

The Spatial-Temporal Evolution of Tourism Economy in the Yellow River Basin

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Abstract

Tourism economic development is characterized by total tourism revenue, and the Exploratory Spatial Temporal Data Analysis (ESTDA) method is employed to explore the spatio-temporal evolution pattern of tourism economic development across 60 prefecture-level cities in the Yellow River Basin. The spatial units of these prefecture-level cities exhibit significant spatial agglomeration characteristics in terms of tourism economic development. From an overall perspective, the relative length of Local Indicators of Spatial Association (LISA) time paths in the eastern region is higher than that in the western region, reflecting a more dynamic and vibrant spatial structure. In 33% of the cities, the bending level of LISA time paths is low, indicating minimal fluctuation in the local spatial structure in terms of spatial dependence direction. There is weak integration in terms of spatial pattern evolution, with insignificant synergistic development effects within the tourism economic region. The spatio-temporal transition index is 7.7%, suggesting inertia in the transition of tourism economic development levels. The local spatial correlation patterns exhibit strong stability, with tourism economic development in the region largely proceeding in isolation, receiving minimal spillover effects from neighboring areas.

Keywords

Yellow River Basin; ESTDA; Spatio-Temporal Pattern.

1. Introduction

On May 7, 2024, General Secretary Xi Jinping pointed out, "In the new era and on the new journey, tourism development faces new opportunities and new challenges. We must be guided by the thoughts of socialism with Chinese characteristics for a new era, fully and accurately implement the new development paradigm, and adhere to upholding principles while innovating, improving quality and efficiency, and pursuing integrated development." Currently, the primary contradiction facing the tourism industry is between the people's ever-growing needs for a better life in tourism and the unbalanced and inadequate development of tourism. It is urgent to enhance tourism development efficiency to achieve high-quality tourism development that empowers rural revitalization and common prosperity. Against this backdrop, conducting timely evaluations of tourism development efficiency and clarifying the spatio-temporal evolution characteristics and influencing factors of tourism development achievements are of great significance for realizing the transformational development of the tourism economy, improving the modern tourism system, adjusting the orientation of tourism policy goals, and promoting the quality and efficiency of the tourism industry. The development of domestic tourism geography has also been rapid. Huang Zhenfang et al. [8] proposed strengthening tourism geography research with "Chinese characteristics." In terms of urban tourism, research has been conducted using geo-tagged photos to analyze the spatial characteristics of tourist flows within cities[1], and methods such as GIS technology[2-4],

entropy weight method[5-6], and coefficient of variation weight method[7-8] have been applied to study the evolution and resilience of the tourism industry[9]. When selecting indicators to measure the level of tourism economy, single indicators such as inbound tourism revenue and domestic tourism revenue, or comprehensive indicators related to the tourism industry, are commonly used. Although a wide range of factors are involved in tourism economic development, the basic influencing factors can be summarized as tourism resource endowments, transportation conditions, industrial structure, government industrial policies, infrastructure, economic level, and tourist information acquisition methods[10-12]. In summary, there is limited research on the spatio-temporal evolution characteristics of tourism economy at home and abroad, and most studies are limited to using a single evaluation index weighting method to assess tourism development levels. Based on this, this paper takes the Yellow River Basin as the research object and uses total tourism revenue to represent the level of tourism development from 2006 to 2022. It employs exploratory spatio-temporal analysis methods to investigate the spatio-temporal evolution characteristics of the tourism economy in the Yellow River Basin from 2006 to 2022, aiming to provide a basis for the future development of tourism in the region, offer references for tourism resource development, and suggest recommendations for the coordinated development of various economic sectors.

2. Overview of the Study Area and Research Methods

2.1. Overview of the Study Area and Data Sources

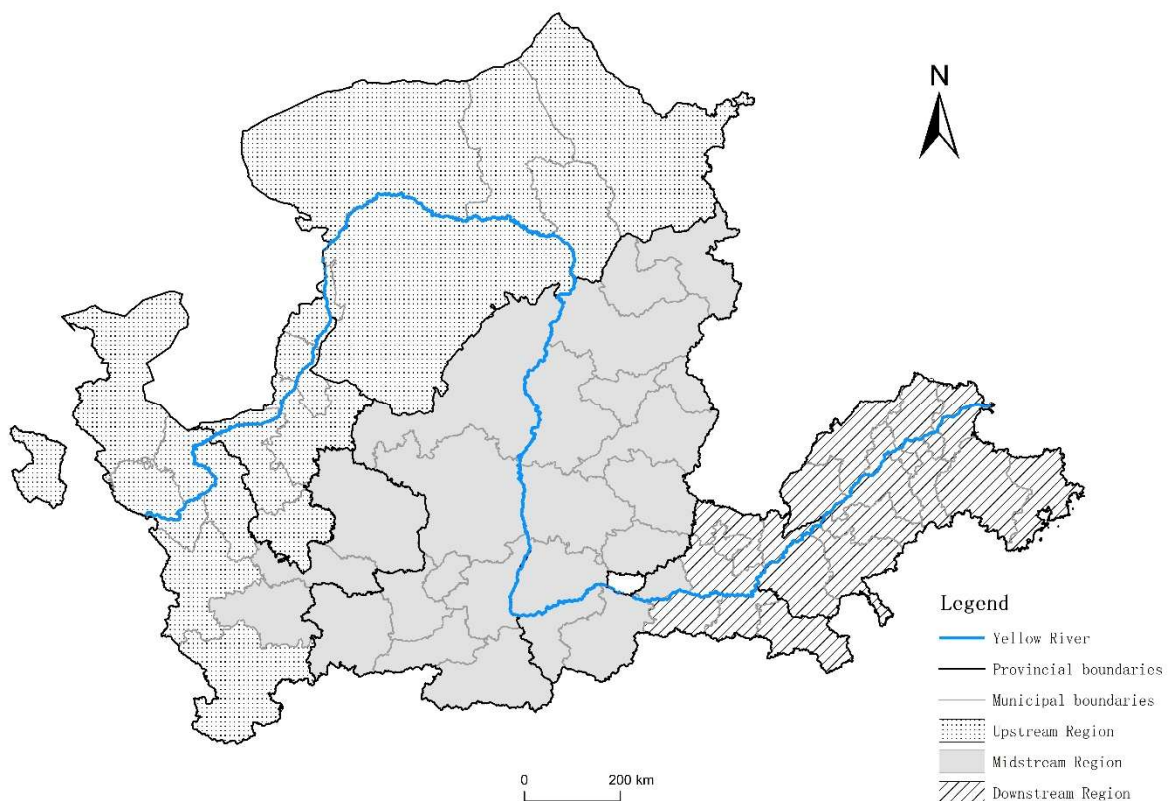


Figure 1. Research region

The Yellow River Basin faces unbalanced regional development and relatively low economic development levels. It spans four major geomorphic units from west to east: the Qinghai-Tibet Plateau, the Inner Mongolia Plateau, the Loess Plateau, and the Huang-Huai-Hai Plain, flowing

through nine provinces and autonomous regions including Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shaanxi, Shanxi, Henan, and Shandong. Thanks to its unique natural resource endowments and rich cultural tourism resources, the tourism industry in the Yellow River Basin has developed rapidly, with 20 World Heritage Sites, 84 national 5A-level tourist attractions, 47 national all-for-one tourism demonstration zones, and 9 national tourism resorts. This paper focuses on the regions naturally traversed by the Yellow River, excluding Sichuan Province, which is included in the Yangtze River Economic Belt, and the eastern part of Inner Mongolia, which broadly belongs to Northeast China. Taking into account the availability and accuracy of data, 60 prefecture-level administrative regions are ultimately selected as the study area[13], See Figure 1. This paper uses total tourism revenue to measure the level of tourism economic development at the prefecture-level cities. The original data are sourced from the "China City Statistical Yearbook" from 2006 to 2022, the National Bureau of Statistics database website, national economic and social development statistical bulletins, official websites of culture and tourism departments, and statistical yearbooks of prefecture-level cities in the Yellow River Basin from 2005 to 2022.

2.2. Research Methods

2.2.1. Exploratory Spatio-Temporal Analysis

Most existing empirical studies on the differences and evolution of spatial patterns of geographical variables analyze cross-sectional characteristics, neglecting the coupling and continuity of spatio-temporal elements by separating time processes from spatial patterns[14]. To address this, based on traditional Exploratory Spatial Data Analysis (ESDA), the ESTDA model proposed by Rey[15] is employed to emphasize spatio-temporal interactive analysis, thereby providing a more comprehensive analysis of the spatial pattern differentiation and temporal evolution characteristics of water eco-civilization development at both the global and local scales. The research methods include the Global Moran's I index, Local Indicators of Spatial Association (LISA), LISA time path, and LISA spatio-temporal transition[16].

2.2.2. Global Spatial Autocorrelation

By calculating the Global Moran's I index, this study reveals the overall spatial correlation degree of tourism economic development in the Yellow River Basin and analyzes the existence of potential spatial agglomeration phenomena .

2.2.3. LISA Time Path

The global Moran's I index reflects overall agglomeration or dispersion phenomena, while the LISA time path can reveal the dynamism of local spatial structures and fluctuations in the direction of local spatial dependence. Its geometric characteristics mainly include relative length (Γ_i) and curvature (Δ_i)[14]. When $\Gamma_i > 1$, it indicates that the movement distance of the LISA coordinates for city i 's water eco-civilization level is greater than the average movement distance of all cities. The larger the value of Γ_i , the more dynamic the local spatial structure of city i 's water eco-civilization development level, and vice versa. The larger the value of Δ_i , the more curved the LISA time path of city i , indicating a more fluctuating process of water eco-civilization construction and local spatial dependence evolution in terms of direction for city i . This suggests a greater influence from the neighborhood spatial effect of the local structure, and vice versa. The direction of LISA movement can reflect the spatial integration of changes in the spatial pattern of water eco-civilization[16]. By examining the changes in the LISA coordinate positions of each city from 2006 to 2022, the direction of LISA time path movement can be calculated[17].

3. Analysis of the Spatio-Temporal Linkage Characteristics of Tourism Economy

To verify the overall spatial agglomeration status of tourism economic development in the Yellow River Basin, the global Moran's I index for tourism economy from 2006 to 2022 was calculated and found to be significantly positive, see Table 1. This indicates that there is a notable spatial positive correlation in the level of tourism economic development in the Yellow River Basin, with cities having similar levels of tourism economic development exhibiting a certain degree of spatial agglomeration, i.e., the existence of high-value or low-value agglomeration areas.

Table 1. Moran's I Index for Tourism Economy from 2006 to 2022

year	<i>Moran'I</i>	P
2006	0.106	0.037
2007	0.177	0.001
2008	0.180	0.001
2009	0.197	0.000
2010	0.228	0.000
2011	0.206	0.000
2012	0.242	0.000
2013	0.262	0.000
2014	0.276	0.000
2015	0.279	0.000
2016	0.269	0.000
2017	0.273	0.000
2018	0.269	0.000
2019	0.271	0.000
2020	0.119	0.025
2021	0.119	0.023

3.1. Lisa Relative Lengths

Based on the natural breaks method combined with manual classification (defining a threshold greater than 1, i.e., above the basin-wide average) [16], the relative lengths of LISA time paths are categorized into four levels, see Figure 2. From an overall perspective, the pattern of relative lengths generally exhibits a trend of "higher in the east and lower in the west." Cities with relatively longer LISA time paths ($\Gamma_i > 1$), accounting for 20 cities or 33% of the total, are primarily concentrated in Henan and Shandong provinces in the eastern downstream area, indicating the strongest dynamism in their local spatial structures. These cities boast higher levels of economic development, greater investments in tourism infrastructure and resource development, and consequently, stronger tourism economic development compared to other regions. Cities with relatively shorter LISA time paths (40 cities, accounting for 66% of the total) are mainly located in upstream and midstream western provinces such as Ningxia, Gansu, Inner Mongolia, Shanxi, and Shaanxi, reflecting a more stable local spatial structure in their tourism economic development. This may be attributed to the unique natural environments in these areas, where cities with distinctive tourist attractions experience higher levels of tourism economic development, whereas those without develop more slowly. This also embodies the "Matthew Effect" characteristic in tourism industry development, where the strong (weak) become stronger (weaker).

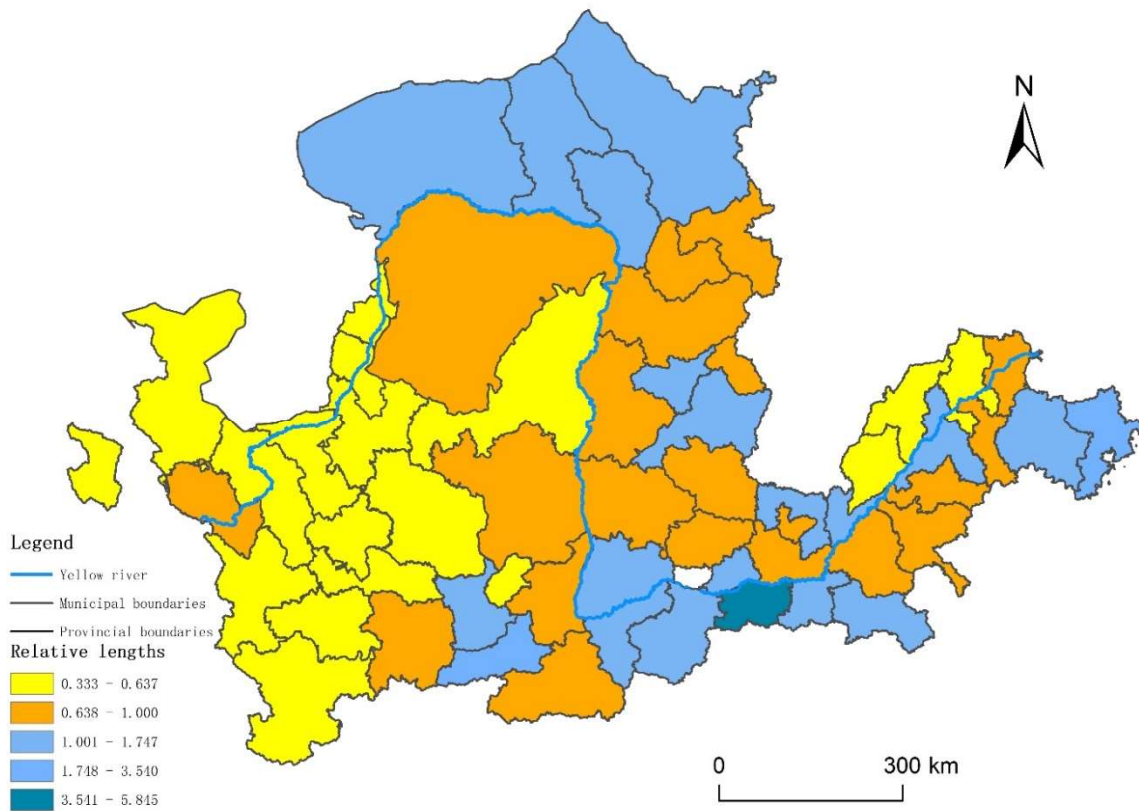


Figure 2. Relative lengths

3.2. Curvature

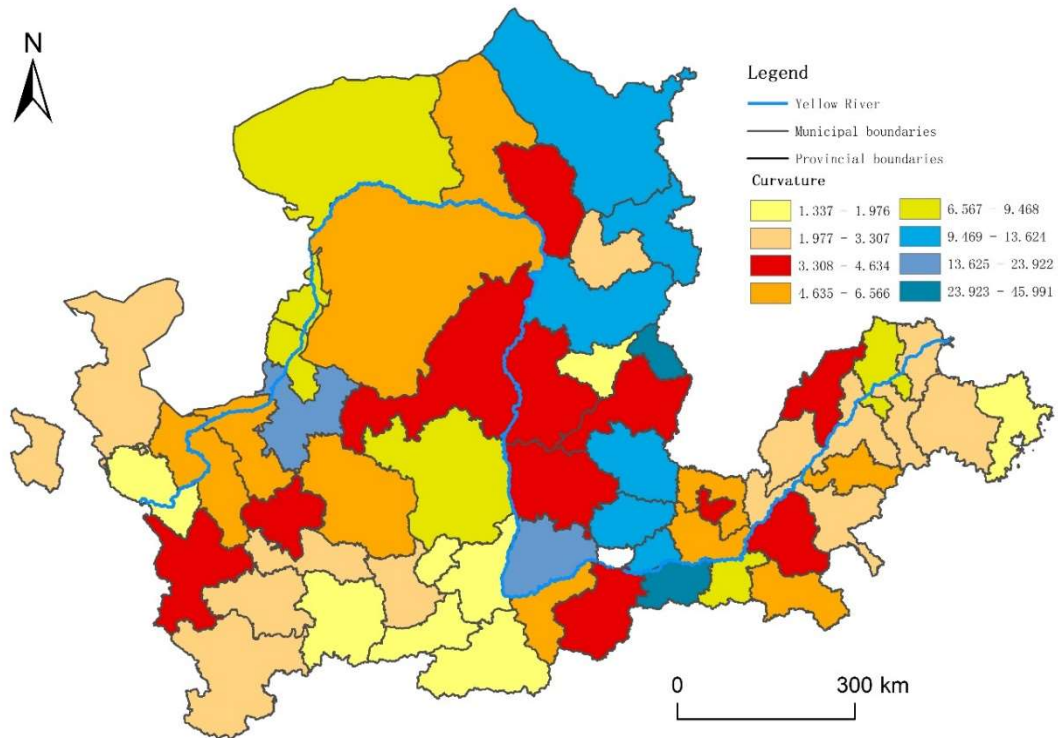


Figure 3. Curvature

The curvature of the LISA time path is classified into eight levels based on the natural breaks method (Figure 3). Twenty-one cities (35%) exhibit low or relatively low curvature. These cities and their surrounding regions mutually constrain and influence the fluctuations in spatial dependence of tourism economic development, resulting in a relatively stable process of spatial dependence change and thus low curvature. Among them, Qingdao and Taiyuan have the lowest curvature (both less than 2), indicating the strongest relative stability in the direction of spatial dependence for these two cities. Zhengzhou and Yangquan have higher curvature values (45.99 for Zhengzhou and 41.72 for Yangquan), suggesting that these cities and their neighboring cities exhibit strong fluctuations in the process of tourism economic development and are more susceptible to the influence of adjacent cities' development.

3.3. Direction of Movement

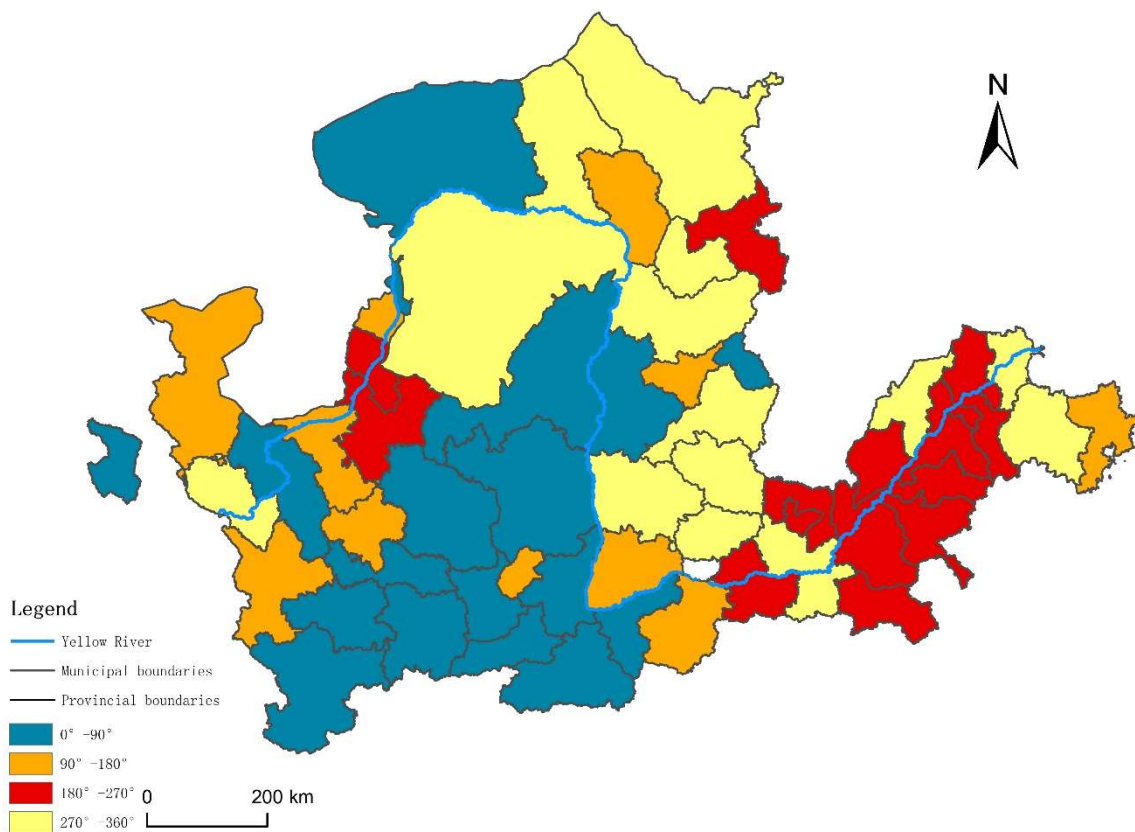


Figure 4. Direction of Movement

Firstly, there are significant differences in the direction of movement of tourism economy within the Yellow River Basin. In regions such as Ulanqab and Baotou in Inner Mongolia Autonomous Region, the tourism economy may exhibit a trend of moving westward or northwestward, which may be related to factors such as the distribution of tourism resources, transportation conditions, and tourist origins in these areas. In contrast, in regions such as Taiyuan and Datong in Shanxi Province, the tourism economy may show a trend of moving eastward or southeastward, which may be associated with closer ties with economically developed neighboring areas. Secondly, there is a clear interactive relationship between the tourism economy of the Yellow River Basin and its surrounding areas. For example, Zhengzhou and Luoyang in Henan Province, as important cities within the Yellow River Basin, not only play a significant role in the region's tourism economy but also exert a notable radiating and driving effect on surrounding areas. By optimizing the allocation of tourism resources and improving

tourism service quality, these cities have attracted a large number of tourists, thereby promoting the development of the tourism economy throughout the Yellow River Basin. Additionally, it is noteworthy that the Yellow River, as an important natural landscape and tourism resource within the basin, plays a crucial role in promoting the development of the tourism economy. As shown in the figure, many cities along the Yellow River Basin have leveraged this unique natural landscape to vigorously develop tourism, forming distinctive tourism economic zones. These zones have not only promoted local economic development but also provided tourists with diverse and enriching travel experiences. In summary, the direction of movement in the evolution of the tourism economy within the Yellow River Basin demonstrates diversified characteristics, reflecting the complexity and diversity of the tourism economy within the basin and revealing its interactive relationship with surrounding areas. In future development, the Yellow River Basin should continue to leverage its strengths, strengthen regional cooperation and exchanges, and promote the sustained and healthy development of the tourism economy.

3.4. Lisa Spatio-Temporal Transition.

According to the probabilities on the diagonal of the transition probability matrix in Table 2, over 85% of the cities in the Yellow River Basin did not transition their LISA coordinate categories to other categories, indicating the existence of transition inertia. This suggests that the spatio-temporal transition in the level of tourism economic development in the Yellow River Basin exhibits strong path dependence or spatial lock-in characteristics. The spatio-temporal fluctuation index (SF) calculated based on the number of each transition type is 7.7%, and the spatio-temporal cohesion index (SC) is 92.2%, further indicating that the local spatial correlation pattern of tourism economic development levels has strong stability. Upon further analysis of the transition types, it was found that Type II transitions (where a city transitions while its neighborhood remains unchanged) account for 4.6%, Type III transitions (where the city does not transition but its neighborhood does) account for 3.1%, and Type IV transitions (where both the city and its neighborhood transition) account for only 0.2%. This demonstrates that the level of tourism economic development in the Yellow River Basin is less influenced by the spillover effects of neighboring cities and more reliant on internal factors to change its position in the overall tourism economic development. The spillover effects of coordinated development have not yet been fully leveraged.

Table 2. Transition Probability Matrix

t/t+1	HH _{t+1}	LH _{t+1}	LL _{t+1}	HL _{t+1}
HH _t	0.900	0.075	0.000	0.025
LH _t	0.033	0.937	0.030	0.000
LL _t	0.003	0.027	0.945	0.024
HL _t	0.054	0.008	0.085	0.854

Table 3. transition types

Type	n	Proportion	SF	SC
I	884	0.921	0.077	0.922
II	44	0.046		
III	30	0.031		
IV	2	0.002		
IV _A	1	0.001		
IV _B	1	0.001		

4. Conclusion and Discussion

The tourism economic development of prefecture-level cities in the Yellow River Basin exhibits significant spatial agglomeration characteristics. From an overall perspective, the relative length values of the LISA time paths in the eastern region are higher than those in the western region, reflecting a more dynamic and vigorous spatial structure. Additionally, 33% of cities have low levels of curvature in their LISA time paths, indicating minimal fluctuation in the local spatial structure in terms of spatial dependency direction. In terms of the integration of spatial pattern evolution, there is a lack of significant coordinated development effects within the tourism economic regions. The spatio-temporal fluctuation index is 7.7%, suggesting the existence of transition inertia in the level of tourism economic development. The local spatial correlation pattern demonstrates strong stability. Meanwhile, tourism economic development within the region tends to operate in isolation, with minimal influence from the spillover effects of neighboring areas.

5. Policy Recommendations

Strengthen cooperation and exchange among prefecture-level cities. By establishing a regional tourism cooperation mechanism, promote the sharing and optimal allocation of tourism resources, and achieve complementarity and joint marketing of tourism products. Simultaneously, facilitate the interconnection of tourism infrastructure to enhance the convenience and comfort of tourism services, thereby enhancing the overall tourism attractiveness of the region. The western region should draw on the successful experiences of the eastern region to optimize its tourism spatial structure and enhance the dynamism and vitality of its tourism economy. By adjusting the layout and development strategies of tourism resources, guide the tourism economy towards directions with greater potential and vitality. Promote diversified development of the tourism economy. By developing diversified tourism products, cater to the needs of tourists at different levels and improve the risk resistance and sustainable development capabilities of the tourism economy. At the same time, encourage and support tourism enterprises to innovate their business models and marketing strategies to enhance the competitiveness and market influence of the tourism economy. Strengthen the regional linkage and spillover effects of the tourism economy. By establishing tourism economic cooperation zones or tourism industry clusters, facilitate the flow and sharing of tourism resources and elements, and improve the overall efficiency and competitiveness of the tourism economy. Meanwhile, strengthen the cultivation and introduction of tourism talents to improve the overall quality and service level of the tourism industry. The government should strengthen policy guidance and support for the development of tourism economy in the Yellow River Basin. By formulating and implementing tourism development plans, tourism industry policies, and other measures, provide strong policy guarantees and support for the development of the tourism economy. At the same time, increase investment in the construction of tourism infrastructure to improve the convenience and comfort of tourism services and provide tourists with a better travel experience. The development of the tourism economy in the Yellow River Basin requires the joint efforts of the government, enterprises, and society. Through the implementation of measures such as strengthening regional cooperation, optimizing spatial structure, promoting diversified development, enhancing spillover effects, and strengthening policy guidance and support, we can promote the sustainable and healthy development of the tourism economy in the Yellow River Basin.

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