Tourism Economic Disparities and Key Driving Factors in the Yellow River Basin: Postprint

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Date: 2024-04-01T00:00:00+00:00

Abstract

Coordinated development of the tourism economy in the Yellow River Basin constitutes a crucial force for promoting high-quality basin-wide development. This study examines the level of tourism specialization as its research object, constructing a driver indicator system across five dimensions: regional economy, innovation capacity, production factors, tourism services, and institutional policies. Based on panel data from 61 prefecture-level cities in the Yellow River Basin spanning 2008–2020, we investigate spatiotemporal evolution patterns of tourism economic disparities and their driving factors using kernel density estimation, global Moran' s I, and geographically and temporally weighted regression (GTWR) modeling. The findings reveal that: (1) Regional disparities in the Yellow River Basin' s tourism economy have expanded temporally, with a right-skewed tail phenomenon observed in certain years. (2) The global Moran' s I for tourism specialization levels is positive, indicating spatial agglomeration tendencies; among local spatial agglomeration types, the spatial extent of "high-high," "low-low," and "high-low" clusters has expanded, while that of "low-high" clusters has contracted. From a spatial perspective, tourism economic disparities in the Yellow River Basin have likewise expanded. (3) The promotional effects of nine driving factors on the tourism economy exhibit three distinct temporal patterns: stable, decreasing, and increasing. (4) The key drivers for tourism economic development vary by basin location: in upstream cities, they are regional economy, innovation capacity, and tourism services; in midstream cities, regional economy, tourism services, and institutional policies; and in downstream cities, innovation capacity, production factors, and institutional policies.

Full Text

Tourism Economic Differences and Key Driving Factors in the Yellow River Basin

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Abstract: The coordinated development of the tourism economy in the Yellow River Basin constitutes a crucial force for promoting high-quality regional development. This study examines tourism specialization levels as the research object and constructs a driving factor index system encompassing five dimensions: regional economy, innovation capability, production factors, tourism services, and institutional policies. Based on panel data from 61 prefecture-level cities in the Yellow River Basin from 2008 to 2020, we employ kernel density estimation, global Moran' s index, and a Geographically and Temporally Weighted Regression (GTWR) model to investigate the spatio-temporal evolution of tourism economic disparities and their driving factors. The findings reveal that: (1) Regional differences in the Yellow River Basin' s tourism economy have expanded over time, with right-trailing phenomena observed in certain years. (2) The global Moran' s index for tourism specialization levels is positive, indicating spatial agglomeration trends. Among local spatial agglomeration types, the scope of "high-high" and "low-low" agglomeration areas expands, while "low-high" agglomeration areas contract. From a spatial perspective, tourism economic differences in the Yellow River Basin also show expansion. (3) The promotional effects of nine driving factors on the tourism economy exhibit three temporal characteristics: stable, decreasing, and increasing. (4) The key driving factors for upstream cities' tourism economic development are regional economy, innovation capability, and tourism services; for midstream cities, they are regional economy, tourism services, and institutional policies; and for downstream cities, they are innovation capability, production factors, and institutional policies.

Keywords: tourism economic differences; driving factors; GTWR model; Yellow River Basin

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1.1 Study Area

Following the approach of Guo Fuyou et al. [**?**], this study designates the 61 prefecture-level cities (prefectures, leagues) through which the Yellow River flows as the research region. Due to data availability constraints, cities and prefectures with severe data gaps—including Jiyuan City, Haixi Prefecture, Yushu Prefecture, Guoluo Prefecture, Haibei Prefecture, Hainan Prefecture, Huangnan Prefecture, Gannan Prefecture, Linxia Prefecture, Aba Prefecture, and Alxa

League—were excluded. The final study area comprises 61 cities.

Note: This map is produced based on the standard map downloaded from the National Administration of Surveying, Mapping and Geoinformation (approval number: GS(2019)1822), with no modifications to the base map boundaries. The same applies below.

[Figure 1: see original paper] Schematic diagram of the study area

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1.2 Indicator Construction

Tourism development exerts strong economic driving effects while being constrained by numerous factors [**?**], resulting in unbalanced tourism economic development. Deeply exploring the driving factors of tourism economic development holds significant theoretical and practical importance for promoting regional coordinated development. New economic growth theory emphasizes that technological progress and institutional innovation constitute fundamental drivers of economic growth, thereby promoting sustainable economic development [**?**]. As a crucial component of economic development, tourism economic development is influenced not only by its own development elements such as tourism resources and tourism services but also by regional economy and human resources. Therefore, this study analyzes the driving factors of tourism economic development differences in the Yellow River Basin from five dimensions: regional economy, innovation capability, production factors, tourism services, and institutional policies. Specific indicators and their meanings are presented in Table 1.

Note: "+" indicates positive indicators; GDP stands for Gross Domestic Product; R&D stands for Research and Development. The same applies below.

Driving factor indices

1.3 Data Sources

This study employs tourism specialization levels to represent tourism economic development in the Yellow River Basin [**?**], calculated as the ratio of each city' s total tourism revenue to its GDP. Data sources for total tourism revenue, tertiary industry output value, R&D expenditure, total population, university graduates, number of A-level scenic spots, tourism employment, highway mileage, and administrative area are derived from local statistical bureaus, the *China Regional Economic Statistical Yearbook*, and national economic and social development statistical bulletins. Tourism resource endowment levels are obtained by applying the entropy method to weight data on A-level scenic spots in each city. The number of travel agencies per 10,000 people is sourced from enterprise registration data on the Tianyancha platform. Policy support is measured by

whether cities have promulgated tourism policies, assigned a value of 1 for municipal tourism policies and 0 otherwise, with specific policy documents queried through the Peking University Law Database. Missing data are addressed using linear interpolation, resulting in a balanced panel dataset of 61 cities in the Yellow River Basin from 2008 to 2020.

1.4 Methods

1.4.1 Kernel Density Estimation Kernel density estimation employs density functions to describe data distribution characteristics [**?**]. This study uses this method to describe the distribution characteristics of tourism specialization levels in the Yellow River Basin through continuous curves, analyzing the dynamic evolution of tourism economic differences by comparing kernel density curves across different years. The formula is as follows:

$$f(x) = \frac{1}{nh} \sum_{i=1}^{n} K\left(\frac{x - X_i}{h}\right)$$

where $f(x)$ represents the kernel density; h is the bandwidth determining the curve' s characteristics; n is the total number of cities; X_i is the tourism specialization level of each city; $\bar{x}$ is the average tourism specialization level; and K is the kernel function.

1.4.2 Spatial Autocorrelation Analysis Spatial autocorrelation analysis explores the degree of spatial association in geographical data [**?**]. This study employs global spatial autocorrelation to analyze the strength of agglomeration relationships in tourism specialization levels across cities in the Yellow River Basin, and local spatial autocorrelation to reveal spatial agglomeration types. The formula is as follows:

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \cdot \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

where I is the global Moran' s index; w_{ij} is the spatial weight matrix (assigned 1 when cities i and j are adjacent, 0 otherwise); n is the total number of cities; x_i and x_j are tourism specialization levels of cities i and j; and $\bar{x}$ is the average tourism specialization level.

1.4.3 Geographically and Temporally Weighted Regression (GTWR) Model The Geographically Weighted Regression (GWR) model effectively addresses spatial non-stationarity in regression coefficients but does not account for temporal differences. Huang et al. introduced temporal characteristics to

propose the GTWR model, aiming to explore how driving factors influence research objects under different spatio-temporal conditions. Tao Jieyi et al. [**?**] found that this model not only improves goodness-of-fit but also enhances explanatory power. The formula is as follows:

$$Y_m = \beta_0(t_m) + \sum_{n=1}^{k} \beta_n(t_m) X_{mn} + \varepsilon_m$$

where Y_m is the tourism specialization level of city m in the Yellow River Basin; (u_m, v_m, t_m) represents the longitude, latitude, and temporal coordinates of city m; $\beta_n(t_m)$ is the regression coefficient of driving factor n' s impact on city m' s tourism specialization level; X_{mn} is the data for driving factor n in city m; k is the total number of driving factors; and ε_m is the regression model error term.

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2 Results and Analysis

2.1 Spatio-Temporal Evolution of Tourism Economy

2.1.1 Temporal Evolution Analysis of Tourism Economy Using 2008, 2012, 2016, and 2020 as representative years, this study employs kernel density curves to analyze the changing patterns of tourism specialization levels in the Yellow River Basin, examining location, shape, number of peaks, and extension characteristics (Figure 2). When analyzing peak morphology, this study measures peak width at half the relative height difference.

From the kernel density curves of tourism specialization levels in the Yellow River Basin (Figure 2), the overall rightward shift indicates improved tourism specialization levels. The curves continued shifting rightward from 2008, but moved leftward in 2020 due to COVID-19 impacts, reflecting reduced tourism specialization levels. In terms of shape, peak values declined from 2008 to 2016, with peak widths expanding as peaks declined and contracting as peaks rose. The overall pattern shows expanding width and declining peaks, indicating widening gaps in tourism specialization levels. Regarding peak numbers, all years except 2012 show unimodal distributions, suggesting weakening polarization. In terms of extension, right-trailing phenomena appear in 2008, 2012, and 2016, indicating that some cities maintained leading tourism specialization levels during these years.

For upstream cities in the Yellow River Basin, kernel density curves show a rightward shift overall, indicating improved tourism specialization levels. Specifically, curves shifted rightward continuously from 2008 to 2016, but moved leftward substantially in 2020, reflecting significant declines. Peak values rose from 2008 to 2012, then declined substantially. Peak widths expanded as peaks fell and contracted as peaks rose, showing an overall pattern of expanding width and

declining peaks, with increasingly dispersed distribution and widening development gaps. All years except 2012 show unimodal distributions, indicating gradually weakening polarization. Right-trailing phenomena appear in 2008, 2012, and 2016, with individual cities maintaining leading positions during these years.

For midstream cities, kernel density curves show an overall rightward shift, indicating improved tourism specialization levels. Curves shifted rightward continuously from 2008 to 2016, but moved leftward substantially in 2020, reflecting significant declines. Peak values rose from 2008 to 2012, then declined substantially and remained below 2008 levels by 2020. Peak widths expanded continuously from 2008 to 2016, then contracted substantially in 2020, showing an overall pattern of expanding width and declining peaks, with widening tourism economic gaps and increasingly dispersed distribution. All years except 2012 show unimodal distributions, with polarization phenomena persisting. Right-trailing phenomena appear in 2008, 2012, and 2016, with individual cities maintaining leading positions.

For downstream cities, kernel density curves show an overall rightward shift, indicating improved tourism specialization levels. Curves shifted rightward continuously from 2008 to 2016, but moved leftward substantially in 2020, likely due to severe COVID-19 impacts. Peak values rose significantly from 2008 to 2012. Peak widths expanded from 2008 to 2016, then contracted substantially in 2020, showing an overall pattern of expanding width and declining peaks, with widening gaps in tourism specialization levels. All years except 2012 show unimodal distributions, indicating weakening polarization. Right-trailing phenomena appear in 2008, 2012, and 2016, with individual cities maintaining leading positions.

2.1.2 Spatial Correlation Analysis of Tourism Economy Using global Moran' s index to analyze spatial correlation of tourism specialization levels across Yellow River Basin cities from 2008 to 2020, all annual global Moran indices are positive and pass significance tests at the 0.01 level, showing significant spatial agglomeration characteristics. The global Moran index rose from 0.247 in 2008 to 0.327 in 2012, indicating strengthened agglomeration and narrowed inter-city tourism economic differences. From 2012 onward, the index declined continuously to 0.194 in 2020, indicating weakened spatial agglomeration and expanded development differences. Overall, tourism economic differences in the Yellow River Basin have expanded.

Global Moran' s I of tourism specialization level in the Yellow River Basin

To further explore spatial agglomeration patterns and evolution trends, this study employs ArcGIS software to plot local LISA cluster maps. Figure 3 shows that high-high agglomeration areas passing significance tests are primarily distributed around cities with high tourism specialization levels. In 2008, these were concentrated in Shuozhou and Lüliang; by 2012, they expanded to Taiyuan

and Dingxi; and by 2020, they covered Taiyuan, Dingxi, and cities in Shandong Province. Low-low agglomeration areas are mainly concentrated in upstream and downstream cities, particularly Wuzhong, Zhongwei, and Yinchuan, which have long remained in low development valleys. Due to poor location conditions and infrastructure, Ningxia' s overall tourism competitiveness is relatively weak, with significant inter-regional economic development gaps leading to low-low agglomeration. Notably, low-high agglomeration first appeared in Heze City in 2008 and expanded across Shandong Province by 2020. Despite Shandong being a major tourism province with positive tourism development trends, manufacturing as the absolute mainstay of its real economy plays a crucial role in economic development, resulting in lower tourism specialization levels and obvious low-high agglomeration. High-low agglomeration areas gradually shifted from Yangquan, Datong, and Linfen to Sanmenxia, Weinan, and Xi' an, and finally extended to Baoji and Tianshui. This may be because Shanxi and Shaanxi provinces' rich natural landscapes and cultural heritage resources provide foundations for tourism development while contributing to economic growth, resulting in relatively high tourism specialization levels that create siphon effects on surrounding cities.

[Figure 3: see original paper] LISA spatial cluster of tourism specialization level in the Yellow River Basin

2.2 Analysis of Driving Factors

2.2.1 Temporal Variation Analysis of Driving Factors This study employs the GTWR model to analyze spatio-temporal variation characteristics of driving factors. To avoid multicollinearity, we conduct multicollinearity tests using Stata software. Variance inflation factors for per capita GDP, tertiary industry proportion, university graduates per 10,000 people, tourism resource endowment level, tourism employment proportion, travel agencies per 10,000 people, road network density, and policy support range from 1.12 to 3.89, indicating no multicollinearity. Regression results show that the model' s goodness-of-fit (R^2) reaches 0.982, with an adjusted R^2 of 0.977, indicating excellent fit. All driving factor regression coefficients are positive, showing positive impacts on tourism specialization levels. Tourism employment proportion shows the largest coefficient, suggesting that adjusting tourism employment proportions could be a primary means to promote Yellow River Basin tourism development, validating Xu Aiping' s research conclusions.

Relevant parameters of GTWR model
Descriptive statistical analysis of driving factors' regression coefficients for GTWR models

Figure 4 shows that university graduates per 10,000 people and tourism resource endowment level exhibit stable regression coefficients, with essentially unchanged positive impacts on tourism economic development. Per capita GDP, tertiary industry proportion, and travel agencies per 10,000 people show decreas-

ing regression coefficients, with gradually weakening positive impacts. Tourism employment proportion, road network density, and policy support show increasing regression coefficients, with continuously strengthening promotional effects.

University graduates per 10,000 people serve as an important source of innovative talent, promoting tourism development. However, current shortages of skilled and service-oriented high-quality talent limit their driving effect on tourism specialization levels. Tourism resource endowment, as the core attraction for tourists, holds significant appeal. However, in the era of mass tourism, the reconfiguration of destination spaces in terms of elements, industries, management, and systems—particularly the widespread application of digital technology—has weakened the driving force of tourism resource endowment on tourism specialization.

Per capita GDP, tertiary industry proportion, and travel agencies per 10,000 people show decreasing impacts on tourism specialization levels. Local economic development can promote tourism revenue growth, but due to downward pressure on the international economy, domestic economic growth has slowed relatively, weakening its positive impact on tourism specialization levels. Meanwhile, the Yellow River Basin exhibits prominent heavy chemical industry characteristics with a weak tertiary sector, requiring considerable time to form scaled modern service industries. Additionally, overall low levels of scientific and technological innovation investment and imperfect transformation platforms make it difficult for R&D investment to generate good market, social, and economic benefits, thereby reducing the impact of tertiary industry proportion on tourism specialization levels. In recent years, travel agency revenue growth has slowed, with limited resource integration and radiation capabilities, similarly affecting tourism specialization levels.

Tourism employment proportion and policy support show increasing regression coefficients, with continuously strengthening promotional effects. Tourism employment, as human resource input, constitutes an important guarantee for tourism development. Road network construction strengthens inter-city connections and activities in the Yellow River Basin, promoting the circulation and flow of tourism resources and enhancing scenic area accessibility, thereby facilitating regional tourism economic development. Tourism policies have economic effects, with governments allocating tourism policies according to market demand to promote steady tourism development.

2.2.2 Spatial Differentiation Analysis of Driving Factors This study selects average regression coefficients from 2008–2020 to analyze spatial differentiation characteristics of driving factors.

Regional Economic Impact: Figure 5 shows that per capita GDP has relatively high impacts on tourism specialization levels in the middle Yellow River Basin, particularly in Baotou, Ulanqab, Hohhot, Datong, Shuozhou, Xinzhou, Taiyuan, Yangquan, Lüliang, and Jinzhong. Impact is lower in upstream cities

like Xining, Haidong, Lanzhou, Wuwei, Baiyin, Dingxi, Tianshui, and Longnan. This indicates that economic scale significantly promotes tourism specialization in midstream cities but has weaker effects on upstream cities. Tertiary industry proportion shows higher impacts in upstream cities like Haidong, Dingxi, Tianshui, Longnan, Pingliang, Baoji, Xianyang, and Xi' an, and lower impacts in cities like Bayannur, Baotou, Ulanqab, Hohhot, Datong, Shuozhou, Binzhou, Dongying, Weifang, and Qingdao, gradually strengthening from northeast to southwest. Industrial structure strongly promotes tourism specialization in upstream cities but weakly promotes it in downstream cities. Therefore, regional economy is a key factor driving tourism economic development in upstream and midstream cities.

Innovation Capability Impact: University graduates per 10,000 people show higher impacts on tourism specialization in upstream cities like Xining, Haidong, Wuwei, Shizuishan, Wuhai, Bayannur, Baotou, and Ulanqab, and lower impacts in downstream cities like Shangluo, Sanmenxia, Luoyang, Jiaozuo, Xinxiang, Hebi, Puyang, Zhengzhou, Kaifeng, Heze, Shangqiu, and Jining, gradually weakening from northwest to southeast. Innovative talent contributes significantly to tourism specialization in upstream cities. Therefore, innovation capability is a key factor driving tourism economic development in upstream and downstream cities.

Production Factors Impact: Tourism resource endowment shows higher impacts on tourism specialization in downstream cities like Kaifeng, Shangqiu, Heze, Jining, Tai' an, Jinan, Zibo, Binzhou, Dongying, Weifang, and Qingdao, and lower impacts in upstream cities like Xining, Haidong, Wuwei, Lanzhou, Baiyin, Zhongwei, Yinchuan, Shizuishan, Wuhai, Ordos, Bayannur, and Baotou, gradually strengthening from northwest to southeast. Tourism resource endowment contributes significantly to downstream cities' tourism economies. Tourism employment proportion shows higher impacts in downstream cities like Binzhou, Dongying, Zibo, Weifang, and Qingdao, and lower impacts in upstream cities like Haidong, Lanzhou, Baiyin, Zhongwei, Wuzhong, Guyuan, Qingyang, Pingliang, Baoji, Xianyang, Xi' an, and Shangluo, gradually weakening from east to west. Human resources significantly promote tourism specialization in downstream cities. Therefore, production factors are key drivers of tourism economic development in downstream cities.

Tourism Services Impact: Travel agencies per 10,000 people show higher impacts on tourism specialization in upstream cities like Xining, Haidong, Wuwei, Lanzhou, Baiyin, Dingxi, Tianshui, Longnan, Zhongwei, Guyuan, Pingliang, Wuzhong, Yinchuan, Shizuishan, and Wuhai, and lower impacts in downstream cities like Jining, Tai' an, Jinan, Zibo, Binzhou, Dongying, Weifang, and Qingdao, gradually strengthening from east to west. Tourism intermediaries promote tourism specialization in upstream cities. Road network density shows higher impacts in midstream cities like Datong, Shuozhou, Xinzhou, Taiyuan, Lüliang, Yangquan, Jinzhong, Linfen, Changzhi, Jincheng, Anyang, Hebi, and Xinxiang, and lower impacts in upstream cities like Xining, Haidong, Wuwei,

Lanzhou, Dingxi, and Longnan, gradually weakening from east to west. Tourism transportation promotes tourism specialization in midstream cities. Therefore, tourism services are key drivers of tourism economic development in upstream and midstream cities.

Institutional Policy Impact: Policy support shows higher impacts on tourism specialization in cities like Bayannur, Baotou, Ulanqab, Hohhot, Datong, Shuozhou, Dezhou, Jinan, Binzhou, Dongying, Zibo, Weifang, and Qingdao, and lower impacts in Dingxi, Longnan, Tianshui, Pingliang, Baoji, Xianyang, Xi' an, and Shangluo, gradually weakening from northeast to southwest. Tourism policies demonstrate promotional effects on tourism specialization in midstream and downstream cities. Therefore, institutional policy is a key driver of tourism economic development in midstream and downstream cities.

[Figure 5: see original paper] Spatial differentiation of regression coefficients for each driving factor in GTWR model

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3 Discussion

Scholars Xue Baoqi et al. [**?**] and Liu Chen et al. [**?**] have explored tourism economic differences and impacts at the provincial level in the Yellow River Basin, while Xue Mingyue et al. [**?**] investigated economic differences and influencing factors at the prefecture level. This study further refines the research area by adopting the geographical concept of "river basin,"selecting prefecture-level cities (prefectures, leagues) through which the Yellow River flows as the study region. Current research primarily uses indicators such as economic development level, tourism resources, location conditions, industrial structure, reception facilities, and policies to explore tourism economic differences [**?**], with some scholars examining openness to the outside world [**?**]. Combining new economic growth theory with inherent attributes of tourism development, this study analyzes driving factors from five dimensions: regional economy, innovation capability, production factors, tourism services, and institutional policies. Xue Mingyue et al. [**?**] used the GWR model to explore tourism economic driving factors, with an adjusted R^2 of 0.641, lower than the GTWR model' s accuracy in this study (adjusted $R^2 = 0.977$). The GTWR model utilizes temporal characteristics of sample data to analyze how driving factors affect tourism economic development under different spatio-temporal conditions, improving parameter estimation accuracy and effectively addressing spatio-temporal non-stationarity issues in regression models.

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4 Conclusions

(1) Over time, regional differences in the tourism economy across the Yellow River Basin, its upstream, midstream, and downstream regions have expanded, with right-trailing phenomena observed in some years.

(2) The global Moran' s index for tourism specialization levels is positive, indicating spatial agglomeration trends. Among local spatial agglomeration types, the scopes of "high-high," "low-low," and "high-low" agglomeration areas expand, while "low-high" agglomeration areas contract. From a spatial perspective, tourism economic differences among cities in the Yellow River Basin also expand.

(3) The promotional effects of nine driving factors on the tourism economy exhibit three temporal characteristics: stable, decreasing, and increasing. Specifically, university graduates per 10,000 people and tourism resource endowment levels show stable impacts; per capita GDP, tertiary industry proportion, and travel agencies per 10,000 people show decreasing impacts; and tourism employment proportion, road network density, and policy support show increasing impacts.

(4) The key driving factors for upstream cities' tourism economic development are regional economy, innovation capability, and tourism services. For midstream cities, they are regional economy, tourism services, and institutional policies. For downstream cities, they are innovation capability, production factors, and institutional policies.

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Note: Figure translations are in progress. See original paper for figures.