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Research Paper

Behavior Modes and Attitudes of Hangzhou's Bike-sharing Systems — Expected Utilities, Real Benefits and Perspective

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ABSTRACT

In the background of the bike-sharing program booming, this research carried an empirical investigation in Hangzhou, China to explore the usage pattern and attitude of different user groups. The actual benefits of this system were evaluated in the light of the expected utilities set up in the beginning and also data from other cities' practices. By a methodological improvement on questionnaire sampling, it is found that besides the frequent user group, there are substantial amount of people who are occasional users or non-users. The latter two groups would be the target groups in the aim of enhancing the effectiveness of the system. By diagnosing the characteristics of the two target groups from the frequent user group in a statistic manner, the paper shed light on the efficient intervention arrangements what the governments should pay attention to. Also, by a comprehensive comparison of international cases, it is believed that although Hangzhou is already a leading city for bike-sharing program in China, there is substantial potential to improve it in terms of three indicators: average daily usage frequency, proportion of trips combined with public transportations, and proportion of trips converted from cars.

1. Introduction

Bike-sharing programs have attracted widespread attention in a variety of cities around the world under the concept of sustainability, because of their high efficiency, low-carbon nature and being a healthy commuting means. At present, 61 cities in China have developed the bike-sharing system. The numbers of bikes in Hangzhou, Wuhan, Minhang district of Shanghai, and Zhuzhou have already exceeded 20,000(Wang 2013). There are over 300 bike-sharing systems all over the world with a total of 400,000 bikes, as indicated by the statistical data in the first half of 2012 (Fishman et al. 2013).

With the rapid increase of bike-sharing programs, there have been a drastically increasing number of studies in this field. In China, existing relevant studies mainly focus on three perspectives: learning from the practices and experiences of the western countries, exploration of system construction methods and technology, empirical research on the real operating situation of the systems. Generally speaking, studies on the last topic are relatively inadequate (ZHU et al. 2012).

Nevertheless, there are quite a few empirical studies on Hangzhou's bike-sharing system (Qian et al. 2010; Huang 2010; Wang et al. 2010; Wu 2013; Gu 2010). Starting from the pilot operation in 2008, the number of bikes in Hangzhou's bike-sharing system reached 69,750 by the end of 2012 and increased to 78,000 in March 2014 (Bao 2013), which is among one of the top ranked cities in the world. In terms of use efficiency, its average daily

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rental frequency was 6 times/bicycle in May 2010 (Shi et al. 2011). When compared with worldwide bike-sharing system usage data from 6 cities in 2011, it is only less than the top ranked city – Barcelona with 6.6 times/bicycle, and much higher than other lower ranked cities, such as Washington, Miami and Melbourne (with 4-0.2 times/bicycle) (Fishman et al. 2013). Therefore, as a successful case for bike-sharing system, Hangzhou has attracted great attention.

From literature review, it is argued that although the current empirical studies have shown the current usage and satisfaction level in Hangzhou, evaluating the operation performance and providing improvement suggestions, there are still limitations in three aspects.

First, the sampling methods used in these studies are not free from suspicious. Some studies did not specify their sampling method, or even the size of the sample (Wu 2013; Gu 2010). In addition, two studies used haphazard sampling (nonrandom) on public bicycle service sites (Qian et al. 2010; Huang 2010; Wang et al. 2010), which would increase the portion of frequent users and result to a biased sampling. Moreover, most of the studies overlooked the relationship between the time of use and the type of users, which has been emphasized in the literature as it reflects a characteristic that user populations on workdays and non-workdays are significantly different (Fishman et al. 2013). Because the ratio of workday vs. non-workday during the survey was not appropriately controlled, the reliability of the conclusions regarding commuting motivation and usage frequency was questionable.

The second deficiency of current researches is, most of the studies did not collect the data of commuting distance, commuting time and replacement transportation methods for the users[3]. Consequently, these studies could not directly address the questions that have been controversial worldwide, such as how much bike-sharing system can transfer private car mode of trip into low-carbon transport; whether the bike-sharing system will gradually replace the use of private bikes in the future (Fishman et al. 2013).

Last and most importantly, when collecting data from users, these studies have not classified the users with different frequencies of usage, they always neglect the survey on non-users' attitude towards the bike-sharing system[4]. Therefore, these studies lacked the data of major target group (potential users) for the discussion concerning the improvement of system utilization.

Considering these limitations, this study made improvements in the survey method. By double random (both location and time) sampling, we collected the data about commuting behavior, recognition and willingness from three groups of subjects: frequent users, occasional users, and non-users. These data will be analyzed for two purposes. The first one was to verify the realization of expected utility which set up in the beginning of the system, also provide new evidence for the clarification of controversial opinions, such as - the goal of low-carbon transport and congestion alleviation, resolution for a commuting problem regarding the "last kilometer of public transit", and replacement of private bikes (Yao and ZHOU 2009). Second, it is aiming at to classify and compare the three user groups, in particular the differences among frequent user group, occasional user, and non-users. The findings would be important evidence to government, who are initiating new regulations on bike-sharing system aiming at enlarging its benefit group.

2. Data collection and Preliminary Analysis

General data from bike-sharing system management platform can be used to address the questions regarding usage frequency and time-location characteristics. However, it is necessary to collect data through on-site survey for information such as identification, motivation and willingness, or replacement transportation. Therefore, in this study, the major tool for data collection is questionnaire; a behavioral observation method is used as a secondary tool[5].

2.1 Questionnaire

To ensure the representativeness of the respondents, we improved the previous data collection method and distributed the questionnaires in two types of locations, including eight locations in lively public space and 16 locations at bike-sharing system service sites. The sampling locations were evenly distributed among the five main districts of Hangzhou, and were intentionally balanced among office areas, residential areas and scenic spots, and between new city sections and older city sections. The samples were collected half from the workdays and half from weekends, and covered different daytime periods (morning, noon and afternoon) and conducted in a face-face interview method. To control the interviewer's bias in terms of respondent's selection, in each time period and sampling location, a quota sampling

[3] J. Qian (2010) collected the data of replacement traffic mode of bicycle users in his research, finding 60% from bus, and followed by walking. But he didn't give the specific proportion in car replacement in his study.

[4] W. Zhu's research (2012) in Shanghai Minhang District focused on the survey of the non-users. But he didn't separate the occasional users from frequent users.

[5] The data collecting period is the mid of 2013.

Table 1. Questionnaire type and sample characteristics

	Type	Frequent users	Occasional users	Non-users	Total(person)
Public areas	a	0	0	75 （39.3%）	75
	b	47（24.6%）	69（36.1%）	0	116
Service point	c	60（62.5%）	36（37.5%）	0	96
Total (person)		107	105	75	287

method was applied to ensure a balanced distribution of gender and age among respondents, in order to cover more diverse user type.

Three types of questionnaires were designed for different locations and usage frequencies. In public locations, the first oral question to the user was “have you ever used the bike-sharing system”. Non-users were asked to complete Questionnaire A, and users were asked to complete Questionnaire B. At the bike-sharing system service sites, Questionnaire C was used for the exact users.

The content of the questionnaire covered three aspects: actual usage behavior, recognition and willingness, and personal information. Questionnaire A was used for the group who had never used the bike-sharing system before, with the expectation to understand their commuting means, the reason for not using the system and the circumstances which they may use the bike-sharing system. Both Questionnaire B and C were designed for the system users, and share similar questions. The only difference between them is that, Questionnaire C also asked the respondent to report their purpose to this particular trip and the replacement transportation means if there was no bike-sharing system. Such a “real-time, on-site” information collection method can increase the reliability of the data.

Each questionnaire took 3-5 minutes to complete. A total of 350 questionnaires were distributed and 287 valid responses were received, with a valid response rate of 82% [6] . Among them, 191 were distributed at public locations (75 Questionnaire A and 116 Questionnaire B), and 96 questionnaires were distributed at service sites (Questionnaire C) **(Table 1)**.

This sampling method can alleviate the bias of the previous empirical studies, which neglect the existence of occasional users group. Subsequently, we found the usage frequency distribution result of this study contradicted with two other Hangzhou studies carried by Qian et al. (2010) and Huang (2010). Data from Huang’s study showed that 55.5% of the users used the system 5 times or more each week, data from Qian’s study showed that 49.5% of the users used the system 7 times or more each week. While, our study found that, less than a quarter of respondents reported that they used the system 7 times or more each week (22.4% for the respondents in the public locations, 28.1% for the respondents at the service sites).

It’s unreasonable that the use frequency have such a big decrease after four years, consideration the improvement of bike-sharing System in recent years. The general data from the bike-sharing system company show that, the number of bikes in the system was 17,000 in 2009, with maximum 100,000 daily uses(Yao and ZHOU 2009), and was 69,000 at the end of 2012, with maximum 380,000 daily uses (Bao 2013).

A possible explanation for this logical contradiction is the sampling bias. By using the haphazard sampling method at the service sites, respondents who were willing to be interviewed were more likely the frequent users of the bike-sharing system. As a result, the sampling bias would lead to an overestimation of usage frequency. Date from such a biased sample pool is still valid for revealing existing problems and collect users’ suggestions to the bike-sharing system; however, it would cause serious errors when used to address the questions related with user motivation, commuting purpose, etc.

Therefore, by the improvement on sampling method, a simple analysis could lead to the first finding of this study: among the bike-sharing system users in Hangzhou, there is a large group of “occasional users”, besides the frequent users **(Figure 1)**. It is most probably that this group is reluctant to provide their opinion in any investigation regarding to bike-sharing system because they did not consider themselves as a relevant group. However, this group should be the main target group for a system which aiming at enhancing the effectiveness of the system, because the main barrier, ‘obtaining a membership card’ for using the system, has been overcome.

[6] There were two types of the responses were excluded from the sampling. First, some respondent have not complete the questionnaire. Second, the answers provided by some respondents have obvious logic error.

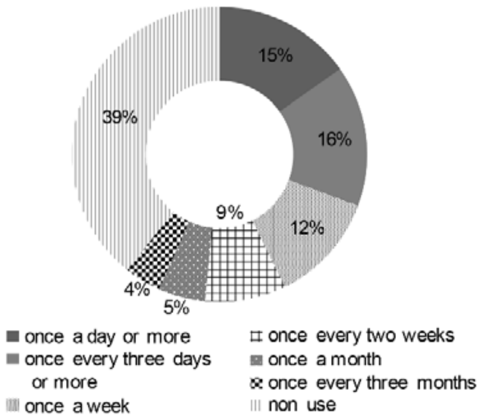

Fig. 1. Frequency of use distribution

This finding inspired the subsequent analyses. In Section 4, the respondents were divided into three categories: frequent users, occasional users and non-users. Frequent users were defined as the users who used the system at least once every three days. Occasional users were defined as ones who use the system once a week or less. The differences in age, commuting distance, and behavioral pattern and attitude among the three categories of users were analyzed to deepen our understanding of the reasons behind the use or non-use of the bike-sharing system.

2.2 Behavioral Observation

Behavioral observation served as a supplementary data source for the questionnaire. Because of its nature of recording actually behavior in specific location, it could help us to give new evidence for a controversial issue: is the bike-sharing system users have different distribution on gender and age other than the city population? Studies in Washington, London, and Montreal found that the average age of bike-sharing system users were significantly lower than the average age of the city population. Studies in London, North America, and Australia found that there were more males among the bike-sharing system users, while the study in Montreal stated that the proportions of male and female were similar (Fishman et al. 2013). Bin Huang's study in Hangzhou found that more males used the system than females (with a ratio of 1.4:1 for the citizens).

In questionnaire, a quota sampling method was used to balance the sample poor for gender and age. Therefore, to get the gender and age distributions information, behavioral observation data is used rather than the questionnaire data. The detailed methods were as follows: parallel with questionnaire survey, observation was carried at each service site repeatedly six periods during day time (10 minutes each). By observation, number of borrowers and returners, gender, and roughly estimated age information were collected. By this method, 520 users in total were observed.

By this sample, it is found that the male and female users' ratio is 1.04:1, which is consistent with the city population structure. A further analysis compared gender distribution by location. And no matter put residential areas verses scenic spots, older city sections verses new city sections, we found similar balance in terms of gender. The age distribution of the users has a distinct pattern. As by visual judgment, we can only collect a low accuracy data of age, which divided the users into three age groups: younger citizen urban 25, adults (from 18-55), and elderly (more than 55). It is found that adult is the core groups, accounting for 68.5%, elderly accounted for 31.3%, while only one teenager user (0.2%) was observed. The phenomenon that very few teenagers use bike-sharing system deserves further exploration. Possible reasons may include: (1) most teenagers have their own bike; (2) parents worry about their children's safety for riding a bike.

3. Comparison between Expected Utility and Actual Benefit

The bike-sharing system in Hangzhou chose a government dominant model for its provision (Pan et al. 2010). In the beginning, there is a clear statement of the expected utility of this system from the government as follows. Under the background of "sustainable development" and "sustainable mobility" (Banister 2008), the bike-sharing system would be used to effectively solve the "last kilometer" problem as a part of the city public transportation system. It would enable local residents and tourists to use "door to door, point to point" commuting through the public transportation system. It was expected to guide the public to form a new travel perspective and thus reduce the use of private cars. Consequently, difficulties in driving and parking could be alleviated and air pollution could be reduced (Deng 2008). Afterwards, the key words that frequently appeared in the news were "last kilometer of public transportation" and "low-carbon environmental protection". Interestingly, the goal of replacing private bikes with public bikes was rarely mentioned. But it is "hidden" in the specialized planning of Hangzhou Public Bike Transportation Development and served as the basis for calculating short-term and long-term overall scale of the bike-sharing system (Yao and ZHOU 2009).

In this study, we evaluated the actual benefit of Hangzhou's bike-sharing system using survey data after five years of the establishment of this system, with a special focus on the relationship between "expected utility" and “actual benefit”. In addition, this study will provide new evidence to address the controversial questions in academic field, such as: to what extent can public bike promote the transformation of private car commuting toward low-carbon transportation? Will bike-sharing system gradually replace the private bikes?

3.1 Overall performance evaluation

The data regarding the total number of public bikes and daily average rental frequency indicated that Hangzhou has developed a relatively mature bike-sharing system with stable user group and can be considered as the city taking the lead in China. Compared with cities in other countries, Hangzhou is also have a higher “daily average rental frequency”, which is six times per bike. However, compared with some European cities, there is still great room for improvement[7].

The survey data demonstrated that, almost all the respondents knew the existence of this system (only one respondent never heard about it), and 61% of the respondents have used the system. From the answers of the “non-users” sub-group, we also get to know that only 12% (nine respondents) of them were not willing to use the system in the future even with good improvement. Among them, three persons believed that car were more comfortable and the other six explained that their commuting distances were not suitable for cycling (too close or too far away). These detailed information shows that, the system is positively evaluated by most people.

3.2 “Last one kilometer” problem and its solution

The aim of solving the “last one kilometer problem” implies comprehensive utilities of bike-sharing system, which including saving both commuting time and cost, improving health by cycling exercise, and encouraging sustainable mobility etc. These benefits are well accepted by the public and therefore it is naturally that the bike-sharing system was elected as one of the “Ten Best Projects” of local government in 2009 and rated as No.1 (Bao 2013).

In this paper, we will focus on its narrow meaning. That is, if the use of bike-sharing system is divided into two types, single mode journey (only by public bike or combined with walking) and transition mode journey (combined use of public bike and other public transportations), what is the percentage of transition mode journey users?

According to the self-reported data, majority of the users (70%) used the system independently; only less than a quarter (23%) of the users combined it with other public transportation modes **(Figure 2)**. This rate is lower than that in Melbourne (50%), Beijing (58%), and Shanghai (55%) (Fishman et al. 2013). Therefore, the actual usage of the system did not reach the goal of the promoted “B+R” (Bicycle & Ride) mode, indicating that the “seamless connection” between the bike-sharing system and other public transportations in Hangzhou needs further improvement. A researcher from local transportation research centre explained that, although in the new constructed urban areas, the parking spaces of public bicycles are guaranteed, in the old urban quarters especially places near public bus stations, it is a serious problem (Liu 2013).

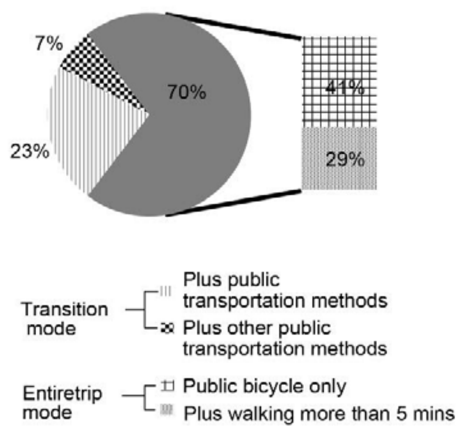

Fig. 2. Usage mode distribution of Hangzhou’s bike-sharing system

3.3 Realization of low-carbon transportation

As an international trend, low-carbon bike commuting has been promoted in many cities to ease the environmental problems brought by private vehicles (J.Pucher and Buehler 2012). As an alternative transport mode, what kind of trip mode has public bicycle replaced? This is a controversy topic many researchers pay special attention to. A United Nation report stated that, there is a possibility that existing studies might exaggerate the benefit of bike-sharing system because the majority of this kind of trips replaced other sustainable journey modes (Midgley 2011). A number of studies found that the switching rate from private cars to public bicycles was not satisfactory, which were approximately 7% in Washington,

[7]France Paris Velib system accounts for 10-15 times (data of 2009). Barcelona Bicing system accounts for 6-12 times (data of 2007). Quoted from Zhigao Wang etc,2009

Lyon, and Dublin, with the highest of 19.3% in Minnesota (Fishman et al. 2013). The result from this study is not optimistic, either. A large amount of users chose to use bike-sharing system to replace other sustainable transportation modes rather than private cars. The top four categories being replaced were public transportation (40%), electric-drive bicycles (15%), walking (15%) and private bike (15%) **(Figure 3)**. The rate of switching from private cars and taxi were both 6% respectively, similar to the levels in Western country cities.

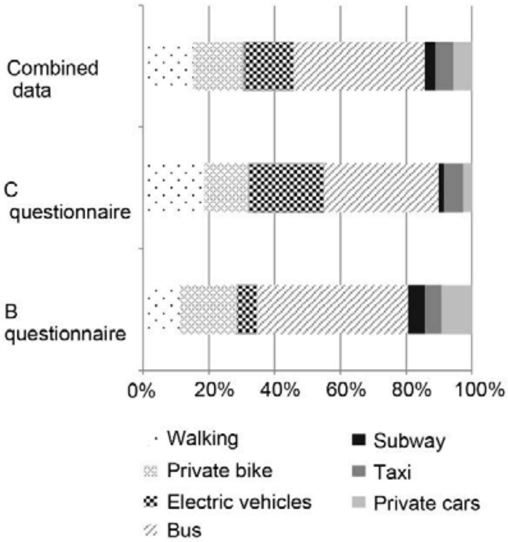

Fig. 3. Distribution of the transportation modes replaced by the bike-sharing system

However, data from the bike-sharing management company showed that, the potential of “public bike replace private car” phenomenon could be reinforced. In 2014, Hangzhou implemented the new “peak restriction” policy in 5th May. In the first three days of this policy, the daily rent number is 70,000 higher than the number collected in the same time period one year before. And the increasing users were mostly concentrated in morning and evening peak hours. On May 5th 2014, a peak of 2014 rental times occurred - reaching 411, 400 times a day (Wei 2014). These data replied that, due to the impact of earlier driving restriction time, the new users most likely switched to public bike from private car transport mode.

3.4 Replacement of private bike by public bike

This survey collected data of various commuting modes. Among the 287 respondents, 64 persons commute by bike, accounting for 22.3% of the total. And the actual number is 37 persons using public bikes and 27 using their own bikes. This finding is consistent with finding in Section 3.3 (15% of the public bike users were switched from private bike users). So, it is safe to make a judgment that the idea of replacing private bikes by public bikes is generally accepted by the citizens.

4. Comparative analysis of the three user groups

In this section, the collected data were classified into three groups by frequency of use the service. The characterization of these sub-groups will be studied in terms of their age, commuting trip distance, behavioral mode, and attitude to address the following questions: (1) are there any differences in the characteristics among the three groups? (2) What is the underlying reason for different usage frequencies?

4.1 Age Characteristics

The average age showed a gradually decreasing trend in an order of frequent users, occasional users, and non-users. Consider the standard deviations, the age distribution of users was more dispersed than that of non-users **(Table 2)**. This finding is contrast with the Canada city Montreal, which showed that this new program is more likely to attract younger (and more educated) people (Fuller 2011).

Table 2. Age distribution of three user groups

	sample size	Age average	Age standard deviation
Frequent users	107	39.9	10.7
Occasional users	105	36.1	10.5
Non-users	75	34.7	8.2

4.2 Commuting characteristics: trip distance and proportion of car users

Many studies on cycling indicated that journey distance might be the most important physical environmental factor that affects the decision on bike usage (Heinen et al. 2010). Large sampled studies in North America found that public bike users are generally live closer to their work place than other people (Shaheen et al. 2012). Does this pattern also apply to Hangzhou? To answer this question, we converted it into another statement “whether the three user groups have distinctive trip distance”.

As many respondents were not able to report their commuting distance accurately, we first collected the data of commuting time and commuting modes, then calculated the approximate commuting distance afterwards by the formula “commuting distant = time * speed”. After referring to relevant documents on actual speeds of different transportation tools in main districts of Hangzhou, the speeds of eight types of transportation tools were divided into four levels. The speed for pedestrian is 3.6km/h, private Bike / Public Bike / bus is unified to 12km/h, electric car is 18km/h, taxi / private car / subway is unified to 30 km/h.

Data showed that the trip distances had an increasing trend in an order of frequent users, occasional users and non-users **(Table 3)**. Chi-square test is then used to test the significance of trip distance differences. Six kilometers or less was defined as short distance and the rest were defined as long distance. The significance level among the three user groups derived from Chi-square tests was Sig (double sided) = 0.000, indicating a strong correlation between the usage frequency and trip distance. That is to say, whether people use public bike and the usage frequency are closely related with their commuting trip distance. People who live closer to their work or study place have a higher possibility to use the public bike.

Table 3. Commuting trip distance of three user groups

	sample size	Average trip distance	standard deviation
Frequent users	101	7.7	6.9
Occasional users	102	8.7	7.1
Non-users	74	11.8	8.7

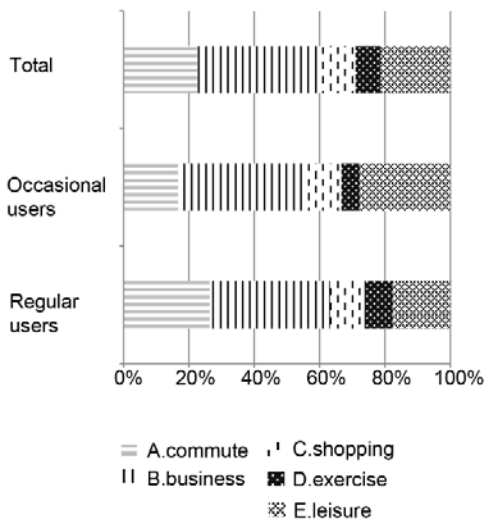

Fig. 4. Distribution of user commuting purposes

Considering the low-carbon mission, we would like to know how many private car users would use public bike in appropriate situations.

Although the proportion of private car commuters in the whole sample was small (14.3%), an obvious trend was observed by comparing the three user groups: the proportion of car users increased with the decrease of usage frequency of public bike **(Table 4).**

Table 4. Proportion of car commuters in three user groups

	Total amount (person)	Car commuter numbers	Car commuter ratio
Frequent users	107	9	8.4%
Occasional users	105	14	13.3%
Non-users	75	18	24.0%

4.3 Usage pattern: trip purpose

In order to increase reliability of the data, we only ask the users who were borrowing or returning the bike, what their trip purpose are. A total of 96 “real-time, on-site” trip purposes were collected. Overall speaking, about 30% were for physical exercise or leisure, and the rest of the trips have clear utilitarian purposes (Figure 4). There is little difference in terms of the trip purpose between occasional users and frequent users. The top three major purposes were doing business, leisure and commute. Compared with other cities in China, the proportion of “commute” is lower and the proportion of “leisure” is higher (Zhu et al. 2012) . Further studies are needed to clarify whether this difference is caused by the tourism city nature of Hangzhou or the survey methodology of this study which emphasizes the balance between workdays and weekends.

4.4 Usage pattern: single or transition mode

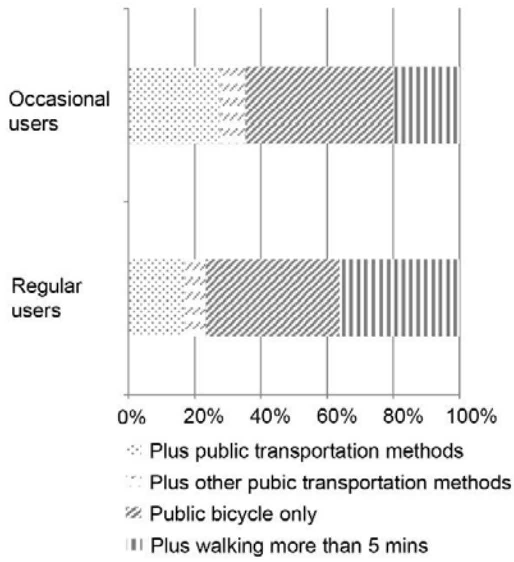

Fig.5. Comparison of Usage patterns between frequent users and occasional users

As discussed in section 3.2, the proportion of transition mode users was low. While, is there any difference in this aspect between occasional users and frequent users? Figure 5 shows that compared with frequent users, occasional users are more likely to combine public bike usage with other public transportation means. However, only a small portion of occasional users was willing to walk for more than 5 minutes to get the public bike **(Figure 5)**. This result implies that the occasional users are more sensitive to the distance between the service sites and their home or workplace.

4.5 Attitude: the advantages of bike-sharing system

Studies on cycling found that individuals in the same built environment and social economic environment might choose different travel mode due to different attitude. “Individual attitude” plays an important role in travel mode selection (Heinenet al. 2010). In this study, multiple-choice questions with five choices were designed in the questionnaire for the respondents to point out the advantages of bike-sharing system in their mind.

Chi-square tests showed that there was no significant difference in the understandings of bike-sharing system advantages, Sig (double sided) = 0.182 **(Table 5)**, among the three groups. However, a further analysis sorting the selections among different groups revealed a clear changing trend of the selection of Choices A, B and E. For Choice A – “faster and more convenient than walking”, the selection frequency decreased with the usage frequency, indicating that non-users did not value this advantage. For Choice B, “exercise”, and Choice E, “low-carbon and environmentally friendly”, the selection frequencies increased with the decrease of usage frequency. That is to say, the importance of these two advantages increased with the decrease of usage frequency.

These stable trends indicate that the preferences regarding the advantages of bike-sharing system are different among the three groups. Occasional users and non-users did not value the physical strength-saving advantage of bike-sharing system in short-distance trip, but valued its advantages in body exercise and low-carbon environmental protection. This attitude tendency is noteworthy.

4.6 Attitude: how would the user increasing their use frequency ?

In order to analyze the key factors that affect the utilization of the system, a question was directly asked to the respondents: “under what circumstances would you use public bike more often”. For non-users, the question was slightly adjusted to be “under what circumstance would you consider using the public bike”. There were

Table 5. Usage frequency * valued advantages

			Valued advantages					Total
			A · fast and convenient	B · physical exercise	C · Cost Savings	D · Convenient access	E · Low carbon	
Use frequency	Frequent users	count	56	21	20	26	25	148
		(%)	37.8%	14.2%	13.5%	17.6%	16.9%	100.0%
	Occasional users	count	38	21	20	21	22	122
		(%)	31.1%	17.2%	16.4%	17.2%	18.0%	100.0%
	Non-users	count	27	31	20	23	27	128
		(%)	21.1%	24.2%	15.6%	18.0%	21.1%	100.0%

Table 6. Usage frequency * factors influencing the increase of usage frequency

			Increased utilization factor			total
			A. Improve service	B. Optimize service layout	**C.** Increasing transit stations	
Use frequency	Frequent users	count	43	49	21	113
		(%)	38.1%	43.4%	18.6%	100.0%
	Occasional users	count	32	40	23	95
		(%)	33.7%	42.1%	24.2%	100.0%
	Non-users	count	26	26	8	60
		(%)	43.3%	43.3%	13.3%	100.0%

three options for this question: A. improve service, B. optimize service site distribution, C. improve the connection with other public transportation methods.

Chi-square analysis showed no significant difference among the three user groups, with Sig. (double sided) = 0.517. A closer analysis of the data **(Table 6)** revealed that “optimize service point distribution” had the highest demand, followed by “improve service”. There were different expectations on “increasing transit stations” among the three groups. Occasional users valued this option relatively higher, while non-users were not sensitive to this option.

4.7 Summary

Comparative analysis revealed significant differences in commuting distance among frequent users, occasional users and non-users; the shorter the distance, the higher the usage frequency. There was no big difference in age distribution among different user groups, with the average age of non-users slightly younger than the others. In terms of trip purpose, occasional users have a slightly higher proportion of “commuting”, and lower proportion of “leisure”. In terms of usage pattern, occasional users were more likely to combine public bike with other public transportation mode, and were less sensitive to the distance between service sites and their homes or work places, when compared with frequent uses. The three groups emphasized different advantages of the bike-sharing system. Occasional users and non-users focused more on its benefits on physical exercise and low-carbon environmental protection.

The self-reported answers to the question how would the user increasing their use frequency, showed no significant statistic difference among the three groups. However, they showed a different expectation on “increase transit stations”, which was valued higher by occasional users.

5. Conclusions and reflections

The significance of this study resides in two aspects. First, it provides solid evidence for local operators to adjust the management focus and provides detailed information for other cities to understand the empirical experiences of this benchmark city. In addition, this study also proposed that, appropriate sampling method, analysis perspective, cross-case analysis, and follow-up updating empirical studies should be emphasized in this new research field. Comparing with data from other cities, it is safe to conclude that the bike-sharing system in Hangzhou is relatively mature and has a stable frequent user group. Nevertheless, there are substantial potential for the improvement of three indicators: average daily usage frequency, proportion of journeys combined with other public transport mode, and proportion of trips converted from cars.

Secondly, this study clearly proposed that, because cycling is limited by weather and trip distance, special attention needs to be paid to the use pattern and attitude of occasional users and non-users in order to increase the utilization and low-carbon benefit of the bike-sharing system. This study also noted key contents for further investigation. Main findings in this aspect include the follows three parts. (1) Because the proportion of private car users is relatively high in the latter two groups, to incorporate the low-carbon goal, the government should encourage the occasional users and no-users to try the public bike more frequently. (2) Occasional users have relatively higher demand on transition convenience with other public transports, while non-users value more on the physical exercise and low-carbon benefits brought by the bike-sharing system. Therefore, to increase the utilization of the occasional users, greater attention needs to be paid to improve the transition between the bike-sharing system and other public transportation methods or parking lots. To attract the non-users (the attitude survey showed that 88% of the respondents did not rule out the possibility of using public bike in the future), the quality of cycling trails need to be improved to emphasize the exercise theme, and the low-carbon concept of bike-sharing system needs to be more publicized. (3) Compared with frequent users, the commuting distances of the latter two groups are longer, which may be the main reason to prevent them from utilizing the public bike. However, if the above two methods can attract them to use the public bike during non-working time, the utilization of the system can be increased and the beneficiaries of this public good can be expanded. In addition, non-working usage can also ease the “tide phenomenon” caused by imbalanced demand during different periods of time, thus bringing extra benefit to ease the system dispatch burden.

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Reference

Banister D. 2008. The sustainable mobility paradigm. Transport Policy 15(2):73–80.

Bao, R. W. 2013. Public Bike Change Hangzhounese's Way of Travel in Five Years Quietly. Hangzhou Daily, April 28, 2013.

Deng, R. G. 2008. Speed up the Construction of Public Bicycle Transportation System to Effectively Solve the Last Kilometre Problem of Public Bus. Hangzhou Daily, March 21st

Fishman, E., S. Washington, and N. Haworth. 2013. Bike share: a synthesis of the literature. Transport Reviews 33 (2):148-165.

Fuller, D., L. Gauvin, Y. Kestens, M. Daniel, M. Fournier, P. Morency, and L. Drouin. 2011. Use of a New Public Bicycle Share Program in Montreal, Canada. American Journal of Preventive Medicine 41 (1):80–83.

Gu, C. 2010. Hangzhou Public Bike Use Survey Analysis. Statistical Science and Practice (12):8-10.

Liu, S. 2013. Research on Urban Bicycle Space Safeguard Strategy -- Take Hangzhou as an Example. In New development of urbanization and transportation - Chinese Urban Transportation Planning Annual Meeting 2013.

Heinen, E., B. v. Wee, and K. Maat. 2010. Commuting by Bicycle: An Overview of the Literature. Transport Reviews, 2010 30 (1):59–96.

Huang, B. 2010. An Evaluation of Hangzhou Public Bicycle System. Urban Planning Forum (6):72-79.

J.Pucher, and R. E. Buehler. 2012. City Cycling: Cambridge: MIT Press.

Midgley, P. 2011. Bicycle-sharing Schemes: Enhancing Sustainable Mobility in Urban Areas. New York: United Nations.

Pan, H.-x., Y. Tang, X.-m. Mai, and Y.-j. Mou. 2010. Overview of Bicycle Transportation Development in Urban Areas. Urban Transport of China 8 (6):40-43.

Qian, J., Z. Zheng, and Y. Feng. 2010. An Assessment of the Public Bicycle Facilities in Hangzhou. Planners 26 (1):71-76.

Shaheen, S., E. Martin, A. P. Cohen, and R. Finson. 2012. Public Bikesharing in North America: Early Operator and User Understanding

San Jose: Mineta Transportation Institute.

Shi, X., D. CUI, and W. WEI. 2011. The Investigation of the Relationship between Using and Planning of Public Bicycle in Hangzhou. Urban Studies 18 (10):105-114.

Wang, L., Q. Yu, and B. Wuang. 2010. Development Status and Optimization of Hangzhou Public Bicycle System. Modern City 5 (4):39-42.

Wang, X. 2013. Pondering the development of urban public bike. Traffic & Transportation (4):21-22.

Wei, R. F. 2014. Public Bicycle Rental Amount Soaring in Morning and Evening Peak. City Express, May 9 , 2014.

Wu, K. 2013. Development Status and Countermeasure of Public Bicycle System in Hangzhou Transportation Science & Technology (2):154-157.

Yao, Y., and Y.-j. Zhou. 2009. Bike Sharing Planning System in Hangzhou. Urban Transport of China 7 (4):30-38.

Zhu, W., Y. Pang, D. Wang, and X. Yu. 2012. Travel Behavior Change after the Introduction of Public Bicycle System: a Case Study of Minhang District, Shanghai. Urban Planning Forum.