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Study on the Coupled Coordinated Development of New Urbanization and Urban Resilience in Huaihe River Basin

Shuang Li

School of Management Science and Engineering, Anhui University of Finance and Economics, Bengbu, Anhui 233000, China

1839938026@qq.com

Abstract

The coupled and coordinated development of new urbanization and urban resilience can promote the disaster response, disaster resistance and high-quality development of urban agglomerations in the Huaihe River Basin. The article constructs a new urbanization system and a chain-type urban resilience evaluation system with the mechanism of "pressure-feedback", selects the central city of Huaihe River Basin as the research object, and measures the new urbanization and urban resilience level and change trend of the central city of Huaihe River Basin in 2012-2021 with the help of the coupling coordination model. Using the entropy value method, we measured the new urbanization and urban toughness level and the trend of change of the central cities in Huaihe River Basin from 2012 to 2021, measured the type of city cluster coupling coordination and its internal factors with the help of the coupling coordination model, and analyzed the coupling coordination relationship between the two.

Keywords

New urbanization; Urban resilience; Coupled coordination model; Huaihe River Basin.

1. Introduction

Since the reform and opening up, the level of urbanization in China has been increasing, with the urbanization rate reaching 63.89% in 2020. While China's urbanization is developing rapidly, the rapid development of population and urban activities has led to the instability of the internal structure of cities, and the contradiction between the traditional urbanization development mode and the ecological environment and resource environment has become more and more prominent. In order to guarantee the promotion of urbanization and reflect the core of "people-oriented", the State proposed in the "Vision 2035" to improve the new urbanization strategy and enhance the quality of urbanization development, and in the "14th Five-Year Plan" to improve the quality of urbanization development, and in the "14th Five-Year Plan" to improve the quality of urbanization. In the "14th Five-Year Plan", it is pointed out that it is necessary to improve the capacity of urban disaster prevention and mitigation, and enhance the resilience of cities. The Huaihe River Basin has a resident population of about 164 million (with a household population of about 191 million), accounting for about 11.8% of the total population of the country, with an urbanization rate of 54.2%, and it is an area covered by the Yangtze River Economic Belt, the Yangtze River Delta Integration, and the Central Plains Economic Zone. Influenced by the natural climate, the climate in the basin is variable, the precipitation varies greatly, the distribution is uneven within the year, the urbanization rate of some cities is higher than the average level of the region, and it is currently on the road of high-speed development, and the traditional mode of urbanization development is increasingly constrained by the natural climate. Therefore, the promotion of new urbanization is a must for future urbanization development, but the development still needs the support of material

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resources, the previous rough high-speed development mode has produced a serious threat to the ecology, the city's ecosystem has endured from the climate, natural disasters and the impact of the disturbance. The only way to improve the resilience of the city is to improve the level of resilience, and to deal with the relationship between the quality of urbanization and the stability of the urban system while the urbanization rate is increasing. Based on this, this paper investigates the coupled and coordinated relationship between new urbanization and urban resilience in the Huaihe River Basin urban agglomeration, which is of great theoretical significance for the promotion of high-quality new urbanization in the Huaihe River Basin.

2. Literature Review

The current research on new urbanization is mainly carried out in three directions, one is the connotation of the elaboration, Liu Yan Sui et al.[1] pointed out that the new urbanization is not an independent unit of development, should be considered from the economic, social, spatial and other multi-dimensional perspectives, scientific coordination of the promotion of the development of the new urbanization; new urbanization of the transformation of the idea is not something out of nothing, but there are traces of it, in accordance with the law of the[2] . Secondly, the status quo and defects of the new urbanization process, at present, there is still a gap between China's urbanization level and that of developed countries[3] , the high-speed development of a large number of towns and cities in the previous period has neglected the quality of construction and overdrawn the vitality of natural resources as a price[4] , and it is necessary to explore a feasible road of new urbanization[5] . Thirdly, the construction of evaluation method and evaluation index system, commonly used subjective empowerment method and objective empowerment method for empowerment, Zeng et al.[6] established hierarchical indexes from environmental, demographic, economic and social aspects to measure the level of urbanization, Lan Qingxin et al.[7] used spatial measurement model to make objective evaluation of the influencing factors, and put forward feasible countermeasures and suggestions for policies and behaviors[8] .

Holling[9] was the first to introduce the concept of "resilience" in physics into ecological research in 1973, using the speed of the system to return to equilibrium to measure the size of resilience, resilience research concepts have gradually extended from "ecological resilience" to "social resilience" to "urban resilience". The concept of resilience research has gradually extended from "ecological resilience" to "social resilience" and evolved to "urban resilience"[10] . At present, the research on urban resilience mainly focuses on three aspects: first, the definition of urban resilience, with the improvement of domestic and international research, it is believed that urban resilience should include the ability of cities to absorb and digest unexpected natural disasters, major infectious diseases, economic losses and other emergencies, and to restore relative stability[11] . Secondly, the construction and measurement of urban resilience index system, based on the concept of urban resilience, experts use the comprehensive assessment method[12] and spatial autocorrelation analysis[13] to measure the level of urban resilience in different places and the characteristics of spatial and temporal distribution. Thirdly, the research framework and development prospect of urban resilience, safety, low carbon, plasticity and sustainability have become the core objectives of urban development[14] . However, the concept of urban resilience has been developed for a relatively short period of time, and there is still a gap in the research on the mechanism of urban resilience.

The research on new urbanization and urban resilience mainly focuses on the coupling relationship between urbanization and urban resilience, and scholars have already explored the related fields and achieved certain results. Most scholars study the relationship between new urbanization and urban resilience from the perspective of city clusters, for example, Wang Shaojian et al.[15] used the Pearl River Delta region as the object of research to explore the

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interactive coercive relationship between urbanization and ecological resilience. Zhang Yueqian et al.[16] explored the spatial and temporal evolution of new urbanization and urban resilience using the Yangtze River Delta city cluster.

In summary, the above studies have analyzed new urbanization and urban resilience from different perspectives, and although they have achieved a lot of results, there are still some shortcomings: first, there is still a gap in the elaboration of the connotation of new urbanization and urban resilience, which only reflects the current development capacity of the city, but fails to explore the potential of the city to transform opportunities into advantages. Second, the evaluation system of new urbanization and urban resilience is not perfect, and no collective consensus has been reached on the multi-dimensional influencing factors to form a systematic evaluation index. Third, the evaluation methods that can identify the interrelationship between new urbanization and urban resilience are not accurate enough to show the interaction between the two in a comprehensive way. In view of this, this paper firstly focuses on the core objective of "people-oriented" to build an evaluation system for new urbanization and urban resilience, and optimizes the evaluation indexes on the basis of the existing resilience theoretical framework; secondly, it considers the influencing factors at multiple levels, and researches the coupling relationship between new urbanization and urban resilience, and searches for the key factors affecting the coordinated development of both sides; finally, it selects the key factors that influence the coordinated development of both sides. The key factors affecting the coordinated development of both sides; finally, the Huaihe River Basin city cluster is selected as the research object to analyze the spatial and temporal differences and advantages and shortcomings among cities, play the leading role of advantageous cities, and provide feasible suggestions for the governance of Huaihe River Basin and the reduction of flood disasters.

3. Evaluation System for Coordinating the Coupling of New Urbanization and Urban Resilience

New urbanization is a complex process that involves a variety of factors, including changes in demographic, economic, industrial and spatial structures. It has livelihood, sustainable development and quality as its connotations, and transformation, green, low-carbon and health as its core objectives. According to existing studies, there are four main aspects to measure the urbanization process: demographic urbanization, economic urbanization, social urbanization, and spatial urbanization. Based on this and existing literature, this paper constructs a new urbanization index system, as shown in Table 1.

Table 1. New urbanization indicator system

Research system	Evaluation dimension	Evaluation indicators	Unit (of measure)	Indicator properties	Markings
new urbanization	urbanization of population	Population urbanization rate	%	+	z1
		Population and urban density	Persons/km2	+	z2
		Share of employees in secondary and tertiary industries	%	+	z3

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	economic urbanization	GDP growth rate	%	+	z4
		Average wage of employees	the Yuan or Mongol dynasty (1279-1368)	+	z5
		Share of employees in secondary and tertiary industries	%	+	z6
	social urbanization	Financial expenditure on science and education	ten thousand dollars	+	z7
		Total retail sales of consumer goods	ten thousand dollars	+	z8
		Public Trams per 10,000 population	classifier for wheeled vehicles; such as cars, bicycles	+	z9
	spatial urbanization	Built-up area as a proportion of urban area	%	+	z10
		Urban living space per capita	Square meters/person	+	z11
		Road area per capita	Square meters/person	+	z12

In terms of urban resilience, it reflects the self-preventive and self-recovery ability presented by cities in the face of disturbances and shocks from uncertainties[17] . Drawing on existing evaluation systems, urban resilience consists of economic resilience, social resilience, ecological resilience and infrastructure construction resilience, and its internal logic can be interpreted as follows: economic resilience is the driving force for maintenance, ecological resilience is the bottom line of development, infrastructure construction resilience is an external tool for upgrading the resilience, and social resilience is the external feature of the optimization of the urban structure, the dynamic evolution of the quality of construction, and the transformation of the human factor that accompanies the resilience upward process. The social resilience is the external characteristics of the optimization of urban structure, the dynamic evolution of construction quality and the transformation of human factors. It can be seen that the ability of urban system to resist, dissipate and adapt to unknown risks can be measured by urban toughness, and urban toughness can play a positive feedback role in the process of new urbanization, forming a "pressure-feedback" mechanism, based on which this paper constructs an urban toughness evaluation system, as shown in Table 2. Based on this, this paper constructs the urban resilience evaluation system, as shown in Table 2.

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Table 2. Urban resilience evaluation system

Research system	Evaluation dimension	Evaluation indicators	Unit (of measure)	Indicator properties	Markings
Urban resilience	economic resilience	GDP per capita	Yuan/person	+	v1
		GDP growth rate	%	+	v2
		Gross industrial output value above scale	ten thousand dollars	+	v3
	social resilience	General higher education enrolment per 10,000 population	man	+	v4
		Health technicians per 10,000 population	man	+	v5
		Urban registered unemployment rate	%	-	v6
		natural population growth rate	%	+	v7
	ecological resilience	Green space coverage in built-up areas	%	+	v8
		Green space per capita in parks	Person/square meter	+	v9
		Municipal waste disposal capacity	kg	+	v10
	Infrastructure resilience	Number of beds	sheet of paper	+	v11
		Number of medical institutions	classifier for individual things or people, general, catch-all classifier	+	v12
		Electricity consumption of society as a whole	Billion kW-h	+	v13
		Total urban gas supply	million m3	+	v14

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4. Research Methodology

4.1. Entropy value method

The entropy value method is the method of determining the weights of indicators based on the size of the amount of information transmitted by each indicator to the decision maker. The greater the difference in an evaluation indicator, the smaller the entropy value, the more information the indicator contains and transmits, and the greater the corresponding weight, thus indirectly portraying the degree of importance of the indicator.

The raw data were first standardized. The calculation formula is as follows:

Standardization of positive indicators:

$$x'_{ij} = \left[\frac{x_{ij} - \min\left(x_{1j}, x_{2j}, \cdots, x_{nj}\right)}{\max\left(x_{1j}, x_{2j}, \cdots, x_{nj}\right) - \min\left(x_{1j}, x_{2j}, \cdots, x_{nj}\right)} \right] \tag{1}$$

Negative indicators are standardized:

$$x'_{ij} = \left[\frac{\max\left(x_{1j}, x_{2j}, \cdots, x_{nj}\right) - x_{ij}}{\max\left(x_{1j}, x_{2j}, \cdots, x_{nj}\right) - \min\left(x_{1j}, x_{2j}, \cdots, x_{nj}\right)} \right] \tag{2}$$

Where x'_{ij} is the value of the *jth* indicator for city *i*. Subsequently, for convenience, x'_{ij} is still denoted as x_{ij} .

Indicator weighting calculation:

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}} \tag{3}$$

Calculate the entropy value of the *jth* indicator e_j :

$$e_j = -k \sum_{i=1}^{n} p_{ij} \ln(p_{ij}), k = \frac{1}{\ln(n)} \tag{4}$$

Calculate the coefficient of variation g for the *jth* indicator$_j$:

$$g_j = \frac{1 - e_i}{m - E_e}, E_e = \sum_{j=1}^{m} e_i \tag{5}$$

Calculate the weights:

$$w_1 = \frac{g_j}{\sum_{j=1}^{m} g_j} (1 \le j \le m) \tag{6}$$

4.2. Coupled Coordination Model

The coupling and coordination model can be used to measure the coupling between new urbanization and urban resilience, reflecting the interrelationships between the two systems, with the degree of coupling illustrating the strength of interdependence and mutual constraints between new urbanization and urban resilience, and the degree of coordination emphasizing the coordinated evolutionary trend of the two systems, new urbanization and urban resilience. The specific model is as follows:

$$C = 2\sqrt{\frac{U_1 \times U_2}{(U_1 + U_2)^2}} \tag{7}$$

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Where C is the coupling degree of new urbanization level and urban resilience level; U_1 is the new urbanization level; U_2 is the urban resilience level. Since the coupling degree cannot measure the consistency between the two systems, and it is easy to have a high coupling state when the evaluation index of the two systems is very low and the value is close to each other, thus the coordination degree model is introduced to reflect the coordination degree of the interaction between the two systems. The coordination degree model is as follows:

$$D = \sqrt{C \times T}, T = \alpha U_1 + \beta U_2 \tag{8}$$

Where D is the degree of coordination between new urbanization and urban resilience, T is the comprehensive coordination index, α and β represent the importance of new urbanization and urban resilience respectively, and this paper considers that the two systems are equally important, so the values of α and β are both 0.5.

4.3. Gray correlation model

Gray correlation analysis reflects the order of proximity of each evaluation object to the ideal object, using the gray correlation model can be used to calculate the degree of correlation between the coupled coordination of new urbanization and urban resilience level in the Huaihe River ecological and economic belt and the various influencing factors, and the specific calculation steps and formulas are as follows:

The coupled coordination degree of new urbanization and urban resilience level of each city selected from the Huaihe River Ecological Economic Zone is used as the reference sequence $y_0 = \{y_0(t)\}, t = 1, 2, ..., n$. The coupled coordination influencing factors of each city are used as the comparison sequence: $\{x_i(t)\}, i = 1, 2, ..., k$.

Calculate the gray correlation coefficient.

$$\varepsilon_i(k) = \frac{\min_i \min_k |y(k) - x_a(k)| + \rho \max_i \max_k |y(k) - x_i(k)|}{|y(k) - x_i(k)| + \rho \max_i \max_k |y(k) - x_i(k)|} \tag{9}$$

Relevance calculation.

$$S_i = \frac{1}{n} \sum_{k=1}^{n} \varepsilon_i(k) \tag{10}$$

Where S_i is the gray correlation degree, $\varepsilon_i(k)$ is the gray correlation coefficient, $\min_i \min_k |y(k) - x_a(k)|$ and $\max_i \max_k |y(k) - x_i(k)|$ are the minimum and maximum values of the extreme deviation, respectively, and ρ is the resolution coefficient（0.5） and $k = 1, 2, ..., n$.

5. Analysis of Results

5.1. New urbanization and the temporal evolution of urban resilience

The development levels of new urbanization and urban resilience in Huaihe River ecological economic belt cities are shown in Figure 1. As a whole, from 2012 to 2021, the new urbanization and urban resilience of Huaihe River Ecological Economic Belt cities are in the trend of steady rise and fluctuating rise, respectively, and the level of urban resilience is slightly higher than the level of new urbanization before 2016, and the level of new urbanization is higher than the level of urban resilience in an accelerating trend after 2016, and it is significantly higher than the level of urban resilience after 2018 . In terms of specific values, the new urbanization level and the urban toughness level are often in the 0.2~0.4 range, indicating that many cities in the Huaihe River Ecological Economic Zone have a low level of construction and still have a large potential for development, in which the new urbanization level increased from 0.2220 in 2012

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to 0.4205 in 2021, a relative increase of 89.41%, with an average annual growth rate of 7.45%, and the new urbanization level has nearly doubled, and in terms of dividing the time period, the rise in the new urbanization level during 2015-2021 is higher, which is mainly due to China's strong support for the construction of new urbanization, and in the process of promoting the construction, it has given policy support for the development of urbanization and demographic restructuring. In addition, the level of urban resilience was raised from 0.2382 in 2012 to 0.3797 in 2021, a relative increase of 59.40%, with an average annual growth rate of 4.95%, compared with the new urbanization level of a slower growth rate, and in 2018 to 0.3152 is slightly lower than the previous year, 2017, 0.3162, the reason for this is that in the process of pushing forward urbanization, blind spreading of the big cake style expansion, resulting in ecological damage to the city, high risk of industrial transformation, urban population pressure and other problems, making urban resilience in an unstable state.

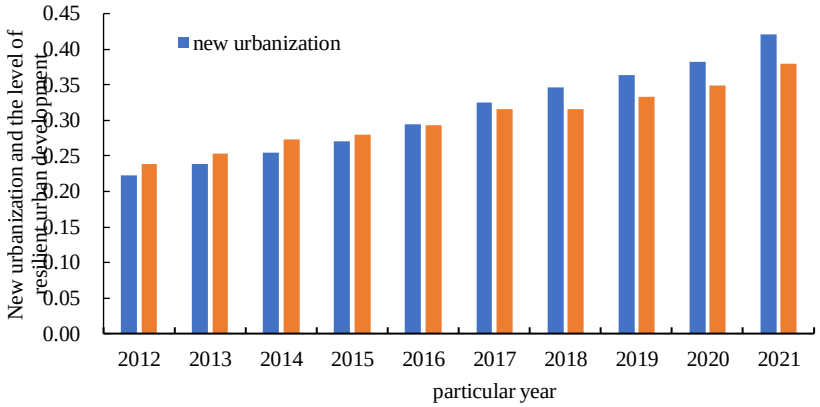

Figure 1. Trends in the level of development of new urbanization and urban resilience

5.2. Analysis of factors affecting the degree of coupling coordination

The coupled and coordinated development process of new urbanization and urban resilience level in Huaihe River Ecological Economic Zone is affected by many factors, combined with the reality and existing research results, this paper uses the gray correlation model to quantitatively analyze the intrinsic influencing factors of the coupled and coordinated degree of new urbanization and urban resilience, and selects the gross domestic product per capita (X1) to represent the level of economic development, the population density of cities and towns (X2) to represent the social construction level, the The green space coverage rate of built-up area (X3) represents the level of ecological construction, the road area per capita (X4) represents the level of infrastructure construction, the amount of utilized foreign capital (X5) represents the level of opening up of the city to the outside world, the number of health technicians per 10,000 people (X6) reflects the ability to cope with risks, the per capita disposable income (X7) reflects the ability to meet market demand, and the proportion of science and education expenditure in the total expenditure (X8) reflects the ability of scientific and technological innovation. innovation ability, as factors affecting the coupling and coordination of new urbanization and urban resilience level. Taking the coupling coordination degree of new urbanization and urban resilience in Huaihe River Ecological Economic Zone as a reference series, the correlation degree of each factor on the coupling coordination of new urbanization and urban resilience level is calculated, as shown in Table 3.

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Table 3. Gray correlation of each influential factor of the coupled coordination degree of new urbanization and urban resilience

factor	norm	relatedness	arrange in order	factor	norm	relatedness	arrange in order
Level of economic development	X_1	0.5963	8	Level of urban openness to the outside world	X_5	0.7967	5
Level of social construction	X_2	0.8176	3	Risk responsiveness	X_6	0.8738	2
Level of ecological construction	X_3	0.8082	4	Market demand capacity	X_7	0.6544	6
Level of infrastructure development	X_4	0.9305	1	Science, technology and innovation capacity	X_8	0.6472	7

From the calculation results in Table 4, it can be seen that the coupling coordination degree of new urbanization and urban resilience in Huaihe River Ecological Economic Zone and the grey correlation degree between each influencing factor are all more than 0.5, which indicates that the above selected influencing factors have a strong effect on the promotion of coupling coordination degree. Among them, the gray correlation rankings of infrastructure construction level, risk response ability, social construction level and ecological construction level are in the top four, and the correlation degree is more than 0.8, which belongs to the strong correlation degree; the level of urban openness to the outside world, the ability of market demand, and the ability of scientific and technological innovation, correspond to the fifth, sixth, and seventh places, respectively, and the gray correlation degree is more than 0.6, which belongs to the stronger correlation degree; and the gray correlation degree of the level of economic development is 0.5963 is slightly lower than 0.6, ranking in the last place, belonging to medium correlation. The top four influencing factors reflect that the internal construction of the city is an important factor affecting the coupling of new urbanization and urban resilience. Accelerating the construction of urban infrastructure improves the ability of the city to cope with and resist disasters, improves the governance mode of the urban society, and protects the urban ecological environment so as to improve the resilience of the city, and provides a strong guarantee for the high-quality development of the city. The last level of economic development indicates that the region needs to pay attention to the internal construction of the city in a timely manner, and can no longer blindly carry out economic expansion, which weakens the level of urban resilience; it should speed up the adjustment of the industrial structure and optimize the strategic approach of the economy, so as to narrow the gap between the two systems and improve the level of coupling and coordination between the two systems.

6. Conclusions and Suggestions

In this paper, 25 cities in Huaihe River Ecological Economic Belt are selected as research objects, firstly, the evaluation index system of new urbanization and urban resilience is constructed, and the new urbanization and urban resilience levels during 2012-2021 are measured respectively, and their spatio-temporal pattern evolution characteristics are analyzed. Finally, the influencing factors affecting the degree of coupling coordination are analyzed by using the gray correlation model, trying to explore the key factors.

From 2012 to 2021, the level of new urbanization and urban resilience in Huaihe River Ecological Economic Zone shows a general upward trend, and the growth rate of new urbanization is slightly faster than the growth rate of urban resilience, and although both are

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growing steadily, the development gap still exists. The coupling and coordination degree of new urbanization and urban resilience is affected by economic development, social construction, ecological construction, infrastructure construction and other factors, in which attention should be paid to the internal construction of the city, avoiding unlimited economic expansion and weakening of the city's carrying capacity, adjusting the development strategy in a timely manner, narrowing the gap between the new urbanization and the urban resilience level, and awakening the vitality of high-quality urban development.

Improve the level of new urbanization, firmly grasp the concept of green development, and promote the high-quality development of new urbanization. Cities with a high level of new urbanization should take the lead and play an exemplary role, and on the basis of their own existing foundation, combine the key influencing factors to continuously explore the road of high-quality development, so as to provide reference for medium- and low-level cities and optimize the previous problem of blind expansion at the same time.

Establish the concept of resilient city development, strengthen the development of urban infrastructure, optimize the planning of spatial pattern, improve the utilization efficiency of resources, protect green ecological space, reduce the pressure on the ecological environment, enhance the strength of the city to withstand risks, implement intelligent construction and management of the city, give full play to the driving effect of the highly resilient city, and promote the balanced development of the Huaihe River Ecological and Economic Belt.

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