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Analysis of Urban Economic Spatial Development and Integrated Development Strategies in the Yangtze River Delta

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Abstract: This paper takes 41 cities in the Yangtze River Delta from 2000 to 2022 as the research object, reveals the evolution law of the regional economic spatial pattern and proposes an integrated development strategy. This study combines spatial econometric models, geographically weighted regression analysis and multidimensional scaling analysis, and uses indicators such as economic density index, spatial association network density and centrality to evaluate regional economic characteristics. The results show that the region presents a significant "core-periphery" distribution feature, among which Shanghai, Nanjing, Hangzhou and Suzhou are core cities, with economic density indexes of 376.5, 215.3, 198.7 and 186.1 respectively in 2022, while peripheral cities such as Anqing and Huaibei are less than 50. Shanghai's economic network density has increased from 0.26 in 2000 to 0.49 in 2022, and inter-city connections have been significantly enhanced, but the economic spillover effects of the core city on surrounding cities are still limited. Based on this, the study proposes to strengthen the radiation and driving role of core cities, optimize the division of labor and layout of the industrial chain, strengthen support for relatively economically backward regions and improve economic linkages among regions, thereby promoting coordinated development and high-quality integration in the Yangtze River Delta region.

1. Introduction

The Yangtze River Delta region is an important driving force for China's economic growth and plays a key role in the country's regional balanced development strategy. With the advancement of globalization and regional integration, the region has become a key region for promoting the sustainable development of China's economy with its superior geographical advantages, strong industrial base and open economic environment. However, there are significant differences in economic development between cities in the region. There is a clear imbalance between core cities and peripheral cities in terms of resource allocation, industrial cooperation and economic

connection intensity, which restricts the in-depth promotion of integrated development. In addition, with the strengthening of regional economic ties, the incoordination of cross-regional resource flow and benefit distribution has gradually emerged. How to promote the overall development of the region while taking into account local economic interests has become a key issue that needs to be solved urgently.

In this context, in-depth research on the urban economic spatial pattern and its evolution laws has important theoretical value and practical significance for scientifically planning the path of regional integrated development. Existing studies mostly focus on the analysis of the region's total economic volume or a single dimension, but lack a systematic study and dynamic measurement of the economic spatial relationship between cities. Based on multidimensional indicators such as economic density and spatial correlation network, this paper uses spatial econometric analysis and geographically weighted regression methods to comprehensively analyze the characteristics of urban economic spatial structure and its evolution trend, and further explore the optimization strategy of regional integration, in order to provide a scientific reference for the coordinated development of the region and even other regions.

This paper first reviews the relevant literature and sorts out the theoretical framework and methodology of regional economic integration and urban spatial development research; then describes the research methods and data sources in detail, focusing on the application of technical means such as spatial econometric models, geographically weighted regression analysis and multidimensional scaling analysis; then shows the evolution of regional economic spatial pattern, and reveals the economic differences and changing trends between core cities and peripheral cities through empirical analysis; finally, based on the research results, this paper proposes an integrated development strategy, summarizes the main findings and plans future research paths.

2. Related Work

The Yangtze River Delta region, as an important strategic experimental zone for promoting regional integration and achieving high-quality development, is one of the most active regions in China's economy. In recent years, the academic community has conducted research on the integration of the region, focusing on regional coordinated development, optimal allocation of resource elements, and exploration of sustainable development paths. These studies provide theoretical support and practical reference for achieving integrated development. For example, Cao et al. studied the problems faced by integrated high-quality development and proposed to promote regional coordination and sustainable development through innovative mechanisms, optimizing infrastructure, promoting industrial synergy and green development [1]. Zhao et al. studied and analyzed the spatiotemporal evolution characteristics of urban-rural integrated development, explored the dynamic impact effects of the four dimensions of economy, society, space and ecology, and put forward policy recommendations for strengthening regional linkage and heterogeneous development [2]. Wu et al. explored the theoretical and practical connection between regional integration and sustainable development, and proposed that future research should focus on interdisciplinary, cross-regional and multi-scale sustainable development issues [3]. Chen et al. analyzed the new trend of integrated high-quality development, constructed a corresponding evaluation index system, and proposed path recommendations for current problems, aiming to promote higher-quality integrated development [4]. Li et al. studied the impact of integration on carbon emissions and found that regional integration is positively correlated with carbon emissions, and optimizing the integrated structure is helpful to reduce carbon emissions [5]. Wen et al. studied the relationship between integration and China's modernization path, proposed a regional practice and development research agenda, and provided a reference for modernization [6]. Li et al.

evaluated the green development of the ecological green integrated development demonstration zone and put forward suggestions such as improving the coordination mechanism, unifying management standards, and developing green finance [7]. Zhang et al.'s research can provide a useful reference for the coordinated improvement of urban tourism economy and human settlement environment [8]. Through the above research, scholars have deeply analyzed the key issues and challenges of regional integration and high-quality development in the Yangtze River Delta from a multi-dimensional perspective, and provided valuable suggestions for achieving regional coordinated development, ecological green development, and urban-rural integrated development. These studies not only reveal the dynamic characteristics and driving mechanisms of regional integration, but also provide reference for the coordinated development of other regions in China. In the future, we should continue to strengthen interdisciplinary research, enhance policy implementation and innovation, so as to help the region play a greater leading role in national strategies.

3. Methods

3.1 Spatial Econometric Model Construction and Data Analysis

This paper uses a spatial economic model [9] to analyze the economic development pattern of 41 prefecture-level cities, focusing on assessing the economic connections and mutual influences between cities. The study uses a spatial autoregression model and a spatial error regression model [10] to reveal the interdependence of economic growth between cities and its changing trends. The spatial autoregression model analyzes whether a city's economic growth is affected by other cities, while the spatial error regression model takes into account the error factors in spatial data [11]. To ensure the accuracy of the model, the study combines multidimensional data such as economic density, GDP, industrial structure and infrastructure, constructs independent variable and dependent variable models, and uses annual data from 2000 to 2022 for analysis. The spatial dependence coefficient between cities is calculated through spatial autocorrelation and spatial covariance matrices. The study found that the economic connections between core cities are strong and have significant spillover effects on surrounding cities. Through this model, the study provides data support for regional economic integration and a theoretical basis for regional economic coordination and policy making. Figure 1 is a network diagram of economic connections between cities in the Yangtze River Delta region.

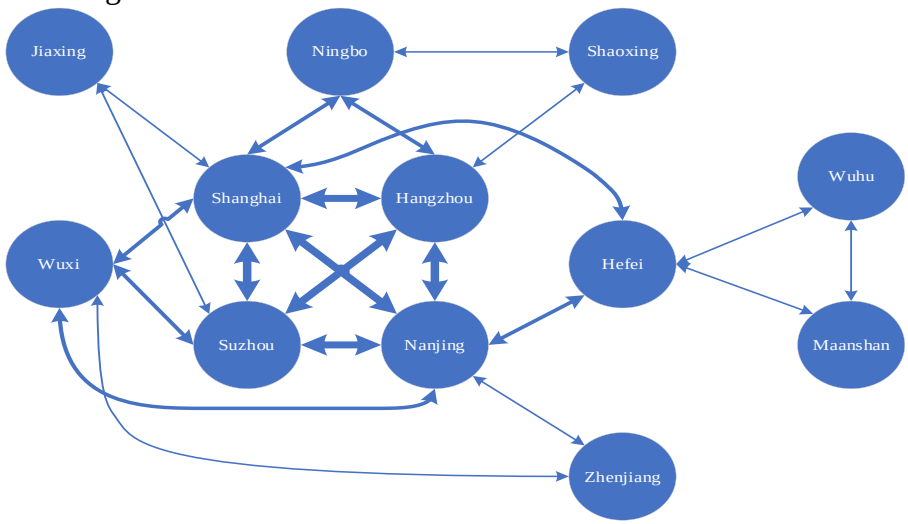

Figure 1: Economic connection network among cities in the Yangtze River Delta region

3.2 Geographically Weighted Regression (GWR) Analysis

In this paper, the GWR model [12] is used to conduct a local regression analysis on the economic density, centrality and spatial correlation [13] of different cities in the region, revealing the differentiated development patterns of core cities and peripheral cities. The GWR model can reveal the characteristic differences in economic development of each city and its surrounding cities, especially in economic density, industrial agglomeration and regional connections. Through this analysis, the study found that core cities, such as Shanghai, Nanjing, Hangzhou and Suzhou, have higher economic density, stronger spatial correlation, and dominate the regional economy; while some peripheral cities, such as Anqing and Huaibei, have lower economic density, relatively weaker connections with core cities, and are in a peripheral position in the regional economy. According to the analysis results of the GWR model, the core city has a strong centrality and a closer spatial correlation with surrounding cities, forming a more obvious economic radiation effect [14]. Table 1 shows the economic density, centrality and spatial correlation data of each city.

Table 1: Economic density, centrality and spatial correlation data of each city

City	Economic Density Index	Centrality	Spatial Association
Shanghai	376.5	High	Strong
Nanjing	215.3	High	Strong
Hangzhou	198.7	Medium	Medium
Suzhou	186.1	Medium	Medium
Hefei	112.3	Medium	Medium
Wuxi	167.4	Medium	Medium
Nantong	90.5	Low	Weak
Shaoxing	135.2	Medium	Medium
Anqing	45.3	Low	Weak
Huaibei	42.1	Low	Weak

Table 1 shows the differences in economic density, centrality and spatial correlation among different cities, indicating that core cities play a more significant role in the economic network, while peripheral cities have weaker economic density and spatial correlation and relatively lower development potential. Through GWR analysis, the study clarified the spatial heterogeneity of regional economic development and provided data support for the formulation of measures and policies for regional integrated development.

3.3 Multidimensional Scaling (MDS) and Network Analysis

In this study, multidimensional scaling (MDS) [15] and network analysis methods were used to further explore the economic gap and cooperation potential between cities in the region. MDS is a dimensionality reduction technique that is often used to reveal the intrinsic structure of data by projecting multidimensional data into two-dimensional or three-dimensional space. Specifically, the MDS method converts indicators such as economic density, centrality, and spatial correlation of cities into visual two-dimensional coordinates, thereby revealing the similarities and differences between cities. The goal of MDS is to minimize the "stress" value of the distance matrix between cities. The formula is as follows:

$$Stress = \sqrt{\sum_{i,j} (d_{ij} - \hat{d}_{ij})^2} \tag{1}$$

Among them, d_{ij} represents the distance between city pairs in the original data, and $\hat{d}_{ij}$ is the distance between city pairs after MDS mapping. By minimizing the stress value, MDS can accurately express the relative positions between cities in low-dimensional space and help identify the economic differences among cities in the Yangtze River Delta.

In terms of network analysis, the study further uses network density and centrality indicators to quantify the economic connections between cities. The formula is as follows:

$$Density = \frac{2E}{N(N-1)} \tag{2}$$

Among them, E is the number of actual economic connections between cities, and N is the total number of cities. A high network density means that the economic ties between cities are relatively close. Centrality measures the importance of a city in the entire regional economic network and is often calculated through degree centrality, betweenness centrality, etc. In this study, the centrality index can reveal the difference in status between core cities and surrounding cities in the regional economic network.

By combining MDS with network analysis, the study reveals the spatial distribution of urban economic disparities in the Yangtze River Delta region and possible cooperation potential, providing a quantitative basis for promoting regional integrated development.

4. Results and Discussion

4.1 "Core-periphery" Economic Pattern and Urban Centrality Analysis

The research results show that the economic spatial pattern of the region presents a significant "core-periphery" distribution feature. The economic density index of core cities represented by Shanghai, Nanjing, Hangzhou and Suzhou reaches 376.5, 215.3, 198.7 and 186.1 respectively in 2022, while the economic density index of marginal cities such as Anqing and Huaibei is less than 50. Time dimension analysis shows that the overall connection of the regional economic network has been significantly enhanced, and Shanghai's network density has increased from 0.26 in 2000 to 0.49 in 2022. However, the problem of spatial imbalance in economic development between cities has not been fundamentally resolved. The economic spillover effects of core cities vary significantly in geographical distribution, and some peripheral cities have failed to effectively share the economic development dividends of core cities. Further analysis shows that transportation infrastructure, industrial chain collaboration and policy synergy are the main factors affecting regional economic connections. Figure 2 shows the economic density and inter-city network density data collected in 2000 and 2022.

The economic density index reflects the intensity of economic activities per unit area in each city. The economic density of core cities is higher, while that of peripheral cities is lower. The density of economic networks between cities shows the closeness of regional economic connections. Data shows that since 2000, the density of economic networks in the Yangtze River Delta region has increased significantly, reflecting the advancement of regional integration. However, despite the strengthening of overall economic connections, analysis in the time dimension still reveals the problem of uneven economic growth among cities, and the economic gap between core cities and peripheral cities has not been fundamentally narrowed.

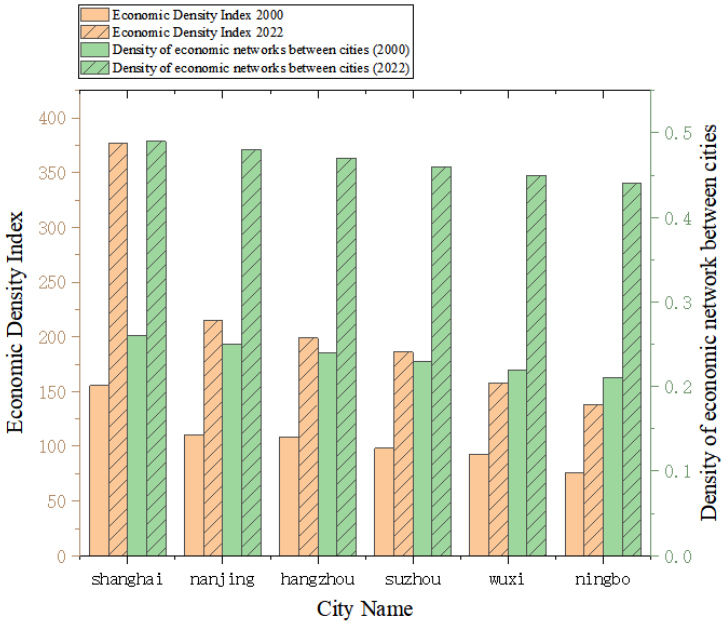

Figure 2: Economic density and inter-city network density data in 2000 and 2022

4.2 Changes in Regional Economic Networks and Economic Linkage

The deepening of regional economic networks has improved the overall level of economic connections in the region, but the core cities still play a dominant role in the network. By measuring the centrality and network density indicators of economic connections between cities, it is found that the dominant role of core cities is mainly reflected in the aggregation and efficient flow of resource elements, while the contribution of peripheral cities to the network is limited. The optimization of the layout of the transportation network is a key factor in promoting the enhancement of regional economic connections, while the distribution of industrial cooperation chains determines the effectiveness of economic spillovers between cities. In addition, policy coordination and regional planning have also played an important supporting role in the standardized development of economic networks, but the current coverage of policy tools for marginal cities still needs to be strengthened. Figure 3 is a data chart of economic connection indicators of core cities, and the data comes from relevant economic databases.

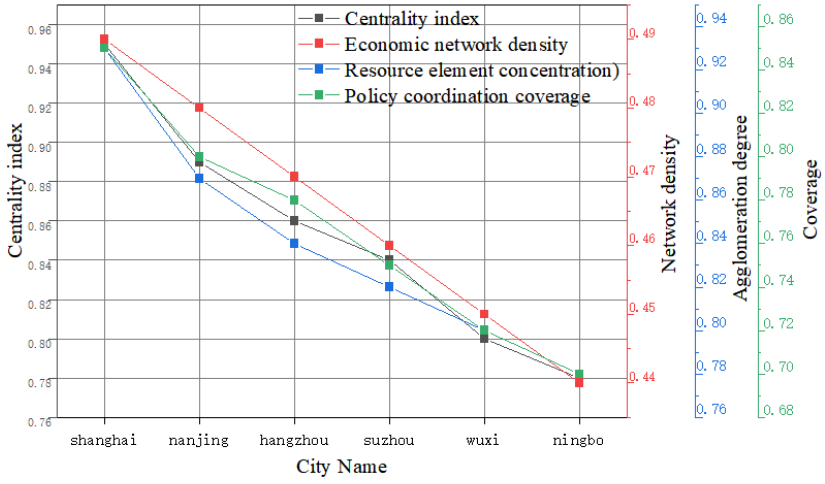

Figure 3: Data of economic connection indicators of core cities

The centrality index reflects the core position of a city in the regional economic network. The higher the centrality, the stronger the influence and dominant role of the city in the economic network. The economic network density measures the closeness of regional economic ties. The larger the value, the closer the economic ties. The policy coordination coverage indicates the coverage and effect of policy coordination in promoting regional economic integration. The stronger the policy synergy, the more significant the effect of promoting regional integration.

4.3 Integrated Development Strategy and Policy Recommendations

Based on the research results, we first strengthen the radiation effect of core cities, optimize the division of labor in the industrial chain and the layout of functional areas, and expand the economic spillover effect on surrounding areas; then improve regional infrastructure, enhance transportation and information network coverage, and reduce connection costs; secondly, promote cross-regional policy coordination, establish an interest coordination mechanism and enhance regional economic governance; finally, support the development of marginal cities, increase resource investment, support characteristic industries, attract talents, and narrow the development gap. Figure 4 shows the relevant indicator data of core cities under the optimization strategy, and the data comes from relevant economic databases.

The optimization degree of industrial chain division of labor reflects the optimization level of the division of labor in the industrial chain of the region. The higher the optimization degree, the closer the economic ties between cities. The policy synergy innovation index reflects the effectiveness and execution of policy coordination and innovation within the region. The higher the value, the better the policy synergy effect. These indicators jointly reveal the leading role of core cities in regional economic integration, as well as the driving force of industrial collaboration and policy synergy on regional economic development.

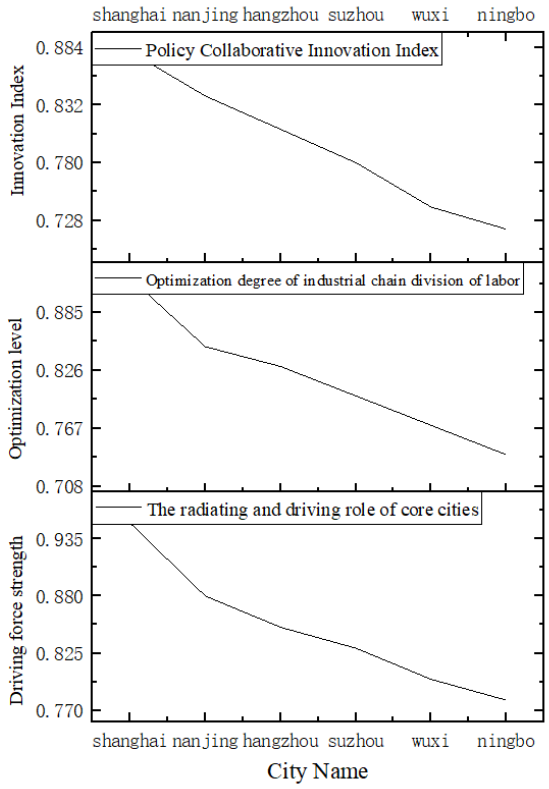

Figure 4: Core city optimization strategy indicator data chart

5. Conclusion

This paper reveals the evolution of the economic spatial pattern of the region and its integrated development trend through an in-depth analysis of the economic data of 41 prefecture-level cities in the Yangtze River Delta from 2000 to 2022. The study found that the region presents a significant "core-periphery" structure. The density of Shanghai's economic network increased from 0.26 in 2000 to 0.49 in 2022, indicating that the connection between cities has significantly increased, but the economic gap between different cities in the region is still large, especially the development of some marginal cities is lagging behind. The contribution of this paper is that it uses spatial econometric models, geographically weighted regression analysis and other methods to comprehensively evaluate the economic characteristics of the region and provide data support and theoretical basis for integrated development. The study proposes suggestions such as strengthening the radiation effect of core cities, improving infrastructure connectivity, and promoting policy coordination, aiming to improve the linkage of regional economy and promote high-quality integrated development. Although the study has achieved important results, it also has certain limitations, such as the long time span of the data. Future research can further promote coordinated and balanced development in the region through more dimensional data analysis and in-depth exploration of the economic spillover effects between core cities and surrounding cities.

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