Spatial Mismatch of Tourism Resources and Tourism Economy: A Case Study of Ice and Snow Tourism in Altay Region

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Abstract The coordinated development of tourism resources and tourism economy is vital improve the quality and efficiency of regional tourism. Taking the ice and snow tourism in Altay region as an example, this study constructed an evaluation indicator system and used the methods of gravity center model, spatial mismatch index model and obstacle degree model to calculate the spatial mismatch index and influencing factors of ice and snow tourism resources and tourism economy in Altay region as a whole and in each county and city. It found in the study period: (i) the ice and snow tourism resources and tourism economy in Altay region was synchronous in the development of time sequence, while the spatial distribution pattern was characterized by regional imbalance; (ii) at the macro scale, the spatial mismatch degree of the ice-snow tourism resource center and the tourism economic center in Altay region was gradually reduced, but they were always separated from the spatial geometric center of Altay region; (iii) at the micro scale, the spatial mismatch index of counties and cities in Altay region was mainly negative mismatch, and the types of spatial mismatch changed in different degrees; (iv) the factors showed certain spatial differentiation characteristics in different counties of Altay region, and there were some differences in the obstacles of different mismatch level areas, and the economic basis was the most frequent obstacle in different mismatch level areas of Altay region.

Key words Ice and snow tourism resources, Tourism economy, Spatial mismatch, Altay region

1 Introduction

In the context of global tourism, high-quality development and digital economy, the extension of tourism itself is constantly highlighted. With ice and snow natural and cultural landscape as tourist attractions, ice and snow tourism with seasonal, regional and fitness characteristics is increasingly valued by the government and loved by tourists[1]. During the two conferences in 2016, the general secretary Xi Jinping made an important instruction that "ice and snow are also invaluable assets"[2]. In 2022, the successful hosting of the Beijing Winter Olympic Games brought unprecedented opportunities for the high-quality development of ice and snow tourism[3]. Altay, located in the golden latitude of skiing in the world, has unique ice and snow tourism resources, a long history of ice and snow culture, and a good foundation for organizing various winter tourism activities. However, due to the differences in location and endowment of ice and snow tourism resources, the development of ice and snow tourism resources and tourism economy in various counties and cities in Altay region is not balanced, which is called spatial mismatch[5]. The "spatial mismatch hypothesis" was first proposed by Kain in the *Quarterly Journal of Economics* in the 1960s, and it was initially used to analyze the separation of employment and employment of black people in the West[6]. Later, with the development of this theory, scholars gradually began to study the spatial match between employment and housing of residents in large cities[7]. By the beginning of the 21st century, this theory has become mature and applied to urban development, agriculture, ecology, tourism and other fields. The research on tourism based on spatial theory mainly focuses on the spatial mismatch between tourism resources and tourism economy[8-10], and the spatial mismatch between tourism resources and ecological environment[11-12], research on the spatial mismatch between the income of scenic spots and the number of tourists[13-14], research on the spatial mismatch between tourism industry and cultural industry[15-16], and research on the spatial mismatch between the three indicators[17-18]. In terms of research scale, most of the studies are nationwide, and relatively few are at the provincial, municipal and county levels. In terms of research objects, the types of tourism resources can also be subdivided and expanded. At present, the research on the spatial mismatch of ice and snow tourism resources and tourism economy has not been paid enough attention. In terms of research methods, there are few scholars who use more rigorous mathematical methods to measure the influencing factors of tourism spatial mismatch.

Therefore, based on the statistical data of winter tourism in counties and cities of Altay region from 2018 to 2022, we employed the gravity center model and spatial mismatch index model to explore the spatial and temporal evolution of ice and snow tourism resources and tourism economy in Altay region. Finally, we explored the related influencing factors through the obstacle degree model, in order to promote the quality and efficiency of ice and snow tourism in Altay region and the coordinated development of space, and provide a reference for the development of ice and snow tourism in other regions.

2 Overview of the study area

Altay Prefecture (85°31′ -91°04′ E, 45°00′ -49°10′ N) is

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located in the northwest of Xinjiang, under the jurisdiction of Ili Kazakh Autonomous Prefecture. It borders Russia, Kazakhstan and Mongolia, and is an important area for the northern passage of the Silk Road Economic Belt and Xinjiang to participate in the construction of the China – Mongolia – Russia Economic Corridor. The region covers a total area of 118 000 km^2 and has six counties and one city under its jurisdiction, including Altay City, Burqin County, Fuyun County, Fuhai County, Habahe County, Qinghe County and Jeminay County. In addition, Beitun City, the 10^{th} Division of the Xinjiang Production and Construction Corps, is also located there, and all of them are border counties (cities). The Altay region has an obvious temperate continental climate because it is located deep inland and distant from the ocean. It has a long snowfall period and a long snowpack period throughout the year. It has abundant snow and is known as the "Snow Capital of China" and the "Origin of Human Skiing". Altay region is the key area of winter ice and snow tourism economic development determined by Xinjiang Autonomous Region. According to statistics, in the snow season of 2022 – 2023, the number of tourists received in Altay region reached 8.066 4 million, and the winter tourism income reached 7.095 billion yuan, accounting for 17.75% of the regional GDP. It can be seen that the development of ice and snow tourism will bring significant economic benefits.

3 Research methods and data sources

3.1 Indicator selection With reference to the existing research results[19-20], from the perspective of tourists' experience and combining with the actual situation of Altay region, we selects six indicators of ice and snow festivals, folk villages, ski resorts, ice and snow competitions, scenic spots above AAA level, and ice and snow performances. The grade of tourist attractions and the scale of ski resorts have a strong impact on ice and snow tourism. Ice and snow activities of different scales will affect the public's attention and participation. It will be biased to compare only in quantity, while ignoring their quality. However, there is no uniform standard for the grade assignment of ice and snow tourism resources in academic circles. Therefore, with reference to the calculation method published in *Journal of Cleaner Production* by Tang *et al.*[20], we distinguished the scale of ski resorts, ice and snow festivals and the level of tourist attractions, as shown in Table 1. For the measurement of the comprehensive development level of tourism economy, limited by the availability of ice and snow tourism economic data, we referred to the existing research results[12-13, 15-17, 21], selected five indicators of domestic and foreign tourists, domestic and foreign tourism income and the proportion of tourism income to GDP to construct the evaluation indicator system for ice and snow tourism resources and tourism economy.

Table 1 Evaluation indicator system for ice and snow tourism resources and tourism economy

Evaluation system	Indicator	Unit	Indicator attribute	Weight	Remarks
Ice and snow tourism resources	Ice and snow festival	Times	+	0.118 7	Calculation method: (International festivals) ×3 + (National festivals ×2) + Provincial and municipal festivals
	Folk village	Pcs	+	0.094 9	
	Ski resort	Pcs	+	0.191 9	
	Ice and snow sports events	Times	+	0.067 6	
	Scenic spots above 3A level	Pcs	+	0.140 3	Calculation method: (5S level ski resort ×3) + (4S level ski resort ×2) + 3S level ski resort
	Ice and snow performance	Times	+	0.067 6	
Tourism economy	Revenue from domestic tourism	10^8 yuan	+	0.108 2	
	Revenue from foreign tourism	10^8 yuan	+	0.010 3	Calculation: (National AAAAA level scenic spot × 3) + National AAAA level scenic spot
	Proportion of tourism revenue to GDP	%	+	0.017 1	
	Number of domestic tourists	10^4 persons	+	0.103 0	
	Number of inbound tourists	10^4 persons	+	0.011 4	

3.2 Data sources Based on the principle of data availability, according to the established indicator system, the data of ice and snow tourism resources were selected from the websites of county and municipal governments in Altay Prefecture, the Bureau of Culture and Tourism of Altay Region, and the Department of Culture and Tourism of Xinjiang Uygur Autonomous Region from 2018 to 2022. The data of tourism economy and obstacles were selected from *Altay Statistical Yearbook*, statistical yearbooks of counties and cities, national economic and social development bulletins, and the longitude and latitude coordinates of administrative centers of counties and cities were obtained through Google Earth. We used interpolation method to supplement the missing data, and eliminated the influence of the differences in the magnitude and physical significance level of the selected indicators through standardization, to ensure the scientificity and objectivity of the evaluation results.

3.3 Research methods

3.3.1 Entropy – TOPSIS model. The rationality of the evaluation results is largely affected by the weight of the evaluation indicators. In order to avoid the interference of subjective randomness, we used the entropy weight method to determine the indicator weight. The TOPSIS model mainly judges the "positive ideal solution" and "negative ideal solution" in each indicator, establishes the two-dimensional data structure of the distance between them and the evaluation indicator, and then compares each evaluation indicator with the positive ideal solution and negative ideal solution. We used TOPSIS model to calculate the abundance of ice and snow tourism resources and the comprehensive development index of tourism economy in Altay region. As the entropy weight-TOPSIS model has been widely used in various fields, its specific calculation formula was not repeated in this study[10].

3.3.2 Gravity center model. The spatial and temporal changes of

the center of gravity can reflect the spatial distribution and trajectory of the research elements at different time points to some extent. From a geometric point of view, spatial mismatch refers to the separation of the geometric center of gravity of two elements[8]. In this paper, the gravity center model is used to analyze the macro spatial mismatch of ice and snow tourism resources and tourism economy in Altay region. The calculation formula is shown in Equation (1):

$$\bar{x}\frac{\sum_{i=1}^{n}M_i x_i}{\sum_{i=1}^{n}M_i},\ \bar{y}\frac{\sum_{i=1}^{n}M_i y_i}{\sum_{i=1}^{n}M_i} \tag{1}$$

where M_i is the index value of a certain element (ice and snow tourism resources, tourism economy) of the city i in Altay region that has been processed and calculated, and x_i and y_i are separately the longitude and latitude coordinates of the city i.

3.3.3 Spatial mismatch index. We introduced the secondary regional spatial mismatch index proposed by Li Lingyan and Weng Gangmin[16] in their study, and modified it to obtain the spatial mismatch index at the micro level in combination with the actual content of this study. The calculation formula is as shown in Equation (2):

$$SMI_i = \frac{1}{P}\left[\left(\frac{e_i}{E}\right]P - p_i\right] \times 100 \tag{2}$$

where SMI is the tourism spatial mismatch index of a county and city in Altay region, P_i is the abundance of ice and snow tourism resources in the county or city i in Altay region, P is the total abundance of ice and snow tourism resources in Altay region, e_i is the comprehensive index of tourism economic development in the county or city i in Altay region, and E is the total comprehensive index of tourism economic development in Altay region.

3.3.4 Obstacle model. In order to further reveal the main factors leading to the spatial mismatch of ice and snow tourism resources and tourism economy in Altay region, we introduced the obstacle degree model based on the research of Peng Fei, Han Zenglin[22], and the calculation formula is shown in Equation (3):

$$A_i = w_i d_i / \sum_{i=1}^{n} w_i d_i \times 100\% \tag{3}$$

where A_i is the influence degree of the i^{th} indicator on spatial mismatch; w_i is the weight of the i^{th} indicator; d_i is the normalized value of the i^{th} indicator.

4 Analysis of spatial mismatch model on ice-snow tourism resources and tourism economic development in Altay region

4.1 Basic situation of ice and snow tourism resources and tourism economy in the counties and cities of Altay Prefecture

Through summarization and statistics of data, we calculated the abundance index of ice and snow tourism resources and the comprehensive index of tourism economy of counties and cities in Altay region from 2018 to 2022 according to the entropy weight TOPSIS model, as shown in Fig. 1.

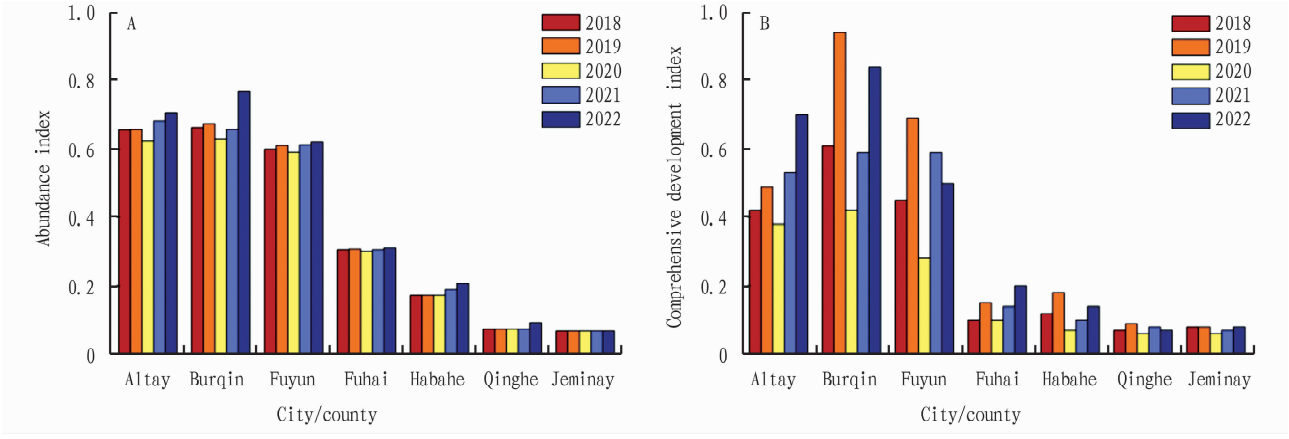


Fig. 1 Abundance index of ice and snow tourism resources and comprehensive development index of tourism economy of counties and cities in Altay region from 2018 to 2022

According to the abundance of ice and snow tourism resources in Fig. 1A, the spatial distribution of ice and snow tourism resources in Altay region shows obvious regional imbalance characteristics. Although the ice and snow tourism resources have increased in general, there are still great differences in the development of ice and snow tourism resources in different counties and cities. The area with the highest abundance of ice and snow tourism resources is Burqin County, with an average abundance of 0.678 in the past five years, followed by Altay City and Fuyun County, with an average abundance of 0.664 and 0.607, while Fuhai County, Habahe County, Qinghe County and Jeminay County are poor in ice and snow tourism resources, with a small number of units and a low level. Therefore, the abundance of ice and snow tourism resources is low and the growth is slow.

As can be seen from Fig. 1B, there are differences in the level of tourism economic development in counties and cities in the Altay region, and the comprehensive tourism economic development index of each county and city can be roughly divided into two stages: 2018 – 2019 and 2021 – 2022 due to the impact of COVID-19. According to the average value of the comprehensive development index of tourism economy of the counties and cities in Altay region, it can be divided into four grades. The average value of the comprehensive development index of tourism economy of Burqin County in the past five years is 0.680, which is the first grade, the highest and the fastest growing among the counties and cities in Altay region; the average comprehensive development index of

tourism economy in Altay City and Fuyun County is 0.506 and 0.501 respectively, which is the second grade; Fuhai County and Habahe County have the third grade of comprehensive development index of tourism economy with the average value of 0.140 and 0.119, respectively; Qinghe County and Jeminay County have the fourth grade of comprehensive development index of tourism economy with the average value of 0.074 and 0.073, respectively.

From the overall spatial layout, the abundance index of ice and snow tourism resources and the comprehensive development index of tourism economy in Altay region are mainly concentrated in Altay City, Burqin County and Fuyun County. Except for the abundance index of ice and snow tourism resources and the comprehensive development index of tourism economy in Altay region in 2020 greatly affected by the epidemic of COVID-19, they showed an increasing trend in the rest of the years.

4.2 Result analysis of gravity center model We introduced the abundance index of ice and snow tourism resources and the comprehensive development index of tourism economy in Altay into the gravity center model formula, calculated the longitude and latitude coordinates of the center of gravity of ice and snow tourism resources and tourism economy in Altay from 2018 to 2022, and used Arcgis to visualize them. The migration track of the ice and snow tourism resources and tourism economy in Altay region in the past five years was obtained. During the study period, the focus of ice and snow tourism resources and the focus of tourism economy in Altay region were both located in Altay City, but the two have been in a mismatch state. We referred to the spatial center analysis model proposed by Bao Xiangping and Xue Dongqian[23] in their research to calculate that the spatial geometric center of gravity of Altay region is located in Fuhai County (88.41° E, 46.99° N), which is separated from the center of gravity of ice and snow tourism resources and tourism economy in Altay region. We found that the ice and snow tourism resources and the gravity center of tourism economy in Altay region are developing northward, the latitude evolution of the gravity center of ice and snow tourism resources is larger, and the longitude evolution of the gravity center of tourism economy is larger. With the passage of time, the two continue to deviate from the spatial geometric center of gravity in Altay region, leading to the deepening of the trend of unbalanced development. This phenomenon of unbalanced development in space is due to the different location conditions, ice and snow tourism resources endowment, and the speed of social and economic development in different counties and cities, and is not synchronized.

In general, the distance between the center of gravity of ice and snow tourism resources and the center of gravity of tourism economy in Altay region shows a mismatch trend of first increasing and then decreasing, which is due to the impact of the COVID-19 epidemic in 2020, the spatial mismatch between ice and snow tourism resources and tourism economy in Altay region has intensified. From 2021 to 2022, in order to meet the arrival of the Winter Olympics, Altay seized the opportunity of winter tourism development, actively exerted its unique advantages in ice and snow resources, continuously upgraded ski resorts and extended the ice and snow industry chain. A series of measures to transform the advantages of ice and snow tourism resources into new momentum of economic development have gradually reduced the distance between the focus of ice and snow tourism resources and the focus of tourism economy in Altay region.

4.3 Result analysis of spatial mismatch model measurement The gravity center model can only reflect the spatial geographical location of the center of ice and snow tourism resources and the center of tourism economy in Altay region from a macro perspective, but it can not reflect the spatial mismatch type and change direction of each sub-region in the region. Therefore, we used the micro-mismatch model formula to calculate the spatial mismatch index of ice and snow tourism resources and tourism economy of counties and cities in Altay region from 2018 to 2022 (Table 2).

Table 2 Changes in spatial mismatch index in counties and cities in Altay region in the past five years

Year	Altay City	Burqin County	Fuyun County	Fuhai County	Habahe County	Qinghe County	Jeminay County
2018	7.95	-6.82	-0.73	1.52	0.36	-0.91	-1.37
2019	8.81	-9.72	-2.58	4.14	-0.01	-0.43	-0.21
2020	8.19	-7.31	-3.85	2.80	3.29	-1.22	-1.90
2021	2.99	-2.45	-4.16	2.95	2.65	-1.09	-0.89
2022	2.35	-4.49	-2.36	2.27	2.35	0.51	-0.63

With reference to the past experience, according to the positive and negative of the spatial mismatch index, it can be divided into positive mismatch area and negative mismatch area[9, 16]. Based on the actual situation of Altay area, the areas where the absolute value of spatial mismatch index is greater than 4.5 are identified as high mismatch areas, and the areas where the absolute value of spatial mismatch index is between 2 and 4.5 are identified as medium mismatch areas, and the areas with an absolute value of the spatial mismatch index between 0 and 2 are identified as a low mismatch areas.

4.3.1 The spatial mismatch index from positive and negative relationship. The negative mismatch shows that the level of ice and snow tourism resources was lower than level of tourism economic development and both were low. During the period of 2018 - 2022, Burqin County, Fuyun County, Jeminay County and Qinghe County belonged to the negative mismatch for a long time. Combined with the level of ice and snow tourism resources, we can know that Jeminay County and Qinghe County are the places where ice and snow tourism resources are relatively scarce in Altay region. In addition, in the process of developing ice and snow tourism resources, these counties need to spend a lot of time and energy to build and publicize their brands, and are affected by

transportation and geographical location, so there is a certain lag in the development of tourism economy. The tourism economic development level of Jeminay County and Qinghe County shows a negative low mismatch with the ice and snow tourism resources level. The Ice and snow tourism resource level and tourism economic development level of Burqin County and Fuyun County are higher in the study area, but the tourism economic development level mainly benefits from the tourism income in summer and autumn, and the comprehensive development index of tourism economy in summer and autumn accounts for about 65% of the whole year. The level of ice and snow tourism resources and the level of tourism economy in Burqin County and Fuyun County show a negative spatial mismatch of medium and high.

The positive mismatch shows that the level of ice and snow tourism resources was higher than level of tourism economic development. Altay City, Fuhai County and Habahe County have been in the positive mismatch area for a long time, among which Altay City was in the positive high mismatch area from 2018 to 2020, because Altay City, as the political and cultural center of Altay region, had a high degree of openness, and the development of ice and snow tourism resources was relatively mature. However, the tourism economy has not reached the level of synchronous development. From 2021 to 2022, the spatial mismatch index of Altay City decreased significantly, and the development speed of ice and snow tourism resources was gradually slower than that of tourism economy, which made the spatial mismatch degree of ice and snow tourism resources and tourism economy in Altay City gradually slowed down, and it was in the positive mismatch area. Although Fuhai County and Habahe County have actively developed winter tourism resources in recent years, through the statistics of the network attention of the ice and snow tourism resources, we found that the popularity of other ice and snow tourism resources was not high except for the Fuhai Winter Catching Festival and the Habahe "Drunken Beautiful Birch" Ice and Snow Festival, so they did not contribute much to the local tourism economy and are in the positive medium mismatch area.

4.3.2 The spatial mismatch index from the pattern evolution. During the study period, the spatial mismatch between the ice-snow tourism resources and the tourism economy in Altay region has always existed, except that the degree of mismatch in Jeminay County and Qinghe County is low and the type of mismatch has not changed. The types of spatial mismatch in other counties and areas have changed in different degrees. The number of counties and cities in high mismatch areas was relatively small, which remained at 1 – 2 in 2018 – 2021 and decreased to 0 in 2022, mainly in medium mismatch areas and low mismatch areas. The number of low mismatch areas decreased from 5 in 2018 to 2 in 2022, showing a gradual downward trend in general. This is due to the different resource endowments, location conditions and publicity efforts in the later period. The ice and snow tourism resources and tourism economic development of each county and city were gradually not synchronized. The medium-high mismatch area gradually shifted from Altay City and Burqin County to the south and northeast.

From the longitudinal analysis of the time series, it can be seen that the spatial mismatch pattern of the counties and cities in Altay region evolved more frequently from 2018 to 2022. In 2018, most of the counties were located in the low mismatch area, only Altay City was located in the positive high mismatch area, and Burqin County was located in the negative high mismatch area, indicating that the spatial synergy between the abundance of ice and snow tourism resources and the comprehensive development index of tourism economy in Altay region was better at this time. In 2019, the "Matthew effect" of the dominant areas of ice and snow tourism development in Altay region was obvious, and Fuhai County ranked among the positive mismatch areas. At the same time, Fuyun County also entered the negative mismatch areas, and the degree of positive and negative mismatch in the region was balanced. In 2020, the comprehensive development level of tourism economy in Altay region reached the lowest level in previous years, and the differences in tourism economic development among counties and cities were also increasing. Affected by COVID-19, compared with 2019, the positive medium and high mismatch areas increased again, which made the Altay region appear obvious regional imbalance. After 2021, except Jeminay County and Qinghe County, the spatial mismatch between the abundance of ice and snow tourism resources and the comprehensive development level of tourism economy in other counties and cities in Altay region has been decreasing. It can be seen that after 2021, the gap between the abundance of ice and snow tourism resources and the comprehensive development index of tourism economy in various counties and cities in Altay region was narrowing.

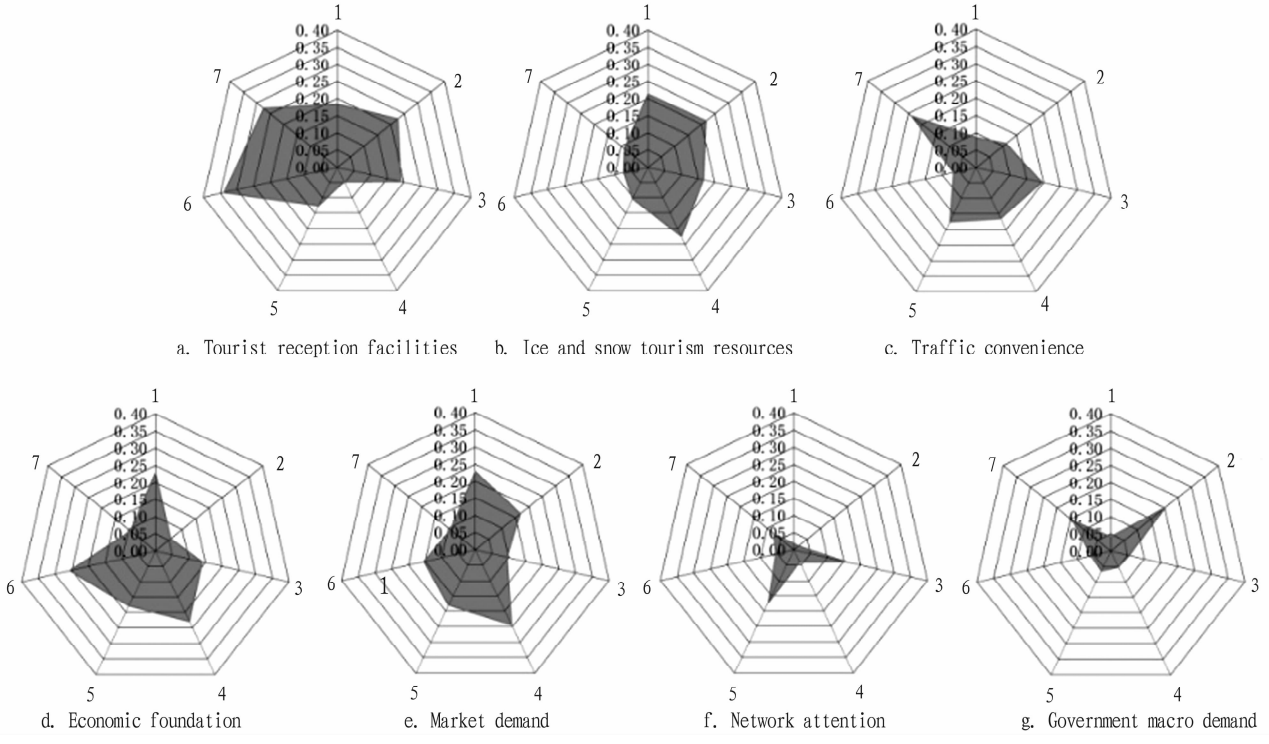
5 Analysis of influencing factors (obstacles)

The spatial differences of ice and snow tourism resources development and tourism economic development in Altay region will undoubtedly lead to the existence of spatial mismatch between ice and snow tourism resources and tourism economy in Altay region. Therefore, it is very important to explore the influencing factors of spatial mismatch pattern. Based on the previous research experience[24 – 27] and combined with the actual situation of Altay region, seven influencing factors of ice and snow tourism resource development intensity, transportation convenience, government macro-control, economic foundation, market demand, network attention, and tourism service level were selected and characterized by the number of tourist attractions (X_1), highway mileage (X_2), proportion of tourism revenue to GDP (X_3), general public budget expenditure (X_4), total commodity sales (X_5), Baidu search index of ice and snow tourism resources (X_6), and number of tourism employees (X_7). Then, we used the obstacle degree model to analyze the main obstacles of spatial mismatch between ice and snow tourism resources and tourism economy in the counties and cities of Altay region in the past five years (Table 3). In this study, we focused on the first three obstacles.

Table 3 Ranking of obstacles to the spatial mismatch of ice and snow tourism resources and tourism economy

City/county	1st rank	2nd rank	3rd rank	4th rank	5th rank	6th rank	7th rank
Atlay	X_4	X_5	X_7	X_1	X_2	X_3	X_6
Burqin	X_7	X_1	X_3	X_5	X_2	X_4	X_6
Fuyun	X_2	X_7	X_1	X_6	X_4	X_5	X_3
Fuhai	X_5	X_4	X_1	X_2	X_3	X_7	X_6
Habehe	X_5	X_4	X_2	X_6	X_7	X_1	X_3
Qinghe	X_7	X_4	X_5	X_1	X_2	X_3	X_6
Jeminay	X_7	X_2	X_3	X_4	X_5	X_1	X_6

Firstly, according to the obstacle degree of each indicator, the number of tourist attractions, highway mileage, the proportion of tourism income to GDP, general public budget expenditure, total commodity sales, and the level of tourism industry have the highest impact on the spatial mismatch degree of ice and snow resources and tourism economy in Altay region. The factors also show certain spatial differentiation characteristics among different counties in Altay region (Fig. 2). For example, economic foundation, market demand and other factors are the main obstacles of spatial mismatch of ice and snow tourism in Fuhai County, Fuyun County and Qinghe County in the south of Altay region, and the level of tourism reception is the main obstacle of spatial mismatch of ice and snow tourism in most counties of Altay region. In addition, the other factors also have different degrees of spatial differences in the intensity of the role of different counties in Altay region.



NOTE 1. Altay; 2. Burqin; 3. Fuyun; 4. Fuhai; 5. Habahe; 6. Qinghe; 7. Jeminay County.

Fig. 2 Distribution of obstacles to the spatial mismatch of ice and snow tourism resources and tourism economy in counties and cities in Altay region

Secondly, by comparing the top three obstacles of ice and snow tourism resources and tourism economic space index in counties and cities of Altay region, we can see that there are some differences in the obstacles of each mismatch grade area. Combined with Table 3, it can be found that Altay City and Burqin County, which are located in high mismatch areas, were mainly affected by key factors such as the development intensity of ice and snow tourism resources, economic foundation, market demand and tourism service level. Fuyun County, Fuhai County and Habahe County, which are located in the middle mismatch area, were mainly affected by the key factors such as the development intensity of ice and snow tourism resources, transportation convenience, economic foundation and market demand, while Qinghe County and Jeminay County, which are located in the low mismatch area, were greatly affected by the factors such as tourism service level, economic foundation and traffic convenience.

On the whole, the main obstacles of different mismatch grade areas in Altay region are the development intensity of ice and snow tourism resources, the traffic convenience, the weak economic foundation, the inability to meet the diversified and multi-level

market demand and the low level of tourism services. Specifically, the development intensity and market demand of ice and snow tourism resources have become the main obstacles to the development of ice and snow tourism resources in Altay region, which is due to the lack of attention to the innovative transformation and development of ice and snow tourism resources in the development of ice and snow tourism resources in Altay region, the lack of deepening of the cultural connotation of ice and snow tourism resources, and the lack of ice and snow tourism resources. The number of ice and snow tourism resources that can not meet the needs and hobbies of most tourists is increasing. The medium and low mismatch grade areas are mainly mountainous and hilly areas, so the traffic convenience has become the main obstacle in these two grade areas. The low level of tourism service is mainly due to the fact that the knowledge content, service awareness and service concept of the people currently engaged in tourism in the region need to be improved, and the lack of high-quality tourism talents, so the service level is not good enough. The economic foundation is the core obstacle of different grade areas in Altay region. Strong economic strength can provide a good foundation and support for the development of tourism, which is beneficial to the construction of transportation infrastructure, the expansion of tourist market and the promotion of tourist destination popularity. For the Altay region as a whole, its economic development level is relatively low. According to the statistics of the Xinjiang Bureau of Statistics, the total GDP of the Altay region in 2022 ranked low in Xinjiang, indicating that the funds that can be invested in basic service facilities, industrial structure and the development of ice and snow tourism resources are very limited, which will inevitably affect the visit rate of tourists.

6 Conclusions and discussion

6.1 Conclusions (i) The abundance of ice and snow tourism resources and the distribution pattern of tourism economy in various counties and cities in Altay region show the characteristics of regional imbalance, and there has been no significant change in the past five years. The abundance of ice and snow tourism resources and the comprehensive development index of tourism economy both showed a fluctuating trend of first rising, then declining and then rising, and the downward trend was mainly affected by the large-scale outbreak of the COVID-19 epidemic in 2020.

(ii) At the macro regional scale, there is an obvious spatial mismatch between the center of ice and snow tourism resources and the center of tourism economy in Altay region, and the degree of spatial mismatch gradually narrows, but they are always separated from the spatial geometric center of Altay region. The center of gravity of ice and snow tourism resources shows a north-south trend, and the center of gravity of tourism economy shows an east-west trend.

(iii) At the micro-regional scale, the mismatch types of the counties and cities in Altay region are mainly negative, while the number of counties and cities with high mismatch types is relatively small, and most of them are medium-low mismatch types; during the study period, the types of spatial mismatch in counties and cities in Altay region have changed to varying degrees, but the overall mismatch situation has improved slightly.

(iv) The spatial mismatch of ice and snow tourism in Altay region is the result of the coupling effect of various factors, which also show certain spatial differentiation characteristics among different counties in Altay region, and there are certain differences in obstacles among different mismatch grade areas. Economic basis is the obstacle with the highest frequency in different mismatch levels in Altay region.

6.2 Recommendations (i) In terms of ice and snow tourism resources, Altay region should be optimized and adjusted from the high mismatch area. The negative high mismatch area should dig deep into the characteristics of ice and snow tourism resources in each area, improve the quality of ice and snow tourism resources, and make use of natural advantages to develop ice and snow mountains, ice and snow geology and other tourism resources and integrate them, so as to make them connotative and innovative. Positive high mismatch area should give full play to the advantages of tourism development, make use of its radiation-driven role to promote the development of ice and snow tourism in the surrounding areas, and also make use of the unique regional characteristics to create ice and snow tourism routes, deepen regional tourism cooperation, and promote the coordinated development of regional ice and snow tourism.

(ii) In terms of social economy, through the continuous improvement of the ice and snow tourism industry chain, winter tourism continues to heat up "growth rate", and through hosting large-scale ice and snow events to enhance visibility and promote local economic development.

(iii) In terms of traffic convenience, with its own geographical advantages and the government's policy support of the "Belt and Road Initiative", it should seize the opportunity of ice and snow tourism development in the post-Winter Olympics era, strengthen the connection with ice and snow tourism routes in Central Asia and strong domestic provinces, and make it a transportation hub between Central Asia and hinterland areas of China.

(iv) In terms of the construction of tourism talents, the implementation of a new type of apprenticeship program for enterprises, through the principle of government guidance, tourism enterprises, and school participation, the mode of school-enterprise cooperation is adopted to jointly train apprentices, promote the cultivation of innovative and skilled talents, and broaden the team of high-quality talents in the tourism industry.

6.3 Discussion Analyzing the phenomenon of spatial mismatch through the theory and model of spatial mismatch is helpful to grasp the actual situation of regional ice and snow tourism development, and to find the path and mode of regional ice and snow tourism development by identifying its key constraints, which is particularly important for promoting the coordinated and sustainable development of regional tourism. In the past, there were few studies on the relationship between ice and snow tourism resources and tourism economy. Through the study of the relationship between ice and snow tourism resources and tourism economy in counties and cities of Altay, this paper finds that there are certain spatial differences between them, and that mismatch and synchro-

nization coexist, rather than a simple linear relationship. The high mismatch areas are mainly distributed in the regions or regional central cities with high popularity of ice and snow tourism resources and high level of scenic spots, and are interlaced with the low mismatch areas, so the synergy of ice and snow tourism in each region is poor, and the "siphon" effect of tourism economic advantage areas is obvious. It can be seen that the allocation efficiency of ice and snow tourism resources in Altay region needs to be improved, and the tourism economy has not yet changed to an intensive growth mode. This is consistent with the research results of scholars such as Wang Shasha[8] and Li Chaojun[9].

However, there are also some shortcomings in the current research. (i) Limited by the availability of the relevant data of ice and snow tourism in the counties and cities of Altay region, we only analyzed the spatial mismatch between ice and snow tourism resources and tourism economy in Altay region in the past five years. In the future, when the data permit, it is necessary to further explore the dynamic evolution process of the longer time series in Altay region. (ii) We only analyzed the main socio-economic factors that affect the spatial mismatch of ice and snow tourism resources and tourism economy in Altay region, and other factors such as physical geography that affect the spatial mismatch of ice and snow tourism in Altay region need to be further explored in the future.

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