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EVALUATING OF THE TOURISM ECONOMIC SPATIAL NETWORK STRUCTURE OF THE URBAN AGGLOMERATIONS¹

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ABSTRACT. *With the rapid development of the tourism industry, the economic interconnection between regions has become increasingly close, forming a complex spatial structure of tourism economy networks. Currently, there is a limited amount of literature available regarding the spatial network structure of tourism economies in urban clusters, and there is a lack of systematic research on the tourism economy spatial network of the urban agglomerations in the middle reaches of the Yellow River (MRYR) in China before and after the COVID-19 pandemic. Using the 2019-2022 period as the time frame, a tourism connectivity matrix for the urban agglomerations in the MRYP in China was constructed based on the gravity model, and the spatiotemporal characteristics of the tourism spatial network structure were explored through social network analysis. Results indicate that from 2019 to 2020, the intensity and volume of tourism economic connectivity among cities in the MRYP declined. The spatial characteristic of being strong in the south and weak in the north of the urban agglomerations in the MRYP is clearly revealed, and a development pattern characterized by the dominance of Taiyuan, Zhengzhou, and Xi'an is basically formed. Under the impact of the COVID-19 pandemic, from 2019 to 2022, the density, total volume, and degree centrality of the tourism economy connectivity network in the urban agglomerations in the MRYP decreased, with more pronounced polarization characteristics. Based on the analysis results, recommendations for the spatial development model of the tourism economy in the urban agglomerations in the MRYP can be proposed from three perspectives: core cities, cluster development, and the tourism network. Evaluating the characteristics of and changes in the spatial network structure of the tourism economy in the urban agglomerations in the MRYP is beneficial for exploring a localized tourism development model.*

KEYWORDS: gravity model, social network analysis method, tourism economy spatial network structure, tourism integration, urban agglomerations

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Introduction

The cities within an urban agglomeration collaborate and cooperate with each other to form an agglomeration effect by aggregating their advantages in terms of industry, population and the economy (Bai *et al.*, 2024). The development of urban agglomerations has become an important part of the development of regional integration (Wan *et al.*, 2019). In particular, the tourism industry ranks first among the “Five Happy Industries”, is recognized as a “gold industry” and “sunrise industry” and plays an important role in urban agglomerations. In particular, due to its comprehensive characteristics, the tourism industry relies on cooperation, competition, and the mutual sharing of resources. These relationships vary throughout the process of regional tourism development and help address resource, economic, and spatial constraints to achieve tourism integration. The network is more dependent on the tourism economy spatial network, as cities serve as nodes (Gan *et al.*, 2021). This economic network is based on tourism economy correlation and connected via tourism elements (Wang *et al.*,

2021). The effective evaluation of the network structure of tourism economy in urban agglomerations plays an important role in promoting the development of tourism and the prosperity of urban economy (Liu *et al.*, 2017). In China, the proportion of tourism in the economy is increasing each year. In 2018, the comprehensive contribution of Chinese tourism reached 5.97 trillion CNY. In particular, the tourism economy of urban agglomerations in China has been developing rapidly, and the tourism economy in the middle reaches of the Yellow River (MRYS) Basin is the most typical of such growth. The Yellow River Basin is the birthplace of China's 5000-year civilization. The MRYS have a rich cultural heritage and a deep cultural foundation. The high-quality and high-standard construction of the construction of high-quality and high-standard urban agglomerations along the Yellow River is very important in our country's economic, social development and ecological security. (Liu *et al.*, 2017) However, during the development of urban agglomerations in the MRYS, problems such as the insufficient integration of tourism resources and a low degree of development and utilization have emerged. Moreover, the development of urban agglomerations in the MRYS is unbalanced due to historical and geographic conditions. Spatial connectivity is lacking. There is an urgent need to evaluate the network structure of tourism economy in the urban agglomeration in the MRYS.

At the theoretical level, the academic community mainly analyzes flow of economic factors and its spatial network structure of urban agglomerations from the perspectives of central place theory and flow space theory. According to the core perspective of central place theory, the differences in the spatial correlation and distribution characteristics between a city in a central position and other cities at the city level and in terms of size and function affect the spatial distribution of central places, thus forming a central place system that spatially self-organizes and evolves (Gao *et al.*, Yan *et al.*, 2020; Osorio-Arjona *et al.*, 2021). At present, this model of central places, which is premised on geographic spatial proximity and hierarchical scale, has gradually changed into an urban flow spatial network model of factor relationships, which emphasizes a form of spatial organization in which material flow does not need to be geographically adjacent to achieve sharing. This complex network consists of strong or weak connections between different subjects, accounts for the attribute characteristics and relationship characteristics of its spatial units and builds a bridge between the behavior of individual spaces and the whole network (Guo, 2022; Zhang, 2020). From the perspective of spatial network construction methods, first, the spatial association network is constructed through mature relational data. Yin *et al.* (2017) used Twitter social media data to describe city boundaries and spatial interactions. Second, the gravity model is used to describe the given spatial network structure. Due to the lack of data directly associated with spatial units, it is difficult to directly describe the strength and direction of the spatial flow of elements. Therefore, the gravity model is used to construct the spatial network structure. Shao *et al.* (2023) selected 30 provinces in China as research samples and a modified gravity model was used to construct a spatial correlation network of our country's regional carbon emissions. They found that the spatial association pattern of carbon emissions exhibited obvious spatial distribution characteristics of regional "clubs". With the upgrading of the energy structure, a gradient correlation trend from west to east and from north to south occurred. Although the economic spatial correlation perspective and quantitative analysis models above offer a variety of possibilities for revealing the network structure of the tourism economy, existing studies still have some deficiencies. First, the intensity of tourism economy connections between cities is closely related to their tourism competitiveness and their characteristics. Therefore, when describing the spatial network of the intercity tourism economy, both the

actual intercity tourism factor flow and the overall functional division and linkage effect of the urban agglomeration should be considered. The intensity of tourism economy connections in urban agglomerations, which spatially represent the most active flow of tourism elements, can be used to describe the overall level of high-quality tourism in such agglomerations. This is possible to comprehensively depict the spatial structure of regional tourism economic network. Second, tourism economy network structure is closely related not only to a city's own tourism competitiveness but also to the intercity tourism economic distance. Interregional travel times, which are based on multiple transportation modes, affect the flow efficiency and quality of tourism and can thus better describe the heterogeneous spatial connection process of tourism economy elements based on various means of transportation. The traditional gravity model describes the strength of space based mainly on the absolute geographic distance. However, the present study revises the gravity model to better describe the spatial correlation process of tourism elements between urban agglomerations under the impact of multiple transportation modes. Therefore, scientific analysis of the strength of spatial connections in the tourism economy from the perspective of urban agglomerations and a description of the dynamic evolution characteristics of tourism economic network structure are worth further investigation.

Based on the discussion above, the traditional gravity model is first revised. From the perspective of time geography and tourism, travel time is used to replace spatial distance to characterize the tourism economy distance between different cities to improve directionality and accuracy in the calculation of the connection strength of the tourism economy and bring it closer to reality that regional tourism economic linkages constitute a complex spatial network.

Next, urban agglomerations are used as the starting point, and the tourism economy connection characteristics of the 30 cities among the three major urban agglomerations in the MRYS Basin and within the urban agglomerations are dynamically analyzed. Methodologically, social network analysis is used to describe the network density, cohesive subgroups and centrality of the tourism economy spatial network structure, which is more in line with the current goal of the Chinese government to promote whole-region tourism, coordinate development of the Yellow River Basin, develop the Yellow River Cultural Tourism Belt and promote the high-quality development of the tourism economy and the urban agglomerations in the Yellow River Basin. This approach can provide theoretical and practical references for promoting the high-quality development of the tourism economy in the Yellow River Basin and the tourism economy spatial network structure of urban agglomerations.

The contributions of this study are mainly as follows. First, with flow space theory as the research framework and urban agglomerations characterized by multiple centers, multiple levels and multiple nodes as the research objects, the relationship between the unbalanced growth of the tourism economy at the spatial level is investigated. The spatial connection phenomenon helps to scientifically measure the intensity of the tourism economy connection of each node city of an urban agglomeration and provides a theoretical basis for analyzing the status of the node cities in the tourism economy spatial network. Second, based on the consideration of the directionality of and difference in tourism flow and the influence of tourists' behavioral perceptions of distance, the present study adapts the traditional tourism economy gravity model to bring tourism economy connections closer to the actual situation. This study provides practical guidance for the establishment of regional tourism cooperation and sharing mechanisms and for the coordinated development of global tourism.

1. Literature Review

In this study, based on flow space theory, spatial network structure of tourism economy in the urban agglomerations in MRYR is investigated. Currently, research on the spatial structure of the tourism economy has focused mainly on the characteristics, evolutionary mechanisms and influencing factors of the tourism economy network. Valeri and Baggio (2021) analyzed the structure of the Italian travel agency network. The application of social networks in the Italian tourism system was analyzed by using Italian travel agencies and travel agency systems as the units of analysis. The results proved that network science methods are useful and effective in this field of study. Ce *et al.* (2020) used social network analysis to explore the structure, forms, and characteristics of tourism cooperation, focusing on issues related to the density and centrality of tourism networks. By improving the knowledge of the particularity of cooperation among tourism stakeholders, their study provided evidence for the utility of social network analysis in understanding destination-specific relationship dynamics. Altuntas *et al.* (2022) applied social network analysis to a case study of isolation-oriented decisions related to the COVID-19 pandemic. They recommended the use of social network analysis based on tourism data to make quarantine decisions in the event of a COVID-19 outbreak and to reduce the potential negative impact of the COVID-19 pandemic on the tourism industry. Zhu *et al.* (2022) used complex network theory to analyze the change characteristics of the global tourism network and to detect the impact of the global network structure on the performance of the international tourism industry. These studies indicate a lack of attention given to spatial optimization strategies for spatial structure of tourism economy. About research scale, we can divide research into three levels: the global, national and regional levels. Lozano and Gutiérrez (2018) analyzed structure of global tourism network and interaction between the source and destination markets of tourism.

The results showed that the indicators calculated via global tourism flow network analysis can be used to supplement and enrich the information provided by current tourism statistics. At the regional scale, Restrepo *et al.* (2021) measured the institutional density of a tourist destination in one region of Colombia, analyzing the empirical results of 107 institutions. These results showed that the configuration of formal interaction spaces determined the destination's governance system, thus turning some institutions into hubs or authorities. Locally, Yu *et al.* (2023) collected tourism digital footprints from an online travel platform, and social network analysis was used to investigate the structural characteristics and flow characteristics of the tourism flow network in Guilin city. Furthermore, in terms of research methods, a variety of methods has been applied to conduct social network analysis. Based on big data network analysis, Li and Law (2020) analyzed the current status of big data research on tourism by using comprehensive network analysis methods, including co-citation, clustering and trend analysis. This method has guiding significance for future big data research on tourism. When evaluating existing hotel and tourism studies via social network analysis methods, Mariani and Baggio (2020) found that both purely qualitative and quantitative studies had limitations. Through the use of mixed methods, the authors effectively explored the role of social network analysis methods in tourism and hotel studies. Lee *et al.* (2017) conducted network analysis based on the search volume of the Korean search engine Naver by using the quadratic assignment problem (QAP) and CONvergent CORrelation (CONCOR) analysis to verify the structural relationship between the tourist destination network and the physical distance network, which they used to determine the structural clusters of tourist destinations. Overall, in research, tourism economy linkages

based on geographic proximity have gradually been replaced by functional linkages generated by factor flows, which also means that the differences in the directionality and intensity of tourism economy linkages have increasingly become popular research areas. Urban agglomerations, which are spatial unit with overall network structure characteristics, are important objects in the study of tourism economy networks.

According to a review of the relevant literature on the gravity model and social network analysis, the gravity model is used in a wide range of fields, including the analysis of the connections between systems (Cerqueti *et al.*, 2019; Narayan *et al.* 2022; Addis *et al.*, 2023). Khan *et al.* (2023) used the gravity model to investigate the influences of natural resources and cultural, geographic, and institutional factors on the outward foreign direct investment (OFDI) of countries along the Belt and Road Initiative. Using the bilateral trade flow of 67 countries from 1986 to 2016 as a sample, Martínez-Martínez *et al.* (2023) analyzed the impact of climate change on the bilateral trade flow via the gravity model, with spatial fairness and spatial density serving as subdimensions. Rajasekharan *et al.* (2023) investigated the important factors of proximity and spatial fairness via the gravity model. To identify key nodes in complex networks, Zhong *et al.* (2023) proposed an improved gravity model considering propagation characteristics. The empirical results showed that this method outperformed previous benchmark methods in terms of accuracy and effectiveness in identifying key nodes. Based on the network analysis framework for rural tourism flow and Ctrip tourist digital footprint data, Qin *et al.* (2022) analyzed the spatial characteristics and spatial development pattern of rural tourism flow. Young *et al.* (2021) used the movement pattern matrix of tourists who came to Hong Kong in the corresponding period before and after the COVID-19 pandemic for network analysis. Their study showed that travel demand was mainly concentrated on the beach, where the tourism density was low. Blázquez *et al.* (2023) used social network analysis and a two-step gravity model to explain the binary trade flow of implied digital services and proved that the effect of implied digital services on trade flow is statistically significant. Ulucak *et al.* (2020) explored the demand-side factors affecting the number of international tourists in Turkey by using an augmented gravity model to analyze the factors affecting the number of international tourists from the top 25 source countries to Turkey from 1998 to 2017. The results showed that the gravity model very effectively explained the number of tourists in Turkey. By establishing a theoretical framework based on the structural gravity model, Gallego and Paniagua (2020) investigated the effects of information, travel costs, and the desire to visit relatives and friends. This model not only provided a better understanding of the relationship between tourism and immigration but also overcame some empirical biases, such as ignoring multilateral resistance and controlling endogeneity in tourism flows. Diaz *et al.* (2020) analyzed provincial domestic tourism flows in Spain based on the gravity model and various spatial econometric models. The results showed that income and relative prices affected the tourism demand in each province in Spain. Nadal and Gallego (2022) reviewed 143 key papers related to the gravity model and helped researchers understand this field through a literature review. The results showed that GDP, population and distance were the most advantageous variables. However, researchers still face many major challenges in the empirical application of the tourism structure gravity model. Ibragimov *et al.* (2021) applied the gravity model to analyze economic determinants of tourism in Middle Asia. The traditional gravitational model and 2008-2018 panel data covering 108 countries indicated that the tourism industry in Central Asia had distance elasticity and price elasticity.

The extensive application of the gravity model in research on the tourism economy has led to in-depth studies on spatial network structure of tourism economy at different scales and with different subjects. However, the effect of the difference in travel time costs related to travel behaviors from a time geography perspective on the actual economic distance element in tourism needs further study.

The study of the cyberspace structure is relatively mature. In research on tourism spatial correlation, multidisciplinary methods and theories such as the spatial correlation of tourism flow, spatiotemporal evolution, economics, management, and geography are used. However, there are still deficiencies in related studies. First, starting from a network perspective is helpful for analyzing the regional tourism network structure from a holistic and systemic perspective. However, some scholars use the spatial econometric method when studying the spatial elements of the tourism economy and focus on adjacent regions of economic development; the research conclusions deviate due to differences in geographic location. Therefore, the gravity model can effectively reduce the bias in the conclusions caused by geographic location, and it is more scientific. Second, most research on the tourism economy network structure studies the overall network structure on a large scale, exploring the tourism economy network structure in a certain year or in a continuous time series, and the research period is mostly prior to 2019. In addition, in relevant studies, the impact of the COVID-19 pandemic has not been fully considered. Third, in terms of research methods for the spatial structure of tourist economy, traditional tourist economy gravitational model seldom measures strength of tourism economy connections from the two dimensions of time and space. In particular, under the impact of tourism behavioral perceptions and time costs among regional urban agglomerations, research on the distance elements of tourism flow needs to be further strengthened.

2. Methodology

2.1 Study Area and Sources of Data

The Yellow River originates at the northern foot of the Bayan Har Mountains on the Qinghai Tibet Plateau and flows through nine provinces, namely, Qinghai, Sichuan, Gansu, Ningxia, Inner Mongolia, Shanxi, Shaanxi, Henan and Shandong. It is the second longest river in China, with a full length of 5464 km.

The MRYS are located between Hekou town, Inner Mongolia, and Taohuayu, Zhengzhou, Henan Province. The basin area is 3.44×10^5 km², accounting for 43.27% of the total area of the Yellow River Basin, and it contains 30 prefecture-level cities and 228 counties in six provinces (autonomous regions): Inner Mongolia, Ningxia, Gansu, Shanxi, Shaanxi and Henan. This area includes seven geomorphic areas, namely, the Ordos Plateau, Jinzhong Basin, northern Shaanxi Plateau, Longdong Plateau, Guanzhong Plain, southern Jin Basin and western Henan Basin, and it includes three urban agglomerations in central Shanxi, Guanzhong and the Central Plains. Vegetation in the MRYS is sparse, covering 61% of the basin area in the Loess Plateau area. The loss of water and soil is serious, this is a main source of sediment and floods in the lower reaches of the Yellow River. Additionally, the Jing River, Beiluo River, Wei River and Fen River converge. Based on the research results of relevant scholars and following the principle of data availability, a total of 30 cities in the Guanzhong Plain urban agglomeration, the central Shanxi urban agglomeration and the Central Plains urban agglomeration in the MRYS were research units (Table 1) (Qin *et al.*, 2021).

Table 1 Overview of the urban agglomerations in the MRYR

Urban agglomeration	Composition of the urban agglomeration
<i>Guanzhong Plain urban agglomeration</i>	Xi'an city, Tongchuan city, Baoji city, Xianyang city, Weinan city, Shangluo city, Yuncheng city, Linfen city, Gansu Province, Tianshui city, Pingliang city, Qingyang city
<i>Central Shanxi urban agglomeration</i>	TaiCNY city, Yangquan city, Changzhi city, Jinzhong city, Xinzhou city, Lvliang city
<i>Central Plains urban agglomeration</i>	Zhengzhou city, Kaifeng city, Luoyang city, Pingdingshan city, Hebi city, Xinxiang city, Jiaozuo city, Xuchang city, Luohe city, Shangqiu city, Zhoukou city, Jiyuan city, Jincheng city, Bozhou city

Source: authors' own results.



Source: authors' own results.

Figure 1. Urban Agglomerations in the MRYR

The tourism statistics came from the 2020 Statistical Yearbooks released by Shanxi Province, Shanxi Province, Gansu Province and Henan Province and from the Statistical Communiqués of National Economic and Social Development of each province in 2019 and 2022. Some missing values were filled in via linear interpolation based on national tourism data. The exchange rate between the US dollar and the Chinese CNY was calculated using the average exchange rate for the year, and the distance between cities was calculated from the driving kilometers on Baidu Maps.

2.2 Research methods

2.2.1 Modified Gravity Model

This study measured the network association characteristics of the tourism economy between regions and emphasized the spatial directivity of the network nodes. Therefore, the gravity model was chosen for quantitative description.

(1) Weighted mean journey- time

The weighted mean journey- time emphasizes the influence of economic status and geographic location on regional connectivity by assigning weight to the shortest travel time, reflecting the travel time required from the origin to the destination. In this study, the weighted average travel time was used to characterize the connectivity of the macroscopic regional mass transportation network via the following Formula (1):

$$t_i = \sum_{j=1}^n t_{ij} \times M_j / \sum_{j=1}^n M_j \quad (1)$$

where t_{ij} is the minimum traffic travel time between city i and city j ($j = 1, 2, \dots, 40$). This study considers the minimum time among the high-speed rail time, ordinary train time and car time. M_j is the quality of city j . In the present study, the urban population is used; that is, the weighted urban population is used to calculate the weighted average time for people in city i to reach the other cities in the area. The economic meaning of population weighting is that the more populous the source city of tourism is, the more influential it is and, therefore, the more weight it carries.

(2) Revised gravitational model

The gravitational model originated from Newton's law of gravitation in physics. It was first used in economics to explain and predict the trade flow between two economies and was gradually developed into an important method to study the economic correlation between regions or within regions. Because it is suitable for aggregating data such as total tourism revenue and can comprehensively consider the impact of geographic distance on tourism economic linkages, it is widely used to study the dynamic evolutionary trend of the spatial network structure of tourism economy linkages. Formula (2) is as follows:

$$R = \frac{\sqrt{P_i V_i} \sqrt{P_j V_j}}{D_{ij}^2} \quad (2)$$

where R denotes the degree of tourism economic linkage between region i and region j ; P and V respectively represent the total number of tourists received and the total income of tourism in different regions; D_{ij} is road mileage between region i and region j .

In this study, the results of gravitational model, regional tourism competition and cooperation relationship and the traffic conditions of the research object are fully considered. Then, the traditional gravity model is revised to scientifically and accurately reflect the degree of economic relevance of tourism between cities. First, traditional tourism economy gravity model ignores the directionality and differences in regional tourism economy connections. As a result, the gravitational attraction of large cities to small and medium-sized cities is equal to the gravitational attraction of small and medium-sized cities to large cities, which is an undirected network in space, and deviation of the research results occurs. On the basis of the study by Santana *et al.*, the correction factor of the gravity of the tourism economy is adjusted by including GDP per capita in the calculation process of the correction factor since, as a strategic pillar industry of the national economy, the tourism industry is integrated into and interdependent on many other industries to form a large industrial chain. Therefore, regional economic development is strongly dependent on the comprehensive economic strength of a region; GDP per capita can reflect regional economic strength to a large extent. As an indicator of comprehensive economic operation, the directionality of and spatial differences in the process of measuring tourism economy connections are enhanced through differences in regional comprehensive economic levels. Second, the traditional tourism economy gravity model uses spatial distance only as a measure of regional distance and ignores the fact that with the popularization of tourism and the continuous development of transportation

conditions, the distance of tourism economy connections cannot only consider the absolute distance in geographic space. Instead, the selection of transportation and travel time generated by travel behavior under the impact of perceived distance should be considered. Accordingly, the regional distance element in the gravity model is revised, the weighted average travel time is used to replace the traditional spatial distance, and the interregional tourism economic distance is characterized by the travel time cost of different interregional transportation modes. Formulas (3) and (4) are as follows:

$$F_{ij} = k \frac{\sqrt[2]{P_i V_i} \times \sqrt[2]{P_j V_j}}{T_{ij}^2} \quad k = \frac{g_i}{g_i + g_j} \quad (3)$$

$$C_i = \sum_{j=1}^i F_{ij} \quad (4)$$

where F_{ij} represents the intensity of the tourism economy connection between city i and city j ; k is the correction coefficient; g is per capita GDP; P is the total tourism revenue (in units of 100 million CNY); and V is the total number of tourists (in units of 10,000 person-times). T_{ij} represents the weighted average travel time between city i and city j ; C is the total number of tourism economy relationships of city i .

2.2.2 Social Network Analysis

Social network analysis is widely used in the economic, social science, management, and tourism fields. Social network analysis is a method for studying the relationships and structural characteristics between social entities from the perspective of group dynamics. This study chose network density and cohesive subgroup models to represent the effect of centrality and the structural holes of individual network characteristics on the strength of tourism economy linkages among cities in the MRYR urban agglomerations, and network spatial analysis was conducted. Due to the obvious secondary differences in the tourism economy connection intensity of the urban agglomerations in the MRYR, to ensure the accuracy of the research data, the median tourism economy connection intensity in 2019, 7.098, was selected as the threshold to binarize the tourism economy connection volume obtained from the gravity model and to construct the network binarization matrix for 2019 and 2022.

(1) Network density

The network density can reflect the spatial structure of tourism economy in the MRYR, and the larger the value, the stronger the network correlation between counties and cities. Formula (5) is as follows:

$$D = \frac{L}{N \times (N - 1)} \quad (5)$$

where D is network density, L represents the actual number of relationships, and $N \times (N - 1)$ is the maximum possible number of relationships.

(2) Cohesive subgroup

A cohesive subgroup refers to the substructure within a regional group and is part of research on social structure. By analyzing the cohesive subgroups of the network spatial structure, cities with relatively strong, direct, and intimate relationships in the overall network can be found. Formula (6) is as follows:

$$EI^{index} = \frac{EL - IL}{EL + IL} \quad (6)$$

where EL represents the relationship between small groups and IL refers to the relationship within small groups. EI^{index} is the distribution index of the cohesive subgroup, and its value ranges from -1 to 1. A data value approaching 1 indicates that the number of small groups is not large and that the groups have close internal connections; a data value approaching -1 indicates that the degree of factionalism is large and that a phenomenon of division and opposition occurs internally.

(3) Degree centrality

Degree centrality mainly measures the core location in an area. In the present study, a certain location point in an area is related to other location points in the area; thus, this location point is within the core position of the area. In addition, degree centrality includes the in-degree and the out-degree. The in-degree refers to the number of relationships through which other locations point to the location point, and the out-degree refers to the number of connections from the location point to other locations. Formula (7) is as follows:

$$C_{Di} = \frac{M_i}{N-1} \quad (7)$$

where C_{Di} represents degree centrality, M_i represents the number of connections between a certain location point and other location points in the area, and N represents the maximum possible number of connections.

(4) Betweenness centrality

In this study, betweenness centrality refers to whether a certain location point is in an intermediate position between other location points in the area. If it is, then the betweenness centrality of this location point is high, and vice versa; it is an intermediate position of a certain municipality relative to its connection to other municipalities. The formula is as follows:

$$C_{Bi} = \frac{2 \sum_j^n \sum_k^n g^{jk(i)} g_{jk}}{(n-1)(n-2)} \quad (8)$$

Where C_{Bi} represents betweenness centrality, g represents the number of all connections in the area, $g^{jk(i)}$ represents the number of connections between area j and area k that pass through area i , and g_{jk} represents the number of all connections from area j to area k in the area, where $j \neq k$.

(5) Structural hole model

The concept of a structural hole was first proposed by Burt, who noted that a structural hole is a nonredundant association between two network nodes that act as actors. Regardless of the strength of ties, if there are structural holes in the network, then actors who connect other actors who are not directly related have stronger control ability and advantage. These types of actors are often called agents. Network restriction is the most important measurement indicator, and the calculation formula is as follows:

$$C_{ij} = \sum_j (1 - \sum_q P_{iq} P_{qi}), q \neq i, j \quad (9)$$

where C_{ij} represents the degree to which actor i in the network is constrained by actor j ; P_{iq} represents the proportion of the relationship invested in q among the total number of relationships among actor i 's relationships; and P_{qi} represents the proportion of the relationship invested in actor j to the total number of relationships among all the relationships of q . The total degree of constraint on actor i in the network is obtained by the sum of all the actor j 's of actor i in the network.

Table 2. Network density of tourism economy connections in the urban agglomerations in the MRYS

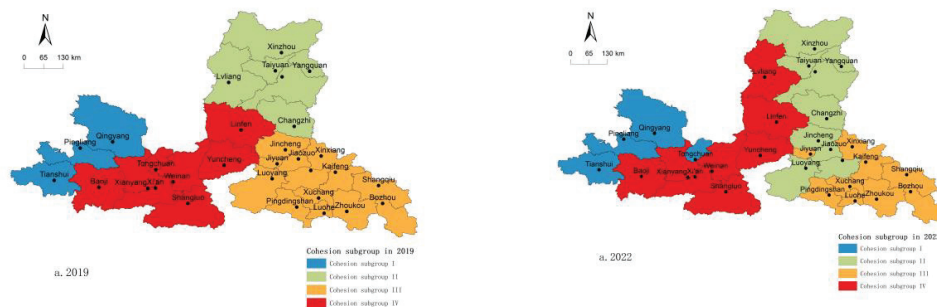
	2019		2022	
<i>Network density</i>	0.514		0.205	
<i>Number of relationships</i>	447		178	
	Core	Edge	Core	Edge
<i>Core</i>	0.933	0.467	0.722	0.228
<i>Edge</i>	0.529	0.129	0.270	0.076

Source: authors' own results.

3.2.2 Cohesive Subgroup Analysis

Cohesive subgroups are often used to reflect small agglomeration groups with strong tourism economy connections in the overall tourism network. Based on the cohesive subgroup model in the social network analysis method, four cohesive subgroups and the density matrix between the subgroups were obtained through calculations (Figure 3, Table 3). The calculation results revealed that in 2019 and 2022, there were four cohesive subgroups with relatively close relationships within the urban agglomerations. In 2019, the distributions of cohesive subgroups I, II, III, and IV were relatively concentrated, and they were basically distributed within the same province. In 2022, the distributions of cohesive subgroups II and III were relatively concentrated, mainly located in Shanxi and Shaanxi Provinces, and they had strong spatial self-organization ability. Some cities in cohesive subgroup I were divided and distributed in Gansu and Shanxi Provinces. Cohesive subgroup IV was within the same province but was analyzed based on the analysis of cohesive subgroup III. The spatial self-organization ability was relatively poor, and its city composition did not undergo significant changes.

From the perspective of density, the density of tourism economy connections among the cities within cohesive subgroup II was relatively high in 2019, and the density was 0.972, which was much greater than the overall urban network density in 2019, reflecting the strong tourism economy connections among the cities within cohesive subgroup II. The tourism economy connection density of the cities within cohesive subgroup III was 0.911, second only to that of cohesive subgroup II. The density correlation coefficient between the two was 0.819, indicating that these two cohesive subgroups had strong connections; they showed clear spatiotemporal proximity. In 2022, the density of tourism economy connections among the cities within cohesive subgroup II was relatively high, and the density was 0.633, which was much greater than the overall urban network density in 2019, reflecting the strong tourism economy connections among the cities within cohesive subgroup II. The tourism economy connection density of the cities within cohesive subgroup III was 0.625, second only to that of cohesive subgroup II. In general, the density within and among the four cohesive subgroups in 2019 was relatively high, indicating strong connectivity overall. The density within and among the four cohesive subgroups in 2022 was lower than that in 2019, indicating that the overall connections were weak.



Source: authors' own results.

Figure 4. Cohesive Subgroups with Tourism Economy Connections in the Urban Agglomerations in the MRZR

Table 3. Density of cohesive subgroups with tourism economy connections in the urban agglomerations in the MRZR

	2019				2022			
Density	Cohesive subgroup I	Cohesive subgroup II	Cohesive subgroup III	Cohesive subgroup IV	Cohesive subgroup I	Cohesive subgroup II	Cohesive subgroup III	Cohesive subgroup IV
Cohesive subgroup I	0.667	0.58	0.222	0	0.449	0.09	0.125	0
Cohesive subgroup II	0.58	0.972	0.722	0	0.09	0.633	0.063	0
Cohesive subgroup III	0.292	0.819	0.911	0.406	0.135	0.063	0.625	0.125
Cohesive subgroup IV	0	0.139	0.5	0.167	0	0	0.167	0

Source: authors' own results.

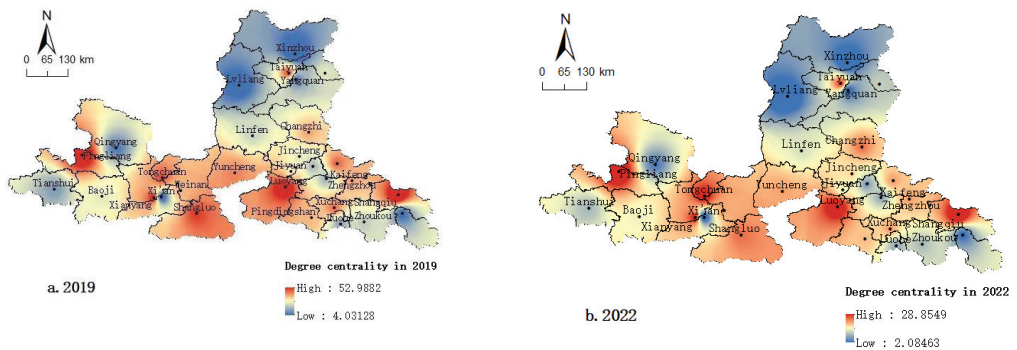
3.3 Analysis of the Network Structure of Individuals in the Tourism Economy

3.3.1 Centrality Analysis

Based on the degree centrality and betweenness centrality models in the social network analysis method, the degree centrality and betweenness centrality of tourism economy were calculated using Ucinet 6.2, and the calculation results were visualized with the help of the ArcGIS 10.8 analysis tool (Figure 4, Figure 5). Overall, the changes in intercity tourism economy relationships decreased; the core node cities still experienced strong radiation and diffusion capabilities. The areas with high degree centrality were distributed in the southern cities of the MRZR, with significant differences between the north and the south. In 2019, the degree centrality of tourism economic contact points in each city was relatively large, and each city exhibited strong radiation and diffusion ability. Among the 30 cities, 23 had scores greater than 20, with Zhengzhou city and Xi'an city having the highest values; these are the capital cities of Henan Province and Shaanxi Province, respectively, and the results indicate that they have strong momentum in tourism development. In 2020, the degree centrality of the tourism economy connections in each city

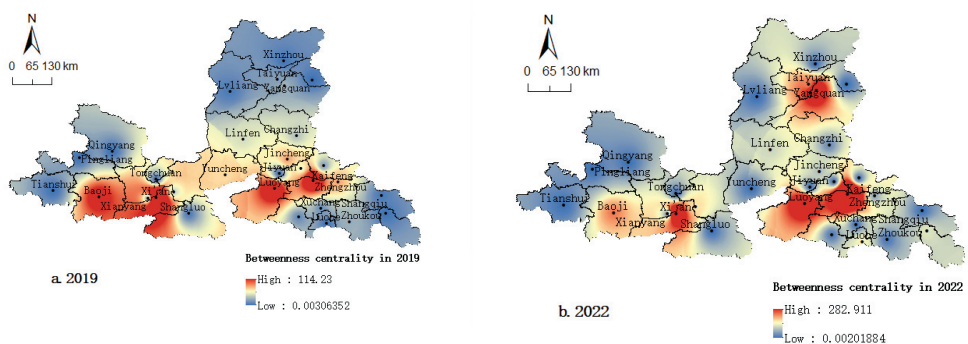
was relatively low, and the tourism connections among cities under the impact of the COVID-19 pandemic were weak. Among the 30 cities, only 3 had scores greater than 20: Zhengzhou, Luoyang and Xi'an.

Betweenness centrality reflects the control and influence of city nodes on other nodes and is considered a “bridge” between nodes. Through comparison, Figure 5 shows that the main channel of the tourism economy changed from the “dual development” of Zhengzhou and Xi'an to the “tripartite confrontation” of Taiyuan, Zhengzhou and Xi'an. In 2019, the betweenness centrality of Xi'an's tourism economy reached a maximum at 114. Cities with betweenness centralities higher than 50 were Zhengzhou and Luoyang, while another seven cities had betweenness centralities of 0. These results suggest significant differences in influence among cities and indicate that the phenomenon of polarization was prominent. In 2022, the city with the highest betweenness centrality was Zhengzhou, with a betweenness centrality reaching 283; the betweenness centrality of Xi'an was 136, second only to that of Zhengzhou. The betweenness centralities of Luoyang, Jinzhong, Baoji and Taiyuan were also greater than 50, and the number of cities with betweenness centralities of 0 increased to 12. Due to the impact of the pandemic, the polarization of tourism economy connections between cities became more obvious.



Source: authors' own results.

Figure 5. Degree Centrality of the Tourism Economy Connections in the Urban Agglomerations in the MRYR



Source: authors' own results.

Figure 6. Betweenness Centrality of the Tourism Economy Connections in the Urban Agglomerations in the MRYR

3.3.2 Analysis of Structural Holes

Based on the structural hole model in the social network analysis method, Ucinet 6.2 was used to calculate the structural holes in the tourism economy connection strength of the 30 cities in the urban agglomerations in the MRYS (Table 4). In 2019, the maximum effective scale was 14.123 for Xi'an, and the minimum effective scale was 1.000 for Tongchuan, Qingyang, Luohe, and Jiyuan. The three cities with the most effective scales were Xi'an, Zhengzhou, and Luoyang, and their index values were all greater than 10.000. The maximum effective size in 2022 was 15.645 in Zhengzhou, and the minimum was 0 in Qingyang. The three cities with the greatest effective scales were Zhengzhou, Luoyang, and Xi'an, and the index values were all greater than 10.000. According to the tourism economy connection network in 2019, Qingyang city had a maximum restriction degree of 1.125, and Xi'an had a minimum restriction degree of only 0.140. The restriction degree in Luoyang and Zhengzhou was only higher than that in Xi'an. In 2022, Tianshui had the maximum restriction degree in the tourism economy connection network of 1.235, while Qingyang, Luoyang, Zhengzhou, Xi'an, Jinzhong and other cities had lower restriction degree indicators. In 2019, the cities with the highest efficiency in terms of the tourism network structure were Xi'an, Qingyang and Zhengzhou, with values of 0.504, 0.500, and 0.485, respectively. The efficiency degrees of both Yangquan and Jiyuan were lower than 0.010. In the tourism network structure, the cities with the highest degrees of efficiency were Zhengzhou, Xi'an and Bozhou, while Qingyang had the lowest degree of efficiency. Comprehensive analysis revealed that Zhengzhou, Xi'an, Luoyang, Jinzhong, Jincheng, Luoyang, Jiaozuo, Kaifeng, Yuncheng, Taiyuan and other cities exhibited high levels of structural holes and low redundancy in the overall tourism economy network. These results indicate that these cities can create tourism connections with other nodes and thus occupy an advantageous position in competition for regional tourism development. However, attention should be given to maintaining interactive relationships between cities to prevent "lost connections". On the other hand, Qingyang, Bozhou, Pingliang, and Lvliang exhibited low levels of structural holes; therefore, their tourism connections with other cities need to be strengthened.

Table 4. Structural hole analysis results of the nodes in the tourism economy connection network of the urban agglomerations in the MRYS

City	2019			2022		
	Effective size	Efficiency	Restriction degree	Effective size	Efficiency	Restriction degree
<i>Pingdingshan</i>	2.741	0.183	0.253	1.864	0.311	0.570
<i>Luohe</i>	1.000	0.143	0.499	4.286	0.536	0.433
<i>Zhoukou</i>	4.117	0.257	0.237	1.75	0.583	0.927
<i>Shangluo</i>	2.159	0.166	0.292	1.000	0.25	0.789
<i>Xuchang</i>	3.741	0.234	0.243	1.000	0.200	0.662
<i>Haozhou</i>	1.100	0.110	0.376	2.000	0.667	0.804
<i>Baoji</i>	7.671	0.404	0.200	4.607	0.576	0.412
<i>Xianyang</i>	4.240	0.283	0.262	2.958	0.423	0.501
<i>Xi'an</i>	14.123	0.504	0.140	10.192	0.679	0.247
<i>Shangqiu</i>	1.700	0.155	0.336	1.750	0.583	0.927
<i>Tianshui</i>	1.750	0.250	0.515	1.000	0.500	1.235
<i>Weinan</i>	6.103	0.321	0.207	4.556	0.506	0.377
<i>Luoyang</i>	12.510	0.463	0.147	11.297	0.665	0.221

Table 4 (continuation). Structural hole analysis results of the nodes in the tourism economy connection network of the urban agglomerations in the MRYS

<i>Tongchuan</i>	1.000	0.111	0.408	1.000	0.333	0.926
<i>Yuncheng</i>	8.012	0.348	0.171	1.000	0.200	0.648
<i>Zhengzhou</i>	13.575	0.485	0.143	15.645	0.745	0.178
<i>Kaifeng</i>	7.821	0.356	0.177	4.882	0.488	0.374
<i>Jiyuan</i>	1.000	0.091	0.339	1.000	0.333	0.926
<i>Jiaozuo</i>	9.333	0.373	0.165	1.000	0.200	0.648
<i>Xinxiang</i>	4.574	0.254	0.214	2.167	0.310	0.516
<i>Pingliang</i>	1.500	0.250	0.584	1.000	0.500	1.125
<i>Jincheng</i>	9.054	0.377	0.164	4.947	0.495	0.358
<i>Qingyang</i>	1.000	0.500	1.125	0	0	0
<i>Linfen</i>	7.113	0.323	0.180	3.882	0.431	0.391
<i>Changzhi</i>	6.154	0.293	0.187	2.769	0.396	0.486
<i>Lvliang</i>	2.111	0.141	0.253	1.000	0.500	1.125
<i>Jinzhong</i>	6.434	0.292	0.183	7.194	0.654	0.316
<i>Taiyuan</i>	5.071	0.254	0.198	4.308	0.615	0.464
<i>Yangquan</i>	1.143	0.095	0.313	1.000	0.333	0.970
<i>Xinzhou</i>	1.479	0.114	0.288	1.000	0.333	0.970

Source: authors' own results.

3.4 Discussion

In the context of the integration and coordinated development of global tourism and the resources of the Yellow River Basin, regional tourism economy connections were quantitatively measured from the perspective of urban agglomerations, and the dynamic evolutionary characteristics of the spatial network structure of the regional tourism economy were comprehensively analyzed. The approach promotes cross-regional flow of tourism industry development elements by optimizing the complementarity of tourism functions and the division of labor and cooperation mechanisms of cities within a region. This study holds strong theoretical and practical significance for strengthening the regional tourism industry.

In this study, the spatial network structure of the tourism economy of the MRYS urban agglomerations was analyzed by fully considering tourism economy connection time constraints, connection directions, multiple transportation systems and other factors. The study revealed significant differences in economic connections between and within the MRYS urban agglomerations. This finding is consistent with the results of Guo and Liu (2023). This study further emphasizes regional imbalance and flow asymmetry of the tourism economic network connections in the post pandemic era. In contrast to Guo and Liu (2023), who used the straight-line distance of different spatial subjects in an area to characterize the tourism economy distance and thus found a balanced trend in the tourism economy development of adjacent node cities inside an urban agglomeration, in the present study, temporal distance was used to measure tourism economy distance. The shortest average travel time was introduced into the gravity model, which calculated the spatial correlation of the tourism economy while considering the actual tourism flow mode and direction in the region to better simulate the internal structure and dynamic changes in the tourism economy correlation of the urban agglomeration. This approach thus lays the foundation for the scientific and accurate construction of a regional spatial network for the tourism economy at methodological level.

An urban agglomeration is an open, complex, massive system with self-organizing characteristics. Within an urban agglomeration, the hierarchical structure of multiple individuals and node cities continues to extend, and the functional differentiation of subsystems, the regional division of labor and the functional dependence of spatial units all continuously strengthen the function of nongeographic proximity. A modified gravity model and social network analysis were used to systematically analyze the spatial correlation, functional division and linkage model of the tourism economy. This study further confirmed the findings of Su (2021), who showed that provincial capitals, tourist cities and economically developed cities have stronger tourism economic connections and that the dominance of high-level cities in the traditional sense is greater. According to the polarization-trickle-down effect proposed by Hirschman, as a growth pole, the central region expands to the periphery through the polarization effect, and the periphery develops under the trickle-down effect or diffusion of the central region. This study further confirmed the applicability of this theory.

Social network analysis was used to explore the tourism economy spatial network structure of the three major urban agglomerations and within the urban agglomerations in the MRYS. The nongeographic continuity of city connections in the urban network emphasized by Taylor was confirmed via the tourism field (Taylor *et al.*, 2010). Tourism economy connections can also occur between cities that do not have proximity relationships. Traditional spatial interaction theory centered on a hierarchical scale has gradually expanded to a polycentric, multiscale spatial association model. Research on the spatial structure of tourism economy networks should give more attention to the connectivity of tourism elements. Geographic proximity is no longer a primary factor in regional tourism development. This finding provides a starting point for additional measures that can guide urban tourism cooperation and optimize the spatial structure of tourism in the urban agglomerations in the MRYS.

Conclusions and Managerial Implications

Main Findings

This study used a modified gravity model to identify the spatial correlation of the tourism economy in the urban agglomerations in the MRYS and constructed a spatial network of the tourism economy. On this basis, social network analysis was used to empirically investigate the structural characteristics of the tourism economy spatial association network in the urban agglomerations in the MRYS and within these agglomerations.

(1) The intensity and extent of the tourism economy connections decreased, revealing the structural characteristics of strong connections in the southern region and weak connections in the northern region. At the interprovincial level, the tourism economy connections between Shaanxi and Shanxi were relatively close, followed by those between Henan Province, while those between Gansu Province were relatively weak. At the level of the tourism economy network, the development trend of “tripartite confrontation” with Taiyuan, Zhengzhou and Xi’an as the core appeared.

(2) As the network density decreased, the overall structure exhibited the structural characteristics of large dispersal and small agglomeration, forming a cohesive subgroup with the provincial capital cities at the core. The core-edge structural characteristics were obvious, and the driving effect of core cities on the peripheral areas was limited. In terms of overall network connections, the economy exhibited an unbalanced distribution; the direction of flows and differences between different regions were asymmetric. A decrease from 0.514 in

2019 to 0.205 in 2022 indicated that the economic connections between tourism destinations decreased. However, the spatial self-organization ability of the cohesive subgroups improved. Cohesive subgroups I, II, III, and IV all formed independent areas. While the internal connection density of the cohesive subgroups decreased, cohesive subgroups II and III still maintained close connections.

(3) The degree centrality of some node cities decreased, but the degree centrality of the core cities remained relatively high, playing a driving role in radiation to the surrounding cities. From 2019 to 2022, the number of core node cities increased; Taiyuan, Xi'an, and Zhengzhou were important "bridges" in intercity tourism and economic linkages in the MRYP urban agglomerations. Node cities such as Zhengzhou and Xi'an had relatively high levels of structural holes and favorable positions to compete for tourism development in the MRYP.

In summary, the findings above show that overall network density weakened and those large-scale cities occupied a core position in the tourism economy network and had a radiating effect on surrounding cities. Furthermore, the study shows that geographically adjacent cities could more easily form groups; therefore, a three-dimensional spatial network structure should be created to enhance the ability of the regional tourism economy to resist risks. While the COVID-19 pandemic did not change the multipolar characteristics of the tourism economy spatial network, it promoted differentiation and reorganization within the region. The results demonstrate the key role of important urban nodes in the stable development of regional economic networks, thus validating the proposed suggestions for optimizing the spatial network structure of tourism economy in the MRYP urban agglomerations.

Managerial Implications

Network development is characterized by large dispersion and small aggregation; core cities play a strong role as bridge hubs; and regional networks are characterized by unbalanced development (Qi *et al.*, 2021; Feng *et al.*, 2017; Pu *et al.*, 2019). The spatial structure of the tourism economy is driven by transportation, location, economic factors, and policy factors (Wu *et al.*, 2021; Li *et al.*, Liu *et al.*, 2022). Based on the study conclusions and on growth pole theory and point axis theory, optimization suggestions for the tourism spatial network structure are proposed:

First, core tourist cities should be developed to improve the coordinated development of regional tourism. According to the centrality analysis results, Xi'an, Zhengzhou, and Taiyuan occupy important positions in the overall network and are closely connected to the tourism economy in surrounding areas. Moreover, as the capital cities of Shaanxi Province, Henan Province and Shanxi Province, their location advantages are obvious, their levels of economic development are relatively high, and their tourism service facilities are complete. The influence of these tourism growth poles will expand, enabling these cities to become core cities, thus strengthening the tourism connections between Xi'an, Zhengzhou, Taiyuan and neighboring cities and driving the tourism development of neighboring cities. This situation, combined with the layered development idea, will allow Shangluo, Xianyang, Luoyang, Xuchang, Jinzhong, Yuncheng and other cities to develop new tourism growth poles, gradually realizing the coordinated tourism development of the urban agglomerations in the MRYP. High-quality capital, resources, technology, talent and advanced concepts of urban agglomerations should be integrated to enhance the carrying capacity of the tourism industry, expand new space for tourism, cultivate new kinetic energy for tourism, improve new tourism patterns, develop new tourism concepts, increase the tourism supply, and develop high-value tourism markets.

Second, groups designed to promote a diversified and large-scale brand effect should be developed. According to the analysis results of cohesive subgroups and structural holes, the brand scale effect can be formed through group development, and a tourism agglomeration area characterized by the Yellow River can be built by combining regional tourism advantages and similar tourism resources. A northern group of the MRYS (Taiyuan, Xinzhou, Yangquan, Jinzhong, Lvliang, Changzhi, Jincheng, Linfen, and Yuncheng), a southwestern group of the MRYS (Xi'an, Shangluo, Xianyang, Qingyang, Pingliang, Tianshui, Baoji, Tongchuan, Weinan), and a southeastern group of the MRYS (Zhengzhou, Xuchang, Xinxiang, Jiyuan, Luoyang, Luohe, Zhoukou, Bozhou, Shangqiu, Kaifeng, Jiaozuo, Pingdingshan) can be constructed. The distinctive geographic advantages of the Yellow River Basin should be promoted, and rich tourism resources such as ancient capitals, ancient cities and historic sites should be marketed. The northern group of the MRYS has ancient buildings with a long history, such as the ancient city of Pingyao and the Wang Family Courtyard, which can create an ancient architectural cultural tourism agglomeration area. The southwestern group of the MRYS contains the ancient capital of Xi'an, which has a profound red history and culture; this area can promote itself as a red history and cultural tourism agglomeration area. The southeastern group of the MRYS can exploit its geographic and transportation advantages, tap its tourism resources and innovate tourism products to create a modern smart tourism agglomeration area.

Third, the administrative boundaries should be disrupted, and a characteristic tourism network of the Yellow River should be built. The tourism economy network shows that the overall synergy is insufficient. The tourism economy of the major tourist cities has a large gap between the east and the west, and serious imbalances exist in the level of urban tourism economy development, with little interaction between core and peripheral cities. Shanxi Province has close connections with Shaanxi Province, and Henan Province has weak connections with Shaanxi and Shanxi Provinces. The construction of cross-regional expressway railways should be strengthened, and interprovincial barriers should be addressed to establish a tourism network that is co-constructed, shared and co-governed by four provinces. The formulation of the overall development plan for tourism in the urban agglomerations in the MRYS should be accelerated. Development planning should focus on strengthening tourism cooperation with outlying cities around travel agencies, tourist transportation, tourist routes and related technologies to create a new pattern of mutually beneficial tourism development and to narrow the development gap between the eastern, central, and western regions. In addition to those with the government, alliances among regional enterprises and universities can promote the integrated development of regional tourism.

Fourth, the development model of symmetry and reciprocity should be promoted to achieve the multi-win outcome of regional industrial development of "one for all, all for one". Governments at all levels can jointly sign strategic cooperation agreements on mutual customer source sharing, jointly carry out large-scale tourism promotions and customer source mutual sharing activities among travel agencies, jointly launch high-quality travel itineraries, encourage travel agencies in different areas to send tourists to each other, and develop a mechanism for sharing tourism promotion channels to disseminate tourism information to each other. The tourist exchange model of the MRYS urban agglomerations of "government promotion, enterprise management, market operation, and independent choice of tourists" can ultimately be established. All cities in the area can jointly launch a reciprocal policy for scenic spots. All the scenic spots in the area can launch discounted tickets for residents of the urban

agglomerations in the MRYSR or jointly launch an all-in-one card for scenic spot admission (annual pass for residents), thus providing special discounts for residents of the MRYSR urban agglomerations to visit tourist attractions in the region.

Limitations and Prospects

This study has several limitations. First, when the gravity model was used to measure the tourism economy connections between cities, the weights were mostly influenced by the intercity highway traffic distance, limited by the availability and usability of data. Moreover, the impact of complex transportation networks such as the aviation network and railway system on regional tourism space was neglected. Second, this study examined only the spatial network structure of the tourism economy. Additional urban agglomerations should be included in the sample for future studies. In addition, the spatiotemporal evolutionary characteristics of the spatial network structure of the tourism economy are worth further studying.

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MIESTŲ AGLOMERACIJŲ TURIZMO EKONOMINIO ERDVINIO TINKLO STRUKTŪROS VERTINIMAS

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SANTRAUKA

Sparčiai vystantis turizmo pramonei, ekonominis regionų tarpusavio ryšys tapo vis glaudesnis ir sudarė sudėtingą turizmo ekonomikos tinklų erdvinę struktūrą. Šiuo metu yra nedaug literatūros apie turizmo ekonomikų erdvinio tinklo struktūrą miestų klasteriuose, taip pat trūksta sisteminių tyrimų apie turizmo ekonomikos erdvinį tinklą miestų aglomeracijose, esančiose Geltonosios upės (MRYR) vidurupyje Kinijoje prieš ir po COVID-19 pandemijos. Naudojant 2019–2022 m. kaip laikotarpį remiantis gravitacijos modeliu, buvo sukurta turizmo ryšio matrica miestų aglomeracijoms MRYSR Kinijoje, o turizmo erdvinio tinklo struktūros vietos ir laiko charakteristikos buvo iširtos atliekant socialinių tinklų analizę. Rezultatai rodo, kad nuo 2019 iki 2020 m. turizmo ekonominio susisiekimo intensyvumas ir apimtis tarp miestų MRYSR sumažėjo. Aiškiai atskleidžiama erdvinė charakteristika, kai MRYSR yra stipri pietuose ir silpna miesto aglomeracijų šiaurėje, ir iš esmės susidaro vystymosi modelis, kuriam būdingas Taiyuan, Zhengzhou ir Xi'an dominavimas. Dėl COVID-19 pandemijos poveikio 2019–2022 m. sumažėjo turizmo ekonomikos junglumo tinklo tankis, bendra apimtis ir svarba miestų aglomeracijose MRYSR, o poliarizacijos charakteristikos buvo ryškesnės. Remiantis analizės rezultatais, rekomendacijos dėl turizmo ekonomikos erdvinės plėtros modelio miestų aglomeracijose MRYSR gali būti siūlomos iš trijų perspektyvų: pagrindinių miestų, klasterių plėtros ir turizmo tinklo. Turizmo ekonomikos erdvinio tinklo struktūros charakteristikų ir pokyčių vertinimas miestų aglomeracijose MRYSR yra naudingas tiriant lokalizuotą turizmo plėtros modelį.

REIKŠMINIAI ŽODŽIAI: gravitacijos modelis; socialinių tinklų analizės metodas; turizmo ekonomika; erdvinio tinklo struktūra; turizmo integracija; miestų aglomeracijos.