

Research on Regional Economic Differences in the Yangtze River Delta Based on Exploratory Spatial Data Analysis

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Abstract: The reasons for the differences in economic development in the Yangtze River Delta region are complex and diverse, and are of great research significance. This project uses exploratory spatial data analysis to explore economic differences in the Yangtze River Delta region. First, the per capita GDP data of 41 prefecture-level cities in 4 provincial-level administrative regions in the Yangtze River Delta region from 2003 to 2020 was used to represent the economic development level of each region, and the Theil index was calculated; The differences in economic development in the delta region; finally, it provides suggestions for the in-depth development of economic integration in the Yangtze River Delta region, so as to narrow the economic development gap in the Yangtze River Delta region, promote economic stability and progress, and achieve a higher degree of development.

Keywords: Yangtze River Delta region, Theil index, In-depth development of economic integration, Economic stability and progress.

1. Introduction

Since the reform and opening up, my country's economic level has steadily improved, and economic development has also brought about differences in regional economic development. Appropriate regional economic differences can promote the spatial flow of production factors, optimize the overall resource allocation, give full play to the comparative advantages between regions, and facilitate coordinated development within regions. However, if the regional economic differences are too large, it is not conducive to the improvement of national quality. The intra-regional cooperation ability and the efficiency of division of labor will be greatly curbed, and even the Matthew effect of extreme regional economic differences will occur. It can be seen that it is of great practical significance to study whether there are differences in economic development in a specific region, and how to effectively control the differences within a reasonable threshold to promote a more stable and balanced development of the regional economy.

The main research contributions of this paper are as follows: First, it enriches the research literature on regional economic development. By discussing the changes and status quo of regional economic development in the Yangtze River Delta region, it provides relevant opinions on how to solve the regional economic differences existing in the Yangtze River Delta region. It will help the government identify the improvement path for high-quality economic development, and alleviate the unstable situation of the economy and society under the influence of the international turbulence and the new crown pneumonia epidemic. Second, based on China's research scenarios, the study of the economic development model of the Yangtze River Delta region has brought inspiration to my country's regional economic development, so as to better promote my country's modernization process, help my country adapt to domestic and foreign environmental changes, and contribute to my country's regional economy. Development-related policy formulation provides reference value.

2. Literature Review

The issue of regional economic differences has always been a research hotspot in academia. As a general phenomenon in the process of social development, economic differences between regions generally exist in developing and developed countries. Many scholars have conducted comprehensive research on regional economy, and the measures used include Theil index, Gini coefficient, weighted coefficient of variation and so on.

In terms of theoretical research, Yang Wanping [1] (2022), based on the new development concept, found that there are obvious spatial differences in the orientation indices of the eight regional dimensions, and the differences in the quality of economic development are mainly open economy and green transformation; Li Xiangyang et al. [2] (2021) Through the analysis of the relevant theories of monetary policy, it was found that the regional differences in China's monetary policy affected the development of regional economy; Sun Jianping [3] (2021), according to the analysis idea from global to local, found that the port industry and economy in coastal areas The growth center is concentrated in the south and has a tendency to gradually move to the Yangtze River Delta.

In terms of empirical research, Si Lijuan et al. [4] (2021) introduced a spatial econometric model to analyze the convergence characteristics, showing that the differences between urban clusters in my country are declining, and urban clusters are the main reason for regional differences in China; Li Hua et al. [5] (2021) By using the gravity model of tourism and social network analysis methods to study the characteristics of the economic space relationship and network in the middle reaches of the Yangtze River, the distribution characteristics of the long tail of the tourism economy will bring about the effect of the long tail, spilling over the effect of the tourism economy and Attractive influence. Meng Fei et al. [6] (2021) used methods such as center of gravity analysis, Theil index and exploratory spatial data analysis to comprehensively investigate the characteristics of the spatiotemporal evolution of Guangdong,

Hong Kong and Macau, and combined the geographic detector model to explore the market size and human capital. [7] (2020) constructed a high-quality economic development evaluation index system, measured and decomposed the high-quality economic development level and difference characteristics by using kernel density and Theil index, and pointed out that the high-quality economic development of my country's provinces The overall level of economic development continued to improve, and the differences continued to expand. The overall differences mainly came from within regions.

To sum up, this project believes that there is already a certain research foundation on regional economic differences at home and abroad, but there are relatively few domestic and foreign studies on the spatial and temporal correlations of the development of the Yangtze River Delta region, and the existence of a fixed time series is relatively small. There is less exploration and analysis of the spatial and temporal differences in the region, and there is still room for further exploration in the study of regional economic differences. Therefore, this project will use exploratory spatial data analysis methods to analyze the regional economic differences of the three provinces and one city in the Yangtze River Delta from 2003 to 2020, and provide suggestions for the subsequent economic integration and development of the Yangtze River Delta region.

3. Data Sources

The data analyzed in this paper come from the National Statistical Yearbook (2004-2021), the statistical yearbooks of the corresponding years of each province and city, and the statistical bulletins of national economic and social development in some regions. The regions in the Yangtze River Delta are divided into provincial administrative regions. The Yangtze River Delta region of Anhui Province includes 16 cities including Hefei, Huaibei, Bozhou, Suzhou, Bengbu, Fuyang, Huainan, Chuzhou, Lu'an, Ma'anshan, Wuhu, Xuancheng, Tongling, Chizhou, Anqing, and Huangshan; the Yangtze River Delta region of Jiangsu Province includes Nanjing, Wuxi, Xuzhou, Changzhou, Suzhou, Nantong, Lianyungang, Huai'an, Yancheng, Yangzhou, Zhenjiang, Taizhou, Suqian 13 cities; the Yangtze River Delta region of Zhejiang Province includes Hangzhou, Ningbo, Wenzhou, Jiaxing, Huzhou, Shaoxing, Jinhua, Quzhou, Zhoushan, Taizhou, Lishui 11 cities; in addition, Shanghai also belongs to the Yangtze River Delta region. In view of the imperfection of the statistical system in individual regions and the existence of missing data, this paper calculates indirectly by using the weighted moving average method.

4. Research Methods

4.1. Theil Index

The Theil index was proposed by Dutch economist Theil in 1967. The Theil index is often decomposed into two parts: the intra-group difference (T_W) of the county within the prefecture-level city and the inter-group difference (T_B) between the prefecture-level cities. The main indicator that is widely used to measure the differences in regional economic development, The calculation formula is

$$T = T_W + T_B = \sum_{i=1}^n y_i \times \left[\sum_{j=1}^n y_{ij} \log(y_{ij}/p_{ij}) \right] + \sum_{i=1}^n y_i \log(y_i/p_i)$$

In the formula, T is the overall regional economic difference value of the Yangtze River Delta. The larger the T value, the greater the difference in the level of economic development between regions, and vice versa. y_i is the proportion of the GDP of the provincial administrative unit i region to the total GDP of the Yangtze River Delta; y_{ij} is the proportion of the GDP of the municipal administrative unit j to the GDP of the provincial administrative unit i ; p_i is the population of the provincial administrative unit i region The proportion of the total population in the Yangtze River Delta; p_{ij} is the proportion of the population of the municipal administrative unit j to the population of the provincial administrative unit i ; n is the number of administrative divisions.

In order to explore the contribution of intra-group differences (T_W) and inter-group differences (T_B) to the economic differences in the Yangtze River Delta region and their impact, the contribution rate of intra-group differences (CR_W) and the contribution rate of inter-group differences (CR_B), the calculation formula is

$$CR_W = T_W/T$$

$$CR_B = T_B/T$$

This paper will rely on the decomposition method of the Theil index to measure the Theil index of per capita GDP in the Yangtze River Delta region in my country from 2003 to 2020, and the four major regions (the four regions refer to Anhui Province, Jiangsu Province, Zhejiang Province and Shanghai in the Yangtze River Delta region) City) Internal Theil Index.

4.2. Exploratory Spatial Data Analysis

The exploratory spatial data analysis method is a relatively mature spatial measurement method, which uses the spatial correlation measure to visualize the spatial distribution pattern of things, so as to study the spatial interaction of objects. For the regional economic differences in the Yangtze River Delta, the exploratory spatial data analysis method can more objectively and vividly reveal the regional economic correlation between the units in the study area, so as to better conduct in-depth analysis.

5. Empirical Analysis

5.1. Overall Changes in Economic Development Gap

This paper uses the per capita GDP data of 4 provincial-level administrative regions and 41 prefecture-level cities in the Yangtze River Delta region to analyze the evolution of the economic development gap in my country's Yangtze River Delta region from 2003 to 2020 since the 21st century. The specific results are shown in Figure 1 and Table 1.

From 2003 to 2020, the overall difference in economic development in the Yangtze River Delta region is relatively large, and the overall difference value, the difference value within the group, and the difference value between groups all show a downward trend, indicating that the difference in

economic development in the Yangtze River Delta region is generally shrinking, as shown in Figure 1. Judging from the contribution rates of intra-group differences and inter-group differences, the contribution rate of intra-group differences in the economic development of the Yangtze River Delta region is significantly higher than that of inter-group differences. The contribution of intra-group differences in regional economic differences occupies an absolute dominant position.

The contribution rate increased from 71.31% in 2003 to 82.07% in 2020, while the contribution rate of group differences decreased from 8.69% in 2003 to 7.93% in 2020. It can be seen that the difference between the cities in the group is the main reason for the large difference in the overall economic development of the Yangtze River Delta region, but as time goes by, the contribution rate of the difference within the group shows a trend of gradually weakening.

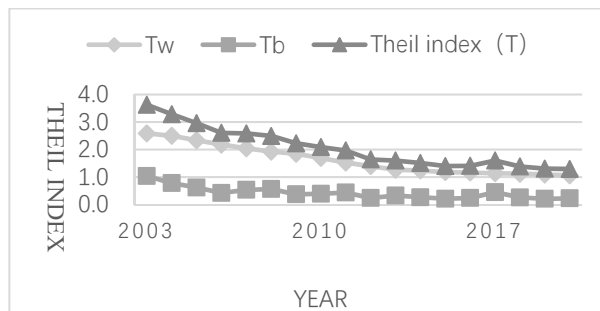


Figure 1. Decomposition trend of Theil index of regional economic differences in the Yangtze River Delta from 2003 to 2020

From 2003 to 2020, the Theil index of per capita GDP of my country's economic development gap fluctuated between 1.296 and 3.626, showing a development trend of shrinking fluctuations on the whole, showing strong heterogeneity. Among them, from 2003 to 2010, the Theil index of per capita GDP in the Yangtze River Delta region dropped from 3.626 to 2.091; from 2011 to 2020, there was a decline, and the Theil index of per capita GDP in the Yangtze River Delta region dropped to 1.296; from 2003 to 2020, the overall regional

economic development gap From 2018 to 2020, the Theil index of per capita GDP was stable between 1.296 and 1.386, with small fluctuations; while there was a large fluctuation between 2003 and 2008, in which the Theil index of per capita GDP in the Yangtze River Delta region in 2003 was the largest difference level of 3.626. ; From 2009 to 2017, the economic development gap in the Yangtze River Delta region narrowed rapidly, and the Theil index of regional per capita GDP dropped from 2.228 to 1.6.

Table 1. The Theil Index Decomposition and Contribution Rate of Regional Economic Differences in the Yangtze River Delta

year	Tw	Tb	T	CRw	CRb
2003	2.586	1.040	3.626	71.31%	28.69%
2004	2.501	0.783	3.284	76.15%	23.85%
2005	2.336	0.623	2.959	78.95%	21.05%
2006	2.179	0.428	2.607	83.59%	16.41%
2007	2.047	0.541	2.588	79.10%	20.90%
2008	1.925	0.569	2.494	77.19%	22.81%
2009	1.850	0.378	2.228	83.05%	16.95%
2010	1.694	0.397	2.091	81.02%	18.98%
2011	1.528	0.441	1.969	77.62%	22.38%
2012	1.400	0.244	1.644	85.16%	14.84%
2013	1.269	0.333	1.602	79.23%	20.77%
2014	1.242	0.270	1.512	82.14%	17.86%
2015	1.184	0.218	1.401	84.47%	15.53%
2016	1.167	0.245	1.412	82.67%	17.33%
2017	1.146	0.455	1.601	71.61%	28.39%
2018	1.122	0.264	1.386	80.93%	19.07%
2019	1.094	0.215	1.309	83.55%	16.45%
2020	1.063	0.232	1.296	82.07%	17.93%

At present, there is no mature criterion for the Theil index of per capita GDP. If a more general standard is used, the Theil index of per capita GDP in the Yangtze River Delta is basically within a relatively reasonable range.

5.2. Partial Analysis of Differences in Economic Development

In accordance with the model research and analysis

methods, this paper further decomposes the per capita GDP of the economic development gap in the Yangtze River Delta region according to the provincial administrative planning with the help of the Theil index decomposition formula, and decomposes the regional economic development gap in the Yangtze River Delta region into, within Anhui Province, within Jiangsu Province, Within Zhejiang Province and within Shanghai.

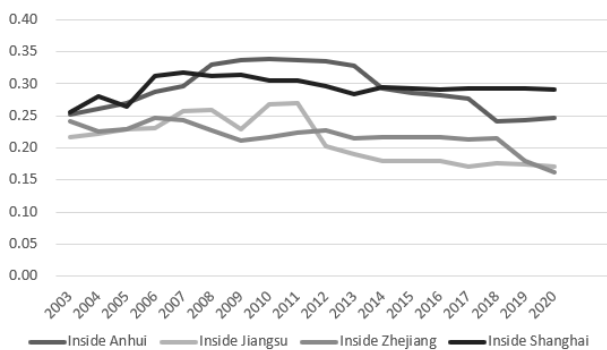


Figure 2. Changes in the economic development gap between provinces in the Yangtze River Delta region from 2003 to 2020

The economic development gap in Shanghai is generally at a relatively high level in the Yangtze River Delta, but the development trend is relatively stable. After China joined the WTO in the early 21st century, Shanghai, as an open coastal city, has experienced rapid economic development and its economic development level is at the forefront of the country. At the same time, it has also driven the economic development of many industries and surrounding areas. and labor flow to Shanghai area, so while economic and social development, it also causes problems such as large per capita income gap, the Theil index is relatively reasonable.

Judging from the per capita GDP Theil index of the differences in economic development between regions in the Yangtze River Delta region, with the continuous in-depth development of the economy and society in the 21st century, the pace of reform and opening up has been accelerated, and the benefits brought by development have continued to spread to more regions. The economically developed provinces and cities have more obvious driving effect on the regions with relatively backward economic development, and the differences in economic development within the regions are generally narrowing.

6. Conclusions and Recommendations

This project uses exploratory spatial data analysis to explore economic differences in the Yangtze River Delta region. From 2003 to 2020, the Theil index of per capita GDP in the Yangtze River Delta region fluctuated between 1.296 and 3.626. The Theil index of per capita GDP in the Yangtze River Delta region was in a reasonable range, and the Theil index of per capita GDP in the Yangtze River Delta region generally showed a shrinking development trend.

To sum up, in order to narrow the economic development gap in the Yangtze River Delta region, promote economic stability and progress, and achieve a higher level of development, the following suggestions are put forward:

- ① Promote the continuous deepening development of

Anhui's innovative economy.

Innovation is an important driving force for economic development. Anhui is in the Yangtze River Delta region, and there is a large gap between its per capita GDP Theil index and other regions, and it should pay more attention to innovation and development, so as to realize the leadership of innovation economy for the province's economic development. The innovative economy is different from the traditional economy. It does not rely too much on capital such as labor and land, but uses the spatial agglomeration of talents, technology, information and other elements to break the shackles of traditional factors and achieve rapid development of the regional economy. For the development of innovation economy in Anhui, the construction of innovation centers in the province should be accelerated, so as to realize the integration and utilization of innovation elements and resources, and strongly support the development of entrepreneurial industries; The development of the innovative economy should promote diversified industrial innovation, drive the innovative development of the industrial chain with the innovation of high-end industries, and link regional innovation with the basic innovation; The development of innovation requires a good institutional soil and environment. Therefore, the government should not only encourage entrepreneurship and innovation, but also constantly improve relevant laws, regulations and institutional mechanisms, strengthen the respect and protection of intellectual property rights, and establish a business with competitive advantages. environment; finally, as Anhui fully joins the development of the Yangtze River Delta region, it should make use of the open resources of developed cities in the Yangtze River Delta, strengthen the integration of regional innovation elements, reduce unnecessary investment in innovation costs, strengthen the development of strategic partnerships, and build a high-level from all aspects. high standard and high open innovation economic ecosystem.

- ② Promote higher-quality economic development in Anhui.

Anhui has fully joined the economic integration of the Yangtze River Delta, which means both opportunities and challenges for Anhui. From the calculation of the Theil index of per capita GDP between regions, it can be known that the economic development of Anhui has a large gap with other provinces in the Yangtze River Delta. In addition, due to the far-reaching influence of farming culture and the relatively late opening to the outside world, Anhui also faces the problems of a relatively low level of industrial structure and a relatively backward development concept in the province. In this regard, if Anhui wants to seize the development brought about by the comprehensive expansion of the Yangtze River Delta region, it should strengthen the construction of the provincial capital city and the "Hefei Metropolitan Circle", promote the agglomeration of related industries, and cultivate Anhui's new economic growth capacity; it should fully Give full play to the advantageous role of science and technology in the Yangtze River Delta region, and promote scientific and technological innovation and progress through relevant economic and research cooperation with Jiangsu, Zhejiang and Shanghai, and promote the transformation and upgrading of Anhui's economy and the deepening of its opening to the outside world; it should give full play to the role of green resources to promote The development and growth of the green economy promotes the construction of industrial branding, strengthens communication with the Jiangsu,

Zhejiang and Shanghai regions of the Yangtze River Delta, facilitates traffic conditions, and promotes the continuous development of the central economy.

③ Optimize the allocation of resources in the Yangtze River Delta region.

As one of the most active and developed regions in my country's economy, the Yangtze River Delta region should give full play to its own comparative advantages, give priority to the development of leading industries that are in line with its own interests and match the regional characteristics, and promote the relationship between related connected industries and leading industries. Coordinate development, strengthen industrial cooperation with eastern and western regions, and then narrow the economic gap between regions across the country. From the perspective of global marketization, the Yangtze River Delta region can establish a national unified market organization based on its superior location advantages. To develop the coordinated development system of regional economy, but at the same time, it is necessary to promote the development model of inter-provincial coordination and division of labor in my country according to local conditions, and finally form a good situation of "a game of chess" in the whole country.

④ Improve the opening level of the Yangtze River Delta region.

On the one hand, actively promote the high-quality development of trade in the Yangtze River Delta region, play a leading role with cities with relatively good locational advantages in the Yangtze River Delta region, strengthen infrastructure, and continuously improve overall competitiveness; on the other hand, the Yangtze River Delta urban agglomeration should also strengthen inter-regional cooperation, encourage the construction of open economic highlands, promote the expansion of new economic zones, improve and optimize the inter-provincial cross-border cooperation mechanism in the Yangtze River Delta region, and develop and explore a wide range of cross-border cooperation fields based on their own advantages, so as to promote the Yangtze River Delta cities. The group achieves the long-term goal of continuously improving the level of opening up and high-quality economic development.

⑤ Thoroughly implement the innovation-driven development strategy.

The theory of regional development proposes that to realize the trend of regional economic integration, the development of the whole region should be driven by regions with relatively good location conditions in the process of regional development. The Yangtze River Delta region should give full play to the resource agglomeration effect of scientific and technological innovation in the central region of the region. According to the characteristics and advantages of the Yangtze River Delta region's own innovation, it should reach a higher level and carry out international scientific and technological innovation cooperation in a broader field. Looking at the world, planning and promoting scientific and technological innovation, creating a new impetus for international competition and international cooperation. At the same time, continue to increase investment in research and

development of science and technology, continue to promote the introduction of talents, lead innovation-driven development with various talents, create a social environment suitable for stimulating talents' enthusiasm for innovation and entrepreneurship, and further promote the prosperity of the "mass entrepreneurship and innovation" situation. development, so as to better promote the process of high-quality development in the Yangtze River Delta region.

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