On the Spatial Network Structure of Self-driving Tourist Flows in Aba Tibetan & Qiang Autonomous Prefecture, Sichuan Province

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Abstract

Based on the social network analysis, this paper analyzes the density, centrality, core-periphery relation and cohesive subgroup of the spatial network structure of self-driving tourist flows in Aba Tibetan & Qiang Autonomous Prefecture, Sichuan Province, and, on this basis, and puts forward an optimization strategy of spatial structure of tourist flows. The results show that: (1) The network of self-driving tourist flows in Aba Prefecture is characterized by unevenly spatial distribution of nodes (dense in the central and eastern parts and sparse in the western part), significant core-periphery contrast, low network density, and loose structure; (2) The self-driving tourist flows in Aba Prefecture are described by a network structure with Hongyuan as the core and Maoxian County, Heishui, Songpan and Nuergai. Finally, the study points out the necessity to further improve the core nodes, speed up the construction of the peripheral areas, and improve the construction of tourist transportation network.

Keywords: self-driving tourist flows, social network analysis, network structure, Aba Prefecture

1. INTRODUCTION

As an essential issue of tourism geography, tourist flow is the result of the interaction between tourist destination and tourist origin. Since the 1950s, the spatial pattern of tourist flows has been a hot topic among foreign scholars, exemplified by the multiple conceptual models on the spatial behavior of tourist flows. Typical models include Campbell’s leisure and vacation model, Thurot’s regional tourist flow supply and demand model, and Lundgren’s spatial hierarchy model of tourist flows. In contrast, the research on tourist flows started rather late in China, focusing mainly on the theory of tourist flow regularity, the spatial behavior of tourists and the spatial structure of tourist flows. Induction and empirical methods are two of the most commonly used ways in China.

Inspired by sociometry, social network analysis is an important method to analyze the social structure and social relations, and an effective way to study the spatial structure of tourist flows. With the development of network dynamics, the tourism system is increasingly studied and investigated from the particular context of social network mechanism. Social network is applied to analyze the historical process of population changes and forecast the network structure of tourist flows. Foreign scholars have long introduced social network analysis into the study of tourist flows. The focal points include the spatial and temporal characteristics of the tourist flow network at the destination (Lue, 1993; Mings-Roert and McHugh-Kevin, 1992; Stewart and Vogt-Christine, 1997; Oppermann, 1995), the evolution of the spatial system at the tourist destination (Lundgren-Jan, 1982), the structure of tourism participants at the destination (Mc-Kercheret al., 2003), and the changes of the tourist flow network (Lew and McKercher, 2006). The social network analysis has also been applied to the study of tourist flows in China, but at a much later time. Chinese scholars mainly probe into the following aspects: the construction of the domestic tourist flow network system, the structural characteristics of domestic tourist network (Bao et al., 2002; Lu, 1994), and the flow pattern of inbound tourist flows in China (Connell and Page-Stephen, 2008; Yang et al., 2011; Zhang et al., 1999). However, the domestic research on the network structure of tourist flows is mainly macro-oriented with few scholars taking the mesoscopic approach. There is also a lack of research on the network structure of tourist flows for special tourism, such as self-driving tourism.

As a typical form of special tourism, self-driving has undergone explosive growth in China and developed into one of the main travel modes among the Chinese people. Aba Tibetan & Qiang Autonomous Prefecture, Sichuan Province (hereinafter referred to as the Aba Prefecture) is a preferred place for self-driving tourists in China. Known as the gateway to the Northwest Sichuan, Aba Prefecture is located in the junction of such three
provinces as Sichuan, Gansu and Qinghai. Owing to the rich and unique tourism resources and the gradual improvement of traffic conditions, the prefecture is developing from a major tourist destination in the province to a popular attraction in western China for self-driving tourists. In spite of the above, Aba Prefecture faces a major challenge from the uneven development of tourism: the eastern part is much more popular than the central and western areas. Fortunately, self-driving tourism stands out as an effective tool to narrow the gap of tourism development between different areas in the prefecture. Against this backdrop, this paper probes into the spatial structure of self-driving tourist flows in Aba Prefecture by social network analysis. On the one hand, the spatial structure of tourist flows is explored from a specific mode of transportation, and, on the other hand, an empirical analysis is conducted against self-driving tourist flows in Aba Prefecture. The research has many implications: the unique perspective makes up the defect of the traditional emphasis on individual tourists, the analysis of the network structure of self-driving tourist flows serves as a prelude to more in-depth and diverse research on tourism, and the empirical study provides a scientific basis for determining the development stage of the spatial structure and the optimization measures of self-driving tourism in Aba Prefecture.

2. DATA SOURCE AND RESEARCH METHOD

2.1 Data source

There are many ways to acquire spatial data for tourist flows. In view of the strong correlation between the data of tourist flow questionnaire and the data of online travelogues, the author decided to collect data from two main sources: travelogues/travel guides and field survey. Specifically, the author gathered the travelogues and travel guides, which keep track of complete travel itineraries, published between January 1, 2014 and May 31, 2016 on the four majors professional tourism service websites in China, namely ctrip.com, qunar.com, tuniu.com and ly.com. In total, 118 copies of effective travelogues were extracted, including 25 from ctrip.com, 38 from qunar.com, 32 from tuniu.com and 23 from ly.com. The spatial flow of tourists was obtained from the travelogues. During the collection and processing of travelogues, it is discovered that 92% of the tourists come from Chengdu. Thus, the Miansi Service Area on Chengdu-Wenchuan Expressway, the only expressway linking up Chengdu and Aba Prefecture, was chosen as the target of the field survey. The survey was carried out in August 2016, a rush season for Aba Prefecture. The author issues 80 questionnaires and received 69 valid responses. The data was processed and merged with the travelogue data via Ucinet.

2.1 Research method

The social network is a collection of social actors and their relationships. The structural characteristics of the network are often demonstrated by the attribute of the whole network and the attribute of individuals. The relationship between the tourist destinations, the rate and direction of tourist flows, and the accessibility between the nodes can be revealed by collection and analysis of the data on the actors and their relationship (Liu, 2009). In light of social network analysis, this paper adopts the overall structure indices and node structure indices of the network to evaluate the spatial network structure of the tourist destination. The overall network structure of self-driving tourist flows in Aba Prefecture is manifested through tourism network density, cohesive subgroup analysis, core-peripheral model and equivalence analysis, while the node structure of self-driving tourist flows in Aba Prefecture is demonstrated by degree centrality, closeness centrality, and structural hole. The overall structure indices and node structure indices are combined to analyze the network structure and spatial differences of self-driving tourist flows in Aba Prefecture. The network structure is measured via Ucinet 6.

3. STRUCTURAL CHARACTERISTICS OF THE NETWORK OF SELF-DRIVING TOURIST FLOWS INABA PREFECTURE

3.1 Construction of the network structure of tourist flows

Based on the social network analysis, this paper chooses 13 connections in Aba Prefecture as the tourist nodes, and constructs a 13*13 matrix considering the rate and direction of tourist flows to the node connections. The initial state of the matrix is set as 0. Suppose a tourist visits Wenchuan and Heishui before reaching the final destination of Jiangyuan, the tourist flow is unidirectional between Wenchuan and Heishui. In this case, the flow from Wenchuan to Heishui is expressed as 1, and the flow from Heishui to Wenchuan is expressed as 0. The rest is deducted by analogy. However, if the tourist only passes by a city with no stop over, the city should not be counted as an effective node in the flow. In the meantime, a proper breakpoint value is selected to convert the multi-valued matrix to a binary matrix. If the number of connections between two nodes
is higher than the breakpoint value, the flow of the binary matrix is assigned the value of 1; if not, the flow is assigned the value of 0. To present the whole network structure in a more intuitive way and highlights the network nodes, the author carries out repeated tests and eventually sets the breakpoint value as 3 and converts the multi-valued matrix to a binary matrix based on the value. With the binary matrix in place, the author uses Netdraw to map the network structure of self-driving tourist flows in Aba Prefecture (Figure 1). Figure 1 is a topological map, where the location of the nodes is independent of its geographical location.

![Network Structure of Self-Driving Tourist Flows in Aba Prefecture](image)

**Figure 1** The network structure of self-driving tourist flows in Aba Prefecture

### 3.2 Structural characteristics of the network of tourist flows

#### 3.2.1 Spatial distribution of tourist flows

The geographical map self-driving tourist flows in Aba Prefecture is drawn with Photoshop (Figure 2). In the map, the lines between the destinations stand for the tourist flow rate. The flow rate is positively proportional the thickness of the lines. The arrows indicate the dominant direction of tourist flows. As shown in the figure, the self-driving tourist flows are “dense in the central and eastern parts and sparse in the western part” of Aba Prefecture. The self-driving tourist flows are distributed differently from the “tourist flows of Aba Prefecture”, judging by the movement relationship and rate of tourist flows. The main differences are as follows: Some of the core nodes in the network of the “tourist flows of Aba Prefecture”, e.g. Jiuzhai and Songpan, are no longer core nodes in the network of self-driving tourist flows in the prefecture. The weak tourist flow connections between them and Rangtang, Jinchuan and Xiaojin leads to the sparse distribution of tourist flows in the southwestern area. In contrast, tourist flows are densely distributed in the Greater Jiuzhai area and the Greater Prairie area. The nodes within the same area boast strong tourist flow connections, much closer than the tourist flow connections across the two areas. In general, the maximum flow rate occurs from Hongyuan to Ruoergai. In the southwestern area, however, the tourist flows converge in Barkam.
3.2.2 Overall structural characteristics of the network

(1) Tourist network density. The self-driving tourist flow network has a density of 0.2051. Out of the 156 possible network connections, only 32 actually appear. The low proportion indicates very loose network structure and insignificant tourist flow interactions between node cities. From the structural map of the network of self-driving tourist flow network in Aba Prefecture, it can be further inferred that the tourist flows tend to converge to core cities like Hongyuan, Heishui, Songpan and Nuergai, resulting in much weaker tourist flow interaction and sparse connections between other nodes. In Aba Prefecture, the tourist flows are mainly concentrated in areas of abundant tourism resources and high accessibility. Therefore, it is of great necessity to strengthen and improve the overall function of self-driving tourist destinations across the prefecture.

(2) Cohesive subgroup analysis. Using the concor algorithm in Ucinet, it is concluded that the self-driving tourist flows in Aba Prefecture form four cohesive subgroups on level 2, and seven cohesive subgroups on level 3 (Figure 3). Subgroup density analysis shows that the connection between the subgroup of Jiuzhaigou and Ruoergai and the subgroup of Songpan is closer than any other connections, and the subgroup of Markam and Rangtang has few connections with other subgroups. In terms of radiation, the subgroup of Wenchuan and Heishui has a strong radiation over the subgroup of Ruoergai and Jiuzhai and the subgroup of Aba County and Hongyuan. However, the radiation effect of this subgroup still must be improved because of its weak connection with the subgroup of Markam and Rangtang.
(3) Core-peripheral analysis. The core-peripheral analysis and equivalence analysis are mostly used to measure the importance of each node in the network and the similarity between nodes. The two methods are employed in this paper to identify the status of each node in the network and analyze the structural characteristics of the network. The results of the core-peripheral analysis further testify the core-peripheral effect in the self-driving tourist flow network of Aba Prefecture (Figure 1). The network density is 2.972 in the core areas and 0.667 in the peripheral areas. The connection density between the core nodes and peripheral nodes is 0.472. The network density is much higher in the core areas, indicating that the tourist flows are concentrated in core areas like Wenchuan, Maoxian County, Lixian County, Heishui, and Songpan, while few tourists drive to peripheral areas.

<table>
<thead>
<tr>
<th>Core-peripheral model</th>
<th>Core</th>
<th>Wenchuan, Maoxian County, Lixian County, Heishui, Songpan, Jiuzhaigou, Hongyuan, Ruoergai, Aba County</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peripheral</td>
<td>Xiaojin, Jinchuan, Markam, Rangtang</td>
</tr>
</tbody>
</table>

Based on the core-peripheral model, the nodes in the tourism network are further categorized via the equivalence analysis, thus forming the matrix of the Euclidean distance of the tourism network. The results are visualized as the structural equivalence cluster graph. According to the cluster graph, the tourist nodes of equivalent statuses and functions are put in the same bracket. After examining the regularity, the author eventually divides the network nodes of self-driving tourist flows into four categories: the cores, sub-cores, important nodes and peripheral nodes (Table 1). The classification provides a clear picture of the function and status of each node in the self-driving tourist flow network of Aba Prefecture.

3.2.3 Structural characteristics of network nodes

The node structure of self-driving tourist flows in Aba Prefecture is obtained through analysis with Ucinet (Table 2).

<table>
<thead>
<tr>
<th>Node cities</th>
<th>Degree centrality</th>
<th>Closeness centrality</th>
<th>Intermediary centrality</th>
<th>Efficacy</th>
<th>Efficiency</th>
<th>Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Outward Inward</td>
<td>Outward Inward</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hongyuan</td>
<td>6.00  5.00</td>
<td>40.00  29.27</td>
<td>46.83</td>
<td>4.64</td>
<td>0.77</td>
<td>0.36</td>
</tr>
<tr>
<td>Heishui</td>
<td>5.00  3.00</td>
<td>37.50  26.09</td>
<td>29.25</td>
<td>4.13</td>
<td>0.83</td>
<td>0.43</td>
</tr>
<tr>
<td>Maoxian County</td>
<td>3.00  2.00</td>
<td>36.36  22.64</td>
<td>15.25</td>
<td>3.00</td>
<td>1.00</td>
<td>0.36</td>
</tr>
<tr>
<td>Nuergai</td>
<td>3.00  4.00</td>
<td>32.43  27.27</td>
<td>19.00</td>
<td>2.71</td>
<td>0.56</td>
<td>0.57</td>
</tr>
<tr>
<td>Songpan</td>
<td>2.00  4.00</td>
<td>26.67  27.91</td>
<td>10.50</td>
<td>3.17</td>
<td>0.79</td>
<td>0.47</td>
</tr>
<tr>
<td>Wenchuan</td>
<td>3.00  1.00</td>
<td>33.33  19.36</td>
<td>2.00</td>
<td>3.00</td>
<td>1.00</td>
<td>0.38</td>
</tr>
<tr>
<td>Jiuzhaigou</td>
<td>2.00  1.00</td>
<td>26.67  23.08</td>
<td>0.00</td>
<td>1.00</td>
<td>0.50</td>
<td>0.89</td>
</tr>
<tr>
<td>Lixian County</td>
<td>2.00  3.00</td>
<td>31.58  26.09</td>
<td>16.75</td>
<td>3.40</td>
<td>0.85</td>
<td>0.39</td>
</tr>
<tr>
<td>Aba County</td>
<td>3.00  3.00</td>
<td>34.29  26.67</td>
<td>6.50</td>
<td>1.67</td>
<td>0.56</td>
<td>0.57</td>
</tr>
<tr>
<td>Markam</td>
<td>2.00  3.00</td>
<td>31.58  26.09</td>
<td>16.75</td>
<td>3.40</td>
<td>0.85</td>
<td>0.39</td>
</tr>
<tr>
<td>Xiaojin</td>
<td>0.00  3.00</td>
<td>7.69   30.00</td>
<td>0.00</td>
<td>2.00</td>
<td>1.00</td>
<td>0.50</td>
</tr>
<tr>
<td>Jinchuan</td>
<td>1.00  1.00</td>
<td>26.09  22.64</td>
<td>0.83</td>
<td>2.00</td>
<td>1.00</td>
<td>0.50</td>
</tr>
<tr>
<td>Rangtang</td>
<td>0.00  0.00</td>
<td>7.69   7.69</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Mean value</td>
<td>2.46  2.46</td>
<td>28.61  24.21</td>
<td>11.62</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.65  1.39</td>
<td>9.79   5.56</td>
<td>13.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>32.00 32.00</td>
<td>371.87 314.78</td>
<td>151.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum value</td>
<td>60.00  5.00</td>
<td>40.00  30.00</td>
<td>46.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum value</td>
<td>0.00  0.00</td>
<td>7.69   7.69</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(1) Node centrality. In terms of the degree centrality index, the 13 selected nodes each has tourist flow convergence and radiation relationships with an average number of 2.46 other nodes. The high centrality variance reflects strong imbalance in the network structure of self-driving tourist flows in Aba Prefecture. Being the transportation hub in the prefecture, Hongyuan has a much higher degree centrality than any other node. With the highest outward centrality of 6, it is a core node of tourist flows. This means the tourist flows converge to Hongyuan and spread from there to other nodes.

In terms of the intermediary index, each node serves as an intermediate stop in the network for an average of 11.62 times. However, the variance is as high as 151.00. The two nodes of Hongyuan and Heishui have much higher intermediary effect than the mean value. Functioning as intermediate stops in tourist flows, the two nodes boast high accessibility thanks to the convenient transportation network and location advantages. The other nodes depend heavily on these two nodes. On the contrary, the intermediary indices of Jiuzhaigou, Xiaojin and Rangtang are valued 0. This indicates the three peripheral nodes have not served as intermediate stops in the network.

In terms of closeness centrality, the node cities differ greatly in the development of travel and reception. With excessively high outward and inward centralities, Hongyuan features high travel convenience and strong accessibility. The relatively high closeness centralities of Songpan and Maoxian County demonstrate the certain advantages of travelling and reception of the two nodes. Rangtang is basically isolated in the network structure of tourist flows because it has the lowest closeness centrality.

In Table 2, Hongyuan ranks high in all of the centrality indices, making it the core and distribution center of self-driving tourism network in Aba Prefecture. Suffice it to say that Hongyuan is the “polar nucleus” of the entire network. Meanwhile, Heishui, Maoxian County, Songpan and Ruoergai are sub-cores due to their relatively strong gathering and radiation effects. Thanks to rich tourism resources, excellence locations, and sophisticated transportation networks, the four nodes have many interactions with each other. In view of the relatively high rate of tourist flows of these nodes, more efforts should be paid to enhance their radiation to the surroundings and tighten their connections with Hongyuan.

(2) Structural hole. The index of structural hole illustrates the advantages/disadvantages of the nodes in self-driving tourist flows network of Aba Prefecture. According to the index analysis, Hongyuan has the highest level of structural hole in the self-driving tourist flow network of Aba Prefecture with maximum efficacy and minimum constraint. Therefore, the place has obvious advantages over other places. Nuoergai, Songpan, Markam and Lixian County also hold the advantages of structure hole and competition opportunities in the network. However, the lack of alternative nodes may cause bottlenecks in tourist flows and impede the balance and optimization of the overall network structure. Hence, the nodes should step up the planning and construction of software and hardware, and ensure the smooth flow of tourists. With the smallest efficacy, Rantang is left behind at a disadvantageous position in self-driving tourist flow network of Aba Prefecture. To improve the situation, Rantang should strengthen the development of tourism resources and the construction of service facilities, and also cooperate with Hongyuan, Heishui, Maoxian County, Markam and other nodes with structural hole advantages.

4. CONCLUSIONS AND SUGGESTIONS

4.1 Conclusions

Using social network analysis, this paper takes the self-driving tourist flows of 13 major cities in Aba Prefecture as the research object, constructs the spatial structure of self-driving tourist flow network in Aba Prefecture based on the data from online travelogues, and carries out an in-depth analysis of the structural characteristics and spatial differences of the tourist flow network. The conclusions are as follows:

(1) On the whole, Hongyuan is the “polar nucleus” of the self-driving tourist flow network of Aba Prefecture. The core nodes are distributed in a fan shape with Hongyuan at the tip and Heishui, Maoxian County, Songpan and Ruoergai on the curved edge. The tourism space network is denser in the central and eastern areas and sparser in the western areas. The self-driving tourist flow network has obvious core-periphery effect. The 13 nodes in the prefecture can be divided into 4 types, ranging from cores, sub-cores, important nodes, and
peripheral nodes. The nodes of the same type bear resemblances on centrality indices. Overall speaking, the tourist flow network consists of a few core nodes and many peripheral nodes. The tourist flows mostly converge and spread between the core nodes. Only a limited number of cities are destinations that can attract and form large-scale tourist flows. There are four cohesive subgroups in self-driving tourist flows of Aba Prefecture. Among them, the subgroup of Markam and Rantange should improve the extremely weak connections with other subgroups.

(2) When it comes to the node structure of self-driving tourist flow network in Aba Prefecture, Hongyuan features particularly high degree centrality and intermediary and strong control of other nodes. In the mean time, Heishui, Maoxian County, Songpan, and Ruoergai fall into the category of sub-cores due to their relatively strong gathering and radiation ability. With certain competitive advantages and opportunities in the self-driving tourism network of Aba Prefecture, these four nodes are able to connect up other nodes in an effective manner. Maoxian County is worth a special mention as it is situated on the only channel through which tourists flow to and from other four sub-core nodes. The county should invest more on transportation and service facilities for tourists.

(3) The author also gives suggestions on the optimization of the spatial structure of self-driving tourist flow network in Aba Prefecture. For the purpose of creating a new spatial pattern of tourism, the prefecture should firstly improve the core nodes, and, on this basis, speed up the development of peripheral nodes, improve the transportation network for tourists, and construct a tourism development circle centering on the core nodes.

Figure 4 The development axes and zoning of self-driving tourism in Aba Prefecture

4.2 Suggestions on structural optimization of self-driving tourist flow network in Aba Prefecture

The following optimization suggestions are put forward in light of the spatial characteristics of the network structure of self-driving tourist flows in Aba Prefecture. The goal is to transform the distribution model of tourism nodes in Aba Prefecture from the multicenter pattern to the chain-like pattern.

First, further build and improve the core nodes and speed up the development of peripheral nodes. Put emphasis on one core node and four sub-core nodes (Table 1). As the “polar nucleus” of tourist distribution, Hongyuan should further improve the tourism facilities and the transportation network to other areas. Heishui and Songpan should improve their status as tourist centers by strengthening urban tourism infrastructure and tourist distribution functions. The two cities should be able to receive and distribute tourists from the east and
northeast. In particular, Songpan should vigorously promote the car rental industry so that tourists could start self-driving once they land at the Jiuhuang Airport. Under the influence of the fast developing core nodes, the peripheral nodes should dig deep into the religious and ethnic tourism resources in the tourism belt along the Tibetan-Yi Corridor, and improve basic service facilities to the level of the core nodes. In this way, the tourist flows will circulate evenly in the entire prefecture.

Second, improve the construction of regional tourism transportation network. Essential to self-driving tourism, tourism transportation and routes planning are effective ways for optimization of tourism spatial structure. Currently, Aba Prefecture has three classic self-driving routes, namely Chengdu-Jiuzhaigou Circular Route, South Circular Route and Hongyuan Circular Route. The three routes are the axes of the whole self-driving tourism network of Aba Prefecture, linking up major tourist destinations in the prefecture. At present, the self-driving tourism centers on Maoxian County and Songpan along the Chengdu-Jiuzhaigou Circular Route, Markam on the Tibetan-Yi Corridor, and Hongyuan on the Hongyuan Circular Route. Thus, Aba Prefecture should make full use of the concentration and diffusion effect of the axes. The tourism transportation facilities of Markam must be improved because it would not only boost the development of the whole Tibetan-Yi Corridor, but also promote the balanced flow of self-driving tourists and optimize the tourism spatial structure.

Third, attach great importance to the product design and image building of gateway cities. The tourists’ impression of a region is greatly affected by the cities on the gateway to the region. Therefore, the prefecture must construct high quality tourist guiding and publicity systems in Wenchuan, the inlet of tourist flows, and the entrance and exit of Hongyuan, the core node of tourism. Apart from displaying the local culture and customs in places of huge tourist flows, the prefecture should also pay attention to strengthening soft powers like environmental health, service quality and so on.

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