Understanding Shared Bike Use Behavior with the Theory of Planned Behavior

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Abstract

The number of shared bikes has seen an exponential increase all over the world, especially cities in China, in recent years due to the rise of the mobile Internet. In the early stage, shared bikes operate mainly in the university campuses. Thus, understanding the motivations underlying shared bikes use behavior for college students is of vital importance for interference towards expected travel behavior. The current study constructs a model to comprehensively analyze the travel decision process on shared bike use behavior, which is performed by integrating the theory of planned behavior and the latent variable of environmental awareness. The empirical study supports the integrated model to understand shared bike use behavior, with a few hypotheses on the cause-and-effect relationships among several related psychological constructs. The proposed model is expected to give useful insights for transportation demand management policies of retaining the current shared bike users and attracting new users in the future, including the measures to be taken to increase the environmental awareness of college students.

Keywords

Theory of planned behavior, Environmental awareness, Shared bike use behavior, Travel mode choice, Habit.

1. INTRODUCTION

As the place of work, study, and life for residents, cities provide the necessary facilities for the survival and development of residents, including transportation, work, education, business, and restaurant systems, and perform a variety of types of service by these systems (Gonzalez et al., 2008). As the blood of the city, the transportation system is used to link other systems, and make sure that residents arrive at their destinations with safety and convenience and complete the necessary activities (Yan et al., 2017). However, most cities in China are struggled with troubles associated with the transportation system, including congestion, accidents, pollution, noise, and parking. According to the "Travel Report of Cities in 2017" from DiDi company, the average transportation index is 1.447, 1.553, 1.540, and 1.554 for four seasons during morning peak hours of working days. The transportation index for Ha'erbin even hits 1.791. In other words, the average travel time of the morning peak is 79.1% longer than that of the early morning. To relieve the congestion, the transportation management tries to promote the development of transit by providing a number of subsidies for both transit operators and transit passengers. However, the transit share rate ranges from 10% to 30% in most cities in China, which is much smaller than the desired transit share rate of 60%. Such a low transit share rate is caused by a number of factors. Besides the well-known low speed, the low time performance, the undesirable comfortability, the inconvenient transfer, and the low coverage, the issue of "the first/last mile" is another important factor to hinder the development of the transit system.

The era of the mobile Internet provides a new solution for the issue of "the first/last mile". As one of the "For New Inventions" in China, shared bikes have seen a rapid development in recent years, and become the important mode for the transfer and trips with short distances. According to the "42th Statistical Report of Internet Development in China" from China Internet Network Information Center (CNNIC), as of June 2018, the number of shared bike users is 245 million, accounting for 30.6% of Internet users, and increase by 24.32 million compared with December 2017. In addition, "Report on Shared Bikes and City Development in 2017" indicates that the mode of "shared bike + transit" outperforms cars for trips with less than five kilometers for Beijing and Shanghai in most cases. Shared bikes have become an indispensable part of the transportation system. Although the rapid growth of shared bikes results in a series of troubles, including the excessive delivery, the chaotic parking, the insufficient maintenance, and the occasional accidents, shared bikes improve the efficiency of the transportation system, and provides an alternative for "the first/last mile".

The existing studies on shared bikes focus on the determinants of shared bike use behavior (Chen & Lu, 2016), the impact of shared bikes on travel behavior (Rowangould & Tayarani, 2016), the shared bike rebalance (reposition, relocation, redistribution) (Faghih-Imani & Eluru, 2015), the choice of the operation model (Ricci, 2015), the choice of the shared bike site (Y. Yang et al., 2017). The current study aims at understanding the shard bike use behavior, and we review the first aspect in details.

Most existing studies analyze the impact of the demographic characteristics on the shared bike use behavior, including the gender, age, education level, income and latent variables. Ran and Li (2017) employed a revealed preference survey to obtain 621 qualified questionnaires from traveler in Shanghai, Beijing, Nanjing, and Hefei, constructed a binary Logit model to explore the shared bike use behavior, and studied the relationship between the use behavior and the demographic characteristics. Results indicated that men were more likely to take shared bikes than women, the younger were more likely to use shared bikes than the elderly, and the population with higher education level were more likely to choose shared bikes than those with lower education level. Among these factors, the education level had the most significant impact on the shared bike use behavior. To explore the travel behavior of shared bike users, Buck et al. (2013) compared the demographic characteristics of short-term (one day) users and annual members of Capital Bikeshare (Cabi) in Washington, DC, as well as users of area bicyclists with descriptive statistics. Data consisted of the household travel survey in Washington, DC in 2007-2008, the street interview for Cabi short-term users, and the online survey for Cabi annual members. Results demonstrated that compared with area cyclists, the Cabi short-term and annual members were more likely to be female, young, and the household with low income, less cars and bikes. Raux et al. (2017) collected the travel diary and the demographic characteristics of 3161 respondents on the Internet, and explored the impact of demographic characteristics on the use preference of shared bikes with the binary Logit model. Results indicated that the shared bike users were more likely to be male, young, as well as those with higher social status and who lived near the shared bike sites and had cars. In addition, other studies indicated that those whose bikes were stolen once were more likely to take shared bikes (Castillo-Manzano et al., 2015; Ji et al., 2017).

Latent variables that prove to have a significant effect on the shared bike use behavior consist of environmental awareness, the health considerations, the safety considerations, the convenience considerations, and the subjective norm. Te Pai and Pai (2015) studied the factors that may have an impact on shared bike use preference based on a survey of 557 respondents in Taipei, Taiwan, and concluded that the environmental awareness, the system perception, the personal preference, and the personal cognition are four key latent factors to influence the shared bike use behavior. In addition, the extent varied based on different travel purposes. R. Yang and Long (2016) used a binary Logit model to examine the impact of four types of factors

(shared bike, household demographic, external, and psychological variables) on the willingness to take part in the bike sharing projects based on the questionnaire survey from 520 residents from Suzhou, Taizhou, Xuzhou in Jiangsu province. Results indicated that the environmental awareness is a vital factor to influence the choice of shared bikes.

Although some above-mentioned studies explore the impact of latent variables including the environmental awareness on shared bike use behavior, they did not integrate latent variables into the model with a unified manner, but treated latent variables as comment independent variables, which may increase the error of the model estimation and decrease the explanatory power of the model. Thus, an integrated framework needs to be developed to examine the impact of the latent variables on the shared bike use behavior. In existing literature, the theory of planned behavior (TPB) (Ajzen, 1991, 2005) have been widely used to explain and predict the intension and actual behavior in the transportation domain (Fu & Juan, 2017; Gao et al., 2018; Jing et al., 2018; Verma & Chandra, 2018). To the best of our knowledge, little efforts have been made to investigate the impact of latent variables on shared bike use behavior with an integrated framework including TPB. Thus, we propose a TPB framework to integrate the latent variables and shared bike use behavior, and employ an empirical study to validate the proposed model.

The remaining contents of the current paper are organized as follows. Next section explains a series of constructs and proposes associated hypotheses. In Survey and variable section, the survey process and the descriptive statistics are given, followed by the exploratory factor analysis and confirmatory factor analysis. The last section demonstrates the main findings and future directions for further studies.

2. THEORETICAL BACKGROUND AND HYPOTHESES

The key points of TPB are that the actual behavior is mainly decided by the behavioral intension, and the behavioral intension depends on the attitude. In the TPB, behavioral intension denotes the extent of individual's preference to complete a given behavior (Ajzen, 1991). According to the definition, attitude is a measure to evaluate the given behavior, e.g., positive or negative, meaningful or meaningless. The more positive attitude one has, the stronger intension to perform the given behavior (Beck & Ajzen, 1991). Similarly, when one has a positive attitude to shared bikes, he/she will probably have a strong behavioral intension to shared bikes. In this case, he/she will probably use shard bikes to make the necessary trip. Based on the above evidence from previous empirical studies, we propose the following hypotheses:

H1: Behavioral intention positively influences shared bike use behavior.

H2: Attitude positively influences the behavioral intension.

The main reason for the exponentially increasing prevalence of shared bikes is that users may pick up/return shared bikes in the places where shared bikes can park, rather than docking points alone. In other words, the high convenience due to the mobile Internet and Global Positioning System (GPS)/Beidou Positioning is the key factor to promote the rapid development of shared bikes. Faghih-Imani and Eluru (2015) indicated that shared bike users prefer destinations with more parking places, shorter travel distance, and that may be accessed with longer bike lanes. In addition, there exist two intensive shared bike picking up/returning places around most subway stations. One is 100-200 meters from the subway station, and the other is 600-800 meters from the subway stations. The former is generally the place to transfer to the subway, while the latter may be used to transfer other modes, including transit. Similarly, Zhao et al. (2015) demonstrated that residential communities and subway stations are two gathering places for picking up/returning shared bikes. Based on these results from empirical studies, the follow hypothesis is proposed:

H3: Perceived convenience positively influences attitude.

As the environmental issue becomes increasingly worse, the environmental awareness become stronger than ever. Most travelers believe that the environment may improve or no longer continue to deteriorate if everyone tries the best to decrease the car use and use environmentally friendly travel modes, including transit and shared bikes. To investigate the travel behavior of Youbike shared bike users, Te Pai and Pai (2015) collected 557 questionnaires from Internet and shared bike parking places, which consists of 369 shared bike users and 188 respondents who do not use shared bikes. The questionnaire required respondents to report their cognition to shared bikes, environmental awareness, travel preference, and demographic characteristics. The principal component analysis was conducted to determine how these factors impacts shared bike use behavior. Results indicated that the environmental awareness was the key factor to use shared bikes. Based on the empirical results, we propose the follow hypothesis:

H4: Environmental awareness positively influences attitude.

H5: Environmental awareness positively influences behavioral intension.

According to the law of the demand in the microeconomics, the demand to a certain product will decrease if its price increases (Clark, 1917). The rule may be applied to the shared bike use behavior. In other words, the number of users will increase if the deposit and the ride cost decreases, and vice versa. For example, the deposits for ofo and Mobike are 99 and 299 yuan. Therefore, most new users may choose to use Mobike shared bikes. In addition, it is a high-frequency behavior to take shared bikes, which indicates the importance of the acceptable ride cost. L. Zhang (2017) interviewed 475 respondents, 458 of which used shared bikes. A further analysis found that over a half used shared bikes frequently, and 14.95% of respondents took shared bikes every day. J. Zhang (2017) explored the effect of several latent variables (including convenience, environmental awareness, and shared bike cognition) on the shared bike use behavior, and found that the ride cost is a major factor to determine the shared bike use behavior. Based on the empirical results mentioned above, we propose the following hypothesis:

H6: Perceived use cost negatively influences behavioral intension.

Subjective norm is “the perceived pressure to conduct or not to conduct a certain behavior”, which is associated with the perceived expectation from members in social circles, including family members, friends, and colleagues. It is demonstrated that subjective norm is an important factor to determine attitude and behavior intension (Wang et al., 2016). Taking the shared bike use behavior as an example, a traveler is more likely to have a positive attitude and behavioral intension to shared bikes if he/she perceives the pressure or expectation to use shared bikes, which may result from environmental or healthy considerations. Based on the above empirical results, we propose the following hypothesis:

H7: Subjective norm positively influences attitude.

H8: Subjective norm positively influences behavioral intension.

The graphical representation of all these hypotheses is denoted in Figure 1, where lines with arrows represent the cause-and-effect relationships among the corresponding constructs.

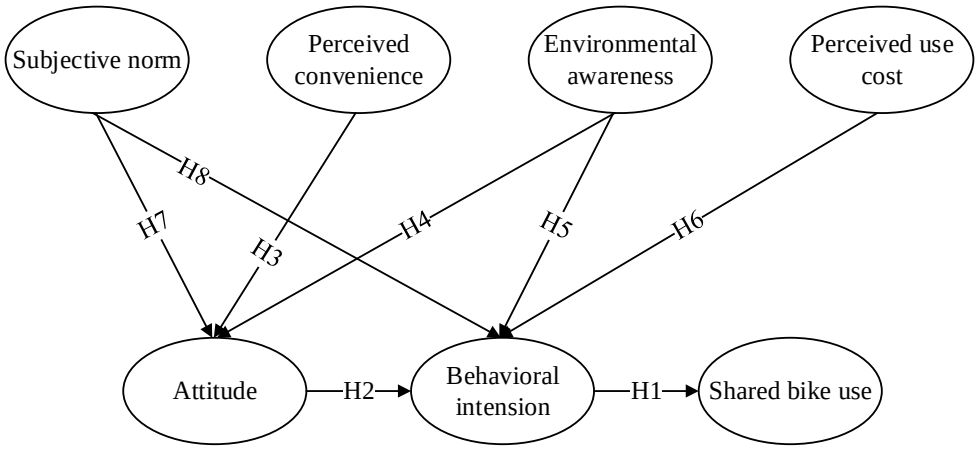

Figure 1. Graphical representation of the hypotheses

3. SURVEY AND VARIABLES

The sample data are collected from students and employees in Shanghai and other cities by Wenjuanxing. The screening mechanism is erected before respondents submit their questionnaires. In total, 647 qualified questionnaires are obtained. The questionnaire consists of three parts, i.e., demographic characteristics, items of several latent variables, and the shared bike use behavior. The descriptive statistics of demographic characteristics are given in Table 1. The monthly living expenses and the monthly income are given for students and employees, respectively, in this table. In addition, a five-point numeric rating scale is used for all items used to measure latent variables.

Table 1. Descriptive statistics of demographic characteristics

Items	Categories	Frequency	Percentage
Use shared bikes?	Yes	466	72.02%
	No	181	27.98%
City	Shanghai	254	39.26%
	Others	393	60.74%
Gender	Male	283	43.74%
	Female	364	56.26%
Occupation	Student	398	61.51%
	Employee	249	38.49%
Monthly living expense (only for students)	Less than 1000 yuan	47	11.81%
	1000-1500 yuan	189	47.49%
	1500-2000 yuan	104	26.13%
	More than 2000 yuan	58	14.57%
Monthly income (only for employees)	Less than 3000 yuan	49	19.68%
	3000-5000 yuan	94	37.75%
	5000-10000 yuan	72	28.92%
	More than 10000 yuan	34	13.65%
Own private transportation?	Yes	158	24.42%
	No	489	75.58%
The type of private transportation (only for private transportation owners)	Private bikes	135	20.87%
	Other vehicles	79	12.21%

4. EXPLORATORY FACTOR ANALYSIS

Although we pre-define all the indicators for each latent variable (as shown in Table 2), exploratory factor analysis (EFA) needs to be conducted to determine whether these indicators are reasonable to measure these latent variables. EFA is conducted with the following two steps. On the one hand, all the factor loadings are computed to decide whether some indicators should be discarded. On the other hand, Cronbach's alpha is also computed for each latent variable to evaluate the internal consistency. Principal component analysis (PCA) is performed with varimax rotation in SPSS 22.0. As shown in Table 3, all factor loadings are more than 0.5, denoting that all these latent variables are derived from the corresponding indicators. All the values of Cronbach's alpha are more than the recommended value 0.5, indicating a preferable internal consistency among indicators (Ajzen, 1991).

Table 2. Latent variables and related items

Latent variables	Items
Shared bike use (SBU)	SBU1 In the past, shared bikes are your major travel mode. SBU2 In the past, the frequency to take shared bikes.
Behavioral intension (BI)	BI1 You choose shared bikes without thinking. BI2 You are willing to take shared bikes in the future. BI3 It has been a part of your life to take shared bikes. BI4 Shared bikes are the most familiar and comfortable mode for you.
Attitude (A)	A1 What is the degree of preference for shared bikes? A2 What is the degree of satisfaction for shared bikes? A3 It is hard for you to stop using shared bikes.
Perceived convenience (PC)	PC1 Is it convenient to pick up shared bikes? PC2 Is it convenient to return shared bikes? PC3 Is it time-consuming to pick up shared bikes? PC4 Is it time-consuming to return shared bikes?
Environmental awareness (EA)	EA1 I am very concerned about the environment, and willing to try to protect it. EA2 I am very concerned about the air pollution, noise, and the use of fossil fuels. EA3 I am very worried about the air pollution, noise, and the use of fossil fuels.
Perceived use cost (PUC)	PUC1 How do you feel about the deposit? PUC2 How do you feel about the ride cost?
Subjective norm (SN)	SN1 Your family members support your shared bike use. SN2 Your family members have a positive attitude toward shared bikes. SN3 Your friends support your shared bike use. SN4 Your friends have a positive attitude towards shared bikes.

Table 3. Results of EFA

Latent variables	Items	Factor loading	Mean	Standard error	Cronbach's alpha
SBU	SBU1	0.712	2.30	0.897	0.830
	SBU2	0.712	2.59	0.902	
BI	BI1	0.773	2.99	0.903	0.851
	BI2	0.508	3.48	0.812	
	BI3	0.759	2.91	0.948	
	BI4	0.773	2.91	0.927	
A	A1	0.557	3.48	0.808	0.720
	A2	0.581	3.36	0.767	
	A3	0.594	3.51	0.831	
PC	PC1	0.647	3.17	0.922	0.816
	PC2	0.606	3.11	0.871	
	PC3	0.683	3.31	0.813	
	PC4	0.611	3.43	0.868	
EA	EA1	0.674	3.65	0.779	0.880
	EA2	0.844	3.62	0.809	
	EA3	0.792	3.66	0.807	
PUC	PUC1	0.651	3.30	0.819	0.789
	PUC2	0.651	3.25	0.821	
SN	SN1	0.760	3.58	0.781	0.891
	SN2	0.753	3.49	0.781	
	SN3	0.774	3.63	0.795	
	SN4	0.754	3.57	0.737	

5. CONFIRMATORY FACTOR ANALYSIS

Before moving to the calibration of the TPB, we estimate the measurement model with confirmatory factor analysis (CFA) using AMOS 22.0 to evaluate the validity of the constructs. According to Table 4, each of these six measures corresponds to an acceptable range (Lomax & Schumacker, 2004). All values of these measures are in the acceptable range, which indicates that the proposed model fit the data well. Specifically, the acceptable values of GFI, AGFI, CFI, and NFI indicate the applicability of the proposed model, while the acceptable value of RMSEA denotes a low error of the model.

Table 4. Six common measures for assessing the model fit

Measures	Values	Acceptable range
The degree of freedom ($\chi 2/df$)	4.63	(2,5]
The root mean square error of approximation (RMSEA)	0.075	(0.05, 0.08]
Goodness-of-fit (GFI)	0.91	[0.90, 0.95)
Adjusted goodness-of-fit (AGFI)	0.86	[0.85, 0.90)
Comparative fit index (CFI)	0.97	[0.95, 0.97)
Normed fit index (NFI)	0.96	[0.90, 0.95)

Next, the convergent validity is assessed with two following measures (Ajzen, 1991): (1) all the standardized loadings need to be greater than 0.50 (i.e., statistically significant), (2) The values of average variance extracted (AVE) should be larger than 0.50. As shown in Table 5, all

the values of standardized loadings and AVE meet the requirements mentioned above, indicating that the convergent validity is confirmed.

Table 5. Results of CFA

Latent variables	Items	Standardized loading	AVE
SBU	SBU1	0.76	0.73
	SBU2	0.94	
BI	BI1	0.81	0.61
	BI2	0.60	
	BI3	0.84	
	BI4	0.85	
A	A1	0.68	0.50
	A2	0.69	
	A3	0.71	
PC	PC1	0.71	0.53
	PC2	0.68	
	PC3	0.78	
	PC4	0.73	
EA	EA1	0.72	0.73
	EA2	0.95	
	EA3	0.87	
PUC	PUC1	0.72	0.66
	PUC2	0.90	
SN	SN1	0.81	0.67
	SN2	0.80	
	SN3	0.84	
	SN4	0.82	

Results of the TPB model are shown in Figure 2. The data on each line is the standardized path coefficient, with T value in the parentheses. Except the impact of environmental awareness and perceived cost on behavioral intension, other cause-and-effect relationships are significant when p value is less than 0.05 (i.e., T value is larger than 1.96).

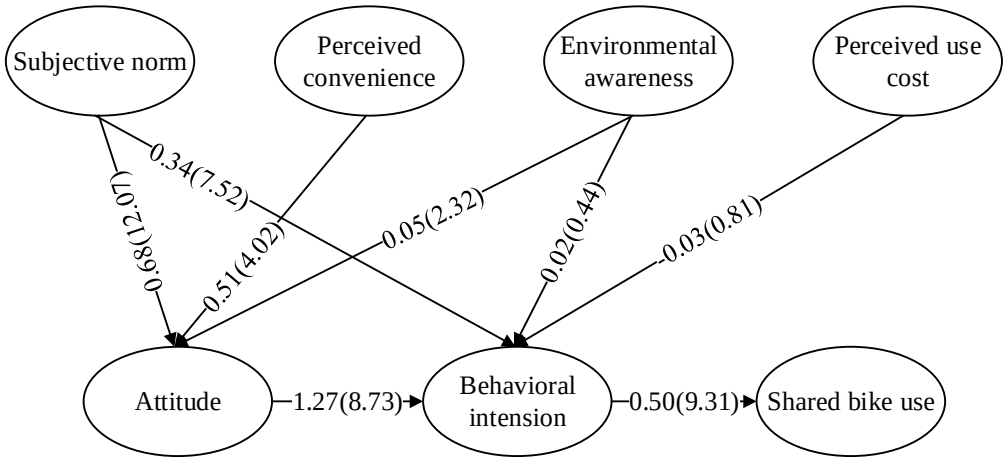

Figure 2. Results of the TPB model

Table 6. Results of the hypothesis validation

No.	Hypothesis	Outcome
H1	Behavioral intension → Shared bike use	Confirmed
H2	Attitude → Behavioral intension	Confirmed
H3	Perceived convenience → Attitude	Confirmed
H4	Environmental awareness → Attitude	Confirmed
H5	Environmental awareness → Behavioral intension	Not confirmed
H6	Perceived use cost → Behavioral intension	Not confirmed
H7	Subjective norm → Attitude	Confirmed
H8	Subjective norm → Behavioral intension	Confirmed

6. RESULTS AND CONCLUSIONS

It is of vital importance to increase the share rate of shared bikes in order to cope with the increasing congestion. Generally speaking, shared bikes are regarded as a means of green, convenient, low-cost and healthy transportation such that it is well received by environmentalists, employees, students, and the elderly. Therefore, this study aims to evaluate the impact of several latent variables (including environmental awareness, perceived convenience, and perceived use cost) on the shared bike use behavior from an empirical perspective by collecting sample data from the Internet. Eight hypotheses are proposed based on theoretical background and most of them are validated according to collected sample data.

Firstly, the attitude is a key factor to determine the behavioral intension, and the behavior intension plays a critical part in the decision mechanism of the shared bike use. Compared with private cars, shared bikes are much more available for most travelers. Such a fact indicates that travelers turn the attitude into the behavioral intension, and further transform the behavioral intension into the shared bike use. Therefore, transportation management and shared bike operators should try to maintain a good management policy and service level, such that most travelers have positive attitude to shared bikes. For transportation management, it is useful to optimize the layout of bike parking places and collaborate with shared bike operators to maintain a preferable parking service. For shared bike operators, it may be critical to guarantee the safety of user accounts and the timeliness of the response to shared bike users.

Secondly, the subjective norm is viewed as an important factor to decide the attitude and the behavioral intension. Generally speaking, shared bike operators encourage their current users to invite new users by providing cash bonus and coupons to both the current users and new users. In this case, if a traveler enjoys riding shared bikes, he/she will be very willing to invite his/her family members, friends, and colleagues to take part in the shared bike program. Therefore, it is understandable that the subjective norm has a significant impact on both the attitude and the behavioral intension.

Thirdly, the perceived convenience proves to play a critical role to decide a traveler's attitude to the shared bikes. Hangzhou urban public bikes are the first bike sharing program in China, which is organized in 2007. Since then, more and more cities become to erect and operate urban public bikes. However, the number of users does not continue to grow, because these public bikes need to be picked up/ returned at designated places by swiping a certain card in most cases. Although this decreases the risk of being stolen and maintain an orderly parking, it poses a great burden on travelers. Compared with urban public bikes, shared bikes may be picked up/returned with much more freedom such that it become a realty to use shared bikes "whenever and wherever".

Fourthly, environmental awareness is demonstrated to have a positive impact on the attitude, but does not have a significant effect on the behavioral intension. This may be due to that the attitude is the mediator between the environmental awareness and the behavioral intension. To promote the use of shared bikes, transportation management and shared bike operators should spread the low-carbon life style with riding shared bikes. In addition, transportation management may subsidize shared bike users to cultivate as many as high-frequency users.

Last but not the least, the perceived cost proves not to have a significant impact on the behavioral intension, although a negative coefficient is obtained as expected. This may be due to the fact that the riding cost is relatively low compared with the monthly living expense or monthly income. In addition, shared bike operators often provide users with a number of coupons in order to achieve a dominant position in the competitive market. In some situations, shared bike operators provide users red packets if they ride designated shared bikes to the desirable place. In total, the perceived cost is not a major factor to impact the decision of taking shared bikes.

Despite these contributions, the current study may be improved from the following two aspects in the future. On the one hand, more sample data should be collected such that the relationships among the latent variables may be analyzed for different types of respondents. On the other hand, it is strongly recommended that more latent variables associated with shard bikes are included in the TPB framework, including the safety consideration.

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