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Spatial Distribution of Tourism and Its Influencing Factors in Shanxi Province

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Abstract

As important carriers of regional tourism resource development and cultural and tourism integration, tourist attractions not only reflect the comprehensive role of natural and human elements but also directly affect the quality of regional tourism development. As a province with a large history and culture and a demonstration area for the transformation of a resource-based economy, the spatial pattern evolution and driving mechanisms of Shanxi Province's A-level tourist attractions have typical research value, but the existing research lacks comprehensiveness in terms of regional adaptability. On the basis of the 2020–2023 data of A-level scenic spots in Shanxi Province, this study comprehensively used the nearest neighbor index, kernel density analysis, and geographic detector methods to systematically analyze the distribution characteristics and influencing factors of A-level scenic spots in Shanxi Province. The results reveal the following: 1) Level A scenic spots in Shanxi Province exhibited a significant spatial pattern of "agglomeration at the center-scattering at the periphery", with Taiyuan as the core forming a high-density area and radiating and diffusing to the surroundings along the main traffic axis; and 2) the spatial distribution type continued to be the agglomeration type, but the aggregation strength showed a weak trend of loosening. 3) Analysis by geographic detector revealed that the distribution of scenic spots was jointly affected by the natural environment and socioeconomic factors, with socioeconomic factors being the leading force; natural environmental factors formed the basic constraints, and the influence of the river system was relatively stable. This study aims to reveal the spatial differentiation pattern of A-level scenic spots in Shanxi Province, comprehensively consider its key elements, and provide an empirical basis for the high-quality development of cultural tourism in resource-based provinces.

Keywords

Shanxi Province, A-level scenic spots, geographic detectors, spatial distribution, influencing factors

1. Introduction

As an important part of the national economy, tourism plays important roles in promoting coordinated regional development, promoting industrial structural transformation, and enhancing cultural soft power (Butler, 1980). In the context of the intertwining of globalization and localization, the spatial pattern of tourism is the result of the multiple effects of resource endowments, market demand, transportation networks and policy guidance (Hall, 2019). These factors work together to form a regional tourism pattern with specific spatial structure and evolution patterns, which can be calculated by using the life cycle theory of tourist destinations (Butler, 1980) and central place theory (Christaller, 1963) and other classical theories to explain.

The tourism development of resource-based provinces needs to solve the problems of the unity of industrial structure and ecological constraints (Duan et al., 2007; Yang & Jiao, 2016).

In this context, as an area enriched in cultural tourism resources, Shanxi Province's "14th Five-Year Plan for Cultural and Tourism Development", released in 2021, clearly proposes the construction of a spatial structure of "one core, one belt, multiple points" to promote the deep integration of cultural tourism; optimize the hierarchical system and spatial layout of the scenic spots; strengthen the radiation-driven role centered on Taiyuan; and promote the coordinated development of the Yellow River, the Great Wall and the Taihang cultural tourism plates (China Culture Daily, 2021). This policy orientation is not only in agreement with the life cycle theory of tourist destinations (Butler, 1980) and central place theory (Christaller, 1963), the high degree of fit also provides realistic support for the exploration of the spatial evolution and layout mechanism of A-level scenic spots.

In recent years, the study of the spatial distribution characteristics and driving mechanisms of scenic spots has received widespread attention in the fields of tourism geography and regional development. Most scholars use spatial analysis tools such as the nearest neighbor index and kernel density analysis in combination with GIS platforms to describe the spatial pattern of tourist attractions at the macroscopic scale. Wu et al. (2017) used the nearest neighbor index and kernel density methods to identify the agglomeration characteristics of A-level scenic spots in Hunan Province and reported that the scenic spots are concentrated mainly in areas with convenient transportation; Song et al. (2025) used the nearest neighbor index, standard deviation ellipse, and spatial autocorrelation to conduct macroscopic analysis on the spatial distribution of supply and demand of tourism resources; Wang and Xu (2017) studied coastal attractions in Qingdao and reported that the fusion of POI data and GIS spatial analysis can accurately identify the "polycentric agglomeration" characteristics of tourism resources and reveal the role of transportation network and water system distribution in shaping spatial patterns.

From the perspective of influencing factors, scholars have used geographic detectors (Zikirya & Zhou, 2023) and have generally confirmed that socioeconomic factors are the leading forces. The transportation network is the core engine of the distribution of scenic spots, while natural elements form the basic constraint framework. In terms of policy response, the national strategy has significantly reshaped the spatial pattern of scenic spots. Liu and Hao (2020) performed a national-scale analysis of 9296 A-level scenic spots and revealed that the level of economic development, population density and transportation facilities are the main driving factors and that the influence of natural factors is relatively stable; Wang et al. (2021) studied the distribution of A-level scenic spots in Shanxi Province and used GIS and geographic detector methods and reported that policy orientation, resident population, and transportation status were the main driving forces, while the influence of natural factors was relatively stable; Xu et al. (2018) reported that the explanatory power of the interaction between tourism investment and GDP was greater than that of the single-factor model.

The existing studies on the geographic adaptability of resource-based provinces (Shanxi, Inner Mongolia, Guizhou, etc.) are still insufficient. Although the cultural tourism policy of Shanxi Province proposes the development strategy of "one core, one belt and multiple sites" (China Culture Daily, 2021), the current literature focuses mostly on developed eastern provinces or case analyses from the earlier period (J. Li et al., 2020; L. Li et al., 2020; Liu & Tang, 2022; Rong & Tao, 2020; Xu et al., 2018). There is a lack of systematic examination of the spatial response of resource-dependent areas in the context of the implementation of the latest policies. Therefore, this study focused on the changes in the spatial pattern of A-level scenic spots in Shanxi Province during 2020–2023 and used multisource data and a spatial econometric model to reveal the evolution characteristics and driving mechanism of the scenic spot pattern over the past four years to dynamically reflect the latest changes in the scenic spot pattern. This study not only provides chronological evidence of the tourism geography of resource-based regions but also provides a practical reference for the high-quality development of cultural tourism integration in Shanxi and the central and western regions.

2. Research Methods and Data Sources

2.1 Research Methods

To systematically analyze the spatial distribution characteristics and influencing factors of A-level tourist attractions in Shanxi Province, the present study comprehensively used methods combined with spatial analysis and geographic statistics, including nearest neighbor index, kernel density analysis and geographic detection methods. The details are as follows:

2.1.1 Nearest Neighbor Index

The nearest neighbor index is a classic method used to quantitatively measure the spatial distribution pattern of point elements, and it can determine whether the research objects exhibit an aggregate, random or uniform distribution. The calculation formula is as follows:

$$R = \frac{r_{obs}}{r_{exp}} = \frac{\frac{1}{n}\sum_{i=1}^{n} d_i}{0.5/\sqrt{n/A}} \quad (1)$$

where r_{obs} represents the actual average nearest neighbor distance, r_{exp} is the mean distance under the theoretical random distribution, n is the number of scenic spots in the study area, A is the area of the study area, and d_i is the No.i Distance from a point to its nearest neighbor.

R <1, indicating that the scenic spots are clustered in distribution.R ≈1, the distribution is random;R >1, the distribution of scenic spots is relatively uniform.

The nearest neighbor index can preliminarily reveal the overall spatial distribution characteristics of the A-level scenic spots in Shanxi Province.

2.1.2 Kernel density analysis

Kernel density analysis is a method of generating continuous spatial distribution maps based on point data and is used to reflect the density of spatial data in different areas. By setting the kernel function and search radius, this method performs weighted summation on the point data in the study area to generate a scenic spot density map to express the spatial agglomeration trend of scenic spots. The expression of the kernel density function is

$$f(x) = \frac{1}{nh^2}\sum_{i=1}^{n} K\left(\frac{d_i}{h}\right) \quad (2)$$

where f(x) is the locationx The density value at n is the total number of samples, h is the kernel function bandwidth, and d_i is the locationx To No.i The distance between the sample points is K, which is the kernel function (the normal distribution kernel function is typically used).

Kernel density analysis was performed using GIS software, such as ArcGIS, to visually display the spatial agglomeration degree and high-density areas of A-level scenic spots throughout Shanxi Province.

2.1.3 Geodetector

Geographic detection is a statistical method used to investigate the spatial differentiation and driving mechanisms of geographic phenomena, and it can effectively reveal the spatial explanatory power of influencing factors. In this study, the factor detector module was used to analyze the explanation level of the spatial distribution of A-level scenic spots by different socioeconomic and natural environmental factors.

The core idea is that if a certain factor is the dominant factor in the spatial differentiation of geographic phenomena, then the spatial differentiation pattern of this factor should be significantly consistent with that of the geographic phenomenon. The calculation formula is as follows:

$$q=1-\frac{\sum_{h=1}^{L} N_h\sigma_h^2}{N\sigma^2} \quad (3)$$

h represents the firsth subarea, L is the total number of subregions,N_h andσ_h^2 represents the subareash The sample size and variance of N and σ^2 are the sample size and population variance in the whole region, respectively.q The value range was [0,1], and a larger value indicated a stronger explanatory power of this factor on the distribution of scenic spots.

In the present study, factors such as altitude, the river system, the proportion of the tertiary industry, and tourism revenue were selected as explanatory variables, and the influence of these factors was quantitatively analyzed using geographic detectors to further understand the main controlling factors of the spatial distribution of A-Level scenic spots.

2.2 Data Source and Processing

The data of the Level A scenic spots in this paper came from the data released by the Shanxi Provincial Department of Culture and Tourism and the municipal affairs service networks of the 11 prefecture-level municipalities in Shanxi Province. The specific geographic locations of the scenic spots were determined using a Tianmao map. The provincial-level administrative divisions and city-level administrative divisions of Shanxi Province were sourced from the Alibaba Cloud data visualization platform. Among the influencing factors, the altitude, topographic slope, and river system were used as the natural environmental factors; the gross national product, the proportion of the tertiary industry, the resident population, the mileage of traffic and the income from tourism were used as the socioeconomic factors, as shown in the following Table 1. Note: The data released in the "Statistical Yearbook" for the current year are from the previous year, such as "Statistical Yearbook 2024" (data year: 2023).

Table 1: Impact Factor Indicators

Level 1 indicators	Secondary indicators	Specific acquisition channels
Natural environment	Altitude X_1	Postprocessing of SRTMDEM 90 M resolution original elevation data downloaded from geospatial data cloud
	Terrain slope X_2	Postdownload geospatial data from the cloud
	River water system X_3	Thematic maps of river systems in Shanxi Province
Socioeconomic	Gross production value X_4	Shanxi Province Statistical Yearbook 2021-2024: Regional Gross Domestic Product
	Proportion of tertiary industry X_5	Shanxi Province 2021-2024 Statistical Yearbook · Regional Gross Domestic Product · Tertiary Industry
	Permanent population X_6	Shanxi Province 2021-2024 Statistical Yearbook: Permanent Population and Composition
	Mileage to traffic X_7	Shanxi Province 2021 – 2024 Statistical Yearbook: Highway Mileage in Operation
	Tourism income X_8	Shanxi Province 2021-2024 Statistical Yearbook: Development of the Tourism Industry

3. Study Results

3.1 Spatial Distribution Characteristics of A-level Scenic Spots in Shanxi Province

3.1.1 Nearest Neighbor Index of A-level Scenic Spots in Shanxi Province

The level A scenic spots in Shanxi Province exhibited significant spatial agglomeration characteristics during 2020–2023 (the R value was consistently less than 1), indicating that the proximity of the scenic spots is significantly greater than the random state, as shown in Table 2. The R value from 2020 to 2021 will remain almost unchanged, indicating that the pattern of scenic spots is relatively stable at this stage. However, the R value has slightly increased since 2021, reflecting that while the agglomeration intensity is still significant, there is a gradual weakening trend, suggesting that the spatial distribution of scenic spots shows a certain extensional expansion under the core agglomeration pattern.

This trend is closely related to regional policies and changes in traffic conditions. From the policy level, during the 14th Five-Year Plan period, Shanxi Province proposed the construction of a cultural tourism development pattern of "one core, one area, and multiple sites" to promote the coordinated development of the Yellow River, the Great Wall and the Taihang Plateau outside the core area of the provincial capital, which directly drove the construction and quality improvement of some scenic spots in the edge areas, and secondary nodes weakened the pattern characteristics of the excessive concentration of scenic spots around Taiyuan as a whole. From a transportation perspective, the extension of expressways and inter-city railways after 2020 has significantly improved accessibility in parts of central and southern China, as well as southeastern and northwestern Shanxi Province. This has created conditions for emerging tourist attractions to be included in regional tourism networks and increased the weight of peripheral tourist attractions in statistical distributions. The slight increase in the R value reflects the transformation of the spatial pattern of scenic spots in Shanxi Province from "single-core strong agglomeration" to "core stability–peripheral gradual dispersion", which is the result of the joint action of policy guidance and transportation improvement.

Table 2: Distribution types of the nearest neighbor index in the A-level scenic spots in Shanxi Province

Year	Actual average observation distance/m	Theoretical average distance/m	Nearest neighbor index (R)	Distribution type
2020	10360.06211	14510.53109	0.713968	Aggregation
2021	10360.06211	14510.53109	0.713968	Aggregation
2022	10274.81624	14327.94543	0.717117	Aggregation
2023	10232.70156	13905.84695	0.735856	Aggregation

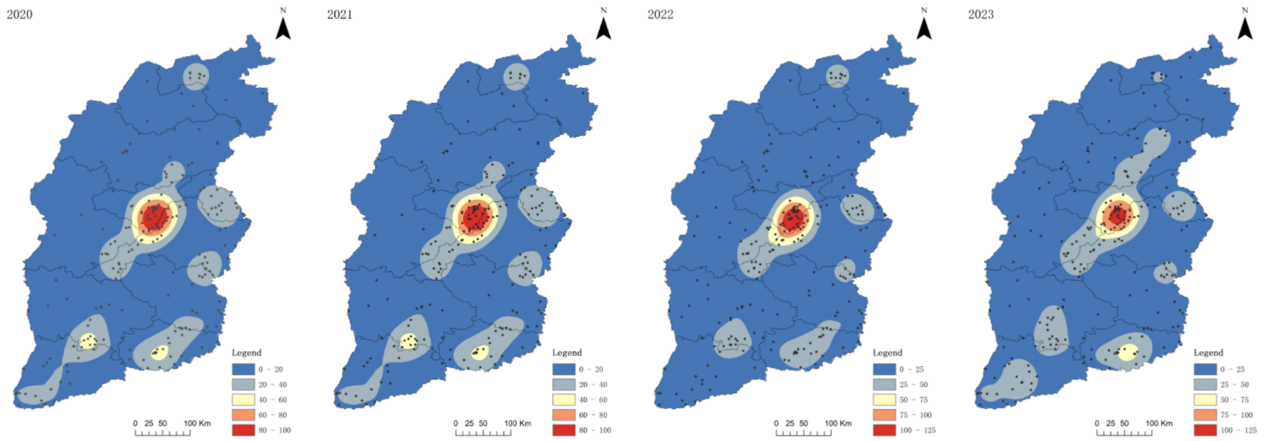
3.1.2 Kernel Density Analysis of A-level Scenic Spots in Shanxi Province

The kernel density values of Grade A scenic spots in Shanxi Province were calculated using kernel density analysis, and the results of the spatial distribution kernel density analysis of A-level scenic spots in Shanxi Province are shown in Figure 1. First, Taiyuan and its surrounding areas have always maintained the highest density level and are the absolute core of the province's tourism resources. Second, Datong, Jincheng, and Yuncheng formed secondary agglomerations, which played a supporting and diverting role within the province. Third, the scenic spots in other cities are mostly distributed at low density and exhibit a typical "core-subcore-periphery" gradient structure.

From the perspective of the evolution path, the influence of the core area has not been weakened, but its spatial scope has shown epilateral expansion: During 2021–2023, the high-density core gradually extends along the two corridors of Taiyuan-Jinzhong-Changzhi and Taiyuan-Xinzhou-Datong, showing the pulling effect of the main traffic axis and the urban development zone. Moreover, the density of some secondary agglomerations has been rising steadily, indicating that tourism development is shifting from being dependent on a single center to being supported at multiple points.

In general, the spatial pattern of A-level scenic spots in Shanxi Province reflects not only the core control power of the provincial capital cities but also the linkage effect of traffic corridors and regional nodes. The formation of this pattern has gradually shifted the distribution of tourism resources in the province from a single-core agglomeration to a stratified evolution pattern of "centering on Taiyuan, radiating to the surrounding areas, and having multiple cores coexist".

Figure 1: Kernel density analysis map of Shanxi Province's A-level tourist attractions from 2020 to 2023



3.2 Factors Influencing the Spatial Distribution of A-level Scenic Spots in Shanxi Province

3.2.1 Determination of Influencing Factors

The spatial distribution of A-level scenic spots is affected by various factors. On the basis of the research results of other scholars, the factors can generally be divided into natural environmental factors and socioeconomic factors. The natural environmental factors included altitude, topographic slope and the river system; the socioeconomic factors included the economic development and tourism development of the locations of Shanxi Province’s A-level scenic spots, which could be specifically divided into gross national product (GNP), the tertiary industry proportion of urban residents, the resident population, traffic mileage and tourism income.

(1) Natural environmental factors: The topography and landforms of Shanxi Province are characterized by thousands of ravines. These findings also reveal that altitude and slope constrain the distribution of A-level scenic spots in Shanxi Province to a certain extent. Natural landscapes such as the Beiyue-Hengshan Scenic Area and Wutai Mountain Scenic Spots and the Baquanxia Scenic Area of the Taihang Mountains are widely distributed in hilly and mountainous areas, whereas cultural landscapes such as the China Coal Museum Scenic Area and the Pingyao Ancient City Scenic Area are widely distributed in flat areas. Ancient people lived by water, so the river system has also become an influencing factor on the distribution of scenic spots. In areas with abundant water resources, the natural scenery is beautiful and is accompanied by a large amount of anthropogenic activity. Therefore, there are natural landscapes and cultural landscapes around the rivers. provides basic conditions for the development of scenic spots.

(2) Socioeconomic factors: Gross national product (GDP) represents the economic aggregate of a region and reflects the level of economic development and financial support strength of the region. In economically developed areas, more funds will be invested in infrastructure construction and greater financial capacity to support a series of tourism industry activities, such as tourism services, cultural protection, publicity and promotion, and the development and maintenance of scenic spots. The proportion of the tertiary industry reflects mainly the development of the service industry. A higher proportion of the tertiary industry indicates that the region pays more attention to the development of the service industry and makes it easier to form a complete service chain and provide tourists with a better service experience. Population size represents the potential tourism consumption market and affects the ability to supply tourism services. Places with a larger resident population are areas with a denser distribution of A-level scenic spots. Convenience transportation is among the basic conditions for tourism development. The stronger the transportation connectivity is, the greater the accessibility of scenic spots. Scenic spots are usually concentrated in areas with convenient transportation or transportation hubs, such as along high-speed rails and around national highways. Tourism income directly reflects the maturity and attraction of the local tourism market. Areas with high income have fully developed tourism resources and active markets. Such areas are usually distributed with more A-grade scenic spots.

3.2.2 Division of Influencing Factors

As for the influencing factors, the eight categories and third-level influencing factors mentioned above were selected and divided. Owing to the short study time and the small changes in the three factors in the natural environment, the altitude, topographic slope, and river system can be ignored during the 2020–2023 period. The GDP, proportion of the tertiary industry, permanent population, mileage of traffic and tourism income of the socioeconomic factors were used as the data for the current year.

In terms of data-level division, altitude, topographic slope, river system, gross national product, proportion of the tertiary industry, permanent population, traffic mileage, and tourism income were used in the present study to meet the requirements of the geographic detector for categorical variables, and the original continuous independent variable is discretized. Three commonly used discretization methods were used for comparative evaluation, namely, the natural breaks method, the quantile method and the geometric interval method. To further optimize the classification effect, 4 to 7 levels were set as candidate values for the number of groups. The geographic detector model conducts multiple experiments on each variable by combining different discretization methods and levels and selects the optimal discretization scheme on the basis of the q value of the detector, that is, the final grouping method and number of levels used by each variable. The optimal value was automatically selected and determined.

3.2.3 Results Analysis

ArcGIS10.5 was used to create vector grids in Shanxi Province. A total of 117,936 meshes were divided. On the basis of the Geodetector model and spatial data from 2020–2023, this study quantitatively analyzed the impact of eight factors on Shanxi Province. Degree of influence (q value) and significance of the spatial distribution pattern of A-level scenic spots. All the analyzed factors passed the significance test (p value < 0.001), indicating that the explanatory power of the selected factors for the spatial differentiation of scenic spots was statistically significant. The results are shown in Table 3.

Table 3: Results of the explanatory power (geographic detector q value) of each influencing factor for 2020 to 2023

Variable	Altitude (X_1)	Terrain slope (X_2)	River system (X_3)	Gross domestic product (X_4)	Tertiary industry share (X_5)	Permanent population (X_6)	Total mileage (X_7)	Tourism revenue (X_8)
2020	0.0289	0.0196	0.0239	0.0231	0.0409	0.0157	0.2234	0.0331
2021	0.0234	0.0169	0.0348	0.0268	0.0324	0.0306	0.3165	0.0271
2022	0.0529	0.0239	0.0349	0.0461	0.0649	0.0114	0.1896	0.0503
2023	0.0508	0.0268	0.0370	0.0300	0.0638	0.0127	0.1831	0.0574

Significance note: All variables had p-values < 0.001 and passed the significance test.

1) Effects of natural environmental factors on the spatial distribution of scenic spots

This study included altitude, topographic slope, and river system as natural environmental factors. The analysis results revealed the following:

Altitude (q value range: 0.0234–0.0529): The q value fluctuated the most, reaching a peak at 0.0529 in 2022. This finding indicates that the effect of altitude on the distribution of scenic spots has obvious spatial heterogeneity and periodical characteristics. The basins and river valleys are at lower altitudes, such as the Fenhe Valley, the Taiyuan Basin, the Xinding Basin, and the Datong Basin, which are population- and economy-intensive areas that have large numbers of human landscapes; the mountainous areas are at higher altitudes, and the main natural scenery of Shanxi Province is concentrated. and ecotourism resources. The fluctuation of the q value may reflect changes in the development intensity or market enthusiasm of different types of scenic spots during different periods, highlighting the dynamic role of the altitude factor in shaping the vertical distribution pattern of scenic spots.

Terrain slope (q value range: 0.0169–0.0268): The q value slightly increases annually, with the maximum q value occurring in 2023. This reflects the dependence of scenic spot selection on topographic conditions; relatively gentle terrain is more conducive to transportation accessibility, the construction of tourist facilities and the development of tourist activities. Moreover, suitable moderate slope areas often form unique mountain and canyon landscapes, but their development costs and accessibility requirements are high. The change in its q value may reflect the dynamic selection of terrain adaptability or the trend toward refined management in scenic spot development.

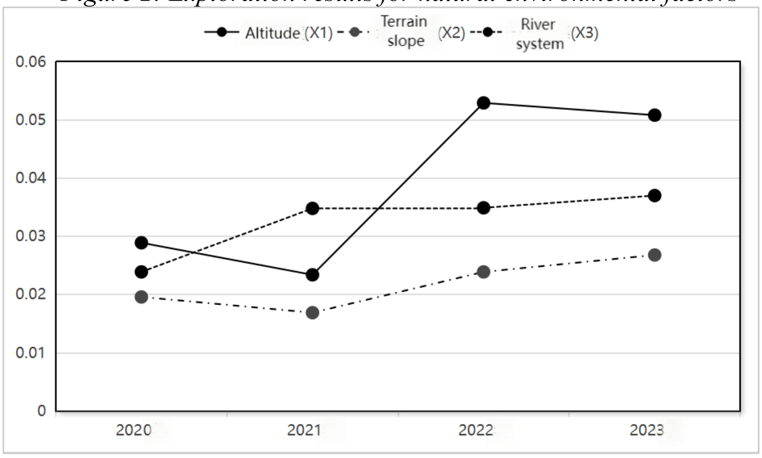
River system (q value range: 0.0239–0.0370): Its explanatory power among natural environmental factors was relatively stable and prominent. These findings indicate that the distribution of A-level scenic spots in Shanxi Province significantly tends to be close to that in the river areas. Rivers not only provide important water sources and shape beautiful natural landscapes but also have been used in history as corridors for human settlement, transportation, and the development of civilization, forming a rich cultural heritage and thus becoming the key physical geographic basis for the location selection and aggregation of scenic spots.

In general, natural environmental factors exerted basic constraints on the spatial distribution of A-level scenic spots in Shanxi Province. Its q value ranged from 0.0169–0.0529, which was significantly lower than that of socioeconomic factors, and the three curves fluctuated slightly, as shown in Figure 2, indicating that the influence of natural factors is relatively stable in time and space. Among the specific influencing factors, the river system, topographic slope and altitude together constitute the basic framework of the spatial distribution of scenic spots.

Taking the river system as an example, scenic areas such as the ancient city of Pingyao and Hukou Waterfall are formed on the basis of the hydrological conditions of the Yellow River and its tributaries. Rivers provide not only unique natural landscapes but also rich historical and cultural resources, which provide the natural basis for the attraction and agglomeration of scenic spots. The slope of the terrain clearly restricts the development of the scenic spot. The Yungang Grottoes are taken as an example. The grottoes were built against the mountain, using the cliffs of the mountain to form a unique landscape. Although the terrain is steep, the landscape value makes it a world-class tourism resource. The altitude factor was particularly prominent in the case of Mount Wutai. The high-altitude environment not only shaped the spatial characteristics of the Buddhist holy site but also made transportation and infrastructure construction more difficult.

In summary, although the natural environmental factors are relatively stable, through the support of the water system, topographical constraints and altitude differentiation, the basic geographic framework and resource endowment conditions for the spatial distribution of scenic spots are jointly shaped, providing stable natural constraints and cultural heritage support for the layout of the A-level scenic spots in Shanxi Province.

Figure 2: Exploration results for natural environmental factors



2) Impact of socioeconomic factors on the spatial distribution of scenic spots

This study included gross domestic product, the proportion of the tertiary industry, the resident population, traffic mileage, and tourism income as socioeconomic factors. The results of the analysis reveal that the overall explanatory power of socioeconomic factors is generally stronger than that of natural environmental factors, which is the core force driving the spatial differentiation of scenic spots:

Gross domestic product (q value range: 0.0231–0.0461) and tertiary industry share (the ratio of the tertiary industry added value in GDP) (q value range: 0.0324–0.0649): These two influencing factors clearly fluctuated. This reflects the level of regional economic development, especially the development level of the service industry, which has an increasing supporting and stimulating effect on the distribution of scenic spots. Economically developed areas have a stronger financial capacity to invest in tourism infrastructure and public services; a greater ability to support the local tourism market; and a more complete service system to meet the needs of tourists, making it easier to cultivate, attract and maintain high-level scenic spots. The q value of the proportion of the tertiary industry was relatively higher, and the growth was more obvious, which directly highlights the positive impact of the transformation of the regional industrial structure to the service industry on tourism development and the upgrading of the scenic spots.

Permanent population (q value range: 0.0114–0.0306): The explanatory power of this factor is relatively weak, with large fluctuations. The role of demographic factors is reflected mainly in two aspects: one is to serve as the basis of the local tourism market, and the other is to reflect the supply of human resources and the comprehensive vitality of the region. The relatively low value of q indicates that in Shanxi Province, the direct driving effect of the local population on the distribution of scenic spots is weaker than that of hard conditions such as transportation and the economy, but the fluctuation in 2021 may reflect the impact of demand for local tourism and peripheral tourism on the distribution of scenic spots during a specific period. The short-term effect of the distribution is magnified.

Total mileage (q value range: 0.1831–0.3165): The explanatory power of this factor outperforms that of all the other factors. This clearly shows that transportation accessibility is the most critical factor in determining the spatial distribution pattern of A-level scenic spots in Shanxi Province. A sound road network greatly decreases the space-time distance, increases the accessibility of scenic spots, and directly guides the flow of tourists and the flow of investment in the development of scenic spots. "The prosperity of the roads" is particularly evident in Shanxi Province, where the arterial traffic lines have become corridors with a high concentration of scenic spots.

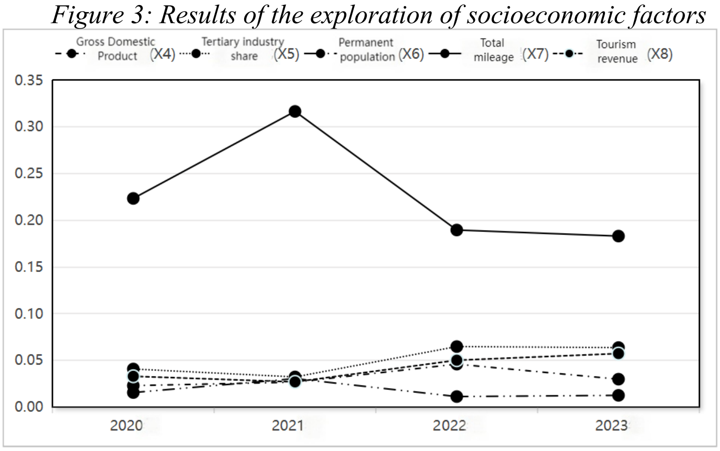
Tourism revenue(q-value range: 0.0271–0.0574): After a slight decrease in 2021, the q value of this factor will rise significantly from 2022–2023, exceeding the previous level. This reflects the feedback and strengthening effect of the economic benefits of the tourism industry on the development of scenic spots. Areas with high tourism income are strongly attracted to tourism resources and high market recognition, which can attract more investment in the quality and expansion of scenic spots, the development of new scenic spots, and the improvement of related industrial chains, forming the “development of scenic spots-increase in income.” The virtuous circle of “reinvestment and development” has further consolidated and strengthened the region’s advantage of scenic agglomeration.

In summary, although socioeconomic factors fluctuate to some extent in the time series, compared with natural environmental factors, they are the leading force in shaping the spatial pattern of A-level scenic spots in Shanxi Province, as shown in Figure 3. Among them, transportation infrastructure, regional economic development level, and tourism income play significant roles in spatial distribution, while the size of the permanent population has a relatively limited effect.

Specifically, the improvement in traffic conditions has a direct driving effect. For example, the opening of the Taiyuan-Jincheng high-speed rail has significantly increased the number of tourists to scenic locations such as the Huangcheng Xiangfu and Jueshan Mountains in Jincheng, which has become a typical case of the agglomeration of scenic spots driven by the optimization of transportation infrastructure. Moreover, the construction of three tourist highways (the Yellow River, Great Wall and Taihang) in Shanxi Province further improved the tourism transportation network and strengthened spatial connectivity. Driven by tourism revenue, which relies on the unique status of world cultural heritage and a stable tourist market, the ancient city of Pingyao has continued to reinvest tourism revenue, forming a virtuous circle from scenic spot protection to tourism industrialization. The improvement in the regional economic development level is particularly prominent in Taiyuan and Jinzhong. With the growth of GDP and the expansion of the proportion of the tertiary industry, the localities have gradually established a relatively complete tourism service system, which has promoted the agglomeration and upgrading of scenic spots. In contrast, in areas with inconvenient transportation and economic lag, such as Luliang, the development process of A-level scenic spots is relatively slow, underscoring the decisive role of socioeconomic conditions in regionally differentiated development.

In general, transportation infrastructure is the core “engine” that affects the spatial distribution of scenic spots, and its spatial guiding effect is irreplaceable; the level of regional economic development, especially the transformation and upgrading of industrial structure to the service industry, provides a solid material foundation for the development of scenic spots and a continuous driving force; and the economic benefits of tourism itself strengthen the agglomeration effect of advantageous areas through the feedback mechanism. In contrast, the size of the permanent population only plays a basic supporting role and has a weak direct effect on the spatial pattern of scenic spots.

Figure 3: Results of the exploration of socioeconomic factors



4. Conclusion

On the basis of the 2020–2023 data of Level A scenic spots in Shanxi Province, this study comprehensively used the nearest neighbor index, kernel density analysis and a geographic detector model to systematically reveal the spatial distribution pattern and driving mechanism of scenic spots. The results revealed the following:

1) The A-level scenic spots in Shanxi Province showed a significant agglomeration type distribution ($R < 1$), with Taiyuan as the core forming a high-density agglomeration area. The secondary nodes are distributed in Datong, Jincheng, Yuncheng and other places and expand radially along the main transportation axis, reflecting the spatial characteristics in which central enhancement and peripheral expansion coexisted.

2) Socioeconomic factors have a decisive effect on the spatial differentiation of scenic spots, with transportation accessibility, regional economic level, and tourism benefits as the core driving factors; natural environmental factors form the basic constraints; and the river system, topographic slope and altitude shape the spatial framework of the layout of scenic spots and resource endowment conditions.

Based on the above findings, regional tourism planning should optimize the layout of the transportation network; strengthen the construction of the "three major plates" of the Yellow River, the Great Wall, and the Taihang District to improve the accessibility of the fringe areas; and rely on the upgrading of the service industry in the core area of Taiyuan to achieve a balanced allocation of scenic resources and high-quality development.

Future research can be further expanded as follows. First, machine learning and spatial statistics methods are introduced to quantify the interaction of multiple factors at different spatial scales to deepen the understanding of the mechanism. Second, combined with the time-space series model, the spatial evolution trend of scenic spots is predicted to provide decision support for planning. Third, the policy text and planning documents should be quantified, and changes in the layout of scenic spots under different policy scenarios should be simulated to enhance the policy applicability and prospectiveness of the research. For example, the identification of potential scenic spot development hotspots through the fusion of multisource data (POI, travel reviews, and big data travel trajectories) through a deep learning model not only helps to more accurately predict the spatial evolution trend of scenic spots but also provides intelligent support for government decision-making. In the future, the multiscale interaction mechanism can be further analyzed in combination with a machine learning model.

In summary, this study not only reveals the evolution characteristics and driving mechanism of the spatial pattern of scenic spots in resource-based provinces but also provides a theoretical basis and operable policy reference for regional cultural tourism integration and high-quality development.

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Conflicts of Interest

The authors declare no conflict of interest.

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