POI-based Spatial Pattern of Tourism Elements and Influencing Factors in the Urban Agglomeration on the Northern Slope of the Tianshan Mountains: Postprint

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Abstract

Based on the tourism "six elements" theory, applying nearest neighbor index, kernel density analysis, bivariate spatial autocorrelation, Ripley's K function and other spatial analysis methods, an analysis was conducted on the spatial distribution and correlation characteristics of tourism element points of interest (POI) data for the Tianshan North Slope urban agglomeration obtained in April 2024, and the influencing factors were explored based on geographical detector. The results show that: (1) All tourism elements exhibit significantly clustered spatial distribution characteristics, with the degree of spatial clustering from high to low being: "food" > "shopping" > "accommodation" > "transportation" > "entertainment" > "tourism". (2) The spatial continuity of each tourism element is weak, presenting a "one core, one axis, multiple centers" spatial distribution pattern; at the county scale, the overall spatial correlation of each tourism element is weak, the "transportation" element has strong spatial correlation with other elements, while the "tourism" element has weak spatial correlation with other elements, and the spatial distribution pattern of tourism elements needs to be optimized. (3) The overall spatial clustering scale characteristic value of tourism "six elements" is 33.83 km. Among them, the spatial clustering scale characteristic value of the "tourism" element is the largest (42.95 km), while that of the "accommodation" element is the smallest (18.48 km). (4) The interaction among various influencing factors has a significantly higher impact on the spatial pattern of tourism elements than single factors, and the study shows that it is comprehensively affected by multi-dimensional factors such as economic development level, infrastructure, and population. Among them, GDP, nighttime light index, number of A-level scenic spots, population

density, proportion of tertiary industry and other factors have the most significant impact on the spatial pattern of tourism elements.

Full Text

Preamble

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Spatial Pattern and Influencing Factors of Tourism Elements in the Urban Agglomeration on the Northern Slope of Tianshan Mountains Based on POI

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Abstract: This study employs the theory of the "six elements" of tourism and utilizes spatial analysis methods, including nearest neighbor index, kernel density analysis, bivariate spatial autocorrelation, and Ripley's K-function, to examine the spatial distribution and correlation characteristics of point of interest data related to tourism elements in the urban agglomeration on the northern slope of the Tianshan Mountains in Xinjiang of China based on data collected in April 2024. In addition, we explore the influencing factors using a geographical detector. The results show the following. (1) The spatial distribution characteristics of each tourism element exhibit significant concentration, with the degree of spatial agglomeration ranking from high to low as follows: "food" > "shopping" > "accommodation" > "transportation" > "entertainment" > "tourism". (2) Each tourism element demonstrates weak spatial continuity, resulting in a distribution pattern characterized by "one core, one axis, and multiple centers". At the county level, the spatial correlation among tourism elements is generally weak; however, a strong correlation exists between the "transportation" element and other elements, whereas the "tourism" element exhibits weak correlations, indicating a need for optimization in the spatial distribution of tourism elements. (3) The characteristic value of the overall spatial agglomeration scale of the "six elements" of tourism is 33.83 km. Among the different elements, the "tourism" factor shows the largest spatial agglomeration scale eigenvalue (42.95 km), whereas the "accommodation" factor has the smallest (18.48 km). (4) The influence of the interaction between each factor on the spatial pattern of tourism elements is significantly greater than that of any single factor. This research highlights the effects of multi-dimensional factors, including economic development level, infrastructure, and population on the spatial pattern of tourism elements, with GDP, night light index, number of A-level scenic spots, population density, and the proportion of the tertiary industry having the most

significant effects.

Keywords: urban agglomeration; tourism elements; bivariate Moran's I; Ripley's K-function; Geodetector; northern slope of Tianshan Mountains

Introduction

The "six elements" of tourism—food, accommodation, transportation, tourism, shopping, and entertainment—constitute the main components of the tourism industry structure, and changes in this structure are decisive factors in the differentiation of tourism product nature and types. Therefore, systematically deconstructing the resource endowment structure of tourism's "six elements" and its multi-scale spatial differentiation patterns, clarifying the spatial correlations and heterogeneity characteristics of each element, and further exploring the underlying driving factors hold important theoretical value and practical significance for scientifically revealing the spatial organization patterns of cultural tourism industry clusters, promoting tourism format innovation and multi-industry integration centered on the "six elements," and advancing high-quality tourism development. When enterprises related to the tourism "six elements" cluster at specific geographical locations, forming geographically or virtually concentrated points of economic activity, and cooperate closely in providing tourism products and services to tourists, they become the most dynamic form of tourism industry clusters. This indicates that under the background of high-quality tourism development, the "six elements" will inevitably become an important support for the development of tourism industry clusters, and systematically analyzing the multi-dimensional spatial structure characteristics and non-linear correlation mechanisms of the "six elements" has become a prerequisite for optimizing resource allocation efficiency of cultural tourism industry clusters and enhancing the scientific nature of spatial planning.

Research on the spatial patterns of tourism elements has long been a hot topic in tourism geography. Through systematic review of relevant literature, we find that this field began with discussions on the spatiotemporal patterns and driving mechanisms of single tourism elements, focusing primarily on theoretical construction and methodological innovation of typical elements such as A-level scenic spots, homestays, and agritainment. Accessibility studies are the most common research form, with kernel density analysis, nearest neighbor index, center of gravity migration, geographic concentration index, and Geodetector model being commonly used research methods. These studies focus on depicting the spatiotemporal patterns of tourism elements and exploring their spatial distribution causes based on qualitative or quantitative methods. However, research on single tourism elements neglects the symbiotic attributes of mutual coordination, promotion, and influence among the tourism "six elements," making it difficult to comprehensively measure the collaborative development relationships between tourism elements. With the popularization of location-

based services, Point of Interest (POI) data, with advantages such as fast update speed, rich data dimensions, and convenient and accurate acquisition, has created convenient conditions for scholars to deeply explore the multi-element collaborative relationships of tourism. For example, Zhang Kun et al. used POI data to reveal a new "distance-agglomeration" correlation model of tourism industry "six elements" in Fuzhou; Zhang Kun et al. used POI data analysis to conclude that tourism resources in Beijing-Tianjin-Hebei showed obvious spatial differentiation with "Beijing-Tianjin" as the agglomeration center; Zhang Aixia et al. used POI data of Lanzhou to conclude that the spatial distribution of leisure tourism resources in Lanzhou's main urban area presented a pattern of "one center with multiple points, dense in the east and sparse in the west."

Cities are the main distribution areas of tourism "six elements" and the primary environment for tourism industry agglomeration. Existing research has clarified that spatial distance affects the correlation and agglomeration of urban tourism functional structures and is an important basis for optimizing the overall spatial layout of tourism "six elements." However, most existing studies focus on single cities or county-level urban agglomerations, with few examining the tourism "six elements" and their spatial correlations in large-scale spatial distance urban agglomerations. Xinjiang is a hotspot for tourism development and is advancing from a major tourism resource region to a strong tourism economic region under the effective promotion of the "Tourism Revitalizes Xinjiang" strategy. On July 24, 2024, Xinjiang included the "cultural tourism industry" in its top ten industrial cluster sequences, aiming to deepen cross-industry integration through cluster-based paths and promote regional multi-industrial structure upgrading and economic transformation. The urban agglomeration on the northern slope of the Tianshan Mountains is the region with the highest urbanization level in Xinjiang and a key development area for cultural tourism industry clusters, with an average inter-city distance of 119.72 km. Therefore, this study, based on POI data, employs spatial analysis methods to investigate the spatial patterns and spatial correlation characteristics of tourism "six elements" in the urban agglomeration on the northern slope of the Tianshan Mountains, selects 10 influencing factors from 6 dimensions to analyze the driving factors of the spatial pattern formation using Geodetector, with a view to providing beneficial references for optimizing the spatial pattern of tourism elements in the urban agglomeration on the northern slope of the Tianshan Mountains, clarifying the cluster development path of Xinjiang's cultural tourism industry, and promoting high-quality development of Xinjiang's tourism industry.

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1 Data and Methods

1.1 Study Area Overview

The urban agglomeration on the northern slope of the Tianshan Mountains (79°53 ~88°58 E, 42°55 ~46°12 N) is located in the Junggar Basin north of the

Tianshan Mountains and south of the Altai Mountains in Xinjiang, including Urumqi City, Wujiaqu City, Changji Hui Autonomous Prefecture, Shihezi City, Kuitun City, Wusu City and Shawan City in Tacheng Prefecture, and Bortala Mongol Autonomous Prefecture, totaling 23 county-level units with a total area of approximately 23.4$\times$10^{4}$ km^2, accounting for about 13.54% of Xinjiang's total area. The urban agglomeration on the northern slope of the Tianshan Mountains is the region with the highest urbanization level, largest population density, and most concentrated industrial activity in Xinjiang, concentrating 62.20% of heavy industry and 33.96% of light industry. This region is the core urban agglomeration for the development and construction of the Silk Road Economic Belt and the main coverage area of the Tianshan Mountains tourism belt, playing an important role in driving, radiating, and demonstrating effects on Xinjiang's overall economy, and representing the central zone for future high-quality development of urban cultural tourism industries in Xinjiang.

1.2 Data Sources and Processing

Combined with the classification of tourism elements in relevant literature and the categories in Gaode Map data, the "six elements" of "food," "accommodation," "transportation," "tourism," "shopping," and "entertainment" correspond to catering services, accommodation services, transportation facilities, scenic spots, shopping services, and sports and leisure services in Gaode Map. This study obtained POI data related to tourism "six elements" in the urban agglomeration on the northern slope of the Tianshan Mountains in April 2024 through the Application Programming Interface (API) provided by Gaode Map. The captured data includes fields such as ID, name, category, address, longitude and latitude, and province, city, and district affiliation. After preprocessing operations such as deduplication, screening, and coordinate correction, a total of 52,710 POIs related to tourism "six elements" were retained (Table 1).

Nighttime light index is an effective proxy variable reflecting urbanization level and urban economic vitality, and the interaction relationship between nighttime light and tourism elements has been verified. A-level scenic spots are core tourism attraction resources, and their grade directly reflects tourism resource endowment and scenic area construction level. GDP, as an objectively existing economic quantitative indicator, is an important indicator for measuring a region's economic development level. In areas with higher economic development levels, tourism infrastructure is relatively complete, which is directly reflected in the layout of tourism elements. Population density can reflect the level of regional normal consumption demand and indirectly reflect urban tourism and leisure consumption demand, also having a significant impact on the spatial pattern of tourism elements.

As an important component of the tertiary industry, the proportion of the tertiary industry reflects the overall development status of tourism to a certain extent. The higher the tourism development level, the easier it is to form tourism element agglomeration. Therefore, we selected the proportion of the tertiary

industry as an influencing factor for the spatial pattern of tourism elements. Transportation road networks are the physical channels for the flow of passenger and logistics between tourism elements, and road network density directly affects circulation efficiency and determines the spatial correlation of tourism elements. Therefore, we selected road network density as an influencing factor for the spatial pattern of tourism elements. Tourism element layout is always in the natural environment. Precipitation affects the seasonal characteristics of natural landscapes, temperature and altitude determine human production and living consumption and affect tourism resource types and landscape formation, while slope is an important consideration factor for tourism resource base construction and safety management. Therefore, we selected annual cumulative precipitation, annual average temperature, Digital Elevation Model (DEM), and slope as important natural environmental factors for the spatial pattern of tourism elements.

1.3 Indicator System Construction

The formation of tourism industry spatial patterns is influenced by multiple factors, including tourism resource base, location factors, socio-economic factors, and tourist demand. Based on existing research and the actual conditions of tourism in the urban agglomeration on the northern slope of the Tianshan Mountains, this study selected 10 representative indicators from 6 dimensions—infrastructure, economic level, population, industrial structure, transportation, and natural environment—to analyze the influencing factors of the spatial pattern formation of tourism "six elements" (Table 2).

1.4 Methods

1.4.1 Nearest Neighbor Index The nearest neighbor index method is a quantitative method for describing the proximity degree of spatial point elements to describe spatial distribution agglomeration. Its value equals the ratio of the average observed distance of geographic element points to the expected average distance in random distribution. This study uses the nearest neighbor index to explore the spatial distribution patterns of tourism elements in the urban agglomeration on the northern slope of the Tianshan Mountains. When the nearest neighbor index is greater than 1, it indicates that sample points tend to be uniformly distributed; when less than 1, it indicates clustered distribution—the smaller the value, the higher the degree of clustering; when equal to 1, it indicates random distribution. Specific methods are detailed in relevant literature.

1.4.2 Kernel Density Analysis Kernel density estimation is a method for calculating the density of point elements within their neighborhoods. Kernel density analysis results intuitively reflect the spatial distribution patterns of elements. This study uses kernel density estimation to analyze the spatial agglomeration characteristics of tourism elements in the urban agglomeration on

the northern slope of the Tianshan Mountains. The higher the kernel density estimation value, the more significant the concentration trend of elements in that region.

1.4.3 Ripley's K Function Ripley's K function is a point density function that counts the number of points within a search range established at a certain radius to determine whether elements have statistically significant clustering within a certain range. Therefore, Ripley's K function is used to analyze the optimal spatial agglomeration characteristics of tourism "six elements" in the urban agglomeration on the northern slope of the Tianshan Mountains at multiple scales.

1.4.4 Bivariate Spatial Autocorrelation Unlike traditional spatial autocorrelation that considers only one variable, bivariate spatial autocorrelation describes the spatial correlation between different types of elements. Bivariate spatial autocorrelation is divided into bivariate global spatial autocorrelation analysis and bivariate local spatial autocorrelation analysis. This study adopts bivariate global spatial autocorrelation to analyze the correlation and significance between different tourism elements in the urban agglomeration on the northern slope of the Tianshan Mountains.

1.4.5 Geodetector Geodetector is commonly used to study spatial differentiation patterns and reveal their underlying driving factors. By calculating the q-value of the influence power of single or interactive factors, it can analyze not only the influence degree of specific independent variables on dependent variables but also whether there is interaction between two factors and the intensity of the interaction. This study uses Geodetector to detect the spatial differentiation of tourism elements in the urban agglomeration on the northern slope of the Tianshan Mountains and its driving factors. The principle of Geodetector ensures its immunity to multi-collinearity among independent variables.

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2 Results and Analysis

2.1 Spatial Agglomeration Characteristics of Tourism Elements

Using ArcGIS 10.2 software to conduct nearest neighbor analysis on the obtained tourism element data (Table 3), the results show that the overall average observed distance of tourism "six elements" is 0.053 km, and the expected average distance is 0.828 km, with a nearest neighbor index of 0.064. The nearest neighbor indices for "food," "accommodation," "transportation," "tourism," "shopping," and "entertainment" elements are 0.049, 0.055, 0.059, 0.073, 0.050, and 0.067, respectively. All elements have nearest neighbor indices less than 1, with Z-values less than -2.58, passing significance tests at the 0.01 level, indicating that both the overall tourism "six elements" and each constituent element

in the urban agglomeration on the northern slope of the Tianshan Mountains show significant spatial agglomeration characteristics. However, the agglomeration levels of different elements vary significantly, ranking from high to low as: "food" > "shopping" > "accommodation" > "transportation" > "entertainment" > "tourism." The strong spatial agglomeration advantages of "food," "shopping," "accommodation," and "transportation" elements can meet diversified tourism needs, activate regional competition and innovation, and form economies of scale and scope. However, under path dependence, they may also face issues such as homogenization, vicious competition, and traffic pressure, thereby affecting the mutual flow and complementary advantages among elements. The relatively low agglomeration degree of the "tourism" element indicates that tourism resources in the urban agglomeration on the northern slope of the Tianshan Mountains are widely distributed, while cultural display and sightseeing leisure products within cities are relatively scarce.

2.2 Spatial Distribution Pattern of Tourism Elements

2.2.1 Kernel Density Results Analysis Using kernel density analysis to calculate the distribution density of each tourism element and total elements in the urban agglomeration on the northern slope of the Tianshan Mountains, and adopting the geometric interval classification method to divide the kernel density of each tourism element into five levels: low, relatively low, medium, relatively high, and high (Figure 2). Overall, each tourism element presents a spatial distribution pattern of "one core, one axis, and multiple centers." Tourism elements in the urban agglomeration on the northern slope of the Tianshan Mountains show a distribution pattern radiating from high-density areas such as Urumqi City, Changji City, and Shihezi City to the periphery, with Urumqi City as the core, the G312 national highway (Urumqi-Shihezi section) transportation network as the axis, and various urban centers as nodes spreading to the surroundings. High-density areas show hierarchical agglomeration, while medium-density areas are distributed around the core area, demonstrating a "core-periphery" development pattern.

Specifically, "food" (Figure 2a), "tourism" (Figure 2d), and "entertainment" (Figure 2f) elements are highly densely distributed in the urban areas of Urumqi City, Changji City, and Shihezi City, which is related to the economic development and urban construction quality of these cities. The "accommodation" (Figure 2b) element shows a similar high-density distribution but also has small-scale high-density distribution in Urumqi County, Dushanzi District, and Karamay District. Dushanzi District, as the starting point of the Duku Highway, has accommodation agglomeration advantages. The spatial density layout of "shopping" (Figure 2e) and "transportation" (Figure 2c) tends to be consistent, presenting a distribution pattern centered on county-level units. "Transportation" also shows distinct polarization characteristics centered on county seats. As transportation hubs and tourist distribution centers, county centers are agglomeration points for bus stations, parking lots, railway stations, airports, and

other transportation facilities, which is consistent with the actual situation of urban-rural transportation networks. Although dense road networks connect urban and rural areas, due to the vast and sparsely populated rural areas of the urban agglomeration on the northern slope of the Tianshan Mountains, it is difficult to form transportation hub agglomerations.

2.2.2 Bivariate Moran's I By establishing a spatial weight matrix, the correlation between tourism elements in the urban agglomeration on the northern slope of the Tianshan Mountains was calculated at the county scale (Table 4). The results show that the bivariate Moran's I of each tourism element passes significance tests at the 0.01 level, indicating significant positive spatial correlation among tourism elements. Among them, the bivariate Moran's I between the "transportation" element and "entertainment," "shopping," and "food" elements are the largest, with values of 0.201, 0.198, and 0.196, respectively, showing strong spatial correlation and matching degree. Stronger correlation among tourism elements is significant for optimizing resource allocation, improving overall tourism industry efficiency, promoting integrated development of tourism and related industries, and forming tourism industry chains. The "tourism" element has the lowest spatial correlation with other elements, with an average bivariate Moran's I of 0.089, and the lowest bivariate Moran's I value with the "accommodation" element (0.072). This may be because the "tourism" element relies more on widely distributed natural and cultural tourism resources, while "accommodation," "transportation," "food," "shopping," and "entertainment" elements are more dependent on urban centers with convenient transportation and high population density.

2.3 Spatial Scale Characteristics of Tourism Elements

Ripley's K function was used to determine the spatial scale distribution characteristics of each tourism element and total elements in the urban agglomeration on the northern slope of the Tianshan Mountains (Figure 3). The L(d) curve represents the spatial agglomeration characteristics of various tourism elements within distance d; L(d) = 0 represents complete spatial randomness (csr); L(d) > 0 indicates agglomeration characteristics; the distance corresponding to the first peak of the L(d) curve is commonly used to represent the spatial characteristic scale of the studied elements; L(d)*{min} and L(d)*{max} represent the lower and upper confidence interval lines, respectively. The calculated L(d) curves for all tourism elements are above the L(d)_{max} line, indicating that the distribution of each tourism element and total elements in the urban agglomeration on the northern slope of the Tianshan Mountains shows significant agglomeration characteristics at different spatial scales.

From the perspective of peak occurrence distance, the "accommodation" element reaches peak agglomeration at 18.48 km, which is smaller than any other tourism element and the total elements. The "accommodation" element is concentrated in livable areas such as valleys and oases with rich resources and

relatively good climate conditions, showing significant agglomeration characteristics. The distribution characteristics of "food" and "shopping" elements are highly similar, reaching peak agglomeration at 33.55 km and 33.56 km, respectively. With increasing spatial distance, the L(d) curve shows a downward trend, indicating decreasing agglomeration intensity, which begins to rise again at 110 km, with agglomeration intensity increasing once more. As basic material conditions closely related to tourism development, "food" and "shopping" elements are more influenced by location conditions such as commercial districts, transportation, and population density.

The spatial scale characteristics of "transportation," "entertainment," and "tourism" elements are roughly similar, with peak occurrence distances of 36.41 km, 42.52 km, and 42.95 km, respectively, indicating that these three types of elements show agglomeration characteristics at larger spatial scales with broader location selection ranges. The "transportation" element mainly includes facilities such as parking lots, railway stations, airports, and bus stations, whose distribution considers transportation convenience more. "Entertainment" and "tourism" elements have certain resource dependencies and are more influenced by resource conditions and cultural history, thus showing agglomeration characteristics at the largest spatial scales.

The overall tourism "six elements" show spatial agglomeration characteristics at 33.83 km, with spatial agglomeration scale characteristics between those of individual elements, indicating that various tourism elements are interconnected, influence each other, and integrate with each other, jointly affecting the spatial scale pattern of tourism in the urban agglomeration on the northern slope of the Tianshan Mountains.

2.4 Analysis of Influencing Factors

2.4.1 Single Factor Analysis Geodetector results are shown in Table 5. Overall, except for the slope factor, which does not pass significance tests at the 0.05 level, all other nine influencing factors pass significance tests at the 0.01 level. The influence of each influencing factor on the spatial distribution of tourism "six elements" varies, with the comprehensive influence ranking from large to small as follows: nighttime light index (X_1), GDP (X_3), number of A-level scenic spots (X_2), population density (X_4), proportion of tertiary industry (X_5), road network density (X_6), annual cumulative precipitation (X_7), annual average temperature (X_8), elevation (X_9), and slope (X_{10}). Notably, the nighttime light index has the highest influence on the spatial pattern of tourism "six elements" in the urban agglomeration on the northern slope of the Tianshan Mountains, with q-values reaching 0.612, 0.598, 0.523, 0.487, 0.456, and 0.523 for "food," "accommodation," "transportation," "tourism," "shopping," and "entertainment," respectively. This indicates that economic development level and urbanization level are key factors determining the spatial layout of tourism "six elements" in the urban agglomeration on the northern slope of the Tianshan Mountains, with "food," "transportation," and "shopping" elements

all highly dependent on this factor. The influence of A-level scenic spot quantity and tertiary industry proportion, reflecting tourism development level, is in the second tier, with A-level scenic spot quantity significantly affecting the layout of "food" and "shopping" elements, reflecting the close linkage between A-level scenic spots and catering/shopping in this region. The influence values of population density and road network density on the spatial differentiation of "six elements" in the urban agglomeration on the northern slope of the Tianshan Mountains are relatively small, possibly related to the small latitude span of the region and the concentration of various elements in major cities, while the natural environment heterogeneity is low within the same region.

2.4.2 Factor Interaction Analysis Interaction analysis results show (Figure 4) that the interaction between factors manifests as nonlinear enhancement and bivariate enhancement, meaning the explanatory power of each pair of factors is greater than that of single factors, indicating that the influence of various factors on the spatial differentiation of tourism elements in the urban agglomeration on the northern slope of the Tianshan Mountains is interactive rather than isolated. At the factor dimension, the interaction between A-level scenic spot quantity and tertiary industry proportion significantly enhances the influence on the spatial layout of "food," "transportation," "shopping," and overall tourism "six elements," increasing to 0.812, 0.798, 0.756, and 0.789, respectively. After interaction between nighttime light index and tertiary industry proportion, it also has prominent influence on the layout of "accommodation," "tourism," and "entertainment" elements, reaching 0.689, 0.712, and 0.698, respectively. This analysis result does not highlight the role of GDP as in single-factor analysis but further demonstrates the close correlation between nighttime light index, A-level scenic spot quantity, and tertiary industry proportion with the spatial layout of tourism "six elements."

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3 Discussion

This study analyzes the spatial distribution and correlation characteristics of tourism elements in the urban agglomeration on the northern slope of the Tianshan Mountains based on POI data, revealing its current multi-scale spatial pattern status. The core polarization and edge estrangement effects of tourism elements in the urban agglomeration on the northern slope of the Tianshan Mountains are obvious. Urumqi City, as the "one core," shows strong agglomeration effects, but its radiation range is limited by large-scale spatial distance, resulting in "island-like" element distribution in peripheral counties. Natural tourism resources in the urban agglomeration on the northern slope of the Tianshan Mountains are relatively scattered, showing broad distribution characteristics of "tourism" elements and urban dependence distribution characteristics of "food," "accommodation," "transportation," "shopping," and "entertainment" elements, leading to significantly weaker spatial correlation of "tourism" elements than

other elements. The peak agglomeration distances of different tourism elements in the urban agglomeration on the northern slope of the Tianshan Mountains vary significantly, with "accommodation" elements showing small-range agglomeration dependent on oasis livable environments (18.48 km) and "tourism" elements showing large-scale coverage dependent on natural tourism resources (42.95 km). The hub role of "transportation" elements is obvious, with strong spatial correlation between "transportation" elements and "food," "shopping," and "entertainment," indicating that transportation hubs have a pulling effect on tourism consumption. The weak correlation between "accommodation" and "tourism" elements indicates a spatial mismatch between "accommodation service supply" and "tourism resource distribution" in the urban agglomeration on the northern slope of the Tianshan Mountains, urgently requiring strengthened planning and construction of high-quality accommodation facilities around tourism attractions through scientific and reasonable spatial layout adjustments to enhance synergistic effects between accommodation services and tourism resources, thereby improving overall tourism service quality and tourist satisfaction and promoting balanced and sustainable regional tourism development.

Regarding influencing factors, the study finds that the driving factors of tourism element spatial differentiation in the urban agglomeration on the northern slope of the Tianshan Mountains have multi-level characteristics. The strong explanatory power of nighttime light index highlights the dominant role of economic level, confirming that economic level and urbanization level are key driving factors for tourism element spatial layout, which aligns with conclusions from other relevant studies. Specifically, higher GDP and nighttime light index not only represent regional economic vitality and urbanization degree but also indirectly indicate the strength of infrastructure construction and service supply capacity, which jointly shape the spatial distribution pattern of tourism elements. Additionally, while A-level scenic spot quantity shows significant advantages in single-factor analysis, its influence weakens in the multi-factor interaction analysis framework. The study further finds that the interaction between nighttime light index, A-level scenic spot quantity, and tertiary industry proportion has more significant influence on tourism element spatial distribution, indicating that these factors can more effectively explain and influence the spatial pattern of tourism elements when acting together. This demonstrates the necessity of "policy combination punches" in cultural and tourism industry development, that is, through comprehensive policy implementation and multi-dimensional optimization of tourism element spatial layout, to achieve more balanced and sustainable development goals.

4 Conclusions and Recommendations

4.1 Conclusions

1) Each tourism element in the urban agglomeration on the northern slope of the Tianshan Mountains shows significant spatial agglomeration, with "food" elements having the highest spatial agglomeration and "tourism" elements the lowest. From the perspective of spatial scale characteristics, "accommodation" elements have the smallest spatial location selectivity while "tourism" elements have the largest. All tourism elements show a spatial distribution pattern radiating from high-density areas such as Urumqi City, Changji City, and Shihezi City to the periphery.

2) Based on bivariate spatial autocorrelation measurement of spatial correlation among tourism elements, the overall spatial correlation is not high, which cannot well meet tourists' basic requirements for tourism activities. The study finds that "transportation" elements have high spatial correlation and matching degree with other tourism elements. By improving transportation networks, reasonably distributing tourist distribution centers as bridges, and tourism attractions as cores, tourism resources can be optimally allocated to achieve high-quality tourism development.

3) The tourism spatial pattern in the urban agglomeration on the northern slope of the Tianshan Mountains has multiple causes and shows that the explanatory power of multi-factor joint action is greater than that of single factors. Infrastructure, economic level, population, industrial structure, transportation, and natural environment dimensions have obvious joint effects, particularly with GDP, nighttime light index, A-level scenic spot quantity, and tertiary industry proportion having significant explanatory power.

4.2 Recommendations

1) In response to the strong correlation between "transportation" elements and tourism consumption, we recommend vigorously developing transportation-tourism integration, strengthening tourism infrastructure and service quality improvement, perfecting the G312 national highway axis transportation network, creating high-quality tourism leisure corridors, densifying the layout of county-level tourist distribution centers, and improving the connectivity between transportation hubs such as passenger stations and airports with scenic spots. Based on the small-scale agglomeration characteristics of "accommodation" elements, high-quality accommodation service supply can be strengthened in tourism resource belts or areas rich in tourism resources to alleviate the spatial mismatch between accommodation services and scenic area distribution.

2) Relying on the broad distribution characteristics of "tourism" elements at 42.95 km, we recommend developing characteristic tourism routes themed

around Tianshan Mountains ecological corridor experience tours and oasis rural tours, effectively integrating regional tourism resources, organically connecting scattered tourism attractions and rich natural resources, enhancing tourism product diversity and attractiveness, and striving to shape and strengthen the unique tourism brand of the urban agglomeration on the northern slope of the Tianshan Mountains to promote sustainable tourism development. Combining the interaction effects of A-level scenic spots and tertiary industry, we should promote integrated formats such as "scenic spot + cultural creativity" and "folk custom + intangible cultural heritage," developing characteristic products such as ice and snow tourism and border cross-border tourism. In high-density areas of tourism industry elements such as Urumqi City, Changji City, and Shihezi City, we should layout cultural tourism complexes and develop nighttime economy and immersive experience projects.

3) We should deepen regional collaborative development mechanisms, address the "core-periphery" structural contradiction through infrastructure quality improvement, break the current situation of isolated distribution of "tourism" elements through format innovation, and promote organic connections and synergistic effects among various tourism elements. By strengthening collaborative cooperation among regions, overcoming challenges posed by large-scale spatial barriers, and building a closed-loop system integrating transportation, data, and services, we can form a new pattern of comprehensive tourism with "transportation + service closed loop," significantly improving the overall attractiveness and competitiveness of the urban agglomeration on the northern slope of the Tianshan Mountains as a tourism destination and generating significant spillover effects across Xinjiang, driving the common prosperity and development of surrounding areas.

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