all regions improved in 2017 compared with the situation in 2007. Only Suqian had moderately coordinated synchronized development in higher education and economic development. The remaining regions exhibited imbalanced development in innovation ability and economic growth, with the development of innovation ability falling behind. This revealed that innovation ability influences economic growth; however, economic growth is not the most crucial factor for regional innovation ability. Enhancing innovation ability substantially promotes regional balanced development.
4. In the higher education–innovation ability system, coupling coordination in regions apart from Nanjing required improvement because of their limited higher education resources. Therefore, enhancing the quality of higher education and increasing investment in regional innovation and talent are critical to achieving balanced regional development and industrial transformation.

In summary, Jiangsu is a province with advanced economic and educational development and has notable advantages in terms of innovation-based economy. Overall, the interactions between economic development, higher education, and innovation capacity became increasingly satisfactory, reinforcing the province's success in sustainable development. However, differences in development were noted between the three Jiangsu districts. Highly coordinated development between economic growth, higher education, and innovation ability was noted in Southern Jiangsu, particularly in Nanjing and Suzhou. By contrast, coordinated development among these systems in Central and Northern Jiangsu was unsatisfactory. Innovation ability and higher education development in these two districts lagged behind economic development, and their higher education development lagged behind their innovation ability.

For future development, stakeholders in Jiangsu should focus on solving the uneven spatial distribution of higher education resources. Capital investment is required to establish additional high-quality universities in Central and Northern Jiangsu to satisfy human resource requirements for innovation. Connotative construction within these universities should be reinforced for human resource development in universities to fulfill the requirements for developing emerging industries in Central and Northern Jiangsu. In addition, support for human resource development in these two districts should be reinforced through policies. Economic disadvantages in Northern Jiangsu critically inhibit its attraction of high-quality personnel. A stable policy that gives preference to human resources should hasten the introduction of high-quality human resources in the district.

The Chinese government should encourage universities to cooperate with enterprises to enhance the positive effect of innovation on economic development. The innovation ability of enterprises should be fully utilized, and R&D investment from enterprises should be reinforced to strengthen their technological innovation and resource integration. Moreover, the government should encourage enterprises to cooperate with universities and research institutes to establish high-level technology centers, engineering technology research centers, and valuable patent development and demonstration centers.

Despite the importance of this study, this study also has disadvantages in that it considers only the interactive relationships among higher education, economic growth, and innovation ability from the perspective of space and time evolution. In future study, we will make an in-depth analysis on the mechanisms of the interaction among the three. In the following study, we will present a richer discussion by data from various firms, universities, and various cases from different regions.

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