High-quality Development Effectiveness of Provincial Regions in China: Data-driven Evaluation and Spatio-temporal Characteristics

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ABSTRACT: Healthy and sustainable high-quality development needs to rely on scientific planning and design of assessment system, enabling high-quality assessment to become an important tool to lead and drive high-quality development in China. A high-quality development evaluation index system is proposed, consisting of six dimensions: economic operation, innovation-driven, coordinated development, green ecology, open development, and sharing and harmony, and the temporal and spatial Differentiation in China's inter-provincial high-quality development levels are discussed after being measured using the entropy weight method. The results show that from the time dimension, China's overall high quality development level shows a fluctuating upward trend with an obvious growth rate, and Jiangsu, Zhejiang and Shanghai maintained a high level of high-quality development during this period. From the spatial dimension, it is found that China's high-quality development level has a significant positive spatial correlation between regions from 2014 to 2020, with a stable "high-high" agglomeration in the eastern coastal areas and the middle and lower reaches of the Yangtze River, the "low-high" agglomeration is mainly distributed in the central plains, and the "low-low" agglomeration effect in the western provinces and regions has spread on a larger scale after 2015, with significant performance in the north-western provinces and regions.

KEYWORDS: High-quality Development, Entropy method, Temporal Differentiation, Spatial Agglomeration

I. INTRODUCTION

"High-quality development" is the main theme of China's economic and social development in the future. It is an epoch-making and forward-looking judgment based on a new historical starting point and conditions of the times when the quantitative economy of China's high-speed development has reached a certain level. Different from high-speed growth, high quality development has a rich connotation, which includes various segments of development and is still evolving in the current development practice. High-quality development is no longer confined to the goal of "seeking efficient development in the pure economic field", but extends this development model to the national governance system and governance capacity, the ecological civilization system, and even the fields that can have a profound impact on increasing people's sense of access and happiness. Therefore, considering the multi-dimensional and dynamic characteristics of high-quality development, and the fact that most of the current research remains at the theoretical level, whether at the national level, it can help to grasp the "time window" of accelerating economic transformation and upgrading, or at the social level, it can further meet the people's needs for a better and quality life, build a set of a scientific, reasonable and comprehensive index system of high-quality development, dig into the current situation of high quality development of China's economy, and respond to high quality development with high quality assessment, this should be the research direction we need to stick to and work hard for.

II. LITERATURE REVIEW

High-quality development is a new concept for the quality of China's economic development. To accurately understand the connotation of high-quality development, the first lies in clarifying the meaning of the quality of economic development. The current relevant literature can be referred to: Barro (2002) explained the quality of economic growth from six perspectives: life expectancy, fertility rate, environmental conditions, income equity, political system, and religious beliefs. HUI and CHAO (2010) have pointed out that quality focuses on the qualitative improvement in the process of economic growth, reflecting its quality in terms of process, outcome, and prospect. REN and WEN (2018) emphasized that the quality of economic development is a multidimensional concept with rich connotations, which is not only expressed as increasing the quantity of total economic volume and material wealth, but also a value judgment of the level, specifically including four aspects of economic development, reform

and opening up, urban and rural development and ecological environment. LIU (2018) believed that the quality of economic development should be analyzed from a diversified perspective, which requires more balance in economic structure, more attention to the improvement of service quality and more emphasis on the market as well as the role of demand. Based on the meaning of economic development quality, LI, SHI and XU (2019) summarize the connotation of high-quality development and divide it into three categories: (1) from the perspective of "new development concept" and the main social contradiction, they point out that high-quality development is development with "meeting the people's growing needs for a better life" as the fundamental purpose and "the five development concepts of innovation, coordination, green, openness and sharing" as the fundamental concept (Zhan and Pei (2016), JIN (2018)). (2) from the perspective of high-quality economic development, it is pointed out that "high quality" is the fundamental requirement in high quality development, and "sustainable" is the fundamental way. (3) from the perspective of distinguishing the different requirements of micro and macro, it suggests that high-quality development needs to meet both products and services at the micro level and structures and efficiency at the macro level (WEI and LI (2018), AN (2018)).

Many researchers have studied regional econimic development measurement and evaluation in recent decades, which has shown a dynamic development process. The methods of evaluation are different at different stages of development and are divided into two main types. The first one advocates the use of a single indicator to evaluate the quality of economic development, such as Total Factor Productivity (TFP) (Zhang, Liu, and Huang (2020), Zeng, Shu and Ye (2022).) or Value-added rate, etc. Mlachila, Tapsoba and Tapsoba (2017) established an indicator for developing countries to measure the quality of their economic development that reflects the intrinsic nature of economic growth and the effectiveness of economic growth at the social level. Yu, Zhang, and Zhang (2019) added environmental factors to total factor productivity to measure the quality development of China's economy. The second advocates building evaluation index systems to evaluate economic development, the results of research have been reflected (Kristensen and Mosgaard (2020), State, Bulin, Oehler-Sincai and et al (2019), SzopikDepczyńska, Cheba, Bąk and et al (2018), et al (2012)). Among the evaluations on China's high-quality development, some scholars consider that the conclusions obtained by a single indicator method may be one-sided and limited. So they also set up evaluation indicator systems, but with slightly different focuses. Song, Zhang, and Yi (2015) defined the quality of economic development as "the extent to which economic development meets the requirements of social and sustainabledevelopment" at the macro level and constructed an evaluation index system from three dimensions: competitive quality, livelihood quality and ecological quality. SHI and Ren (2018) proposed the evaluation index system from two dimensions: growth fundamentals and social outcomes. CHEN and SHI (2019) established the index system from six dimensions: innovation, coordination, green, openness, sharing, and efficiency, guided by the "Five Development Concepts".

However, there are few studies on the spatial and temporal differentiation of high-quality development. Lu, Xing, and Yang (2019) concluded that there is a high spatial dependence effect of high- quality economic development in different regions of China by using a spatial correlation model, forming a distribution pattern of "high in the east", "flat in the middle" and "low in the west". CHEN and SHI (2019) pointed out that the high-quality level of China's economy in the eastern coastal region is much higher than that in the central and western regions, and the effectiveness of high-quality development has accelerated in recent years, with the largest gap in the eastern region and the smallest gap within the northeastern region. Fang and Ma (2019) explored the regional clustering of China's high-quality development with the combination of GIS and exploratory spatial data analysis (ESDA) methods, pointing out that there is an obvious and still continuously enhancing agglomeration effect of inter-provincial high quality development level in China, and it spreads from the eastern coast to the central and western inland regions. According to the above discussion, the consensus has been basically reached that high-quality development is a dynamic and multidimensional concept, and it is relatively mature to measure the level of high-quality development by constructing an indicator system, but there remain the problems of incomplete indicator system and redundancy of indicator settings. And there is a lack of quantitative research on the spatial and temporal characteristics of high-quality development. Therefore, with the guidance of economic growth and "new development concept", the index system is constructed from six dimensions: economic operation, innovation-driven, coordinated development, green ecology, open development, sharing and harmony. We measure the level of high-quality development in China's inter-provincial economy from 2014 to 2020 and analyze its spatial and temporal differentiation, providing support for exploring ways to achieve quality development.

III. EVALUATION INDEX SYSTEM

High-quality development is a description of the quality of economic growth, which is different from the speed of economic growth, and focuses on solving the problem of "how to develop in different spheres of economic process". Secondly, high-quality development is a concrete manifestation of the new development concept, representing a comprehensive economic development model of higher quality, more efficient, more stable, and more open in the new era of China. And it requires development on multiple aspects: dynamic and sustainable healthy development of the national economy without blindly pursuing GDP growth; high-efficiency development driven by innovation; green development with continuous improvement of the ecological environment; and the development with continuous improvement of people's quality of life. Therefore, the evaluation of high quality development has puts forward new and higher requirements for the reform and innovation of the statistical index system: we should pay more attention to the performance of development in terms of effectiveness, coordination, innovation, openness and sharing when judging the level of high-quality development, and the evaluation index should also reflect the changes in the main contradictions of Chinese society and the characteristics of economic development in the new era.

Based on the above, we construct an evaluation index system of China's inter-provincial high-quality development from three levels: target layer, criterion layer and indicator layer. The target layer is about the research purpose, which is China's high-quality development, the criterion layer is constructed around the "economic growth" and the five contents of the new development concept, including six indices of economic operation, innovation-driven, coordinated development, green ecology, open development, sharing and harmony, according to the core connotation of each index and the established target tasks, we further determine quantitative indicators to measure the degree of their completion, i.e. the indicator layer. Table 1 specifically displays the constructed evaluation index system of high-quality development.

Table 1. Comprehensive evaluation index system of High-quality development

Target layer	Guideline layer	Index layer	Index Company	Index direction
Economic operation	Economic development intensity	GDP growth rate	%	+
		Fiscal revenue	million yuan	+
		Social Labor Productivity	%	+
	Rationalization of economic development	Service industry value added as a percentage	%	+
		Contribution rate of residential consumption	%	+
Innovation drive	Innovation inputs	R&D investment intensity	%	+
		R&D staff full-time equivalent	person per year	+
	Innovation output	Patent effective volume	piece	+
		Technical market turnover	million yuan	+
Coordinate development	Rural and urban development	Urban-rural income disparity	yuan	-
		Urbanization rate	%	+
	Industry structure development	Rationalization of industrial structure	%	-
	Material and spiritual civilization development	The proportion of cultural expenditure to fiscal expenditure	%	+
		Per capita cultural consumption expenditure of residents	yuan	+
Green Ecology	Ecological Environment	Energy consumption per unit of GDP	ton of standard coal / million yuan	-
		Percentage of days with good air quality	%	+
		Greening coverage of built-up areas	%	+

Opening up development	Sustainability	Sewage treatment rate	%	+
		Harmless disposal rate of domestic waste	%	+
		General industrial solid waste comprehensive utilization rate	%	+
	Trade opening	External trade dependency	%	
	Investment opening	Actual Foreign Direct Investment(FDI)	million yuan	+
	Tourism opening	100	10000 people	+
Sharing Harmony	People's lives	Per capita disposable income of residents	yuan	+
		Urban registered unemployment rate	%	-
		Number of urban workers' pension insurance participants	person	+
		Number of beds in health facilities per 1,000 people		+
	Development achievements	Public library holdings per capita		+
		General university student-teacher ratio	%	+

The weight of each index is determined by the entropy weight method. The steps are as follows:

(1)For m evaluation units and n evaluation indicators, the original data matrix is formed:

$$R = \left(r_{ij} \right)_{m \times n} \tag{1}$$

(2)The individual evaluation indicators are homogenized, that is, the indicator values are transformed into weights P of the indicator values of the ith program under the jth indicator:

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{2}$$

(3)Calculate the entropy coefficient of the jth indicator:

$$e_j = -k \sum_{i=1}^{m} p_{ij} \times \ln p_{ij} \tag{3}$$

where $k = \frac{1}{\ln m} > 0, e_j > 0$

(4) Calculate the information entropy redundancy of the jth indicator: $g_i = 1 - e_i$

(5) Calculate the weights of each indicator:

$$a_j = \frac{g_i}{\sum_{i=1}^{n} g_i} \tag{4}$$

(6) Calculate the composite score:

$$v_i = \sum_{j=1}^{n} a_i p_{ij} \tag{5}$$

IV. ANALYSIS OF EMPIRICAL RESULTS

A. Temporal Differentiation of High-Quality Development in China

After comparing the average value of China's high-quality development level, it is found that there is a fluctuating upward trend from 2014 to 2020, rising from 0.3556 in 2014 to 0.3782 in 2020. From the magnitude of change in the mean value, there is a most significant growth in the overall national level of quality development from 2016 to 2017, and since 2017 the growth has been stable year by year. And Jiangsu, Zhejiang and Shanghai have the highest level of high-quality development and will continue to play the role of high-quality development "leader" in the future, they ensure a more leading position but also maintain the most stable, lasting, and excellent development trend. However, Tibet, Qinghai, Xinjiang, Ningxia, and Gansu are lagging in high-quality development, which fully confirms the characteristics of the long-standing development gap between the east and the west in China.

B. Spatial Differentiation of High-Quality Development in China

Considering the variability in the level of China's provincial economic quality development, we analyze its spatial characteristics further. Global and local spatial autocorrelation analysis are used to explain the spatial clustering and differences of China's economic high-quality development.

1) Spatial global autocorrelation analysis: The Global Moran's I index is used to determine the spatial correlation of economic quality development differences among provinces. The global Moran's I index is defined as follows:

$$I = \frac{n}{\sum_{i=1}^{n}(x_i - \overline{x})} * \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \overline{x})(x_j - \overline{x})}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \tag{6}$$

where, n is the number of provinces in China, x_i denotes the observed value of the ith region, and denotes the regional average. w_{ij} is the spatial weight matrix, and here a 0-1 weight distance matrix is used, 1 if the province is spatially adjacent to the province and 0 if it is not, while taking into account the special case: Hainan Province is an island, so Guangdong and Hainan are considered as each other's neighboring regions. The Global Moran's I index takes values in the range of (-1, 1). When Moran's I index > 0, it indicates that there is a spatially positively correlated agglomeration effect of China's high-quality development, while <0 is the opposite, and the closer the index value is to -1 or +1 indicates a higher degree of agglomeration, the index value of 0 means that there is no spatial correlation. Table 2 shows the Moran's I index of China's high quality development level for the period 2014-2020

Table 2: global Moran's I Index for China's high-quality development during 2014-2020

Year	2014	2015	2016	2017	2018	2019	2020
Moran's I	0.21	0.20	0.19	0.22	0.24	0.26	0.26
Z-value	3.20	3.05	2.96	3.24	3.55	3.68	3.85
P-value	0.0016	0.0023	0.0030	0.0012	0.0004	0.0001	0.0001

During this period, the Global Moran's I index showed positive values, and the p-values all passed the 1% significance level test, which indicated that the spatial distribution of China's high quality economic development level was not completely random, but there was a significant positive spatial correlation, that is, provinces (cities and autonomous regions) with higher development level were adjacent to each other, and provinces (cities and autonomous regions) with lower level were adjacent to each other. It can also be found that 2016 was the turning point, with Moran's I index declining continuously during 2014-2016 and starting to show an upward trend of a larger magnitude after 2016, which reflects the spatial dependence of high-quality development level in China's provinces has been strengthening in recent years, and the forward pace of high-quality development across the region has accelerated significantly, with inter-regional collaboration further deepening.

2) Spatial local autocorrelation analysis: Local autocorrelation analysis describes the similarity between a spatial region and its neighboring regions, which is generally measured by the Local Moran's I index. The Local Moran's I index is defined as follows:

$$I_i(d) = \left(\frac{n(x_i - \overline{x}) \sum_{j=1}^{n} w_{ij}(x_i - \overline{x})}{\sum_{i=1}^{n}(x_i - \overline{x})} \right) = z_i \sum_j w_{ij} z_j \tag{7}$$

where z_i, z_j are the normalized values of the i-th and j-th observations. When $I_i(d)$ is greater than 0, it means that region i and its neighboring regions have similar spatial distribution, in which case there will be the same high level or the same low level. On the contrary, when $I_i(d)$ is less than 0, it means that region i and its neighboring regions have opposite spatial distribution (high-low aggregation distribution or low-high aggregation distribution). Thus four patterns of spatial distribution will exist: high-high pattern; high-low pattern; low-low pattern and low-high pattern. We visualize the spatial distribution of China's provincial economic quality development by plotting the Lisa aggregation map (in Figure1).
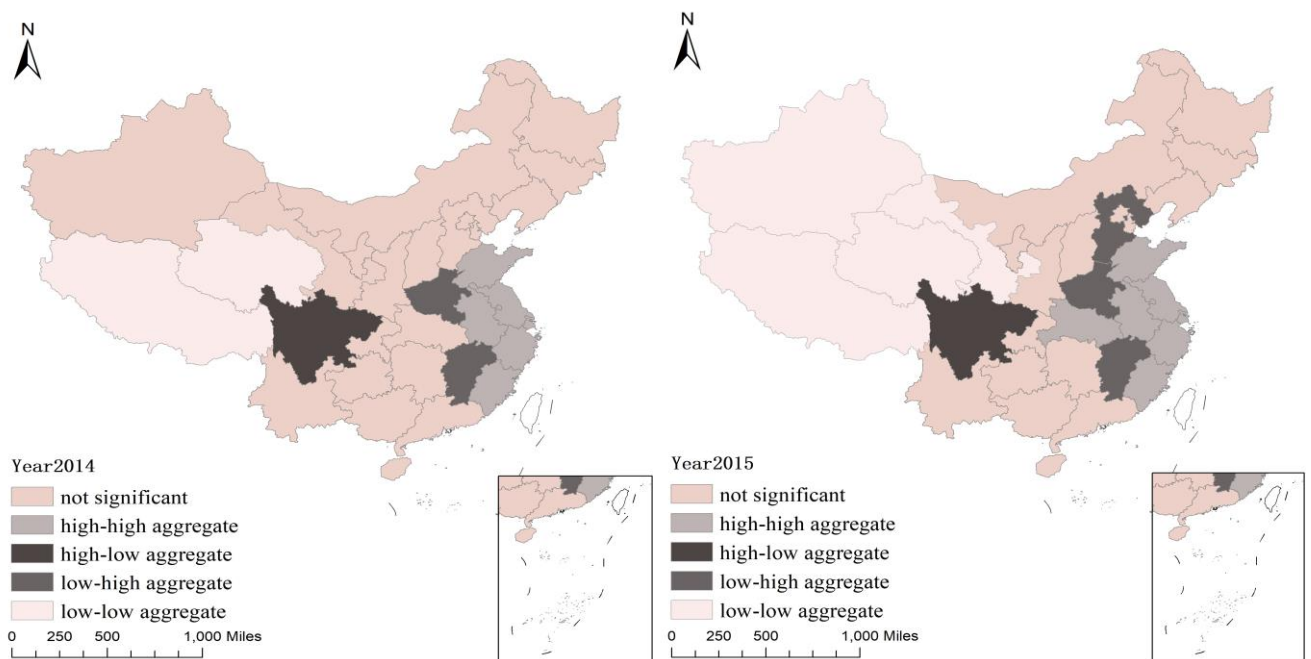

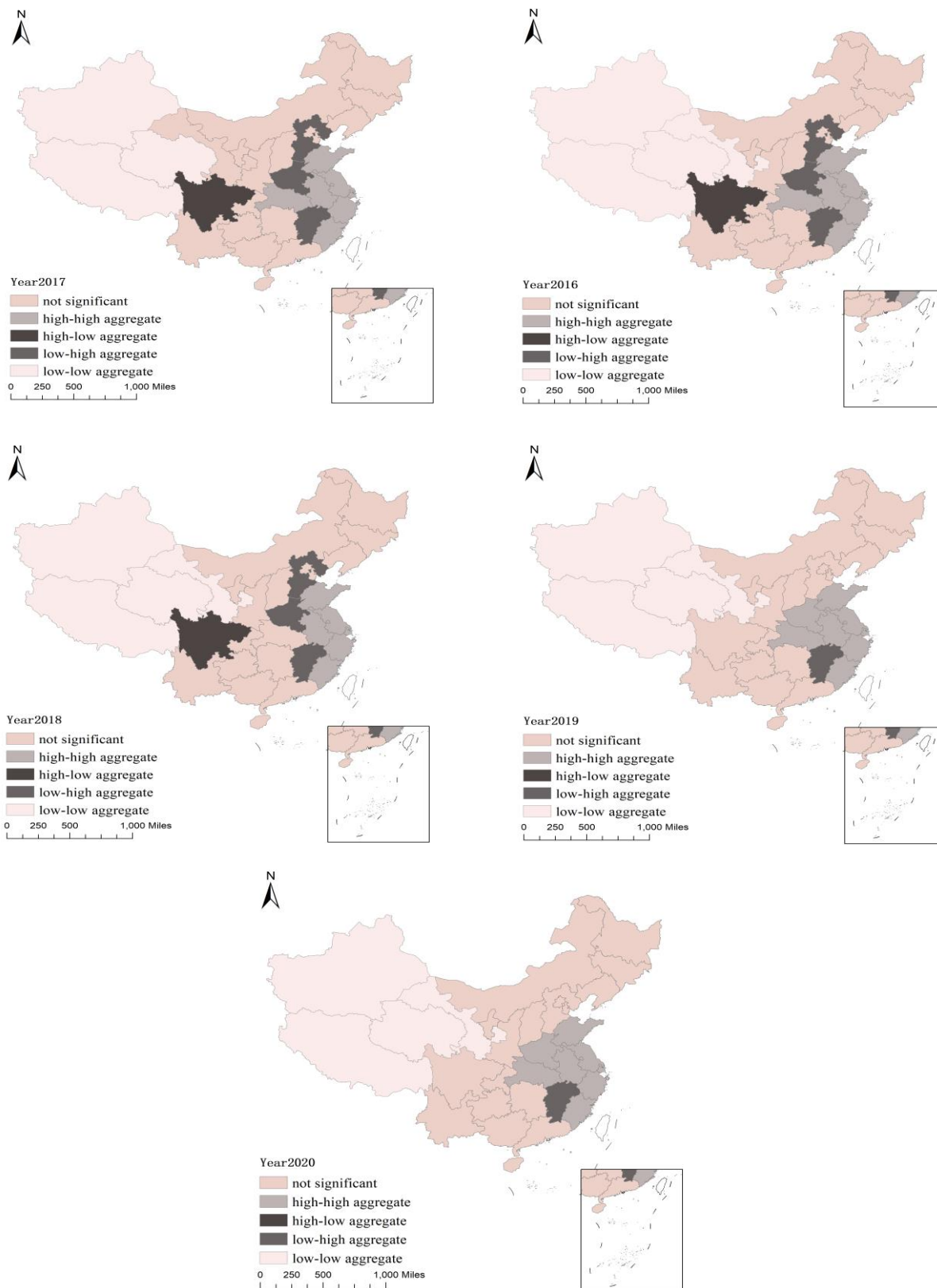**Figure 1**. China's provincial high-quality development aggregation in 2014-2020

Figure 1. China's provincial high-quality development aggregation in 2014-2020(Continued from previous figure)

In general, the regions with "high - high pattern" are the most, basically 5-7 provinces can be stabilized every year, which reflects that China's economy has shown good results in achieving high quality development. And there is a relatively stable high-high aggregation in China's eastern coastal region and some regions in the middle and lower reaches of Yangtze River, especially Jiangsu, Shanghai, Zhejiang, Hubei, etc., which have shown a high level of high-quality economic development and obvious spillover effects in the past five years. They are mostly adjacent to each other and have formed a spatially clustered and mutually reinforcing whole, which is a crucial part of China's goal of achieving high-quality economic development. The second is the region with "low-high pattern", which Hebei, Henan as well as Jiangxi provinces belonged for four of the last six years (2015-2018), with their low high-quality development level and a significant gap between them and their neighboring provinces. Hebei locates in the Beijing-Tianjin-Hebei city cluster, close to the Bohai Sea. Despite its geographical location, but in the early stage of development, it lagged far behind compared with the neighboring Beijing and Tianjin. On the one hand, it may be related to the fact that the cooperation between Beijing and Tianjin had not been deepened, the Beijing-Tianjin-Hebei cooperative development strategy was first proposed in 2014, and the effectiveness was not revealed by some factors such as inappropriate cooperation methods and unstable cooperation models, on the other hand, it may also lie in the fact that the two regions, Beijing and Tianjin, attract a large amount of human, financial and other resources from the surrounding area, resulting in a greatly restricted development space. In 2019 a turnaround was ushered in, with further synergistic development and closer and more effective inter-regional cooperation, the positive radiation effect of the Beijing-Tianjin region has been released and the low - high agglomeration phenomenon in Hebei province disappears. Similarly, although Henan and Jiangxi have obvious location advantages, close to the Yangtze River Delta region with active economic development, high degree of openness and strong innovation capacity, they did not bring it into play, their high-quality development derailed from surrounding areas, which may be related to the lack of close cooperation with the surrounding areas weak initiative to absorb the successful experience of high-quality development. Now Henan has gotten rid of the dilemma of high-quality development and entered a high aggregate of high area. It is reported that regions with "low-low pattern" are mainly distributed in western China, with Xinjiang and Gansu added to the original Tibet and Qinghai after 2015, and the low-low agglomeration of the four provinces has been basically stable, indicating that the reverse driving role of the low region has exceeded the original positive driving role played. Although China's overall high quality economic development level has improved significantly, the situation in the western region is not optimistic. The western region should further accelerate the breaking of geopolitical restrictions and seek high quality cross-regional cooperation in the future.

V. CONCLUSIONS AND POLICY RECOMMENDATIONS

After using the entropy method to measure the level of high-quality economic development in China's provinces from 2014 to 2020, we explore the characteristics of their spatial and temporal differences, and the results are as follows:

(1) Since 2015, China's economic quality development trend has been generally positive, with most provinces improving their quality development level year by year.

(2) China's provincial economic quality development shows a significant positive spatial correlation: the eastern coastal region and the middle and lower reaches of the Yangtze River belong to the "high-high agglomeration" pattern, and this phenomenon has basically stabilized in the region. The low-low agglomeration phenomenon in the western region intensifies after 2015.

(3) The spatial and temporal differences fully illustrate that there is also a problem of unbalanced and insufficient development between regions in China's high-quality development.

Therefore, against the background of good quality development of China's economy, but with development differences between regions, further achieving the goal of high-quality development still requires the joint efforts of all regions:

(1) As the main driver of China's high-quality economic development, the eastern coastal regions should continue to develop new models of high-quality development in various fields and promote the implementation of various policies and strategies. At the same time, it should further play an active radiating role to drive the development of its neighboring regions and take the initiative to strengthen cooperation with the central and western regions, including sending local high-quality counterpart technologies, professional talents and investment projects with high return rates and high feasibility, helping them break through bottlenecks in economic development.

(2) Geographically, the central regions act as a bridge between the eastern and western regions and has both opportunities and challenges in promoting high-quality economic development. They possess the opportunity to absorb and learn from the advanced

development experience of the eastern region to build a suitable development system for itself, and also bear the challenge of transferring resources and driving the high-quality development of the western region under the premise of ensuring its own benign development goals. So the central regions need to clarify own orientation, actively seek interaction with neighboring regions, and use geographical advantages to grasp, or even create opportunities to achieve high-quality economic development.

(3) The western region is the focus of China's high-quality economic development, the introduction and implementation of various national support policies can certainly bring strong development momentum to them, coupled with their own unique characteristics in nature, culture, environment and other resources, they can fully break through the geographical restrictions, while changing the mode of economic development, optimizing the economic structure with the introduction of talent, technology, capital and other active policies, with the aim of achieving the leap to high-quality development.

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