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Evolution and optimization of China's urban tourism spatial structure: A high speed rail perspective

De-gen Wang [a], Yu Niu [b, *], Jia Qian [c]

[a] School of Architecture of Soochow University, Suzhou, Jiangsu, China
[b] Department of Tourism, Recreation and Sport Management of University of Florida, Gainesville, FL, USA
[c] Department of Tourism of Soochow University, Suzhou, Jiangsu, China

HIGHLIGHTS

- To divide the hinterland of tourist cities in non-HSR and HSR networks.
- To analyze the impact of the HSR on national tourism hinterland.
- To propose China's tourist urban agglomeration and optimization measures.

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ABSTRACT

High-speed rail (HSR) networks in China profoundly altered China's urban tourism spatial patterns. This paper examines the characteristics and evolution of spatial patterns of the urban hinterland before and after HSR network. Economic relation model and spatial analysis in ArcGIS were utilized on 338 national prefecture-level administrative units. The results show: (1) HSR strengthens tourism-based economic relationships between cities, and demonstrates a “corridor” effect of the spatial distribution of the change rates of tourism external economic relationships; (2) Center cities with larger tourism comprehensive scale are enhanced with expanding trans-province hinterland; the hinterland of central cities are enlarged, of which spatial linkages between the hinterlands are increased; (3) the competition and difference for the hinterland of central cities are intensified. Based on these, this paper proposes a tourism spatial structure with 19 urban agglomerations, 6 1st-class and 21 2nd -class tourist economic zones, and strategies for optimizing China's tourist space.

1. Introduction

Transportation, an important component of tourism industry (Roselyne, 2008) and a bridge between tourists and tourist destinations (Wang, Huang, Zou, & Yan, 2012), has a significant influence on the development of tourism. The development of tourist destinations cannot do without the establishment and improvement of tourism transportation system. The accessibility index of transportation system, including air lines, highways and classified highways, has a high correlation with the development of tourist destinations (Wang & Chen, 2011). Transportation plays an important role in the development of both new tourist destinations and existing ones (Gilbert, 1939). Appropriate transportation system not only stimulates recessionary tourist destinations, promotes promote the emergence, evolution, growth and expansion of tourist destinations (Kaul, 1985, p. 54). The impact of transportation system on the spatial pattern of tourist destinations is multi-dimensional, and the evolution of the tourism transportation system directly leads to the change of internal organizational structure and the evolution of external form of the tourist destinations (Yang & Lu, 2013). As a result, the transportation system affects the diffusion and attractive range of tourist destinations.

Different transportation modes have varied characteristics in aspects of economy, speed, convenience and safety, causing diverse effects on tourism. The diversification of competition of different transportation modes can be conducive to the reduction of traffic price and the improvement of service quality, which can bring great benefits to the tourism industry (Bruce, 2000). In the nineteenth

* Corresponding author. 206F Florida Gym, PO Box 118208, Gainesville, FL 32603, USA.
E-mail addresses: wdg713@163.com (D.-g. Wang), niuyu1008@ufl.edu (Y. Niu), qj2115@163.com (J. Qian).

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century, depending on the greater convenience and lower travel costs, the development of British seaside resorts has been promoted by railway in the first place (Gilbert, 1939; Robinson, 1976, p. 98). The opening of the English Channel tunnel greatly impacted on sea and air transportation. The Britain government seized this opportunity to promote and sell the railway tourist routes to attract a large number of European tourists to UK, so as to improve the competitiveness of the local travel market (Janet, 1991). By the twentieth century, the development of automobile industry promoted the construction of tourism service facilities, increasing the number and size of the restaurant, the hotel along the road, thus expanded the travel distance. The tourism of Europe and North America gained rapidly development (Nelson & Wall, 1986). As the main means of transportation of urban recreational activities, car becomes a hot spot in the academic field (Connell & Page, 2008). After that, the emergence of aviation technology made intercontinental trips a reality, causing global tourist markets and destinations closely linked (Prideaux, 1993). Air transport and tourism are also interlinked. One the one hand, tourism stimulated the change in air transport, such as charter airlines, a most notably new business models. On the other hand, air transport opened new destinations and tourism forms such as long-haul excursions. The impact of aviation on tourism is influenced by many factors, such as the number of stopover, aviation policies and route planning (Daniel, 2009), as well as the establishment of international aviation hub (Bowen, 2000).

Any application of new technology on transportation will significantly impact tourism (Leiper, 1990) by changing accessibility (Marcin & Piotr, 2013). High-speed Rail (HSR), an important symbol of the "transportation revolution" worldwide (Wang & Chen, 2012), has a time compression effect that will change the accessibility of tourist cities along the HSR line (Wang, 2011), especially for mountain areas (Ravazzoli, Streifeneder, & Cavallaro, 2017). HSR thus impacts the regional spatial structure, society and the economy. The improvement of cities' accessibility by the HSR differs by the locations of cities and stations as well as the development level of traffic networks (Ortega, López, & Monzón, 2012). Benefits from accessibility are primarily gained by cities that have HSR stations while little is gained by other cities, thus causing an imbalance in regional development; this is called "corridor effect" of the HSR (Andrés, Emilio, & Elena, 2013; Shaw, Fang, Lu, & Tao, 2014). Jin, Jiao, Qi, and Yang (2017) examined high-speed rail in East Asia and found that HSR brings about substantial improvement in accessibility, but also increase the inequality of nodal accessibility. On the one hand, after the HSR opened, the tourist flow became significantly concentrated in certain major tourist nodes and then spread to surrounding tourist nodes, demonstrating an obvious "core-periphery" trend of regional space. The "diffusion effect" of the HSR stimulates the integration of regional tourism development (Wang, Niu, & Chen, 2015). The HSR acted as a catalyst in the integration of European economy, society and culture, thus consolidating international tourism cooperative efforts (Commission of the European Communities, 1989). On the other hand, the opening of the HSR is helpful for the agglomeration of many economic activities in the developed cities (López, Gutiérrez, & Gómez, 2008), thus consolidates the central position of big cities and demonstrates a "siphon effect" from the HSR (Andrés et al., 2013). For example, the opening of Shinkansen in Japan consolidated economic activities and employment opportunities along HSR lines and formed the "Pacific Industrial Zone." In 1989, with the opening of the Atlantic HSR, business tourism in Le Mans had improved — especially in relation to hosting exhibitions —that extended from provincial to national and even international users.

The agglomeration and diffusion effects brought by the time-space compression of the HSR change the position of a city in terms of the urban system and the hierarchy structure (Garmendia, de Ureña, Ribalaygua, & Coronado, 2008); thus, the spatial pattern of regional tourism changes. One the one hand, HSR promotes regional economic potentials, on the other hand, it increases the imbalance between primate city and its hinterland (Gutiérrez, González, & Gómez, 1996; Jin et al., 2017; Zhu, Diao, & Fu, 2016). Masson and Petiot (2009) predicted that the influence of the HSR that runs between Spain and France on Perpignan tourism with a core-periphery model. He found that the HSR intensified the spatial competition and strengthened the tourism agglomeration in Barcelona, causing a "Matthew effect," while spatial competition in Perpignan decreased and resulted in an HSR "filtering effect" (Masson & Petiot, 2009). The HSR strengthens regional connections by increasing the accessibility of the central city of an urban agglomeration, such that significant changes take place in terms of the degree and mode of interaction between key regional center cities (Kingsley, 1997). The regional impact of large cities separated by a medium distance are weakened and replaced by access to a long-distance metropolis after the HSR opens (José, Philippe, & Maddi, 2009). The time distance between these metropolises is greatly shortened and the flow of resources between urban agglomerations is stimulated. The hinterland of urban agglomerations continues to grow and expand so that adjacent urban agglomerations tend to integrate (Liu, 2011). Cities along HSR lines that have good infrastructure conditions and rich tourist resources become centers for elements of the tourism industry, thus introduce a new format for tourism development growth. Therefore, the urban hinterland changes, and the traditional spatial patterns of urban agglomeration are disrupted by the HSR (Jiang & Chu, 2014). Spatial differentiation and reorganization become increasingly complex, which may facilitate the reconstruction of urban agglomeration.

Since the opening of the Beijing-Tianjin intercity rail line in August 2008, China entered the era of the HSR. By the end of October 26, 2014, China's HSR mileage had reached 12,000 km, ranking number one worldwide. Not only China, countries such as Europe, the United States, India, Turkey - Iran area, Arabia Union and other countries and regions are also planning to build a HSR network in large area in the future. In addition, with the advance of China's national policy of "One Belt and One Road", the Trans-Siberian Railway, and four world-class HSR lines, which are Pan-Asian HSR, Central Asia HSR, Eurasian HSR, China-Russia-Canada-USA HSR, will gradually be put on the agenda. The impact of HSR on the regional tourism spatial structure, which will play a leading role in the evolution and optimization of the space structure in the future, has become an urgent research topic. In today's increasing global HSR construction, China will finish the "four vertical and four horizontal" HSR network by 2020 and go ahead in the forefront of the world's HSR development. China will also become a typical case for HSR tourism research. China's HSR construction has provided profound changes of city's tourism spatial pattern along the lines, which may provide an example for other countries in the world. The evolution of China's regional tourism spatial pattern revealed by this study shows the important role of HSR in reconstructing tourism space. The theory and method of this research are also applicable to other countries' HSR tourism research.

At present, researches on the relationship between the HSR and regional tourism spatial structure mainly start with the accessibility. The main measure methods include travel cost indicators (e.g. weighted average travel time (WATT)), daily accessibility (DA), and potential accessibility (Liu, 2011; Jin et al., 2017). Potential accessibility includes the attribute of nodes (economic and demographic data), which enables the result more fit with the actual situation. Meanwhile, the hinterland theory is adopted to study the attraction and radiation power of the HSR, in order to describe the evolution and optimization of regional tourism spatial pattern

(Blum, Haynes, & Karlsson, 1997; Wang, Chen, & Lu, 2015). For example, Cheng, Loo, and Vickerman (2015) examined changes in accessibility and provides evidence on changes in specialization for both main cities and their hinterlands. Gravity model is widely used in exploring interaction between spaces and distance-decay effect, as well as in examining hinterland division as a measure of economic relation (Gu & Pang, 2008). With the development of modern transportation, the relative distance between regions changes significantly, and gravity model has been adopted to examine the various influences of transportation on space. For example, Khadaroo and Seetanah (2008) evaluated the importance of transport infrastructure in determining the tourism attractiveness of destinations with gravity model. Meng and Lu (2012) calculated economic relation between provinces caused by rail. Liu and Wang (2014) explored the influence of transportation infrastructure on regional economy of Silk Roads economic belt. Gravity model is often used with linear distance, which neglects geographic condition, social and economic factors, and the development of transportation infrastructure (Zhang & Meng, 2014). Since transportation significantly influences the “distance” between center city and its hinterland, and accessibility can contribute to precise expression of “distance” in gravity model, this study replaces liner distance with time distance. Also, this study utilizes comprehensive scale of urban tourism to indicate tourism economic. The indicator is a composite index, reflecting the comprehensive strength of urban tourism and showing the development strength of tourism economic, the reception capability of tourism, the support power of urban tourism completely and the tourism radiation force of center cities (Fang, Yin, & Zhang, 2013; He, 2013). Comparing to traditional model which commonly uses population and GDP, this model can comprehensively reflect tourism economic relation.

In this paper, firstly, principal component analysis and ArcGIS spatial analysis have been applied to calculate the comprehensive scale of urban tourism and nationwide accessibility of cities in non-HSR and HSR networks; secondly, the theory of economic relations is introduced in the study of the large scale hinterland. The economic relationship model is used to calculate tourism-related economic relationships between 338 prefecture-level cities in non-HSR and HSR networks, respectively. Then, a “top-down” division method is used to divide the hinterland of tourist cities in non-HSR and HSR networks, and the impact of the HSR on national tourism of the hinterland is analyzed. Finally, the classification of tourist cities has been conducted according to the division of the hinterland. The tourist urban agglomeration has been built in the HSR network. Tourist zones in the HSR network have been created in accordance. Optimization measures of urban tourism spatial structure have been proposed for the HSR network, thus providing suggestions for other countries' urban tourism spatial development.

2. Methods

2.1. Study object

The objects for this study include prefecture-level administrative units of China (prefecture-level cities, prefectures, autonomous prefectures and leagues). Among them, 4 centrally-administered municipalities — Beijing, Tianjin, Shanghai and Chongqing — are also included in this study because these administrative units act as cities. Administrative units like prefectures (such as Hami Prefecture), autonomous prefectures (such as Qiandongnan Miao and Dong Autonomous Prefecture) and leagues (such as Xilinguole league), take cities where seats of government exist as study objects. As Haikou and Sanya are the only prefecture-level cities in Hainan Province and the rest provincial counties, data are difficult to obtain. However, considering the wide geographical ranges and the large number of counties, which also have stimulated the development of tourism in Hainan, this paper combines the counties into one region using the name of directly-controlled counties in Hainan and taking the regional center as a node. Similarly, Tianmen, Qianjiang and Xiantao of Hubei are provincial counties, which are merged and named for the directly-controlled counties of Hubei in which the regional center is taken as the node. Although Shennongjia is also a provincial county, its distance to the three cities is too great to be merged, and the area is too small to have much influence on the results of the study; therefore, this paper merges data from Shennongjia with that of the neighboring city of Shiyan. Chaohu, a city in Anhui, is not included in the study since it was split in 2012. Sansha in Hainan Province was established in June 2012 with no corresponding data and is therefore not included in this study. Due to the multiple identities of centrally-administered municipalities, prefecture-level cities, prefectures, autonomous prefectures and leagues, the following analysis only mentions the names of the cities. Only mainland China is included in this study. Data from two special administrative regions — Hong Kong, Macao, and Taiwan are currently not incorporated. Therefore, 338 study subjects are included in this paper.

2.2. Data source and processing

2.2.1. Economic data

Economic data of prefecture-level cities are taken from the Statistical Yearbook for the Regional Economy of China (2013), the Tourism Statistics Yearbook of China (2013) and the 2013 Statistical Yearbook of all provinces and cities, including tourism-related resources endowment, number of inbound tourists, number of domestic tourists, international tourism income, domestic tourism income, number of Star Hotels, employees in the service industry, total transportation passengers, GDP, service industry GDP, et al. Some missing data from the urban statistical yearbook were collected from the Municipal Statistics Bulletin.

2.2.2. Graphical data

ArcGIS Desktop 9.3 is used in this study. The vector data of spatial administrative boundaries use basic Chinese geographic information data from a 1:4 million map provided by the National Basic Geographic Information Center; the locations of resources are determined by ArcMap's coordinate input function on the underlying graph after locating city points, with exact coordinates taken from Google Earth. River and road data (including ordinary railways, expressways, national highways, and provincial highways) are taken from a “1:4 million road traffic map” and “basic elements from a 1:4 million map,” drawn by the Ministry of Communications. HSR data for 2020 is taken from the current HSR status and “medium and long term railway network planning” (2020). After manual digitization using a Beijing 1954 geodetic coordinate projection system, the HSR data are stored in a geographical information database to generate a base map of the national transportation network of the non-HSR and HSR networks.

2.3. Method and model

2.3.1. Measurement of comprehensive scale index of urban tourism

A principal component analysis is used to estimate the index.

The analysis uses a selection of indexes that evaluate the comprehensive scale of urban tourism, which is followed by the principles of systematisms, comparability, comprehensiveness and operability. Based on previous research (Lv, 2013; Song, Mu, & Ren, 2010), 16 indicators have been selected, including tourism-related resources endowment, number of inbound tourists/ten thousand, number of domestic tourists/ten thousand, international tourism income/ten thousand dollars, domestic tourism income/hundred million yuan, number of Star Hotels, accommodation and catering industry turnover/hundred million yuan, employees in the service industry/ten thousand, total transportation passengers/ten thousand, GDP/hundred million yuan, service industry GDP/hundred million yuan, fiscal revenue/hundred million yuan, fixed-asset investment/hundred million yuan, population/ten thousand, per capita disposable income/yuan, highway distance/km. Among these indicators, data for tourism-related resources endowment are calculated by counting the number of World Heritage Sites, national scenic areas, 5A level and 4A level scenic areas in the city — and given 10, 8, 6 and 4 points, respectively, depending on the resource level. For resources that have several classifications, the highest level is used. Finally, the total tourism-related resources endowment amount can be calculated. To obtain concise data for the index system and to fully measure available resources endowment, correlation analysis has been conducted on the indexes, after which two indicators — per capita disposable income/yuan and total transportation passengers/ten thousand — were deleted. Fourteen indicators have ultimately been used.

Secondly, data standardization was performed. To exclude the influences of dimension and order of magnitudes and to avoid ascertaining a negative value after standardization, which affects related operations later, this study uses average standardization to process the original data, i.e.,

$$M_{ij} = X_{ij} \Big/ \frac{1}{n}\sum_{i=1}^{n} X_{ij} \quad (1)$$

In the formula, M_{ij} and X_{ij} represent the new and original statistical data of index j of city i, respectively, after the standardization of $n = 14$.

Thirdly, measurement of comprehensive scale was performed. This study uses SPSS 21.0 to process standardized data through principal component analysis. Bartlett's test of sphericity shows that the chi square approximation is 8506.371 with the freedom degree 91. Concomitant probability is 0.000, which is less than 0.001, indicating that the selected factors are correlated. The coefficient of Kaiser-Meyer-Olkin (KMO) is 0.856. Therefore, the data are suitable for factor analysis. The principal components have been extracted according to the principle that characteristic values should be greater than 1. The variance contribution rates of the first three principal components are 62.93%, 12.56% and 9.70%, respectively. The cumulative contribution rate is 85.19%, and characteristic values were 8.8102, 1.7577 and 1.3584. Therefore, 3 main factors have been extracted (Table 1). The first principal component reflected the development strength of urban tourism economic and was named as development strength of tourism economic, which has a high load factor on tourism-related resources endowment, number of inbound tourists, number of domestic tourists, international tourism income and domestic tourism income. The second principal component reflected the urban reception capability of tourism and was named as the reception capability of tourism, which has a high load factor on number of Star Hotels, accommodation and catering industry turnover and employees in the service industry. The third principal reflected the support power of urban tourism and was names as the support power of urban tourism component, which has a high load factor on GDP, service industry GDP, fiscal revenue, fixed-asset investment, population and highway distance.

Fourthly, a calculation of comprehensive scale of urban tourism was performed. The formula is as follows:

$$Z_i = \sum_{k=1}^{m} \left[A_k \times \left(C_{kj} \times M_{ij}\right)\right] \quad (2)$$

In the formula, Z_i is the comprehensive strength value of city i; m is the number of principal components with feature values greater than 1, and $m = 3$ in this paper; "k" is the serial number of principal components, which is valued as 1, 2 or 3 in this paper; A_k is the contribution rate of the principal component k; C_{kj} is the load of the principal component k on index j; n is the number of indexes involved in the evaluation; M_{ij} is the standardized value of indicator j of city i.

2.3.2. Estimation of urban accessibility and extraction of the shortest temporal distance

This study measures accessibility by adopting a cost-weighted distance method based on raster data and the spatial analysis module of ArcGIS. The spatial pattern of accessibility is then visualized using the reclassify module and the raster calculator. The study rasterizes the original vector map with a selected grid size of 1 km × 1 km, and the study area is then divided into 9,450,543 homogeneous grids.

The speeds of each traffic mode is set for non-HSR and HSR networks, and each grid is valued by the corresponding time cost in this study. The roads mainly include expressways, national highways, and provincial highways. According to the Technical Standards for Highway Engineering of the People's Republic of China (JTGB01-2003), and considering the density and quality of the national road network, the road speeds are set as follow: 120 km/h for

Table 1
Total variance explanation.

Component	Initial Eigenvalues			Rotate squares and loaded		
	Sum	Variance %	Accumulation %	Sum	Variance %	Accumulation %
1	8.810	62.930	62.930	4.779	34.135	34.135
2	1.758	12.555	75.485	4.163	29.739	63.874
3	1.358	9.703	85.188	2.984	21.314	85.188
4	0.629	4.496	89.684			
5	0.458	3.274	92.958			
6	0.322	2.298	95.256			
7	0.201	1.435	96.691			
8	0.174	1.241	97.931			
9	0.128	0.915	98.846			
10	0.074	0.526	99.372			
11	0.060	0.429	99.801			
12	0.020	0.144	99.945			
13	0.006	0.043	99.988			
14	0.002	0.012	100.000			

freeways, 80 km/h for national trunk highways and 60 km/h for provincial trunk highways. The land is assumed to be homogeneous, the speed of which is set at 5 km/h by foot. Considering the certain capacity for water area and a higher cost than that of land since bypass is needed in some certain areas, the paper set the average speed of water transportation at 1 km/h (Wang, Xu, Zhu, Qi, & Xu, 2010). The railway is divided into ordinary railways and HSR railways. The speed of the ordinary railways (including bullet train and express trains) is set at 160 km/h, while the speed of the HSR is set at 300 km/h and 200 km/h according to different HSR levels.

According to the cost value, spatial elements are extracted from the basic database. A field of cost is added to the attribute table of each vector layer to store the time cost value. The time cost value considers the average time (minute) of 1 km when traveling. The formula is:

$$cost = \frac{1}{V} \times 60 \tag{3}$$

First of all, a cost field in the attribute table of each vector layer has been added to represent time cost value by using raster calculator. Secondly, all traffic lines have been merged into a traffic network layer, following with the rasterizing of traffic network, land and water layers with the time cost value. Finally, traffic network, land and water layers have been combined in accordance with the minimum cost value, and the final grid map has been created with the value of each grid representing the maximum available speed of the region.

Charts of spatial diffusion patterns of urban accessibility in non-HSR and HSR networks are obtained by using 338 prefecture-level cities as point sources and using Distance Cost Weighted from the spatial analysis module in ArcGIS; accessibility values between pairwise cities are then extracted. The specific steps are: single city + accessibility cost map → spatial distribution chart of accessibility → time distance extracted from one city to other cities.

2.3.3. Intensity model of urban economic relationships

This paper divides hinterland based on its urban economic relationships. Based on Newton's gravity model, the formula is obtained by optimizing the relevant parameters of the model:

$$F_{xy} = \frac{lP_xP_y}{D_{xy}^b} \tag{4}$$

F_{xy} is the interaction strength between cities; P_x and P_y are the demand levels or productive power of city x and city y, which are replaced by a comprehensive scale of urban tourism; D_{xy} is the distance or time from city x to city y, taking the shortest travel time between two cities here. b is the friction coefficient of distance, taking 2 here; l is a constant, taking l here (Zhong & Lu, 2012).

Meanwhile, calculating the total urban external economic relationships to reflect spatial interaction between each city with the other 337 cities:

$$F_x = \sum_{y=1}^{n} F_{xy} \tag{5}$$

2.3.4. Division of the urban hinterland based on economic relations

According to Metropolitan-Hinterland Thesis Theory, as the core of regional space, center cities play a role in spatial gathering and diffusion, and interacting with surrounding areas, of which the largest area center cities can influence is known as hinterland (Innis, 1956). The division method of urban influence regions, based on urban spatial connections, is a “bottom-up” division method that includes the concept of complete administrative divisions. In this method, cities are gradually merged according to urban relationships, which will ultimately belong to the highest-level central area. The level and quantity of central areas are produced naturally in the merging process with stronger objectivity (Zhong & Lu, 2012).

Firstly, the largest economic relation between a certain city and other 337 cities is selected:

$$F_x^{max} = \max(F_{xy})\ (y = 1\text{–}337) \tag{6}$$

Thus, cities that have the corresponding strongest economic relationships with each city are found.

Secondly, cities that have the strongest economic relationships are merged. Cities with the strongest regional tourism influence — which are considered central city in the region according to the comprehensive scale of urban tourism — are used along with other cities within the region, which are considered as constituting the central cities' hinterland. Functional levels, centrally-administered municipalities and provincial capital cities are considered delayed once in the initial merger.

3. Evolution characteristics of the urban tourism spatial structure in China's HSR network

3.1. Change features of national urban tourism economic relationships in the HSR network

In the non-HSR network, the total number associated with urban tourism economic relationships was 146978.52; the average value was 434.85 and standard deviation was 1206.46. The total number associated with the tourism-related economic relationships of 62 cities was above average, accounting for 18.34%. In the HSR network, the total number associated with urban tourism-related economic relationships is 349119.02 and the average value is 1032.90. The total number of tourism-related economic relationships of 59 cities is above average, accounting for 17.46%. The total number associated with tourism-related economic relationships expands 2.38 times with a change rate of 137.53%, showing that the total number associated with tourism economy relationships is significantly improved by the HSR.

For the changes in the total number associated with tourism-related economic relationships, significant enhancement takes place in the urban tourism economy relationships in each city to different spatial extents. Fig. 1a shows that the enhancement is spatially concentrated in the Beijing-Tianjin-Hebei region, the Pearl River Delta and the Yangtze River Delta. Meanwhile, the Central Plains region, Chengdu-Chongqing region, Changsha-Zhuzhou-Xiangtan region and the Wuhan urban agglomeration also see significant change values in total number associated with tourism-related economic relationships. In the western regions of Tibet, Xinjiang, Gansu and other provinces, the change value is not obvious because these provinces originally had small total numbers associated with tourism-related economic relationships in the non-HSR network and are generally not included in the HSR network.

In terms of the change rate of total tourism-related economy relations (Fig. 1b), the spatial distribution shows a strong “corridor” effect before and after the presence of the HSR network. The distribution of the regions with high rates of change is highly consistent with the HSR layout. The total external tourism-related economic relationships of cities along the Beijing-Shanghai, Beijing-Harbin, Beijing-Guangzhou, Shanghai-Changsha, Wuhan-Guangzhou, Xi'an-Chendu, Chengdu-Mianyang-Leshan and Harbin-Dalian HSR lines have relatively high rates of improvement.

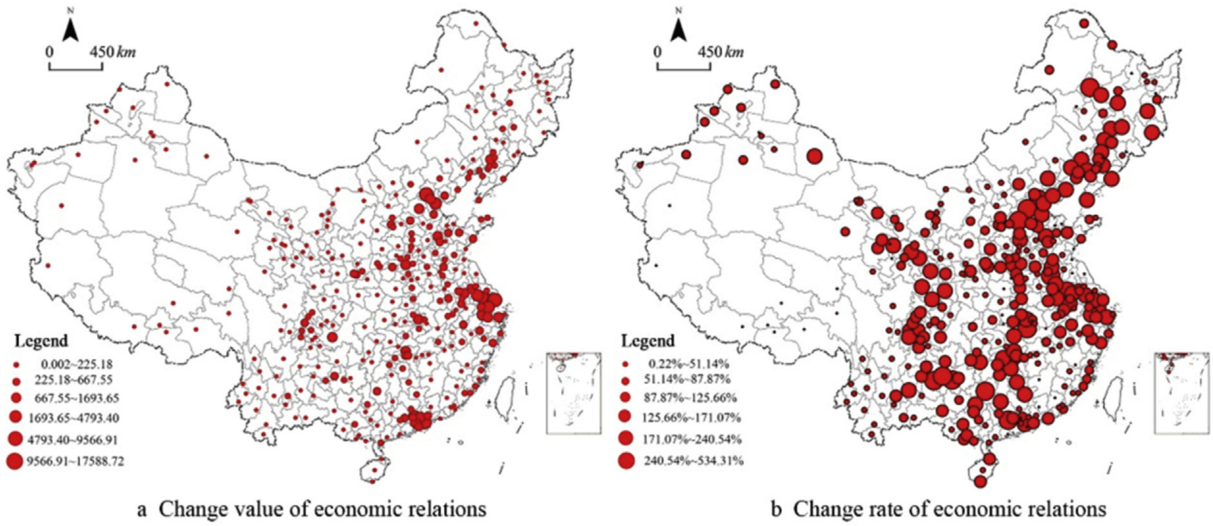

Fig. 1. Changes in spatial patterns of urban tourism-related economic relations in China's HSR network.

In the northwest region, due to the construction of the Lanzhou-Xinjiang HSR line, Lanzhou, Jiayuguan, Jiuquan and Zhangye also have clear change rates in total external tourism-related economic relationships.

3.2. Spatial change features of urban tourism in hinterland in the HSR network

3.2.1. The HSR increases the competition in hinterland and reduces the number of central cities

National tourism centers and their hinterland in non-HSR and HSR networks have been indicated (Fig. 2). Fig. 2a shows that 52 central cities have been divided according to region in the non-HSR network, among which 22 cities are in the east: Beijing, Tianjin, Shijiazhuang, Guangzhou, Shanghai, Shenyang, et al.; 16 cities are in the central region: Wuhan, Harbin, Hohhot, Zhengzhou, Taiyuan, Changchun, et al.; 14 cities are in the west: Chongqing, Chengdu, Urumqi, Kunming, Lhasa, Diqing, et al. Overall, the central cities with influencing roles are concentrated in the east, followed by the central region and the west, but few gaps lie between the three areas.

In the HSR network, 38 central cities have been indicated (Fig. 2b), 15 of which are in the east: Beijing, Fuzhou, Guangzhou, Haikou, Hangzhou, Jinan, et al.; 9 of which are in the central region: Harbin, Hefei, Hohhot, Nanchang, Taiyuan, Wuhan, et al.; 14 of which are in the west: Chengdu, Diqing, Guiyang, Jiuquan, Kashi, Kunming, et al.

In terms of changes in the central cities in non-HSR and HSR networks, the number of central cities has been reduced by 14 due to the HSR network and is mainly concentrated in the eastern and central regions, including Anshan, Handan, Jining, Jinzhou, Shantou, Wenzhou and Xuzhou in the east, and Baicheng, Baotou, Huaihua, Nanyang, Shangqiu, Tonghua and Yuncheng in the central region. Analysis shows that the diminished central cities are surrounded by provincial capitals or directly-controlled municipalities that experience a larger scale of tourism. The HSR improves regional accessibility, greatly expanding the influential range of cities with larger-scale tourism in which tourism is extended to more distant areas. On the contrary, hinterland of central cities with relatively weaker comprehensive strength in the non-HSR network are “nibbled” by stronger central cities. These weaker cities not only lose their original hinterland but also become incorporated into the

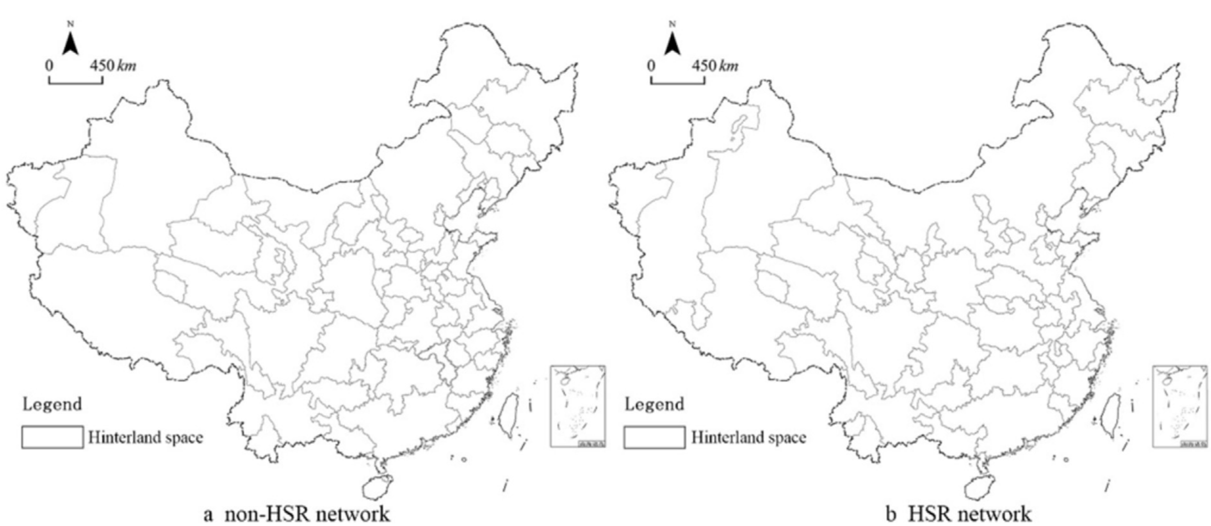

Fig. 2. Spatial change features of urban tourism hinterland in the HSR network.

surrounding areas of stronger cities. For example, the hinterland of Xuzhou is divided by Beijing and Shanghai, with Xuzhou itself becomings a hinterland Beijing; the hinterland of Wenzhou is divided by Shanghai and Hangzhou, with Wenzhou itself becoming a hinterland of Shanghai; Shantou and its hinterland was incorporated into the hinterland of Guangzhou; the hinterland of Jinzhou is divided by Shenyang and Beijing, with Jizhou itself becoming part of Shenyang's the hinterland; Handan, Jining, Baicheng, Baotou and their hinterland are incorporated into the hinterland of Beijing; Anshan and its hinterland became incorporated into the hinterland of Shenyang; the hinterland of Huaihua is divided by Changsha and Chongqing, with Huaihua itself becoming part of the hinterland of Changsha; the hinterland of Nanyang is divided by Wuhan and Beijing, with Nanyang itself becoming part of the hinterland of Beijing; Shangqiu and its hinterland merged into Zhengzhou; Tonghua and its hinterland are merged into Changchun; the hinterland of Yuncheng is divided by Xi'an and Zhengzhou, with Yuncheng itself becoming part of the surrounding area of Xi'an.

3.2.2. HSR enhances the influence radius and intensifies the competition for hinterland of central cities

The spatial pattern of hinterland areas of central cities in non-HSR and HSR networks shows that hinterland areas in eastern China are relatively small, balanced in the central region and relatively large in the west. In the non-HSR network, cities with top 5 largest hinterland area are Beijing, Urumqi, Lhasa, Chongqing and Guangzhou, with the areas of 2,074,255 km^2, 1,068,045 km^2, 978,620 km^2, 680,511 km^2 and 401,075 km^2, respectively. In the HSR network, the top five cities are Beijing, Urumqi, Lhasa, Chongqing and Chengdu, with areas for3,272,112 km^2, 891,327 km^2, 681,503 km^2, 615,331 km^2 and 403,383 km^2, respectively. The advantage of Beijing's hinterland area of Beijing has been further highlighted. Although hinterland rankings of Urumqi and Lhasa are high due to the vast western geographic characteristics of the area, hinterland areas of Urumqi and Lhasa were reduced by 176,718 km^2 and 297,117 km^2, respectively, with decreases of 16.55% and 30.36%, respectively, compared with cities in the non-HSR network. The main cause is that the comprehensive scale of tourism in Urumqi and Lhasa are not large, which generates a weak influence on their hinterlands. The accessibility of the two cities are relative weak in the HSR network, and some of their hinterlands have been appropriated by other central cities that have more comprehensive tourism scales and have gained accessibility enhancements in the HSR network.

In the non-HSR network, the mean and standard difference of the hinterland areas of the 52 central cities are 181,741.21 km^2 and 342,646.90 km^2, respectively, and the mean and standard differences for the 38 central cities in the HSR network are 248,698.5 km^2 and 533,417.31 km^2. These numbers indicate that the presence of the HSR has exacerbated the differences of hinterland areas of central cities and has intensified the competition for hinterland areas. Some hinterland areas of central cities have grown and some have decreased, and others have remained unchanged. Specifically, cities with increased hinterland areas are Chengdu, Nanning, Fuzhou, Changsha, Zhengzhou, Hangzhou, Shanghai, Jiuquan, Haikou, Xining, Wuhan, Changchun and Beijing. Most of these cities have HSR sites and their radii of influence have expanded with the increase of accessibility, which was improved by HSR. Cities with reduced hinterland area include Guangzhou, Qingdao, Nanjing, Shenyang, Xiamen, Jinan and Shijiazhuang in the east; Harbin and Nanchang in the central region; and Lhasa, Urumqi, Lanzhou, Chongqing, Xi'an, Kunming, Yinchuan and Guiyang in the west. Most hinterland of these cities have merged into the hinterland of Beijing and Shanghai under HSR network, among which Lhasa and Urumqi have seen the greatest decrease in hinterland areas due to appropriation by Beijing. Taizhou and Huai'an, hinterland of Nanjing, were appropriated by Shanghai. Cities with no change in their hinterland areas include Tianjin, Hohhot, Yantai, Hefei, et al. Among them, the hinterland areas of Xishuangbanna, Diqing and Kashgar have not experienced any change due to their peripheral locations, where there is no HSR station, nor does an HSR line pass through; this has caused these areas to remain unaffected by the HSR.

The largest change rates in the hinterland are seen in Haikou and Xining, with rates of 2008.44% and 662.84%, respectively. Haikou's influence has been strengthened since the east and west rings of the HSR opened. This change has expanded hinterland space of Haikou and caused the hinterland of Guangzhou to be incorporated into Haikou's hinterland. The opening of the Lanzhou-Xinjiang HSR allowed Haibei to integrate into Xining's hinterland. Lanzhou, Changchun and Hangzhou have also seen large change rates of hinterland areas. The hinterland area of Lanzhou was reduced by 65.38%, part of which was appropriated by Beijing and Chongqing, both of which experience larger-scale urban tourism. The hinterland areas of Changchun and Hangzhou expanded by 73.73% and 58.18%. For Changchun, the opening of the Changchun-Jilin HSR expands Changchun's radius of influence to Baishan, Yanbian and Tonghua, causing these cities to merge into Changchun's hinterland. Many HSR lines pass through Hangzhou, which strengthens Hangzhou's influence within the province. Cities in the, hinterland cities within the province increased from 3 in the non-HSR network to 6 in the HSR network, and Ningbo, Lishui and Huzhou merged into Hangzhou's hinterland radius. Cities experiencing low change rates in their hinterland include Chengdu and Changsha, with rate increases of 3.41% and 9.88%. Although the accessibility of the two cities are increased by the HSR and their hinterlands are enlarged, their proximity to Chongqing makes the change rate insignificant.

3.2.3. HSR expands the space of urban agglomerations and strengthens the integration development of regional tourism

HSR expands the influence range of central cities in urban agglomerations, including more medium and small cities. For the number of cities contained by the hinterland of central cities of urban agglomerations, Beijing, the main city of the Beijing-Tianjin-Hebei urban agglomeration; Guangzhou, the main city in Pearl River Delta; Shanghai, the main city in the Yangtze River Delta; and Chongqing, the main city in the Chengdu-Chongqing urban agglomeration, are at the forefront. Among them, the number of hinterland cities in Beijing increased from 31 to 64 before and after the establishment of the HSR network, respectively, which laid the foundation for Beijing to become the nation's central city with the greatest amount of advantage. In the HSR network, the hinterlands of Beijing almost entirely encompass Mongolia and its hinterland space in Shandong has been further expanded; Heze and Jining were incorporated into the hinterland of Beijing; Hegang, Jiamusi and Shuangyashan, northern cities in Heilongjiang, also merged into hinterland of Beijing. Meanwhile, Beijing's hinterland radius of western regions such as Xinjiang and Tibet also expanded. The number of hinterland cities for Shanghai and Chongqing increased from 18 in the non-HSR network to 21 and 19 in the HSR network, respectively. Among them, Huaian and Taizhou, which originally belonged to the hinterland of Nanjing in the non-HSR network; Lianyungang, which belonged to the hinterland of Qingdao; Fuyang, which belonged to the hinterland of Wuhan; Suqian, which belonged to the hinterland of Xuzhou, were all appropriated by Shanghai. Wenzhou, a central city, also became part of the hinterland of Shanghai. In the HSR network, Zhangjiajie, Xiangxi, Lincang, Hainan (state) and Bijie, which were originally in the hinterland of Changsha, Huaihua, Kunming, Xining and Guiyang, respectively, have become hinterlands of Chongqing. Although the number of hinterland cities of Guangzhou, the core city in the Pearl River Delta, reduced from 30 in the non-HSR network to 29 in the HSR network, the total number of cities still places Guangzhou in second place. Zhanjiang, Sanya and counties directly governed by Hainan, which originally belonged to the hinterland of Guangzhou, became part of the hinterland of Haikou in the HSR network. Guigang and Beihai become part of the hinterland of Nanning in the HSR network. Yongzhou was originally part of the hinterland of Changsha in the non-HSR network but was transferred into the hinterland of Guangzhou in the HSR network. In the non-HSR network, Shantou was a central city with hinterland cities of Jieyang and Chaozhou; in the HSR network, Shantou's influence declined and it became part of Guangzhou's hinterland, Shantou's original urban hinterland, Jieyang and Chaozhou, also merged into the hinterland of Guangzhou.

To summarize, the HSR further strengthened the links between the urban agglomerations of the Beijing-Tianjin-Hebei region, the Yangtze River Delta and the Pearl River Delta. This integration will speed up the centralization and exchange of various factors of production in these areas. Finally, the entire economic system that places large cities at its core and includes a number of large, medium and small cities will be formed, and the development of regional tourism integration will be further enhanced.

4. Construction and optimization of China's tourism spatial structure system based on the HSR network

4.1. Construction of tourism spatial structure system of China in the HSR network

4.1.1. Tourism classification in cities in the HSR network

After merging hinterlands for the second and third time in the HSR network, a ranking for urban tourism has been established (Table 2).

Beijing, Shanghai, Guangzhou, Chongqing and Wuhan are 1st-level tourism central cities. As a result of the third merger, Tianjin, Xi'an, Shenyang, Jinan, Harbin, Taiyuan, Shijiazhuang and Qingdao became part of Beijing's hinterland; Nanjing became part of Shanghai's hinterland; Xiamen became part of Guangzhou's hinterland; Chengdu, Kunming, and Lanzhou became part of Chongqing's hinterland; Zhengzhou, as Wuhan's hinterland city, became a 2nd-level tourism central city. In the second merger, Hohhot, Kashi, Lhasa, Urumqi, Yinchaun, Haikou, Nanning, Xining, Hefei, Yantai, Fuzhou, Hangzhou, Changchun, Nanchang, Changsha, Diqing, Guiyang, Jiuquan and Xishuangbanan become 3rd-level tourism central cities. All other cities are 4th-level tourist cities.

4.1.2. Construction of urban tourism agglomerations of China in the HSR network

Urban tourism agglomerations in China are considered in the construction of the HSR network according to the division of the cities above as well as the hinterlands of the central cities in each stratum. Urban agglomerations are named according to the standards of the city selection and the names of urban agglomerations, which is proposed by Fang (2011). On the premise of maintaining the existing divisions of urban agglomerations and naming standards, if new regional growth takes place or the relationship between cities in an urban agglomeration disintegrates, the urban agglomeration will be split into new lower-level urban agglomerations, in which the name used is taken from its central city and hinterland. Therefore, on the basis of 5 1st-level tourism central cities and their hinterlands, 19 urban agglomerations have not been divided (Table 3 and Fig. 3).

Seven urban tourism agglomerations from Beijing's hinterland area of Beijing are divided. They are: (1) the north-east urban tourism agglomerations, in which Shenyang and Ha'erbin are the primary cores and Changchun is the secondary core, and includes Anshan, Fushun, Benxi, Dandong, Liaoyang, Yingkou, et al.; (2) the Beijing-Tianjin-Hebei urban tourism agglomeration, in which Beijing is the primary core, Tianjin and Shijiazhuang are the secondary cores, and include Zhangjiakou, Qinhuangdao, Tangshan, Baoding, Lang fang, Xiangtan, et al.; (3) the Jinzhong urban tourism agglomeration, in which Taiyuan is the core and includes Jingzhong and Yizhou; (4) the Shandong peninsula urban tourism agglomeration, in which Jinan and Qingdao are the primary cores and Yantai is the secondary core, and include Dezhou, Laiwu, Tai'an, Zibo, Weihai, et al.; (5) the Tianshan northern slope urban tourism agglomeration, in which Urumqi is the core and includes Changji and Karamay; (6) the Lhasa urban tourism agglomeration, in which Lhasa is the core and includes Nagqu, Shigatse and Shannan; (7) the Lanzhou-Xining urban tourism agglomeration, in which Xi'an is the core and includes Xianyang, Baoji, Weinan, Tongchuan and Shangluo (Fig. 3).

Hinterlands of Shanghai are divided into 2 urban tourism agglomerations. One is the Shanghai urban tourism agglomeration, in which Shanghai is the primary core and Hangzhou is the secondary core, and includes Suzhou, Wuxi, Changzhou, Zhenjiang, Nantong, Taizhou, Yan Cheng, Huainan, Suqian, Ningbo, Zhoushan, Shaoxing, Huzhou, Jiaxing, Taizhou, Jinhua, Quzhou, Lishui and Wenzhou. The second is the Nanjing urban tourism agglomeration, in which Nanjing is the primary core and Hefei is the secondary core, and includes Bengbu, Chuzhou, Ma'anshan, Wuhu, Yangzhou, Huaian and Luan.

The hinterlands of Wuhan are divided into 2 urban tourism agglomerations. One is the central plains urban agglomeration, in which Zhengzhou is the core, and includes Luoyang, Kaifeng, Xinxiang, Jiaozuo, Xuchang, Ping'dingshan, and Luohe. The other is the urban tourism agglomeration of the middle reach of the Yangtze River, in which Wuhan is the primary core and the Changsha is the secondary core, and includes Huangshi, Huanggang, Ezhou, Xiaogan, Xianning. These cities are directly controlled by Hubei, Jingzhou, Jinmen, Xiangyang, Yichang, Nanchang, Jiujiang, Jingdezhen and Xiangtan.

Hinterlands of Chongqing are divided into 4 urban tourism agglomerations: (1) the Chongqing urban tourism agglomeration, in which Chongqing is the primary core and includes Guiyang, Anshun, the southeastern area of Guizhou, the southern area of Guizhou, Zunyi, Duyun, Kaili, Suining, Neijiang, Nanchong, Zigong, Guang'an, and Dazhou; (2) the Chengdu urban tourism agglomeration, in which Chengdu is the core and includes Mianyang, Meishan, Leshan, Ziyang and Deyang; (3) the Kunming urban tourism agglomeration, in which Kunming is the core and includes Qujing, Yuxi and Chuxiong; (4) the Lanzhou urban tourism agglomeration, in which Lanzhou is the primary core and Xining as the secondary core, and includes Haibei, Haidong, Baiyin, Dingxi and Linxia.

Table 2
Levels of tourism in central cities of China in the HSR network.

Levels of cities	Component cities
1st-level tourism central cities	Beijing, Shanghai, Guangzhou, Chongqing, Wuhan
2nd-level tourism central cities	Tianjin, Xi'an, Shenyang, Jinan, Harbin, Taiyuan, Shijiazhuang, Qingdao, Nanjing, Xiamen, Chengdu, Kunming, Lanzhou, Zhengzhou
3rd-level tourism central cities	Hohhot, Kashi, Lhasa, Urumqi, Yinchuan, Haikou, Nanning, Xining, Hefei, Yantai, Fuzhou, Hangzhou, Changchun, Nanchang, Changsha, Diqing, Guiyang, Jiuquan, Xishuangbanna
4th-level tourism central cities	Other cities in China

Table 3
Division of urban tourism agglomerations in the HSR network.

Affiliation of hinterland	Urban tourism agglomeration	Primary core city	Secondary core city
Beijing	Northeast	Shenyang, Harbin	Changchun
	Beijing-Tianjin-Hebei	Beijing	Tianjin, Shijiazhuang
	Central Shanxi	Taiyuan	–
	Shandong Peninsula	Jinan, Qingdao	Yantai
	Central Shaanxi plain	Xi'an	–
	Lhasa	Lhasa	–
	Tianshan north slope	Urumqi	–
Shanghai	Shanghai	Shanghai	Hangzhou
	Nanjing	Nanjing	Hefei
Guangzhou	West coast of the Taiwan Straits	Xiamen	Fuzhou
	Pearl River Delta	Guangzhou	Shenzhen
	Beibu Bay	Nanjing	
	Hainan	Haikou	–
Chongqing	Central Yunnan	Kunming	–
	Chengdu	Chengdu	–
	Lanzhou-Xining	Lanzhou	Xining
	Chongqing	Chongqing	–
Wuhan	Central Plains	Zhengzhou	–
	Middle reaches of Yangtze River	Wuhan	Changsha

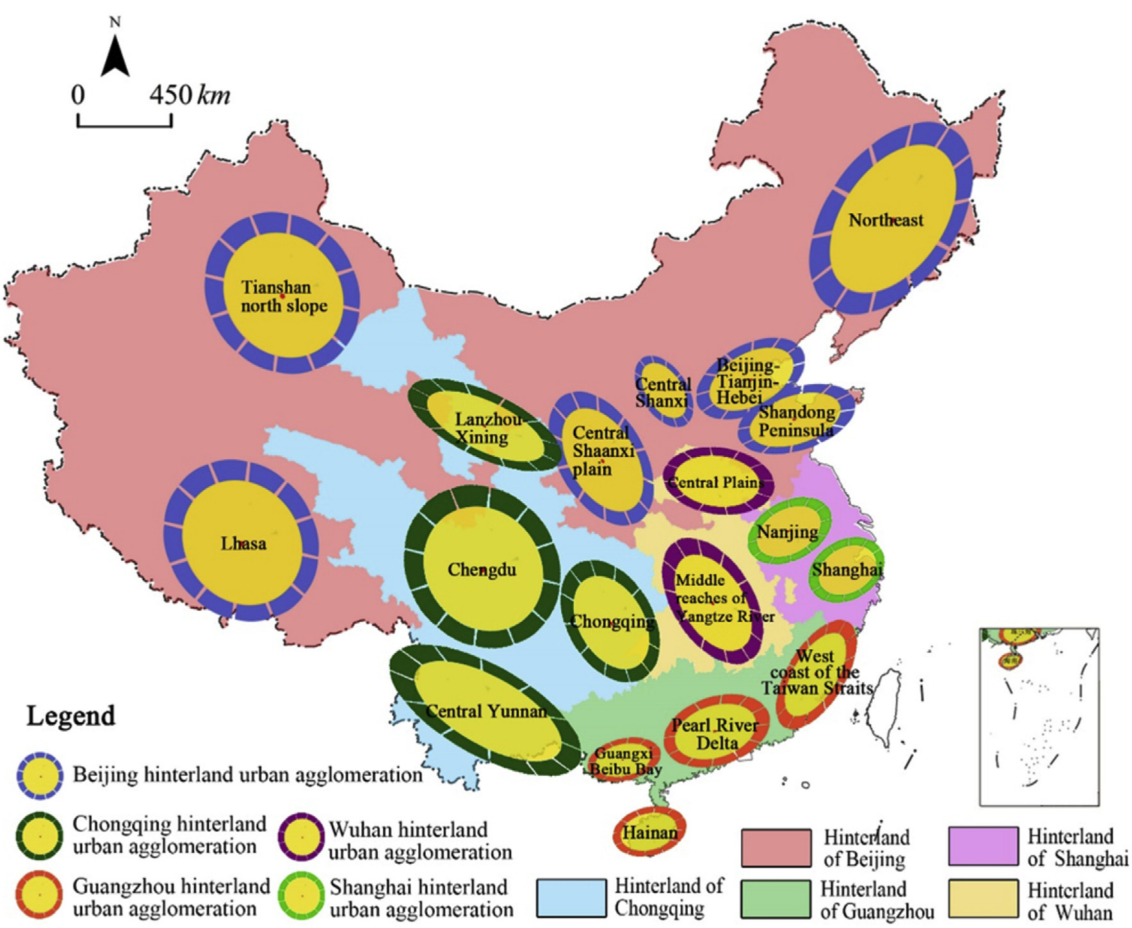

Fig. 3. Spatial pattern of tourism urban agglomerations of China in the HSR network.

Hinterlands of Guangzhou is divided into 4 urban tourism agglomerations: (1) the Pearl River Delta urban tourism agglomeration, in which Guangzhou is the primary core and Shenzhen is the secondary core, and includes Zhuhai, Huizhou, Dongguan, Zhaoqing, Foshan, Zhongshan and Jiangmen; (2) the Guangxi Beibu Bay urban tourism agglomeration, in which Nanning is the core and includes Beihai, Qinzhou, Fangchenggang, Yulin and Chongzuo; (3) the Hainan urban tourist agglomeration, in which Haikou is the core and includes cities directly controlled by Hainan, Sanya and Zhanjiang; (4) the west coast urban tourism agglomeration, in which Xiamen is the primary core and Fuzhou is the secondary core, and includes Nanping, Ningde, Putian, Quanzhou, Sanming, Longyan and Zhangzhou.

In summary, Beijing owns the largest hinterland area and the most urban agglomerations. Chongqing, Guangzhou, Shanghai and Wuhan rank second, third, fourth and fifth. The trend of the integrated development of regional tourism is obvious, where 1st-level tourism central cities serve as cores, a number of large, medium-sized and small urban agglomerations serve as supplements in the HSR network.

4.1.3. Construction of tourism economic zones in the HSR network

Tourism economic zones in the HSR network are constructed based on the city rank after the third restructuring, spatial relationships among hinterlands of the central cities, comprehensive tourism scales and transportation accessibility of central cities. Because hinterlands of some central cities also have hinterland, such as Beijing, Shanghai and Chongqing, this study reassigns and merges the hinterlands that belonging to the same 1st-level central city to keep the tourism zones separate. In the HSR network, the tourism economic zones in China can be divided into two levels, 6 1st-level and 21 2nd-levels tourism economic zones (Table 4, Fig. 4, Fig. 5).

The primary tourism economic zone has 6 1st-level central cities as cores and includes the northern and the western tourism economic zones that places Beijing at the core. These tourism economic zones both belong to Beijing's hinterland, which are split due to the geographical division. The northern and the western tourism economic zones cover the entire northern region and most of Xinjiang and Tibet. The Yangtze River Delta tourism economic zone, in which center is Shanghai, encompasses Shanghai, Jiangsu, Zhejiang and Anhui provinces. The central region tourism economic zone, in which Wuhan is the center, encompasses the Yunnan-Guizhou region and the middle reaches of the Yangtze River. The southwest tourism economic zone, in which the center is Chongqing, encompasses Yunnan, Guizhou and Sichuan provinces and extends into Gansu Province. The southern coast tourism economic zone, which is centered in Guangzhou, encompasses the entire Pearl River Delta region and the N-B-Q-F urban agglomeration (Fig. 4).

Based on the division of the primary tourism economic zones and the division of 1st-level and 2nd-level cities, 21 secondary tourism economic zones can be subdivided from the primary tourism economic zones (Fig. 5). Among them, the northern tourism economic zone comprises 4 secondary tourism economic zones, including the Shandong Peninsula tourism economic zone that centering on Jinan, Qingdao and Yantai; the central Shaanxi plain tourism economic zone centering on Xian and Yinchuan; the Shijiazhuang-Taiyuan tourism economic zone centering on Shijiazhuang and Taiyuan; the northeast tourism economic zone centering on Shenyang, Harbin and Changchun; and the Beijing-Tianjin tourism economic zone centering on Beijing, Tianjin and Hohhot.

The western tourism economic zone contains 2 secondary tourism economic zones, including the Tibet and Xinjiang tourism economic zones that center on Lhasa and Urumqi, respectively. The central region tourism economic zone contains 3 secondary tourism economic zones, including the Nanchang tourism economic zone that centers on Nanchang and Changsha; the Wuhan tourism economic zone centering on Wuhan; and the Central Plain tourism economic zone that centers on Zhengzhou. The Yangtze River Delta tourism economic zone comprises 3 secondary tourism economic zones, which are the Shanghai tourism economic zone centering on Shanghai; the Hangzhou tourism economic zone centering on Hangzhou; and the Nanjing tourism economic zone centering on Nanjing and Hefei. The southwest tourism economic zone contains 4 secondary tourism economic zones, which are the central Yunnan tourism economic zone centering on Kunming; the Chongqing tourism economic zone centering on Chongqing; the Lanzhou-Xining tourism economic zone centering on Lanzhou and Xining, the Chengdu tourism economic zone centering on Chengdu. The southern coast tourism economic zone contains 4 secondary tourism economic zones, including the Guangzhou tourism economic zone centering on Guangzhou; the Guangxi Northern Gulf tourism economy zone centering on Nanning; the Fuzhou-Xiamen tourism economic zone centering on Xiamen and Fuzhou; and the Hainan tourism economic zone centering on Haikou. Other cities encompassed by the secondary tourism economic zones are listed in Table 4.

In summary, the changes of urban hinterlands promote the redivision of tourism economic zones, which has led to a spatial distribution pattern with 6 1st-level and 21 2nd-levels tourism economic zones in the HSR network. Areas of the 1st-level tourism economic zones in the north, west and southwest are larger than those in the southern coast, central region and Yangtze River Delta. Among 2nd-levels tourism economic zones, those belonging to northern tourism economic zones are most, followed by southern coast, southwest, Yangtze River Delta, central region and west rank second.

4.2. Optimization of Chinese tourism spatial structure under HSR

Based on the analysis above, the tourism development model of cities in China in the HSR network, which stimulates a tourism spatial development pattern with multi-center networks and "relies on points to foster groups, axes to cascade groups, groups to stimulate the development of areas," is proposed. In this model, 5 1st-level tourism major cities are regional primary growth poles, including Beijing, Shanghai, Guangzhou, Wuhan and Chongqing; 15 2nd-level tourism central cities are regional secondary growth poles, including Tianjin, Xi'an, Shenyang, Jinan, Harbin, Taiyuan, Shijiazhuang, Qingdao, Nanjing, Xiamen, Chengdu, Kunming, Lanzhou and Zhengzhou; 19 urban agglomerations are regional groups dominating tourism development; the national HSR lines are key development axes; and 6 1st-level tourism economic zones and 21 2nd-level tourism economic zones are in the development domain.

4.2.1. Development of nodes

(1) Tamping regional core status of 5 1st-level tourism central cities

The HSR will lead to the spatial agglomeration and polarization of tourism services, flow and elements, mainly aggregating around 5 1st-level central tourist central cities that include Beijing, Shanghai, Wuhan, Guangzhou and Chongqing in which the polarization effects are strengthened and their leading positions as being tourist origins and destinations are also further strengthened, showing the "Matthew effect" of the HSR. Compared with the situation without the HSR network, due to the sharply compressed time distances, distances between Beijing, Shanghai, Wuhan, Guangzhou and Chongqing as well as their hinterlands will continue to be reduced, thus expanding the intensity and scope of their tourism influence to their surrounding areas. Therefore, to strengthen the 5 regional tourism central cities in the HSR network, their tourism-related economic influence should be expanded and their orientation toward tourism should be improved. Among these 5 cities, Beijing, Shanghai and Guangzhou should strengthen their leading regional role and their

Table 4
Division of tourism economic zones of China in the HSR network.

Primary	Affiliation of hinterland	Secondary	Core city	Other cities
The north	Beijing	Shandong Peninsula	Jinan, Qingdao, Yantai	Dezhou, Laiwu, Tai'an, Zibo, Weihai, Rizhao, Weifang
		the central Shaanxi plain	Xi'an, Yinchuan	Ankang, Baoji, Guyuan, Hanzhong, Pingliang, Qingyang, Shangluo, Shiyan, Tianshui, Tongchuan, Weinan, Xianyang, Yanan, Yuncheng, Yinchuan, Shizuishan, Wuzhong
		Shitai	Shijiazhuang, Taiyuan	Jinzhong, Xinzhou, Shuozhou, Datong, Yangquan, Baoding, Langfang
		Northeast	Shenyang, Harbin, Changchun	Anshan, Benxi, Dandong, Fushun, Fuxin, Jinzhou, Liaoyang, Liaoyuan, Panjin, g Siping, Tieling, Yingkou, Baishan, Jilin, Songyuan, Tonghua, Yanbian, Dalian, Daqing, Jixi, Mudanjiang, Qitaihe, Qiqihar, Suihua, Yichun
		Beijing-Tianjin	Beijing, Tianjin, Hohhot	Alashan, Anyang, Bayannur, Baicheng, Baotou, Binzhou, Chaoyang, Chifeng, Great Khingan, Dongying, Ordos, Heze, Hebi, Hegang, Heihe, Hengshui, Hulun Buir, Huludao, Huaibei, Jining, Jiamusi, Jinchang, Liaocheng, Linfen, Linyi, Luliang, Nanyang, Puyang, Shuangyashan, Tongliao, Wuhai, Wulanchabu, Wuwei, Xilin Gol, Xingtai, Xing'an, Suzhou, Xuzhou, Yili, Yulin, Zaozhuang, Zhangjiakou, Changzhi, Zhongwei
The west	Beijing	Tibet	Lhasa	Ali, Nagqu, Shigatse, Shannan, Linzhi
		Sinkiang	Urumchi	Kertz, Kashgar, Aksu, Hotan, Bayan, Turpan, Haixi, Golog, Huangnan, Bortala, Tacheng, Altay, Changji and Hami, Karamay
Central region	Wuhan	Nanchang	Nanchang, Changsha	Changde, Yiyang, Yueyang, Jiujiang, Fuzhou, Ji'an, Pingxiang, Xinyu, Yichun, Hengyang, Shaoyang, Huaihua, Loudi, Xiangtan, Zhuzhou, Jingdezhen
		Wuhan	Wuhan	Xiangfan, Suizhou, Xinyang, Huanggang, Ezhou, Huangshi, Xianning, Jingzhou, cities directly controlled by Hubei, Xiaogan, Yichang, Jingmen, Zhumadian
		Central Plains	Zhengzhou	Jincheng, Xinxiang, Jiaozuo, Sanmenxia, Luoyang, Pingdingshan, Xuchang, Zhoukou, Bozhou, Kaifeng, Luohe, Shangqiu
Yangtze River Delta	Shanghai	Shanghai	Shanghai	Anqing, Changzhou, Chizhou, Huai'an, Lianyungang, Nantong, Shangrao, Suzhou, Taizhou, Tongling, Wuxi, Suqian, Xuancheng, Yancheng, Yingtan, Zhenjiang
		Hangzhou	Hangzhou	Huzhou, Jiaxing, Zhoushan, Shaoxing, Jinhua, Lishui, Quzhou, Taizhou, Wenzhou, Huangshan, Ningbo
		Nanjing	Nanjing, Hefei	Bengbu, Chuzhou, Ma'anshan, Wuhu, Yangzhou, Huainan, Lu'an, Fuyang
Southwest	Chongqing	Chengdu	Chengdu	Aba, Deyang, Yushu, Qamdo, Ganzi, Diqing, Lijiang, Liangshan, Leshan, Yibin, Meishan, Ziyang, Ya'an, Mianyang, Guangyuan
		Central Yunnan	Kunming	Baoshan, Chuxiong, Dali, Dehong, Honghe, Nujiang, Panzhihua, southwestern of Guizhou, Qujing, Wenshan, Yuxi, Xishuangbanna, Pu'er, Anshun, Liupanshui, Lincang
		Chongqing	Chongqing	Guiyang, Southeast of Guzhou, South Guizhou, Tongren, Bazhong, Bijie, Dazhou, Enshi, Guang'an, Luzhou, Neijiang, Nanchong, Suining, Xiangxi, Zhangjiajie, Zhaotong, Zigong, Zunyi
		Lanzhou-Xining	Lanzhou, Xining	Longnan, Gannan, Hainan (state), Haibei, Haidong, Baiyin, Dingxi, Linxia, Jiuquan, Jiayuguan, Zhangye
Southern coast	Guangzhou	Guangzhou	Guangzhou	Chaozhou, Chenzhou, Dongguan, Foshan, Ganzhou, Guilin, Hechi, Heyuan, Hezhou, Huizhou, Jiangmen, Jieyang, Laibin, Liuzhou, Maoming, Meizhou, Qingyuan, Shantou, Shanwei, Shaoguan, Shenzhen, Wuzhou, Yangjiang, Yongzhou, Yulin, Yunfu, Zhaoqing, Zhongshan, Zhuhai
		Guangxi north bay	Nanning	Baise, Beihai, Chongzuo, Fangchenggang, Guigang, Qinzhou
		Fuzhou-Xiamen	Xiamen, Fuzhou	Nanping, Ningde, Putian, Quanzhou, Sanming, Longyan, Zhangzhou
		Hainan	Haikou	Cities directly controlled by Hainan, Sanya, Zhanjiang

comprehensive tourist services as international metropolises, use their full potential to serve their districts, radiate their influence throughout the country and to the outside world to become international tourist cities with international influence and competitiveness. As key transportation hubs, Wuhan and Chongqing should make full use of their advantages and take full advantage of the HSR effect. Based on their resources, they should increase the speed of the agglomeration and diffusion of various tourism elements within the city to exert their leading roles, perfect and optimize their urban functioning and creation of infrastructure, enrich tourism product systems, enhance the quality of the tourism industry, create new tourism development models, strengthen tourism product development and specific projects. In doing so, Wuhan and Chongqing will become major tourist transportation centers and national tourism transportation hubs in the central region and the southwest.

(2) Fostering the secondary growth poles centered on the 2nd-level cities

The construction of HSR has greatly shortened the travel time between cities. The following cities — Tianjin, Xian, Shenyang, Jinan, Harbin, Taiyuan, Shijiazhuang, Qingdao, Nanjing, Xiamen, Chengdu, Kunming, Lanzhou and Zhengzhou — have strengthened economic relations with regional 1st-level tourism major cities. On the one hand, it is remarkable that 2nd-level cities are influenced by the diffusion effect of resources in a 1st-level city, thus stimulating the urban integration of HSR tourism. For example, the Nanjing-Shanghai inner-city HSR strengthens the connection between two cities. The Beijing-Tianjin inner-city HSR enable the two large cities to gradually become one because the travel time is only 30 min by HSR. On the other hand, in benefitting from the HSR, 2nd-level major tourist cities have stimulated their ability to gather tourism elements and strengthen their core status in regional development. The reduced time results in an enlarged radius of influence and scope of the tourism market. For example, because of the HSR — except for its own province — Jinan's tourist market also includes Beijing, Shanghai, Jiangsu, Anhui, Hebei, Henan, Shanxi and even more distant provinces. Therefore, 2nd-level major tourist cities should not only stimulate the overall level of the tourism-based economy and their ability to organize tourist-related elements, increase influence, driving force and service ability but also join in the regional

Fig. 4. Spatial pattern of primary tourism economy zones of China in the HSR network.

tourism hour radii as soon as possible, strengthening the "urban integration" effect with 1st-level major tourist cities to become secondary tourist growth poles, which can then be influenced by large cities and stimulate growth in other cities as well.

(3) Being alert to "the corridor" effect of small and medium cities

On the one hand, the Matthew Effect enables some competitive tourism nodes to become much more attractive in the HSR network; on the other hand, it may result in the replacement of some tourism nodes that are weak in terms of the quality of resources or competitiveness despite having advantages in terms of location and distance, such as some remote, famous tourist destination. For example, Langfang, Cangzhou, Baoding, Dezhou, Shijiazhuang and Weifang demonstrate obvious "filter" effects while the "filter" effect on Wuxi, Changzhou and Suzhou is slight (Wang & Chen, 2015). Therefore, we should perform overall planning on the national macroscopic level to improve the regional and urban tourism development planning along HSR lines, and be alert to the homogenization and the filter effect. Moreover, connecting HSR lines with inner-city rail transit or other transportation modes to enhance the accessibility would increase the scope radiated by central cities and help smaller cities avoid marginalization.

4.2.2. Development of axes

To obtain the development of axes, we should take urban agglomerations as carriers, main central cities as nodes and a group of national key development axes to accelerate the construction of HSR development axes and accelerate the formation of the axis network of urban tourism economic development in China, which uses "four vertical and four horizontal" as its spindle and the intercity HSR as the vice shaft. First of all, as the fast passenger channels that connect direct-controlled municipality, provincial capital cities, and large and medium-sized cities, the "four vertical and four horizontal" HSR network not only connects the major cities of a region but also stimulates the tourism-related economic interactions between 6 1st-level tourism economic zones and 21 2nd-level tourism economic zones, which will further develop tourism interactions within urban agglomerations. Secondly, the inter-city HSR lines of Beijing-Tianjin, Tianjin-Qinhuangdao, Shanghai-Nanjing, Shanghai-Hangzhou, Hangzhou-Ningbo, Guangzhou-Zhuhai and Guangzhou-Shenzhen will experience reduced travel time within urban agglomerations, which is beneficial to urban integration. Therefore, accelerating the cultivation of the HSR tourism development axis will greatly stimulate tourism economic contact. To engender the shift and optimize and upgrade regional tourism industries, it is necessary to use the HSR network as the foundation and taking advantage of the tourism elements cost, industrial chains and market.

4.2.3. Development of areas

(1) Focus on establishing 5 national tourism urban agglomerations

Taking 1st-level tourism central cities as cores, formation of the growth poles should occur, which can stimulate the tourism development of China while having worldwide influence and competition capability. Priority should be given to the construction of 5 national tourism urban agglomerations: Yangtze River Delta, the Pearl River Delta, the Beijing-Tianjin-Hebei region, the midstream of Yangtze River and the Chengdu-Chongqing region, and eventually become international tourism urban agglomerations.

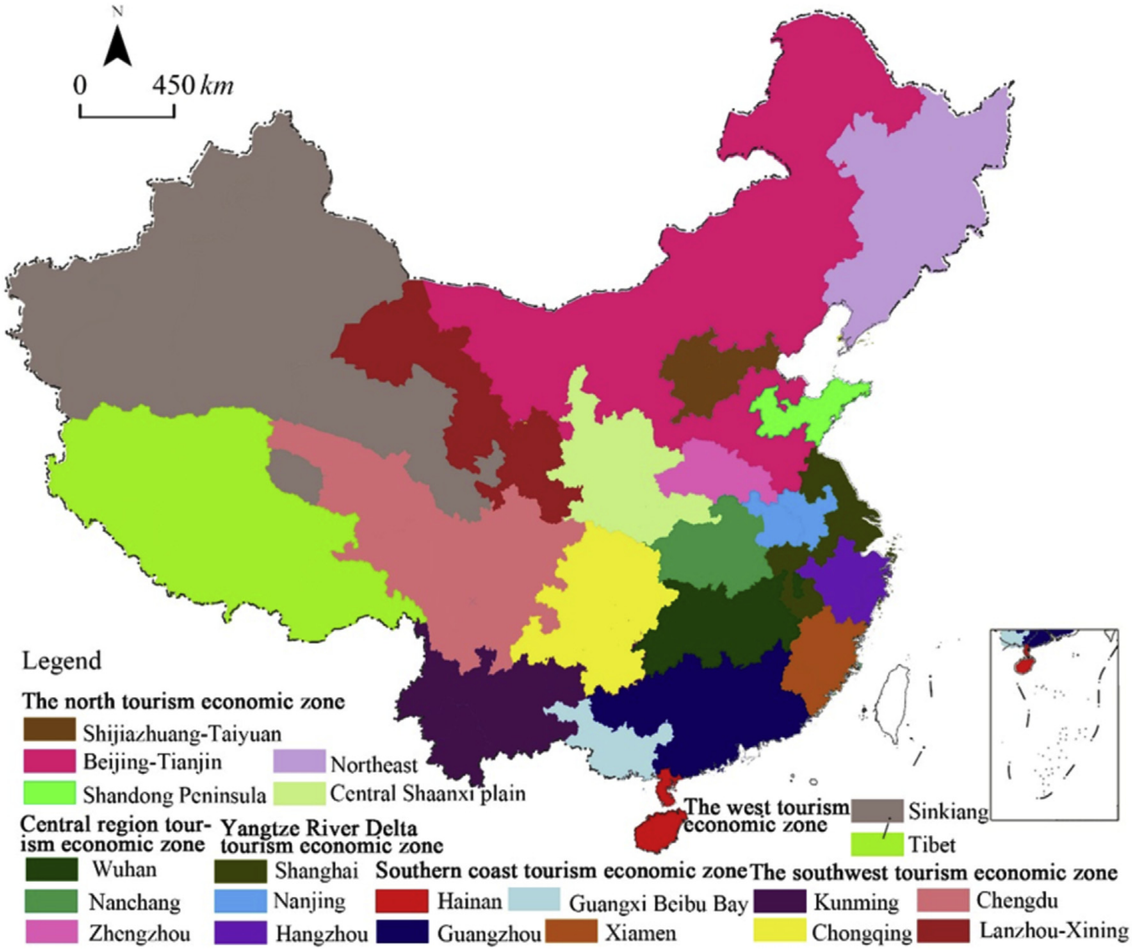

Fig. 5. Spatial pattern of secondary tourism economy zones of China in the HSR network.

(2) Construct cluster development mode of urban agglomerations and improve synergetic development ability

The HSR network would stimulate the expansion of hinterland of urban agglomerations along HSR lines and then promote the overlapping and fusion of hinterlands. Therefore, to integrate the spatial system of urban agglomerations, a clustered development model should be adopted. This model would put more emphasis on inter-regional integration, trans-regional collaboration and trans-regional configuration of tourism-related resources to stimulate a complementary set of advantages and share of tourism-based elements between urban agglomerations with different type and scale to accelerate the speed of tourism and information flows between urban agglomerations. This would strengthen tourism economic relations and the diffusion of tourism elements and to improve the ability of deploying tourist resources between urban agglomerations.

(3) New pattern for tourism regional cooperation

The transportation radius of 1–8 h around Beijing will be formed by a “4 vertical and horizontal” HSR network. Aside from Urumqi, Lhasa, Haikou and Taipei, most provincial capitals will be incorporated in this circle. This will decrease the space-time distance between Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta and other urban agglomerations to increase the transformation rate of tourist and element flow and strengthen the link between central cities as well as the fusion of elements that they lead.

With the deepening of the transition of tourism spatial patterns, new tourism zones are formed, which have different functioning and ways of cooperation. Changes in tourism contacts and cooperation, coordination of policies and organizations, and distribution of functions and elements are all increased with the change in spatial organization. Under the current administration's organization system, inner or trans-regional cooperation systems should be accounted for in the establishment.

5. Conclusions and discussion

With the development of globalization entering a new stage, China has put forward the important development strategy of “One Belt and One Road”, which is a new mode of China's cooperation with the international regional economy. China's HSR “going abroad” faster and more stable, which made China's HSR a “national card”. China's “HSR diplomacy” has strengthened the international cooperation, and has become an important guarantee for the implementation of the “One Belt and One Road” national policy. Intercontinental HSR is an important measure of China's HSR “going out” strategy, which will lead to regional tourism cooperation between China and Europe, Southeast Asia and other countries. Intercontinental HSR will have a profound impact on the regional tourism spatial pattern. The distribution pattern of the intercontinental tourism resources, the pattern of the intercontinental entry and exit tourism market, and the structure of the intercontinental tourism industry will all face “cards-shuffling”. Therefore, this paper provides a new method and perspective for the study of the intercontinental regional tourism spatial pattern evolution under HSR. In this study, the economic relations theory of economic geography has been introduced into the tourism geography to study the tourism hinterland classification, which has provided a new method and perspective for the study of the large scale regional tourism spatial structure. In addition, tourism regionalization is an important part of regional tourism theory. This paper analyzes the redistribution of large scale tourism area caused by HSR to enrich the regional tourism theory, which will provide a reference for the optimization and layout of the intercontinental tourism space in the HSR conditions.

Taking China as a case, the analysis used principal component analysis, accessibility model and intensity model of urban economic relationships with the application of GIS spatial analysis and SPSS statistical analysis to analyze the evolution of the China's urban tourism spatial structure. The following rules are obtained, which can be used for other countries and regions: (1) The total number associated with urban tourism economy relations can be significantly enhanced by HSR, but there are spatial differences of increasing rates, which are mainly concentrated in developed tourist areas. The spatial distribution characteristics of the change rate of total number associated with urban tourism economic relations reflects a corridor effect of HSR, which means that the change rates of the regions along HSR lines are high. The change in the total number associated with the urban tourism economy along HSR lines are obvious. (2) The HSR intensifies the competition of central cities to hinterland. Some central cities are merged into higher-level ones. The number of central cities decreases. HSR enhances the influence and expands the hinterland area of the central city; in this study, Beijing has the largest hinterland area and significantly increases its area, showing that the HSR further strengthens the absolute superiority of hinterland of Beijing, and highlights its tourism status in the spatial pattern. Meanwhile, the HSR exacerbates the area difference and competition for hinterland area of central cities. The HSR expands the spatial ranges of urban agglomerations and stimulates a trend of connection between urban agglomerations, which forms a bigger and more complete tourism economy entity and strengthens the integrated development of regional tourism. (3) Due to significant changes of the hinterland of the cities in the HSR network, tourism central cities are recreated. From central cities and their hinterlands, urban tourism agglomerations are recreated. Based on this, tourism economic zones are also recreated. Finally, the tourism spatial pattern with multi-center network that "relies on points to foster groups, axes to cascade groups, groups to stimulate the development of areas" is built. This pattern uses 1st-level tourism central cities as primary regional growth poles, 2nd-level tourism central cities as secondary regional growth poles, urban agglomerations as leading regional tourism development groups, the HSR as a key development axis, 1st-level and 2nd-level tourism economic zones as development domain constructs.

HSR changes accessibility between cities, causing the changes in the tourism economic relationship of cities, thus having profound influences on the spatial structure of urban agglomerations and playing an important role in reinventing regional urban tourism's spatial structure. With the development of the HSR network, the gaps between inner cities of urban agglomerations and temporal distance between urban agglomerations are narrowed, the development of urban integration is stimulated and favorable conditions for the development of regional tourism cooperation inside and between the urban agglomerations are provided. Therefore, in the future HSR network, cities, countries and regions should strengthen the integration of regional tourism cooperation, deepen the government guidance mechanism of regional integration, integrate tourism-related resources and stimulate tourism products in their regions, according to HSR. Meanwhile, they should also actively explore development strategies in accordance with their own local features to avoid homogenization of competition and to take advantage of the positive effect of urban tourism development brought by the HSR.

The limitations of this study are about the gravity model. Firstly, the model does not consider air transportation, which underestimates accessibility thus influences the measure of urban economic relation. Secondly, this model focus on tourism supply factors rather than actual tourism demands. For example, high travel cost influences the choices for HSR, especially for low-income passengers, by which economic relations are overestimated. Meanwhile, the influences of HSR on different cities should be varied based on different tourism demands for cities in reality, while this model assumes that tourism demands are evenly distributed. Lastly, this model is proposed to address domestic tourism, more factors such as tourism preference, safety, and national policy, laws and regulations should be considered when it comes to international tourism.

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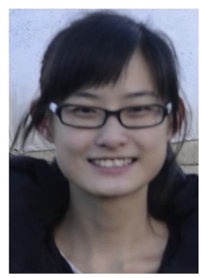
Degen WangProfessor of School of Architecture of Soochow University. Master's supervisor and PhD. His research interests include urban tourism and High-speed rail tourism.Email: wdg713@163.com.Mailing address: School of Architecture, Dushuhu Campus, Soochow University, Suzhou, China



Yu NiuDoctoral student of College of Health and Human Performance of University of Florida. Her research interests include High-speed rail tourism, urban tourism, leisure and tourism in later life.Email: niuyu1008@ufl.edu.

Jia QianPostgraduate Student of Department of Tourism of Soochow University. Her research interests are High-speed rail tourism, urban tourism and tourist behavior.E-mail: qj2115@163.com.