

Article

Intensity of Tourism Economic Linkages in Chinese Land Border Cities and Network Characterization

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Abstract: The purpose of this study is to analyze the characteristics of tourism economic links and networks within the tourism sector of China's land border cities. It seeks to reveal the spatial and temporal evolution of tourism economic links in order to facilitate regional coordination among border cities. The article adopts the modified gravity model to measure the degree of tourism economic linkage of China's land border cities, and utilizes UCINET 6.0 software, based on social network theory, to analyze the characteristics of the tourism economic linkage network of China's land border. The findings show that the overall network density of China's land border tourism economic linkages is relatively low, with uneven development in the "three borders" tourism economic linkages. There is a significant core-periphery structure, with the core area gradually expanding to the northwest and southwest, and geographically neighboring border cities are more likely to form a subgroup. The analysis of the socio-spatial network relationship of China's land border cities yields suggestions for coordinated regional development, providing a foundation for the sustainable development of land border tourism.

Keywords: border tourism; tourism economic linkages; tourism intensity; network structure; land border cities



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1. Introduction

In 1997, the Interim Administrative Measures on Border Tourism of the National Tourism Administration defined border tourism as tourism activities organized and received by approved travel agencies for citizens of China and adjoining countries, who collectively leave the country through designated border crossings and travel in the area and within the period of time agreed upon by the governments of both sides [1]. Subsequently, China's academics conducted in-depth research on border tourism, defining it as a tourism activity that involves crossing national borders through border crossings [2]. As domestic scholars' understanding of the concept of border tourism deepened, the conceptual scope of border tourism has also been gradually expanded. This expansion primarily involved broadening the scope of border tourism to include cross-border tourism between the two countries, allowing for the inclusion of a third country or even multiple countries. It also encompassed an expansion of the participants in border tourism, extending beyond neighboring countries and cross-border residents to include the residents of their own country and residents of other counties not geographically adjacent. Furthermore, the forms of border tourism activities are subdivided to include tours of the home country's border area and cross-border tourism in the various forms [3,4].

Early foreign studies on border tourism mainly focused on the economic, political and cultural impacts until the 1990s. Prof. Dallen J. Timothy of the University of Arizona

pioneered the systematic study of the relationship between borders and tourism, including the management and planning of border tourism, etc. [5]

In 2015, 193 member states of the United Nations adopted the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development, with 5 major areas relevant to the sustainable development of tourism. The comprehensive realization of sustainability and resilience in tourism development is the foundation and prerequisite for high-quality tourism development [6]. In recent years, foreign scholars have explored promoting the sustainable development of border tourism and its impact of border tourism on rural border areas [7–9], while domestic scholars have studied and analyzed the sustainable development of the Yunnan border region and the Sino-Vietnamese border region in China and proposed countermeasures for the sustainable development of the border region [10–12]. The sustainable development of border tourism is not only about the growth of the national economy but also about fostering of political relations with neighboring countries and the prosperity and stability of border communities [13].

Throughout the existing results, the social network analysis method is considered to be one of the most effective methods for studying the formation, evolution and interaction of tourism development and tourism spatial structure. It enables a comprehensive examination of the relationship and function between the nodes of the cities in the economic network of border tourism from a social network perspective [14,15]. In line with the research content and purpose of this paper, the modified gravity model is selected to depict the dynamic evolution trend of the spatial network structure of the border tourism economic linkage. This model is better suited for total tourism data and offers a more accurate reflection of the influence of geographic distance on the overall network structure. This paper takes China's land border prefecture-level cities (states, regions) and nine central provincial capitals as the study area. It involves constructing a modified gravity model, conducting in-depth analysis of the economic intensity and network characteristics of the tourism economic linkage network of China's land border cities using social network analysis, and visualizing the findings using ARCGIS10.7 software.

The research objective of this paper is to analyze the characteristics of tourism economic linkages and networks in China's land border cities. It seeks to uncover the spatial and temporal evolution of tourism economic linkages in each border city (state, region), with the ultimate goal of providing insights for the sustainable development of the border tourism economy.

The novelty of this paper lies in its research method and scope. In terms of research scope, the existing research on the tourism economy mainly focuses on city clusters and economically developed areas along the Yangtze River, and there are fewer studies on the spatial structure of the tourism economy in remote land border areas. Additionally, existing studies often have a limited scope, typically confined to a single province or national provincial area. In contrast, this paper refines its research scope by selecting 45 border prefecture-level cities in China. In terms of research methodology, this paper constructs the tourism economic linkage network of China's land border cities, considering both time and space dimensions. It delves deeper into the analysis of the overall network and individual network.

This paper consists of six parts. The first part outlines the key insights and research methodology to the spatial structure of tourism and border tourism. Section 2 presents the literature review. Section 3 details the research methodology, data acquisition, and study area. Section 4 describes the results derived from the modified gravity model and the social network analysis method. Section 5 discusses the findings of this paper in relation to the existing research results. Finally, Section 6 draws conclusions based on the analysis and proposes countermeasures to optimize the economic linkage network of land border tourism in China.

2. Literature Review

Research from as early as 1960 examined the spatial structure of tourism economy, focusing on the regional differences and spatial differentiation characteristics of tourism economic development [16,17]. On the one hand, it aims at the research of cultural tourism and the spatial distribution pattern of tourism supply, and, on the other hand, it concentrates on the research of the spatial network relationship of the tourism economy, which mostly adopts the gravity model, the social network analysis, the GIS method and so on. The main objects of research are the tourism flow, tourist attractions and so on [18–20].

For instance, Hwang Y H explored the tourism multi-city model using social network analysis in the United States as an example [21]; Scotten analyzed the structural characteristics of inter-organizational networks within tourism destinations with the help of social network analysis, taking Australia as an example [22]; García-Palomares analyzed the tourism potential of European hotspot cities based on social networks, using GIS technology and photo sharing [23]; Sanghoon and Leung X Y used social network analysis and GIS methods to visualize the spatial structure of the tourist attraction system and the spatial behavior of tourists in Korea and Beijing, China, respectively [17,24].

Domestic research on the spatial structure of tourism economy began in 1980, and the commonly used methods include gravity model, social network analysis, Dubin spatial model, geographic detector, Gini coefficient, Terre index, coefficient of variation, and constructing the evaluation index system, etc. [25–35]. The object of the research involves the flow of tourism, tourism scenic spots, rural tourism, etc., and the scope of the research is mainly focused on the provinces, cities and special economic zones, etc. [36,37]. Ma L J, Yan H L et al. analyzed the spatial structure of tourism economy and the interaction of spatial differences in the evolution of cities in the Yangtze River Basin [38,39].

Land border cities plays a crucial role in China's land border tourism economic linkage network and are integral to the regional spatial structure of border tourism economy. With over 20,000 km of land border, China's border areas boast unique natural and human resources shaped by geographical location and cultural diversity, which in turn drive the development of border tourism through border trade.

Domestic research on China's land border tourism is becoming increasingly comprehensive. For instance, Zhang S R analyzed the development pattern of border tourism in terms of spatial variability and spatial autocorrelation by taking Chinese land border provincial cities as the research object, and the results showed that topographic conditions, cultural diversity, location conditions, and international geopolitical relations are important influencing factors affecting the development of border tourism [40].

Similarly, Liu M K analyzed the spatial differentiation characteristics of the vulnerability of the tourism economic system in China's border areas with the help of geo-detectors, and the results showed that the local development water quality, the tourism development status and the degree of opening up to the outside world are the important reasons for the vulnerability of the tourism economy [41].

Additionally, Huang A L et al. analyzed the spatial pattern and evolutionary characteristics of tourism economic linkages in China's border provinces using the modified gravity model and social network analysis, and the results demonstrated that the shape of the spatial network structure of the tourism economy has a significant impact on the effectiveness of the overall tourism economic development in China's border provinces [42]. Building on this foundation, this paper further refines the scope of the study to investigate the tourism economic network of Chinese border prefecture-level cities and explore the tourism economic linkages among Chinese land border cities. Meanwhile, it incorporates data from central cities for comparison to analyze the tourism economic links between central cities and border cities.

3. Materials and Methods

3.1. Study Area

China's land borders are long and continuous, distributed in the northeast border economic zone, northwest border economic zone and southwest border economic zone. The specific distribution and bordering countries are shown in Table 1.

Table 1. Distribution of China's land border cities and neighboring countries.

Area	Provinces	Land Border Prefecture-Level Cities	Bordering Countries
Northeastern	Liaoning	Dandong	DPRK, Russia, Mongolia
	Jilin	Baishan, Tonghua, Yanbian Korean Autonomous Prefecture (YBKAP)	
	Heilongjiang	Da Hinggan Ling Prefecture (AHLP), Heihe, Yichun, Hegang, Jiamusi, Shuangyashan, Jixi, Mudanjiang	
	Eastern Inner Mongolia Autonomous Prefecture	Hulunbeier, Xing'an League (XAL), Xilin Gol league (XLGL)	
Northwestern	Gansu	Jiuquan	Russia, Mongolia, Kazakhstan, Tajikistan, Kyrgyzstan, Afghanistan, Pakistan, India, Nepal, Bhutan
	Tibet	Linzhi, Shannan, Shigatse, Ali area	
	Xinjiang	Hotan area (HA), Kashgar region (KR), Tacheng District (TD), Altay region (AR), Aksu region, Hami, Kizilsu Kyrgyz Autonomous Prefecture (KKAP), Ili Kazakh Autonomous Prefecture (IKAP), Bortala Mongol Autonomous Prefecture (BMAP), Changji Hui Autonomous Prefecture (CHAP)	
	Western Inner Mongolia Autonomous Prefecture	Baotou, Ulanqab, Bayannur, Alxa League (AL)	
	Yunnan	Wenshan Zhuang Autonomous Prefecture (WZAP), Honghe Hani and Yi Autonomous Prefecture (HHAYAP), Xishuangbanna Dai Autonomous Prefecture (XDAP), Dehong Dai and Jingpo Autonomous Prefectures (DDAJAP), Nujiang Lisu Autonomous Prefecture (NLAP), Pu'er, Lincang, Baoshan	
Southwestern	Guangxi	Baise, Chongzuo, Fangchenggang	Vietnam, Laos, Myanmar

3.2. Data Source and Processing

Based on the purpose of this paper, the content of the study and the availability of data, the years 2005, 2010, 2016 and 2019 were selected as the time cross-section. The sources of data such as total tourism revenue and total tourism trips involved are the same as the statistical yearbooks of tourism in each border province and city, the Statistical Bulletin of National Economic and Social Development of each region, the official website of the regional government, and the statistical yearbooks of the nine provinces and districts along the borders. For a few border cities (states and districts) with no statistical data, the three-time Elmit interpolation method in the software MATLAB2022b was used for prediction. Transportation network data were obtained from the Baidu map and Lutong APP. After calculating the degree of tourism economic linkage between each land border city (state, region) through the formula, a 54×54 tourism economic linkage matrix was obtained, which was converted into a two-valued relationship matrix recognizable by the UCINET6.0 software for analysis using the row mean as the queue value.

3.3. Methodology

The modified gravity model serves as an important method to study the tourism economic linkage, while the social network analysis method mainly explores the relationship characteristics in the overall network of border tourism. By combining these two methods, this paper effectively analyzes the scientificity and reasonableness of the structural characteristics of the economic linkage network of China's land border tourism. In this paper, the modified gravity model is used to quantitatively measure the degree of tourism economic linkage and the amount of tourism economic linkage between China's land border cities and their central provincial capitals, on the basis of which the resulting tourism economic linkage is subjected to the corresponding data processing, which is further used to measure the density of the network, the centrality, the core–edge structure, the cohesive subgroups, the structural holes, etc., of the space of tourism economic linkage of China's land border cities (states and regions).

3.3.1. Modified Gravitational Model

The famous geographer T. F. Taaffe argued that the strength of economic ties was directly proportional to its population and inversely proportional to the square of its distance [43]. According to the gravity model, experts, both domestically and internationally, have proposed theories and methods such as the basic gravity model, comprehensive scale, diffusion potential, etc., and establish an economic intensity model and tourism economic intensity model by using population index, income index, road network distance, etc., so as to analyze the economic linkage between cities and the intensity of the tourism economic linkage and the total amount of economic linkage [44,45]. This paper refers to the existing research results, with the help of the modified tourism economic gravity model, to measure the degree of tourism economic linkage and interaction between different border cities based on the total tourism income, total number of tourists and the geographical distance between border cities [32,46]. The formula is as follows:

$$R_{ij} = k \frac{\sqrt{P_i V_i} \sqrt{P_j V_j}}{D_{ij}^2} \quad (1)$$

where R_{ij} is the intensity of tourism economic ties between the two land border cities; P_i and V_i , respectively, represent the total number of tourist trips and the total income of tourism in city i ; P_j and V_j , respectively, represent the total number of tourist trips and the total income of tourism in city j ; k is a constant 1; D_{ij} represents the geographic distance between city i and the city on. In the determination of geographical distance, we use the distance between the train stations of two border cities as a criterion, with the railroad distance obtained from the software. In cases where border cities lack a train station and the rail distance is unavailable, we supplement this with the highway distance between the two city governments, obtained using Baidu's mapping software.

In measuring the intensity of tourism economic ties between the two land border cities, calculating tourist spending between two cities is challenging. As an alternative, we use the total tourism economy and geographical distance to establish a gravitational force between them and derive new values. This economic linkage represents a mutual attraction between the two economies. In the gravity model, the two total tourism economies are denoted as M_1 and M_2 , and the gravitational pull of these two economic aggregates is inversely proportional to the square of their distance. G is a constant 1. Thus, the gravitational relationship between them is studied using this equation.

3.3.2. Social Network Analysis

The social network analysis method is employed to investigate the structural properties of the network by conducting in-depth analysis of individual relationships in the network [47]. This encompasses the overall structure of the network and the network relationships between individuals. In the overall network analysis, key indicators include

network density, core–edge structure and cohesive subgroups. On the other hand, in the individual network analysis, centrality analysis and the structural hole level are the key indicators.

Network Density

Network density is an indicator that reflects the degree of connection between the nodes of the tourism economic network in border cities. It is used to determine whether the overall network of the border tourism economy is compact or decentralized, with a range of values [0, 1]. The results of the study show that the higher the network density, the closer the tourism economic links between the border cities, which leads to a more centralized form of tourism economy, and a smaller density yields the opposite result; the formula is as follows:

$$D = n / (m - 1) \quad (2)$$

In the formula, D is the network density, n is the number of relationships actually contained in the tourism economic network, and m is the number of node cities.

Core–Edge Structure Analysis

The main purpose of the core–edge model is to gain a deeper understanding of the geographic location characteristics of the border city nodes in the network, so as to determine whether these nodes are located in the core or edge regions of the network, and to further study the interconnections between border cities and between border cities and central cities.

In the border tourism economic linkage network, the core area represents that the area is in a dominant position within the overall network. It has good advantages in terms of the importance of location conditions, availability of tourism resources, and transportation accessibility, which can radiate and drive the neighboring border cities. The marginal zone indicates that the region is in a passive position in the network and is strongly influenced by the core zone and reliant on the core zone to drive the tourism economic linkage.

Network Cohesion Subgroup Analysis

“Structural holes” are used to describe non-redundant links between two border cities in a network. Taking the tourism economic linkage network of land border cities as an example, when a border city establishes a linkage with two other border cities, there will not be any linkage between these two cities, while a structural hole will be formed between the three border cities. When evaluating the level indicators of the structural hole, the key considerations are the effective size, efficiency, and constraint. Effective size refers to the size of the individual network minus its redundancy of the network, i.e., the non-redundant elements of the network. Efficiency is calculated as the effective size of the node divided by the actual size of the individual network in which the point is located. Constraint measures the extent to which the point can leverage structural holes or negotiate within the individual network. The border city node with higher efficiency and effectiveness, and constraint, indicates a more dominant role with less influence from other node cities in the network.

Centrality

Centrality is a measure of the degree of centrality of a land border city in the overall network. Centrality includes degree centrality, proximity centrality, and intermediate centrality. Degree centrality refers to the total number of direct connections between a border city and other border cities; the higher the value, the greater the power of the city and the more obvious the degree of centrality. The degree of proximity centrality refers to the sum of the contact distance between a border city and all other border cities, and a higher value means that it is the closest to any other city and has more frequent with the contact with other cities, which is also spatially reflected in the center position. The intermediate centrality refers to the fact that the overall network of land border tourism

economy contains several city subgroups, and cities with high intermediate centrality play the role of connecting these subgroups, and the higher the value, the stronger the intermediary role. The formula is shown in Table 2.

Table 2. Centrality index.

Centrality Indicators	Formula	Description of the Formula
Degree Centrality	$C_{PD}(i) = c_{PD}(i) / n - 1$ (3)	$C_{PD}(i)$ is the degree center degree of the node and n denotes the number of other points in the network connected to i
Closeness Centrality	$C_{ni} = [\sum d(ni, nj)]^{-1}$ (4)	C_{ni} is the proximity centrality of the node; $d(ni, nj)$ denotes the shortest distance between point i and point j
Betweenness centrality	$C_{Rbi} = \frac{2\sum_j^n \sum_k^n b_{jk}(i)}{n^2 - 3n + 2}$ (5)	C_{Rbi} is the relative median centrality of point i ; $b_{jk}(i)$ indicates that the shortest path from j to k passes through i . The denominator indicates the number of paths between the two points, i.e., the number of all paths

Structural Hole Analysis

“Structural holes” are used to describe non-redundant links between two border cities in a network. Taking the tourism economic linkage network of land border cities as an example, when a border city establishes a linkage with two other border cities, there will not be any linkage between these two cities, while a structural hole will be formed between the three border cities. When evaluating the level indicators of the structural hole, the key considerations are the effective size, efficiency, and constraint. Effective size refers to the size of the individual network minus the redundancy of the network, i.e., the non-redundant elements of the network; efficiency is equal to the effective size of the node divided by the actual size of the individual network in which the point is located; and the constraint is the degree to which the point possesses the ability to utilize the structural holes or the ability to negotiate in the individual network. The border city node with higher efficiency and effectiveness, and constraint, indicates a more dominant role with less influence from other node cities in the network.

4. Results

4.1. Degree and Volume of Tourism Economic Linkages in Chinese Land Border Cities

Tourism Economic Linkages

In this paper, the change in the total amount of tourism economic linkages in China’s land border cities from 2000 to 2019 is analyzed, considering the completeness and comparability of the node data, as well as national policies supporting the development and opening of key areas along the border. The years 2005, 2010, 2016, and 2019 are chosen as the time cross-section for measuring the intensity and total amount of tourism economic linkages among land border prefecture-level cities and between them and their central provincial capitals. The analysis is spatially visualized and expressed using the ARCGIS natural breakpoint method.

1. Uneven Development of “Trilateral” Tourism Economic Linkages

Based on the spatial evolutionary history of the intensity of tourism economic ties between prefecture-level cities (states and regions) along China’s land borders in 2005, 2010, 2016, and 2019 (Figures 1–4), the border cities along the Northeast Border Economic Belt have consistently maintained close ties, with Shenyang-Tonghua and Shenyang-Dandong being relatively close, while Changchun-Dandong, Harbin-Mudanjiang, Harbin-Hulunbeier, Changchun-Dandong, Harbin-Mudanjiang, Harbin-Hulunbeier, and Changchun-Yanbian Prefecture, and many other pairs of inter-city links are moderately high. The Southwest border economic zone has been closely followed, as shown in Figure 1 2016, with Nanning-Chongzuo, Nanning-Fangchenggang, Kunming-Honghezhou, Xishuangbanna-Pu’er, Xishuangbanna-Kunming and other pairs of cities to achieve economic ties to catch up with the northeast

border economic zone, breaking the phenomenon of its “monopoly on the top”. The northwest border economic zone shows growth in tourism economic ties, but due to a smaller base, it has remained at the lower end nationally, especially Urumqi-Changji Prefecture, Urumqi-Ili Prefecture, and Kexue-Kashi region, where in the early contact it is slightly more obvious, and Lhasa-Shannan, Lhasa-Shigatse, Lanzhou-Jiuquan, and Lanzhou, Alxa League are the four pairs of cities in the latter part of the growth of the larger, but overall still present the “Outliers” state. Overall, the development of tourism and economic ties within the three major border economic zones appears unbalanced.

2. Central Cities Remain Central

From 2000 to 2022, of the total tourism economic ties between the border cities and the center of the city ranked as the top 20, the center of the capital city occupies the top three of the sky; Changchun, Shenyang, Harbin, Kunming, and Nanning are five provincial capitals from the beginning to date to assume the core of the tourism economic ties of the border cities, to radiate to the surrounding area, driving the development of tourism in the border cities. Due to their social, economic, cultural and transportation advantages, the central provincial capitals spread their resources, increase the tourism influence of the border cities, and become the link between the border cities and the inland cities. Even in the northwest region, where the degree of connection is relatively low, the development of the three provincial capitals of Lhasa, Urumqi and Lanzhou has played a crucial role in driving the growth of tourism and economic ties with neighboring border cities such as Changji Prefecture, Shannan, Rikaze, Jiuquan and Alxa League. The sustainable development of central cities leads to rural tourism in neighboring border cities, aligning with the objective of sustainable tourism development in terms of boosting tourism revenue and providing employment opportunities.

3. Enhanced Tourism Economic Linkages in Neighboring Cities

Driven by the central city, the tourism and economic ties between geographically close border cities and border cities began to rise, and even border cities exceeded the ties with the central city, forming a new “small group”. For example, in 2019, Xishuangbanna-Pu’er, Wenshanzhou-Honghezhou, and Lincang-Baoshan formed a “small group in the southwest”. Additionally, cities like Kexu and Kashgar, despite being farther away from the center of the provincial capital city, have developed strong ties with its center city due to geographical proximity, indicating a “group warming” trend. The geographical distance between border cities in the northeast border economic zone is small compared to the northwest border economic zone; Jixi-Yichun, Tonghua-Dandong, Tonghua-Baishan and other neighboring cities have also seen a growing level of interaction, in the context of the development of the national tourism implementation, the formation of regional tourism integration, and complementary resources, and drive the development of border tourism economy. The practice of ecological civilization and the formation of a virtuous cycle among border tourism cities represent significant strides towards achieving sustainable tourism development.

4.2. Social Network Analysis

4.2.1. Network Density Analysis

The 54×54 two-value matrix was imported into UCINET software, and the network density was analyzed along the “Network-Density” path; the results are shown in Table 3.

Table 3. Tourism economic connection network density of China’s land border cities from 2005 to 2019.

Particular Year	Densities	Growth Rate/%
2005	0.1191	-
2010	0.1366	14.69
2016	0.1461	6.95
2019	0.1488	1.85

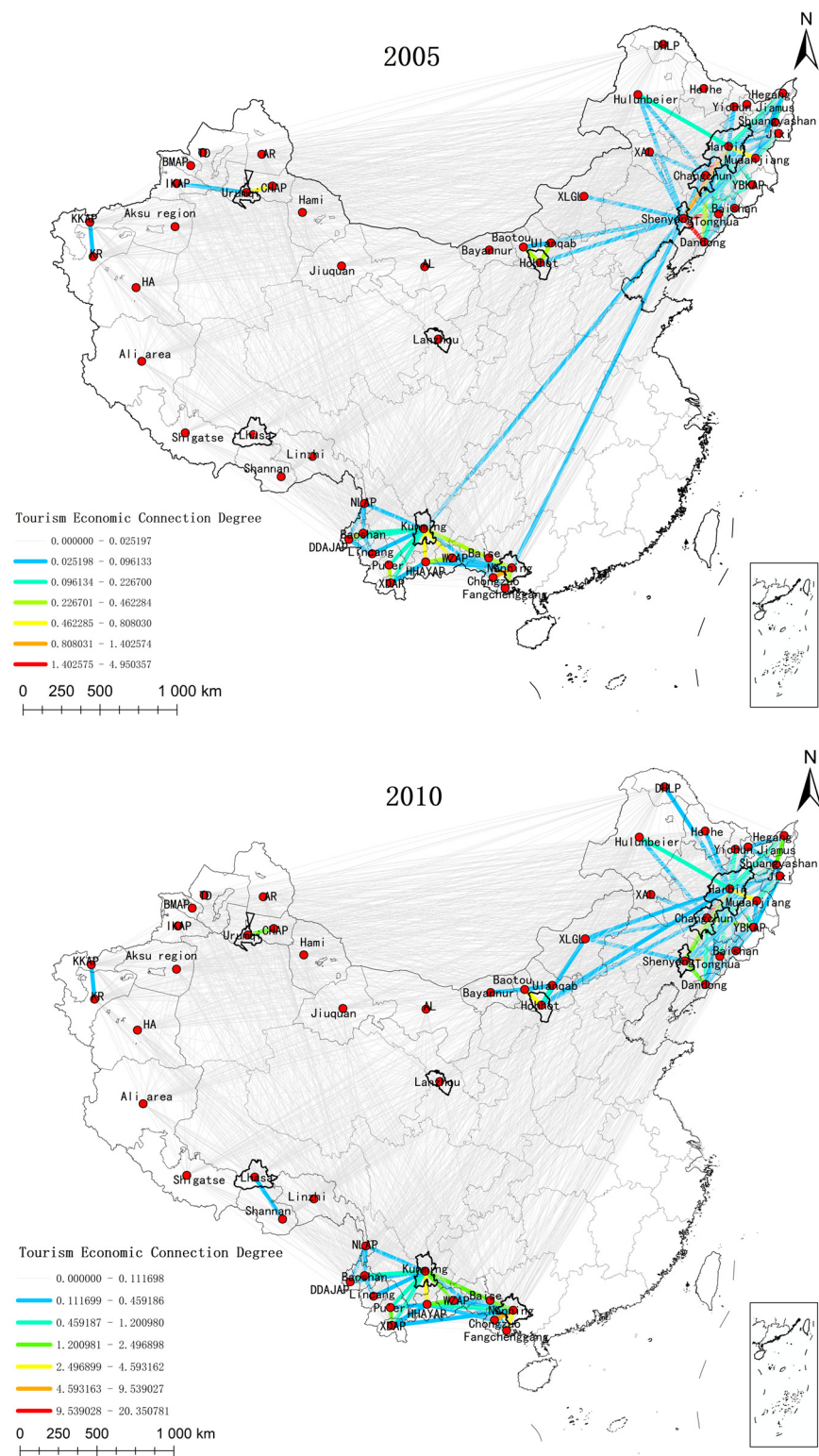


Figure 1. Cont.

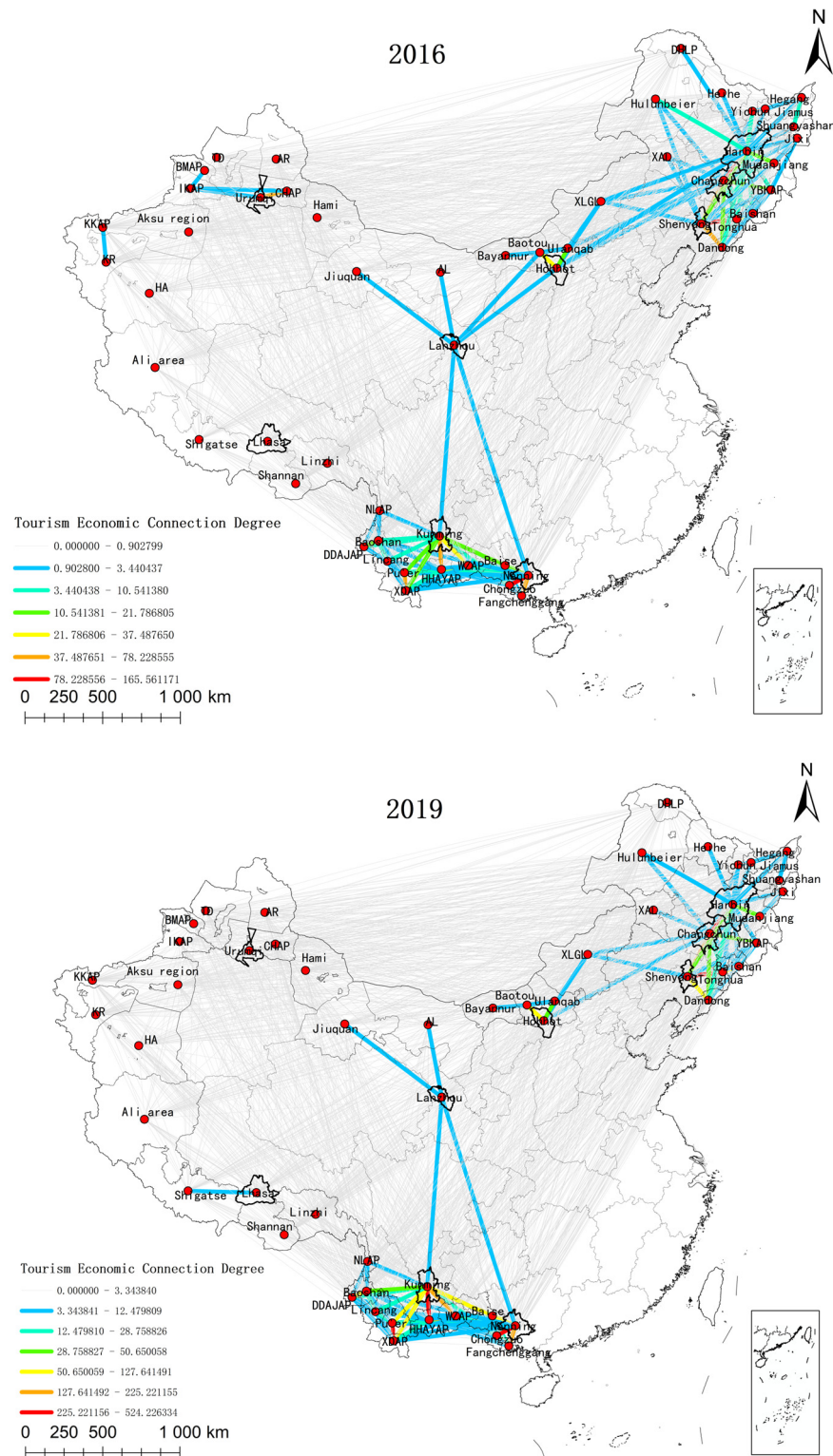


Figure 1. Intensity of tourism economic ties in China's land border cities.

During the period of 2005–2019, the network density of tourism economic linkages in China's land border cities increased year by year, from 0.1191 in 2005 to 0.1488 in 2019, with a growth rate of 24.94%, but the growth rate was relatively slow. In terms of the overall value, the network density value is lower than 0.5, hovering only around 0.1, which indicates that the overall network structure is relatively loose and the degree of tourism economic linkage among the border cities is low, suggesting that there is still a lot of

room for improvement in the structure of the tourism economic network of China's land border cities.

4.2.2. Core–Edge Structure Analysis

The 54×54 two-value matrices were imported into UCINET software, and the core–periphery model was analyzed along the “network–core–periphery” path. The analysis of the core–periphery structure is based on the degree of connection of border tourism economy to determine whether the border node city is located in the center or the periphery of the network (see Tables 4 and 5), with the following general characteristics:

1. The core–edge structure is remarkable

Table 4. Core–edge structure of tourism economic connection network of China's land border cities.

Area	2005 Core Area	2010 Additional Core Areas	2016 Additional Core Areas	2019 Additional Core Areas
Northeastern	Baishan, Tonghua, Yanbian Korean Autonomous Prefecture, Changchun, Dandong, Shenyang, Yichun, Heihe, Shuangyashan, Mudanjiang, Jixi, Jiamusi, Harbin, Hulunbeier	Hegang	Xilin Gol league	-
Northwestern	-	-	Jiuquan, Lanzhou	Ili Kazakh Autonomous Prefecture, Ali Region
Southwestern	-	-	Kunming	Baise, Nanning, Honghe Hani and Yi Autonomous Prefecture

Table 5. Density matrix of core area and marginal area of tourism economic connection network of China's land border cities.

Particular Year		2005		2010		2016		2019	
Contact Density		Core Figure	Interface	Core Figure	Interface	Core Figure	Interface	Core Figure	Interface
Core figure		0.44	0.005	0.516	0.007	0.404	0.069	0.35	0.088
Interface		0.129	0.119	0.109	0.149	0.183	0.119	0.224	0.072

The “core–edge” structure is highly pronounced in the tourism economic linkage network of prefecture-level border cities in China. From 2005 to 2019, Tonghua, Yanbian Prefecture, Dandong, Yichun, Mudanjiang, Jixi, and the central provincial capitals of Changchun, Shenyang, and Harbin consistently occupy central positions in the network, signifying significant dominance. By 2005, the core area includes 14 cities, Baishan, Tonghua, Yanbian Prefecture, Changchun, Dandong, Shenyang, Yichun, Heihe, Shuangyashan, Mudanjiang, Jixi, Jiamusi, Harbin and Hulunbeier. By 2010, the city of Hegang was added, and in 2016, in addition to Xilingol League, there was growth in the northwest and southwest, including Jiuquan, Lanzhou, and Kunming. By 2019, the development increased to 20 core zones, with the northeastern border economic zone occupying 12 cities, the northwest and southwest each occupying 4 cities, and the 5 border cities (regions, states) of Ili Prefecture, Ali Prefecture, Baise, Nanning, and Honghe Prefecture representing new core zones. Overall, there are fewer core zones than edge zones.

2. The core area gradually extends to the northwest and southwest

Between 2005 and 2019, the number of core zones in China's land border cities' tourism and economic linkage network gradually increased, with most of the border cities in the

northeast border economic zone maintaining their core status, while gradually extending to the southwest and northwest. The dominance of the northeast in the core area in 2005 has evolved to a more balanced distribution by 2019. For example, in 2005, 2010 and 2016, Baishan in the northeast remained the core area, but in 2019, with the rapid development of the northwest and southwest, Baishan has become a marginal area, indicating gradual weakening of its core position in the border tourism economic linkage network.

3. The impact of the core zone on the tourism economy of the marginal zone has increased

As shown in Table 4, from 2005 to 2019, the connection density of cities in the core zone of the network structure ranged from 0.44 to 0.35, and the connection density of cities in the fringe zone ranged from 0.119 to 0.072; moreover, the value of the connection density decreased, and both were small. However, the connection density of the core area and the marginal area increased from 0.129 to 0.224 in 2005, indicating a closer interaction and a stronger connection between the cities in the core area and the cities in the marginal area. This suggests an increasing radiation effect of the cities in the core area on those in the marginal area, as well as a growing spillover effect of the tourism economy.

4.2.3. Analysis of Network Cohesion Subgroups

The 54×54 two-value matrices were imported into UCINET software, and the cohesive subgroups of China's land border cities' tourism and economic linkage network were analyzed along the "Network-Concor" path (Tables 6–10), with the following characteristics:

1. Geographically Neighboring Border Cities Are More Likely to Form a Subgroup

In Figure 2, the cohesive subgroups of the tourism economic linkage network of China's land border cities are depicted in the tree diagram for the years 2005–2019. At both level 2 and 3, the division of the cohesive subgroups in each year is extremely similar, the regional spatial organization of the shape of the region is extremely consistent, and the elements of the border cities in the subgroups are relatively stable (e.g., Table 6), and the geographic location of cities within the subgroups is close to each other, which facilitates easy exchange of tourism and economic activities and fosters a close relationship with the tourism economy.

Table 6. Distribution of condensed subgroups of tourism economic connection networks of China's land border cities from 2005 to 2019.

Cohesive Subgroup	Regional Distribution
subgroup 1	Heilongjiang, Jilin, Liaoning, eastern Inner Mongolia Autonomous Region
subgroup 2	Eastern Inner Mongolia Autonomous Region, Western Inner Mongolia Autonomous Region
subgroup 3	Guangxi, Yunnan, Tibet South
subgroup 4	Xinjiang, Gansu, Mongolia West, Tibet North

2. Border Region's Tourism Economy "Embraces the Warmth"

Within the same subgroup, the tourism economic linkages among border cities are closer, and the mutual influence among individuals is more significant. The linkage density analysis in Tables 7–10 reveals that the overall density of the cohesive subgroups is increasing year by year, which indicates a positive and balanced development in the network of tourism economic linkages in China's land border cities.

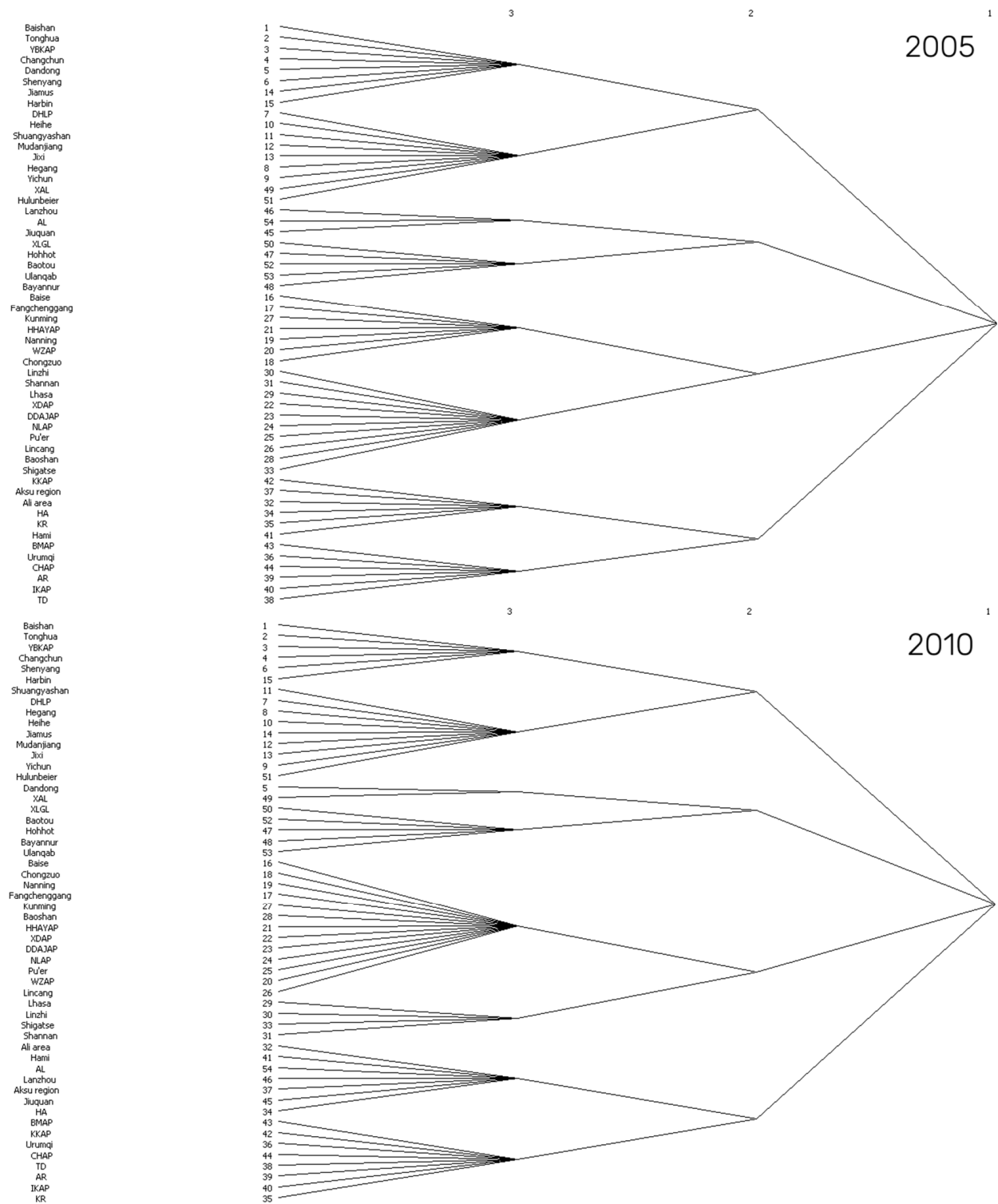


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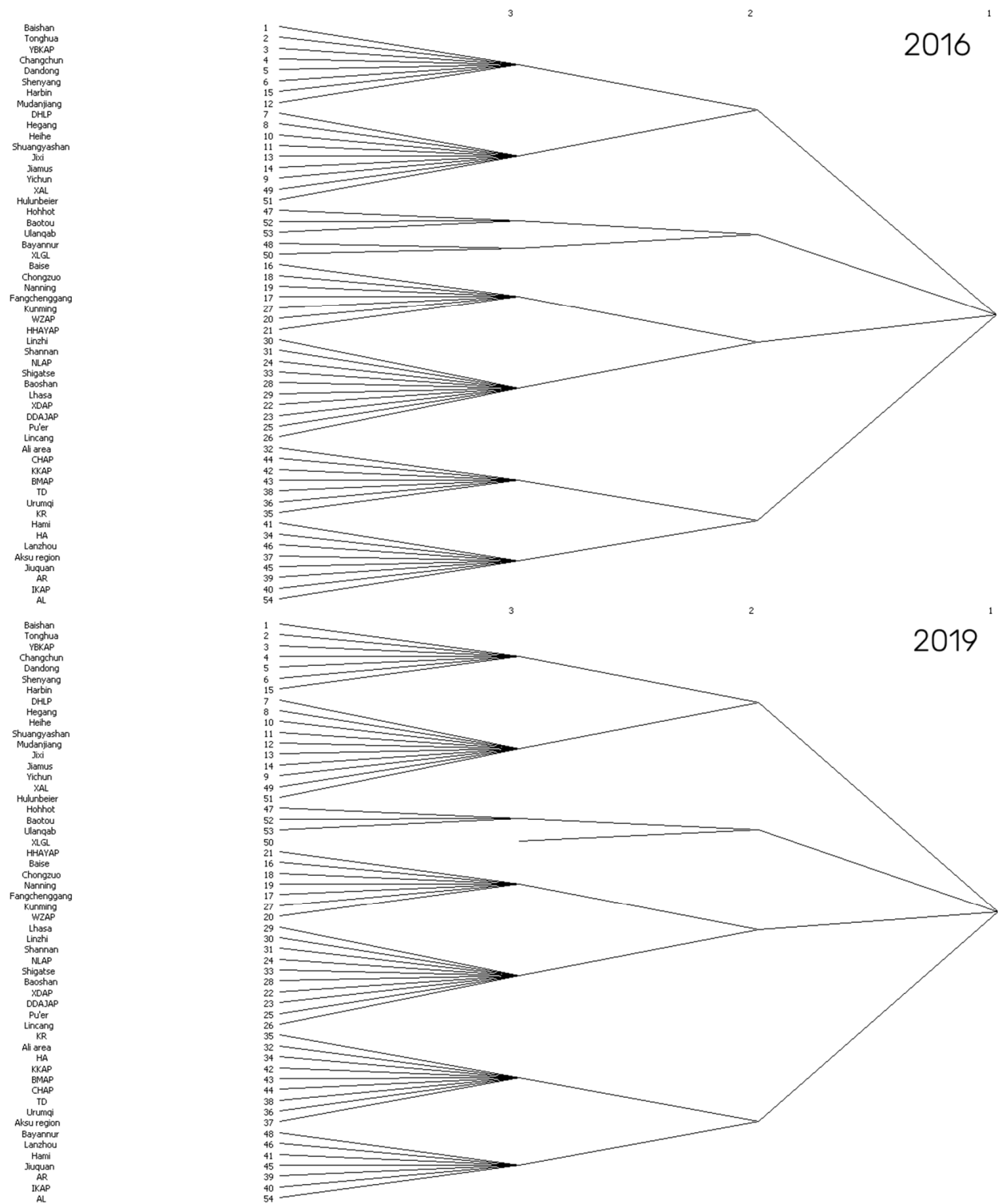


Figure 2. Bifurcation map of condensed sub-groups of tourism economic connection network of China's land.

Table 7. Density matrix of condensed subgroups of tourism economic connection network of China's land border cities in 2005.

Subgroup	1	2	3	4	5	6	7	8
1	0.5	0.121	0	0	0	0	0	0
2	0.621	0.373	0	0.026	0.013	0	0	0
3	0.375	0	0.333	0	0.071	0	0.036	0.75
4	0.429	0.013	0	0.405	0.041	0	0.02	0.036
5	0	0	0	0	0.643	0	0	0
6	0.083	0	0	0	0.375	0.393	0.089	0.031
7	0.357	0	0.143	0.204	0.306	0.107	0.095	0.536
8	0.083	0	0.375	0	0.071	0	0.036	0.417

Table 8. Density matrix of condensed subgroups of tourism economic connection network of China's land border cities in 2010.

Subgroup	1	2	3	4	5	6	7	8
1	0.8	0.148	0.167	0	0	0	0	0
2	0.574	0.611	0	0.022	0.009	0	0	0
3	0.833	0.111	0.5	0.2	0	0	0	0
4	0.367	0.022	0.2	0.8	0.031	0	0.029	0
5	0	0	0	0	0.442	0	0	0
6	0.083	0	0	0	0.231	0.917	0.036	0
7	0.405	0	0	0.514	0.231	0.107	0.357	0.339
8	0.125	0	0	0.075	0.058	0	0.071	0.446

Table 9. Density matrix of condensed subgroups of tourism economic connection network of China's land border cities in 2016.

Subgroup	1	2	3	4	5	6	7	8
1	0.768	0.042	0	0	0	0	0	0
2	0.708	0.458	0	0.111	0.016	0	0	0
3	0.167	0	1	0.667	0	0	0	0.83
4	0.5	0.111	1	0.5	0.071	0	0	0.25
5	0	0	0	0	0.786	0	0	0
6	0.05	0	0	0	0.457	0.014	0.014	0.075
7	0.036	0.016	0	0	0.061	0.357	0.357	0.161
8	0.25	0	0.417	0.188	0.286	0.304	0.304	0.411

Table 10. Density matrix of condensed subgroups of tourism economic connection network of China's land border cities in 2019.

Subgroup	1	2	3	4	5	6	7	8
1	0.875	0.057	0	0	0	0	0	0
2	0.729	0.5	0	0.2	0.014	0	0	0
3	0.143	0	1	0.667	0	0	0	0.19
4	0.714	0.2	1	0	0.286	0	0	0.143
5	0	0	0	0	0.833	0.1	0	0
6	0	0	0	0	0.429	0.433	0	0.071
7	0.111	0	0	0.204	0.222	0.067	0.125	0.333
8	0.408	0	0.714	0	0.408	0.014	0.079	0.595

4.2.4. Centrality Analysis

According to Formulas (3)–(5), the 54×54 two-value matrix was imported into UCINET software, and the centrality results were obtained along the path of “Network-

Centrality-Degree". The spatial visualization was expressed by using ARCGIS inverse distance weight interpolation method (Figure 3), yielding the following result.

1. Degree Centrality

Degree centrality, which measures the number of connections a border city node has with other border cities, emphasizes the individual value of a border city node. Figure 3 illustrates that the degree centrality degree of China's inland all-level border cities and central provincial capital cities between 2005 and 2019 keeps growing, with the total value of degree centrality degree growing from 554 in 2005 to 658 in 2019, indicating a relatively rapid growth rate. However, in 2019, the Kizilsu Kirghiz Autonomous Prefecture remained at 1, and the Bortala Mongol Autonomous Prefecture declined to 1, indicating that the degree of tourism and economic ties between these two border states and other border cities has not been enhanced, and they remain in an outlier state. This highlights the need for the tourism and economic ties of the border cities in the northwest region.

2. Closeness Centrality

Closeness centrality refers to the inverse of the sum of the distances between a border city node and other border city nodes in the network. A larger value indicates a more central position and faster reachability to other border city nodes. It also measures the degree of a city's independence from other border cities in the tourism and economic network, which emphasizes the value of the border city nodes in the overall tourism and economic linkage network. From Figure 4, it can be seen that from 2005 to 2019, the proximity centrality of the tourism economic linkage network of prefecture-level border cities along the Chinese border showed an upward trend, with the average value increasing from 11.03 in 2005 to 20.56 in 2019. By 2019, 37 out of the 45 prefecture-level border cities in China had a closeness centrality higher than the average value, which indicates that most of the border tourism cities have been able to connect with other border cities more quickly after years of efforts. Efforts have led to the establishment of tourism economic relations with other urban nodes relatively quickly, with cities like Dandong, Tonghua, and Baishan serving as core connectors to southwest Baise, Chongzuo, Fangchenggang. Similarly, Ulaanchab City acts as the core connector to Jiuquan, Changji Prefecture, and Yili Prefecture, while Shannan serves as the core connector to Baoshan, Hotan area. This has facilitated the formation of a national border tourism economic linkage closed loop between northeastern, northwestern, and southwestern border cities, driven by unique locational conditions. This has enabled information sharing between border cities and improved access to resources.

3. Betweenness Centrality

The betweenness centrality degree refers to whether the shortest distance between other border cities passes through a certain border city node. If it does, it means that this point is important, emphasizing its regulating ability of the border city node between the other nodes, controlling ability, and intermediary regulating effect. From Figure 5, it is observed that from 2005 to 2019, the average value of betweenness centrality tends to stabilize, or even shows a downward trend. In 2005, the average value of intermediate centrality is 29.074, indicating that the average number of times each border city node as a node of the other cities in the network for the intermediary of the tourism and economic linkage is 29.074, and the intermediate centrality of Harbin City is the highest, amounting to 460.5 times, which is in absolute dominance, indicating that Harbin has the strongest control over other border city nodes as a bridge intermediary in the network's economic ties. By 2010 and 2016, the central city still occupies a dominant position, and the intermediate centrality degree of land border cities such as Yichun City, Hulunbeier City, Xilingol League, Lanzhou City and Kunming City has a larger growth and a stronger intermediary effect. The average value of intermediate centrality degree in 2019 is 28.019; except for the central provincial capital city, only seven border cities are more than the average value, and there are nine cities with an intermediate centrality degree of 0, which are in the network in an isolated state.

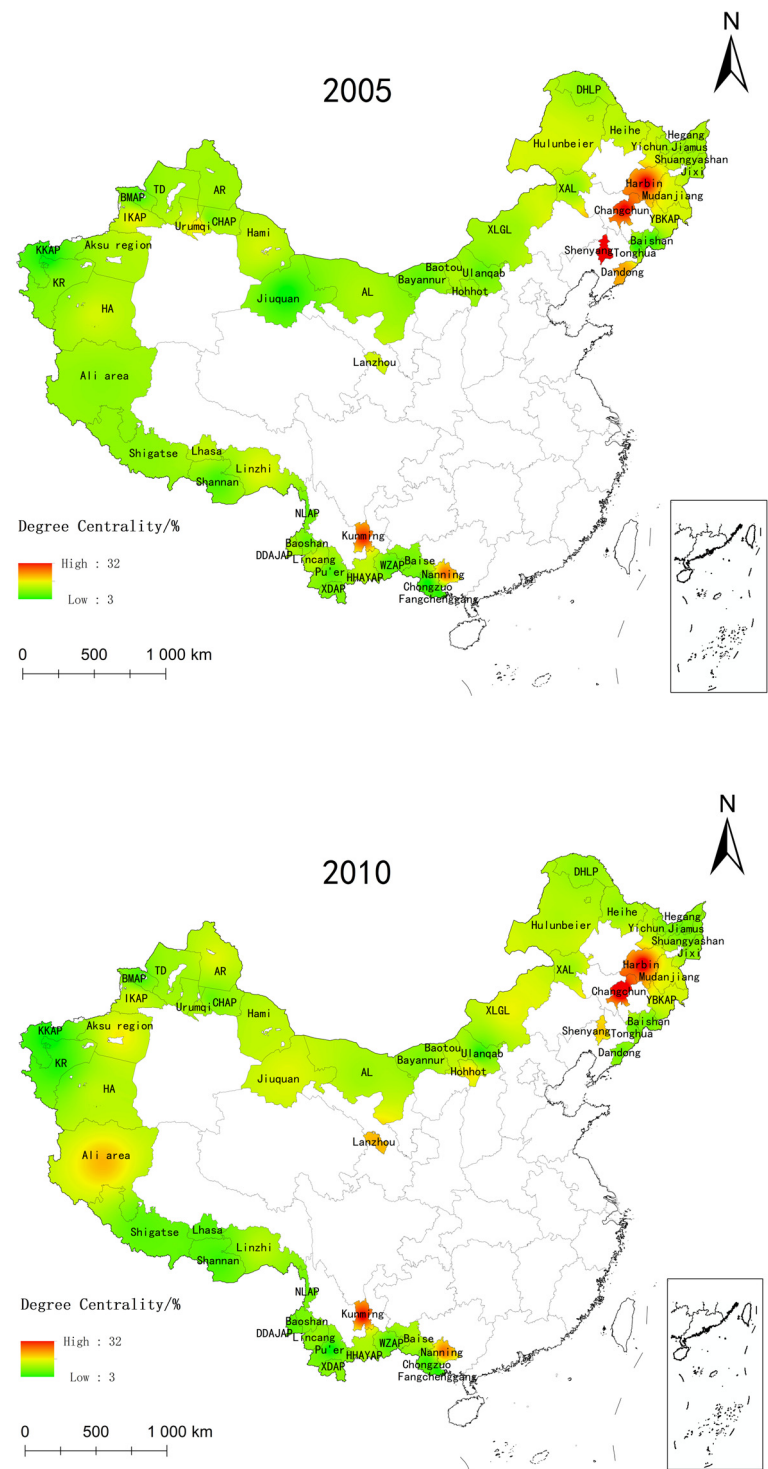


Figure 3. Cont.

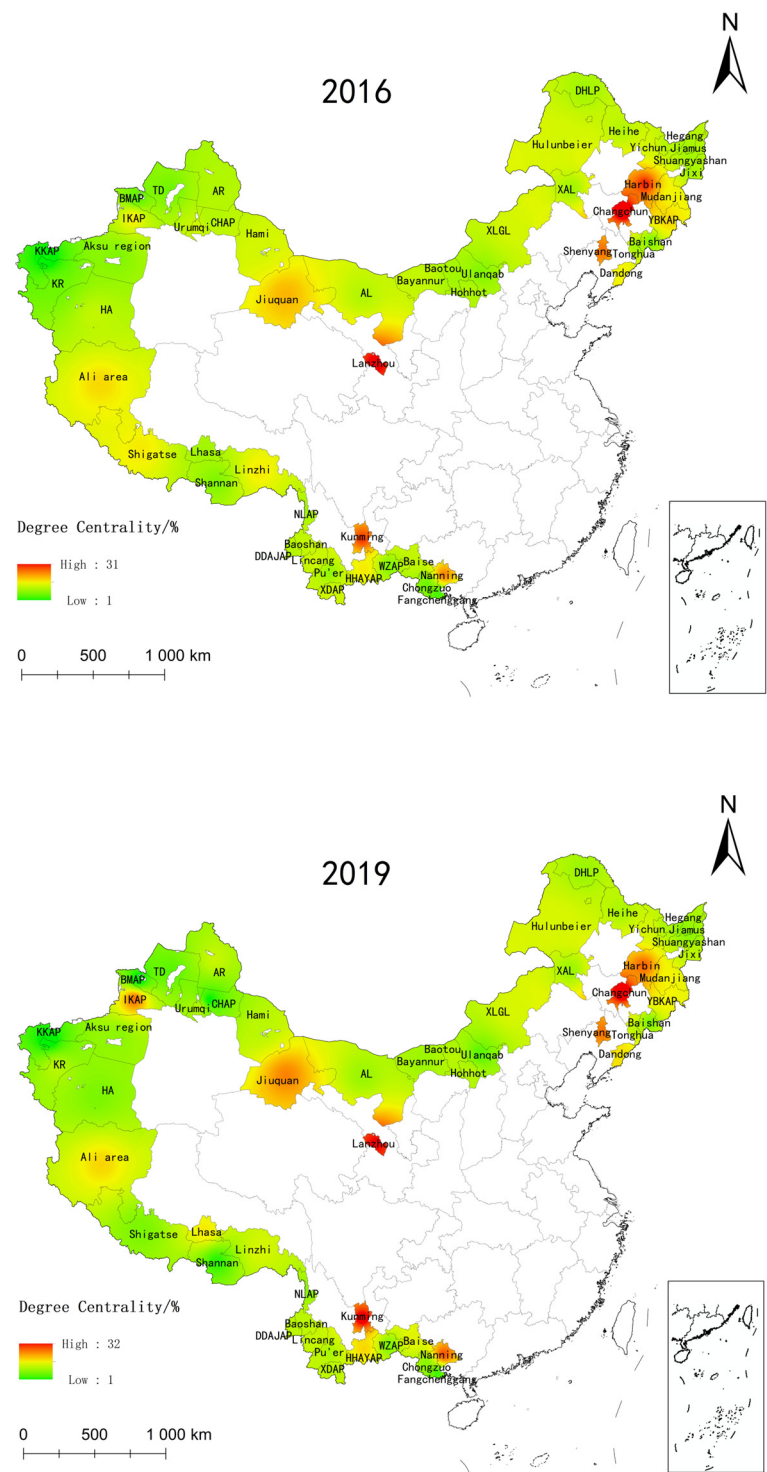


Figure 3. Degree centrality of tourism economic connection of China’s land border cities.

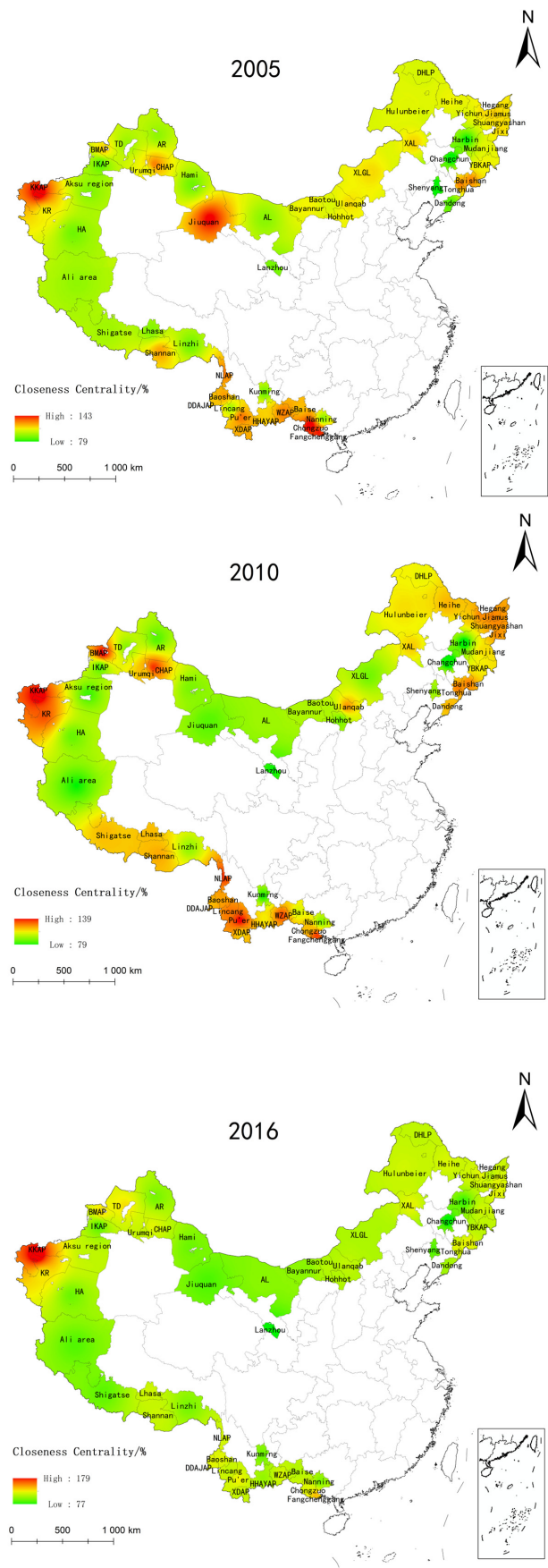


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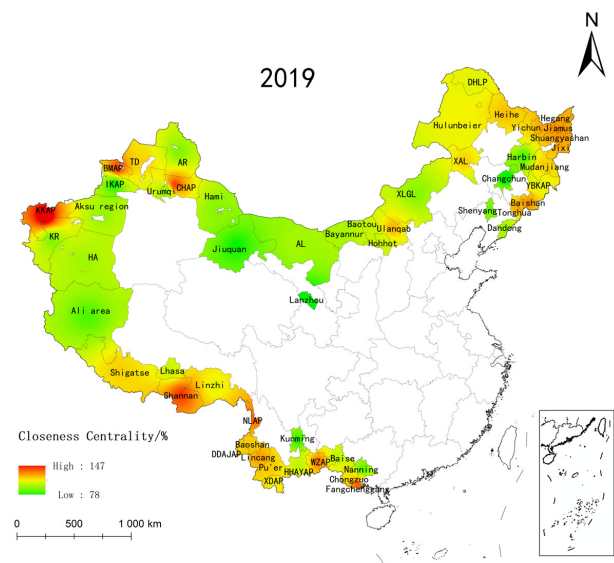


Figure 4. Closeness centrality of tourism economic relations of China’s land border cities to the center.

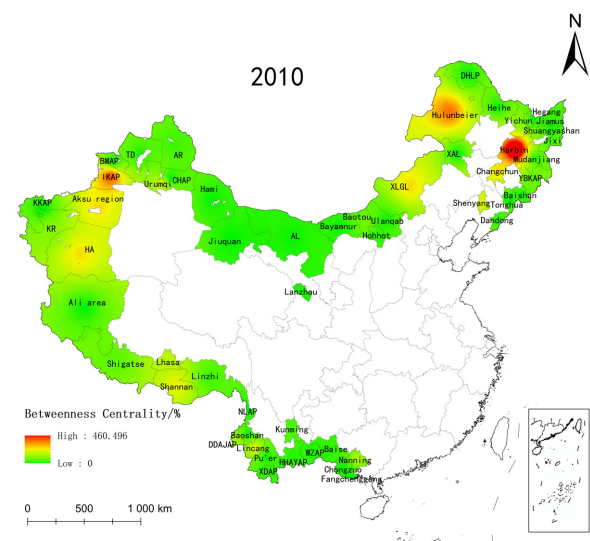
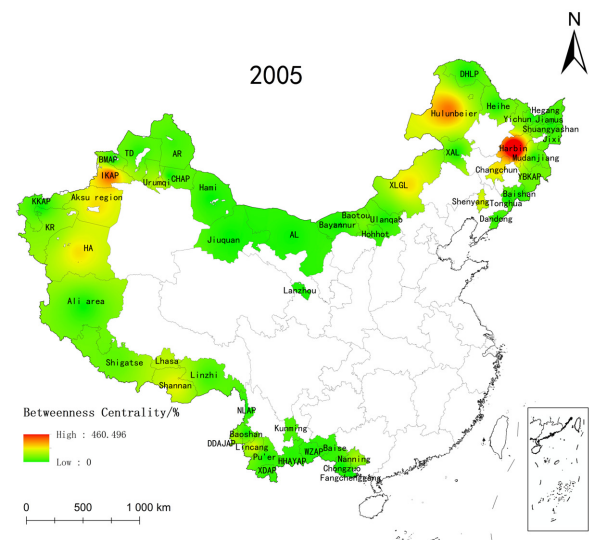


Figure 5. Cont.

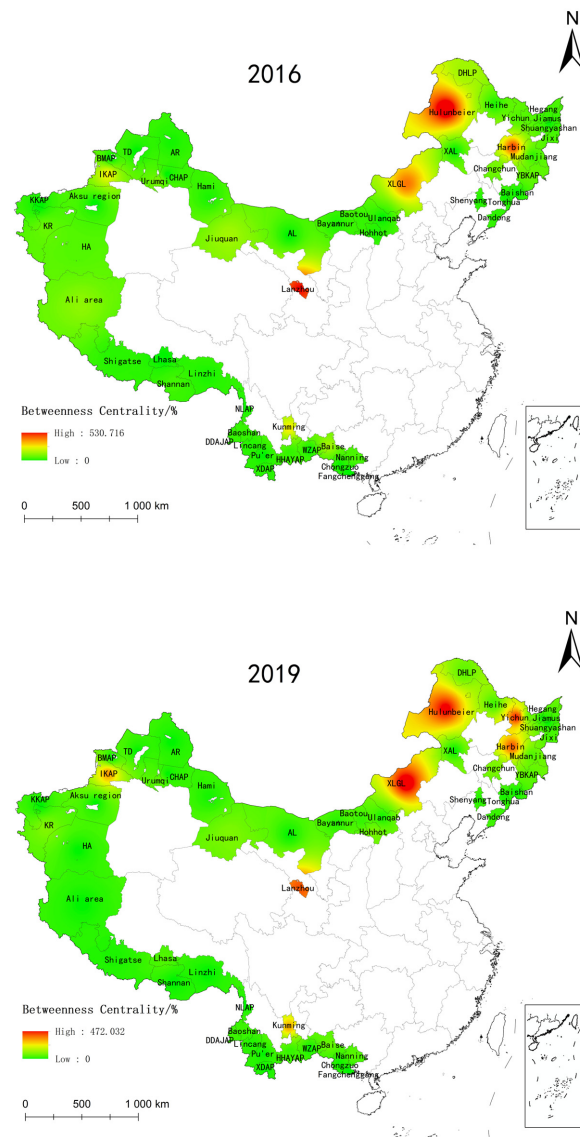


Figure 5. Betweenness centrality of tourism economic relations of China’s land border cities.

4.2.5. Structural Hole Analysis

The 54×54 two-value matrices were imported into UCINET software to analyze the trend of structural holes in the China land border tourism economic linkage network along the path of “Network-Egonetworks-Structural Holes”, and the results are shown in Figure 6.

Between 2005 and 2019, in terms of EffSize and Efficenc, Tonghua, Daxinganling region, Mudanjiang, Jiamusi, Chongzuo, Yili Kazakstan, Jiuquan, and Xilinguolemeng’s EffSize and Efficenc have continued to increase, suggesting that their ability to control and influence tourism and economic linkages in other border cities has been increasing and that their structural hole advantage has been growing. In terms of the constraint, Dandong, Shuangyashan, Jiamusi, Lincang, Linzhi, Shannan, Shigatse, Hotan, Aksu region, Tacheng region, Hami, Kizilsu and Kizilsu Kyrgyz Autonomous Prefecture, Bortala, Changji Hui Autonomous Prefecture, and Alxa League have increased in constraint value, and their influence by other border cities is also increasing; however, overall, the increase is not significant, and the horizontal gap between the border cities is gradually narrowing. To a certain extent, the structure of the tourism economic network in China’s land border cities is developing in the direction of rationalization, and the degree of coordination of tourism economy between individuals and regions is also increasing.

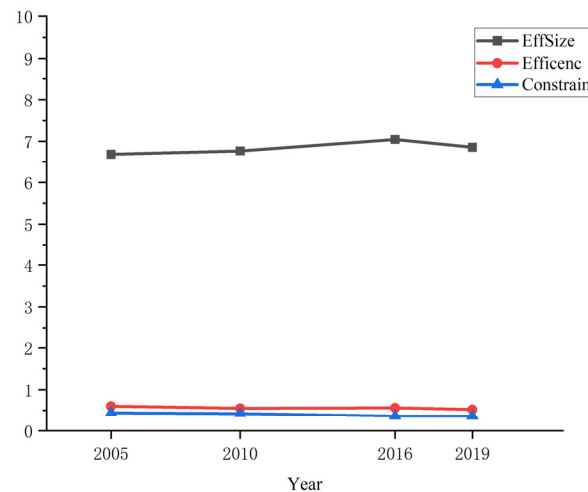


Figure 6. Structural change trend of tourism economic links in China's land border cities from 2005 to 2019.

5. Discussion

5.1. Tourism Economic Linkages and Linkage Volume Perspectives

Previous studies have examined the scope of China's land border provinces [42]. Over time, the intensity of tourism economic linkages among Liaoning, Jilin, and Heilongjiang provinces was higher than that of other provinces in 2006, while Tibet, Xinjiang, and Gansu had fewer tourism economic linkages with other border provinces and were on the periphery. Yunnan and Guangxi caught up later in 2018. Similarly, the results of this paper indicate a growing trend in the tourism economic linkage between all prefecture-level border cities in the country from 2005 to 2019. The spatial network of the overall tourism economic linkage of border cities in the northeast region served as the growth pole before 2010, until the tourism economic linkage of border cities in the southwest region surpassed that of border cities in the northeast region in 2010.

Spatially, the development of border tourism cities is uneven, with geographically neighboring border cities exhibiting stronger tourism economic ties [42]. This aligns with the results of this paper, which show three characteristics of uneven development of the "three sides" tourism economic linkage, the central city consistently maintaining a central position, and the stronger tourism economic linkage among neighboring cities in the land border prefecture-level cities in China.

5.2. Perspectives on Social Network Characteristics of Tourism Economic Linkages in Land-Level Border Cities in China

The overall network characteristics of tourism economic ties in the border provinces exhibit relatively low network density and a loose structure, indicating the need for further strengthening of links between various node cities within the network in terms of tourism economy. The core–edge structure is remarkable, with the core area gradually expanding to the northwest and southwest, exerting increasing influence on the tourism economy of the edge area. Geographically adjacent border cities are more likely to form a subgroup, and the development trend of border tourism group booking is obvious [42]. The results of this paper align with the change trend of tourism economic linkage network in border provinces. Various factors contribute to this result, including the level of economic development, location conditions, regional topographic conditions, and political geopolitical relations between countries. The level of economic development determines the adequacy of local tourism facilities and transportation facilities, while location conditions limit the connection between the border cities and geographically distant areas, regional topographic conditions affect accessibility and the abundance of tourism resources in the border cities, and geopolitical relations between countries impact tourism security in border areas [40].

In this paper, the comparison between land border cities and central provincial capital cities is added to the city selection. The results indicate an increase in the number of tourism economic links of border city nodes in the individual network structure, with the central provincial capital city consistently holding an absolutely dominant position. Its degree of centrality, proximity to centrality, intermediary centrality, and the level of structural holes are ranked as the leading ones. This outcome is primarily attributed to the high level of economic development of the capital city, which possesses more resources and markets. The transportation of resources from the central cities to the border cities, the return of talents and the increase in jobs are in line with the promotion of economic growth and the provision of equal and suitable job opportunities for all in sustainable development [6]. It appears that the sustainable development of tourism economy in border cities still needs to be driven by the central cities.

In the context of sustainable tourism development, the integrated development of culture and tourism has significantly enhanced the technical efficiency of the tourism industry. At the same time, the tourism economy of China's economically underdeveloped western regions has been growing, with border tourism playing a crucial role. Therefore, greater attention should be directed towards integrating national culture and tourism resources [48] to improve the competitiveness and satisfaction of border tourism while promoting the sustainable development of cultural tourism and border tourism [49–51]. Throughout this process, it is important to address easily overlooked issues in sustainable tourism development, such as the role of tourism demand, the nature of tourism resources, the measurement of sustainability and forms of sustainable development [52,53].

Due to the lack of tourism data for border tourism cities in 2020–2022 and the lack of updated data for border cities in 2023 resulting from the new Crown Pneumonia outbreak, these deficiencies will be addressed in a subsequent study.

6. Conclusions

The overall network structure of China's land border tourism economic links exhibits loose connectivity, accompanied by uneven regional tourism economic development. Strengthening cultural and tourism exchanges between border cities is an effective approach to improve border tourism and economic ties. Establishing a border tourism economic cooperation circle and strengthening cooperation among border cities can help enhance border tourism economic links, optimize the spatial structure of border tourism economic linkage network, maximize the economic benefits and utilization rate of tourism resources, and promote the sustainable development of border tourism, which is the way to benefit the border, revitalize the countryside and integrate the regional economy. This paper synthesizes the overall network characteristics and individual network characteristics of China's land border cities' tourism economic linkage and proposes the spatial cooperation and development mode of tourism economy in six border tourism cooperation circles, which are (1) the "Dandong-Baishan-Tonghua-Yanbianzhou" tourism cooperation circle; (2) the "Hulunbeier-Daxinganling" tourism cooperation circle, which is the most important one in China; the "Hulunbeier-Daxinganling-Heihe-Shuangyashan-Mudanjiang" Tourism Cooperation Circle; (3) the "Kashgar-Tacheng-Altai" Tourism Cooperation Circle; (4) the "Jiuquan-Bayannur" Tourism Cooperation Circle; (5) the "Chongzuo-Baise-Wenshan Prefecture" Tourism Cooperation Circle, and (6) the "Baoshan-Linzhi-Shannan" Tourism Cooperation Circle. The overall idea of the tourism economic cooperation circle is to leverage the unique characteristics of each border city's ethnic culture, geographic environment and seasonal landscapes. This approach aims to achieve complementary resources, share sources of passengers and win-win markets, and ultimately lead to the synergistic development of the overall land border tourism economy (Figure 7).

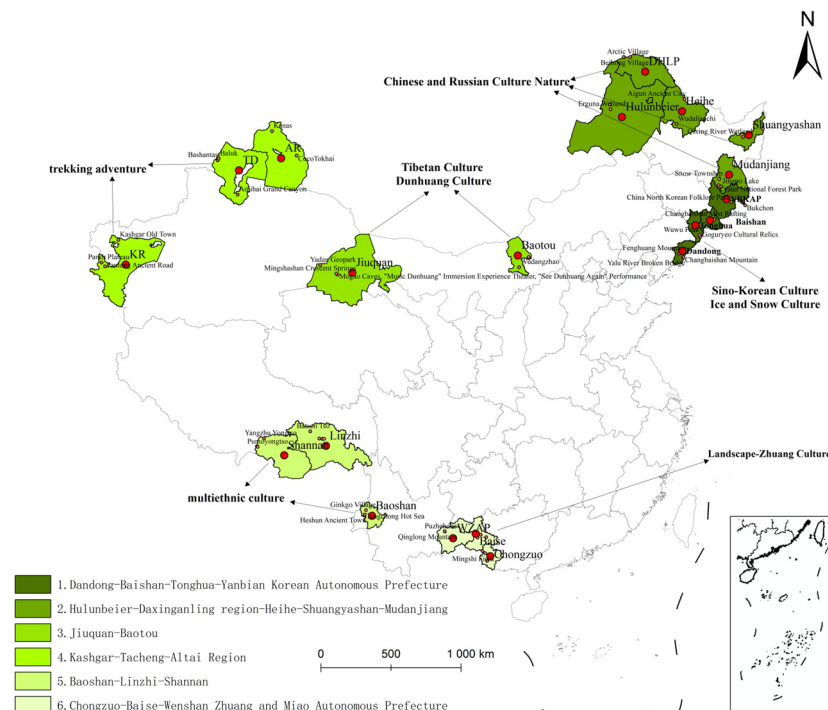


Figure 7. Key tourist routes and product culture of tourism economic cooperation circle of China's land border cities.

The core–edge structure is remarkable, with the core area gradually expanding to the northwest and southwest, exerting increasing influence on the tourism economy of the edge area. The core–edge theory emphasizes the importance of the radiation-driven role of the core area to the edge area. Therefore, in the border tourism economic linkage network, it is of great significance to enhance the radiation-driven function to optimize the network structure. On the one hand, it is necessary to strengthen the radiation-driven function of the existing core area, and, on the other hand, it is necessary to cultivate a new core area to strengthen the overall tourism economic linkage, ultimately transforming the peripheral area into the core area. It is recommended to enhance the flow rate of border tourism resources to advocate for a development mode of border tourism resources that balances development and protection, ensuring sustainable utilization of border tourism resources.

The trend of the geographically neighboring border cities forming a cohesive group is obvious, with the central city consistently holding the core position in the network. Neighboring cities with easy access to transportation and resources can significantly contribute to improving the regional economy.

In addition, border tourism is the result of the operation of a multifactorial, multilevel and complex system that requires multifaceted collaboration for steady development. This includes focusing on the ethnic economy and leveraging the multi-ethnic cultural characteristics of the border. It also entails accelerating the construction of the northwest border air transportation network to improve accessibility, thereby enhancing the degree of tourism and economic ties between the border cities. Additionally, it requires the formulation of a multi-party synergistic mechanism to enhance the efficiency of the flow of the border cities. Lastly, enhancing the safety coefficient of the border city tourism is crucial, as it is the primary consideration for tourists when choosing a travel destination. Strengthening the safety guarantee of tourism will help to improve the inflow of tourism, thereby promoting the prosperous development of border tourism economy.

This study holds significant importance in optimizing the spatial network of economic linkage of land border tourism in China, enhancing the economic level of border tourism, and promoting the sustainable development of meridian tourism.

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