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# Assessment of Coordinated Development of Economic Development, Public Services and Ecological Environment in the Yellow River Basin

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**Abstract:** Ecological protection and high-quality development of the Yellow River Basin has become an important national strategy. As the economic development, public services and ecological environment in the Yellow River Basin are increasingly complicated, the quantitative evaluation of their coupling coordination is therefore of great significance for high-quality development of the Basin. Based on the synergy effects of economy, public service and ecology in the Yellow River Basin, this paper firstly constructed a comprehensive evaluation index system of coupling synergy in the Yellow River Basin. Then discussed the spatial-temporal differences of the synergetic development of the Yellow River Basin by using 2 kinds of quantitative methods, which are entropy method coupling coordination degree model, spatial autocorrelation model. And the following conclusions are drawn: (1) The prefecture-level cities "coupling coordination degree" of economic development, public services and ecological environment in the Yellow River Basin are generally stable, with little fluctuation within years, however, there are huge differences among cities, and the overall coordination remain to be improved. (2) There is spatial autocorrelation in the coupling coordination degree among cities within the basin, and it shows a spatial club convergence with the characteristic of high-high and low-low aggregation. Therefore, it is vital to strengthen the linkage of development within the basin, reinforcing the financial support, and optimizing the industrial structure, thus ultimately make good use of the aggregation effect and "siphon effect" of urban agglomeration in promoting the coordinated development of the Yellow River Basin.

**Keywords:** Yellow River Basin; coupling coordination degree model; spatial autocorrelation model

**JEL Classification:** Q56; F63

## 1. Introduction

The coordinated development of the Yellow River Basin has become an important strategy. The National Development and Reform Commission (NDRC) recently unveiled the National Standard for Basic Public Services (2021 edition), which covers elderly care, education, medical care, employment, housing and transportation, and calls for ensuring people's livelihood and improving their sense of well-being. This shows that high-quality development means that on the basis of not damaging the environment, we should constantly improve the level of

economic development and provide better public services to the people. Economy, public service and ecology are three important subsystems in evaluating regional coordinated development. The economic development level of the Yellow River Basin is affected by whether the ecological environment is fragile or not, and the level of the ecological environment is also affected by the quality of public service supply, which largely depends on the level of economic development. Therefore, under the background of high-quality development of the Yellow River Basin as a new national major strategy, it is of great significance to discuss the coordinated development level, spatial and temporal differences of economic development, public services and ecological environment in the Yellow River Basin.

At present, many achievements have been made in the field of high-quality development of the Yellow River basin, mainly including two aspects. First, scholars have discussed the connotation and realization path of high-quality development in the Yellow River Basin from the macro level (Chen & Jin, 2019; Guo, 2020). An and Li (2020) believe that the key points of high-quality development in the Yellow River Basin are ecological governance, industrial division of labor and regional connection. Ren (2020) believes that the high-quality development of the Yellow River Basin can be guided by green development and integrated with coordinated development, linkage development, classified development and cooperative development. Second, scholars further measure the high-quality development level of the Yellow River Basin from different dimensions. Shi et al. (2021) measured the high-quality development level of cities in the Yellow River Basin from three aspects of economic fundamentals, society and ecology. Xu et al. (2020) measured the high-quality development level of the Yellow River Basin from the five development concepts of innovation, coordination, green, openness and sharing. The study found that the development of the Yellow River Basin varies greatly among provinces, and there are still many problems in the high-quality development of the Basin.

To sum up, there have been abundant achievements in the high-quality development of the Yellow River Basin, but there are few articles on the evaluation and measurement of prefecture-level cities. In addition, it can be seen that there are many literatures on the relationship between economy, public service and ecological environment in the academic circle, but there is a lack of research on the synergistic relationship among the three, especially considering the synergistic level of the three at prefecture-level and city level in the Yellow River Basin. Therefore, the coupling coordination degree of research on the three is conducive to promoting the high-quality development of the Yellow River Basin.

## 2. Methodology

### *2.1. Indicator System*

The Yellow River flows through nine provinces and regions of Qinghai, Ningxia, Sichuan, Gansu, Inner Mongolia, Shanxi, Shaanxi, Henan and Shandong. In order to ensure the integrity and availability of data, 71 prefecture-level cities in the Yellow River basin were selected as the research objects from 2012 to 2019. This paper constructs an economic index system from the three dimensions of economic aggregate, economic quality and development

**Table 1.** Comprehensive evaluation index system of coupling coordination of economic development, public services and ecological environment in the Yellow River Basin

| system | level | index | unit | pointer type |
|---|---|---|---|---|
| Comprehensive economic evaluation | economic aggregate | gross regional production | Wan Yuan | Are indicators |
| | | Public revenue | Wan Yuan | Are indicators |
| | economic quality | Gross regional product per capita | Yuan | Are indicators |
| | | Per capita retail sales of consumer goods | Yuan | Are indicators |
| | | Average salary of employees on the job | Yuan | Are indicators |
| | | Regional GDP growth rate | percent | Are indicators |
| | developmental level | Average home sales price | Yuan | Are indicators |
| | | Population urbanization rate | percent | Are indicators |
| | | Proportion of output value of tertiary industry | percent | Are indicators |
| Comprehensive evaluation of public services | educational level | Number of primary and secondary school teachers per 10,000 people | person | Are indicators |
| | | Number of students in institutions of higher learning | person | Are indicators |
| | | Proportion of financial expenditure on education | percent | Are indicators |
| | medical level | Number of hospital beds per 10,000 people<br>Number of doctors in hospitals | quantity | Are indicators |
| | cultural development | The number of books in public libraries per 10,000 people | | Are indicators |
| | infrastructure | Per Capita Domestic Electricity Consumption of Urban and Rural Residents (Municipal districts) | kilowatt-hour | Are indicators |
| | | Per capita Household Water Consumption (Municipal district) | ton | Are indicators |
| | | Per Capita Household Gas Consumption (artificial and natural gas) (municipal districts) | stere | Are indicators |
| | | Number of broadband Internet access users | object | Are indicators |
| | social insurance | Basic endowment insurance participation rate | / | Are indicators |
| | | Basic medical insurance participation rate | / | Are indicators |
| | | Unemployment insurance participation rate | / | Are indicators |
| Comprehensive evaluation of ecological environment | surroundings | Per capita garden green area | Ha/ten thousand people | Are indicators |
| | | Green coverage rate of urban built-up area | percent | Are indicators |
| | pollutant discharge | Discharge of industrial wastewater | Ten thousand tons of | Negative indicators |
| | | Industrial sulfur dioxide emissions | ton | Negative indicators |
| | | Industrial dust emission | ton | Negative indicators |
| | environmental governance | Domestic sewage treatment rate | percent | Are indicators |
| | | Harmless treatment rate of household garbage | percent | Are indicators |
| | | Comprehensive utilization rate of solid waste | percent | Are indicators |

level under the new normal (Ren, 2021), taking into account public financial revenue, per capita retail sales of consumer goods, urbanization rate, housing price and average wage of on-duty employees. In addition, the main development indicators of basic public service in the 13th Five-Year Plan period (Ren, 2019; Li, Li, & Zhu, 2015; Xin, 2019). As a reference, five partial indicators including social security, medical and health care, education level, cultural construction and infrastructure are selected to measure the level of basic public services.

Secondly, reference to previous studies (Zhao, Liu, & Zhu, 2020; Liu, Huang, & Zuo, 2021), measure the level of ecological environment from three dimensions of living environment, pollution discharge and environmental governance.

The data used were from China Urban Statistical Yearbook, the provincial statistical yearbook of the provinces involved, and the national economic development bulletin of prefecture-level cities from 2012 to 2019. For missing data, interpolation method is used to interpolate.

*2.2. Assessment Model*

1. System comprehensive level evaluation model

For the processing of raw data, dimensionless standardization is first used

$$For\ positive\ indicators: Y_{ij} = \frac{X_{ij} - Min\ (X_{ij})}{Max(X_{ij}) - Min\ (X_{ij})} \tag{1}$$

$$For\ the\ inverse\ index: Y_{ij} = \frac{Max(X_{ij}) - X_{ij}}{Max(X_{ij}) - Min\ (X_{ij})} \tag{2}$$

where, $i$ represents the system, $j$ represents the measure index, $X_{ij}$ and $Y_{ij}$ represents the original data and standardized value of the index respectively. Then the entropy method is used to calculate the index weight $W_{ij}$ one by one.

The composite level index for each system can be calculated by:

$$U_i = \sum_{j=1}^{n} W_j Y_{ij} \tag{3}$$

where, $U_i$ represents the comprehensive level index of each system, and n represents the number of indicators in each system.

2. Coupling coordination degree model

Referring to existing studies, the specific calculation formula for the coupling coordination degree of economic development, public services and ecological environment in the Yellow River Basin is as follows:

$$T = \alpha U_1 + \beta U_2 + \gamma U_3 \tag{4}$$

$$C = \sqrt[3]{\frac{U_1 * U_2 * U_3}{\prod_{i \neq j}(U_i + U_j)}} \tag{5}$$

$$D = \sqrt{CT} \tag{6}$$

where, $T$ represents the comprehensive coordination index; $U_1$、$U_2$ and $U_3$ are the comprehensive level indexes of the three systems respectively; $\alpha$，$\beta$，$\gamma$ each value 1/3; $C$ is the coupling degree; $D$ is the coupling coordination degree; $I$ and $j$=1, 2, 3. According to the method of uniform distribution, the coupling coordination degree is divided into ten levels.

Formula (3) is used to calculate the comprehensive level index of economic development, public service and ecological environment in the Yellow River Basin.

**Table 2.** Classification of coupling coordination degree

| Coupling coordination degree value | Coordination level | Coupling coordination degree value | Coordination level |
|---|---|---|---|
| 0-<0.1 | Extreme imbalance | 0.5-<0.6 | Barely coordination |
| 0.1-<0.2 | A serious imbalance between | 0.6-<0.7 | Primary coordination |
| 0.2-<0.3 | Moderate disorders | 0.7-<0.8 | Intermediate coordinate |
| 0.3-<0.4 | Mild disorder | 0.8-<0.9 | Good coordination |
| 0.4-<0.5 | On the verge of disorder | 0.9-<1.0 | Good coordination |

## 3. Results

### *3.1. Time Series Evolution Analysis of Economic Development, Public Service and Ecological Environment*

From 2012 to 2019, the coupling and collaborative evolution of economic development, public services and ecological environment in the Yellow River Basin generally tended to be stable. The coupling coordination degree of most cities did not change much in recent years and the coordination degree was generally low. Most regions were barely coordinated, and the coordinated development level still needs to be improved. Specifically, the system coupling index increased year by year from 2012 to 2016, indicating that the level of coordinated development of economy, ecological environment and public services is gradually improving. The fluctuation decreased from 2016 to 2018, indicating that the prefecture-level cities in the Yellow River Basin are facing great pressure and challenges in economic transformation and ecological protection, and the synergy of development has decreased, but the range of change is not big. And then in 2019, the coupling and synergy gradually improved.

**Table 3.** Comprehensive Level Index of Economic Development, Public Services and Ecological Environment in the Yellow River Basin (2012-2019)

| year | economic development | public service | ecological environment |
|---|---|---|---|
| 2012 | 0.292277 | 0.214533 | 0.641721 |
| 2013 | 0.305645 | 0.217581 | 0.649694 |
| 2014 | 0.293235 | 0.212344 | 0.668589 |
| 2015 | 0.310404 | 0.227369 | 0.637867 |
| 2016 | 0.391103 | 0.22437 | 0.626255 |
| 2017 | 0.353737 | 0.191147 | 0.619577 |
| 2018 | 0.327904 | 0.233762 | 0.675592 |
| 2019 | 0.330687 | 0.22881 | 0.629832 |

In terms of economic development, the level of economic development in the Yellow River Basin varies from place to place. The level of economic development is generally stable in recent years and shows a slight upward trend with an average value of 0.3256. The economic development is in good condition. Industrial transformation and upgrading drive the economic development of each region. The central city also plays its aggregation effect

and radiation effect to drive the development of surrounding areas. Developed cities such as Qingdao, Jinan, Zhengzhou, Xi 'an and so on can give full play to their talent quality, and the development of strategic emerging industries can promote transformation and upgrade the high-tech enterprises.

In terms of public service, the public service level of prefecture-level cities in the Yellow River Basin was generally stable from 2012 to 2019, with an average value of 0.2187. It showed a trend of slow rise, with only a slight decline in 2017, and then gradually increased. The public service level of different prefectural cities is different, among which the public service level of Qingdao, Yantai and other cities are higher, while the public service level of Zhongwei, Tianshui, Guyuan and other cities are relatively lower. In comparison, the allocation of public resources such as education, medical care and social security is more reasonable in areas with high economic level. The level of public resource allocation in economically backward areas still needs to be improved.

In terms of ecological environment, the comprehensive ecological level of prefectural cities in the Yellow River Basin fluctuated from 2012 to 2019, gradually increased from 2012 to 2015, and fluctuated and declined from 2015 to 2017. In 2018, it recovered slightly, and then declined slightly in 2019, with an average value of 0.6436. The reason is related to the changes of economic policies and environmental policies at this stage, but compared with the level of economic development and public service, the level of ecological environment is generally higher, indicating that governments at all levels in the Yellow River Basin have strictly implemented environmental protection policies in the Yellow River Basin to promote green development.

### *3.2. Spatio-temporal Difference Analysis of the Coupling Coordination Degree of Economic Development, Public Services and Ecological Environment*

The overall coupling coordination degree of the Yellow River Basin from 2012 to 2019 increased from 0.5703 in 2012 to 0.5992 in 2016 and then to 0.585 in 2019, but the overall coordination degree fluctuated. In the 71 prefecture-level cities in the Yellow River Basin, the number of cities with the coupling coordination degree less than 0.5 decreases in fluctuation, and the number of cities with the coupling coordination degree greater than 0.6 also increases in fluctuation, indicating that the coordinated development level of economic development, public services and ecological environment in the Yellow River Basin is improving.

As a whole, the coupling coordination degree is related to urban economy development condition. According to the coupling coordination degree 71 cities 2012-2019 average, three cities including Jinan, Qingdao and Xi 'an are in good coordination. Those cities have convenient transportation, good education and other services, therefore overall coordination development level is higher. Taiyuan, Hohhot, Baotou, Zhengzhou, Lanzhou and Yinchuan are at the intermediate level of coordination. There are 13 cities in the primary coordination category, including Ordos, Zibo, Yantai, Xining and other cities. Datong, Yangquan, Changzhi, Jincheng and other 34 cities are barely coordinated. While there are thirteen cities, including Xinzhou, Linfen, Luliang, Zhoukou, Shangluo and so on are on the verge of disorder. Compared with these cities, they are relatively backward in economy, blocked in

development, slow in the development of livelihood undertakings, and low in overall coordinated development.

### *3.3. Global Space Autocorrelation of Economic Development, Public Services and Ecological Environment in the Yellow River Basin*

Geoda software was used to construct a spatial weight matrix to measure the global Moran index of the coupling coordination degree of the three systems of 71 prefecture-level cities in the Yellow River Basin from 2012 to 2019.

**Table 4.** Global Moran's I index of coupling coordination degree in the Yellow River Basin (2012-2019)

| year | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|
| Moran's I | 0.173 | 0.202 | 0.215 | 0.211 | 0.194 | 0.176 | 0.132 | 0.143 |
| P value | 0.012 | 0.004 | 0.012 | 0.006 | 0.008 | 0.013 | 0.033 | 0.032 |

From 2012 to 2019, the global Moran index of 71 prefecture-level cities in the Yellow River Basin was all greater than 0, and all passed the significance test ($P < 0.05$), indicating that the spatial distribution of coupling coordination degree in the Yellow River Basin was positively correlated. The global Moran index showed an upward trend from 2012 to 2014, rising from 0.173 to 0.215. From 2015 to 2018, it decreased year by year from 0.211 to 0.132. In 2019, it rose to 0.143. The coupling coordination degree of economy, public service and ecology in the Yellow River Basin showed a trend of agglomeration, dispersion and agglomeration.

### *3.4. Local Spatial Autocorrelation of Economic Development, Public Services and Ecological Environment in the Yellow River Basin*

The global Moran index can only reflect the overall correlation trend of the coupling coordination degree of the three systems. To compensate for this deficiency, the local spatial autocorrelation is carried out to measure the aggregation and spatio-temporal evolution of the coupling coordination degree in the Yellow River Basin.

According to the Moran scatter diagram, the spatial clustering type of coupling coordination degree in each region can be divided into four regions: high-high indicates that the coupling degree of itself is high and the coupling degree of adjacent regions is high; High-low indicates that the coupling degree of itself is high and the coupling degree of adjacent areas is low. Low-high indicates that the coupling degree of itself is low but the coupling degree of adjacent area is high; Low-low indicates that the coupling degree of itself is low and that of adjacent areas is low.

First of all, most prefecture-level cities are in high-high and low-low regions, accounting for 69% in 2012 and 64.8% in 2019, both greater than 50%. The results show that the prefecture-level cities with high coupling coordination degree of economic development, ecological environment and public service and the prefecture-level cities with low coupling coordination degree have agglomeration effect, which has a positive spatial correlation. Specifically, high-high zones include most prefecture level in Shandong and Henan part level city. Those cities' economic development level is high, while education, health care, and social security levels are relatively high.

**Table 5.** Spatial variation classification of coupling coordination degree in the Yellow River Basin

| Spatial correlation model | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|
| High-high | Qingdao, Dongying and other 18 cities | Jinan, Baotou, Qingdao, Yinchuan and other 17 cities | Qingdao, Jinan, Zibo and other 17 cities | Qingdao, Weihai, Yantai, Zaozhuang and other 15 cities | Qingdao, Weihai, Yantai, Tai 'an and other 20 cities | Yinchuan, Qingdao, Shizuishan, Tai 'an and other 17 cities | Qingdao, Baotou, Weifang and other 16 cities | Jinan, Dongying, and other 16 cities |
| High-low | Xi 'an, Tongchuan, Zhengzhou and other 7 cities | Xi 'an, Xianyang, Baotou, Taiyuan, Jining and other 11 cities | Luoyang, Lanzhou, Tongchuan, Xi 'an, Xianyang and other 11 cities | Taiyuan, Xi 'an, Tongchuan, Lanzhou and other 11 cities | Taiyuan, Xi 'an, Zhengzhou and other 9 cities | Lanzhou, Xi 'an, Tongchuan, Zhengzhou and other 8 cities | Taiyuan, Xi 'an, Tongchuan, Yinchuan and other 12 cities | Zhengzhou, Baotou, Yinchuan, Xi 'an and other 10 cities |
| Low-high | Luoyang, Jiaozuo, Pingdingsh an, and other 15 cities | Jinzhong, Zaozhuang, Shangluo, Haidong and other 13 cities | Jiaozuo, Pingdingsh an, Shangluo, Weinan and other 11 cities | Jiaozuo, Pingdingsh an, Haidong, Shangluo and other 14 cities | Jiaozuo, Pingdingsh an, Haidong, Shangluo and other 10 cities | Jiaozuo, Kaifeng, Pingdingsh an, Haidong and other 16 cities | Shizuishan, Liaocheng, Yangquan and other 14 cities | Jiaozuo, Shizuishan, Liaocheng and other 15 cities |
| Low-low | Pingliang, Baoji, Xianyang, Zhongwei, Guyuan and other 31 cities | Longnan, Pingliang, Tianshui, Weinan and other 30 cities | Longnan, Pingliang, Qingyang, Tianshui and other 32 cities | Zhongwei, Guyuan, Shangqiu, Tianshui and other 32 cities | Zhongwei, Weinan, Shangqiu, Xinxiang and other 32 cities | Guyuan, Yan 'an, Yulin, Pingliang and other 30 cities | Longnan, Pingliang, Tianshui, Zhoukou and other 29 cities | Shangqiu, Zhoukou, Zhongwei and other 30 cities |

In addition, low-low zones mainly include Qinghai, Ningxia and Gansu province. The main reason is that these areas are sparsely populated, and economy is relatively backward. While education, health care, social security and other public utilities supply there are large space of ascension. The unreasonable industrial structure there makes the consumption of energy and water larger and the pollution to the ecological environment larger.

Secondly, there are fewer cities in low-high and high-low coupling coordination areas and they are scattered, which is due to the significant difference between the coupling coordination degree of this area and the surrounding areas.

In general, the spatial coupling coordination degree of prefecture-level cities in the Yellow River Basin presents high-high aggregation and low-low aggregation, showing aggregation effect. In 2012, these cities with low concentration were Yulin, Guyuan, Tianshui, Longnan and so on. In 2019, low-low clustering cities include Yulin, Yan 'an, Linfen, Qingyang, Guyuan and so on, while high-high clustering cities include Weifang, Laiwu, Zibo, etc.

## 4. Discussion

Based on the influencing mechanism of the synergy of economy, public service and ecology in the Yellow River Basin, this paper constructed a comprehensive evaluation index system of coupling synergy in the Yellow River Basin, and discussed the spatio-temporal differences and driving factors of the synergy development level of the Yellow River Basin by using entropy method, coupling coordination degree model, spatial autocorrelation model and grey correlation model. There are big differences among cities, and the overall coordination level needs to be improved. There is spatial autocorrelation in the coupling coordination degree between cities within the basin, and it shows the spatial club

convergence characteristics of high-high aggregation and low-low aggregation. Therefore, it plays an important role in promoting the coordinated development of the Yellow River basin to strengthen the linkage of development within the basin, increase financial support, and optimize the industrial structure. In this paper, representative index data of 71 cities are adopted. If possible, more indicators can be used for systematic research.

## 5. Conclusions

General Secretary Xi pointed out that ecological protection and high-quality development of the Yellow River Basin require concerted and long-term efforts of all parties. In order to realize the coordinated development of economic development, public service and ecological environment in the Yellow River Basin, it is necessary to establish the support system of coupling coordination between economic development, public service and ecological environment. The enlightenment of the above analysis on the establishment of support system is as follows:

First, we should improve the quality of the population and promote scientific and technological innovation. We will comprehensively improve the physical, intellectual and cultural quality of the population and enhance its capacity for scientific research and technological innovation. Comprehensively we should promote use of the internet and new technology means. For example, artificial intelligence can assign ecology and so on various aspects of production and life, and we should make good use of the new digital economy development pattern, promoting the fusion of artificial intelligence and the real economy. It is important to promote green industrial transformation, to improve the level of environmental protection and to improve residents' happiness of life, making the Yellow River Basin into an important link connecting east and west.

Second, we should increase financial input to improve the allocation capacity of public infrastructure. It is important to bear in mind that people's livelihood is the most important political issue, and earnestly solving the interests of the people most concerned is important. Governments at all levels should, in light of local conditions, formulate economic development systems suited to their respective regions and provide corresponding preferential policies and support. Poor areas in the River Basin, in particular, should also seize the development opportunity, get on board the express train of national development strategy so that they can improve local public infrastructure, service level, and people's livelihood.

Third, we should optimize the industrial structure and promote the development of tertiary industry. Emerging and high-tech industries should be developed in the basin to promote the development of digital economy. While it is important to construct new infrastructure, and new pension institutions and new business models to improve local development.

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