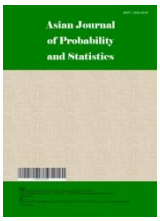

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The Statistical Measurement System of High-Quality Development Level of Cities - Based on Yangtze River Delta Region of China

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Authors' contributions

This work was carried out in collaboration between both authors. Author HF designed the study, performed the statistical analysis, and wrote the first draft of the manuscript. Author KW provided constructive advice, managed the analyses and process of the study. Both authors read and approved the final manuscript.

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Abstract

Combining China's development concepts of innovation, coordination, green, openness and sharing, the paper constructs a high-quality development measurement system of Yangtze River Delta of China, which contains five dimensions: the optimization of economic structure, the efficient allocation of resource, the stable growth of economic, the regional development coordination and the presentation of economic achievements. Using 2019 municipal data, the entropy weighted TOPSIS method was used to statistically measure the level of high-quality development level of 27 cities in the Yangtze River Delta region. And four categories of cities, namely excellent, good, normal and lagging, were classified. The results show that Shanghai has the highest level of high-quality development, and most cities have lower scores in the subsystem of the stable growth of economic. Finally, this paper makes targeted reasonable suggestions for cities, especially the lagging cities.

Keywords: High-quality development; Yangtze River Delta of China; entropy weight TOPSIS method; statistical measurements.

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1 Introduction

At the beginning of the 21st century, China experienced a phase of accelerated economic development, and its scale continued to expand. However, the development mode is relatively sloppy, the economic structure is unreasonable, the resource constraint is increasingly obvious, and the problem of economic development mode is becoming more and more prominent. In 2017, China clearly proposed for the first time to shift from the stage of high-speed development to the stage of high-quality development. High-quality development is built on the new development concept of innovation, coordination, green, openness and sharing, which is also a combination of macroscopic and microscopic perspectives. The high quality of macro economy is inevitably based on the high quality of micro subjects such as products and technologies. In 2018, the integrated development of Yangtze River Delta region was proposed to be elevated to a national strategy. The plan includes the whole area of Shanghai, Jiangsu Province, Zhejiang Province and Anhui Province, and takes 27 cities in Shanghai, Nanjing, Wuxi, Changzhou, Suzhou, Nantong, Yangzhou, Zhenjiang, Yancheng, Taizhou_1 (that is a city of Jiangsu province), Hangzhou, Ningbo, Wenzhou, Huzhou, Jiaxing, Shaoxing, Jinhua, Zhoushan, Taizhou_2 (that is a city of Zhejiang province),, Hefei, Wuhu, Ma'anshan, Tongling, Anqing, Chuzhou, Chizhou and Xuancheng as the central area, radiating and driving the high-quality development of the Yangtze River Delta region. It will be built into a demonstration area for high-quality development in the country. However, no unified measurement system for high quality development has been established so far. As a result, the Yangtze River Delta study has substantial theoretical implications for economic development statistics. It is of tremendous practical importance for inter-regional collaboration and exchange, common development, and the creation of a national demonstration area for high-quality development, as a result of the study.

Numerous experts and scholars have conducted extensive research on the construction of high-quality development system. Based on 61 cities, Yang and Yan used Entropy Weight TOPSIS method and spatial econometric model to study the level of high-quality development in the Yellow River Basin. Their development suggestions are to strengthen regional strategic cooperation and optimize the spatial spillover effect of cities [1]. Huang et al. constructed a measurement system based on the new development concept and used factor analysis to evaluate the high-quality development status of the Huai River Economic Belt of China. It was found that there is strong spatial heterogeneity [2]. Zhou and Hu constructed an index system based on the five development concepts and studied 13 prefecture-level cities in Jiangsu Province for evaluation and analysis. It was found that the level of high-quality economic development in the province showed a decreasing trend from south to north [3]. Wu et al. constructed agricultural high-quality indicators from four aspects: supply quality, efficient production, innovation and integration, and sustainable development. They explored the influence mechanism of digital economy on agricultural development [4].

As a pioneer and demonstration area for national economic development in the new era, the status of high-quality development in the Yangtze River Delta region has received attention from a wide range of researchers. Fang and Cao analyzed five major cities of Yangtze River Delta, Hangzhou, Ningbo, Suzhou, Hefei and Nanjing, in four dimensions: innovation, coordination, green and sharing. The high-quality level was found to be higher along the coast than inland [5]. Yang et al. constructed a system of relevant indicators in five dimensions: economic vitality, innovation efficiency, green development, people's life and social harmony, and made statistical measurements of the Yangtze River Delta cities [6]. Guo and Deng analyzed and discussed the level of high-quality development in the Yangtze River Delta region from three dimensions: total economic scale, coefficient of variation of economic growth rate, industrial upgrading and structural changes of manufacturing industry, and made suggestions: clarifying governmental responsibilities, improving institutional construction, refining industrial division of labor and encouraging equal competition [7].

For the description of the quality of economic development, influenced by the economic models in studies of Solow [8] , Jorgenson and Griliches [9], scholars usually use total factor productivity as a simple measure [10-12], but it has some limitations. Its inability to explore the level of development from multiple perspectives, such as the results of scientific and technological development, and the level of education. We would like to have a system that describes the level of regional development as accurately as possible. Being driven by the above papers, we combine traditional measurement methods [13] and the new development concept of China to show a more comprehensive level of development from multiple perspectives. This paper constructs a statistical measurement system with five dimensions: the optimization of economic structure, the efficient allocation of resource, the stable growth of economic, the regional development coordination and the presentation of

economic achievements, and studies the high-quality development of 27 central cities in the Yangtze River Delta region. Compared with existing studies, the system constructed in this article utilizes the most recent data and includes specific indicators in multiple fields such as science and technology, education, environment, employment, and business. Theoretically, the article broadens and develops the study of regional high-quality development measurement system and makes it continuously improved.
The system allows government departments to understand the development gaps and shortcomings between cities more clearly and concretely, and to make timely adjustments. Therefore, it is of great importance for the high-quality development of the region.

2 Method and Methodology

The system of high-quality development in this paper consists of five subsystems, each of which contains several criteria layers. The logical idea is as follows.

2.1 Construction of Subsystems

2.1.1 Optimization of economic structure

The Yangtze River Delta region is a key development region in the south of China. It has excellent geographical and humanistic advantages, and has also developed a complete variety of industrial chains. The economic structure is mainly reflected by industrial manufacturing, investment and consumption, and domestic and foreign import and export. High-quality development urgently needs to break the shackles of traditional development. There is a need to change the way of thinking about economic development, to integrate a variety of industries, to increase the variety of employment, to boost people's income, and to drive the consumption of multiple groups. What's more, it needs to take advantage of developed transportation methods and technology levels, adhere to open policies, fully embrace multiple economic agents, and innovate diversified industrial structures. The subsystem is constructed according to three guideline layers: industrial structure, consumption structure, and economic openness structure.

2.1.2 Efficient allocation of resource

One of the important implications of economic research is to achieve efficient allocation of resources. In the earlier stages of development, China pursued high speed development and made full use of the regional characteristics of various natural resources rich in each region to develop vigorously, and achieved certain results. However, this has brought harm to people's living environment. Rational and effective allocation of resources is an important means to achieve more happiness for the people and high-quality economic development. Based on the three traditional basic criteria of energy productivity, labor productivity and capital productivity, this paper adds innovation productivity to reflect the rational allocation of resources driven by science and technology innovation.

2.1.3 Stable growth of economic

In today's globalization, the exchange of various countries, regions and industries has increased extensively, bringing development opportunities and uncertainties to all economic agents, i.e., opportunities and risks coexist. We must always be alert to prevent risks and actively cooperate to cope with them. Only a smooth economic environment can enable a reasonable distribution of labor, capital, knowledge and technology and other factors of production, otherwise it will produce unpredictable situations for industrial development structure, resource injection. Achieving stable economic growth is the basic condition for high-quality development. The subsystem of the economic growth stability consists of three guideline layers: the growth of output values, the industrial capital and the labor capital.

2.1.4 Regional development coordination

In China the economic level is higher on the eastern coast, and the closer to the inland, the bigger the gap between the development level of cities and it. As we all know, Anhui Province is located inland and has a certain gap with the eastern region as a whole. And its own various cities at prefecture level have different levels

of development. Coordinated development is an important part of the new development concept and an important condition for the formation of the new development pattern, which requires communication and interoperability between various regions from multiple fields such as culture and products. This paper explores the two guideline levels of GDP per capita and products and services separately.

2.1.5 Presentation of economic achievements

The ultimate goal of China's development and construction is to achieve common prosperity. The ultimate goal of high-quality economic development is also to benefit the people with the results. This requires that the fruits of culture, science and technology and many other fields really fall into the hands of the people in a tangible way. While enjoying the fruits of social development, it increases people's happiness and satisfaction. Combined with the fact that China is now implementing sustainable development policies, this paper shows the results of economic benefits to the people from two guideline layers: public infrastructure development and ecological civilization.

2.2 The system of measurement and evaluation of high-quality development

All 34 specific indicators of the measurement and evaluation system and property are shown in Table 1. The positive property indicates that it is conducive to high quality-development, and the negative property indicates that it will have a certain degree of inhibitory effect.

Table 1. The system of measurement and evaluation of high-quality development.

Subsystem	Guideline	Indicator	Property
Optimization of Economic Structure	Industry Structure	Proportion of added value of tertiary sector in GDP	+
		Employment in the information technology sector	+
		Employment in the financial sector	+
		Proportion of domestic enterprises	+
	Consumption structure	Proportion of total social consumer goods in GDP	-
		Balance of deposits of financial institutions	+
		Balance of loans of financial institutions	+
	Economic Open Structure	Amount of foreign direct investment	+
		Amount of actual utilized foreign capital	+
		Total industrial output value of foreign-invested enterprises	+
Efficient Allocation of Resource	Innovation Drivers	Public budget expenditures for education	+
		Public budget expenditure on science and technology	+
	Capital Productivity	GDP/fixed asset investment	+
	Labor Productivity	GDP/the number of employed persons in urban units	+
	Energy productivity	GDP/Total amount supply of artificial gas and natural gas	+
		GDP/Total supply of water	+
Stable Growth of Economic	Growth rate of output	Growth rate of GDP	+
	Industrial capital	Electricity consumption of industrial production	+
	Labor capital	Number of employed persons in urban units	+
		Number of registered unemployed persons in urban areas	-
Regional Development	GDP per capita	GDP per capita	+
	Products and	Number of general secondary schools	+
		Number of full-time teachers in general higher education schools	+
		Number of full-time teachers in general secondary schools	+

Subsystem	Guideline	Indicator	Property
Coordination	Services	Number of full-time teachers in secondary vocational education	+
		Number of full-time teachers in general elementary school	+
		Electricity consumption of urban and rural residents' living	+
Presentation of Economic Achievements	Basic Public Facilities	Area of park green space	+
		Area of roads	+
	Ecological Civilization Construction	The greening coverage of living areas	+
		The average salary of urban unit workers on the job	+

2.3 Entropy weight TOPSIS

2.3.1 Standardization

$$Y_{ij} = \begin{cases} \dfrac{X_{ij} - min(X_{\cdot j})}{max(X_{\cdot j}) - min(X_{\cdot j})}, \ if\ the\ property\ of\ X_{ij}\ is\ positive; \\ \dfrac{max(X_{\cdot j}) - X_{ii}}{max(X_{\cdot j}) - min(X_{\cdot j})}, \ if\ the\ property\ of\ X_{ij}\ is\ negative. \end{cases}$$

Here, i denotes the city, j denotes the indicator. X_{ij} is the initial data of the cities' indicators.

2.3.2 Entropy of information

$$E_j = \ln \frac{1}{n} \sum_{i=1}^{n} \left[\left(\frac{Y_{ij}}{\sum_{i=1}^{n} Y_{ij}} \right) \ln \left(\frac{Y_{ij}}{\sum_{i=1}^{n} Y_{ij}} \right) \right],$$

where n is the number of the cities.

2.3.3 Weight

$$W_i = \frac{(1 - E_j)}{\sum_{j=1}^{m} (1 - E_j)},$$

where m is the number of the indicators.

2.3.4 Weighting matrix

$$R = (r_{ij})_{n \times m}, \text{where } r_{ij} = W_j \times Y_{ij}$$

2.3.5 Calculate the euclidean distance

$$Q_j^+ = (max(r_{i1}), max(r_{i2}), \cdots, max(r_{in}))$$
$$Q_j^- = (min(r_{i1}), min(r_{i2}), \cdots, min(r_{in}))$$
$$d_i^+ = \left[\sum_{j=1}^{m} (Q_j^+ - r_{ij})^2 \right]^{\frac{1}{2}}$$
$$d_i^- = \left[\sum_{j=1}^{m} (Q_j^- - r_{ij})^2 \right]^{\frac{1}{2}}$$

d_i^+ is the Euclidean distance between the actual high-quality development status and the optimal status Q_j^+, and d_i^- is the Euclidean distance between the actual high-quality development status and the inferior status Q_j^-.

2.3.6 Relative proximity of the real situation to the ideal situation

$$C_i = \frac{d_i^-}{d_i^+ + d_i^-}$$

The relative proximity of calculation result is between 0 and 1. When its value is larger, it indicates that the city has a higher level of high-quality economic development, and when its value is smaller, it indicates that the city has a lower level of high-quality development.

2.4 Sources of data

This paper used the data of 2019, which is from provincial and municipal statistical yearbooks, China City Statistical Yearbook, China City Construction Statistical Yearbook and China Regional Economic Statistical Yearbook.

3 Results

3.1 High-quality development level of 27 cities

The comprehensive score of each city's high-quality development level was calculated and scores are shown in Fig. 1, by using the developed comprehensive measurement system and Entropy Weight TOPSIS method. The mean value of the scores of the 27 cities in the Yangtze River Delta region is 0.1469, and the standard deviation is 0.1719. This paper follows the relationship between mean and standard deviation: score greater than 1 standard deviation from the mean, score between 0.5 and 1 standard deviation from the mean, score within 0.5 standard deviations from the mean, score less than 0.5 standard deviations from the mean and score more than 0.5 standard deviations from the mean. Since there are no cities studied in the second interval, the 27 cities are finally classified into four types: excellent, good, normal and lagging in terms of high-quality development status.

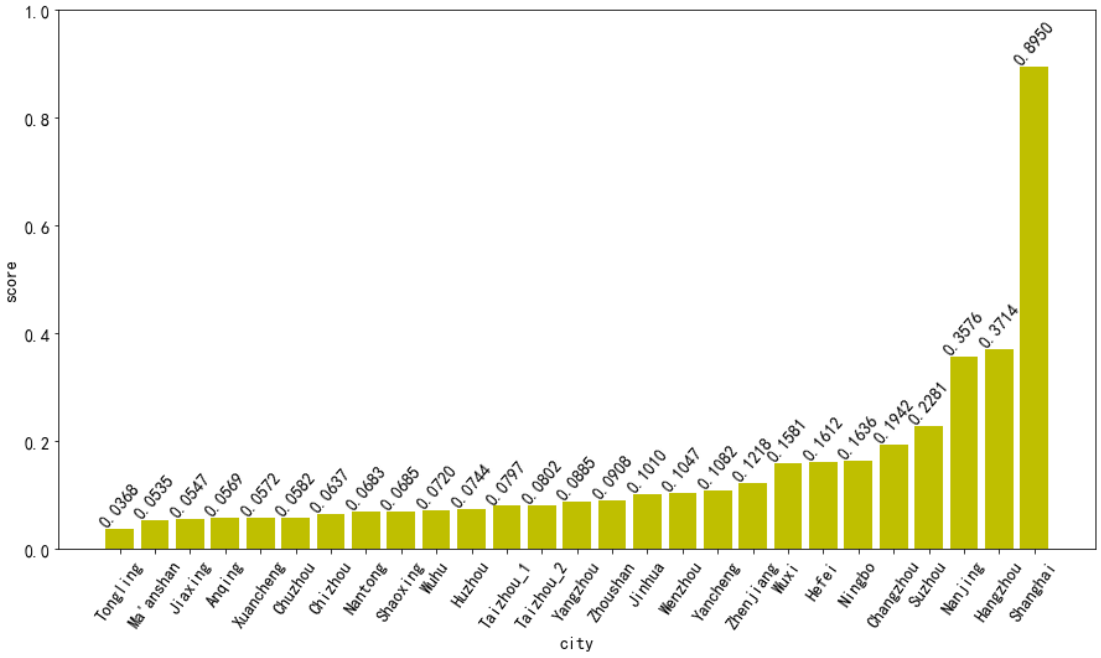

Fig. 1. This is a histogram of the cities' scores for high-quality development

Table 2. The level of cities

Level	City
Excellent	Nanjing, Hangzhou, Shanghai
Good	Suzhou, Changzhou, Ningbo, Hefei, Wuxi
Normal	Zhenjiang, Yancheng, Wenzhou, Jinhua, Zhoushan, Yangzhou, Taizhou_1, Taizhou_2, Huzhou, Wuhu, Shaoxing, Nantong and Chizhou
Lagging	Chuzhou, Xuancheng, Anqing, Jiaxing, Ma'anshan, Tongling

As can be seen from Fig. 1 and Table 2, Shanghai has the highest overall development level, far surpassing Hangzhou, which ranks second. Next, Hangzhou and Nanjing have similar comprehensive scores, and there is a more obvious gap with other cities. Excellent cities account for about 11% of the total number of cities. The three cities are municipalities directly under the central government or provincial capitals, which have developed earlier and have their own characteristics in terms of economic structure and institutional reform, driving high-quality regional development in many ways. Their overall performance is excellent, and they are well positioned to benefit society from the fruits of development.

The cities with relatively high scores after the excellent level are Suzhou, Changzhou, Ningbo, Hefei and Wuxi, which are above the average value of 0.1469. These cities are able to implement high-quality development policies and measures well in the development process, accounting for 19% of the total number of cities. Zhenjiang, Yancheng, Wenzhou, Jinhua, Zhoushan, Yangzhou, Taizhou_1, Taizhou_2, Huzhou, Wuhu, Shaoxing, Nantong and Chizhou, which have scored less than 0.5 standard deviations from the average. These 13 cities are normal development cities. Their scores are relatively small, and they are all in the early stage of transforming the economic development mode.

The normal cities with high quality development occupy 48% of the number of cities. For below average score of 0.5 standard deviations are Chuzhou, Xuancheng, Anqing, Jiaxing, Ma'anshan, Tongling 6 cities, occupying 22% of the total number of cities. They were in new stage in the transformation of development mode, failed to fully enter the new development track. The cities need to pay great attention to the strength of the same time, adjust the concept of development, and actively promote the deepening of reform in various areas to accelerate the improvement of high-quality level.

3.2 Levels of development of subsystems

High-quality development in the Yangtze River Delta region requires efforts from many aspects. At the same time, in order to understand more clearly the development strengths and weaknesses of each aspect, this paper calculates the distribution of each subsystem of the high-quality development measurement and evaluation system as shown in Fig. 2.

The above heat map shows that Shanghai is the absolute leader in terms of overall score because it is at a high level of development in all five subsystems. Hangzhou has the lowest score of 0.2607 in the subsystem of stable economic growth, mainly due to its relatively high number of unemployed people. Nanjing's score of the efficient allocation of resources is 0.0923, and the data collected shows that its capital productivity and labor productivity are low. On the one hand, it may be that fixed asset investments are not transformed into produced goods and services faster, and on the other hand, due to the dense population of large cities, they absorb a large number of migrant workers with different levels of knowledge. Changzhou is able to make full use of resources such as energy, capital and labor. Suzhou scores higher in the Economic Achievement subsystem, which shows a high attention to the construction of ecological civilization and infrastructure. Hefei's disadvantage is mainly in the subsystem of efficient resource allocation. In recent years, due to regional expansion and accelerated construction of new technologies, it has performed average in productivity of energy and has relatively low capital productivity and labor productivity with 1.3729 and 15.9324, respectively. Ningbo has a relatively low share of domestic enterprises and a relatively high number of foreign enterprises. Wuxi needs to improve its high-quality development level in both economic structure optimization and economic growth stability。

Among the other cities at the level of the subsystems, there is a general low level of economic growth stability. Compared with excellent cities: the difference in GDP growth rate is not large, but most of them pull away in

terms of employment. In the cities with average and backward development levels, there is indeed a problem of low employment and brain drain. On the other hand, the cities with excellent development and good development attract most of the foreigners for employment, which leads to the problem of employment situation in this type of cities. In particular, cities of the lagging type generally have lower scores in the subsystem of stable economic growth.

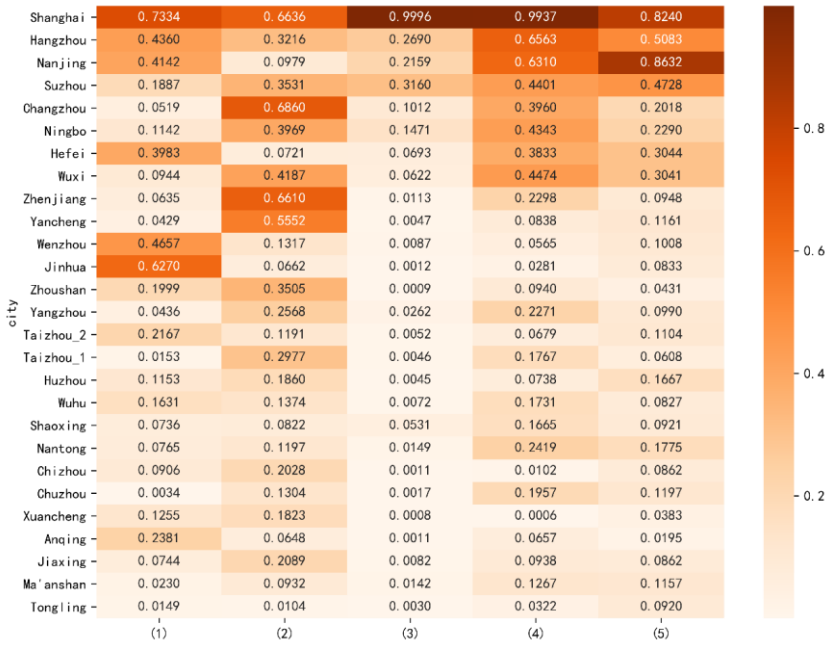

Fig. 2. This is the heatmap of five subsystems, where (1), (2), (3), (4) and (5) represent the optimization of economic structure, the efficient allocation of resource, the stable growth of economic, the regional development coordination and the presentation of economic achievements, respectively

4 Disccussion

By the results of the study, this paper puts forward some recommendations. Starting from a regional perspective, we need to focus on caring for the implementation of provincial and municipal one-to-one support policies, taking advantage of Jiangsu Province and Zhejiang Province to increase inter-regional exchanges. From multiple fields such as culture and science and technology, the government can drive the common high-quality development of all regions in Anhui Province.

Based on the heat map of subsystems and the indicators contained in each of the subsystems, we have analyzed and discussed the cities. From the perspective of individual cities, Hangzhou needs to further increase the number of jobs for reducing the number of unemployed people. Nanjing and Hefei need to further work on energy productivity and labor productivity, reduce waste of resources, improve employment security mechanisms, and rationalize the use of human capital. Ningbo, Wuxi and Changzhou mainly face a low number of domestic enterprises and need the government to focus on innovation and entrepreneurship areas, especially in the field of infrastructure with high quality talents. Actively advocate industrial prosperity. Zhenjiang, Yancheng, Wenzhou, Jinhua, Zhoushan, Yangzhou, Taizhou_1, Taizhou_2, Huzhou, Wuhu, Shaoxing, Nantong and Chizhou are particularly concerned with stable economic growth. It is not just focusing on achieving rapid growth in output value, but also high-quality capital accumulation. This requires more application of scientific and technological achievements to social life and more talent to stay in reasonable positions. Chuzhou, Xuancheng and Tongling to achieve the level of development to catch up, but also need the full range of enhancements: actively deepen institutional reform, accelerate the construction of tertiary industries, adjust the industrial structure, promote employment and maximize the solution to structural unemployment. Anqing, Jiaxing and Ma'anshan should optimize the economic market structure, create a fair and progressive market atmosphere, and effectively implement resource-related policies. In addition, young people are the future of the

country, there is a need to increase investment in education and ensure the quantity of educational resources while improving the teaching level of teachers and the management level of schools. Finally, in the face of the increasingly serious problem of aging, it is necessary to accelerate the construction of ecological environment, so as to enhance people's satisfaction and happiness.

5 Conclusion

The Yangtze River Delta region, as an important national development pioneer area, and is now in an important period of change to high-quality development. How to develop with high quality and how to evaluate the development results are key questions. Therefore, our study is of great practical significance. In addition, we utilize more comprehensive indicators and improve on the original statistical system, which can also provide theoretical guidance for the statistical evaluation of other regional development.

This paper proposes a new high-quality measurement system and examines the high-quality development levels of 27 cities in the Yangtze River Delta region of China by using 34 specific indicators in the context of five major subsystems: the optimization of economic structure, the efficient allocation of resource, the stable growth of economic, the regional development coordination and the presentation of economic achievements. The five subsystems are also explored separately to analyze and explore the development status of the Yangtze River Delta city.

According to the scores of cities' high-quality development level, cities were divided into four types: excellent, good, normal and lagging, accounting for 11%, 19%, 48% and 22% respectively. The classification results show that Shanghai has the highest level of development in terms of city types, and the capital city of each province is generally higher than other prefecture-level cities in the province. Most cities in Jiangsu Province are in the general development type, only Jiaxing in Zhejiang Province is in the lagging type. Anhui Province has Chuzhou, Xuancheng, Anqing, Ma'anshan, Tongling 5 cities in the lagging development level. Then this paper focuses on analyzing the development shortcomings of each city and puts forward scientific and reasonable suggestions.

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Competing Interests

Authors have declared that no competing interests exist.

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