Spatial Pattern and Planning Response of the County-Level Cultural Tourism Industry in Shanxi Province Based on Multi-Source Data

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Abstract. Taking the theory of six elements of tourism as the research framework, this paper adopts multiple methods including the nearest neighbor index, kernel density analysis, bivariate spatial autocorrelation model and Ripley's K function. Based on the point of interest (POI) dataset, it analyzes the spatial distribution of cultural tourism industry and the correlation between various elements, and discusses planning response strategies combined with spatial risk identification. The results show that: (1) The county-level cultural tourism industry in Shanxi Province presents an extremely significant agglomeration distribution on the whole. The agglomeration degree from high to low is ranked as Shopping > Sightseeing > Catering > Accommodation > Entertainment > Transportation, forming a dual agglomeration mode of city dependence and resource orientation. (2) The six tourism elements have weak capacity for continuous spatial expansion, presenting a hierarchical layout of "one primary center, one secondary center and multiple supporting nodes". At the micro county level, the overall global spatial coupling correlation of the six elements is relatively low. The Transportation element plays a prominent role in connecting spatial corridors, while the spatial matching degree between Sightseeing and supporting service elements is low, leading to insufficient coordination among all elements. (3) The six tourism elements show obvious spatial scale differentiation. Service-oriented elements rapidly agglomerate and decline on small and medium scales, while resource-oriented elements continuously expand on large scales. The Accommodation element maintains stable agglomeration across all scales and possesses the strongest spatial resilience. (4) Aiming at the problems of spatial imbalance, element mismatch and insufficient coordination, this study proposes to build a spatial network development system of "one core, three corridors and multiple nodes". Combined with corridor connection, supporting facility improvement for scenic spots, transportation hub upgrading and differentiated development of counties, relevant planning response strategies are put forward.

Keywords: Cultural tourism industry, Spatial pattern, POI, Planning response, Shanxi Province

1. Introduction

In 2024, General Secretary Xi Jinping put forward during his inspection tour in Fujian Province that efforts should be made to further the in-depth integration of culture and tourism, and cultivate the cultural tourism industry into a pillar industry. In March 2026, *Outline of the 15th Five-Year Plan for National Economic and Social Development of the People's Republic of China* pointed out that we should adhere to the principle of leveraging culture to enrich tourism and highlighting culture through tourism, promote the construction of a country with strong tourism industry, and accelerate high-quality development, in-depth integration of culture and tourism, technological empowerment and international development of the tourism industry. It further indicates that China's tourism development has entered the strategic stage of building a country with strong tourism industry. At present, Shanxi Province is in an important period of transformation from a resource-based economy. All county-level territorial spatial plans approved by the provincial government clearly state that it is essential to deeply explore the value of cultural and tourism resources, regard the cultural tourism industry as a key direction for economic transformation, and advance the construction of high-quality scenic spots. Nevertheless, as the basic units carrying cultural and tourism resources, county-level regions in Shanxi still face prominent unbalanced development, and their spatial pattern of cultural tourism is in urgent need of overall planning.

The research on the spatial pattern of cultural tourism industry is a core direction of tourism geography. A review of existing literature reveals that fruitful achievements have been made in theoretical and empirical research in this field. Foreign studies started earlier, mainly focusing on data measurement and classification of tourism spatial structure, as well as analyzing the spatial distribution form and development characteristics of scenic spots. The accessibility theory proposed by Hansen [1] has become a methodological basis for subsequent research on tourism space. Since then, spatial econometric analysis has been widely applied in relevant studies. With the continuous development of Geographic Information System (GIS) and the extensive promotion of location-based service data, point of interest (POI) data has become an important data source for researching tourism spatial pattern, accessibility and influencing factors due to its advantages in timeliness, accuracy and semantic information [2, 3]. In terms of research methods, spatial statistics and geospatial econometric methods have become mainstream approaches in this field. Among them, the nearest neighbor index is often used to measure the agglomeration or dispersion of tourism elements in geographical space [4]. Kernel density analysis adopts data smoothing fitting to clearly present the agglomeration intensity and spatial distribution form of tourism elements [5].

In terms of research scales, domestic and foreign studies on tourism spatial pattern have gradually refined their research scope from national and provincial levels to urban agglomerations and county units. The county unit has gained increasing attention as a basic spatial research unit, and relevant research has expanded from the spatial difference analysis of single tourism elements to comprehensive analysis of the six elements of tourism. Domestic scholars have conducted in-depth research on the spatial agglomeration and correlation intensity of tourism elements in regions such as the Guanzhong Plain Urban Agglomeration [6], county-level areas in Inner Mongolia [7] and the Northern Tianshan Urban Agglomeration [8]. In international research, scholars have systematically analyzed the spatial pattern of cross-border natural tourism resources in China [9]. Meanwhile, spatial visualization methods and the Geodetector model have been adopted to explore the spatial distribution and accessibility of tourism and leisure industry in Qingdao [3], and summarize the factors affecting the spatial distribution of tourism resources in Hubei Province [2]. For tourism research in resource-based regions, Chen Hongxing et al. [10] discussed the spatial correlation

between the accommodation industry and tourist attractions based on POI data. Wang Ke and Zhou Jingkui [11] analyzed the co-evolution process of manufacturing and producer services in the Beijing-Tianjin-Hebei region. In the research of single tourism element, scholars have analyzed the influencing factors of the spatial distribution of A-level tourist attractions in Shanxi Province [12], summarized the spatial distribution characteristics of farm stays and rural tourism sites in Beijing and Hunan Province [13, 14]. Some scholars have explored the spatial distribution and driving factors of rural tourism sites across China [15, 16], and further analyzed the spatial distribution differences of model villages for rural tourism in the five northwestern provinces along the Silk Road Economic Belt [17]. Based on the above research, although substantial progress has been made in the study of tourism element spatial pattern, many deficiencies still exist. On the one hand, current studies mainly focus on economically developed eastern coastal areas and typical tourist cities, while systematic research on resource-based provinces undergoing economic transformation is insufficient. Most existing studies are carried out at the provincial or urban agglomeration scale, and the analysis of the six tourism elements at the county scale needs further deepening. Shanxi Province is in a key stage of transforming its coal industry into tourism industry. The development of cultural tourism is restricted by the original development model and the adjustment of regional spatial pattern. Although a few scholars have preliminarily analyzed single elements such as A-level scenic spots and traditional villages in Shanxi, comprehensive research on the spatial pattern and correlation characteristics of county-level cultural tourism from the perspective of six tourism elements is quite limited. On the other hand, most spatial optimization suggestions put forward in existing studies are guided by a global perspective, without combining with spatial risk identification, so they cannot accurately guide county-level planning practices. Located in the middle reaches of the Yellow River, Shanxi has 117 county-level administrative units and abundant cultural and tourism resources. The spatial pattern of county-level cultural tourism is undergoing rapid restructuring. However, obvious disparities exist in the agglomeration level of tourism elements among different counties, leading to practical planning problems including unreasonable spatial layout of the six tourism elements and weak element correlation. Therefore, taking 117 county-level units in Shanxi Province as research objects, this paper establishes a POI spatial database of six tourism elements for county-level tourism in Shanxi. By comprehensively using the nearest neighbor index, kernel density analysis, standard deviation ellipse and bivariate spatial autocorrelation, this paper explores the spatial pattern and correlation characteristics of the six tourism elements. Combined with spatial risk identification, corresponding planning response strategies are proposed. This study also provides references for the spatial optimization of county-level cultural tourism industry in resource-based regions.

2. Study area overview and research design

2.1. Study area overview

Shanxi Province (34°34′~40°44′N, 110°14′~114°33′E) is located in North China, in the middle reaches of the Yellow River and the eastern part of the Loess Plateau. It borders Hebei Province to the east across the Taihang Mountains, faces Shaanxi Province to the west across the Yellow River, adjoins Henan Province to the south and connects Inner Mongolia Autonomous Region to the north. The terrain is higher in the northeast and lower in the southwest, dominated by mountains and plateaus. The Taihang Mountains and Lvliang Mountains run through the east and west respectively, and a series of bead-like basins including Datong, Xinding, Taiyuan, Linfen and Yuncheng are distributed in the central area. Mountains and hills account for 80.1% of the total provincial area.

Shanxi serves as an important transportation hub connecting Northwest China, North China and the Central Plains. The province has 11 prefecture-level cities including Taiyuan, Datong, Shuozhou, Yangquan, Changzhi, Jincheng, Xinzhou, Lvliang, Jinzhong, Linfen and Yuncheng, with a total of 117 county-level administrative units and a total land area of 156,700 square kilometers. In 2025, the provincial GDP reached 2.54957 trillion yuan and the permanent population was 34.24 million. Shanxi boasts four World Cultural Heritage sites including the Ancient City of Pingyao, Yungang Grottoes, Mount Wutai and the Shanxi section of the Great Wall. It has 531 National Cultural Relics Protection Units, ranking first across China, and 462 A-level scenic spots. In 2025, driven by the continuous advancement of the three major tourism brand strategies themed on the Yellow River, the Great Wall and the Taihang Mountains, the growing influence of the digital IP "Travel in Shanxi with the Monkey King", and the mature seasonal marketing systems such as "Enjoy Cool Summer in Shanxi" and "Winter Tour in Shanxi", the total number of tourist receptions in Shanxi exceeded 820 million person-times, and the total tourism revenue reached 794 billion yuan, with a year-on-year growth of 12.3% and 14.1% respectively. The cultural tourism industry has become the core driving force for the economic transformation of this resource-based province. For the above reasons, this paper selects 117 county-level units in Shanxi Province as the study area (Figure 1), which makes a typical and representative case for exploring the spatial pattern of cultural tourism industry in resource-based regions.

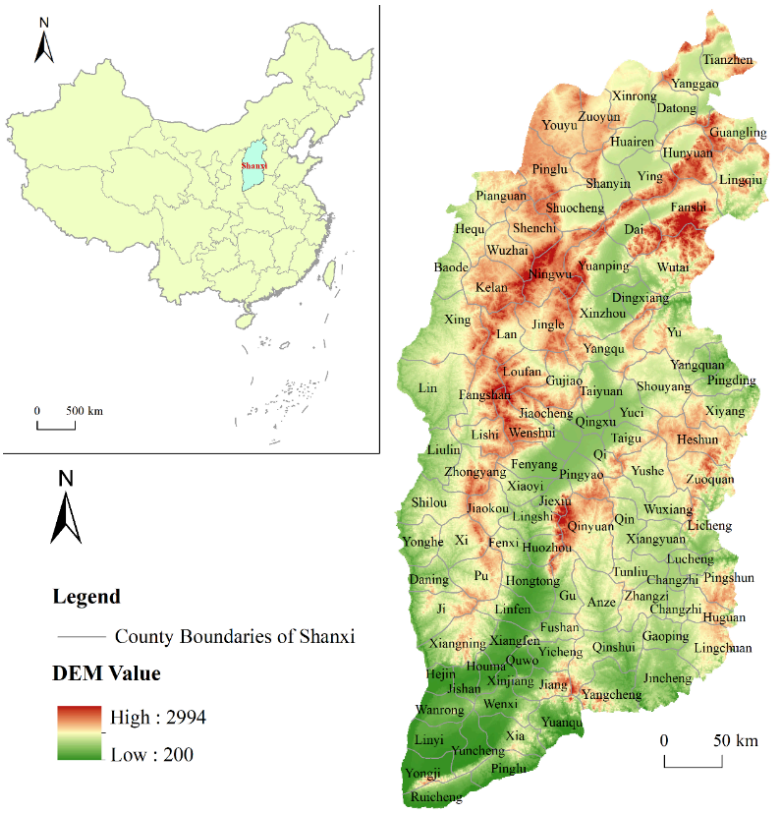

Figure 1. Location map of cultural and tourism resources in Shanxi Province

Note: The base map of this study is produced based on the standard map of China downloaded from the Standard Map Service System of the Ministry of Natural Resources (Map Review No. GS〔2020〕4619), with no modification to the base map. The same applies to the following maps.

2.2. Data sources and processing

The POI data used in this paper were acquired in March 2026 via a web crawler program based on Amap API. In accordance with the theory of six tourism elements, keywords such as catering, accommodation, transportation facilities, scenic spots, shopping and sports & leisure were used for data retrieval, corresponding to the six tourism elements of Catering, Accommodation, Transportation, Sightseeing, Shopping and Entertainment respectively. A total of 6,400 POI records were collected. After removing duplicate and erroneous data, 5,877 valid records were retained, including information such as ID, name, longitude and latitude, classification level and coordinates (Table 1). Vector data of the study area were obtained from the Standard Map Service System of the Ministry of Natural Resources (http://bzdt.ch.mnr.gov.cn/). DEM data with a resolution of 30 meters were downloaded from the Geospatial Data Cloud Platform, which were used to extract topographic factors such as elevation and slope. The original POI data were processed through deduplication, coordinate correction (conversion from GCJ-02 to WGS-84), classification calibration and spatial matching with county-level units. Finally, a spatial database of tourism elements for county-level regions in Shanxi Province was established.

Table 1. Classification and statistics of POI for cultural tourism industry elements at the county level in Shanxi Province

Element	POI Category	Number of POIs	Percentage /%
Catering	Catering related: Restaurants, beverage shops, farm stays, etc.	467	7.946
Accommodation	Accommodation related: Hotels, camps, inns, hostels, etc.	189	3.216
Transportation	Transportation related: Bus stations, bus stops, transfer stations, etc.	60	1.021
Sightseeing	Recreation related: Scenic spots, botanical gardens, science and technology museums, etc.	4635	78.867
Shopping	Shopping related: Malls, convenience stores, chain supermarkets, etc.	477	8.116
Entertainment	Entertainment related: Vacation clubs, sports venues, fitness centers, etc.	49	0.834

2.3. Research methods

2.3.1. Methods for spatial pattern analysis

2.3.1.1. Nearest neighbor index method

The nearest neighbor index judges whether the spatial distribution of point features is agglomerated, dispersed or random by comparing the actual average nearest neighbor distance of point features with the theoretical expected distance under random distribution. The calculation formula is as follows:

$$R = \frac{\bar{r}_o}{\bar{r}_E}, \bar{r}_E = \frac{1}{2\sqrt{n/A}} \tag{1}$$

In the formula: $\bar{r}_o$ refers to the actual average observed distance; $\bar{r}_E$ is the expected distance under random distribution; A represents the total area of the study area; n stands for the total number of point features. If $R < 1$, the features present an agglomerated distribution, and a smaller

R value indicates a higher agglomeration degree. If $R = 1$, the distribution is random. If $R > 1$, the distribution is dispersed. This paper adopts the nearest neighbor index to determine the overall and classified spatial distribution patterns of the six tourism elements in each county of Shanxi Province.

2.3.1.2. Kernel density analysis method

Kernel density analysis is a non-parametric density estimation method. It calculates the distribution density of point features within their neighborhood to intuitively reflect the agglomeration hotspots and gradient changes of tourism elements in space. The calculation formula is as follows:

$$f(x) = \frac{1}{nh} \sum_{i=1}^{n} k\left(\frac{x - X_i}{h}\right) \tag{2}$$

In the formula: $f(x)$ is the kernel density value at the estimated point x; n is the number of samples; h represents the search bandwidth; k is the kernel function; (xX_i) refers to the distance between the estimated point and the sample point X_i. A higher kernel density value means a stronger agglomeration degree of tourism elements in this area. This paper uses kernel density analysis to identify high-density agglomeration centers and spatial diffusion characteristics of the six tourism elements in Shanxi Province.

2.3.1.3. Ripley's k function

This method is used to reveal the agglomeration degree of point features at different spatial distances and identify the optimal agglomeration scale. The calculation formula of the $L(d)$ function is as follows:

$$L(d) = \sqrt{\frac{K(d)}{\pi}} - d \tag{3}$$

In the formula: $K(d)$ is the value of Ripley's K function within the distance d; $L(d) > 0$ indicates significant agglomeration, and the distance corresponding to the first peak of the curve is the optimal spatial agglomeration scale. This paper applies Ripley's K function to analyze the multi-scale spatial agglomeration characteristics of the six tourism elements in Shanxi Province.

2.3.2. Methods for spatial correlation analysis

Bivariate global spatial autocorrelation is used to test the spatial correlation between two different geographical variables, and reveal the matching or exclusive relationship between the spatial distributions of different elements. The calculation formula is as follows:

$$I = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij}(x_i - \bar{x})(y_j - \bar{y})}{S^2 \sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij}} \tag{4}$$

In the formula: I is the bivariate Moran's I index, with a value range of [-1, 1]; n is the total number of county-level units; W_{ij} is the spatial weight matrix (the Queen contiguity rule is adopted in this paper); x_i and y_j represent the attribute values of two different tourism elements in the i-th and j-th county respectively; $\bar{x}$ and $\bar{y}$ are the corresponding mean values; S^2 is the variance. If $I > 0$, there is a positive spatial correlation between the two elements, and the closer the value is

to 1, the stronger the positive correlation. If $I < 0$, a negative spatial correlation exists. If $I = 0$, there is no spatial correlation. Taking the POI quantity of each tourism element in every county as the attribute value, this paper calculates the bivariate Moran's I index between every two elements to analyze the spatial matching and coordination characteristics of tourism elements in county-level regions of Shanxi Province.

3. Spatial pattern and correlation characteristics of county-level cultural tourism industry in Shanxi Province

3.1. Spatial distribution characteristics of cultural tourism industry

3.1.1. Agglomeration types of cultural tourism industry

ArcGIS 10.8 software was used to conduct nearest neighbor analysis on the screened POI data of county-level cultural tourism industry in Shanxi Province (Table 2). The results show that the nearest neighbor index of all POIs of cultural tourism industry in Shanxi Province is 0.137, which passes the significance test at the 1% level ($p<0.001$,$z=-126.497$). It proves that the cultural tourism industry in Shanxi presents an extremely significant agglomeration distribution and an obvious core-periphery agglomeration trend in space.

The nearest neighbor indexes of Catering, Accommodation, Transportation, Sightseeing, Shopping and Entertainment are 0.154, 0.267, 0.442, 0.148, 0.145 and 0.323 respectively. All Z-scores are less than -2.58 and all P-values are 0.000, passing the significance test at the 1% level. Combined with the current development situation of cultural tourism industry in Shanxi Province, the Sightseeing element has a high agglomeration degree and presents an annular distribution around core scenic spots, which is a typical resource-oriented agglomeration. In contrast, elements such as Shopping, Catering and Entertainment rely on pedestrian flow and commercial centers, belonging to typical city-dependent agglomeration. The coexistence of the two agglomeration modes forms the basic differentiation pattern of the spatial structure of county-level cultural tourism industry in Shanxi. The agglomeration intensity of each element is ranked from high to low as: Shopping (0.145) > Sightseeing (0.148) > Catering (0.154) > Accommodation (0.267) > Entertainment (0.323) > Transportation (0.442), which further reflects the hierarchical difference in the overall agglomeration degree of different types of elements. Among them, Shopping, Sightseeing, Catering and Accommodation are spatially concentrated, which can effectively meet tourists' demands for shopping consumption, sightseeing experience, catering and accommodation services and boost the consumption vitality of county-level cultural tourism. However, excessive agglomeration may also lead to problems such as spatial congestion and over-commercialization of culture. The Transportation element has the lowest agglomeration degree, indicating that transportation facilities in county-level regions of Shanxi are distributed relatively scattered. It also reflects that the urban and rural transportation system in Shanxi is relatively balanced, while the tourism transportation connection capacity in some remote counties needs to be improved. The agglomeration degree of the Sightseeing element is second only to Shopping. It shows that as a major province rich in cultural and tourism resources, Shanxi has concentrated tourist attractions such as A-level scenic spots and cultural relic protection units in county-level regions, which is conducive to the construction of high-quality tourist routes. Meanwhile, it is necessary to prevent the impact of excessive development around key scenic spots on the ecological environment and historical style.

Table 2. Spatial agglomeration characteristics of various elements of county-level cultural tourism industry in Shanxi Province

Element	Average Observed Distance (km)	Expected Average Distance (km)	Nearest Neighbor Index	z-score	p-value	Spatial Distribution Type
All Elements	0.4473	3.2539	0.137	-126.497	0.0000	Significantly Agglomerated
Catering	1.4390	9.3191	0.154	-34.958	0.0000	Significantly Agglomerated
Accommodation	4.1058	15.3802	0.267	-19.279	0.0000	Significantly Agglomerated
Transportation	6.0520	13.6773	0.442	-8.262	0.0000	Significantly Agglomerated
Sightseeing	0.5255	3.5483	0.148	-110.954	0.0000	Significantly Agglomerated
Shopping	1.3493	9.3129	0.145	-35.728	0.0000	Significantly Agglomerated
Entertainment	6.8811	21.3316	0.323	-9.072	0.0000	Significantly Agglomerated

3.1.2. Agglomeration density of cultural tourism industry

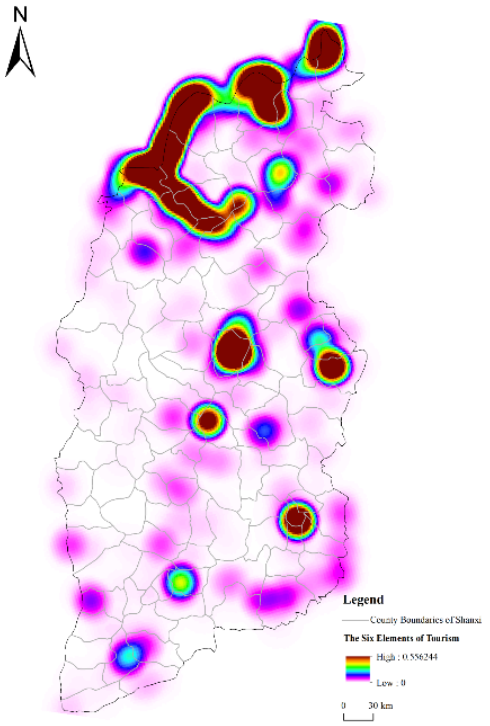

Figure 2. Overall Kernel density distribution of cultural tourism industry

Based on kernel density analysis, this paper calculates the spatial distribution density of the six tourism elements including Catering, Accommodation, Transportation, Sightseeing, Shopping and

Entertainment in county-level regions of Shanxi Province. Continuous gradient color bands are used to visually display the difference of kernel density values of each element (Figure 2). On the whole, the six elements of cultural tourism industry in Shanxi present a northeast-southwest distribution trend, which is consistent with the layout of major traffic lines and basin terrain. Its spatial pattern can be summarized as "one primary center, one secondary center and multiple supporting nodes". The Taiyuan Basin forms a high-density core agglomeration area, and the Linfen-Yuncheng Basin serves as a secondary agglomeration center. Tourism elements extend in a zonal pattern along major traffic lines including the Tongpu Railway, G5 Beijing-Kunming Expressway and G55 Erlianhaote-Guangzhou Expressway. Local density peaks are formed in multiple cities such as Datong, Changzhi and Jincheng. The spatial continuity is weak, showing an obvious core-periphery structural feature. This layout is highly consistent with the strategic orientation of fostering axial economic growth poles proposed in the 15th Five-Year Plan.

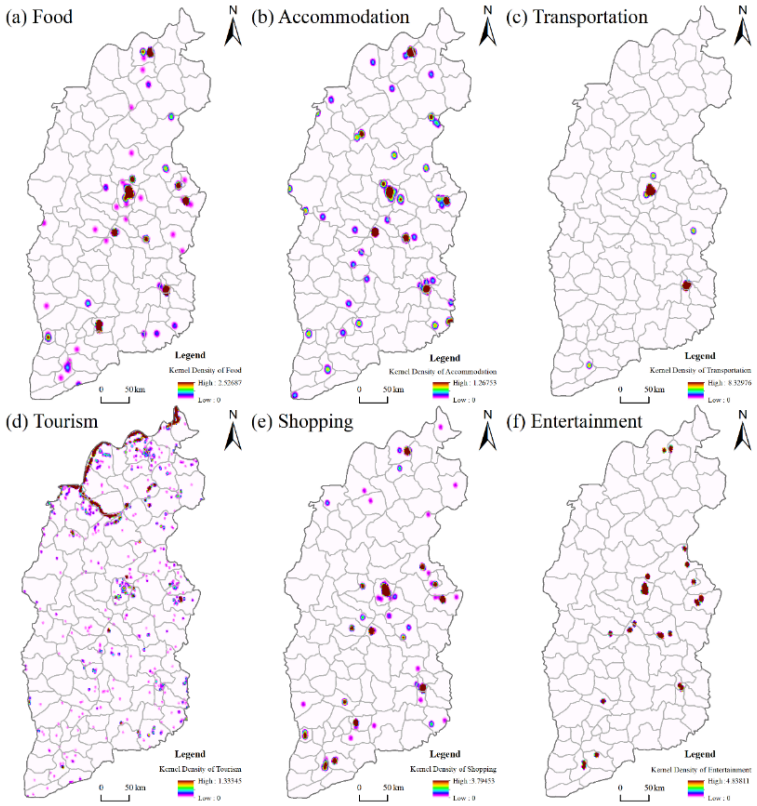

Figure 3. Kernel Density Distribution of the six elements of cultural tourism industry

Specifically for each element: The high-density areas of the Catering element (Figure 3a) are mainly concentrated in the urban area of Taiyuan and Yuci District of Jinzhong City, forming a single-core distribution. Secondary density patches appear in Yaodu District of Linfen, Yanhu District of Yuncheng and Pingcheng District of Datong. It is generally characterized by large-scale agglomeration and small-scale dispersion. The distribution of the Accommodation element (Figure 3b) is highly similar to that of Catering, while the scope of high-density areas is relatively narrowed. The density advantage of the Taiyuan core area is more prominent, and local high-value patches are formed around popular tourist destinations such as Mount Wutai Scenic Area and the Ancient City of Pingyao, indicating that accommodation facilities are highly dependent on tourism resources. The Transportation element (Figure 3c) shows the most prominent polarization feature. High kernel

density areas are only distributed in the central urban area of Taiyuan. At the municipal level, transportation facilities including parking lots, railway stations and bus stops are highly concentrated in administrative centers and transportation hubs, while fragmented distribution is observed in most other counties. The high-density areas of the Sightseeing element (Figure 3d) are relatively scattered. Besides the Taiyuan core area, multiple independent high-density patches are formed around high-quality scenic spots such as Mount Wutai, the Ancient City of Pingyao, Yungang Grottoes, Hukou Waterfall and Imperial Prime Minister's Mansion. It features numerous central areas and wide coverage. The high-density areas of the Shopping element (Figure 3e) follow the Central Place Theory. The core area of Taiyuan is the highest-density center, and secondary density cores are formed in regional central cities including Linfen, Yuncheng, Datong and Changzhi. Shopping facilities show central agglomeration and weak diffusion in each county. The Entertainment element (Figure 3f) presents a pattern of prominent core agglomeration and weak peripheral development. The kernel density value in Taiyuan is far higher than that in other regions, and a local density high point is formed around Datong. Entertainment facilities are sparsely distributed in the rest areas.

To sum up, the spatial pattern of cultural tourism industry in Shanxi Province is featured by prominent central agglomeration, large north-south development gap, agglomeration along traffic axes and unbalanced layout of various elements. As the growth pole of cultural tourism industry in the province, the Taiyuan Basin dominates the development of Catering, Accommodation, Transportation, Shopping and Entertainment elements and produces an obvious siphon effect on provincial cultural tourism elements. In contrast, high-value areas of the Sightseeing element present a multi-center distribution. High-quality tourism resources are widely distributed in northern, southern and southeastern Shanxi, which do not match the spatial distribution of consumption and service elements concentrated in central urban areas. This reflects the common contradiction of a strong center and weak periphery in the development of cultural tourism in resource-based regions.

3.1.3. Spatial scale characteristics of each element

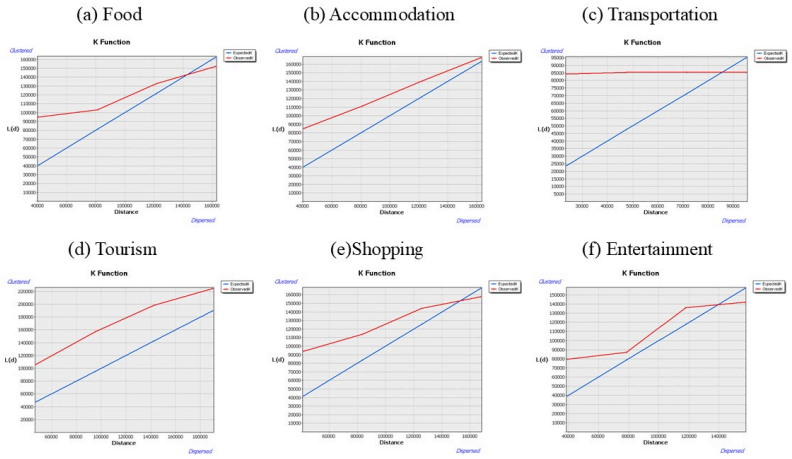

Figure 4. Ripley's K function analysis of various tourism elements in Shanxi Province

Multi-distance spatial cluster analysis of the six tourism elements in county-level cultural tourism industry of Shanxi Province was carried out by using Ripley's K function (Figure 4). The results show that all elements present significant agglomeration (Diff > 0), but obvious differences exist in

peak distance and spatial attenuation rules. Restricted by the current measurement step length, the actual peak values of each element may be smaller than the first measured distance, while the relative ranking still has reference significance. The measured peak distances in ascending order are: Transportation (23.75 km), Entertainment (39.28 km), Catering (40.59 km), Accommodation (40.68 km), Shopping (41.85 km), Sightseeing (94.97 km).

On the small spatial scale, the overall agglomeration intensity of tourism elements rises first and then tends to be stable with the increase of distance. The Transportation element has the minimum peak distance (23.75 km) and reaches the highest agglomeration level on a small scale, which indicates that transportation stations and service facilities are highly dependent on urban settlements and road networks with extremely prominent small-scale agglomeration characteristics. The peak distances of Entertainment, Catering, Accommodation and Shopping are concentrated within the range of 39–42 km, belonging to medium-scale agglomeration. Their effective agglomeration scope covers central urban areas and suburban counties. Among them, although the Diff value of the Accommodation element keeps declining, it remains positive all the time, with the strongest spatial stability. The Sightseeing element has the maximum peak distance and keeps rising to the peak on a larger scale, which means tourism resources maintain significant agglomeration on a wide spatial scale and present a regionalized and wide-range distribution pattern.

Overall, the county-level cultural tourism industry in Shanxi Province shows the spatial scale differentiation characteristics of strong agglomeration of transportation elements on a near scale, agglomeration of urban supporting elements on a medium scale, and continuous expansion of resource elements on a large scale. Service and consumption elements have a small agglomeration scale, strong centripetal force and rapid attenuation, while resource attraction elements have a large agglomeration scale, wide coverage and gentle attenuation. The obvious scale difference between the two types of elements further aggravates the spatial mismatch of concentrated service facilities and scattered tourism resources. To solve the problem of scale mismatch, it is necessary to strengthen transportation connection, tourist distribution and matching layout of service facilities within the 20–100 km circle, give full play to the role of the Transportation element in small-scale linkage and trunk line connection, and promote the extension of service elements to resource agglomeration areas. The results also prove that the cultural tourism industry in the province is still dominated by agglomeration in central cities. The scale mismatch between service elements and resource elements has not been solved, and a cross-county, large-scale and networked coordinated development pattern has not been fully formed.

3.2. Bivariate spatial autocorrelation

A spatial weight matrix was established, and GeoDa software was used to calculate the spatial correlation degree of the six tourism elements at the county level in Shanxi Province (Table 3). As shown in Table 3, the overall spatial correlation between various tourism elements in Shanxi Province is extremely weak. The Moran's I values between Sightseeing and Catering, Accommodation, Entertainment are 0.003, 0.001 and 0.003 respectively, indicating an extremely low spatial matching degree. This hinders the coordinated development of various elements and restricts the overall improvement of the tourism industry. The correlation between Catering and other elements is also low, especially the correlation between Catering and Accommodation is only -0.000, which reflects an extremely low spatial correlation and insufficient interactive development capacity. In general, the spatial matching degree of various tourism elements across the region is extremely low. The Catering element is relatively independent in some areas and cannot fully meet

tourists' basic demands. The spatial layout of the Sightseeing element and its surrounding supporting elements needs to be optimized.

Table 3. Spatial autocorrelation test of cultural tourism industry elements in Shanxi Province

Element	Catering	Accommodation	Transportation	Sightseeing	Shopping	Entertainment
Catering	0.666	-0.000	-0.001	0.003	-0.002	0.000
Accommodation	-0.000	0.657	-0.000	0.001	0.000	0.005
Transportation	-0.001	-0.000	0.702	0.001	-0.000	-0.000
Sightseeing	0.003	0.001	0.001	0.521	0.003	0.003
Shopping	-0.002	0.000	-0.000	0.003	0.671	0.001
Entertainment	0.000	0.005	-0.000	0.003	0.001	0.630

4. Planning response strategies

4.1. Optimize spatial pattern

This study finds that county-level cultural tourism resources in Shanxi Province are highly concentrated in central areas and distributed along major traffic lines, with uncoordinated layout of various elements. Combined with the zigzag-shaped overall spatial framework of all-for-one tourism proposed in *Shanxi Tourism High-quality Development Plan (2026—2030)*, taking the three control lines of territorial spatial planning as the bottom-line constraints, this paper constructs a corridor-based network spatial pattern of "one core, three corridors and multiple nodes" from three aspects: strengthening the core area, building tourism corridors and cultivating functional nodes. This will transform the development pattern of county-level cultural tourism industry from scattered points and prominent polarization to corridor connection and network linkage. First, strengthen the radiation and leading role of the Taiyuan core area to alleviate the unbalanced spatial polarization of the provincial cultural tourism industry. According to the kernel density calculation results, five types of cultural tourism elements including Catering, Accommodation, Transportation, Shopping and Entertainment are concentrated in the Taiyuan Basin, with kernel density values far higher than those in other counties, forming an obvious siphon effect. Although this layout can form economic scale in the short term, it leads to uneven resource distribution and weakens the development momentum of cultural tourism in resource-rich areas such as northern and southeastern Shanxi. Therefore, it is necessary to balance the pressure relief of the core area and functional layout optimization. Three tourism corridors including Datong-Taiyuan-Yuncheng Corridor, Taiyuan-Changzhi-Jincheng Corridor and Lvliang-Taiyuan-Yangquan Corridor are planned and constructed to guide the excessive concentration of tourism resources in the Taiyuan Basin to extend to counties along the corridors, so as to ease passenger flow pressure and avoid overload of regional carrying capacity. Meanwhile, guide the relocation of consumption and service elements such as Catering, Shopping and Entertainment from Taiyuan to suburban counties such as Yuci District and Taigu District of Jinzhong, and build suburban cultural tourism complexes and themed tourist resorts. Second, construct three axial tourism corridors to solve the problem of element mismatch in the provincial cultural tourism industry. The research shows that the resource-oriented Sightseeing element presents a regionalized and wide-range distribution, while the radiation scope of supporting service elements including Catering, Accommodation, Shopping and Entertainment is obviously limited. This results in discontinuous tourist experience. Many tourists cannot find qualified accommodation and catering services after visiting high-quality scenic spots and have to return to

urban areas on the same day. It not only reduces tourists' staying time and consumption willingness, but also prevents counties where scenic spots are located from gaining full-industry chain benefits from cultural tourism. Therefore, priority should be given to developing three axial tourism corridors. The Datong-Taiyuan-Yuncheng Tourism Corridor serves as the main north-south axis, connecting cultural and tourism resources such as Yungang Grottoes, Mount Wutai, the Ancient City of Pingyao and Guan Emperor Temple in sequence. It guides consumption and service elements to distribute in counties along the corridor and improves the spatial mismatch between Sightseeing elements and supporting elements along the north-south axis. The Taiyuan-Changzhi-Jincheng Tourism Corridor acts as the secondary southeast axis, connecting the Taihang Mountain landscape belt and cultural heritage clusters in southeastern Shanxi to make up for the insufficient supporting services in high-value areas of Sightseeing elements. The Lvliang-Taiyuan-Yangquan Tourism Corridor, as the secondary northwest axis, links the cultural and tourism resources along the Yellow River with counties undergoing transformation from coal industry to tourism industry, and promotes the optimal distribution of service elements in resource-rich areas with weak supporting facilities. Third, resolve the problem of isolated distribution of tourism elements and actively build multiple county-level functional nodes. The study finds that the Sightseeing element forms multiple independent high-density patches around high-quality scenic spots, which are spatially mismatched with Catering, Accommodation, Shopping and Entertainment elements, making it difficult to form a complete and continuous consumption experience. Thus, differentiated development strategies for counties should be implemented to focus on cultivating node-type counties with reasonable allocation of multiple elements. Relevant implementation guarantees shall be improved to ensure the implementation of the corridor network pattern. The optimization of spatial pattern ultimately needs to be implemented through statutory planning and supporting mechanisms. It is also essential to coordinate resource development, facility construction and brand promotion among counties along the corridors to realize resource sharing, tourist source exchange and win-win cooperation. Only in this way can the provincial cultural tourism industry get rid of the fragmented development dilemma and truly form a networked development layout featured by corridor connection and all-region coordination.

4.2. Promote element coordination

According to the bivariate spatial autocorrelation analysis, the spatial correlation among the six tourism elements including Catering, Accommodation, Transportation, Sightseeing, Shopping and Entertainment in county-level regions of Shanxi Province is generally extremely weak, forming an obvious island-like distribution trend. This structural mismatch is reflected in many aspects: the density of consumption and service elements such as Catering, Accommodation and Shopping is relatively low, and most counties cannot meet tourists' consumption demands. The Entertainment element is mainly concentrated in counties around Taiyuan, and mature entertainment forms have not been developed in other areas of the province, resulting in insufficient space for night-time economy and secondary consumption. In addition, the six elements are not effectively connected in space, failing to form a complete cultural tourism industrial chain. In view of the above problems, planning should focus on improving supporting facilities around scenic spots to make up for the shortage of entertainment and consumption services, and rely on transportation facilities to connect various functional sectors so as to promote element coordination. First, complete various supporting facilities around high-quality scenic spots. Taking Mount Wutai Scenic Area as the core, Taihuai Town, the south entrance of the scenic area and Jingangku Township are designated as tourism service supporting areas. Priority shall be given to land use indicators for constructing high-quality

hotels, characteristic homestays, cultural and creative shopping centers and catering blocks, and attract investment to concentrate supporting facilities around the scenic area, so as to solve the problem of discontinuous consumption connection before and after visiting the scenic area. Centering on Hukou Waterfall Scenic Area, a group of Yellow River-themed homestays and agricultural and special products exhibition and sales centers are built in Hukou Town of Ji County, extending the single waterfall-viewing experience into a complete consumption chain integrating catering, accommodation and shopping. Second, enrich leisure and entertainment projects and improve the industrial layout. At present, the Entertainment element is mainly distributed around Taiyuan with insufficient supply in other counties. Both stock resources and new construction projects shall be regulated. In terms of stock resources, idle public courtyards in the Ancient City of Pingyao shall be revitalized to build immersive performances themed on Shanxi merchant draft banks and small entertainment projects such as intangible cultural heritage craft workshops for polished lacquerware, so as to enrich night-time consumption content in the ancient city without increasing construction intensity. Revitalize shops on the North and South Main Streets of Xinzhou Ancient City and introduce interactive experience projects such as northern Shanxi wind instrument performances and paper-cutting handcraft experience to enhance tourists' participation. In terms of new construction, for provincial-level tourist resorts such as Datong Volcanic Group and Taihang Mountain Grand Canyon, relevant regulations shall be specified in project approval procedures to require a certain proportion of supporting performance venues, sports experience facilities and night tour facilities, so as to realize the integration of sightseeing and entertainment in new projects. Third, upgrade the functions of transportation nodes to make them comprehensive service nodes connecting various elements. A total of 13,000 kilometers of three major No.1 tourist highways have been built in Shanxi, with a large number of highway service areas, parking and viewing platforms and township passenger stations distributed along the routes. However, most of these facilities only undertake the function of rest and parking at present and are not connected with tourism consumption. The railway and highway hubs along the Datong-Taiyuan-Yuncheng Tourism Corridor including Datong South Railway Station passenger hub, the square in front of Xinzhou Wutai Mountain Airport and Linfen West Railway Station shall be expanded into comprehensive tourist service stations with functions of scenic spot information inquiry, local special product sales and casual dining and rest. Tourists can obtain information of subsequent scenic spots and complete part of consumption upon arrival or transfer. Township passenger stations in towns such as Gujiao Township of Lingchuan County and Qiaoshang Township of Huguan County along the Taihang No.1 Tourist Highway shall be reconstructed into rural tourist stations providing homestay reservation, agricultural and special product consignment sales and bicycle rental services to extend tourism services to villages and towns. Pre-service centers at scenic spots integrating parking and transfer, tourism consultation and the display of the Great Wall culture shall be built at the entrances of scenic spots such as Laoniuwan in Pianguan County and Shanhukou in Youyu County along the Great Wall No.1 Tourist Highway. Through the hierarchical functional upgrading of transportation nodes, the Transportation element will transform from a single transportation corridor into a spatial link connecting Sightseeing with Catering, Accommodation, Shopping and Entertainment.

4.3. Implement differentiated development strategies

According to the results of kernel density analysis and Ripley's K function, the agglomeration of cultural tourism elements in 117 counties of Shanxi Province presents an obvious polarization pattern, and the development level of cultural tourism in each county also has distinct hierarchical differences. It means that county-level cultural tourism planning must adopt targeted policies based

on local resource endowments and development stages. For resource-rich counties with World Cultural Heritage sites or 5A-level scenic spots, priority shall be given to the protection of core areas and the centralized construction of supporting service facilities in peripheral areas. For example, counties including Wutai, Hunyuan and Pingyao have high-density Sightseeing elements but insufficient supporting services, facing the common dilemma of easy tourist attraction but difficult tourist retention. Hierarchical management and control shall be adopted: protect core scenic spots first to retain local cultural characteristics and protect the ecological environment to the maximum extent. In the peripheral service reception circle, supporting facilities shall be centrally arranged in areas with convenient transportation. For instance, build meditation-themed hotel clusters in Taihuai Town of Wutai County and North Yue culture-themed exhibition and sales centers in Yong'an Town of Hunyuan County. For city-dependent counties where prefecture-level municipal governments are located, the focus shall shift from simply gathering resource elements to external radiation and driving surrounding areas. Urban areas of Taiyuan, Pingcheng District of Datong and Yuci District have concentrated consumption and service elements, but they also face problems such as excessive pedestrian flow, homogeneous industrial development and fierce internal competition. Their capacity of absorbing resources is far stronger than external radiation and driving capacity. Therefore, planning shall guide these areas to take the path of coordinated development of quality improvement and functional decentralization. In terms of quality improvement, build regional characteristic cultural consumption landmarks in urban historical blocks, such as the cluster of time-honored brands of Shanxi on Liuxiang and Zhonglou Streets in Taiyuan, and the Northern Wei culture performance cluster in Datong Ancient City. In terms of functional decentralization, gradually transfer the tourist distribution function of Taiyuan to adjacent suburban counties such as Yuci and Taigu. For eco-tourism counties, a green development path featuring low-intensity, scattered layout and high-quality construction shall be explored. Counties such as Youyu, Pingshun and Pianguan have superior ecological background but high ecological sensitivity, with low-density distribution of cultural tourism elements and no conditions for large-scale development. Strictly abide by the ecological protection red line and adopt the scattered land supply policy. Make use of stock spaces such as idle rural houses and forest farm buildings to arrange small-scale and low-disturbance business forms in a scattered way, such as forest health cabins in Youyu, mountain boutique homestays in Pingshun and Yellow River culture research and study camps in Pianguan. Focus on connecting the terminal sections of the three major No.1 tourist highways and supporting the construction of greenways and new energy shuttle buses.

4.4. Risk management and policy guarantee

In the process of optimizing spatial pattern and implementing development strategies for county-level cultural tourism industry in Shanxi Province, three potential risks may emerge: intensified polarization, resource mismatch and excessive development. The continuous absorption of cultural tourism development elements by the Taiyuan metropolitan area will widen regional gaps. Blind construction of large-scale cultural tourism projects in some counties will cause capital waste, and inadequate management of some scenic spots will damage cultural features and ecological environment. Therefore, a complete risk prevention and control system needs to be established to ensure the implementation of the "one core, three corridors and multiple nodes" spatial layout and relevant development measures. First, establish a monitoring and early warning mechanism for cultural tourism industry across all counties in Shanxi, and improve the supervision information system based on the territorial spatial planning of Shanxi Province, including three modules: element matching, regional balance and carrying capacity. The element matching module monitors

the density changes of Accommodation, Catering and Shopping elements within 15 kilometers around five major core tourist attractions. An early warning will be automatically triggered when the growth rate of supporting elements continues to be lower than the growth rate of tourist volume. The regional balance module compares the development gap between the Taiyuan metropolitan area and northern and southeastern Shanxi on an annual basis. Relevant policy adjustments on investment will be prompted actively when the gap exceeds the threshold. The carrying capacity module controls the tourist volume and construction intensity of core scenic spots, and the monitoring data are linked to tourist flow restriction and construction permit approval of scenic spots. Second, establish a cross-regional coordinated promotion mechanism for cultural tourism corridors. The three tourism corridors span multiple prefecture-level cities and counties, and the overall functional development cannot be realized relying solely on internal efforts of single counties. A special provincial-level coordination mechanism shall be set up. For example, the Department of Culture and Tourism of Shanxi Province takes the lead in coordinating seven prefecture-level cities along the Datong-Taiyuan-Yuncheng Tourism Corridor to connect core scenic spots and supporting service facilities along the route. The Taiyuan-Changzhi-Jincheng Tourism Corridor links four prefecture-level cities to integrate the Taihang Mountain landscape and cultural heritage in southeastern Shanxi. The Lvliang-Taiyuan-Yangquan Tourism Corridor unites three prefecture-level cities to develop cultural and tourism resources along the Yellow River and foster characteristic cultural tourism industries for counties undergoing transformation from coal industry to tourism industry.

5. Conclusions and discussion

5.1. Main conclusions

Taking 117 county-level units in Shanxi Province as research objects, this paper adopts POI data of the six elements of tourism and comprehensively uses the nearest neighbor index, kernel density analysis, Ripley's K function and bivariate spatial autocorrelation method. It reveals the spatial pattern, scale characteristics and element correlation of cultural tourism industry in resource-based transformation regions, and puts forward planning response strategies combined with spatial risk identification. The main conclusions are as follows:

(1) The county-level cultural tourism industry in Shanxi Province presents an extremely significant agglomeration distribution on the whole, forming a layout of "one primary center, one secondary center and multiple supporting nodes" with the Taiyuan Basin as the core, the Linfen-Yuncheng Basin as the secondary center and extending along major traffic axes. Catering, Accommodation, Transportation, Shopping and Entertainment elements are mainly concentrated in central cities, while Sightseeing elements are distributed around high-quality scenic spots on a large scale. The separation of the two distribution modes leads to the structural contradictions of excessive agglomeration of partial elements and scattered layout of tourism resources.

(2) Obvious differences and spatial mismatch exist in the spatial distribution of the six tourism elements. Service-oriented elements agglomerate on small and medium scales and decline rapidly beyond the effective range, while resource-oriented elements agglomerate on larger scales with wide coverage. The Accommodation element maintains stable agglomeration and possesses the strongest spatial resilience.

(3) The overall spatial correlation among the six tourism elements is extremely weak, presenting a fragmented distribution. The supporting services including catering, accommodation, shopping and entertainment around high-quality scenic spots are mismatched, resulting in an incomplete industrial ecosystem.

(4) Aiming at the problems of uncoordinated spatial development, element mismatch and insufficient coordination, this paper proposes to build a cultural tourism spatial network system of "one core, three corridors and multiple nodes", optimize tourism routes, improve supporting facilities and upgrade transportation hubs. The research provides practical directions for the high-quality development of cultural tourism industry in resource-based regions.

5.2. Research limitations and prospects

Based on multi-source data, this paper explores the spatial pattern, scale differentiation and element correlation characteristics of county-level cultural tourism industry in Shanxi Province and proposes corresponding planning paths. Nevertheless, certain limitations still exist. Firstly, this paper only uses the quantity of POIs to reflect the agglomeration level of cultural tourism elements, without analyzing from the perspectives of facility grade, tourist satisfaction and industrial quality, so the research is not comprehensive enough. Secondly, this study mainly focuses on the analysis of spatial pattern and element correlation, and does not adopt models such as the Geodetector to quantitatively study the interaction mechanism of multiple factors including economic level, policies and population agglomeration, leading to insufficient explanation of the underlying causes for the formation of spatial pattern. Thirdly, the planning response strategies are mainly formulated at the macro county level, and refined indicators such as land use control, facility construction standards and style guidance for micro township space need further improvement.

On this basis, future research can integrate cultural tourism quality evaluation, multi-factor interaction analysis and refined management and control of micro township space to deepen the research on cultural tourism spatial pattern. Multiple data sources including POI data, night light data, tourist trajectory data, tourism revenue data and land use data can be combined to depict the spatial pattern of cultural tourism development in a refined manner. In addition, methods such as Geodetector, spatial regression and fuzzy-set Qualitative Comparative Analysis (fsQCA) can be introduced to quantitatively analyze the interaction effects of natural, economic, transportation, policy and population factors, and reveal the evolution rules of cultural tourism spatial pattern in resource-based regions. Meanwhile, formulate detailed classified guidelines for resource-rich counties, city-dependent counties and eco-tourism counties, so as to provide more scientific theoretical support and planning reference for the high-quality development of cultural tourism industry in Shanxi Province.

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