Tourism Management 78 (2020) 104070

Contents lists available at ScienceDirect

Tourism Management

journal homepage: http://www.elsevier.com/locate/tourman

The influence of high-speed rail on ice–snow tourism in northeastern China

Shanhe Jin [a], Jun Yang [a,b,*], Enxu Wang [b], Jun Liu [c]

[a] Human Settlements Research Center, Liaoning Normal University, 116029 Dalian, China
[b] Jangho Architecture College, Northeastern University, Shenyang, 110169, China
[c] Tourism School, Sichuan University, 24 South Section 1 Ring Road No. 1, Chengdu, Sichuan, 610065, China

ARTICLE INFO

Keywords:
Ice-snow tourism
Accessibility
High-speed rail
Weighted mean travel time
Northeastern China

ABSTRACT

Ice-snow tourism is trendy in the global tourism industry. High-speed rail improves the accessibility of these destinations. However, the influences of accessibility on regional economies are understudied. This study investigated changes in accessibility between urban areas and ice-snow tourist destinations after implementation of high-speed rail in northeastern China. Data on transportation networks, destinations, and economic factors were used to compute weighted mean travel times and daily accessibility, and a tourism-economy linkage model was utilized. After implementation, (1) the shortest intercity travel times were significantly shorter, (2) numbers of one-day and weekend trips significantly increased, (3) distribution of accessible tourist destinations expanded northward and southward, (4) isochrone analysis revealed that central cities promoted tourism development in nearby cities, and (5) intercity tourism-economy linkages increased. Accessibility to Shenyang was the most powerful influence on economic development. The tourism-economy linkages between Liaoyang and other cities were greatly enhanced between 2008 and 2018.

1. Introduction

The term “ice and snow tourism” refers to tourism that uses the ice and snow natural resources generated by a region’s cold weather to attract tourists to seasonal cultural activities related to winter. Ice-snow landscapes have become important components of urban planning, development, and landscaping (Huang, 2018). As part of the tourism market, ice and snow tourism can change the structure of the tourism market and provide better services for tourism strategies (Wang, Zhong, Zhang, & Zhou, 2014; Xia et al., 2010). China introduced its high-speed rail (HSR) transit system, the Beijing-Tianjin intercity line, in 2008 and since then, the HSR system has evolved into a convenient mode of mass transit in China (Wang, Huang, Zou, & Yan, 2012; Wang, Liu, Mao, & Sun, 2018). China’s HSR system has inspired other countries to develop HSR systems (Danapour, Nickkar, Jeihani, & Khaksar, 2018), and investing in HSR has become a vital development strategy for speedy and efficient intercity travel, and to facilitate urbanization and national economic growth (Chen & Haynes, 2017). As a new type of mass transit, HSR also promotes tourism development.

The most recent studies on ice-snow tourism were set in Western countries. For example, one study found that climate change had limited the development of ice-snow tourism in the United States (Wobus et al., 2017), and technological changes were related to reduced ticket prices, implementation efficiency, and productivity at French ski resorts (Goncalves, 2013; Wolff, 2014). It is challenging to develop ice-snow tourism in these places. However, when China was selected to host the 2022 Winter Olympics, its tourism industry increased its focus on ice-snow tourism. The China Tourism Academy released the “China Ice and Snow Tourism Consumption Big Data Report” (2018) which pointed out that during the 2016–2017 ice and snow season, China’s ice and snow tourism market reached 170 million visitors and generated a revenue of about CNY 270 billion. China has become a sizable ice and snow tourism country (http://www.ctaweb.org/). Clearly, ice-snow tourism is becoming a popular type of tourism in China.

Tourism development is cyclical and seasonal (Liu, Cheng, Jiang, & Huang, 2019; Song & Li, 2013). Because of China’s regional variation in seasons, topography, and weather, the influences of ice-snow tourism vary across municipal and regional economies. Ice-snow tourism is characterized by regional variation, seasonal variation, the extent of participation, and physical exercise (Liu, Zhao, & Liu, 2018). However, in addition to promoting the tourism industry’s overall development, ice-snow tourism has been responsible for some regional economic recovery. Reliable mass transit might promote sustainable and consistent economic development (Aratuo & Etienne, 2019), and, because tourist

* Corresponding author. Human Settlements Research Center, Liaoning Normal University, 116029 Dalian, China.
E-mail addresses: 359296196@qq.com (S. Jin), yangjun@lnnu.edu.cn (J. Yang), wangenxu801007@163.con (E. Wang), liujun_igsnrr@126.com (J. Liu).

https://doi.org/10.1016/j.tourman.2019.104070
Received 28 May 2019; Received in revised form 19 November 2019; Accepted 18 December 2019
Available online 29 January 2020

destinations are important to tourism, the spatial structure of tourist destinations are significant guides in urban tourism development (Chaabouni, 2019; Deng, Hu, & Ma, 2019; Xia, Zeephongsekul, & Packer, 2011). Regarding ice-snow tourism, accessibility to and the spatial distribution of tourist destinations are vital to economic development, social economic planning, and to mass transit to destinations. Access and spatial considerations have theoretical and practical significance for urban planning and development.

In the mid-twentieth century, Hansen first proposed that accessibility is a spatial concept (Hansen & Walter, 1959) that is related to factors such as scale, spatial location, and spatial interaction. Evaluation and assessment tools of accessibility include distance attenuation, the two-step floating catchment area method, market potential, and daily accessibility (Miller & Baker, 2016; Wang & Wang, 2018; Wu, Liang, & Wu, 2016). Mass transit networks connect tourists' points of origin to their destinations, which is a vital service for tourism success (Campa, López-Lambas, & Guirao, 2016; Currie & Falconer, 2014; Liu, Wang, Wang, Wang, & Deng, 2018). Transportation such as aviation, roads, and water transport changes the connection between cities and restricts each other (Rehman Khan, Qianli, SongBo, Zaman, & Zhang, 2017). The opening of the high-speed rail has led to a 27% reduction in China's air traffic and has had a greater impact on hub cities (Chen, Wang, & Jiang, 2019; Yang, Burghouwt, Wang, Boonekamp, & Dijst, 2018). Previous studies have found that mass rail transit encourages tourism development (Khan et al., 2017). The opening of the high-speed rail has both shortened the time between cities and promoted the desire of residents to travel, thereby generating economic benefits.

Travel is an expected tourism cost. In the context of marketing, travel costs have been related to the socioeconomic and demographic characteristics of a region (Lin, Mao, & Song, 2015). Another study found that an intercity HSR system sped up the intercity connectivity of the transportation network (Huang, Lu, Yang, & Zhao, 2018). HSR influences accessibility within a region via mass transit, and changes in accessibility to mass transit might further develop a region's spatial structure and thereby provide economic benefits derived from tourists' increased accessibility to various destinations. Some studies have demonstrated that HSR connectivity was likely to produce local effects and to diffuse the central economy into surrounding areas (Meng, Lin, & Zhu, 2018; Xu, Zhang, Zhang, Wang, & Zhang, 2019). The HSR network has a huge impact on the motives of tourists, location of tourism companies, and structure of the tourism space. Its growth has promoted more domestic tourists to the surrounding areas of big cities (Yin, Lin, & Prideaux, 2019). At present, studies have identified four primary impacts of HSR on tourism: (1) HSR created opportunities for the cities, (2) the spatial structure of the tourist destinations changed after the HSR was implemented, (3) travel times between connected cities was much shorter and the accessibility of the connected cities was improved, and (4) regional tourism rapidly developed at the HSR-connected destinations, which changed the interregional economy.

China's highly efficient and inexpensive HSR system was previously found to create additional destination options for tourists, alter demands for tourism products, and redistribute tourist destinations, which transformed the tourism market (Cao, Liu, Wang, & Li, 2013). In addition, shortening the distance between the source and tourist destination led to tourists avoiding wasting time on the journey and enabled more passengers to arrive at the city (Ureña, Menerault, & Garmendia, 2009); as a result, the tourism industries of nearby cities have rapidly developed. Gao, Su, and Wang (2019) found that China's HSR promotes people's entry into neighboring cities and increases the number of tourists with unique tourism resources (Gao et al., 2019). From the perspective of regional development, the HSR has changed China's economic distribution pattern in the past decade. Small and medium-sized cities are more suitable for HSR investment and construction than large developed cities (Ato Xu & Huang, 2019). In the tourism economy, economic growth and tourism development are interdependent, and tourism development stimulates economic growth (Dogru & Bulut, 2018; Pagliara, Mauriello, & Garofalo, 2017). Enhancing the accessibility of tourist destinations has significantly grown regional urban economies in China (Hongchang, Strauss, Shunxiang, & Lihong, 2017). However, regions that invest more in HSR do not necessarily reap more economic benefits (Xua, Zhoub, Yangc, & Li, 2018). Therefore, it is important to understand the influences of the HSR on regional economies.

Northeastern China is a region particularly suited to ice-snow tourism (Yang, Yang, Sun, Huang, & Ge, 2017), and has taken the tourism lead in development and scale. Its tourism development has significantly contributed to the reduction of regional inequalities (Li, Chen, Li, & Goh, 2016). Therefore, this study employed data on the transportation network, tourism destinations, and socioeconomics of three provinces in northeastern China in 2008 and in 2018 to compare accessibility and economic factors related to ice-snow tourism before (2008) and after (2018) implementation of the HSR. Network analysis was used to compute regional accessibility, and tourism-economy linkages were analyzed to investigate the temporal and spatial differences in accessibility and the economies of the three provinces. The study's main objective was to develop a reference for the sustainable development of the ice-snow tourism industry in China.

2. Materials and methods

2.1. Study area

Heilongjiang, Jilin, and Liaoning provinces in northeastern China (120°E−135°E, 38°N–56°N) comprise 36 cities with mostly temperate monsoon climates, warm (but short) summers, and long cold winters. Snowfall usually spans November through February. There are 314 ice-snow tourist attractions and 3 airports which are located in Harbin, Changchun, and Shenyang. Plains and mountains dominate the terrain and the three provinces are rich in natural resources, with about 38.75 km^2 of forestry land which accounts for 14.7% of China's total forestry land area. The forests' share of the region's total land area is about 39.6%, which exceeds the national mean. The three provinces have special features, advantages, and generous environmental resources for developing an ice-snow tourism industry (Fig. 1).

2.2. Data

2.2.1. Route data

The route data collected on 2008 comprised information about national highways, provincial highways, expressways, ordinary rail lines, and some county roads. The route data collected in 2018 included all the types listed for 2008 plus data on the HSR. Speed limits on all the types of routes were derived from the Industrial Standards of the People's Republic of China: Technical Standards for Highway Engineering (JTGB–2003) while referencing actual regional behavior. The HSR's speed limit was derived from the 2008 edition of the "Medium- and Long-Term Railway Network Plan" (Medium- and Long-Term Railway Network Plan, 2008).

The 2008 and 2018 route maps were merged, and the intersections of all the routes in the merged map were connected to create a complete interconnected transportation network. An origin-destination (OD) cost matrix was used to compute the travel times between the nodes of the network. Those results were used to indicate accessibility. Each province's statistical yearbook was used to obtain the socioeconomic indicators (National Bureau of Statistics., 2009; Statistics Bureau of Heilongjiang Province., 2009, 2017, Statistics Bureau of Jilin Province., 2009, 2017, Statistics Bureau of Liaoning Province., 2009, 2017). Tables 1 and 2 describe the data used in the study and the speed limits by route type, respectively.

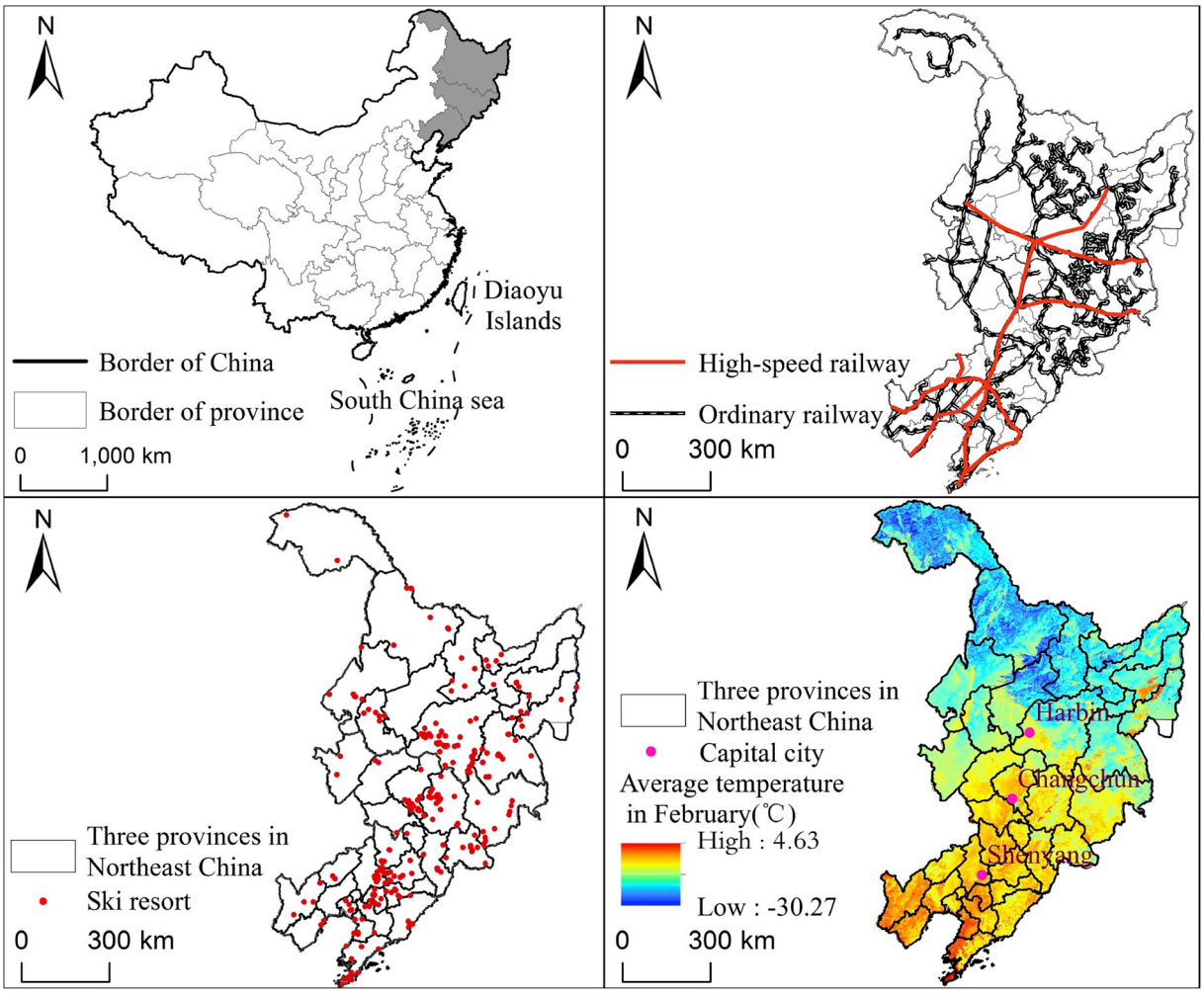


Fig. 1. The location of the study area.

Table 1
Sources and descriptions of the data used in the study.

Types of route	Sources	Description
National highway Provincial highway Other Highways Ordinary rail County road	National Geographic Information Bureau	–
High-speed rail (2008 and 2018)	National Geographic Information Bureau	High-speed rail line
Tourist destinations (Heilongjiang, Jilin, and Liaoning provinces)	National Tourism Bureau	Northeast China's winter tourist destinations (n = 314)
Socioeconomic factors	Liaoning Statistical Yearbook (2009, 2017) Heilongjiang Statistical Yearbook (2009, 2017) Jilin Province Statistical Yearbook (2009, 2017) China Regional Economic Statistical Yearbook (2009)	Gross domestic product (CNY 100 million) GDP per capita (CNY) Total population (10,000) Total number of domestic tourists (10,000) Total tourism revenue (CNY 100 million)

2.3. Variables and methods of analysis

2.3.1. Weighted mean travel time

The choice of measures used to indicate the accessibility of the nodes in the transportation network was very important, and because this study compared the travel times between cities and their ice-snow tourist destinations before and after the implementation of the HSR, the weighted mean travel time was used in the analysis. The weighted mean travel time used integrated time to measure the spatial differences among the cities' accessibilities. A lower weighted mean travel time indicated less time needed to travel from a city to a tourist destination.

The tourists' costs represent the feasibility of a trip. Travel cost was computed similarly to the computation of weighted mean travel time. The use of the weighted average travel time model reflects regional traffic accessibility, and the economy and city size should be used in the calculation (Jiao, Wang, Jin, & Dunford, 2014; Wang, Liu, Sun, & Liu, 2016). First, the gross domestic product and population data were obtained for each study site. Then, network analysis was used to obtain the temporal cost and compute a city's accessibility.

$$M_j = \sqrt{GDP_j \times P_j} \tag{1}$$

$$A_i = \frac{\sum_{j=1}^{n} T_{ij \times M_j}}{\sum_{j=1}^{n} M_j} \tag{2}$$

In Equation (1), M_j represents the quality of the city j; GDP_j represents the total economic output of j; and P_j represents the population of j. In Equation (2), A_i is the accessibility of i calculated using the weighted mean travel time; and T_{ij} indicates the shortest travel time between cities.

Table 2
Designated route speeds by types of route.

	Route Types					
	National highway	Provincial highway	Other highway	Ordinary Rail	County road	High-speed rail
Designated route speed (km/h)	80	60	100	90	40	300/250/200/160
Calculating speed (m/min)	1333.33	1000	166.66	1500	666.66	5000/4166.66/3333.33/2666.66

2.3.2. Maximum number of tourist destinations

OD cost matrix analysis was employed to obtain the number of tourist destinations that could be reached from the tourists' points of origin. The destinations that could be reached within four hours (0–4 h) were defined as "daytrips," and those that could be reached within six hours (0–6 h) were defined as "weekend trips." In addition, the cities of Harbin, Changchun, Shenyang, and Dalian were used as case studies, and a cost raster was used to calculate the isochrones and quantitatively analyze the changes in spatial patterns of destination accessibility.

2.3.3. Daily accessibility

Daily accessibility reflected the largest number of people and greatest extent of activity that a node could accomplish during a specified period (Gutiérrez, 2001; Wang et al., 2016), with daily accessibility time less than four hours or six hours, meaning that one could complete a day trip plan. Exceeding this range means visiting the destination for more than two days (weekend tour), so this article takes four hours and six hours as the node and reflects the market size of the attraction.

$$DA_i = \sum_{j=1}^{n} p_j \delta_{ij} \tag{3}$$

In Equation (3), DA_i signifies the daily accessibility of node i; p_j signifies the population size of j; and δ_{ij} is the coefficient. When the travel time between i and j is up to four or six hours, the value of the coefficient equals 1, and when the travel time exceeds four or six hours, the value of the coefficient equals 0.

2.3.4. Tourism-economy linkage model

The economic effects of the revenue changes in the tourism industry were determined using the tourism-economy linkage model. According to economic gravity theory, economic laws similar to Newton's law of universal gravitation apply to the economic relationships between cities. Newton's law can be applied to the economic relations between cities within a region (Guo, Wang, Li, Peng, & Wang, 2016). Hence, this study used this theory to ascertain the economic radiation of a central city (with ice-snow tourist destinations) to its nearby cities, thus verifying the change of traffic time introduced by the HSR and replacing the spatial distance with time.

$$R_{ij} = \frac{\sqrt{P_i V_i} \times \sqrt{P_j V_j}}{T_{ij}^2} \tag{4}$$

$$C_{ij} = \sum_{j=1}^{n} R_{ij} \tag{5}$$

In Equation (4), R_{ij} represents the tourism-economy linkage; P_i and P_j are the total number of tourists (10,000 people) in cities i and j; V_i and V_j represent the total tourism revenue (CNY 100 million) of i and j; and T_{ij} is the shortest travel time between the two cities (in minutes). In Equation (5), C_{ij} is the sum of the links between tourism and economic growth between i and the other cities, reflecting the status and role of tourism in northeastern China.

3. Results

3.1. Temporal and spatial differences in accessibility of ice-snow tourist destinations

3.1.1. Temporal and spatial changes in accessibility between cities

The weighted mean travel time and network analysis were used to determine the accessibility of each city in the three provinces to ascertain the temporal and spatial changes in accessibility after implementation of the HSR. Table 3 shows that the shortest travel time between the prefecture-level cities and the other cities was a total of 3334.99 h shorter after the implementation of the HSR, suggesting that the HSR significantly shortened travel time between cities and created a foundation for increasing regional tourism. In addition, the mean travel time needed to arrive at tourist destinations from cities was 35.16% shorter, which further suggests that the HSR promoted tourism.

Figs. 2 and 3 illustrate that the accessibility to cities along the HSR routes greatly increased between 2008 and 2018. The Harbin-Dalian HSR and the Harbin-Jiamusi intercity HSR improved accessibility in the central and northern parts of the study region. The changes were largest in Jiamusi and Harbin, where total travel times to other cities were 3.86 and 2.62 h shorter, respectively. After the Harbin-Qiqihar HSR and the Harbin-Mudanjiang HSR were implemented, travel to Qiqihar, Daqing, and Mudanjiang was 3.37 h, 2.98 h, and 3.2 h shorter, respectively. The Beijing-Shenyang HSR, Tianjin-Shenyang HSR, and Xinmin-Tongliao HSR greatly increased accessibility to the southwestern region of Liaoning Province. The change in travel time to Chaoyang was the greatest (3.62 h less).

Among the HSR lines in the study region, the Harbin-Dalian HSR is the longest (921 km), passing through 22 stations and connecting more cities than other lines of the high-speed rail. Cities' accessibility along the Harbin-Dalian HSR line significantly improved. Specifically, the accessibility of Harbin, Changchun, Shenyang, and Dalian improved to 2.66, 2.18, 2.36, and 3.97 h, respectively. The mean travel time to Harbin and Dalian decreased by 49.62% and 47.69%, respectively. Travelers generally choose their travel modes based on the distances between their points of origin and their destinations' stations. Figs. 2 and 3 above show that after the implementation of the HSR, accessibility was relatively more changed for the cities closer to the HSR stations. For example, the accessibility of Fushun, a city near Shenyang, increased by 41.13%; however, the accessibility of the Daxinganling area, Heihe, Baicheng, and Baishan increased just 17.61%, 23.29%, 25.57%, and

Table 3
Changes in travel times after the implementation of HSR in 2008; change computed between 2008 and 2018.

Travel origins and destinations	High-speed rail		Change	
	Yes (hours)	No (hours)	Change value (hours)	Rate of change (%)
Total travel time between cities	5694.65	9029.64	3334.99	36.93
Travel time from cities to tourist destinations	49,397.77	76,186.35	26,788.58	35.16
Mean travel time from cities to tourist destinations	157.32	242.63	85.31	35.16

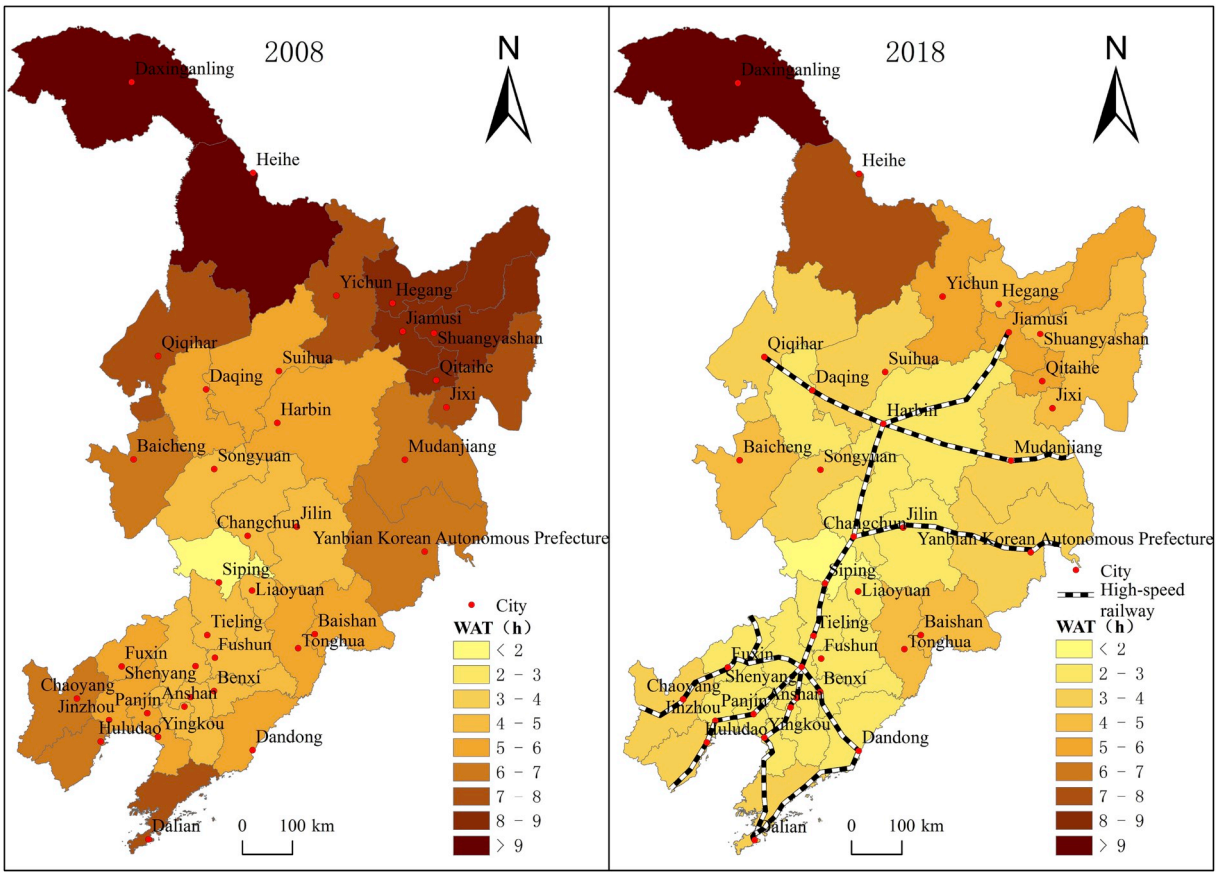


Fig. 2. Spatial distributions of weighted mean travel time (A) 2008 and (B) 2018.

17.06%, respectively, because they are farther away from the HSR stations.

The number of ice-snow tourist destinations in Heilongjiang Province, Jilin Province, and Liaoning Province were 136, 82, and 96, respectively. The major cities for ice-snow tourism were the central cities of Harbin, Jilin, Shenyang, and Dalian. The destinations in Heilongjiang Province, the majority of which are ski resorts, were concentrated in its southeastern region; therefore, the destinations directly competed with one another. The destinations in Jilin Province were concentrated in the province's central region alongside the Harbin-Dalian HSR. Travel times to Jilin Province for those who lived in the region's cities that were far from it were shorter using the HSR; hence, the HSR attracted new tourists. The destinations in Liaoning Province were distributed in the south-central region of the province. Shenyang, the provincial capital, has ample resources for developing ice-snow tourism products. Shenyang's well-developed mass transit system connects to three HSR lines, and tourists wishing to participate in ice-snow tourism can easily access Shenyang. Dalian, a coastal city in Liaoning Province, offers skiing and hot springs during the winter as newly developed tourism products in addition to its island tourism. The HSR is an ideal mass transit system for transforming the region's tourism industry.

3.1.2. Changes in daily accessibility of the ice-snow tourist destinations

Fig. 4 shows the changes in the numbers of ski resorts (ice-snow tourist destinations) accessible from specific points of origin within four or six hours between 2008 and 2018. The number within four travel hours from Daqing, Qiqihar, Changchun, Jilin, Yanbian Korean Autonomous Prefecture, and Tieling greatly increased. The largest increase was in Yanbian Korean Autonomous Prefecture (from 65 to 226). The HSR line from Jilin to Hunchun runs through the Yanbian Korean Autonomous Prefecture and connects to the Harbin-Dalian HSR. The Yanbian Korean Autonomous Prefecture is near Jilin and Harbin and has many ice-snow tourism resources. The number of ski resorts accessible within six travel hours from Daqing, Chaoyang, Fuxin, Huludao, and Jinzhou notably changed; Chaoyang experienced the largest increase (from 98 to 273). Fig. 4(b) shows that the cities with the largest increases in the numbers of ski resorts accessible within six hours were concentrated in southwestern Liaoning Province, which is connected to the Xinmin-Tongliao HSR line, Beijing-Shenyang HSR line, and Tianjin-Shenyang HSR line. The number of these tourist destinations accessible to Heihe within six hours increased by 14.

Fig. 5 compares the isochrones among the central cities. Ten years after the HSR was implemented, Shenyang's isochrones were the most changed. Before implementation in Shenyang, the percentages of the total accessible area in the study area within one to two hours, one to four hours, and one to six hours were 6.43%, 20.37%, and 31.04%, respectively. Ten years after the HSR was implemented, the percentages of the total accessible area within one to two hours, one to four hours, and one to six hours were 21.03% (an increase of 14.6%), 19.55%, and 34.04%, respectively. The percentages of accessible area from Harbin, Changchun, and Dalian within two hours increased by 2.36%, 2.64%, and 0.05%, respectively, and those of Harbin, Changchun, and Dalian within four hours increased by 6.18%, 8.56%, and 1.73%, respectively. It is clear that the HSR lines around Shenyang had the most influence on the one-hour isochrone from Shenyang. Specifically, the HSR apparently increased the daily accessibility of Shenyang and strengthened the spatial connections between Shenyang and other cities. Moreover, the changes in accessibility from Changchun within one to two hours and within one to four hours were greater than those of Harbin and Dalian. Therefore, the government's Tourism Plus policy, which encourages coordination between the tourism and transportation industries in

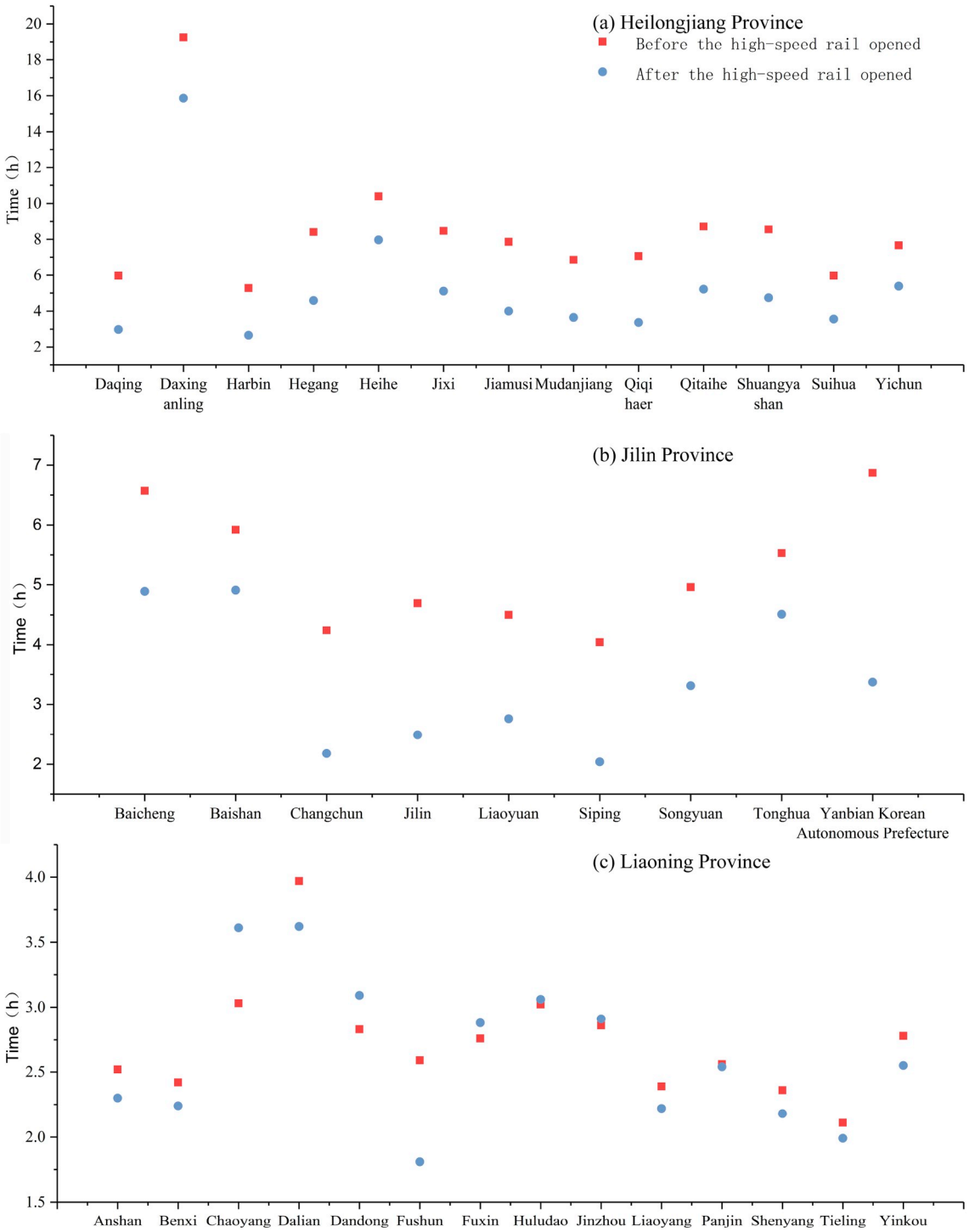


Fig. 3. Travel times before and after implementation of high-speed rail in (a) Heilongjiang Province, (b) Jilin Province, and (c) Liaoning Province.

northeastern China, seems to be promoting tourism development and regional economic development.

There are 314 tourist destinations in the study area. In addition to shortening the travel times between cities and ice-snow tourist destinations, the HSR apparently changed the spatial structure of the accessible tourist destinations (Fig. 6). In 2008, the destinations within a four-hour travel period from the points of origin were mostly centrally distributed. As the travel times to the tourist destinations increase, the distribution of accessible areas increasingly manifest as concentric ellipses. Ten years after the HSR was implemented, the numbers of tourist destinations accessible within a shorter travel time had expanded northward and southward, which was particularly evident in Harbin and Dalian. In 2008, just six tourist destinations were accessible within five hours on average; the mean travel time between the cities and the Changchun Dianfeng Huaxue Julebu (Changchun Summit Ski Club) was the shortest. After the HSR was implemented, the number of tourist destinations accessible within five hours had increased to 236, suggesting that by using the HSR, tourists could access about 75% of the tourist destinations within five hours. The largest destination with the shortest travel time was the Kazuo Longyuan Lake Ice and Snow Carnival. In addition, the changes in travel time to the tourist destinations at the study area's periphery were most noticeable, particularly in

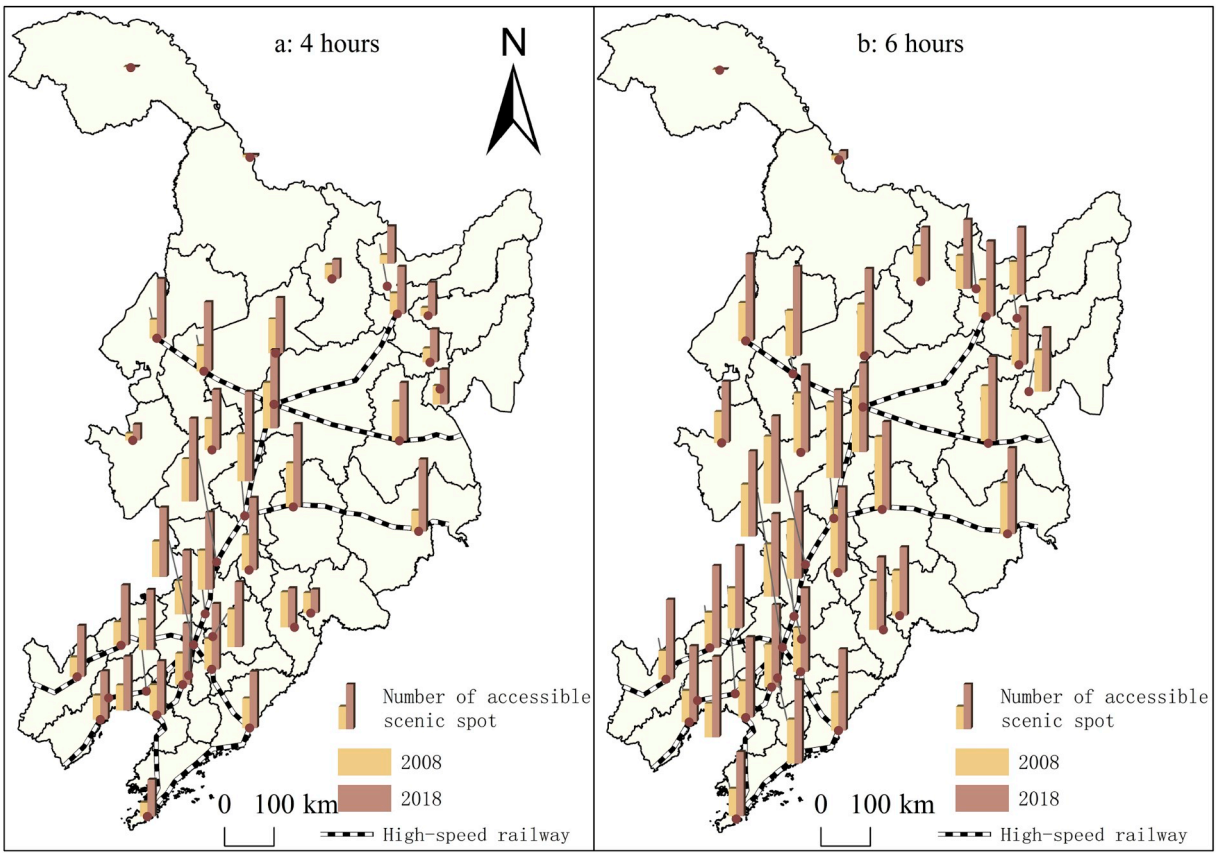


Fig. 4. Numbers of ski resorts accessible in (a) four hours and (b) six hours before and after the high-speed rail implementation.

the southern part of the region, such as the Dalian Labor Park Ski Field and the Polar Ice and Snow Festival at Dalian Laohutan Ocean Park.

Table 4 shows that after the implementation of the HSR, the potential diffusion of tourists to areas within various travel times to the destinations substantially increased. In 2018, the famous AAAA ice-snow tourist destinations in Liaoning Province (mostly in Shenyang) such as Shenyang Qipanshan Ski Resort and Shenyang Magic Slope International Ski Field were much more accessible. The mean travel time to Qipanshan Ski Resort decreased from 5.3 h to 3.2 h, and the travel time to the Magic Slope International Ski Field was shortened by 2.3 h. The mean travel time to the famous Yabuli Ski Resort, a popular AAAA tourist destination in Heilongjiang Province, was 2.7 h shorter in 2018 than it had been in 2008.

3.2. Temporal and spatial differences in the tourism-economy linkages of ice-snow tourist destinations

The analysis found that the cities' tourism-economy linkages greatly increased during the 10-year period (Fig. 7). Regarding accessibility, the largest influence on economic development was in Liaoning Province, where tourism in Shenyang after the implementation of the HSR increased and stimulated the development of the tourism industry in neighboring regions. The tourism-economy linkages between Liaoyang and Anshan and other cities were greatly enhanced after the implementation of the HSR. Changchun and Jilin became the new driving forces of economic development in Jilin Province. However, the radial effect of the HSR was somewhat limited because changes to the tourism-economy linkages between Daxinganling and Heihe and other cities were not observed. Specifically, the tourism-economy linkages of Shenyang, Anshan, Liaoyang, and Changchun increased by 21,662.45 (10,000 people) × (CNY 100 million)/min^2; 18,082.07 (10,000 people) × (CNY 100 million)/min^2; 16,426.63 (10,000 people) × (CNY 100 million)/min^2; and 11,431.84 (10,000 people) × (CNY 100 million)/min^2. Among the 11 HSR lines in northeastern China, the Harbin-Dalian HSR line contributed most to the development of the region's tourism industry. The Harbin-Dalian HSR line connects to five other HSR lines which together form a distinctive tourism beltway of HSR lines that also promotes the tourism industry in nearby cities. The most typical case is Songyuan, which experienced an increase in tourism-economy linkages by 238.80 (10,000 people) × (CNY 100 million)/min^2.

However, the influence of the HSR was not consistent across cities. Calculated changes to the tourism-economy linkages revealed that Suihua, Qitaihe, Fushun, and Yichun had smaller increases in tourism-economy linkages than other cities (increases of 15.76%, 254.89%, 717.54%, and 1932.18%, respectively). This finding implies that the influences of the HSR on tourism development were weakest for the cities farthest from the HSR stations. Although the HSR spurred both rapid tourism and tourism product development along its lines, the low accessibility to tourist destinations from cities farther away from the stations discouraged tourism development there.

4. Discussion

A tourist destination's attractiveness increases tourists' interest in reaching that destination (Reitsamer, Brunner-Sperdin, & Stokburger-Sauer, 2016). Among the many types of tourism products such as Island tourism, rural tourism, and shopping tours (Shen, Wang, Quan, & Xu, 2019; Wang, Liu, Wang, Zhu, & Lin, 2018; Yang, Ge, Ge, Xi, & Li, 2016), ice-snow tourism is a newcomer, and the so-called "ice and snow towns" are increasingly attracting broad attention. However, during the design process for tourism products, cultural differences between China and Western countries should be considered (Dewar, Meyer, & Li, 2001). Transportation networks are foundational in the tourism industry, and their role in tourism growth is vital (Lohmann &

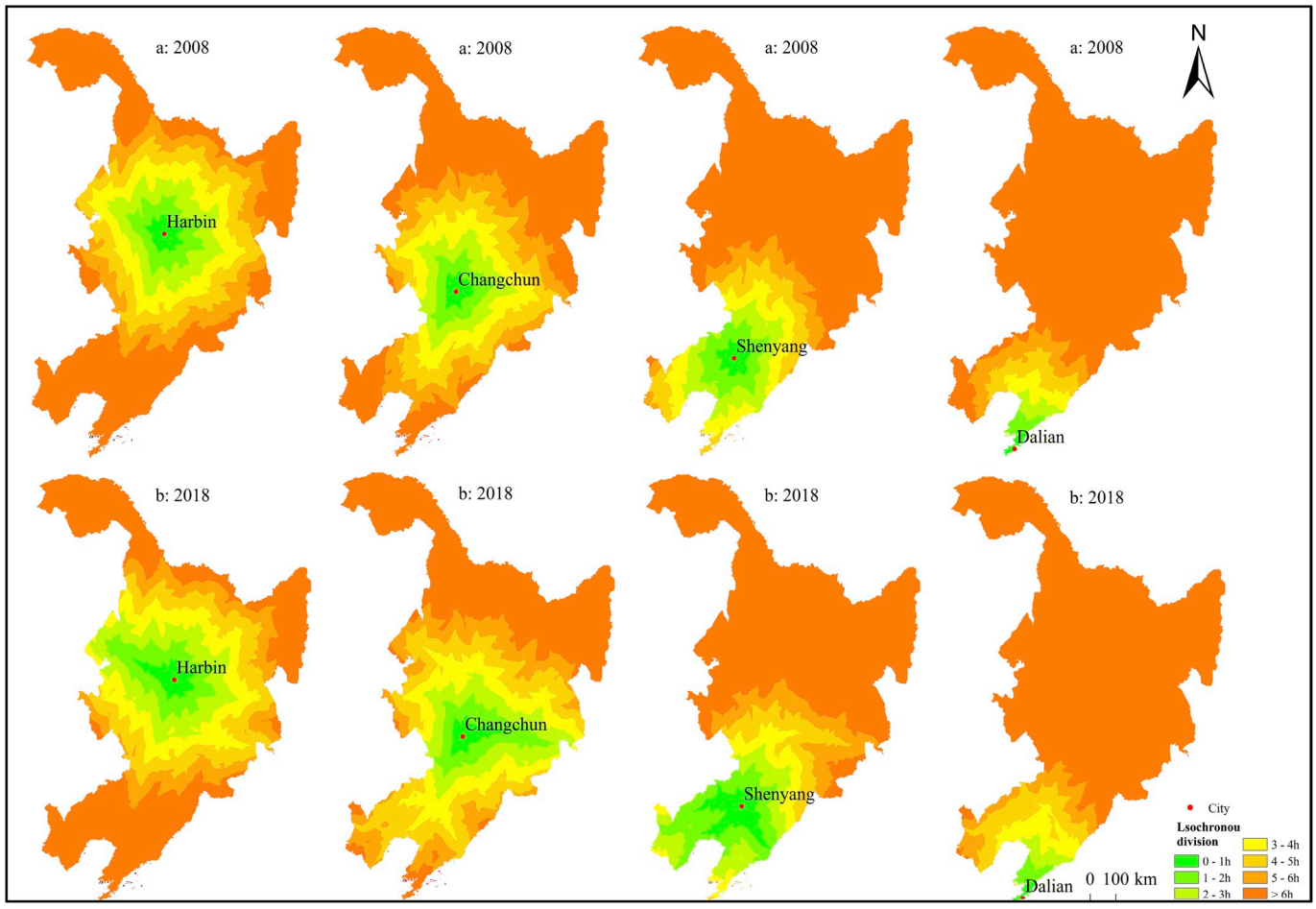


Fig. 5. Variation in the isochronous circles of the central cities.

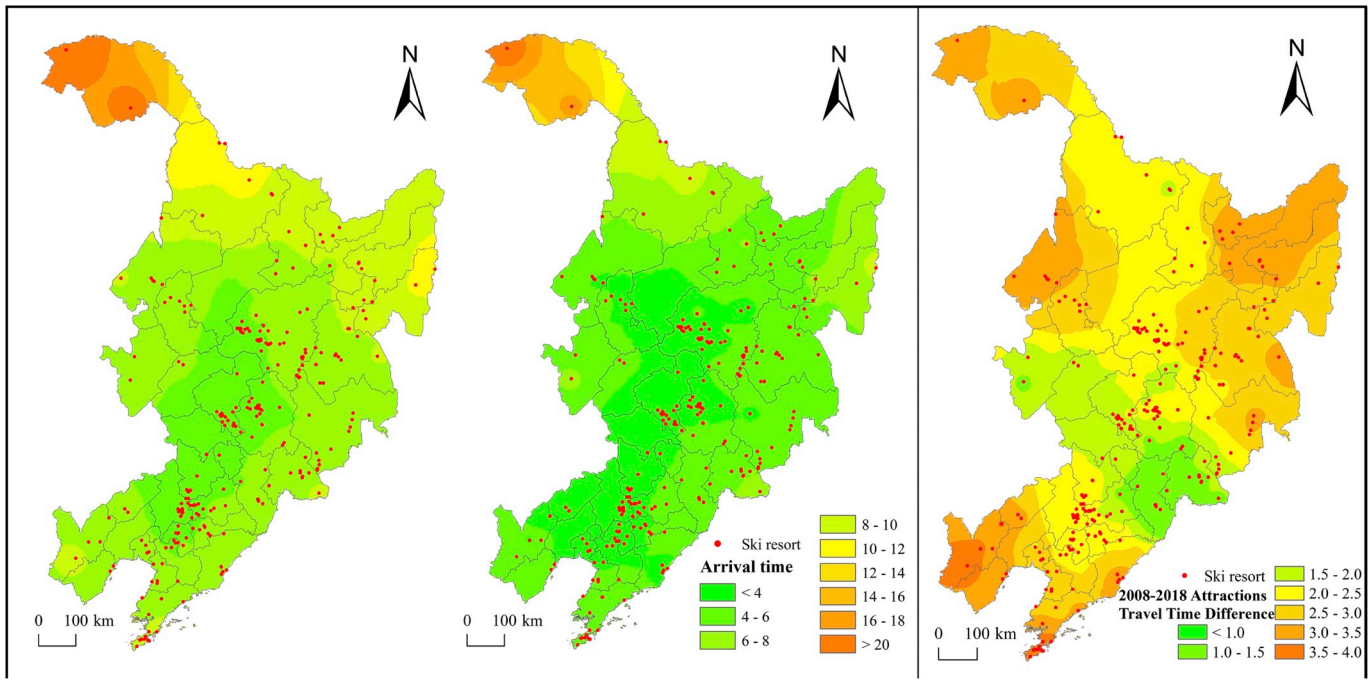


Fig. 6. Spatial variation in travel times in 2008 (left) and 2018 (right) and in travel time change of tourist destinations in the study area.

Table 4
Accessibility to selected tourist destinations in two timeframes in 2008 and 2018.

Winter tourist destination	Accessibility (in 10,000 individuals)			
	2008 travel time (in hours)		2018 travel time (in hours)	
	Zero to four	Four to six	Zero to four	Four to six
Yabuli Ski Resort	2118.20	5293.74	5728.52	9595.91
Changbai Mountain Lotus Ski Resort	4383.52	8192.86	9813.05	10,251.76
Songyuan Chagan Lake Fishing Ground	3848.19	5791.32	5665.61	9993.80
Shenyang Weipo National Ski Resort	5536.85	7525.16	9202.55	10,251.76
Shenyang Chessboard Ski Resort	5103.27	7525.16	8890.19	10,134.18

Duval, 2014). The majority of previous studies have focused on the effect of the HSR on other transportation modes, and on the relationship between the HSR and tourism (Castillo-Manzano, Castro-Nuño, López-Valpuesta, Pedregal-Tercero, & Garrido-Michó, 2018; Li, Strauss, & Lu, 2019; Zhang, Johnson, Zhao, & Nash, 2019). These studies generally concluded that the HSR might change tourists' preferred travel modes and influence their destination choices (Delaplace, Pagliara, Perrin, & Mermet, 2014). Although the current study found that the HSR at the three provinces under observation apparently promoted tourism development, implementing the HSR alone is insufficient in reversing the general economic downturn in northeastern China. Even so, ice-snow tourism is a new tourism product with the potential to develop the region's tourism and improve its economy.

The focus of this study is based on the transportation network to investigate the impact of the HSR's implementation on the accessibility of tourist cities, attractions, and on the tourism economy. First, rich tourism resources are determining conditions for the formation of characteristic tourism in the region (Chaulagain, Wiitala, & Fu, 2019). The transportation network closely connects the cities. Therefore, this study uses the weighted average travel time and a daily reachability model to analyze the accessibility of cities and urban attractions. The degrees of accessibility for the examined areas and changes in the central cities' isochronous circles further illustrates the importance of the spatial location of urban tourist attractions and the role of transportation networks in promoting urban tourism. The change in the number of accessible attractions illustrates how the HSR can bring more types and numbers of visitors to the attraction. Second, the tourism economies of tourist destinations have clearly improved under the promotion of the HSR, and the tourism supply and demand market has gathered along the HSR lines, promoting the formation of the HSR tourism economic belt. In order to promote the growth of tourism, winter tourist locations should support not only skiing, but also resort-based winter fishing, winter hot springs, the construction of ice and snow tourism towns, ice sculpture exhibitions, and ice and snow cultural exhibitions. Each of these activities can encourage tourism development. This paper has a reference value and significance for the study of traffic accessibility and fair development of the tourism industry.

In studying the accessibility of tourist cities, the weighted average travel time refers to the travel time, cost, and economic indicators between cities, and does not consider the weight of an individual's chosen travel mode. Therefore, future research must further improve the accessibility model. Limited by the available data, this article does not consider aviation or water transport. The degree of accessibility refers to the difficulty of reaching the destination from the starting point by means of railway and highway transportation. In addition, there is no classification of the different attractions of local scenic spots to human beings, which will be carried out in future research.

5. Conclusions

By using the weighted mean travel time, accessibility, and tourism-economy linkage model, this study investigated spatial and temporal accessibility between cities and ice-snow tourist destinations in northeastern China before and after the implementation of HSR in the region. First, the differences in the weighted mean travel times indicated an increased accessibility after the HSR was implemented (the spatial characteristics). Second, accessibility and isochrones were used to quantitatively analyze the difference in the numbers of destinations for

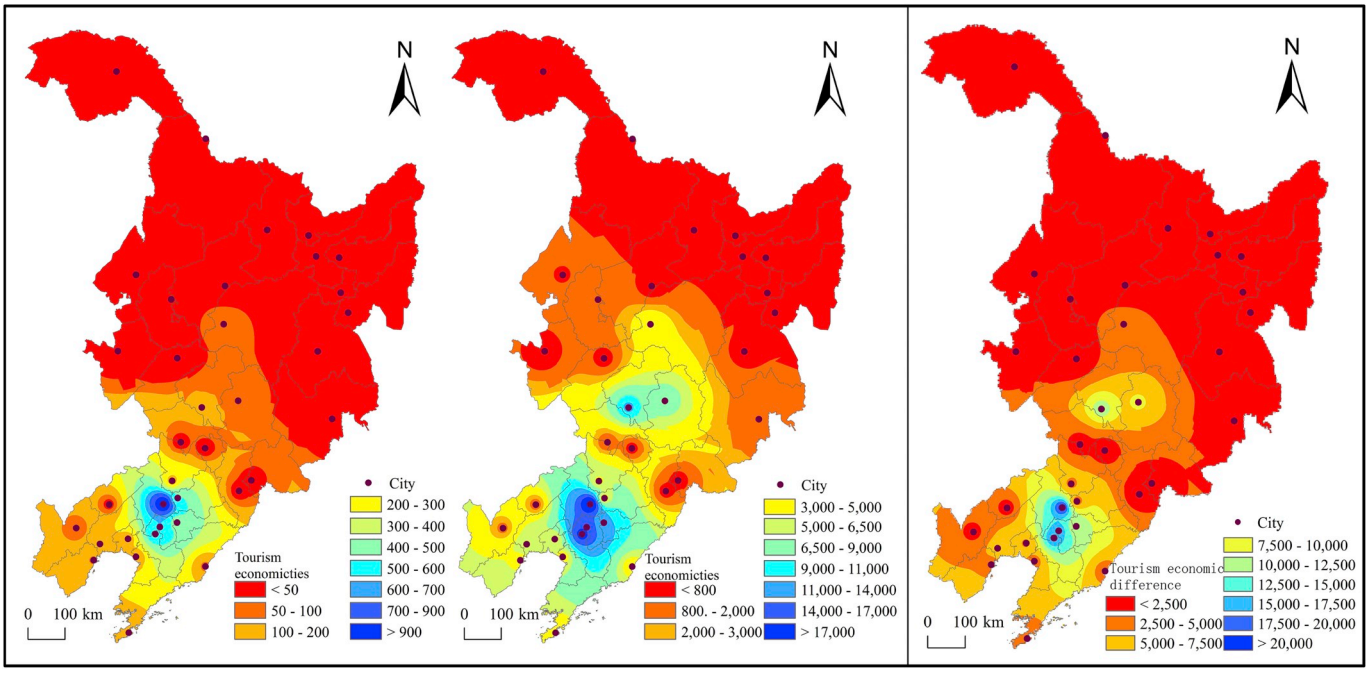


Fig. 7. (A) The relationships between the tourism industry, urban growth, and the local economies in the study area and (B) change in the tourism-economy linkages between 2008 and 2018.

daytrips and weekend trips between 2008 and 2018. Last, the tourism-economy linkage model analyzed the economic influences of the HSR on ice-snow tourism.

The main conclusions are as follows:

(1) Shorter travel times changed the spatial distribution of ice-snow tourist destinations. Ten years after the implementation of HSR, the shortest travel times between prefecture-level cities and other cities in the study area were significantly shorter, which created a basis for cities to enhance their tourism products. The implementation of the Harbin-Dalian HSR line and the Harbin-Jiamusi intercity HSR line increased the accessibility of the central and northern parts of the three provinces. The ice-snow tourist destinations in Heilongjiang Province, mostly ski resorts, became concentrated in the southeastern region and formed a competitive tourism market. The ice-snow tourist destinations in Jilin Province became concentrated in the central region along the Harbin-Dalian HSR line.

(2) Shorter travel times increased the numbers of tourists to ice-snow tourist destinations. The implementation of the HSR apparently attracted new tourists. The ice-snow tourist destinations in Liaoning Province are distributed in the south-central region where the transportation systems are well developed, which supported the increased accessibility to new ice-snow tourism resources in the area. As a coastal city, Dalian has a large variety of tourism products. In addition to island tourism, skiing and hot springs during the winter are newly developed tourism products. The HSR could provide an effective and efficient mass transit system to help transform the region's tourism industry.

(3) The HSR had a significant effect on daytrips and weekend trips. The number of accessible daytrips in the Yanbian Korean Autonomous Prefecture significantly increased. Perhaps Jilin is attractive because of its rich ice-snow tourism resources plus its other tourist products, which are characterized by the multifaceted local ethnic minority cultures. In addition, the connection between the Harbin-Dalian HSR line and the Jilin-Huichun HSR line shortened the travel times between cities. Analysis of the isochrones of the central cities (Harbin, Changchun, Shenyang, and Dalian) revealed changes in the spatial accessibility patterns, which were the greatest for Shenyang's isochrones. These results imply that HSR significantly influenced the central cities' tourism industries.

(4) After the HSR, the accessible destinations expanded. Regarding temporal and spatial changes in the accessibility of tourist destinations, northward and southward expansion is evident 10 years after the implementation of the HSR. Moreover, decreased travel time was most noticeable on the periphery of the study area.

(5) The HSR promoted tourism-economy linkages. Shenyang's increased accessibility had the strongest influence on economic development in Liaoning Province. The tourism-economy linkages between Liaoyang and Anshan/other cities were greatly enhanced after the implementation of the HSR. Changchun and Jilin have become the driving economic forces of Jilin Province.

Author contributions

Jun Yang contributed to all aspects of this work; Shanhe Jin wrote the main manuscript text, Enxu Wang and Jun Liu conducted the experiment and analyzed the data. All authors reviewed the manuscript.

Declaration of competing interest

The authors declare no competing financial interests.

Acknowledgements

This research study was supported by the National Natural Science Foundation of China (Grant No. 41771178, 41630749, 41471140, 41671151), Innovative Talents Support Program of Liaoning Province (Grant No. LR2017017) and the Liaoning Province Outstanding Youth Program (grant no. LJQ2015058). The authors would like to acknowledge all experts' contributions in the building of the model and the formulation of the strategies in this study.

References

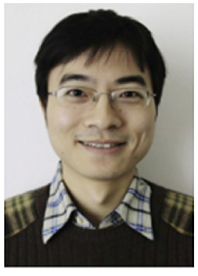
Aratuo, D. N., & Etienne, X. L. (2019). Industry level analysis of tourism-economic growth in the United States. *Tourism Management, 70*, 333–340.
Ato Xu, W., & Huang, Y. (2019). The correlation between HSR construction and economic development – empirical study of Chinese cities. *Transportation Research Part A: Policy and Practice, 126*, 24–36.
Campa, J. L., López-Lambas, M. E., & Guirao, B. (2016). High speed rail effects on tourism: Spanish empirical evidence derived from China's modelling experience. *Journal of Transport Geography, 57*, 44–54.
Cao, J., Liu, X. C., Wang, Y., & Li, Q. (2013). Accessibility impacts of China's high-speed rail network. *Journal of Transport Geography, 28*, 12–21.
Castillo-Manzano, J. I., Castro-Nuño, M., López-Valpuesta, L., Pedregal-Tercero, D. J., & Garrido-Michó, J. M. (2018). High speed rail: Fast tracking tourism in the EU? *Annals of Tourism Research, 71*, 64–66.
Chaabouni, S. (2019). China's regional tourism efficiency: A two-stage double bootstrap data envelopment analysis. *Journal of Destination Marketing & Management, 11*, 183–191.
Chaulagain, S., Wiitala, J., & Fu, X. (2019). The impact of country image and destination image on US tourists' travel intention. *Journal of Destination Marketing & Management, 12*, 1–11.
Chen, Z., & Haynes, K. E. (2017). Impact of high-speed rail on regional economic disparity in China. *Journal of Transport Geography, 65*, 80–91.
Chen, Z., Wang, Z., & Jiang, H. (2019). Analyzing the heterogeneous impacts of high-speed rail entry on air travel in China: A hierarchical panel regression approach. *Transportation Research Part A: Policy and Practice, 127*, 86–98.
Currie, C., & Falconer, P. (2014). Maintaining sustainable island destinations in Scotland: The role of the transport–tourism relationship. *Journal of Destination Marketing & Management, 3*(3), 162–172.
Danapour, M., Nickkar, A., Jeihani, M., & Khaksar, H. (2018). Competition between high-speed rail and air transport in Iran:the case of Tehran Isfahan. *Case Studies on Transport Policy, 4*(6), 456–461.
Delaplace, M., Pagliara, F., Perrin, J., & Mermet, S. (2014). Can high speed rail foster the choice of destination for tourism purpose? *Procedia - Social and Behavioral Sciences, 111*, 166–175.
Deng, T., Hu, Y., & Ma, M. (2019). Regional policy and tourism: A quasi-natural experiment. *Annals of Tourism Research, 74*, 1–16.
Dewar, K., Meyer, D., & Li, W. M. (2001). Harbin, lanterns of ice, sculptures of snow. *Tourism Management, 22*(5), 523–532.
Dogru, T., & Bulut, U. (2018). Is tourism an engine for economic recovery? Theory and empirical evidence. *Tourism Management, 67*, 425–434.
Gao, Y., Su, W., & Wang, K. (2019). Does high-speed rail boost tourism growth new evidence from China. *Tourism Management, 72*, 220–231.
Goncalves, O. (2013). Efficiency and productivity of French ski resorts. *Tourism Management, 36*, 650–657.
Guo, J., Wang, S., Li, B., Peng, F., & Wang, D. (2016). The spatial effect of Harbin-Dalian high-speed Rai to the Northeast city tourism economic link. *Scientia Geographica Sinica, 36*(4), 521–529.
Gutiérrez, J. (2001). Location, economic potential and daily accessibility: An analysis of the accessibility impact of the high-speed line Madrid–Barcelona–French border. *Journal of Transport Geography, 9*(4), 229–242.
Hansen, & Walter, G. (1959). How Accessibility Shapes Land Use. *Journal of the American Institute of Planners, 25*(2), 73–76.
Hongchang, L., Strauss, J., Shunxiang, H., & Lihong, L. (2017). Do high speed railways lead to urban economic growth in China?: A panel data study of China's cities. *Quarterly Review of Economics & Finance, 69*, 70–89.
Huang, L. (2018). Research on ice and snow landscape design. *IOP Conference Series: Materials Science and Engineering, 371*, 12065.
Huang, Y., Lu, S., Yang, X., & Zhao, Z. (2018). Exploring railway network dynamics in China from 2008 to 2017. *ISPRS International Journal of Geo-Information, 7*(8), 320.
Jiao, J., Wang, J., Jin, F., & Dunford, M. (2014). Impacts on accessibility of China's present and future HSR network. *Journal of Transport Geography, 40*, 123–132.
Khan, S. A. R., Qianli, D., SongBo, W., Zaman, K., & Zhang, Y. (2017). Travel and tourism competitiveness index: The impact of air transportation, railways transportation, travel and transport services on international inbound and outbound tourism. *Journal of Air Transport Management, 58*, 125–134.
Li, H., Chen, J. L., Li, G., & Goh, C. (2016). Tourism and regional income inequality: Evidence from China. *Annals of Tourism Research, 58*, 81–99.
Lin, V. S., Mao, R., & Song, H. (2015). Tourism expenditure patterns in China. *Annals of Tourism Research, 54*, 100–117.
Li, H., Strauss, J., & Lu, L. (2019). The impact of high-speed rail on civil aviation in China. *Transport Policy*, (74), 187–200.

Liu, J., Cheng, H., Jiang, D., & Huang, L. (2019). Impact of climate-related changes to the timing of autumn foliage colouration on tourism in Japan. *Tourism Management, 70*, 262–272.
Liu, J., Wang, J., Wang, S., Wang, J., & Deng, G. (2018a). Analysis and simulation of the spatiotemporal evolution pattern of tourism lands at the Natural World Heritage Site Jiuzhaigou, China. *Habitat International, 79*, 74–88.
Liu, M., Zhao, L., & Liu, K. (2018b). *Study on ice and snow tourism development strategies in Changbai mountain nature reserve*, 2018-01-01.
Lohmann, G., & Duval, D. T. (2014). Destination morphology: A new framework to understand tourism–transport issues? *J. Destin. Market. Manag., 3*(3), 133–136.
Medium- and Long-Term Railway Network Plan (2008 edition) (Ed.). (2008). *Medium- and long-term railway network plan* (2008 edition, pp. 4–7).
Meng, X., Lin, S., & Zhu, X. (2018). The resource redistribution effect of high-speed rail stations on the economic growth of neighbouring regions: Evidence from China. *Transport Policy, 68*, 178–191.
Miller, M., & Baker, J. W. (2016). Coupling mode-destination accessibility with seismic risk assessment to identify at-risk communities. *Reliability Engineering & System Safety, 147*, 60–71.
National Bureau of Statistics. (2009). *China Regional Economic Statistical Yearbook*. Beijing: China Statistics Press.
Pagliara, F., Mauriello, F., & Garofalo, A. (2017). Exploring the interdependences between high speed rail systems and tourism: Some evidence from Italy. *Transportation Research Part A: Policy and Practice, 106*, 300–308.
Rehman Khan, S. A., Qianli, D., SongBo, W., Zaman, K., & Zhang, Y. (2017). Travel and tourism competitiveness index: The impact of air transportation, railways transportation, travel and transport services on international inbound and outbound tourism. *Journal of Air Transport Management, 58*, 125–134.
Reitsamer, B. F., Brunner-Sperdin, A., & Stokburger-Sauer, N. E. (2016). Destination attractiveness and destination attachment: The mediating role of tourists' attitude. *Tour. Manag. Perspect., 19*, 93–101.
Shen, S., Wang, H., Quan, Q., & Xu, J. (2019). Rurality and rural tourism development in China. *Tour. Manag. Perspect., 30*, 98–106.
Song, H., & Li, G. (2013). Tourism demand modelling and forecasting–A review of recent research. *Tourism Management, 29*(2), 203–220.
Statistics Bureau of Heilongjiang Province. (2009). *Heilongjiang Statistical Yearbook*. Beijing: China Statistics Press.
Statistics Bureau of Heilongjiang Province. (2017). *Heilongjiang Statistical Yearbook*. Beijing: China Statistics Press.
Statistics Bureau of Jilin Province. (2009). *Jilin Statistical Yearbook*. Beijing: China Statistics Press.
Statistics Bureau of Jilin Province. (2017). *Jilin Statistical Yearbook*. Beijing: China Statistics Press.
Statistics Bureau of Liaoning Province. (2009). *Liaoning Statistical Yearbook*. Beijing: China Statistics Press.
Statistics Bureau of Liaoning Province. (2017). *Liaoning Statistical Yearbook*. Beijing: China Statistics Press.
Ureña, J. M., Menerault, P., & Garmendia, M. (2009). The high-speed rail challenge for big intermediate cities: A national, regional and local perspective. *Cities, 26*(5), 266–279.
Wang, X., Huang, S., Zou, T., & Yan, H. (2012). Effects of the high speed rail network on China's regional tourism development. *Tour. Manag. Perspect., 1*, 34–38.
Wang, L., Liu, Y., Mao, L., & Sun, C. (2018a). Potential impacts of China 2030 high-speed rail network on ground transportation accessibility. *Sustainability, 10*(4), 1270.
Wang, L., Liu, Y., Sun, C., & Liu, Y. (2016). Accessibility impact of the present and future high-speed rail network: A case study of Jiangsu province, China. *Journal of Transport Geography, 54*, 161–172.
Wang, L., Liu, J., Wang, L., Zhu, H., & Lin, J. (2018b). Tourism resource assessment and spatial analysis of wine tourism development: A case study of the eastern foothills of China's helan mountains. *Journal of Mountain Science, 15*(3), 645–656.
Wang, F., & Wang, K. (2018). Measuring spatial accessibility to ecological recreation spaces in the pearl river delta region: An improved two-step floating catchment area method. *Journal of Spatial Science, 63*(2), 279–295.
Wang, L., Zhong, L., Zhang, Y., & Zhou, B. (2014). Ecotourism environmental protection measures and their effects on protected areas in China. *Sustainability, 6*(10), 6781–6798.
Wobus, C., Small, E. E., Hosterman, H., Mills, D., Stein, J., Rissing, M., et al. (2017). Projected climate change impacts on skiing and snowmobiling: A case study of the United States. *Global Environmental Change, 45*, 1–14.
Wolff, F. (2014). Lift ticket prices and quality in French ski resorts: Insights from a non-parametric analysis. *European Journal of Operational Research, 237*(3), 1155–1164.
Wu, W., Liang, Y., & Wu, D. (2016). Evaluating the impact of China's rail network expansions on local accessibility: A market potential approach. *Sustainability, 8*(6), 512.
Xia, J. C., Evans, F. H., Spilsbury, K., Ciesielski, V., Arrowsmith, C., & Wright, G. (2010). Market segments based on the dominant movement patterns of tourists. *Tourism Management, 31*(4), 464–469.
Xia, J. C., Zeephongsekul, P., & Packer, D. (2011). Spatial and temporal modelling of tourist movements using Semi-Markov processes. *Tourism Management, 32*(4), 844–851.
Xua, W. A., Zhoub, J., Yangc, L., & Li, L. (2018). The implications of high-speed rail for Chinese cities: Connectivity and accessibility. *Transportation Research Part A: Policy and Practice, 116*, 308–326.
Xu, J., Zhang, M., Zhang, X., Wang, D., & Zhang, Y. (2019). How does city-cluster high-speed rail facilitate regional integration? Evidence from the Shanghai-Nanjing corridor. *Cities, 85*, 83–97.
Yang, H., Burghouwt, G., Wang, J., Boonekamp, T., & Dijst, M. (2018). The implications of high-speed railways on air passenger flows in China. *Applied Geography, 97*, 1–9.
Yang, J., Ge, Y., Ge, Q., Xi, J., & Li, X. (2016). Determinants of island tourism development: The example of Dachangshan Island. *Tourism Management, 55*, 261–271.
Yang, J., Yang, R., Sun, J., Huang, T., & Ge, Q. (2017). The spatial differentiation of the suitability of ice-snow tourist destinations based on a comprehensive evaluation model in China. *Sustainability, 9*(5), 774.
Yin, P., Lin, Z., & Prideaux, B. (2019). The impact of high-speed railway on tourism spatial structures between two adjoining metropolitan cities in China: Beijing and Tianjin. *Journal of Transport Geography, 80*, 102495.
Zhang, R., Johnson, D., Zhao, W., & Nash, C. (2019). Competition of airline and high-speed rail in terms of price and frequency: Empirical study from China. *Transport Policy, 78*, 8–18.

Shanhe Jin (e-mail: 359296196@qq.com) is a postgraduate student at the School of Urban and Environmental Sciences at Liaoning Normal University. Her research interests are tourism development and sustainable development.

Jun Yang, PhD (e-mail: yangjun8@mail.neu.edu.cn) is a Professor in the effect of human settlement and GIS at Liaoning Normal University. He has published in a wide range of Journals including Tourism Management, Science of the Total Environment, Sustainable Cities and Society and the like.

Enxu Wang, PhD (email: wangenxu801007@163.com) is an associate professor at Jangho architecture college, Northeastern University, China. His research interests include tourism spatial economy, tourism impact, tourism geography and tourism planning.



Jun Liu, PhD (e-mail: liujun_igsnrr@126.com) is a professor at tourism school, Sichuan University, China. His research interests include sustainable tourism, impacts of climate change on tourism and tourism planning.