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Article

Exploring the Coordinated Development of Smart City Clusters in China: A Case Study of Jiangsu Province

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Abstract: As urbanization has accelerated, China has started to build smart cities, which have formed smart city clusters. It is critical to coordinate development within smart city clusters to enhance the efficiency of city cluster construction. From the perspective of demographic economics, this study innovatively constructed an evaluation system for the coordinated development of smart city clusters and utilized the coupled coordination degree model to conduct an in-depth study of smart city clusters in Jiangsu Province. The results show that there are clear differences in the development between the three regions of Jiangsu Province: Southern Jiangsu, Central Jiangsu, and Northern Jiangsu. The development within Jiangsu Province is imbalanced, where the overall development trend is high in the southern region and low in the northern region. The main driving factors include geography, the Matthew effect, game thinking, and industrial structure. Accordingly, the results suggest the following recommendations for the coordinated development of smart city clusters: strengthening cross-regional cooperation, promoting data sharing and interoperability, deepening synergistic industrial development, and expanding innovation capacity.

Keywords: smart city cluster; coordinated development; evaluation index system; coupled coordination degree model; Jiangsu Province

1. Introduction

With the accelerating pace of urbanization in China, the demographic, economic, social, ecological[1], and environmental elements of cities are undergoing rapid transformation. With the rapid development of new-generation information technology, China started constructing pilot smart cities as early as 2012 to better cope with the new challenges brought about by such transformations[2]. At present, there is no consensus among scholars on the definition of smart cities[3], and there are various perspectives from which to define the term, including technology, urban development[4], "humanism"[5], and systems engineering[6]. However, scholars agree that smart cities are inevitable products of urbanization and a path to achieve high-quality urban development. Building smart cities can help planners intelligently manage and optimize all aspects of the city, improve the efficiency of urban operation, and improve the quality of life for urban residents[7]. Since 2019, cities in Jiangsu Province have introduced plans to transform themselves into smart cities. After several years of construction, relatively well-functioning smart city clusters were established. However, the development among these smart city clusters is imbalanced, which is not in line with China's goal of coordinated regional development.

China has been promoting coordinated regional development in recent years, focusing on equity and efficiency to achieve the goal of balanced and high-quality development across all regions[8]. In 2010, Jiangsu Province proposed a strategy for coordinated regional development in 2010 to narrow

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the regional development gap[9]. In regional balanced development[1], the local population, economy, and social development[10] are important factors and measurement indices. Therefore, this study constructs an evaluation index system from these three perspectives[2], which includes a development index [11]and a degree of coordination index[12], to judge whether regional development is balanced. In the case of Jiangsu Province, factors such as the industrial structure, location, economic structure, and differences in domestic and foreign asset inputs lead to significant differences in development between urban agglomerations[13]. Therefore, this study takes Jiangsu Province as an example to study the balanced development of smart city clusters in the region. This study aims to scientifically assess regional development, which provides a basis for domestic and foreign government departments to formulate regional development policies in a scientific and reasonable manner and theoretical references for academic research on balanced regional development.

2. Review of evaluation studies on balanced regional development

An important objective of balanced regional development is the balance between regional coordination [14]and regional development. While there is no common definition of regional coordinated development in academia, its connotation has evolved with social practice. The focus of regional coordinated development in China lies in coordinating economic development. A report from the Twentieth National Congress of the CPC noted that "the state ensures that the national economy can realize coordinated development in proportion to its size through the auxiliary role of market regulation and the comprehensive balance of economic planning." With the deepening of reform and opening up, the economic and social development of China has become unbalanced and the level of development between different regions has gradually widened[15]. These disparities have led to many social problems, pushing the balanced development of regions to be one of the important goals on the government's agenda. Quantitative evaluation of the level of regional coordinated development is an important part of applying theoretical research to social practice[16]. To create an index system[17], Chinese scholars mainly adopt three methods: theoretical analysis, frequency statistics, and principal component analysis[18]. Such an index system usually takes on the form of either a hierarchical index system or a comprehensive index system[19,20]. From a spatial perspective, researchers have analyzed at the country, geographic region, urban agglomeration, and administrative region levels, considering a variety of factors[21–24]. To evaluate the coordinated development of regions in China, Xu Yingzhi and Wu Haiming used the "four-point method," by constructing four evaluation subsystems of society, economy, ecology, and science and technology, covering ten levels of criteria and a total of 27 evaluation indices[25]. Zhang Chao constructed a regional coordinated development evaluation index system that encompassed five components, namely, public services, infrastructure, economic development, the ecological environment, and quality of life, and measured the regional coordinated development level of 30 provinces in China from 1996 to 2017[26]. Song Shengnan constructed eight first-level indices and 27 second-level indices

[1] Regional balanced development in this study refers to the balance between regional coordination and regional development. For the purpose of this study, regional balanced development refers to the balance of inter-regional development, and regional coordinated development refers to the coordination of demographic, economic, and social development factors within cities, and the balance of regional development is measured through the development index of urban development and the degree of coupled coordination.

[2] There are various studies on the connotation of social development. In this paper, social development refers to the ecological environment, infrastructure, social security system, scientific and educational development of the whole society, excluding population development and economic development. Essentially, social development is the social attributes of the environment and resources. The study of population-economic-social development system in this paper belongs to the research subfield of population economics.

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of industrial structure, spatial connection, market development, infrastructure, public service, environmental protection, urban-rural integration, and development mechanisms to evaluate the regional coordinated development level of the Hefei Metropolitan Area[27]. These studies constructed different evaluation index systems depending on their study area and purpose, but the selection of the all the indices commonly reflect the concepts of hierarchy, diversity, and complexity. Population mobility highlights the comparative advantages of regional development[28], while economic development provides the material conditions for coordinated regional development[29]. However, studies on coordinated regional development have not considered the influence of demographic and economic factors in designing an index system[30].

The idea of a demographic economy originated with the emergence of mercantilists in the 16th century. Classical economists, including François Quesnay and William Peddie, considered demographic factors in the field of economics. These authors first discussed the relationship between wealth and population[31]. In subsequent studies, scholars such as David Ricardo, Thomas Robert Malthus, and Adam Smith proposed the theory of demographic economics based on the law of diminishing land harvest and the theory of value of labor[32]. After the 20th century, the study of Western demographic economics formed a neoclassical economic theoretical framework based on macroeconomics and microeconomics, which included the theory of neoclassical economics[33], the push-pull model, the quadratic exponential model[34], and Lee's migration theory[35]. Compared with those in Western countries, research on population economics in China began much later. After the reform and opening up, Chinese researchers and scholars systematically studied population economics theory by drawing on relevant theories from Western population economics[36]. Many scholars have studied regional coordinated development from the perspectives of the economy, population, resources, and the environment[37]. However, most studies focus on regional sustainable development from the perspective of the environmental sciences[38], and few studies address regional coordinated development by combining demographic and economic factors from the perspective of the social sciences[39]. Therefore, this study attempts to construct an evaluation framework for the population-economic-social development system and explore whether interregional development is balanced by comparing the coordination index with the development indices of cities in these regions[40].

3. Research methods and data sources

3.1. Construction of the evaluation index system

Building an index system is a core component of systematic evaluation and thus affects the reliability of the evaluation results. The regional population-economic-social development evaluation index system constructed in the study follows the following four principles[41]: 1)Representativeness: The selected indices must reflect the situation and characteristics of regional population-economic-social development to the maximum extent possible; 2)Operability: The indices should be selected in a simple and clear way in which the data are easy to collect and calculate; 3) Scientific Rigor: The indices must adopt scientific calculation methods; (4) Systematicity: There should be a certain degree of logic between indices that reflects the main characteristics of the demographic-economic-social subsystems from different aspects.

3.1.1. Construction of the evaluation index system for the population development subsystem

The population development subsystem is complex and contains many elements[42]. Under the primary index of the population development subsystem, this study constructed three secondary indices: population size, population quality, and population structure. The demographic factor itself has both natural and social attributes, corresponding to both the quantity and quality of the population. Population scale is then divided into four three-level indices: the number of births, the number of deaths, the household population at the end of the year, and the resident population at the end of the year. The quality of the population refers to the education level of the population, which is captured by three tertiary indices: the illiteracy and semi-illiteracy rate, the percentage of

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people with a bachelor's degree or higher, and the percentage of people with a high school education or lower. The population structure usually includes gender structure, age structure, and urban-rural structure, and encompassed six three-level indices: sex ratio at birth, ratio of 0-14 years old, ratio of 15-64 years old, ratio of 65 years old and above, population density, and ratio of the urban population. The results of the construction of the evaluation index system for the population development subsystem are shown in Table 1.

Table 1. System of indices for evaluating the population development subsystem.

Target Level	Standardized Layer	Serial Number	Index Layer	Index Properties
Population development subsystem indices	Size of population	A1	Number of births (persons)	+
		A2	Number of deaths (persons)	-
		A3	Household population at the end of the year (10,000)	+
		A4	Year-end resident population (10,000)	+
	Quality of population	A5	Illiteracy and semi-illiteracy (%)	-
		A6	Percentage of people with bachelor's degree or above (%)	+
		A7	Percentage of people with high school education or less (%)	-
	Population structure	A8	Sex ratio at birth	-
		A9	Percentage of 0-14 year olds (%)	+
		A10	Percentage of 15-64 year olds (%)	+
		A11	Percentage of persons aged 65 and over (%)	+
		A12	Population density (persons/km^2)	+
		A13	Percentage of urban population (%)	+

3.1.2. Construction of an evaluation index system for the economic development subsystem

Regional economic development includes both the quantitative and qualitative aspects of economic development of regions[43]. Under the first-level index of the economic development subsystem, the study constructs three second-level indices: economic scale, economic quality, and economic structure. Three third-level indices are divided under the second-level index of economic scale: year-end gross domestic product, general public budget revenue, and total industrial output value. These indices were selected to reflect the dimension of social activities and public life in a region from an economic perspective. Four tertiary indices were selected under the second-level index of economic quality: per capita GDP, GDP growth rate, per capita local financial revenue, and per capita gross industrial output value. The evaluation index system for the economic development subsystem are shown in Table 2.

Table 2. System of indices for evaluating the economic development subsystem.

Target Level	Standardized Layer	Serial Number	Index Layer	Index Properties
Economic development	Size of economy	B1	Year-end gross domestic product GDP (billions of yuan)	+

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Target Level	Standardized Layer	Serial Number	Index Layer	Index Properties
subsystem indices		B2	General public budget revenue (billions of yuan)	+
		B3	Gross industrial output (billions of yuan)	+
		B4	GDP per capita ($)	+
	Quality of the economy	B5	GDP growth rate (%)	+
		B6	Per capita local fiscal revenue (million yuan)	+
		B7	Per capita gross industry output (yuan)	+
		B8	Share of primary production value (%)	+
	Economic structure	B9	Share of secondary production value (%)	+
		B10	Share of output value of the third sector (%)	+

3.1.3. Construction of an evaluation index system for social development subsystems

Social development generally includes many elements, such as politics, culture, ecology, and economy[44]. In this study, the elements of social development exclude the other two factors of the population and economy[45]. Under the first-level index of the social development subsystem, there are four second-level indices: infrastructure, culture and education, the medical system, and the ecological environment. Under the second-level index infrastructure, there are four third-level indices: road area per capita, public transportation vehicles per 10,000 people, Liquefied petroleum gas supply per 10,000 people, and water supply per capita. Under the second-level index culture and education, there are four tertiary indices: per capita financial expenditure on education, total number of students at each stage of schooling, total number of teachers at each stage of schooling, and number of books in public libraries per capita. There are five tertiary indices under the secondary index of healthcare: total number of hospitals and health centers, number of hospital beds per 10,000 people, percentage of people enrolled in basic medical insurance, percentage of people enrolled in work-related injury insurance, and percentage of people enrolled in worker's unemployment insurance. The ecological environment is captured by three tertiary indices: sewage treatment rate, amount of domestic garbage removal, and per capita green space in parks. The results of constructing the evaluation index system for the social development subsystem are shown in Table 3.

Table 3. System of indices for evaluating the social development subsystem.

Target Level	Standardized Layer	Serial Number	Index Layer	Index Properties
Social development subsystem indices	Infrastructure	C1	Road area per capita (square meters)	+
		C2	Public transportation vehicles for 10,000 people (standard units)	+
		C3	Supply of liquefied petroleum gas per 10,000 people (tons)	+
		C4	Water supply per capita (tons)	+
	Cultural Education	C5	Per capita financial expenditure on education (yuan)	+
		C6	Total number of students enrolled in school at all levels (10,000)	+

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Target Level	Standardized Layer	Serial Number	Index Layer	Index Properties
	Medical System	C7	Total number of teachers at all levels (10,000)	+
		C8	Public library holdings per capita (volumes)	+
		C9	Total number of hospitals, health centers	+
		C10	Number of hospital beds per 10,000 persons (sheets)	+
		C11	Percentage of persons covered by basic health insurance (%)	+
		C12	Percentage of employees insured against work-related injuries (%)	+
		C13	Unemployment insurance participation (%)	+
	Ecological Environment	C14	Sewage treatment rate (%)	+
		C15	Volume of domestic waste removed (tons)	+
		C16	Green space per capita in parks (square meters)	+

3.2. Construction of the coupled and coordinated development evaluation model

3.2.1. Determination of weights using the entropy weight method

When choosing methods to measure the level of coordinated development of a region, we chose to use the entropy weight method[46], which is relatively accurate and objective. The steps involved in this method are as follows.

Step 1: Construct the initial judgment matrix. The evaluation target of region n for year r is s, and there are a total of m evaluation indices; then, there is a judgment matrix.

$$A=\left\{X_{qij}\right\}\left(q=1,2\cdots r;i=1,2\cdots n;\ j=1,2\cdots m\right) \tag{1}$$

Step 2: Conduct dimensionless quantization of indices. Since the selected indices contain positive and negative indices, each index has a different magnitude and unit. To facilitate uniform calculation, the indices are made dimensionless using the method of polarity transformation. A new matrix is obtained:

$$A^{*}=\left\{x_{qij}^{*}\right\} \tag{2}$$

Positive indices: $$x_{qij}^{*}=\left(x_{qij}-\min\left\{x_{qij}\right\}\right)/\left(\max\left\{x_{qij}\right\}-\min\left\{x_{qij}\right\}\right) \tag{3}$$

Negative indices: $$x_{qij}^{*}=\left(\max\left\{x_{qij}\right\}-x_{qij}\right)/\left(\max\left\{x_{qij}\right\}-\min\left\{x_{qij}\right\}\right) \tag{4}$$

Step 3: Calculate the entropy weight of the j-th index in the q-th year (0≤<1). P_{qij} is the weight of the j-th index, k=1/ln(m), k>0, and m is the number of indices

$$p_{qij}=x_{qij}^{*}/\sum_{q}\sum_{i}x_{qij}^{*} \tag{5}$$

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$$e_j = k\sum_q \sum_i p_{qij} \ln\left(p_{qij}\right) \tag{6}$$

Step 4: Calculate the coefficient of variation (d_j) for index (column) j.

$$d_j = 1 - e_j \tag{7}$$

Step 5: Calculate the weight of the j-th index (column).

$$w_j = d_j / \sum d_j \tag{8}$$

Step 6: Calculate the final evaluation target weights for region *i*

$$S_{gk} = \sum_j w_j x_{qij} \tag{9}$$

3.2.2. Modeling the degree of coordination of coupled demographic-economic-social systems

The coupling coordination degree model is used to analyze the level of coordinated development[47]. The coupling degree refers to the degree of mutual influence between two or more systems and can reflect the degree of connection between systems. The degree of benign coupling development between coordination degree subsystems can reflect the degree of coordination between systems. The study constructs the coupling coordination degree model of the population-economy-society (PES) integrated system to judge the coordination level status of social development in district cities. The standardized population, economic, and social system indices and the multiplication of the weights of each index can be accumulated to obtain the score of each subsystem, which is denoted as α, β and λ, respectively.

PES (population-economy-society) system development coupling index:

$$C1 = \sqrt[3]{\frac{\alpha\beta\lambda}{\left(\frac{\alpha+\beta+\lambda}{3}\right)^3}} \tag{10}$$

To measure the degree of coordination between subsystems, a development index T and a coordination index D are introduced.

Calculation of the PES Development Index (T_{ijk}) and coordination index (named D_{ijk}):

Development indices:

$$T_{ijk} = \theta * A + \zeta * B + \gamma C\left(\theta = \zeta = \gamma = \frac{1}{3}; A、B、C \in (\alpha、\beta、\lambda)\right) \tag{11}$$

Coordination index:

$$D_{ijk} = \left(C_{ijk} * T_{ijk}\right)^{\frac{1}{2}} \tag{12}$$

According to previous relevant studies[48–50], the classification criteria of the development indices adopted in this study are shown in Table 4, and the coupling coordination degree level classification criteria are shown in Table 5.

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Table 4. Criteria for classifying development indices.

Development Index	**[0-0.3)**	**[0.3-0.4)**	**[0.4-0.5)**	**[0.5-0.6)**	**[0.6-0.7)**	**[0.7-0.8)**	**[0.8-1]**
Level of development	Extremely low	Medium low	Lower	Medium	Higher	Medium high	Extremely high
	Low			Medium		High	

Table 5. Classification of the coupling coordination degree.

Coordination index	**Coordination phase**	**Degree of coordinated development**
[0-0.1)	Disordered type	Extremely disordered
[0.1-0.2)		Severely disordered
[0.2-03)		Mildly disordered
[0.3-0.4)		Endangered coordination
[0.4-0.5)	Transition type	Fragile coordination
[0.5-0.6)		Barely coordinated
[0.6-0.7)		Basic coordination
[0.7-0.8)		Intermediate coordination
[0.8-0.9)	Coordinated development	Well-coordinated
[0.9-1.0]		High-quality coordination

3.3. Study area and data sources

Jiangsu Province is located in the center of the eastern coast of mainland China, with an area of approximately 107,200 square kilometers, which accounts for 1.12% of the country's total area. The province also has the smallest per capita land area in China. The terrain of Jiangsu Province is dominated by plains, with the proportion of plains is the highest in the country. Jiangsu Province governs a total of 13 district cities. According to the geographical location of its district-level cities, Jiangsu Province can be divided into three regions: Southern Jiangsu, Central Jiangsu, and Northern Jiangsu. South of the Yangtze River is the Southern Jiangsu region, north of the Huai River is the Northern Jiangsu region, and between the Yangtze River and the Huai River is the Central Jiangsu region. The Southern Jiangsu region includes the five cities of Nanjing, Suzhou, Wuxi, Changzhou,

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and Zhenjiang; the Jiangsu region includes the three cities of Yangzhou, Taizhou, and Nantong; and the Northern Jiangsu region includes the five cities of Xuzhou, Lianyungang, Suqian, Huai'an, and Yancheng. These three regions are characterized not only by geographical and cultural differences but also by significant differences in their levels of economic development. Therefore, Jiangsu Province is selected as the research object for regional coordinated development because it is diverse and representative. This research provides some reference and guidance for research on regional coordinated development strategies in Jiangsu Province, in China and even worldwide.

The research data come from the annual statistical yearbooks published on the official website of the Jiangsu Provincial Bureau of Statistics. To study the balanced regional development of Jiangsu Province during the 12th and 13th Five-Year Plan periods, the statistical data from 2010, 2015, and 2020 were selected for analysis.

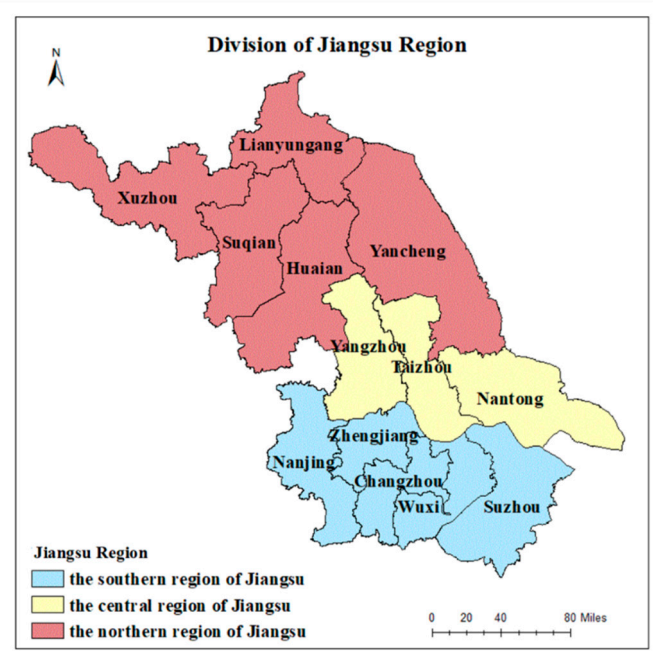

Figure 1. Location map of Jiangsu Province divided into southern, central and northern Jiangsu Province.

4. Analysis of results

4.1. Index weighting values

The final results of the weight values of the indices for the demographic, economic, and social systems for 2010, 2015, and 2020 were calculated using the entropy weighting method and are shown in Table 6.

Table 6. Weights of demographic-economic-social system indices (2010, 2015, 2020).

Level 1 indices	Secondary indices	Tertiary indices	W_{20} 10	W_{20} 15	W_{20} 20
Population development subsystem indices	Size of population	Number of births (persons)	0.09	0.08	0.07
		Number of deaths (persons)	0.05	0.06	0.05
		Household population at the end of the year (10,000)	0.06	0.06	0.06
		Year-end resident population (10,000)	0.08	0.07	0.09

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Level 1 indices	Secondary indices	Tertiary indices	W_{20}^{10}	W_{20}^{15}	W_{20}^{20}
Economic development subsystem indices	Quality of population	Illiteracy and semi-illiteracy (%)	0.07	0.10	0.06
		Undergraduate education and above (%)	0.07	0.10	0.06
		High school education and below (%)	0.08	0.06	0.07
		sex ratio at birth	0.08	0.08	0.05
	Population Structure	Percentage of 0-14-year-olds (%)	0.08	0.07	0.07
		Percentage of 15-64-year-olds (%)	0.12	0.10	0.12
		Percentage of persons aged 65 and over (%)	0.04	0.05	0.07
		Population density (persons/km2)	0.07	0.09	0.11
		Percentage of urban population (%)	0.10	0.09	0.11
	Size of economy	Year-end GDP (billions of yuan)	0.11	0.13	0.12
		Public budget revenue (billions of yuan)	0.12	0.14	0.15
		Gross industrial output (billions of yuan)	0.11	0.12	0.12
	Quality of the economy	GDP per capita ($)	0.09	0.10	0.08
		GDP growth rate (%)	0.05	0.05	0.07
		Per capita local fiscal revenue (ten thousand yuan)	0.09	0.09	0.11
		Gross industrial output per capita (million yuan)	0.10	0.12	0.10
	Economic Structure	Share of primary production value (%)	0.11	0.12	0.11
		Share of secondary production value (%)	0.10	0.05	0.04
		Share of output value of the third sector (%)	0.12	0.06	0.10
	Infrastructure	Road area per capita (square meters)	0.05	0.05	0.08
		Public transportation vehicles for 10,000 people (standard units)	0.06	0.04	0.07
		Oil and gas supply for 10,000 people (tons)	0.05	0.06	0.04
		Water supply per capita (tons)	0.07	0.08	0.07
Social development subsystem indices	Cultural Education	Per capita financial expenditure on education (yuan)	0.06	0.06	0.06
		Total number of students in school (10,000)	0.04	0.06	0.07
		Total number of teachers at all stages (10,000)	0.05	0.05	0.06
		Public library holdings per capita (volumes)	0.06	0.07	0.06
	Medical Protection	Total number of hospitals, health centers (number)	0.04	0.04	0.04
		Number of beds per 10,000 people (beds)	0.07	0.06	0.03
		Number of people enrolled in basic health insurance (%)	0.06	0.07	0.06
		Number of persons insured against work-related injuries (%)	0.08	0.09	0.09
		Number of participants in unemployment insurance (%)	0.07	0.07	0.08
	Ecological Environment	Sewage treatment rate (%)	0.08	0.03	0.07
		Volume of domestic waste removed (tons)	0.11	0.12	0.09

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Level 1 indices	Secondary indices	Tertiary indices	W_{20} 10	W_{20} 15	W_{20} 20
		Per capita green space in parks (square meters)	0.05	0.03	0.04

4.2. Development indices

According to the formula of the development index, the PES development indices of the 13 cities in Jiangsu Province in 2010, 2015, and 2020 were obtained. According to the classification criteria of the development indices in Table 4, the development levels of the 13 cities in Jiangsu Province in the corresponding years were determined, as shown in Table 7. Combined with the spatial-temporal evolution of the development indices of the PES system in Jiangsu Province (Figure 2), the following conclusions can be drawn.

In 2010, Suzhou had the highest level of development at 0.71, which indicates medium-high development. The second and third ranked cities were Nanjing and Wuxi, with values of 0.65 and 0.63, respectively, which indicate high development levels. Moreover, all three of these cities are located in Southern Jiangsu. In Central Jiangsu, except for the city of Taizhou, which has an extremely low development level, Nantong and Yangzhou have medium-low and lower development levels, respectively. In Northern Jiangsu, except for Xuzhou, which is at the medium-low development level, the remaining four cities have an extremely low level of development. In 2010, the development of the three regions was extremely uneven, with a large development gap. Generally, Southern Jiangsu has a significantly higher level of development than that of the Central Jiangsu and Northern Jiangsu.

During the 12th Five-Year Plan period, Jiangsu Province proposed the development goal of "promoting scientific development and building a better Jiangsu." After the 12th Five-Year Plan period, the city with the highest level of development according to the PES system was still Suzhou in 2015, with a score of 0.77, which was six percentage points higher than that of 2010 and remains at the middle-high development level. Nanjing had a score of 0.70, which is five percentage points higher than its score in 2010, taking it from the higher development level to the middle-high development level. Wuxi had a score of 0.60, which is three percentage points lower than that of its score 2010 but is still within the middle-high development level. Overall, the development level of Southern Jiangsu Province is higher than that of other areas within Jiangsu. The development level in cities in Central and Northern Jiangsu is the same as that in 2010, which was not high overall. Thus, during the 12th Five-Year Plan period, while Jiangsu Province grew overall, the level of economic development within the province was still unbalanced due to the strong level of development in Southern Jiangsu but the relatively weak development in Central and Northern Jiangsu. In particular, four cities with extremely low development levels exist in Northern Jiangsu.

During the 13th Five-Year Plan period, Jiangsu Province proposed the "Strong, Rich, Beautiful, and High" development agenda, which specifically refers to "Strong Economy," "Rich People," "Beautiful Environment," and "High Social Civilization." After the development of the 13th Five-Year Plan period, the city with the highest development level in the PES system was still Suzhou, and the city with the next highest development level was Nanjing in 2020; both of these cities had medium-high development. Taizhou in the central region of Jiangsu Province has risen from an extremely low level of development to a medium-low level of development, which means that there are no remaining cities in Central Jiangsu with an extremely low level of development. In addition, in Northern Jiangsu, there remains four cities with extremely low levels of development. Overall, the spatial distribution of the PES development indices in Jiangsu Province is somewhat stable. The areas with higher levels of development are mainly in Southern Jiangsu. The number and spatial distribution of cities with an extremely low level of development, which are mainly concentrated in Northern Jiangsu, remained relatively consistent over the 2010-2020 period.

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Table 7. List of PES Comprehensive Population-Economic-Social Development Indices for Prefectural-level Cities in Jiangsu Province.

Regions		2010			2015			2020		
		Index	Rankings	Level	Index	Rankings	Level	Index	Rankings	Level
Southern Jiangsu	Suzhou	0.71	1	Medium High	0.77	1	Medium High	0.76	1	Medium High
	Nanjing	0.65	2	Higher	0.70	2	Medium High	0.72	2	Medium High
	Wuxi	0.63	3	Higher	0.60	3	Higher	0.59	3	Higher
	Changzhou	0.45	4	Lower	0.45	4	Lower	0.46	4	Lower
	Zhenjiang	0.36	6	Medium Low	0.39	6	Medium Low	0.37	6	Medium Low
	Nantong	0.40	5	Lower	0.42	5	Lower	0.40	5	Lower
Central Jiangsu	Yangzhou	0.35	7	Medium Low	0.34	8	Medium Low	0.33	8	Medium Low
	Taizhou	0.29	9	Extremely Low	0.28	10	Extremely Low	0.30	9	Medium Low
	Xuzhou	0.33	8	Medium Low	0.36	7	Medium Low	0.32	7	Medium Low
	Yancheng	0.26	10	Extremely Low	0.29	9	Extremely Low	0.27	10	Extremely Low
Northern Jiangsu	Huai'an	0.24	11	Extremely Low	0.28	11	Extremely Low	0.25	11	Extremely Low
	Lianyungang	0.22	12	Extremely Low	0.24	12	Extremely Low	0.23	12	Extremely Low
	Suqian	0.21	13	Extremely Low	0.23	13	Extremely Low	0.22	13	Extremely Low

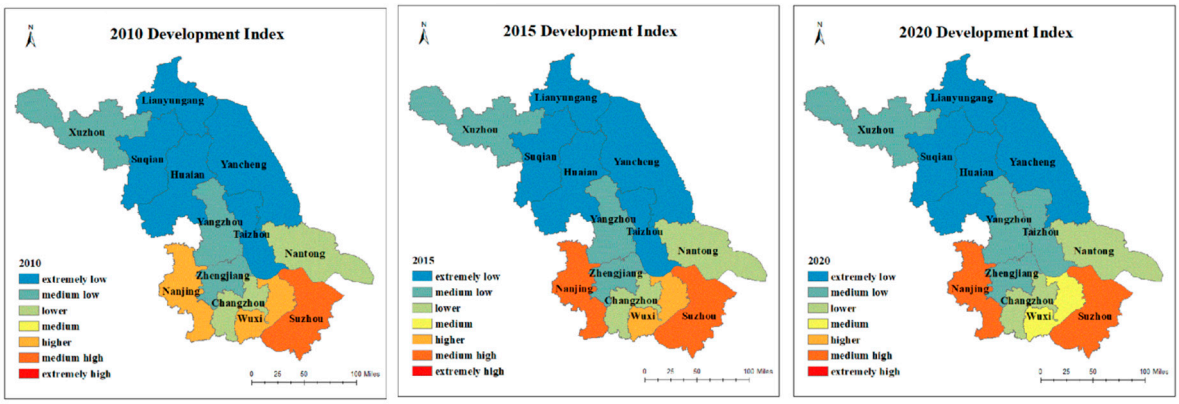

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Figure 2. Distribution of the PES system development indices of each prefecture-level city in Jiangsu Province from 2010 to 2020.

4.3. Coordination indices

According to the system coupling coordination degree calculation formula, the PES coupling coordination degree values of 13 cities in Jiangsu Province in 2010, 2015, and 2020 were derived, and the rankings are shown in Table 8. Combined with the distribution map of the PES system coupling coordination degree indices of each city in Jiangsu Province from 2010 to 2020 (Figure 3), it can be seen that the coupling coordination degree value of Suzhou was the highest in 2010, at 0.84, which is within the well-coordinated development stage. Therefore, Nanjing and Wuxi were both in the intermediate coordinated stage of development. In Southern Jiangsu, one city is in the stage of well-coordinated development, two cities are in the stage of intermediate coordinated development, and two cities are in the stage of basic coordinated development. In Central Jiangsu, one city is in the stage of basic coordinated development (Nantong), and two cities are in the stage of barely coordinated development. In Northern Jiangsu, one city is in the stage of barely coordinated development (Xuzhou), and four cities are in the stage of fragile coordinated development. Accordingly, the coupled coordination of population, economic, and social development systems in a city is strongly and positively related to the city's overall development level. After the 12th and 13th Five-Year Plans, Suzhou had the highest coupling coordination degree of 0.87 in 2020, which was three percentage points greater than that in 2010, and was in a well-coordinated development stage. The coupling coordination degree value of Nanjing is 0.85. Compared with 2010, it improved by six percentage points and is in the stage of well-coordinated development. In Central Jiangsu, Nantong is still at the primary coordination stage, with a coupling coordination value of 0.63, while Taizhou and Yangzhou are at the barely coordinated stage. Nantong benefited from the influence of the Shanghai Economic Circle, and the coordinated development of population, economy, and society was better than that of the other two cities. In Northern Jiangsu, Xuzhou is in the barely coordinated stage, and Yancheng improved from the fragile coordinated stage in 2010 to the barely coordinated stage in 2020, which was the result of rapid development within the city in the past few years. The remaining cities in Northern Jiangsu (Huai'an, Lianyungang, and Suqian), are still in the fragile coordination stage.

Achieving balanced regional development in Jiangsu Province faces two problems. First, the regional development of Jiangsu Province is unbalanced, and there are clear coordinated development blocks in Southern Jiangsu around Suzhou and Nanjing, barely coordinated development clusters in Central Jiangsu, and fragile coordinated development centers in Northern Jiangsu. Second, progress in closing the development gap in Jiangsu Province has been slow. Only Nanjing progressed from the intermediate coordination stage in 2010 to the well-coordinated coordination stage in 2020, and Yancheng improved from the fragile coordination stage to the barely coordinated stage over the same period. Otherwise, there was no change in the coupled coordination status of the remaining cities in the region.

Table 8. Ranking of PES System Coupling Coordination Degrees of Various Cities in Jiangsu Province.

Regions		2010			2015			2020		
		Value	Level	Rankings	Value	Level	Rankings	Value	Level	Rankings
Southern Jiangsu	Suzhou	0.84	Well	1	0.87	Well	1	0.87	Well	1
	Nanjing	0.79	Intermediate	2	0.83	Well	2	0.85	Well	2
	Wuxi	0.79	Intermediate	3	0.77	Intermediate	3	0.77	Intermediate	3

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Regions		2010			2015			2020		
		Value	Level	Rankings	Value	Level	Rankings	Value	Level	Rankings
Central Jiangsu	Changzhou	0.67	Basic	4	0.67	Basic	4	0.67	Basic	4
	Zhenjiang	0.60	Basic	6	0.62	Basic	6	0.60	Basic	6
	Nantong	0.63	Basic	5	0.65	Basic	5	0.63	Basic	5
	Yangzhou	0.59	Barely	7	0.58	Barely	8	0.57	Barely	7
	Taizhou	0.53	Barely	9	0.53	Barely	10	0.55	Barely	8
	Xuzhou	0.57	Barely	8	0.60	Basic	7	0.55	Barely	9
Northern Jiangsu	Yancheng	0.49	Fragile	10	0.54	Barely	9	0.51	Barely	10
	Huai'an	0.48	Fragile	11	0.52	Barely	11	0.49	Fragile	11
	Lianyungang	0.45	Fragile	12	0.48	Fragile	12	0.47	Fragile	12
	Suqian	0.45	Fragile	13	0.48	Fragile	13	0.46	Fragile	13

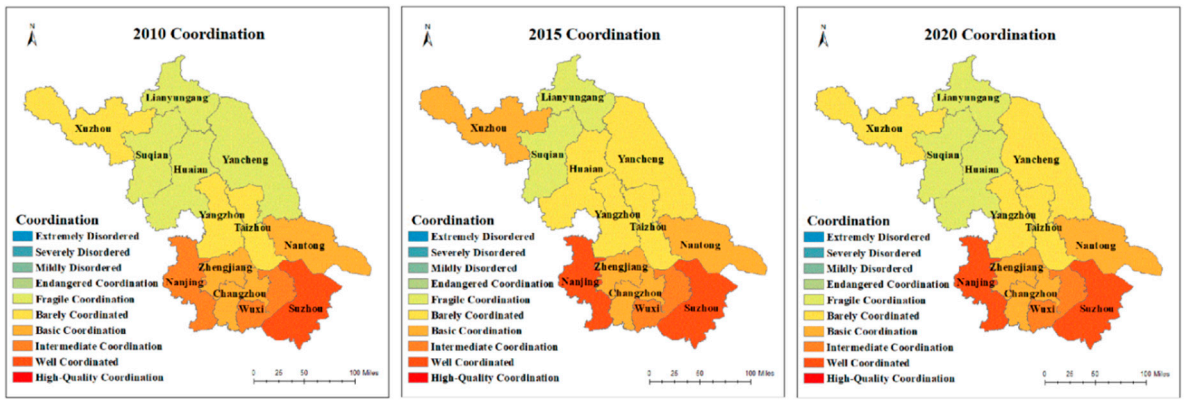

Figure 3. Distribution of the PES system coupling and coordination indices of each district-level city in Jiangsu Province from 2010 to 2020.

5. Discussion

Balanced and high-quality development of urban agglomerations is an important component and the foundation for building a new development pattern[51]. Thus, it is crucial to explore the reasons for the uneven development of urban agglomerations and discover countermeasures to establish new high-quality development patterns. The present study showed that the uneven development of city clusters in Jiangsu Province is mainly due to the following four reasons:

5.1. Geographic differences

Southern Jiangsu belongs to the core of the Yangtze River Delta Economic Circle. Influenced by the Shanghai area, from the 1980s, Southern Jiangsu vigorously developed township and village enterprises, established development zones, and attracted foreign investment[52]. These changes led to industrial and technological transfer throughout the Shanghai area, which was a major catalyst for economic development in Southern Jiangsu. This is a significant driving factor that enabled Southern

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Jiangsu to be in the leading position in the province in terms of economic development. Central Jiangsu has also achieved a certain degree of development under the influence of the Nanjing Metropolitan Area and the Yangtze River Delta Economic Belt[53]. However, compared with Southern Jiangsu, there remains room for improvement in terms of economic development. Northern Jiangsu is far from Shanghai, Nanjing, and other economic centers, so geographic is a disadvantage. There are no large and thriving cities to drive development[54], and development is lagging behind that of other cities. Geographic differences are a significant factor in the uneven regional development in Jiangsu Province.

5.2. The Matthew Effect

The Matthew effect is a theory of accumulation of dominance that is used to describe the phenomenon of "the strong becoming stronger and the weak becoming weaker"[55]. This theory has been widely applied to research in various disciplines[56]. The "Matthew effect," when applied to regional development, refers to the fact that regions with a high level of regional development will continue to grow, which means that the level of development in Southern Jiangsu will always be higher than that in Central Jiangsu and Northern Jiangsu[57]. Since the reform and opening up, Southern Jiangsu has accumulated wealth that is incomparable to that of Central Jiangsu and Northern Jiangsu and has formed a solid economic foundation of technology, capital, and talent. This solid good foundation provides the necessary conditions for all kinds of innovation[58], which then attracts more resources, creating a "siphon" phenomenon where Southern Jiangsu absorbs more advanced technology, talented people, and high-quality capital, accelerating further development[59]. The economic foundation of Northern Jiangsu has always been inferior to that of Southern Jiangsu. Therefore, this area is unable to attract production factors; thus, its development continues to lag behind. The difference in economic foundations has led to the Matthew effect in regional development, which exacerbates the unevenness of regional development.

5.3. Game thinking

Economic development is, to some extent, linked to the performance of local governments. In practice, local authorities tend to maximize their own interests[60], and economically developed regions may believe that “gaming” is preferable to “mutual benefit" [61]. This leads to a lack of mobility of production factors and inter-regional links are weak, which hinders the formation of effective cooperation mechanisms. Thus, these inter-regional barriers make it difficult to achieve balanced development within Jiangsu Province. Game thinking is one plausible explanation for unbalanced regional development in Jiangsu Province[62].

5.4. Differences in industrial structure

Industrial structure refers to the proportional relationship between industries in the national economy and the connections between them[63]. According to data from the Jiangsu Provincial Statistical Yearbook, the proportion of the output value of primary and secondary industries in each region of Jiangsu Province from 2010 to 2020 decreased over time while the proportion of the output value of tertiary industry increased. However, in terms of industrial structure, the proportion of the output value of primary and secondary industries in Southern Jiangsu is much smaller than that in Central and Northern Jiangsu, while the proportion of the output value of tertiary industry is much greater than other areas[64]. The difference in industrial structure has caused different speeds of economic development between the three major regions of Jiangsu Province[65], which have resulted in unbalanced regional economic development.

6. Conclusions and Recommendations

The development and coordination indices of the three regions in Jiangsu Province were analyzed in depth. There are clear differences in the development levels of the three regions, with the overall development level of Southern Jiangsu being higher than that of Central and Northern

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Jiangsu. In terms of the degree of coupling and coordination, the overall development of Southern Jiangsu is better than that of Central and Northern Jiangsu. Throughout the history of economic and social development in China and the West, due to different factors, such as location, resource endowment, productivity level, and social system, the problem of uneven regional development has existed for a long time. This problem should be addressed in a scientific manner[66]. Given the context of smart cities developing worldwide, smart city clusters will ultimately form. To increase the efficiency of such development [67], it is important to balance the development between city clusters. To foster coordinated development among smart cities and city clusters within a region, this study proposes the following recommendations:

6.1. Strengthen cross-regional cooperation

Strengthening regional cooperation is important to ensure balanced development between city clusters[68]. Therefore, it is necessary to clearly define and plan development strategies for each city, breakdown geographical barriers, and deepen cooperation among cities in the region. By facilitating the flow of production factors and effectively integrating various types of resources, each region can leverage their respective comparative advantages and maximize their benefits through an optimal division of labor. Moreover, deepening cross-regional cooperation between city clusters can solve common problems in building smart cities[69]. Smart cities should share their successful experiences and best practices, specify the goals and areas of cooperation, and collectively explore the common challenges and solutions in the construction of smart cities. By strengthening cooperation among cities, duplication of resources and waste can be avoided, raising the overall efficiency of smart city construction, respective development capacities, and mutual benefits[70].

6.2. Promote data sharing and interoperability

The construction of smart cities involves the collection and processing of a large amount of data [71], including transportation data, environmental data, and energy data. Thus, data sharing and interoperability are important components of creating smart cities. Cities can establish a data sharing platform to achieve data interoperability and sharing. The data sharing platform can include functions such as data collection, storage, processing, and visualization[72]. Cities can share their data resources with other cities through this platform, improving the efficiency of data utilization. In addition, data sharing can promote exchanges and cooperation between cities and foster synergistic development[73]. This approach can better utilize data resources and improve the efficiency of urban management and decision-making.

6.3. Deepen industrial synergistic development

The synergistic development of industries among city clusters is important for the construction of smart cities, which involves the integrated development of several industries, including transportation, energy, and the environmental. City clusters within the same region can strengthen cooperation in these sectors to create industrial synergy[74]. For example, in transportation, cities can jointly develop intelligent traffic management systems to share traffic information and improve the efficiency of traffic management[75]. In energy, cities can collectively promote clean energy to reduce energy consumption and pollution emissions[76]. In environmental protection, cities can work together to carry out environmental monitoring and pollution control[77]. The competitiveness of smart city construction can be enhanced through collaborative industrial development.

6.4. Foster innovation capacity

Enhancing urban innovation capacity is key to the construction of smart cities[78], which requires innovative thinking and technology[79]. Thus, city clusters within the same region can create and strengthen innovation mechanisms and institutions to cultivate innovation capacity. Specifically, cities should increase their investment in science and technology innovation to support the relevant enterprises and scientific research institutions. Cities should also strengthen the development of

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talent, establish a knowledge base for smart city construction, and cultivate a group of smart city construction professionals with innovative mindsets and practical skills. In addition, cities should adopt a healthy talent management system to absorb and retain talent. Furthermore, cities should increase cooperation with international advanced science and technology enterprises and research institutions as doing so can enhance urban innovation capacity[80].

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