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Spatio-temporal Coupling Analysis of New-type Urbanization, Rural Revitalization and Economic Resilience in the Yellow River Basin

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ABSTRACT

Research on the coupling coordination of new-type urbanization, rural revitalization and economic resilience development in the Yellow River Basin is important for the country to achieve sustainable development. In this study, the comprehensive index system was built to assess the levels of new-type urbanization, rural revitalization and economic resilience of nine provinces (autonomous regions) in the Yellow River Basin from 2009 to 2020. Coupling coordination degree model(CCDM)and obstacle degree model (ODM) were used to explore the interactive relationship between these three subsystems and the influencing factors of coupling coordination degree. The study found that the spatial and temporal differences in the coupling coordination degree of new-type urbanization-rural revitalization-economic resilience in the Yellow River Basin are significant. The overall spatial pattern shows the distribution characteristics of high in the southwest and low in the northeast, and the overall evolution pattern of coupling coordinated development from low level to high level. In addition, the factors influencing the coupling coordination degree of the three systems in each province are basically the same, and the coupling coordination degree is most influenced by the proportion of technology market contract turnover to GDP.

KEYWORDS

New-type Urbanization; Rural Revitalization; Economic Resilience; Coupling Coordination Degree; Yellow River Basin.

1. INTRODUCTION

The Yellow River Basin spans nine provinces and is an important economic zone in China. In the context of China's rapid economic development, the overall economic performance of the Yellow River Basin has shown a positive trend since the reform and opening-up period, with GDP steadily increasing. In the Yellow River Basin, despite the high economic growth rate, the economic policies associated with traditional urbanization have exacerbated the gap between urban and rural areas, leaving villages increasingly vulnerable to decline and decay [22]. Therefore, how to mitigate the widening urban-rural gap resulting from traditional urbanization and economic growth, as well as how to leverage urban-rural coordination to transform the economic growth model and enhance the quality of economic growth, have consistently been subjects of broad academic interest [11, 15].

Rural revitalization and new-type urbanization are key development strategies in China's new era. Urbanization refers to the process of concentrating non-agricultural industries and rural populations in cities and towns, serving as a significant driver of economic development [13]. Traditional urbanization studies focus too much on population gathering, industrialization and urban space expansion, and not enough attention is paid to the problems of urban-rural dual structure and

uncoordinated development of industry and agriculture in each province [4]. The new-type urbanization study enriches the connotation of urbanization, and on the basis of the original content of concern, emphasizes that urban and rural integration is people-oriented, promoting agriculture with industry, and taking urban and rural areas into consideration [23]. And the rural revitalization strategy is proposed to solve the“Agriculture, Countryside and Farmer” issues, especially the unbalanced development of urban and rural areas and the inadequate development of rural areas [28]. In pursuing high-quality development under the strategies of new urbanization and rural revitalization, China's focus is shifting from aggregate economic expansion to building resilience—the capacity to withstand disruptions and maintain stability, which is termed economic resilience [8].Therefore, during this critical period, it is essential to examine the relationship between the two major strategies and economic resilience in order to promote integrated urban-rural development and achieve high-quality development of China’s regional economy

The existing research on new-type urbanization and rural revitalization mainly focuses on two aspects [2]: theoretical discussion and empirical analysis. (1) The theoretical exploration of development pathways and strategic coupling mechanisms. By analyzing the current situation of the development of rural revitalization and new-type urbanization, the problems of rural revitalization and new-type urbanization strategies were pointed out [20, 24], and the realization mechanisms for the coupled and coordinated development of new-type urbanization and rural revitalization were constructed [9], such as the mechanism of two-way flow of urban and rural factors and resources, the mechanism of integrated development of urban and rural industries, the mechanism of balanced allocation of urban and rural public services, the mechanism of integrated development of urban and rural spaces, and the mechanism of coordinated management of urban and rural ecological environment. (2) This study aims to explore the interaction between the two through data analysis. This type of research mainly takes the development of towns and villages in a certain region as the research object, constructs the evaluation index system of the development level of new-type urbanization and rural revitalization in the region. This leads to the conclusion that the two are not simply "When one is rising, the other is falling.", but are mutually reinforcing and influencing each other.

Scholars have more frequently examined the relationship between rural revitalization and economic resilience from the perspective of data analysis. Li et al. (2021c) and Duan and Xuan (2021), employing the Pressure-State-Response model and a Coupling Coordination Degree Model (CCDM) respectively, assessed rural economic resilience in Henan and Jiangsu provinces [7, 12]. Their findings indicate that the Rural Revitalization Strategy enhances economic recovery, while also revealing significant spatial and temporal divergences and spatial correlations between resilience and rural revitalization

The study of urbanization and economic development has gained significant attention within the research community, with numerous scholars investigating the interaction between urbanization and economic development. Liang et al. (2022) explored the causal relationship between urbanization and economic development in China, arguing that economic development is an important factor in promoting urbanization and that urbanization is a product of economic development [13]. However, there is no mature theoretical system for economic resilience as a research branch of economic development, so there are fewer studies on the mutual relationship between urbanization and economic resilience.

In this study, nine provinces (autonomous regions) in the Yellow River Basin were selected as the study area. The main objectives of this study include: (1) Constructing an evaluation index system for the coupling and coordination of new urbanization-rural revitalization-economic resilience; (2) Quantitatively examining the coupling and coordination relationship between the development status of the three subsystems in time and space in nine provinces and regions of China from 2009 to 2020 using the coupling and coordination degree model. (3) Constructing a barrier degree model to analyze the influencing factors of the coupling coordination degree of new-type urbanization-rural revitalization-economic resilience. This study will provide a theoretical basis for promoting the

coordinated development of urban and rural economies, thus contributing to the task of sustainable development.

2. MATERIALS AND METHODS

2.1. Study Area

The Yellow River is the mother river of the Chinese nation and the second largest river in China. It flows through 9 provinces (autonomous regions) of Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shaanxi, Shanxi, Henan and Shandong (Fig. 1). The implementation of new-type urbanization and rural revitalization strategies in this region has a very important impact on the level of economic resilience and the status of high-quality development in China. [17]Therefore, the article selects nine provinces (autonomous regions) flowing through the Yellow River Basin as the research object for data collection and study.

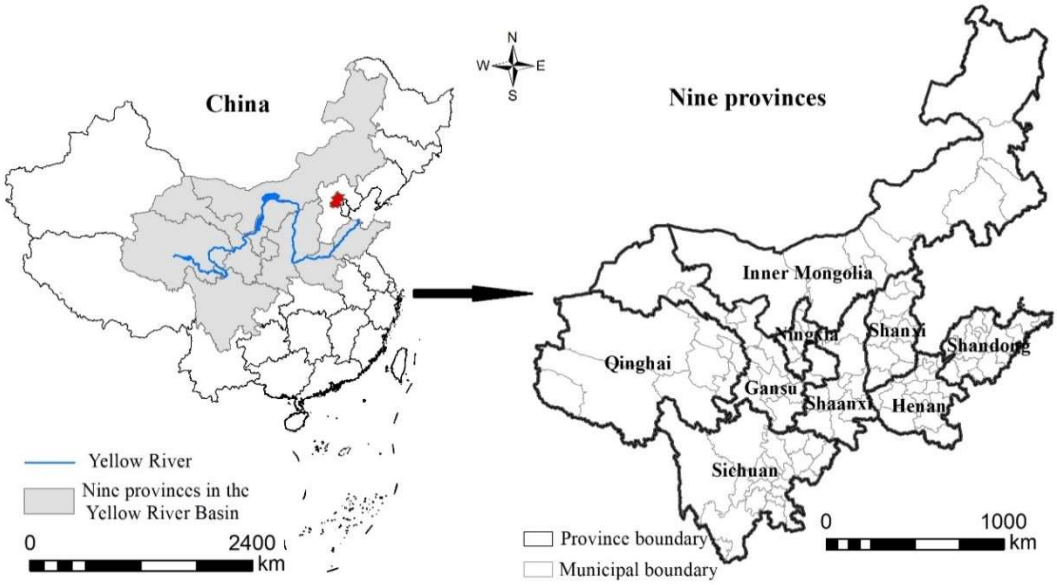

Fig. 1 Location of the nine provinces in the Yellow River Basin

2.2. Data Source and Pre-processing

This paper takes the province (autonomous regions) as the evaluation unit, and chooses 2009-2020 as the research period to study the evolutionary characteristics of the coupling coordination degree of new-type urbanization-rural revitalization-economic resilience in the Yellow River Basin. The data sources include China Urban Statistical Yearbook, China Rural Statistical Yearbook, China Population and Employment Statistical Yearbook and provincial statistical yearbooks for each year, etc. Some indicator data are obtained from the National Bureau of Statistics, and missing values are filled in through data processing methods.

In order to eliminate the obstacles to the analysis caused by the dimensional differences in the acquired data, the raw data need to be normalized using the maximum difference normalization method whose formula is as follows:

$$\text{Positive Indicator: } X_{ij} = \frac{x_{ij} - min(x_{ij})}{max(x_{ij}) - min(x_{ij})} \quad (1)$$

$$\text{Negative Indicator: } X_{ij} = \frac{max(x_{ij}) - x_{ij}}{max(x_{ij}) - min(x_{ij})} \quad (2)$$

where x_{ij} is the original value of the jth indicator in year i, $X_{ij} \in [0,1]$ denotes the normalized indicator value; $Max(X_{ij})$ and $Min(X_{ij})$ denote the maximum and minimum values of the jth indicator in each year, respectively.

2.3. Research Framework

New-type urbanization-rural revitalization-economic resilience is an open system with complex structure and extensive content. The conceptual framework in Fig. 2 is established to understand the interaction between the three subsystems.

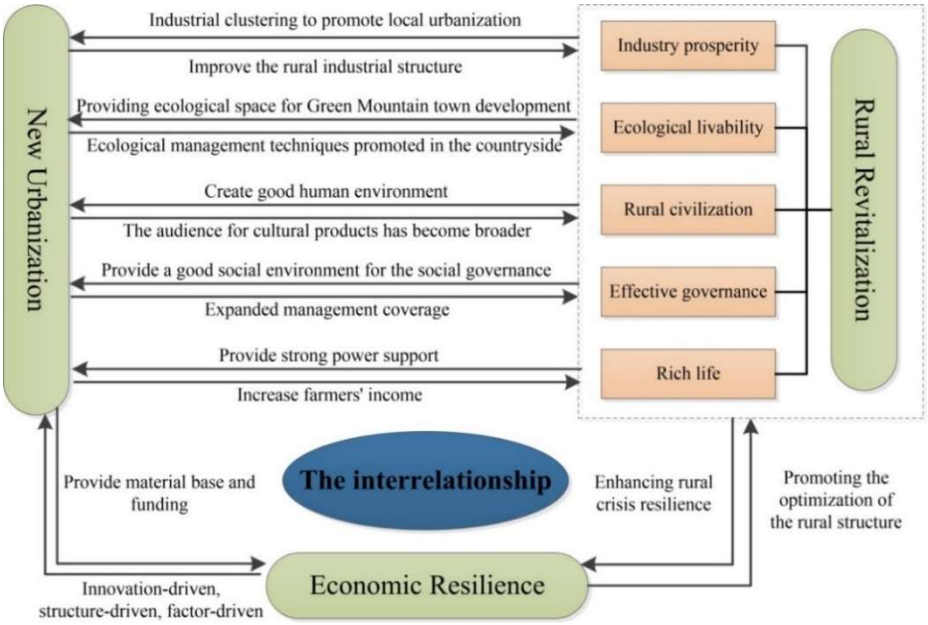

Fig. 2 The interrelationship of the three systems

The connotation of rural revitalization is vividly embodied in industry prosperous, ecological livability, rural civilization, effective governance, and rich life [26]. The development of new-type urbanization will have an obvious radiation effect on the surrounding areas, promote the free flow of urban and rural resources and elements, and facilitate the realization of the basic tasks of industry prosperous and rich life in the rural revitalization strategy [22]. In turn, the implementation of rural revitalization is conducive to the adjustment of industrial structure and the formation of industrial agglomeration. Its implementation can effectively improve the problems such as the weak correlation between urban and rural industries, make rural industries actively integrate into urban-rural industrial system, and thus promote the urbanization of rural areas in close proximity to local areas. The new-type urbanization mainly relies on factor-driven, innovation-driven and structure-driven to enhance the socio-economic resistance to various risks [10]. In terms of innovation-driven, the government has continuously given innovation investment support in the construction of new-type urbanization and enhanced innovation capacity by building urban innovation platforms and cultivating innovative talents. The resulting technological progress has been obtained and played an important role in enhancing economic efficiency, expanding the size of the economy, and finally improving economic resilience. At the same time, the increase in economic resilience has prompted factors of production, such as capital, technology and labor, to gather in cities, finally driving the level of urbanization. The

increase in economic resilience has led to a continuous restructuring of the economic system, resulting in a more rationalized and advanced structure of the economic system. Then, it accelerates the absorption of surplus rural labor and provides economic resources to the countryside. In this way, the optimization of rural structure is promoted. The rural revitalization strategy develops rural resilience through multiple dimensions such as strengthening agricultural production, improving farmers' livelihoods, and protecting rural ecology. The implementation of this strategy enables the countryside to effectively cope with the current shocks of environmental pollution, widening urban-rural gap, and rural decline brought about by globalization, industrialization, and urbanization, enhancing the resilience of China's countryside in the face of risks and crises [7].

2.4. Methods

2.4.1. Indexes System

In order to reveal the coupling relationships between new-type urbanization，rural revitalization and economic resilience in the Yellow River Basin, the most important and representative evaluation index system that can fully reflect the level of new-type urbanization development, rural revitalization and economic resilience is constructed in this paper based on the existing research results [3, 6, 19] (Table 1). The selection of indicators follows the principles of typicality, availability and systematic analysis. In the evaluation system, the coupling subsystem is determined according to the respective indicators. Among them, the new-type urbanization subsystem includes 6 secondary indicators and 13 tertiary indicators of population urbanization, economic urbanization, resources and environment, spatial urbanization, social urbanization, and urban-rural integration. The rural revitalization subsystem includes 5 secondary indicators and 11 tertiary indicators of industry prosperous, ecological livability, rural civilization, effective governance, and rich life. The economic resilience subsystem includes 4 secondary indicators and 9 tertiary indicators, and the secondary indicators are risk resistance, economic resilience, self-adaptability and innovation development capability.

Table 1. The evaluation index system

Subsystems	Secondary indicators	Variables	Tertiary indicators	Units	Weight	Indicator direction
New-type urbanization	Population urbanization	X_1	Urbanization rate	%	0.0270	+
		X_2	Urban population density	People/km^2	0.0370	+
	Economic urbanization	X_3	GDP growth rate	%	0.0340	+
		X_4	Per capita general budgetary revenue of local finance	Yuan	0.0239	+
		X_5	Proportion of secondary and tertiary industries in GDP	%	0.0378	+
	Resources and environment	X_6	Urban sewage treatment rate	%	0.0189	+
		X_7	Greening coverage of built-up areas	%	0.0307	+
	Spatial urbanization	X_8	Per capita built-up area	m^2	0.0291	+
		X_9	Urban road area per capita	m^2	0.0366	+
	Social urbanization	X_{10}	Number of beds in medical institutions per 1,000 people in cities	—	0.0207	+
		X_{11}	Registered urban unemployment rate	%	0.0310	+
	Urban-rural integration	X_{12}	Ratio of per capita living consumption expenditure of urban residents to rural residents	%	0.0256	-
		X_{13}	Ratio of per capita health care expenditure for urban residents compared to rural residents	—	0.0247	-
Rural revitalization	Industry prosperous	X_{14}	Rural per capita output value of agriculture, forestry, animal husbandry and fishery	Yuan	0.0293	+
		X_{15}	Grain production capacity	10,000 tons	0.0239	+
		X_{16}	Level of agricultural mechanization	kW/hm^2	0.0357	+
	Ecological livability	X_{17}	Number of health technicians per 1,000 people in rural areas	People	0.0177	+
	Rural civilization	X_{18}	Average years of schooling for rural population	Year	0.0287	+
		X_{19}	Proportion of expenditure on education, culture and entertainment of rural residents	%	0.0319	+
	Effective governance	X_{20}	Proportion of rural subsistence allowance population in total rural population	%	0.0341	-
		X_{21}	Number of people adopted by nursing institutions per 1,000 people in rural areas	People	0.0325	-
	Rich life	X_{22}	Engel coefficient of rural residents	%	0.0270	-
		X_{23}	Per capita disposable income of rural residents	Yuan	0.0322	+
Economic resilience	Risk resistance	X_{24}	Engel coefficient	%	0.0298	-
		X_{25}	Foreign trade dependence	%	0.0315	-
	Economic resilience	X_{26}	GDP per capita	Yuan	0.0230	+
		X_{27}	Total retail sales of consumer goods	100 million Yuan	0.0304	+
	Self-adaptability	X_{28}	Per capita fiscal expenditure	Yuan	0.0260	+
		X_{29}	Number of beds in health facilities for 10,000 people	—	0.0299	+
	Innovation development capability	X_{30}	Number of patent applications granted	—	0.0478	+
		X_{31}	Ratio of new product sales revenue of high-tech enterprises to GDP	%	0.0483	+
		X_{32}	Ratio of technology market contract turnover to GDP	%	0.0634	+

2.4.2. The Entropy Weight Method

To reduce the influence of subjective factors in the evaluation process, the entropy weighting method was used to determine the weights of each indicator [14, 25]. According to the definition of information entropy, entropy value can be used to judge the dispersion degree of an index. The smaller the information entropy value of the index is, the greater its dispersion degree is, and the greater the influence of the index on the comprehensive evaluation (namely, the weight) is (Zou et al., 2006) [29]. The weights of each evaluation index are shown in Table 1, and the specific calculation method is as follows.

(1) Calculate the weighting. The weight of the jth indicator in year i is:

$$Y_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \tag{3}$$

(2) Calculate the entropy value. The entropy value of the jth indicator is:

$$E_j = -k \sum_{i=1}^{n} Y_{ij} \times ln\, Y_{ij} \tag{4}$$

where $k = \frac{1}{ln\, n}$, $0 \leq E_j \leq 1$, when $Y_{ij} = 0$, it is stipulated that $Y_{ij}\, ln\, Y_{ij} = 0$.

(3) Calculate the information utility value. The formula for calculating the information utility value of the jth indicator is as follows:

$$N_j = 1 - E_j \tag{5}$$

(4) Determine the weights. The formula for calculating the weight of the jth indicator is as follows:

$$W_j = \frac{N_j}{\sum_{j=1}^{m} N_j} \tag{6}$$

2.4.3. Comprehensive Development Index

After determining the weight of each indicator, the development level of new-type urbanization, rural revitalization and economic resilience in the Yellow River Basin over the years can be calculated, and the formula is as follows:

$$U_i = \sum_{j=1}^{m} W_j \times X_{ij} \tag{7}$$

According to the different coupling subsystems of indicators, the above equation (7) can calculate the development level of the new-type urbanization subsystem, the development level of the rural revitalization subsystem and the development level of the economic resilience subsystem in the Yellow River Basin in turn.

2.4.4. The Coupling Coordination Degree Model

Coupling refers to the interrelationship between different systems that affect each other, and the coupling degree is the degree of association between systems [1]. However, it does not reflect the state of coordination between systems. This study introduces a CCDM to quantitatively measure the coupling coordination relationship between new-type urbanization, rural revitalization and economic resilience in the Yellow River Basin.

$$C = \left\{ \frac{U_1 \times U_2 \times U_3}{[(U_1+U_2+U_3)/3]^3} \right\}^{1/3} \tag{8}$$

$$T = \alpha U_1 + \beta U_2 + \gamma U_3 \tag{9}$$

$$D = \sqrt{C \times T} \tag{10}$$

where U_1, $U_2$and U_3 represent the level of new-type urbanization, the level of rural revitalization and the level of economic resilience, respectively, and C represents the coupling degree of the k systems, between 0 and 1, reflecting the degree of mutual influence between the systems. T is the coordination degree of the three systems. D is the coupling coordination degree of new-type urbanization, rural revitalization and economic resilience level, with values ranging from 0 to 1. The smaller the value, the more unbalanced and mutually unfavorable effects exist among the subsystems; the higher the value, the more coordinated the subsystems are, and relatively sustainable development is achieved. α, β and λ represent the contributions of new-type urbanization, rural revitalization and economic resilience indicators, respectively, and α+β+λ=1. In this study, it is assumed that the level of new-type urbanization, the level of rural revitalization and the level of economic resilience are equally important in the process of coupling and coordinated development of the three systems, so a coefficient of α=β=λ=1/3 is used.

Referring to the existing studies [21], this study classifies the coupling coordination degree into ten types (Table 2).

Table 2. The classification of the coupling coordination degree

Degree of Coordination(D)	**0<D≤0.1**	**0.1<D≤0.2**	**0.2<D≤0.3**	**0.3<D≤0.4**	**0.4<D≤0.5**
Coordination situation	Extreme disorder	Serious disorder	Medium disorder	Minor disorder	Barely disorder
Degree of Coordination(D)	**0.5<D≤0.6**	**0.6<D≤0.7**	**0.7<D≤0.8**	**0.8<D≤0.9**	**0.9<D≤1**
Coordination situation	Barely coordination	Primary coordination	Medium coordination	Good coordination	Extreme coordination

2.4.5. The Obstacle Degree Model

The obstacle degree model (ODM) is commonly used to identify the main obstacle factors affecting the evaluation objects [5]. In order to sort out the main obstacle factors of the coordinated development of new-type urbanization-rural revitalization-economic resilience in the nine provinces of the Yellow River Basin and further develop targeted regulation strategies, ODM needs to be introduced for obstacle factor analysis, and the calculation formulae are as follows [18, 27]:

$$OD_{ij} = \frac{W_j(1-X_{ij})}{\sum_{j=1}^{m} W_j(1-X_{ij})} \times 100\% \quad (11)$$

where OD_{ij} denotes the obstacle degree of the jth indicator in year i.

3. RESULTS

3.1. The Spatio-temporal Patterns of New-type Urbanization-rural Revitalization-Economic Resilience

The temporal changes of the level of new-type urbanization development, the level of rural revitalization and the level of economic resilience are shown in Fig. 3.

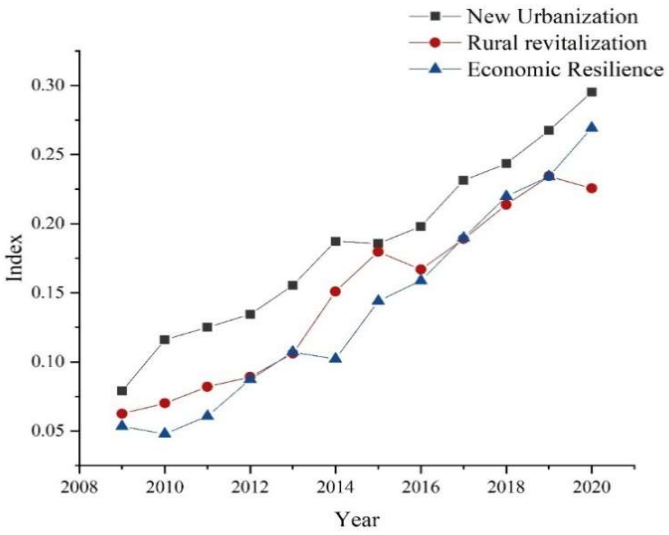

Fig. 3 Dynamic changes of New-type urbanization-Rural Revitalization-Economic Resilience level during 2009 and 2020.

As can be seen from Fig. 3, the development indexes of all three systems in the nine provinces of the Yellow River Basin maintain growth during the period 2009-2020, with the level of new-type urbanization development higher than the other two subsystems. This indicates that new-type urbanization contributes the most to the development process of the Yellow River Basin and has been increasing over time. Meanwhile, the level of rural revitalization and the level of economic resilience play an increasing role in the benign development aspects of the Yellow River Basin. From 2015 to 2020, the growth of the comprehensive evaluation index of the new-type urbanization and economic resilience subsystems was larger, while the level of rural revitalization showed a fluctuating upward trend, with a slower increase in the level of rural revitalization after 2018. These results indicate that the level of economic resilience in the Yellow River Basin has been effectively improved in recent years along with the practice of China's new development philosophy and the promotion of high-quality economic development.

At the spatial level, there are significant regional differences in the levels of new-type urbanization, rural revitalization, and economic resilience among the nine provinces in the Yellow River Basin (Fig. 4).

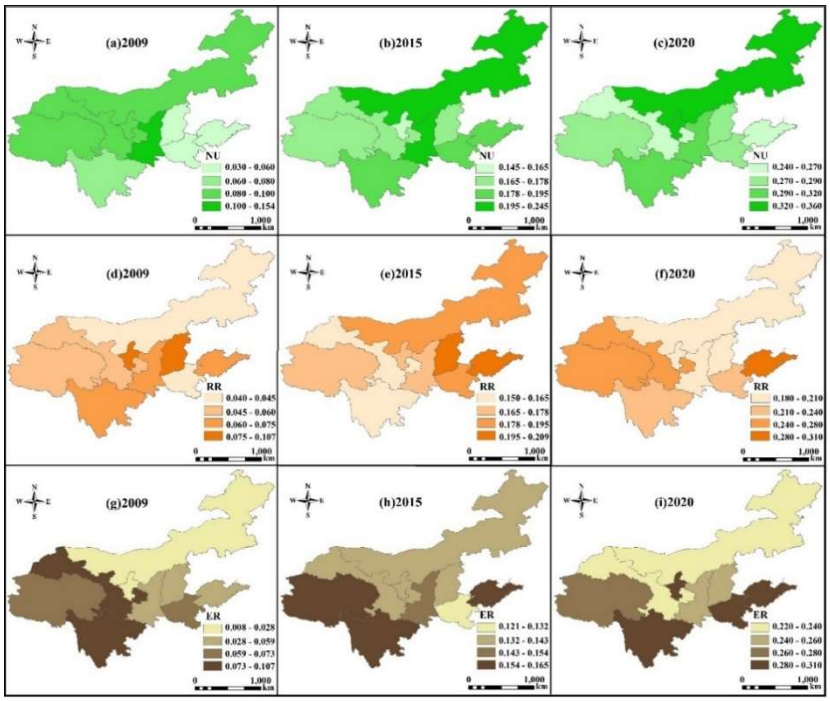

Fig. 4 Spatiotemporal changes of New-type urbanization-Rural Revitalization-Economic Resilience level during 2009 and 2020.

In 2009, the areas with high level of new-type urbanization development were mainly concentrated in the northern part of the Yellow River Basin, and gradually expanded to the southern part of the Yellow River Basin in 2018. And the areas with low level of new-type urbanization development in the Yellow River Basin are distributed in Shanxi and Shandong provinces in the eastern part of the Yellow River Basin and Sichuan province in the south. On the whole, the spatial distribution of the new-type urbanization level in the Yellow River Basin shows a pattern of "high in the north and low in the south", and the new-type urbanization in the plain areas is better developed, while the mountainous areas are slightly behind. The overall level of rural revitalization in the Yellow River Basin is low. From 2009 to 2015, the gap between the level of rural economic development in the upper, middle and lower reaches of the Yellow River Basin was large, resulting in huge differences in the living standards of farmers in different regions. From 2015 to 2020, the gap between the level of rural revitalization development in the upper, middle and lower reaches of the Yellow River Basin is gradually reduced. During the study period, the economic resilience level of the Yellow River Basin generally shows a pattern of "high in the south and low in the north"; from 2009 to 2020, the economic resilience level of Henan and Shandong in the eastern part of the Yellow River Basin increases significantly, while the economic resilience level of Gansu Province in the western part decreases significantly.

3.2. Coupling Coordination Characteristics of New-type Urbanization-rural Revitalization-economic Resilience

Fig.5 shows the changing trend of coupling coordination degree of the Yellow River Basin as a whole and nine provinces from 2009 to 2020.

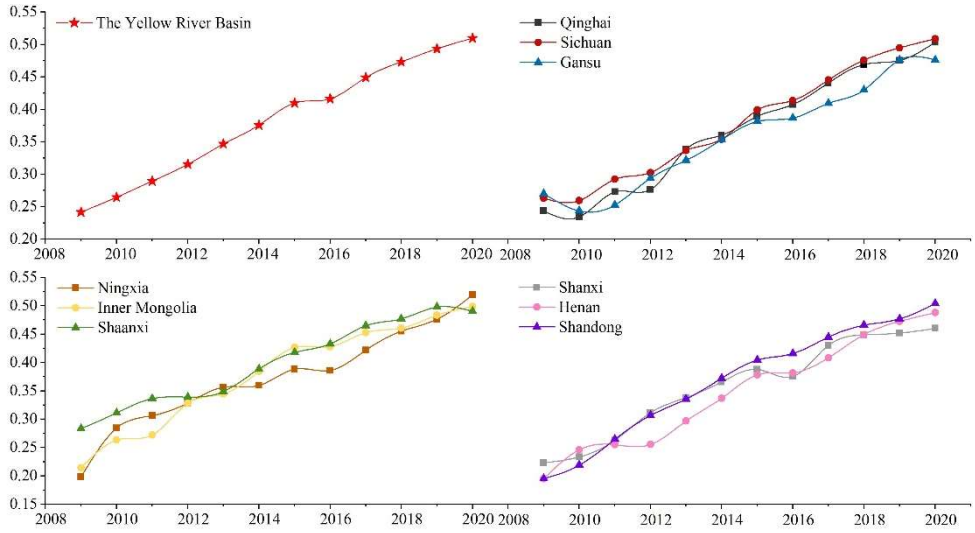

Fig.5 The evolution curves of coupling coordination degree during 2009 and 2020.

The coupling coordination degree of new-type urbanization, rural revitalization and economic resilience in the Yellow River Basin is generally low, and it shows an upward trend and tends to be stable during the study period. The coupling coordination degree of all the nine provinces (autonomous regions) in the Yellow River Basin shows an increasing trend, but the increasing trend of each province is more volatile than that of the Yellow River Basin as a whole. Among them, the fluctuation is more obvious in Henan Province, which has a more obvious "N" type fluctuation trend in the coupling coordination degree during the study period.

The spatial distribution and evolution of coupling coordination degree and coupling coordination types in nine provinces (autonomous regions) in the Yellow River Basin in 2009, 2015 and 2020 are shown in Fig.6.

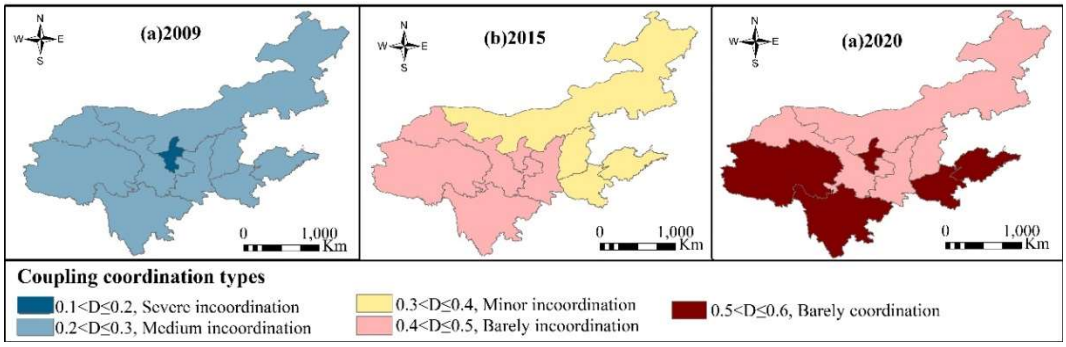

Fig. 6 Spatial differentiation of coupling coordination degree and type in the nine provinces of the Yellow River Basin.

The level of coupling coordination of the three systems varies widely among regions, and generally shows the characteristics of high in the southwest and low in the northeast. Among them, Qinghai and Sichuan provinces in the southwest have been leading in the three system coupling coordination degree. In 2009, Ningxia Hui Autonomous Region was severely uncoordinated, while the other eight provinces were moderately uncoordinated. In 2015, the spatial distribution of coupling coordination degree is more concentrated, with Inner Mongolia Autonomous Region, Shaanxi Province, Shandong Province, and Henan Province in the northeast region shifting from medium disorder to minor

disorder level, and all other regions reaching barely disorder levels, indicating a more coordinated relationship among new-type urbanization, rural revitalization， and economic resilience. Among the provinces in the Yellow River Basin, Ningxia Hui Autonomous Region has the most significant increase in coupling coordination degree from 2009 to 2020. Its coordination degree spans four levels in a row, changing from Serious disorder to barely coordination. In 2020, the coordination degree of Inner Mongolia Autonomous Region, Gansu Province, Shaanxi Province, and Shanxi Province is about to leave the disorder level, while the coupling coordination degree of other provinces (autonomous regions) in the Yellow River Basin has completely left the barely disorder level and reached the barely coordinated level. Overall, the distribution pattern of coupling coordination shows obvious spatial differences, and the main type of coupling coordination gradually changes from medium disorder to coordinated state, and the relationship between new-type urbanization-rural revitalization-economic resilience in the Yellow River basin becomes more coordinated.

3.3. Diagnosis of Obstacle Factor

The 32 indicators were ranked according to ODM (Table 3). It can be seen that the level of "innovation development capability" of the Yellow River Basin has always had the greatest influence on the level of coordinated development of the three systems during the study period, and has shown an increasing trend year by year. During 2009-2017, the factor with the highest obstacle is ratio of technology market contract turnover to GDP (X32); in 2018 and 2019, ratio of technology market contract turnover to GDP is ranked second and third, respectively. The biggest obstacle factor in these two years is level of agricultural mechanization (X16), and this factor is also ranked second in 2020. It indicates that science and technology have a significant impact on the socio-economic development of the Yellow River Basin, and the level of agricultural development has a gradually increasing impact on the coordinated development of the three systems in the Yellow River Basin.

Table 3. Dominant obstacle indicators and the order of obstacle degree

Year	Top-1	Top-2	Top-3	Top-4	Top-5
2009	X_{32}(21.40%)	X_{30}(17.24%)	X_{23}(14.35%)	X_{14}(13.01%)	X_{9}(11.89%)
2010	X_{32}(20.92%)	X_{30}(16.19%)	X_{23}(14.11%)	X_{14}(13.50%)	X_{9}(12.82%)
2011	X_{32}(20.92%)	X_{30}(16.80%)	X_{31}(14.10%)	X_{23}(13.41%)	X_{9}(12.58%)
2012	X_{32}(19.46%)	X_{30}(17.88%)	X_{31}(16.96%)	X_{19}(14.13%)	X_{21}(12.90%)
2013	X_{32}(23.07%)	X_{30}(18.32%)	X_{19}(15.99%)	X_{31}(15.67%)	X_{20}(15.36%)
2014	X_{32}(22.54%)	X_{20}(19.51%)	X_{30}(17.76%)	X_{31}(17.55%)	X_{21}(16.31%)
2015	X_{32}(25.76%)	X_{31}(20.61%)	X_{20}(19.18%)	X_{30}(18.42%)	X_{18}(16.19%)
2016	X_{32}(27.42%)	X_{31}(22.58%)	X_{16}(21.42%)	X_{30}(18.29%)	X_{20}(14.63%)
2017	X_{32}(23.07%)	X_{30}(18.32%)	X_{19}(15.99%)	X_{31}(15.67%)	X_{20}(15.36%)
2018	X_{16}(29.19%)	X_{32}(21.87%)	X_{31}(21.42%)	X_{25}(20.79%)	X_{30}(19.27%)
2019	X_{16}(34.98%)	X_{25}(25.58%)	X_{32}(24.66%)	X_{3}(24.26%)	X_{31}(23.46%)
2020	X_{3}(38.37%)	X_{16}(36.84%)	X_{25}(31.08%)	X_{11}(21.73%)	X_{19}(18.07%)

In order to clarify the obstacle factors for the coordinated development of new-type urbanization development-rural revitalization-economic resilience in each province of the Yellow River Basin, this paper calculates the obstacle contribution of each influence factor in three systems in nine provinces (autonomous regions) of the Yellow River Basin, as shown in Fig. 7.

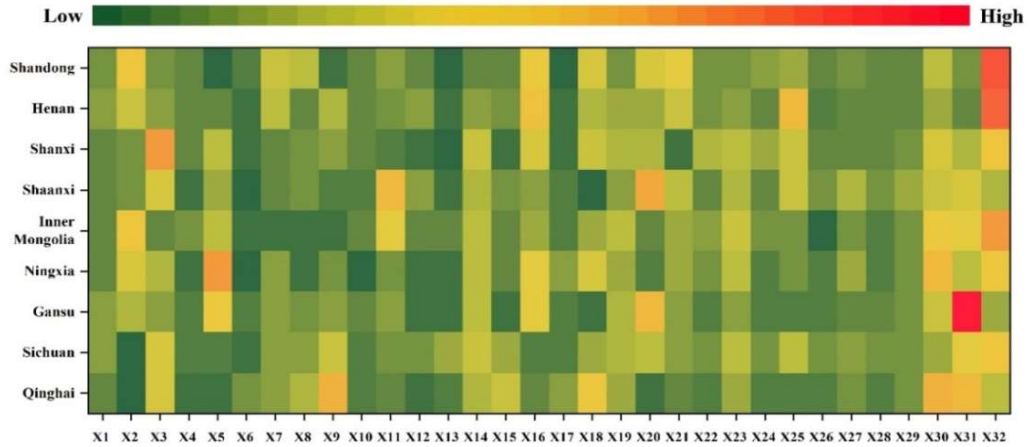

Fig. 7 The obstacle degree of 32 indicators in nine provinces of the Yellow River Basin.

The results show that the most influential obstacle factor for Sichuan, Inner Mongolia, Henan and Shandong are ratio of technology market contract turnover to GDP (X32), and the biggest obstacle factors for Qinghai, Gansu, Ningxia, Shaanxi and Shaanxi are urban road area per capita (X9), ratio of new product sales revenue of high-tech enterprises to GDP (X31), proportion of secondary and tertiary industries in GDP(X5), proportion of rural subsistence allowance population in total rural population (X20), and GDP growth rate (X3) , respectively. Even though the maximum obstacle factors are not exactly the same in all provinces of the Yellow River Basin, similar major obstacle factors exist in most provinces (autonomous regions).

4. DISCUSSION

This study constructs a comprehensive evaluation index system for the level of development of new-type urbanization, the level of implementation of rural revitalization and the level of economic resilience, and reveals in depth the spatial and temporal evolution characteristics of the three subsystems in the Yellow River Basin. The results of the study show that the new-type urbanization development index of the nine provinces (autonomous regions) in the Yellow River Basin is significantly higher than the rural revitalization development index and the economic resilience index. This indicates that the level of agricultural and rural modernization lags far behind the level of urbanization. In the modernization process, it is a general trend that the urbanization rate rises and the proportion of rural areas decreases. At the same time, good urbanization is a prerequisite for achieving rural revitalization as well as maintaining good economic resilience, because the level of urbanization is one of the important measures of a country's modernization. No country (region) can achieve modernization of economic and social development with a low level of urbanization.

The results of the study on the coupling coordination degree of new-type urbanization-rural revitalization-economic resilience in the Yellow River Basin show that there are large differences in the coupling coordination relationships among the three systems in the nine provinces (autonomous regions) of the Yellow River Basin. In this context, differentiated development strategies are implemented based on different coupling coordination characteristics. In general, the overall coupling coordination degree of the Yellow River Basin is low, but the coupling coordination degree between

new-type urbanization, rural revitalization and economic resilience development in each province shows an obvious increasing trend. Among them, Sichuan and Shaanxi provinces have been in a higher level of coupling coordination stage than other provinces in the Yellow River Basin, and other provinces have been transitioning to a higher level of coupling coordination stage. It indicates that the coordinated development of new-type urbanization-rural revitalization-economic resilience in each region is good. Sichuan Province has a high level of new-type urbanization, and a good level of new-type urbanization drives the economic resilience of cities, which provides impetus for the development of villages and accelerates the revitalization of villages, forming a benign interaction among the three. Among these provinces, although the three systems in Inner Mongolia Autonomous Region and Qinghai Province also have a higher level of development, they are more inclined to strive for economic development and still do not pay enough attention to rural issues, which to a certain extent hinders the development of rural revitalization. Due to the limitation of backward infrastructure, Gansu, Ningxia, Shanxi and Shandong are not subject to a strong level of economic resilience, although their coupling coordination degree is increasing. While the country is vigorously promoting rural revitalization and enhancing economic resilience, these provinces are implementing the strategy less effectively and more slowly in urban and rural areas due to their weak economic foundation. Coupling coordination degree in Henan Province has been consistently low for many years. In recent years, Henan province has been striving to become a model of rural revitalization in an agricultural province. The rural development in Henan Province has achieved better results, but the development speed is obviously lower than that of new-type urbanization, which to a certain extent restricts the economic resilience [16]. Therefore, all regions in Henan Province should actively coordinate the integrated social and economic development of urban and rural areas, strengthen the construction of various infrastructure and public service facilities in rural areas, guide the organic integration of financial and human resources, and continuously activate rural elements to help the process of rural revitalization.

In summary, the key reason that hinders the coordinated development of new-type urbanization-rural revitalization-economic resilience in the Yellow River Basin is the lagging development of rural revitalization. On the one hand, because the rural revitalization strategy was proposed later than the new-urbanization strategy process, on the other hand, regions are biased towards economic development and still do not pay enough attention to rural issues, which hinders the development of rural revitalization to a certain extent. In the obstacle degree analysis, it is shown that innovation and technology have the most significant impact on the coordination degree of the three systems in the Yellow River Basin. Innovative scientific and technological development leads to the improvement and accumulation of economic power, helps the construction and development of the countryside, and promotes the positive interaction between the two strategies. Therefore, the provinces of the Yellow River Basin should pay attention to the development of science and technology in urban and rural areas, promote the regional sharing of transportation, energy, and network information in urban and rural areas, and promote the transition of the new-type urbanization-rural revitalization-economic resilience of the river basin to a higher level of coupling and coordination stage.

5. CONCLUSION

This study established comprehensive evaluation index systems to assess the levels of new-type urbanization, rural revitalization and economic resilience, and proposed a conceptual framework to better understand their interactive relationship. The CCDM and ODM were constructed to quantitatively measure and identify the spatio-temporal pattern and influencing factors of the coupling coordination degree of new-type urbanization-rural revitalization-economic resilience in nine provinces (autonomous regions) in the Yellow River Basin. The results show that the development level of new-type urbanization, rural revitalization and economic resilience in the Yellow River Basin has improved during the study period. Among them, the development level of new-type urbanization is obviously higher than that of the other two systems, but the gap with them

is gradually narrowing. The results of coupling coordination analysis showed that the coupling coordination degree shows an increasing and stabilizing trend during the study period, and changes from medium disorder state to barely coordination state. The results also indicate that there is significant spatial heterogeneity in the coupling coordination among the nine provinces in the Yellow River Basin, and its spatial distribution is characterized by high in the southwest and low in the northeast. The results of the obstacle degree analysis indicate that there is a strong link between rural and urban socio-economic development and urban-rural technology application in the Yellow River Basin, and that the innovative application and diffusion of technology has a great impact on urban-rural economic development in the Yellow River Basin.

The Yellow River Basin has long been an economically developed agricultural region of China and an important economic center for the country, where the economic development of rural and urban areas is crucial. While promoting the development of rural revitalization strategy and new-type urbanization strategy, the provinces in the Yellow River Basin should pay attention to the coordinated development of the two strategies and economic resilience, and accelerate the integration of urban and rural areas. It can provide an important reference for the policy implementation of the Rural Revitalization Strategic Plan (2018-2022) in other regions of the country, as well as theoretical support for other provinces to achieve high-level coordinated resonance between urban and rural areas and integrated urban-rural development.

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