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ORIGINAL RESEARCH ARTICLE

Spatial structure characteristics and effects of self-driving tourism flows before and after the new crown epidemic: Taking Yunnan Province as an example

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ABSTRACT

To obtain the impact of the new crown epidemic on the spatial structure of self-driving tourism flow during the Spring Festival Golden Week, social network and spatial statistical analysis methods are used to integrate road traffic flow big data and travelogue data to analyze the spatial structure characteristics of self-driving tourism flow in Yunnan Province during the Spring Festival Golden Week in 2018 and 2021. The results show that: 1) The self-driving tourism flow in Yunnan Province during the Spring Festival Golden Week in 2021 shows the "dragonfly" spatial clustering characteristics of "two centers, one axis and two wings", and the new sub-core area of Qujing is added to the core area of Kunming in 2018, and the self-driving tourists are affected by the epidemic. 2) During the Spring Festival Golden Week in 2021, compared with 2018, there is no significant change in the spatial structure of tourism flow into Yunnan from outside the province, but the degree of intermediary centrality of provincial boundary nodes is significantly weakened, and the self-driving tourism flow at Wenshan junction and Lijiang junction decreased by 72.54% and 87.26%. The New Crown epidemic hindered the development of self-drive tours into Yunnan from Guangxi and Sichuan. 3) During the New Crown epidemic, tourists were less willing to visit hotspot cities, and showed overall behavioral preference characteristics of avoiding crowd gathering and focusing on health and safety. Under the New Crown epidemic, the tendency of long-distance self-driving shifts to close distance self-driving between neighboring cities centered on Kunming.

Keywords: self-driving tourism flow; spatial structure characteristics; COVID-19; Golden Week; social network analysis; Yunnan Province

1. Introduction

At present, the development of "transportation and tourism integration" has become an important part of the transportation power strategy. With the implementation of free expressway policy on major holidays and the increasingly improved expressway network, "expressway + tourism" has become the

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mainstream trend of domestic tourism, and self-driving tour in Golden Week occupies an important position in the tourism market. The novel coronavirus pneumonia epidemic ("COVID-19" for short) has had a huge impact on self-driving travel. The analysis of the spatial structure and influencing factors of self-driving tourism flow during the Spring Festival Golden Week before and during the COVID-19 helps to clarify the spatial differences of self-driving tourism flow under the influence of COVID-19, and provides a basis for the integrated development of transportation and tourism under the normalization of the epidemic.

Tourism flow is the nerve center and link of a tourism economic system with spatial attributes, the basis of tourism development, and plays an important role in the study of tourism geography[1]. Holiday tourism has been regarded as an important measure to stimulate domestic demand, promote consumption and economic development[2]. In recent years, this research topic has been rapidly paid attention to, with research scales including large[3], medium[4] and small[5,6]. The research data transits from small sample data to network big data, and from simplification to multi-source. The research on holiday tourism flow by foreign scholars originated from the prediction of holiday tourism flow, such as Chen et al. used adaptive genetic algorithm and vector regression model to predict holiday tourism flow[7]. The domestic research mainly focuses on the spatio-temporal distribution characteristics, which can be roughly divided into the research on the spatio-temporal distribution characteristics of the overall tourism flow of seven holidays[3,8,9] and the focused research on the "National Day" Golden Week[10–13], while the research on the spatial behavior mode of self-driving tourism flow in the Golden Week has become a research "depression". The lack of theoretical research and the urgency of practical needs highlight the important theoretical value and practical significance of the research on self-driving tourism flow during the Golden Week. From the perspective of research data, most scholars use single data for analysis. Wang[14], Zhou[15], Luo[16] and others all use travel data to analyze the spatial and temporal distribution characteristics of tourism flow and network structure characteristics. For the first time, Ji[8] and others used highway traffic flow big data to characterize the spatial and temporal distribution characteristics of self-driving tourism flow in special periods. It is an effective method to sort out the tourist routes from the travel notes, but it is difficult to obtain the relatively comprehensive flow and distribution characteristics of self-driving travel from small sample data. Expressway big data has the advantage of sufficient data, but it can't reflect tourists' emotional preferences and behavior choices. The fusion of multi-source data is an inevitable trend in future tourism flow research[17]. The accuracy and scientificity of research results can be improved through cross validation and fusion of multi-source data. Yan Shanshan, for example, combined the big data of the network including travel notes with the survey data, and explored the characteristics of the spatial network structure of Luoyang urban tourism flow based on social network and spatial statistical analysis methods[18]. In addition, the existing research on the influencing factors of tourism flow focuses on the long-term impact on an annual basis, and most of the indicators used are from the statistical yearbook[19]. Li et al. took Guizhou Province as an example to study, and found that the spatial distribution of summer resort tourism flow is jointly affected by climate comfort, spatial proximity, tourism resource endowment, reception service capacity and traffic convenience[20]. Liu and others analyzed the influencing factors of tourist flow in scenic spots, taking the 4A level and above scenic spots in Jiangsu Province as an example[21]. There is a lack of research on the influencing factors of tourism flow during the golden week, and the literature using multi-source data is rarely reported.

In this paper, the self-driving tourism flow during the Spring Festival Golden Week in 2018 and 2021 is taken as the research object, and the essential characteristics of the mobility of self-driving tourism are taken as the starting point. The road traffic flow

data and travel notes data are integrated, and the real flow direction and trajectory of self-driving tourism flow are restored through the traffic flow of road websites. Based on the perspective of "point and line", the spatial structure characteristics of self-driving tourism flow during the Spring Festival Golden Week in Yunnan Province before and after the COVID-19 are compared and analyzed, and based on the travel data, comparative analysis of influencing factors is made to provide a theoretical basis for self-driving travel planning and integrated development of transportation and tourism.

Figure 1. Overview of the study area.

Note: This map and other maps in the text are based on the standard map with the review number of GS (2019) 3333 downloaded from the standard map service website of the National Bureau of Surveying, Mapping and Geographic Information, and the base map boundary is not modified

2. Materials and research methods

2.1. Overview of the study area

Yunnan Province is located in the southwest border of China, and its unique geographical characteristics, geographical environment and geomorphic types have bred unique tourism resources (**Figure 1**). The expressway is the basic supporting network of tourism transportation in Yunnan Province. The expressway access rate of scenic spots above Grade A in the province exceeds 75%, of which more than 65% are within the 20km buffer zone of the expressway. Therefore, Yunnan Province is an ideal case for the study of self-driving tourism flow during the Spring Festival Golden Week.

2.2. Data source and processing

In this paper, the 2018 Spring Festival Golden Week and 2021 Spring Festival Golden Week are selected as the research periods before and during the COVID-19 epidemic. Research data includes big data of highway traffic flow and website travel data. The big data of highway traffic flow comes from the expressway online toll collection system and traffic flow monitoring platform in Yunnan Province. The travel notes data are from Qunar.com and Ctrip. com. All travel notes to Yunnan Province during the Spring Festival in 2018 and 2021 are collected through Octopus collectors. The basic data information is shown in **Table 1.**

Table 1. Basic information of the data

Data source		Data type	Select period	Quantity	Purpose
Big data of highway traffic flow	Expressway networking toll data	Expressway name, management unit, station name at each entrance and exit toll station of each expressway, and od (entrance toll station → exit toll station) flow of various models	The Spring Festival Golden Week before the covid-19 epidemic: February 13, 2018 to February 21, 2018	315 toll stations	Basic data of feature analysis
	Traffic flow monitoring data	OD flow of each vehicle type at different road traffic flow monitoring stations	Spring Festival Golden Week during the covid-19 epidemic: February 9, 2021 to February 17, 2021	31 traffic control stations of primary and secondary highways	Supplementary data for characteristic analysis
Travels		Text		172	Basic data of influencing factor analysis
				37	Supplementary data for characteristic analysis

2.3. Research methods

Social network analysis uses a series of network measurement indicators to explain the structural characteristics of tourism flow network and reveal the hierarchical nature of network nodes. In this paper, the node structure index is used to evaluate the characteristics of tourism nodes[22], and the analysis process is completed by using Gephi, ArcGIS and other software.

(1) Egress and ingress. Each node has its own input and output in the self-driving tourism flow network. The input reveals the attraction of the node to other nodes, while the output reflects the radiation of the node to other nodes[23]. In the tourism flow network, the output and input of nodes reflect the importance of nodes in transmitting and undertaking tourism flows.

(2) Intermediary centrality. The intermediary centrality reflects the degree of control and dependence of one tourism node on other tourism nodes. The higher the centrality of the intermediary, the more it can control other nodes to become key nodes in the network, which are dependent on the flow transmission relationship between other nodes, and the more important it is in the network.

3. Results and analysis

3.1. The “point” characteristics of the spatial structure of self-driving tourism during the Spring Festival Golden Week before and after the epidemic

In order to intuitively express the access and intermediary centrality of expressway toll stations

during the Golden Week of the Spring Festival in 2018 and 2021, the expressway toll stations are used as network nodes to draw social network relationship images with the help of Gephi.

(1) The nodes with high degree of access in 2018 and 2021 are mostly concentrated in Kunming, Yuxi, Dali and Qujing, and the degree of access in Kunming is significantly higher than that in other cities. In addition, the number of visitors to and from Kunming during the 2021 Spring Festival is 10 times higher than that in 2018, which indicates that the connectivity of tourism flow in Kunming, as the center of self-driving travel network, has significantly improved during the COVID-19 epidemic period, and tourists tend to take short distance self-driving travel centered on Kunming.

(2) During the 2018 Spring Festival Golden Week, Kunming, Xishuangbanna, Chuxiong, Wenshan and Qujing ranked among the top five in terms of intermediary centrality. Among them, Jinghong Toll Station in Xishuangbanna has the highest degree of intermediary centrality, which is 5392. Self-driving tours during the 2018 Spring Festival are willing to travel far away. The intermediary centrality of each node during the Golden Week of the Spring Festival in 2021 is generally higher than that during the Golden Week of the Spring Festival in 2018. The effect of taking Kunming as the main transit node is more obvious. The degree of intermediary centrality is five times higher than that in 2018, followed by Qujing. The degree of intermediary centrality of Honghe, Yuxi and Dali rank third, fourth and fifth respectively. Comparing the node intermediary centrality of the Spring Festival Golden Week in 2018 and 2021, it can be seen that self-driving travel during the COVID-19 epidemic is more likely to travel closer than before the COVID-19 epidemic. In addition, the connection role of provincial nodes during the Spring Festival in 2021 is significantly weaker than that in 2018, indicating that the COVID-19 has restricted the development of trans provincial self-driving travel.

3.2. The "line" characteristics of the spatial structure of self-driving tourism during the Spring Festival Golden Week before and after the epidemic

The natural fracture classification method is used to group the OD pairs of the 2018 Spring Festival into five levels. At the same time, in order to intuitively analyze the spatial changes of self-driving tourism flow in the 2018 and 2021 Spring Festival, the classification levels of the OD pairs of self-driving tourism in the 2021 and 2018 Spring Festival are uniformly processed (**Figure 2**).

(1) From the perspective of the overall spatial concentration and distribution of self-driving tourism flow, the self-driving tourism flow in Yunnan Province during the 2018 Spring Festival Golden Week is characterized by "one center, one axis and two wings". A "dragonfly like" spatial agglomeration is formed, with Kunming downtown and its surrounding areas as the core area, Zhaotong Xishuangbanna as the north-south vertical axis, Chuxiong, Dali, Lijiang and Baoshan as the west wing, and Yuxi, Qujing, Honghe and Wenshan as the east wing. The spatial agglomeration characteristics of self-driving tourist flows during the Spring Festival Golden Week in 2021 are significantly different from those in 2018, showing the spatial agglomeration characteristics of "two centers, one axis and two wings". Among them, "two centers" are the core areas dominated by Kunming City and the secondary core areas supplemented by Qujing City. The distribution of "one axis" and "two wings" is similar to that of the Spring Festival in 2018.

(2) From the perspective of the characteristics of tourist flow agglomeration during the two golden weeks, under the influence of the COVID-19, there will be no obvious phenomenon of large flow agglomeration of self-driving tourist flow during the Spring Festival in 2021. Compared with 2018, the tourist flow between toll booths on expressways shows the circulation characteristics of "small flow, dense distribution". The self-driving tourism flow of the 2018 Spring Festival Golden Week is the most

prominent in the Chuxiong Dali section, and the overall self-driving tourism flow is relatively scattered. The "West Wing" in 2018 and 2021 will form a spatial distribution feature with Dali as the core node, scattering in the direction of Baoshan and Lijiang in the shape of "Y". Self-driving tourism flows along the north-south "vertical axis" is highly concentrated, mainly because the typical tropical monsoon climate in Xishuangbanna during the Spring Festival attracts tourists from inside and outside the province to take shelter from the cold. Zhaotong, as a provincial city, undertakes a large number of tourism flows into Yunnan, which formed a typical "north-south axis" gathering feature.

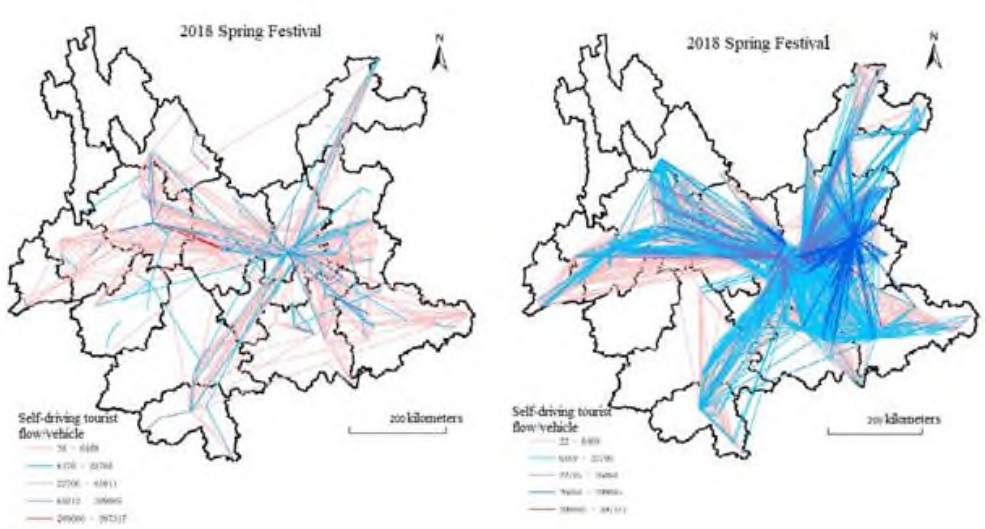

Figure 2. Spatial distribution of traffic flows in self-driving tourist flow nodes in Yunnan province during the Spring Festival in 2018 and 2021.

Table 2. The largest number of self-driving tourist flow nodes in the provincial boundaries of Yunnan province

OD pair	Spring Festival traffic in 2018 (vehicle/time)	Spring Festival traffic in 2021 (vehicle/time)	Decrease percentage (%)
Baise Wenshan junction → Puzhehei	62,316	17,113	72.54
Yibin Zhaotong junction → Kunming	20,490	11,350	44.60
Panzhou Qujing junction → Kunming	39,893	17,003	57.38
Panzhihua Lijiang junction → Lugu Lake	33,665	4,290	87.26
Panzhihua Chuxiong junction → Kunming	11,454	4,689	59.06

3.3. Spatial structure characteristics of self-driving tourism flow into Yunnan from outside the province

Taking each provincial boundary station as the starting point, the spatial structure characteristics of self-driving tourism flow entering Yunnan Province from each provincial boundary station are statistically analyzed. First of all, through the interpretation of the travel notes, it is found that Kunming and its surrounding areas, Lugu Lake and Puzhehei Lake are the first tourist destinations for the self-driving tourist flows into Yunnan. Further, through the big data analysis of road traffic flow, it is concluded that the self-driving tourist flows into Yunnan to Puzhehei, Kunming and Lugu Lake are the maximum OD pair flows of each provincial border station (**Table 2**), indicating that the spatial distribution of the main tourist flows into Yunnan has no significant changes. The overall self-driving tourism flow into Yunnan during the Spring Festival in 2021 is significantly lower than that during the Spring Festival in 2018, with an overall decline of

67.6%. The OD of Baise Wenshan junction → Puzhehei junction and Panzhihua Lijiang junction → Lugu Lake decreased the flow by 72.5% and 87.26%, respectively, indicating that the COVID-19 has had a significant impact on the volume of self-driving travel outside the province and has hindered the self-driving travel of tourists from Guangxi and Sichuan to Yunnan. In addition, during the Golden Week of the Spring Festival in 2018, more than 65% of the self-driving tourism flows outside the province from provincial nodes such as Qujing, Chuxiong and Zhaotong directly into Kunming, and then to other tourism nodes. From the travel notes, it can also be found that few tourists from outside the province will stay in provincial cities such as Zhaotong, Chuxiong and Qujing, and only a few will choose provincial city nodes for a short visit when returning Qujing and others are significantly affected by the aisle effect.

4. Influential factors of epidemic situation on spatial structure of self-driving tourism flow

According to the push pull theory of tourism flow and the driving force model of tourism flow, the influencing factors of tourism flow are considered from four aspects: the pull of destination, the push of departure, the spatial resistance of route, and the driving force of tourism flow. Among them, destination pull can be divided into destination attraction and destination support force. Destination attraction is the primary power to stimulate tourists' desire to travel, and support force provides tourists with tourism quality assurance[24]. As an important prerequisite for tourism attraction, tourism resource endowment determines the degree of attraction of the destination. Considering the rich ethnic culture and unique landform of Yunnan Province, and the IP traffic effect of many TV dramas and variety shows shot here, the number of A-level scenic spots, the popularity of tourist attractions Featured performances and IP traffic represent the pull of the destination (the popularity of tourist attractions is represented by Baidu index, and the featured performances and IP traffic are derived from travel notes). The number of high-quality hotels with Qunar.com score higher than 4.5 and the proportion of highway mileage (highway mileage/total highway mileage) indicate the supporting force of the destination. The number of expressway service areas represents the line support force. The starting point thrust is expressed by the regional economic development level. The line space resistance is expressed in expressway mileage. The driving force of tourism flow during the Spring Festival is expressed by the total toll amount of non-holiday expressways.

Table 3. Distribution of directional lines in the spaces of "One center, one axis, two wings"

Space distribution	Line
North-south vertical axis	Kunming Zhaotong, Kunming Yuxi Pu'er Xishuangbanna
East wing	Kunming Qujing, Yuxi Honghe, Kunming Honghe, Honghe Wenshan, Qujing Wenshan
West wing	Kunming Dali, Dali Lijiang, Kunming Baoshan

Based on the spatial structure characteristics of tourism flow obtained above, the directional route in the space of "one center, one axis and two wings" is selected (**Table 3**). Taking the tourist flow of the expressway toll stations between the two cities as the dependent variable, and the above indicators as the independent variables, based on the multiple regression model, this paper analyzes the factors affecting the tourist flow, with a view to differentiating the influence and degree of effect of each factor on the self-driving tourist flow during the Golden Week of the Spring Festival in 2018 and 2021. The multiple regression model is:

$$Y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \varepsilon \quad (1)$$

Where: Y is the tourist flow. β is the standard coefficient. X1~X10 respectively represent the difference in the number of A-level scenic spots, the difference in the popularity of tourist attractions, the difference in characteristic performances, the difference in IP flow, the difference in the number of high-quality hotels, the difference in the proportion of highway mileage, the number of highway service areas, the difference in GDP, the difference in highway mileage, and the total toll of non-holiday highways.

Table 4. Multiple regression and test analysis

Model	Influence factor	Standard coefficient	t	Sig.	Collinearity statistics	
					Tolerance	VIF
2018	GDP margin	-0.838	-6.502	0.000	0.307	3.256
	Difference in number of Grade A scenic spots	0.251	2.425	0.042	0.477	2.096
	Expressway mileage	-1.946	-5.377	0.001	0.0392	5.696
	Total toll amount of non-holiday expressway	0.884	2.500	0.037	0.0412	4.544
	Characteristic performance difference	0.436	3.742	0.006	0.376	2.660
	IP traffic difference	0.242	2.317	0.049	0.469	2.134
2021	GDP margin	-1.047	-4.819	0.001	0.416	2.406
	Percentage difference of expressway mileage	0.418	2.323	0.050	0.561	1.783
	Total toll amount of non-holiday expressway	-1.009	-6.047	0.000	0.705	1.418
	IP traffic	-0.364	-2.231	0.050	0.738	1.355

A multiple regression analysis model is established based on various data of the Spring Festival Golden Week in 2018 and 2021. After adjustment, it is found that the overall fitting degree of the model in 2018 and 2021 is high, and the Durbin Watson test values have passed the independence test of observation values. From the analysis of variance, it can be seen that the overall significance value of the model is far lower than 0.05, with good significance and reliability. The regression results of the 2018 and 2021 models are shown in **Table 4**. The GDP difference, the number difference of Grade A scenic spots, the mileage of expressways, the total toll of non-holiday expressways, the difference of characteristic performances, and the difference of IP flow in the 2018 model are significant at the 0.05 level in the regression. After passing the significance test, the other four factors cannot have a significant impact on the flow of self-driving tourism during the 2018 Spring Festival Golden Week. The GDP difference, the percentage difference of highway mileage, the total toll amount of non-holiday highways, and the IP traffic in the 2021 model are all significant at the 0.05 level in the regression, passing the significance test, and the significance values of other factors are higher than 0.05, indicating that there is no significant impact on the flow of self-driving tourism during the 2021 Spring Festival Golden Week. By analyzing the standard coefficients of various indicators, it can be seen that in 2018, intercity tourism flow has a significant positive correlation with various influencing factors except GDP difference and highway mileage. The correlation coefficients of the number difference of A-level scenic spots, characteristic performance difference and IP flow difference are high, indicating that tourism resource endowment plays an important role in tourism flow.

The tourism resource endowment in 2021 can no longer have a significant impact on tourism flows. Compared with 2018, the impact of the total toll amount of non-holiday expressways on tourism flows has changed from positive to negative, and the

absolute value of the standard coefficient is large, indicating that the total toll amount of non-holiday expressways has a high impact on tourism flows before and after the COVID-19 epidemic. The percentage difference of expressway mileage will become a positive factor affecting tourism flow in 2021. To sum up, it can be found that:

(1) Under the COVID-19, tourism resource endowment is no longer a significant factor in attracting self-driving tourists. In terms of destination selection, self-driving tourists are less willing to go to hot spots than those before the epidemic, and even tend to choose cold spots. The behavior preference of avoiding crowd gathering and paying attention to health and safety is shown as a whole.

(2) Before the COVID-19, the golden week toll free policy largely promoted the flow of self-driving travel and stimulated the generation of long-distance self-driving travel. However, under the influence of the COVID-19, the toll-free policy can't attract self-driving tourist flows to travel over long distances. In terms of spatial distance, the travel distance is shortened, and most tourists travel around.

(3) During the COVID-19 period, the difference in the proportion of highway mileage significantly and positively affects the tourist flow, indicating that highway construction has a positive role in promoting self-driving travel, and is a key factor for self-driving tourists during the epidemic. Cities with a higher proportion of highway mileage can attract self-driving tourists during the COVID-19 epidemic.

5. Discussions

The tourism industry is characterized by its comprehensiveness, dependence and serviceability, and is highly sensitive to major public health emergencies. The COVID-19 has had a major impact on the tourism industry as a whole due to its fast spread, wide spread and difficult prevention and control. In the face of the tourism dilemma caused by the COVID-19, it is worth carrying out theoretical discussion to promote the sustainable development of self-driving tourism in the context of epidemic normalization.

The study found that there were significant differences in the spatial structure of self-driving tourist flows before and after the COVID-19 epidemic. The Spring Festival Golden Week under the COVID-19 is characterized by a spatial agglomeration of "two centers, one axis and two wings". Qujing has become a secondary core node supporting the connection of Kunming's tourism flow. Qujing should give full play to its geographical advantages of connecting Guizhou externally and undertaking Kunming internally, increase the publicity of tourism products, cooperate with the tourism industry cluster of Kunming, and build itself into the core area of self-driving tourism in Yunnan Province. At the same time, self-driving tourists during the COVID-19 preferred to travel in short distance. Chuxiong, Zhaotong and others affected by the aisle effect should carry out in-depth development and structural adjustment of tourism products, create core attraction, increase efforts to develop short distance self-driving tours, develop the surrounding self-driving tour market, and get rid of the aisle effect.

6. Conclusions

(1) From the point of view of node access and intermediary centrality change, in 2018, the node access and intermediary centrality of expressway toll station are low as a whole, but Jinghong toll station has the highest intermediary centrality, and there is a tendency of long-distance self-driving travel. In 2021, the degree of node access and intermediary centrality will be significantly improved, especially in Kunming, which is 9 times higher than that in 2018, and the degree of intermediary centrality will be 4 times higher than that in 2018. It shows that under the influence of the COVID-19, the spatial distance tendency of self-driving travel has changed from a long distance to a short distance travel in neighboring cities with Kunming as the center. At the

same time, the connection role of provincial border nodes during the Spring Festival in 2021 is significantly weaker than that in 2018, indicating that the development of cross provincial self-driving travel is severely restricted during the COVID-19 epidemic.

(2) From the perspective of the changes in the spatial agglomeration characteristics of self-driving tourism flows, the self-driving tourism flows in Yunnan Province during the Spring Festival Golden Week in 2018 showed the spatial agglomeration characteristics of "one center, one axis and two wings", and the self-driving tourism flows during the Spring Festival Golden Week in 2021 showed the spatial agglomeration characteristics of "two centers, one axis and two wings", which indicates that under the influence of the COVID-19, the agglomeration center has produced obvious differences, forming a core area centered on Kunming and a secondary core area centered on Qujing. Compared with 2018, 2021 will show the circulation characteristics of "small flow and dense distribution", which reflects the characteristics of self-driving tourists who actively avoid high flow aggregation under the COVID-19 epidemic.

(3) From the perspective of spatial distribution of tourist flows into Yunnan, there is no significant change between 2021 and 2018. From the perspective of the change of the tourist flow into Yunnan, the self-driving tourist flow into Yunnan outside the province during the 2021 Spring Festival decreased by 67.6% compared with that in 2018. The OD flow of Baise Wenshan junction → Puzhehei junction and Panzhihua Lijiang junction → Lugu Lake in the provincial border into Yunnan node decreased significantly, by 72.5% and 87.26% respectively, indicating that the COVID-19 has seriously restricted the development of self-driving tourism into Yunnan from Guangxi, Sichuan and other provinces.

(4) From the perspective of the difference in influencing factors of self-driving tourism flow, the tourism resource endowment of the Spring Festival Golden Week in 2018 and the policy of free expressway tolls during the Golden Week have an obvious attraction for self-driving tourists, and tourists tend to travel far away by self-driving. After the outbreak of the COVID-19, self-driving tourists during the Spring Festival Golden Week in 2021 tend to go to hot spots with superior tourism resources compared with those before the epidemic, and the toll-free policy is also difficult to attract self-driving tourists to travel far away. The construction of expressways has become an important factor for self-driving tourists during the epidemic, which has actively promoted the development of self-driving tourism.

Conflict of interest

The authors declare no conflict of interest.

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