Study on Users’ Travel Behavior of Urban Car Sharing System Based on Spatio-temporal Big Data in Chengdu

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Abstract. Based on the big data of time and space for shared cars in Chengdu, this paper conducts a visual analysis of the travel needs of car sharing users in Chengdu. Clarified the hotspot areas for shared cars in Chengdu. In order to explore the spatial distribution characteristics of car sharing in Chengdu, the average daily travel space distribution of car sharing was visualized. It also counts the number of demand interactions within and between districts on weekdays and weekends. Comparative analysis of the travel characteristics of operators Evcard and GoFun. It provides a direction for further research on the travel timing characteristics of urban car sharing.

1. Introduction
In China, especially in big cities, people's consumption of buying and maintaining cars has increased year by year. And due to problems such as fewer parking spaces and the impact of policies such as license restrictions and number restrictions. This makes car sharing system have great development potential in these big cities[1]. Whether in first-tier cities or second-tier cities, the main users of car sharing system are young people, low- and middle-income groups, and people in urgent need of cars. Now, car sharing are gradually developing from first-tier cities to second- and third-tier cities. The development of car sharing in different cities is different. But most of them face similar problems. Among them, the most feedback is "It’s not enough outlets, finding a car and parking is troublesome".

Users born in the 80s and 90s have an increasing demand for convenient travel, which is driving the development of the car sharing industry. At the same time, car sharing can also provide stable parking spaces and car maintenance services to reduce car use concerns for consumers. From the perspective of foreign development experience, car sharing will reduce people's purchases of cars, leading to a reduction in the total number of cars in society [2]. The development of car sharing can not only effectively alleviate traffic congestion and road occupation, but also save a lot of resources and reduce environmental pollution [3]. The most important thing is that car sharing has changed people's lifestyles and has a better role in promoting sustainable development [4].

Luo [5] based on the improved object' Lewin metal of behavior, through questionnaire surveys, the behavior of car sharing travel is analyzed from the perspective of individual characteristics, travel characteristics, and information perception. By constructing a disaggregated model, it analyzes the influencing factors of whether users choose to car sharing, the travel intensity of car sharing, and whether
non-car sharing users choose to car sharing in the future. The results of the study show that there are more male users than female users. And the higher the level of education, the greater the willingness to choose car sharing. With the methods of questionnaire and statistical analysis, Gou[6] takes Kunming as an example to study the changes of residents’ travel behavior around Chenggong University City before and after the emergence of car sharing. The related problems of car sharing are discussed. And put forward feasible solutions. To analyze the influence of car sharing service on the travel mode choice behavior of urban users, Zhang [7] analyzed the influence of car sharing service on the travel mode choice behavior of urban users. Based on the theory of random utility and the data of behavior survey and intention survey, a multinomial logit model is constructed. SPSS software was used to test the model and estimate the parameters. Li [8] is based on a new perspective of customer delivered value, combined with the characteristics of "online self-service" of car sharing, and adds the perceived risk cost factor to supplement the original customer delivered value theory. From the two dimensions of value and cost, it integrates the attributes and use process of shared cars. The customer delivered value model of car sharing users is constructed. They explored the factors that affect consumers' choice of car sharing travel.

To the inherent law analysis of the behavior choice of urban car sharing is not perfect. This paper presents a visual analysis method of urban car sharing travel characteristics. The purpose of this paper is to reflect the current situation and problems of urban car sharing users’ travel characteristics from the spatial distribution and travel space demand of car sharing.

2. Research Data Sources
The data used in this study comes from the car sharing GPS data of Chengdu in 2017. The survey objects are app users of Evcard and GoFun in Chengdu. The survey was conducted from October 16 to October 22, 2017. The survey data source is the data research of big data company, which has certain confidentiality. The survey content is the spatiotemporal GPS data of the corresponding number vehicles of the corresponding brand car sharing.

Through data mining and analysis, the detailed data of residents’ whole day travel can be obtained: the starting coordinates, starting time, arrival coordinates, arrival time, station coordinates, license plate information and other data. The survey covers the car sharing in different areas of Chengdu City. The total number of monitored vehicles is 1943, the total number of evcard stations is 734, and the total number of gofun travel stations is 311.

3. Analysis on Users’ Travel Behavior Characteristics of Car Sharing in Chengdu

3.1. Analysis on Visualization of Distribution Space of Driving Edge Connection
The distribution of the driving space along the edge can intuitively see the operating status of car sharing. figure 1 and figure 2 respectively show the distribution of driving space along the edge of EVCARD and GoFun.
Due to the difference in travel costs, vehicle models and station configurations, they present different distribution states. The intensity of entry and exit reflects the inflow and outflow of users in the region, and also reflects the attractiveness of different geographic locations. It can be seen from the figure that the distribution of major commercial districts and CBD areas is relatively stable. Residents travel regularly.

3.2. Analysis of Users’ Travel Spatial Distribution Characteristics

Figure 3 and figure 4 respectively show the daily average travel space distribution of Evcard and GoFun. Evcard is more evenly distributed within the Third Ring Road of Chengdu. Each area outside the third
ring road has a demand concentrated plot. The travel demand of GoFun is mainly within the third ring road. This may be due to the low density of site settings. The distribution of travel demand is getting lower and lower with the central urban area outward.

![Figure 3. Average daily travel space distribution of car sharing for Evcard.](image1)

![Figure 4. Average daily travel space distribution of car sharing for GoFun.](image2)

To analyze the user travel characteristics of the two operators EVCARD and GoFun. Using the method of dividing working days (Monday to Friday) and weekends (Saturday to Sunday) and combining data, the feature extraction of demand spatial interactions between various districts in Chengdu is carried out. Since the Tianfu District was still under construction when the data was obtained, the number of data items was relatively small, and this analysis is of little significance, so it is not considered.
Table 1. Demand interaction within and between districts in Chengdu.

| District      | Number of interactions | Working days (internal) | Working days (other Dist.) | Weekends (internal) | Weekends (other Dist.) |
|---------------|------------------------|-------------------------|---------------------------|---------------------|------------------------|
| Chenghua      | 886                    | 927                     | 260                       | 292                 |
| Dujiangyan    | 387                    | 74                      | 156                       | 36                  |
| Jinniu        | 735                    | 844                     | 234                       | 300                 |
| Jinjiang      | 685                    | 763                     | 235                       | 291                 |
| Longquanyi    | 1015                   | 583                     | 377                       | 245                 |
| Pidu          | 1227                   | 718                     | 393                       | 314                 |
| Qingbaijiang  | 171                    | 139                     | 82                        | 67                  |
| Qingyang      | 601                    | 943                     | 225                       | 348                 |
| Shuangliu     | 2786                   | 1639                    | 1032                      | 608                 |
| Wenjiang      | 663                    | 468                     | 233                       | 149                 |
| Wuhou         | 2330                   | 1921                    | 766                       | 647                 |
| Xindu         | 1024                   | 810                     | 303                       | 299                 |
| Total         | 12510                  | 9829                    | 4296                      | 3596                |

The GPS data is mined and cleaned, and the number of demand interactions within and between the districts is counted, as shown in Table 1. The number of interactions on weekdays is significantly higher than the number of interactions on weekends, and the number of external interactions in central urban areas such as Jinniu District, Wuhou District, Jinjiang District, and Qingyang District is higher than the number of internal interactions. It shows that the interaction state between the districts is better. However, Shuangliu District and Dujiangyan District are far away from the city center. The number of internal interactions is high, and the number of external interactions is low. It shows that the travel of shared car users in these districts is mainly in the destinations in the district. In other words, the setting of external sites does not meet the travel wishes of users in the outer suburbs.

4. Conclusion
In this paper, we use car sharing space-time big data to visualize shared car pickup/return points. It also analyzed the travel hot spots in Chengdu. It reveals the degree of application of car sharing in urban traffic conditions. In addition, based on the space-time big data of car sharing, it visualizes the spatial interaction of the travel needs of car sharing users within and between districts. It reveals the characteristic law of car sharing user demand among various regions. It provides a direction for further analysis and exploration of the time and space characteristics of urban car sharing travel.

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