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Behavior Patterns of Long-term Car-sharing Users in China*

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Abstract

This paper presents the behavior patterns of long-term users in detail on the basis of empirical data of car sharing in Hangzhou, China. Users, whose utility time are more than three months and frequency of usage are beyond once per month, have been selected as the subject investigated (long-term users) in this study. Unlike other studies on car sharing in China, which only conducted theoretical analyses and investigation of willingness for car sharing, this study was based on real operation data of Hangzhou, which was the first massive pilot city for car sharing project in China. The major objective of this study was to analyze the differences between groups classified from the long-term users group according to the different frequency of usage, and identify and summarize the typical usage patterns by using indices such as new members, monthly orders, single-use time, single-use distance, time of taking-out and placing-in a car, and so on. The findings indicate that the behaviour patterns of each group are different: that of the highest frequency users group are similar to the characteristics of commuting travel and that of lowest frequency users group are more similar to the car-sharing users abroad. The key contribution of this paper is presenting the different behaviour patterns of the Chinese users in groups differing in frequency, and act as a foundation for questionnaire surveys and policy analysis in the future.

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1. Introduction

Against the background of rapid urbanization and the rapid rise in private car ownership in China, balancing resources, efficiency, and fairness while meeting the diverse travel needs of residents has become an extremely difficult challenge. Car sharing, which offers the mobility and flexibility of private cars and at the same time eases the pressure on public transportation can reduce private car ownership to a certain extent (Meijkamp, 1998). This is being increasingly considered as an innovative mobility tool from the viewpoint of transportation policy in Europe and other developed countries (Ohta et al, 2009).

The practice of car sharing dates back to the 1990s in European countries. Shaheen classified the progress of car sharing into three phases: initial market entry and experimentation phase (1994–2002); growth and market diversification phase (2002–2007); and commercial mainstream phase (2007–present). (Shaheen, 2009) It has already reached the third phase in some of the developed countries in North America. Car sharing has become not only a part of numerous urban transportation systems, but also an effective means of reducing car ownership and the total mileage (Stillwater et al, 2008). Most initial studies on car sharing in North America dealt with the mobility and flexibility of the car-sharing system, its influence on the urban transportation system, and ways to expand car-sharing membership; however, the behavior patterns of car-sharing users was rarely explored in these studies. However, researchers soon discovered that the characteristics of user behavior were significant to topics studied in the previous works because behavior patterns may explain some system operation problems from the root itself. Several researchers, for example, Nobis (2006), Millard-Ball (2006), Celsor and Millard-Ball (2007), Morency (2008, 2009), and Khandlker M. et al (2011) analyzed users' behavior patterns, and they all considered it as an important factor determining the success of the car-sharing system operation.

Thus far, several studies have been conducted outside China on the behavior patterns of car-sharing users. Seik (2000) analyzed actual car-sharing conditions, investigated the characteristics of travel distance and travel destination in Singapore, and discovered significant differences between members and non-members. Some studies (2009, 2010) showed that after joining a car-sharing club, members mainly used car-sharing systems for long holidays or for shopping and travel; for regular commuting, the members always used public transportation. In the terms of the frequency and distance of usage, some studies in England showed that 75% of the members used car-sharing less than 5 times per year, that the distance travelled thus by 64% of the members was less than 40 miles. Some studies in Belgium indicated that used car-sharing less than thrice a month and mainly used it for shopping, visiting friends, and taking holiday in their leisure time. Millard-Ball (2005) also found that only a small proportion of the members used car-sharing for regular commuting, and most members used car-sharing for carrying heavy things or for trips with many destinations. Khandlker et al. (2011) analyzed the empirical data and found that men and French-speaking members tend to practice car sharing only for short trips, but their usage frequency is high. Meanwhile, it could not be proved that increasing the number of cars has any effect on maintaining the membership, but it may lead to an increase in the frequency of usage to some extent.

Unlike in North America, in China, car sharing is only in the initial stage. Because of the lack of practical support, relatively less research has been carried out on car sharing in China. Huang Zhaoyi (2000) summed up the car-sharing concept and proposed a number of car-sharing initiatives. Many researchers summarized and analyzed the practice abroad. Hui Ying (2008) and Ye Liang (2012) opined that by actively encouraging car sharing, households can be guided into using this alternative rather than buying a car, thus slowing down the trend of households buying a second car. After reviewing car-sharing practices in cities abroad, Xu Qing (2014) reported various problems related to car sharing in China. Qie Lisha studied the empty car distribution and created a model to validate this distribution for car-sharing networks. Although some studies on the behaviors of car-sharing users are noteworthy, most still dealt only with the level of willingness. Hui Ying (2010, 2012, 2013) and Wang Zengquan (2013) used discrete choice models for the willingness of joining a car-sharing club and analyzed the potential requirements and possibility of changing travel behavior.

In China, car-sharing studies just stayed in the level of theoretical analysis and willingness investigation, extremely lack of the study on members' behavior patterns, which was based on the empirical data. Based on the no-personal privacy information car rental data of a car-sharing system initiated in July 2013 in Hangzhou, China, this work analyzed the behavior patterns of long-term users. These users were classified into several groups, and the typical

usage patterns of behavior in each group were identified and summarized. So far we just have the data about operation orders, without any data on user profile (e.g. age, income, gender,...) and destination of each trip. So this paper only discussing the behavior patterns of long-term users, which is based on the time of using and distance of one time use. The results of this work will act as the basis for studying target users and changes in travel behavior, and thus, have a profound implication on the development and implementation of car sharing in the future.

2.Data source

In July 2013, a car-sharing system started operating in Hangzhou, which was the first massive pilot city for the project in China. The system was operated by Chelizi Intelligent Technology Company, which had been established in 2010. Unlike the traditional car rental companies, the node of a car-sharing network is not a store with many workers but several parking spaces; users can take a car from these spaces and park the car there all by themselves without any staff supervision. Up to September 2014, 73 nodes of the car-sharing network were in operation. The number of nodes has continued to increase. At the end of August 2015, the network had 79 nodes and more than 2000s members.

Based on the no-personal privacy information car rental data of the car-sharing operation system, from September 2013 to September 2014, the detailed behavior patterns of long-term users who had registered through the car-sharing system more than three month ago and had used the system more than once each month were analyzed. According to the frequency of usage, these uses were classified into several groups. Meanwhile, the typical usage patterns of behavior in each group were identified, summarized, and compared with those of the all users group. The total number of orders was 19120. Invalid orders such as revoked orders, orders with unreasonable time points between taking-out and placing-in the car, and orders with wrong telephone number were eliminated. The number of orders after eliminating the invalid ones was 14772.

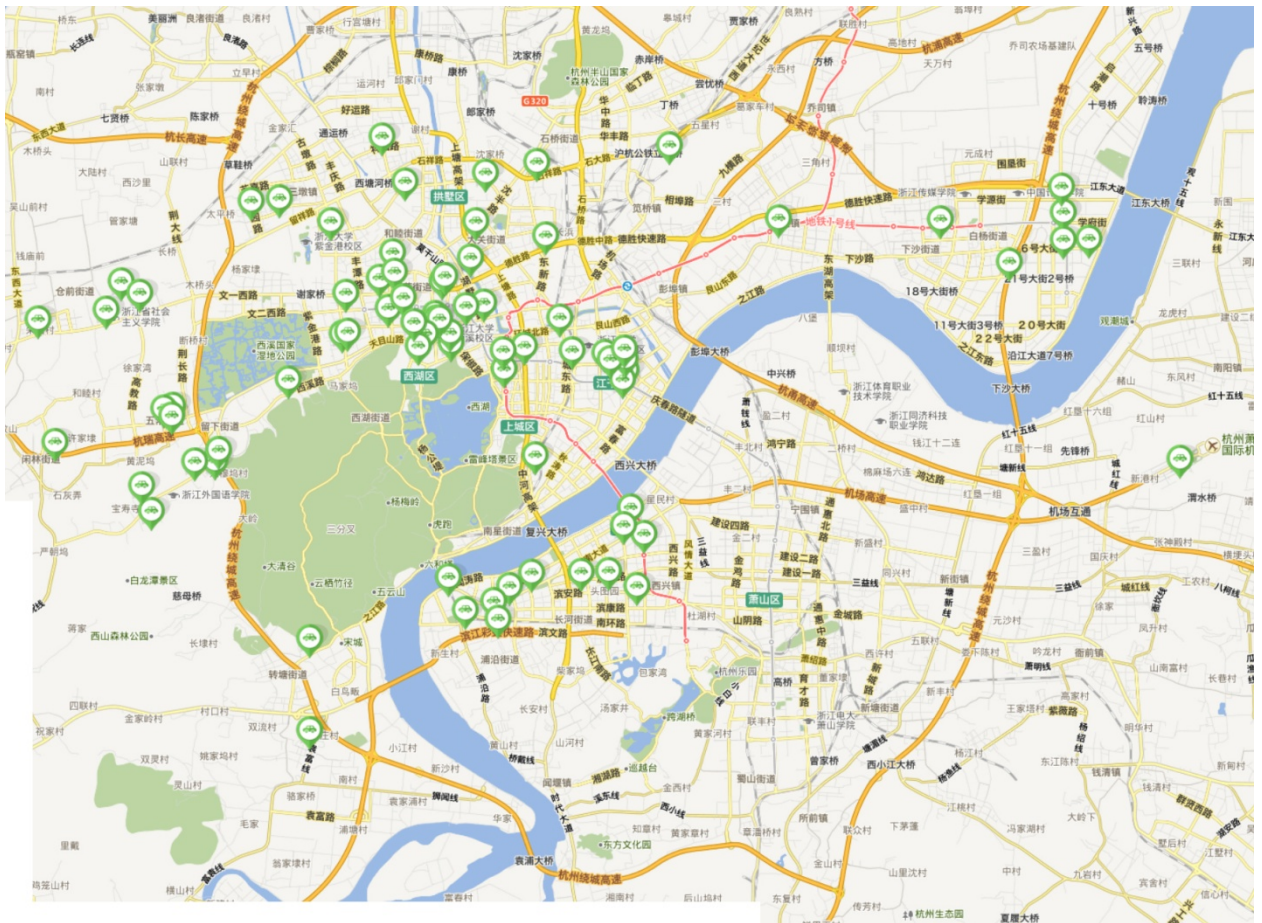


Fig. 1. car-sharing network nodes in Hangzhou, China

3. Grouping of users

3.1. Target users determinations

This study analyzed only the effective duration of the members. For example, if the first order of a member was placed in October 2013 and the last order in January 2014, this member's effective duration was four months.

The total number of users was 1938, and this included two types of users—the long-term users and occasional users. The usage period and frequency of usage of occasional users were relatively random. Some of them used the system for only one or two months. Hence, it was difficult to sum up their regularity. Meanwhile, long-term users had more stable characteristics of behavior patterns. This group of users contributed just 21% of the total members, but placed 66% of all valid orders. Therefore, long-term users who had used the system for more than three months and whose frequency of usage was more than once a month (406 members) were the target of this study.

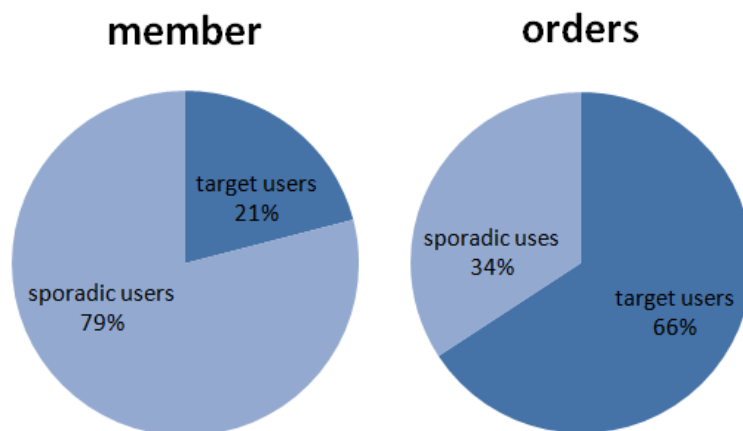


Fig. 2. (a) proportion of target users; (b) proportion of target users' orders

3.2 Classifying target users

Since the frequency of usage varied greatly even among the long-term users, in order to describe the behavior patterns of different users' precisely, they were classified depending on the interval time between orders, which is the best index of the frequency of usage. Meanwhile, the number of long-term users fluctuated greatly in terms of monthly orders and the rapid increase in orders in a peak month would have an adverse impact on the description of the frequency of usage.

First, the coefficient of fluctuation in peak month orders (the ratio of number of peak month orders to that of off-peak month) for 406 long-term users was calculated and a scatter diagram, as shown in Fig 3, was plotted. The coefficient of 2.5 was found to be the boundary in the diagram. The area with coefficient < 2.5 was denser, while that with coefficient > 2.5 was sparser. Hence, in study, the users whose fluctuant coefficient was more than 2.5 were considered as the fluctuant users group; the fluctuant coefficient of this group and of stable users group are as listed in Table 1.

Table 1. Fluctuant coefficients of the peak month

	stable users group	fluctuant users group
amplitude	1.92	3.17

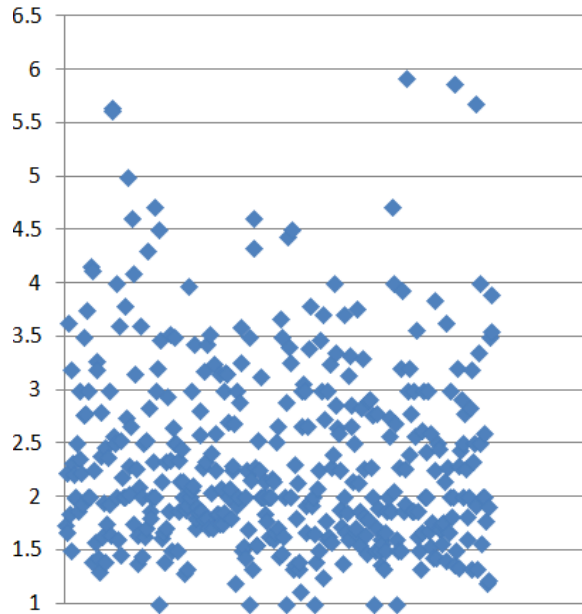


Fig. 3. scatter diagram of the coefficient of fluctuation of peak month orders

Then, the rest of the long-term users were classified according to the frequencies of use. The upper quartile, median, and lower quartile of order interval time were calculated (Fig 4). In Fig 4, the ordinate is the order interval days. The green dot and the starting and end points of the vertical lines indicate the median, upper quartile, and lower quartile, respectively. The lines corresponding to intervals of 2 days and 16 days form the boundaries. In the graph, the region corresponding to intervals of less than 2 days and more than 16 days are sparse, while the region between intervals of 2 days and 16 days is dense. This region can be further divided at the interval of 8 days. Thus, the stable users were classified into four groups: the highest frequency users (order intervals mostly within 2 days), higher frequency users (order interval mostly between 2 days and a week), lower frequency users (order interval mostly between a week and 2 weeks), and lowest frequency users (order interval mostly more than 2 weeks).

The grouping of stable users is described in Table 2. The fluctuant users group and lower frequency users group had more members, accounting for 37% and 30% of the total members. In the next place, were the members of higher frequency users group, accounting for 16%, while the numbers of members of the highest frequency users group and the lowest frequency users group were less.

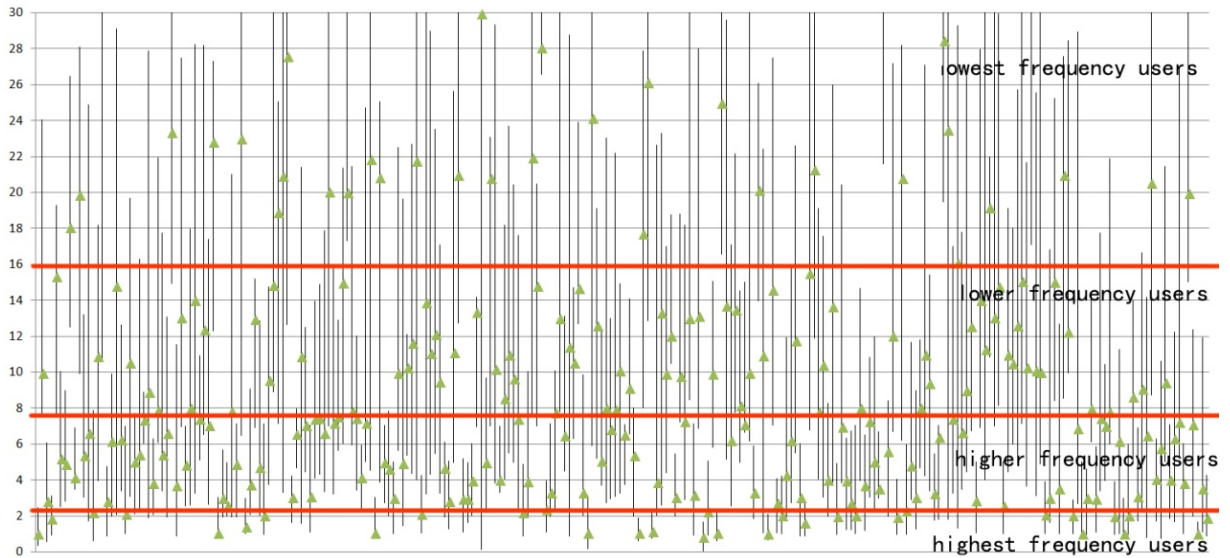


Fig. 4. scatter diagram of order interval

Table 2. Grouping of users

Users Group		Characteristic of each group	members	orders	
all users		includes all users	1938	14772	
long-term users		users who had the used car-sharing system for more than three months and whose frequency of usage was more than once per month	406 (account for 21% in all users group)	9722 (account for 66% in all orders)	
long-term users group	fluctuant users group	users whose fluctuant coefficient was more than 2.5	152/37%	3283/33.8%	
	highest frequency users group	the order interval mostly within 2 days	34/8%	2707/27.8%	
	stable users group	higher frequency users group	the order interval mostly between 2 days and a week	63/16%	1814/18.7%
	higher frequency users group	the order interval mostly between 1 week and 2 weeks	120/30%	1646/16.9%	
	lower frequency users group	lowest frequency users group	the order interval mostly more than 2 weeks	37/9%	271/2.8%

Label: In the fluctuant, highest frequency users, higher frequency of users, lower frequency users, and lowest frequency users groups, the ratio of members and orders are shown with respect to the long-term users group.

4 Analysis of the behavior patterns of target users

4.1 New members

Members of all users group maintained a relatively stable growth trend, despite a decrease in February 2014 and a rebound thereafter. The stable users had 35 new users; this number is less than the number of new users in the all users group (about 120 users per month). Since March 2014, the number of new members in the stable users group gradually diminished. Further analysis of the new members of this group showed that the highest frequency users and lowest frequency users groups both had less than 5 new users per month, while the lower frequency users and fluctuant users groups had much more new members each month; however, the trends of the five groups of stable users were basically the same.

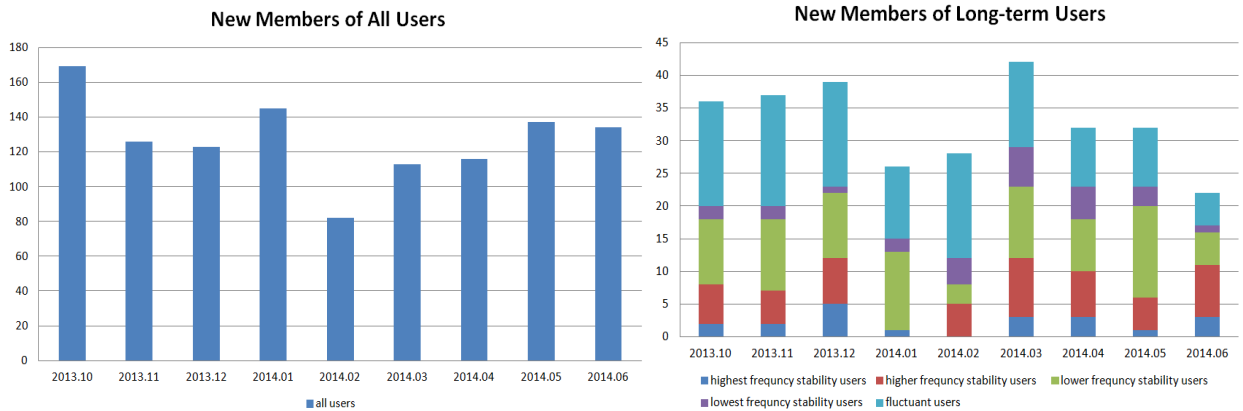


Fig. 5. (a) new members of all users group; (b) new members of long-term users group

Label: In this study, the month of users' first order is defined as the month of new member. Since the study only included data from September 2013 to September 2014, if a user's first order was before September 2013, this paper still considered month of the user becoming a new member as September 2013. Because of the method of analysis, the data for September 2013 yielded a cumulative result in the early months, and after July 2014, there were no new members in the stable users group. Hence, this figure only includes the new member data from October 2013 to June 2014.

4.2 Monthly orders

Monthly orders of all users group maintained a growth ratio of 4.5%, despite of a decrease in growth in October 2013 and February 2014. The increase in orders of the long-term users group was slower than that of the all users group. Before July 2014, the trend of the number of orders of the long-term users was the same as that of the all users group. However, after July 2014, the number of orders of the long-term users declined. This transformation may be related to the change in the number of new members.

The stability of the monthly orders of long-term users was in sharp contrast with the fluctuations of the monthly orders of all users. The obvious decline of the all users group in October 2013 and February 2014 was much sharper than that of the long-term users group. Meanwhile, in the target year of study, there were two long legal holidays, namely, the National Day in October 2013 and the Spring Festival in February 2014. This sharp contrast may be a result of the different sensitivities attributed to the holiday. The members of the all users group were more sensitive to the long-term holiday than were the long-term users, for the former group included some occasional users.

The monthly orders of five stable users group maintained a stable slow growth despite the changes in February and March 2014. There was a little decline, which may be attributed to the decrease in the number of new members in February 2014. Although that month coincided with the Spring Festival, it is considered that this little decline was not caused by the legal holiday because the National Day did not affect the orders in October 2013.

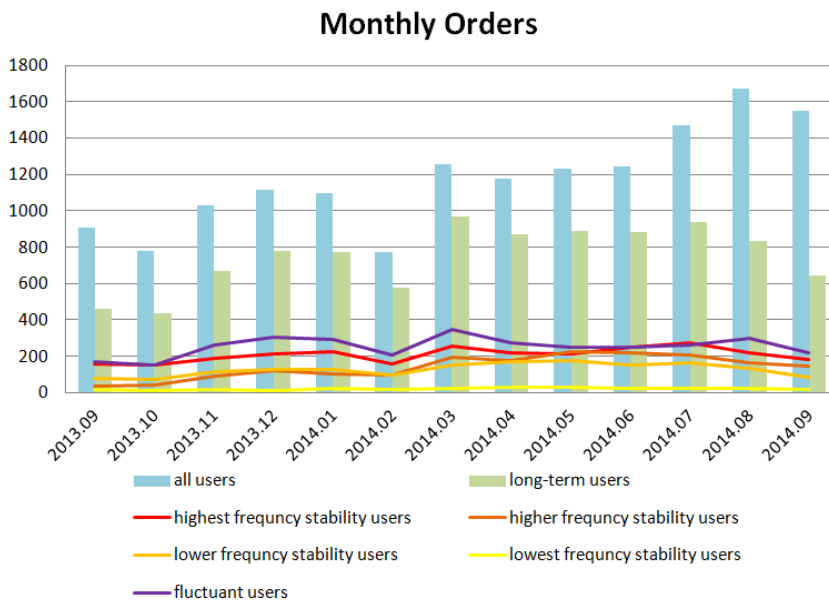


Fig. 6. monthly orders of each group

4.3 Weekdays and weekends

The orders were classified according to weekdays and weekends. It was clear that the data of the all users, long-term users, and fluctuant users groups showed little difference, and the daily ratio for each group was close to the average of four stable groups for that day.

The times of usage of these four stable users group were different. The lower frequency of the users group was more likely to use car-sharing over the weekend, and the ratio members of using car-sharing on Saturday was much more than that for Sunday. Meanwhile, the higher frequency of the users group preferred to use car sharing on weekdays. Orders on weekdays were analyzed in detail, and the variance of each group was calculated. Among the four stable users group, the higher the frequency of users, the smaller was the variance of the group. That is, the higher the frequency of users, the more likely it was the number of daily orders during weekdays was the same. Thus, it was found that there was a small trend of traffic commuting in the highest frequency users group.

Table 3. Variance of the ratio of orders in weekdays

Group	Highest frequency stability users	Higher frequency stability users	Lower frequency stability users	Lowest frequency stability users	Fluctuant users	All users	Long-term users
Variance	0.000144	0.000341	0.00062	0.001053	0.000282	0.000153	0.000228

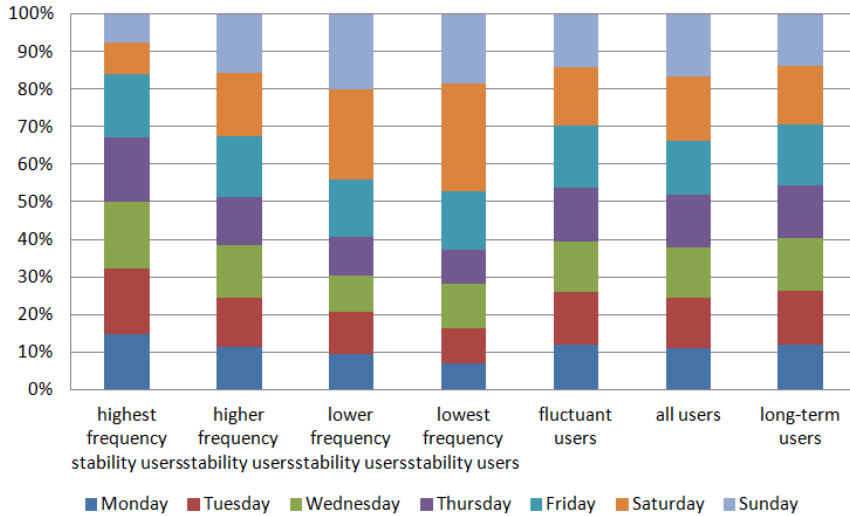


Fig. 7. daily ratios of each group

4.4 Single-use time

The relative graph between the single-use time and ratio of orders was plotted as shown in Fig 8, considering units of day and hour. The curves of all groups almost coincide. More than 90% of the users used car-sharing within one day, and the single-use time of only a few (less than 2%) users was more than 3 days.

The orders for which single-use time was within 1 day was analyzed on an hourly basis. Even in this case, the curves for all the groups were found to coincide. The ratio of single-use time peaked at 1–3 hours, and peak lasted for 0–6 hours. Meanwhile, the ratio of single-use time reached a secondary peak, which was approximately a quarter of the main peak, at 15–16 hours, and its peak lasted for 12–18 hours. The only difference between these four stable users group was in terms of the height of the main peak. The higher the frequency of the users, the higher was the main peak. The height of the main peak of the highest frequency users group was 21.6%, while that of the lowest frequency users group was 13.94%.

Car-sharing thus forms complements the taxi and traditional car rental services, and 95% of all taxi orders have a single-use time of ≤ 30 min. Meanwhile, for the traditional car rental service, a day is considered as a unit. These diverse services enrich the overall traffic modes of the transportation system.

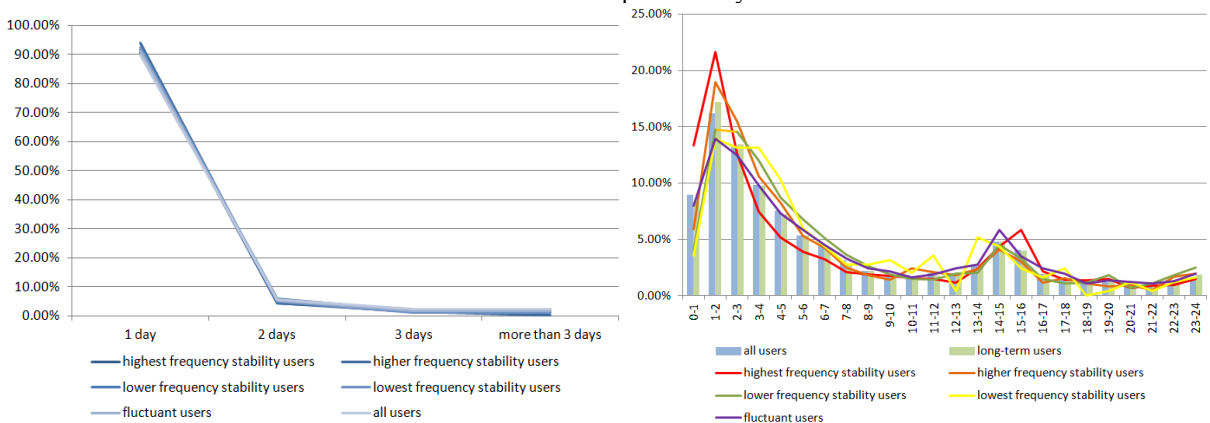


Fig. 8. (a) single-use time of each group with unit of day; (b) single-use time of each group with unit of hour

4.5 Taking-out and placing-in of cars

The taking-out time of the all users group and long-term users group were basically the same; similarly, the placing-in time for both groups were same too. The taking-out time reached a peak at 7:00 hours and began to decline 19:00 hours. Meanwhile, the placing-in time had two peaks—6:00 hours and the 16:00 hours.

The taking-out time and placing-in time for the four stable users groups all started at 6:00 hours, but their ending times were different. The taking-out and placing-in times of the highest frequency users group had best concentricity and was more in line with the time of commuting traffic (7:00 hours to 20:00 hours). Meanwhile, the lowest frequency users group had better dispersity. In addition to the time before shut down (1:00 to 5:00 hours), the ratio of taking out a car and placing in a car was high. The higher frequency users and lower frequency users groups had taking-out and placing-times intermediate those of the highest frequency users group and lowest frequency users group. The characteristic of the fluctuant users group was similar to that of the lower frequency users group.

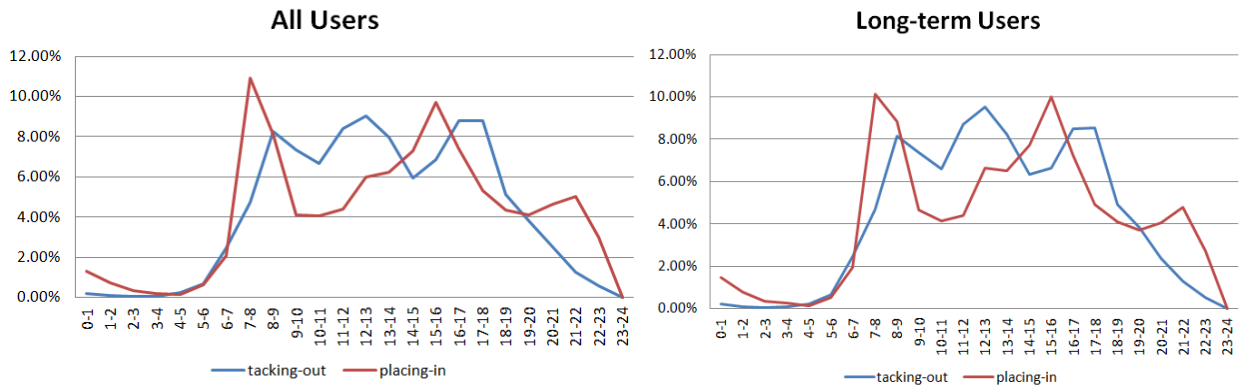


Fig. 9. (a) taking-out and placing-in time of all users; (b) taking-out and placing-in time of long-term users

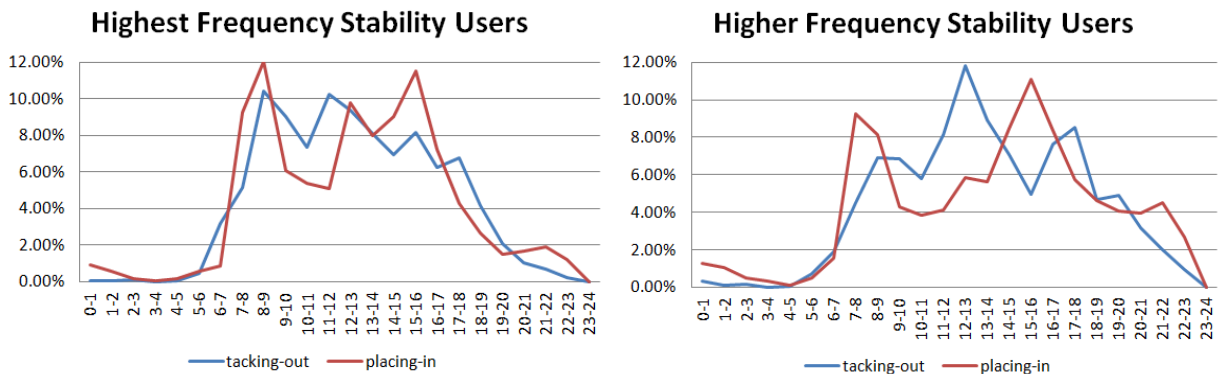


Fig. 9. (c) taking-out and placing-in time of highest frequency users; (b) taking-out and placing-in time of higher frequency users

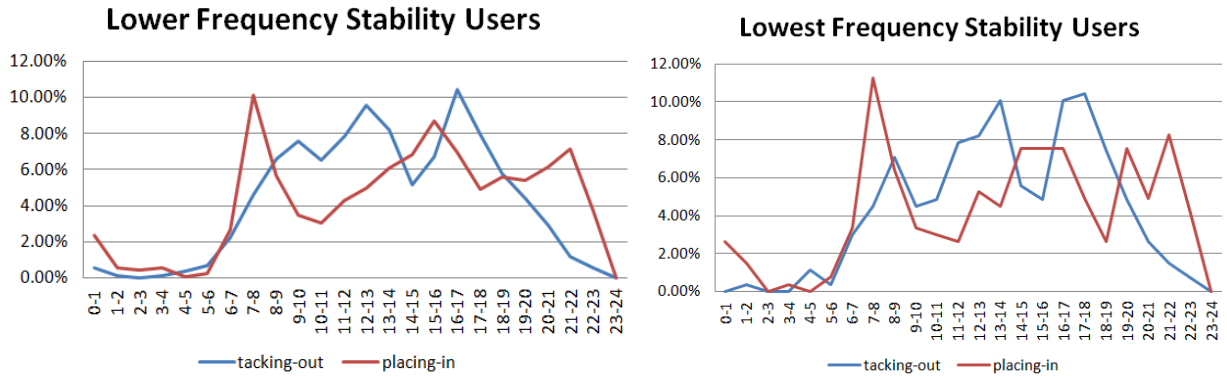


Fig. 9. (e) taking-out and placing-in time of lower frequency users; (f) taking-out and placing-in time of lowest frequency users

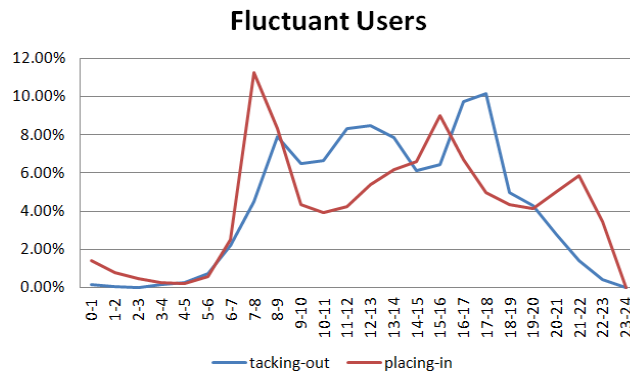


Fig. 9. (g) taking-out and placing-in time of fluctuant users

4.6 Single-use distance

The scale graphs of single-use distance and orders' proportion of all groups also essentially coincided. Peaks of the graphs were between 20 and 30 km, and its fastigium was located in the range 1–70 km, which contained more than 80% orders. The only difference was the obvious increase in the ratio of the highest frequency users group for the short distance (1–20 km).

In order to describe the characteristics of the highest frequency users better, the cost of taxi was compared with that of car-sharing for short distance travel (Fig 10) by considering 8 km for the price equilibrium point. In another words, within 8 km, selecting a taxi was cheaper than car sharing. Under this condition, the members of the highest frequency users group were still willing to choose car sharing. Thus, combined with their single-use time, it is obvious that the members of the highest frequency users group had the trend of short time and short distance travel, which was quite similar to commuting travel, and this trend may develop into a habit that cannot be changed easily in the future.

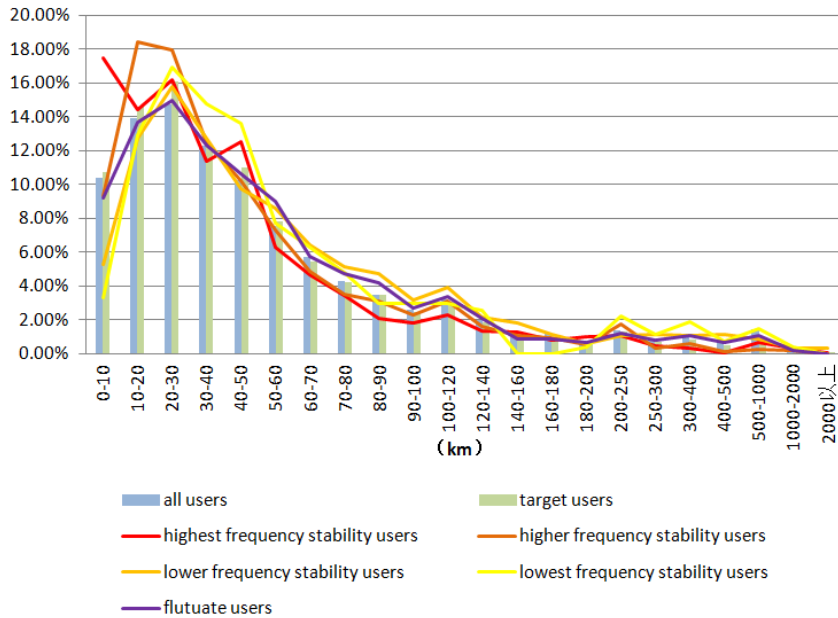


Fig. 10. single-use distance of each group

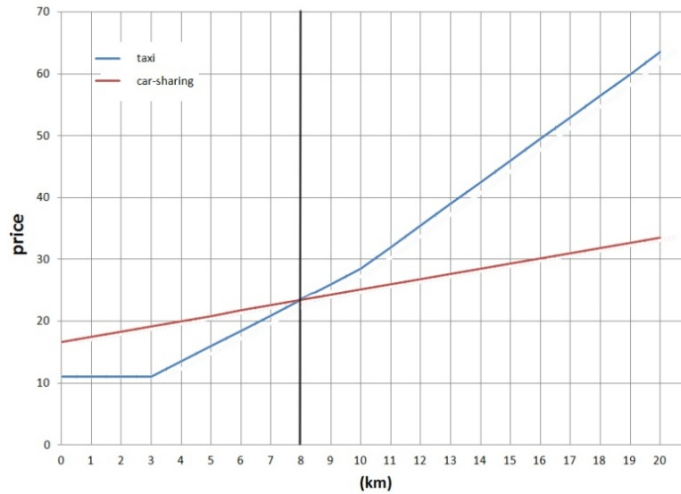


Fig. 11. price of taxi and car-sharing for short distance travel

Label: 1. The price of taxi referred was obtained by referring to taxi operators’ unified pricing in Hangzhou.

2. The price of car-sharing was obtained by referring to the official website and chosen vehicle type (Buick), which was chosen more than 60% of the members.

4.7 Fluctuant Users

Fluctuant users were studied intensively based on the curve of monthly orders. It was found that only peak month existed, and there was no low ebb month. The orders’ indexes in the peak month and off-peak month were compared

among the four stable users group (Table 3) in terms of monthly orders, frequency of usage, orders' ratio for weekdays and weekends, single-use time, and the time of taking-out and placing-in the car.

Table 4. Characteristics of peak month orders and off-peak month orders

	Peak month orders	Off-peak month orders
Frequency of Usage	7.53 (similar to higher frequency users group)	2.02 (similar to lower frequency users group)
Orders' ratio of weekdays and weekends	the daily ratio was same within each group, but differed among the four stable users group	similar to higher frequency users group
Single-use time	similar to lower frequency users group	similar to lower frequency users group
Time of taking-out and placing-in the car	similar to higher frequency users group	similar to lower frequency users group

Members of the fluctuant users group had frequency of usage similar to that of lower frequency users, but with higher fluctuation. However, this study did not consider behaviors such as the factor of this fluctuation, whether this fluctuation can be influenced, and whether this fluctuation will become stable or fluctuate forever in the future; these matters need to be discussed in the future.

4.8 Summary

The characteristics of all users, long-term users, fluctuant users, and four stable users groups were analyzed mainly in terms of new members, monthly orders, orders' ratio of weekdays and weekend, sing-use time, time of taking-out and placing-in car, and single-use distance. Through comparisons, it was found that the members of all users group maintained a growing trend, which was faster than that of the long-term users group. The numbers of orders of the all users group was more sensitive than that of the long-term users group.

Members of the four stable users group were analyzed in detail. The difference among them was obvious. The higher the frequency of usage, the more likely the group was to use car sharing during weekdays. In contrast, the users with lower frequency of usage preferred to use car-sharing services over the weekend. With regard the time of taking-out and placing-in the car, the higher the frequency of usage, the better was the centrality of single-use time. The times for lower frequency users were more discrete. Meanwhile, the curves of single-use time and single-use distance were basically the same. The only difference was that the higher the frequency of the users, the higher was the proportion of the orders of short time travel (1 to 3 h). In addition, the ratio of short distance travel for the highest frequency users group was obviously larger than that for the other three groups. The different characteristics of the four stable users group were plotted in a radar graph (Fig 12), and the numbers 1 to 4 were used to represent the significance level from weak to strong. The typical users' behavior patterns were summarized as follows:

Highest Frequency Users Group: Members' monthly orders were maintained at a high but stable level, and the interval time of great majority of orders was within 2 days. From the viewpoint of single-use period, compared with members of the other three stable groups, there was a higher proportion of using car-sharing services on weekdays, and the ratio of daily orders was almost the same from Monday to Friday. Their single-use time was concentrated from 7:00 to 20:00 hours, and the proportion of orders at other times was very low. Meanwhile, the short time and short distance travel was more likely unlike in the case of the other three stable groups. Overall, the travel behavior of the members of this group was closely related to commuting traffic.

Lowest Frequency Users Group: Members' monthly orders were maintained at a low but stable level, and the interval time for a great majority of the orders was between 2 weeks and a month. With regard single-use period, compared with the members of other three stable groups, there was a higher proportion of using car-sharing services over the weekend, and the ratio of orders on Saturday was larger than that on Sunday. Their single-use time was disperse. In addition to the time from 1:00 to 17:00 hours, the proportion of orders at other times were maintained at a higher level, and there was no obvious fluctuation. Meanwhile, the orders for short time and short distance travel were the least among the four stable groups. Overall, the travel behavior of these users was closely related to living trips, and they showed little tendency of commuting traffic.

The characteristics of the higher frequency users and lower frequency users groups were intermediate those of the highest frequency users and lowest frequency users groups. The behavior of the higher frequency users group was more similar to the highest frequency users group, while that of the lower frequency users group was more similar to that of the lowest frequency users group.

Members of the fluctuant users group showed frequent usage in off-peak months at rates of twice per month, and this is similar to the behavior of lower frequency users, but with a large fluctuation in the peak month. Their characteristics were somewhat similar to those of the members of the higher frequency users group and lower frequency users group, though the similarity was not very obvious.

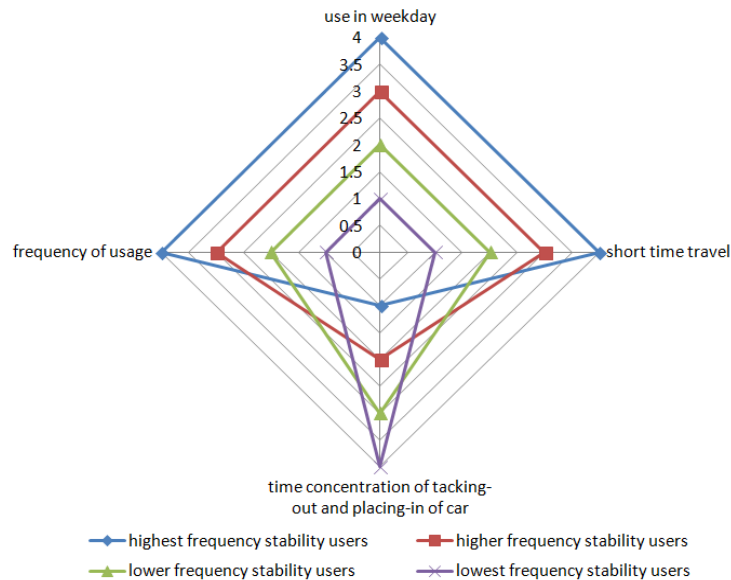


Fig. 12. different characteristics of the four stable users groups

5 conclusions

Car sharing, which is an innovative transportation method, is in its initial stage in China. The studies on car sharing until date were mostly made at a theoretical level and did not consider the characteristics of user behavior patterns. After a detailed analysis of one-year data of car-sharing (the data was a kind of car rental data without personal privacy information) in Hangzhou, it was found that orders of the long-term users group were more stable and less sensitive to legal holidays than those of the other groups. Meanwhile, the number of long-term users tended to be stable, while the number of new members of the all users group still maintained an increasing ratio of 4.5%. Other characteristics, such as single-use time and single-use distance showed, were slightly different among the all users and long-term users groups.

Long-term users were studied intensively based on the difference of user behavior pattern in terms of four stable users group. The behavior patterns of the highest frequency users group (for example: order interval was almost within 2 days; a higher proportion of using car-sharing on weekdays; single-use time was concentrated from 7:00 to 20:00 hours; the short time and short distance travel was more likely) were similar to the characteristics of commuting travel. To a great extent, these members considered car-sharing only as a substitute for private car or public transportation, and maybe they use car-sharing only as a transition phase before buying their own car. Abroad, car-sharing was established when families had more than one private car, and members always used car-sharing to go shopping or for entertainment in their leisure time. Owing to the different conditions between China and other countries, few users abroad use car sharing in a manner similar to the members of the highest frequency users in China. Thus, considering the need of families to purchase private cars, several issues still need to be studied intensively. For example: Whether this members lead to an increase in the usage of cars and cause an increase in the burden on the transportation system; and whether car sharing promotes potential users to buy their private car. Meanwhile, from the viewpoint of a typical transportation system, further study on whether such users needed to be given some positive policies to maintain their car-sharing habit is also necessary.

On a separate note, the lowest frequency users (characteristics, for example: interval time of a great majority of orders was between 2 weeks and a month; a higher proportion of using car-sharing over the weekend; and single-use time was disperse) enjoyed the mobility of car-sharing resources and thus decreased private car ownership effectively. Because of the dispersity of the single-use time, these users do not increase the burden on the transportation system. In fact, these members are more similar to the car-sharing users abroad. However, there are some differences between China and abroad in that whether such users are the major users of car-sharing system and whether positive policies should be in place for them; these matters should be studied in the future.

Meanwhile, members of the fluctuant users group are a type of special users. Their frequency of usage in the off-peak month was low, about three times less than that in the peak month. The single-use time of these users was disperse, and the possibility of being influenced was not clear now. Hence, how to lead the behavior patterns of these users through policy, and how to balance the mobility of travel and reduce the burden on the transportation system still need to be analyzed through questionnaire surveys.

This work analyzed the behavior patterns of long-term users of car sharing. The study will be a foundation of questionnaire surveys and political analysis. Car sharing, which is an innovative transportation method, has been attempted in China. Whether car sharing will reduce the rate of purchase of private cars by families and will change the users' travel behavior patterns still need to be investigated in detail. Meanwhile, with the development of the car-sharing system, balancing enterprise efficiency and the profits of citizen transportation system also need to be considered in the long term.

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