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Using the sustainable modified TAM and TPB to analyze the effects of perceived green value on loyalty to a public bike system

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ABSTRACT

This article explores the effects of perceived green value, perceived green usefulness, perceived pleasure to use, subjective norms and perceived behavioral control on green loyalty to a public bike system. The mediators between perceived green value and green loyalty and a moderator of general attitude toward protecting the natural environment are also discussed. The aim of this research was to understand how to establish green loyalty via the other dimensions based on the sustainable modified technology acceptance model (modified TAM), the theory of planned behavior (TPB), and a moderator. The findings reveal that perceived pleasure to use and subjective norms have the strongest power to influence loyalty for both users and non-users. The implications of this finding are that fun in people's lives has a strong influence on sustainable continuous use of public bikes, and that subjective norms are more effective for non-users. In addition, environmental attitude has stronger moderating effects for non-users than for users on perceived green usefulness, perceived pleasure and subjective norms. Therefore, governmental policies should promote the attitude of protecting the natural environment, perceptions of pleasure, and subjective norms so as to increase green loyalty to public bike-sharing.

1. Introduction

The environment has become a crucial and influential issue owing to the recent global warming phenomenon (Wirl, 2012; Cho et al., 2014). In order to create a better living environment, reducing the utilization of energy and carbon emissions has become the responsibility of all of us in the international community (Curtis, 2009; Trappey et al., 2012; Murphy et al., 2014). The transportation sector produced nearly 23% of global CO^2 emissions from fossil fuel combustion in 2012 and is also the largest energy purchase source in 40% of the world's countries (UN and Climate Change, 2015). Hence, governmental policies should reshape public transport systems so as to provide a cleaner, safer and more sustainable future.

Many transportation policies have been instituted to enhance alternative transportation systems, such as, for example, the systems of bike-and-ride and public bike-sharing in urban areas. Such systems aim to reduce the harm inflicted on the environment by transportation (Martens, 2004; Lin and Yang, 2011; Pucher et al., 2011). However, despite the current focus on environmentalism, and the environmental value of these public transportation services, usage of such systems is still not high. Hence, a clear understanding of the psychology of using bikes is crucial in order to be able to increase the

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use of bike-and-ride and public bike-sharing services by the general public. This research therefore focused on the analysis of a public bike-sharing system (YouBike) run by the Taipei City Government since 2012, which aims to promote the short distance use of bicycles, thus reducing private transportation use in the city.

YouBike is a public bike system with an online membership registration system and radio frequency identification control panel system in an urban area. As such, it can be regarded as a new transportation technology from the traveler's perspective. The modified technology acceptance model (modified TAM) and the theory of planned behavior (TPB) are the most commonly utilized theories for evaluating technology acceptance (Davis, 1989; Ajzen, 1991; Moon and Kim, 2001; Chen and Chao, 2011). This study therefore aimed to explore this research gap based on the five constructs of perceived green value, perceived green usefulness and perceived pleasure to use, subjective norms and perceived behavioral control on green loyalty for public bike use according to the modified TAM and the TPB, with a moderator of general attitude toward protecting the natural environment. TAM can be used to focus on the antecedents of perceived green usefulness and the consequences of usage behaviors (Benbasat and Barki, 2007). This study therefore used perceived green value as the antecedent to investigate green loyalty to public bikes. Since the modified TAM and the TPB were used to study the psychology of public bike use and to identify loyalty, which is a sustainable perception, in this study, traditional usefulness and loyalty were reframed as perceived green usefulness and green loyalty to form a green modified TAM and TPB (Davis, 1989; Ajzen, 1991). Because this research focused on a sustainable modified TAM and TPB and a moderator of environmental attitude, direct, indirect and moderation relationships were implemented to test environmental commitment to public bike usage.

The modified TAM and TPB are used to determine which of the five constructs is the most significant factor for green loyalty. Hence this research can provide empirical evidence to guide governmental policies to promote public bike use via discussion of green consciousness, and to enhance green loyalty to public bikes via the five proposed constructs. Past surveys have extensively studied the issues of these five constructs, but no survey has as yet studied whether the external variable of perceived green value or psychology and a moderator of green attitude influence the effects on green loyalty in the modified TAM and TPB for public bike use. This paper hence aims to fill this gap in the understanding of transport behaviors.

A framework consisting of these five constructs and a moderator of public bike use is proposed, combined with the modified TAM and TPB, to address the issue of public bike adoption. In this research, the framework is applied to identify the ways in which governmental policies can increase green loyalty via YouBike users' other five constructs and a moderator. Local governments can allocate more resources to encouraging citizens' sustainable loyalty to the long-term usage of bikes by enhancing their perceptions of the bikes being fun and useful; by encouraging recommendations from friends, relatives and social contacts to use the bikes; and by highlighting the health benefits of cycling, the ease of use and availability of the bikes, and the contribution riding the bikes makes to protecting the natural environment. This research also discusses non-users' impressions of the two models and a moderator to attract first-time users. The literature regarding green consciousness, psychological marketing and modified TAM and TPB is reviewed in order to create a novel theoretical framework for public bike usage.

This article is structured as follows: the literature review and hypotheses are presented in Section 2; the methodology is discussed in Section 3, which also presents details of the sample, data information, scale development and constructs. The descriptive statistics, reliability and common method variance, multivariate normality, reliability analysis, multicollinearity, correlation coefficients among the variables, discriminant validity and convergent validity, as well as the multi-group analysis and moderation results of the structural model for users and non-users are all described in Section 4. Finally, Section 5 presents the discussion and suggestions based on the findings, while also discussing the implications of the findings, and suggesting further research directions.

2. The concepts and research hypotheses

2.1. Green transportation and public bike services

A significant contributor of carbon emissions in the average household is transportation (Froehlich et al., 2009; Yang et al., 2009; Nagurney et al., 2010; Dirgahayani, 2013). Hence, transportation is a critical factor in governmental and commercial environmental policies because of its huge impact on the planet. However, even though the impact of transportation is huge, few definitions of green transportation services have been put forward in the literature. The focus of prior investigations has tended to be on how to support green transportation through taxation (Potter et al., 1999; Björklund, 2011).

One definition that has been suggested for green transportation services was provided by Dudow (1998) and Jeon et al. (2010): (1) it makes the transportation needs of individuals and society consistent with human and ecosystem health and ensures equity within generations, (2) it is affordable, operates efficiently, offers choice of transportation mode, and supports a vigorous economy, and (3) it produces limited emissions and waste which fall within the ability to absorb them, minimizes the usage of non-renewable resources, reuses and recycles its materials, and minimizes the depletion of land and the production of noise. As such, green transportation is an essential and unavoidable development to achieve sustainable economic development, and plays a critical role in the human living environment (Bai et al., 2006; Gehlert et al., 2013).

Public bike services conform to the above characteristics because of their low emission and waste levels, and include the attributes of low access cost, moderate travel speed and flexibility of departure time compared to other travel modes. The service also brings many health benefits, while helping to improve the environment and the user's quality of life

(Akar and Clifton, 2009; Fishman et al., 2013). In addition, public bike usage is a sustainable transport form and can contribute to lowering greenhouse gas emissions and waste, and to minimizing the use of land and the output of noise (Gärling et al., 2013). Therefore, public bikes are an obvious green transportation choice.

2.2. Modified TAM and TPB

A bike-sharing system with an online membership registration and radio frequency identification control panel in an urban area, such as YouBike, can be regarded as a new transport information technology from the perspective of the traveler. The TAM is the most commonly utilized theory for evaluating technology acceptance (Davis, 1989; Chen and Chao, 2011), and therefore is appropriate in this case for evaluating the acceptance of the system by its users. The TAM, as proposed by Davis (1989), is derived from the theory of reasoned action (TRA) (Ajzen and Fishbein, 1980), which is related to the behaviors of the use of new information technologies. TAM considers the results of external factors with beliefs, attitudes and intentions (Davis et al., 1989; Venkatesh and Morris, 2000). TAM consists of two constructs that affect the intentions of technical innovations: perceived usefulness and perceived ease of use. However, it does not account for social influence in the adoption of new technologies; hence, scholars have proposed that subjective norms represent social influence (Malhotra and Galletta, 1999). In this paper, the construct of perceived pleasure to use, based on the modified TAM of Csikszentmihalyi (1975) and Moon and Kim (2001), and perceived green usefulness are considered in the effects on green loyalty (Teo et al., 1999).

Furthermore, it has been argued that future implementations of TAM should focus on the antecedents of perceived usefulness and the consequences of usage behaviors (Benbasat and Barki, 2007). This study therefore uses perceived green value as the antecedent of perceived green usefulness and perceived pleasure to use to investigate green loyalty to public bikes. Some prior surveys have adopted TAM to explore issues in the transportation field such as behavioral intentions regarding public transport systems and environmental transportation (Chen and Chao, 2011; Cheng and Huang, 2013); however, no studies have explored green consciousness integrated with the modified TAM to investigate issues of green psychology in public bike usage.

The TPB is successful in forecasting and interpreting human behavior using different information skills (Ajzen and Fishbein, 1980; Ajzen, 1991) and has explained many human behaviors in a wide range of environmental cases (Greaves et al., 2013; Huijts et al., 2014). TPB also argues that a person's real behavior is directly affected by that person's behavioral intentions, and is entirely decided by their attitudes, subjective norms and perceived behavioral control of executing the behavior (Ajzen, 1991). This paper therefore applies these two constructs with the modified TAM to predict green loyalty to public bikes.

2.3. Research hypotheses development

The desire to use bicycles in the city is likely to be influenced by emotions and attitudes, and anticipated emotions are likely to have a critical influence on such a desire (Carrus et al., 2008; Passafaro et al., 2014). Similarly, for TPB, positive emotions, attitude, and subjective norms all show positive effects on the intention to act. Subjective norms are also affected via perceived effective value, as was found for hydrogen fuel station acceptance (Huijts et al., 2014). In the context of public bike use, perceived pleasure to use is defined as the degree to which users believe that the use of public bikes can help them obtain a feeling of interest and relaxation. On the other hand, perceived green usefulness refers to the extent to which users believe that using public bikes would improve their contribution to the protection of the environment. Researchers have found a relationship between the virtual environment and users' psychology, and have pointed out that economic value can influence entertainment value and perceived usefulness. They have also found that perceived usefulness and the feeling of delight have positive impacts on users' intention through TAM (Verhagen et al., 2012). Moreover, car usage is often accompanied by functional, economic, emotional, and social values, and perceived environmental value has been proved to have a crucial impact on these four value dimensions as well as on consumption loyalty (Koller et al., 2011). Hence, based on these findings, perceived green value could be the antecedent in TAM.

Travel mode choice is an example of reasoned action or habit, and has been found to be the main factor for switching to use a public rapid transit system (Chen and Chao, 2011). Chen and Chao's (2011) work revealed that perceived usefulness is the most significant variable for using attitude for both motorcycle and car users. Moreover, subjective norms and perceived behavioral control also have critical effects on switching intentions and are not a habitual factor via TAM and TPB applications. However, perceived behavioral control is affected by habitual value (Chen and Chao, 2011). In another transportation investigation, driver acceptance of a car navigation system and perceived locational accuracy value were proved to have important positive effects on perceived usefulness and using attitude, while perceived usefulness and satisfactory value explained the most positive aspect of the intention to use the system (Park and Kim, 2014).

On the other hand, the general attitude of wanting to protect the natural environment can moderate the relationships between perceived ecological value and loyalty via perceived functional, economic, emotional, and social values (Koller et al., 2011). This current work therefore aimed to test the mediative and moderation effects on green loyalty through perceived green value, perceived green usefulness, perceived pleasure to use, subjective norms and perceived behavioral control. Consequently, this research asserts the positive effects among the dimensions with the following hypotheses:

Hypothesis1 (H1) Perceived green value is positively associated with perceived pleasure to use, perceived green usefulness, subjective norms, perceived behavioral control and green loyalty to public bike usage.

Hypothesis 2 (H2) Perceived pleasure to use, perceived green usefulness, subjective norms and perceived behavioral control are positively associated with green loyalty to public bike usage.

Hypothesis 3 (H3) General attitude toward protecting the natural environment can moderate the relationships for green loyalty via perceived green value, perceived green usefulness, perceived pleasure to use, subjective norms and perceived behavioral control to public bike usage.

In order to establish these hypotheses, it is supposed that perceived green value, perceived green usefulness, perceived pleasure to use, subjective norms and perceived behavioral control positively influence green loyalty. Furthermore, perceived green value can also generate positive paths for perceived pleasure to use, perceived green usefulness, subjective norms and perceived behavioral control. The general attitude toward protecting the natural environment can moderate the effects on green loyalty via the other five constructs. This conceptual framework is shown as Fig. 1.

3. Data and dimensions

3.1. Background

YouBike is a public bike system run by the Taipei City Government since 2012. The purpose of this system is to promote the short distance use of the bicycles, thus decreasing private vehicle use in the city. As of July 2015, there were around two hundred YouBike stations in twelve administrative districts, and 5000 bikes available for rent. The system generates a total monthly income of 0.62 million ($US), and there are in excess of ten rentals per bike per day on average. YouBike uses the technology of radio frequency identification.

The data for this study were collected via a questionnaire which went through two rounds of testing. First, nine experts and scholars were invited to comment on the design of the questionnaire, while in the second round, 18 YouBike users were approached at YouBike sites and were asked to fill in the questionnaire and point out any terms, meanings, or issues which might be unclear. As a result of this process, the questionnaire achieves high content validity. After these two pretests, the formal study of selectively interviewing both experienced users and non-users at YouBike sites was carried out with the aim of testing the hypotheses of the theoretical model.

The samples were from selected YouBike sites and were interviewed after inquiring whether they had time to complete the questionnaire. Data were collected during August and September 2014. The purpose of the study was explained to the respondents, and their written consent to take part in the survey was obtained. The time required to answer the questionnaire ranged from 10 to 20 min. Due to this procedure, high content validity was achieved, and of the 288 questionnaires administered, a total of 261 valid questionnaires were obtained; there were 11 refusals to answer the questionnaire. The effective response rate was thus 90.62%. As the sample size is between 150 and 300 it is acceptable because the model has seven constructs, modest item communalities (0.5), and identified constructs with more than three items, thus meeting the requirements of Hair et al. (2010). Besides surveying users, non-users' information was also collected at the same sampled sites. Before surveying the non-users, the assistants informed them that although they had not used YouBike, they could choose which constructs for public bikes in the modified TAM and TPB they cared about when answering the questionnaire. The questionnaire also included indicators regarding the demographic characteristics comprising age, monthly income, gender, occupation, main travel mode and level of education, as displayed in Table 1.

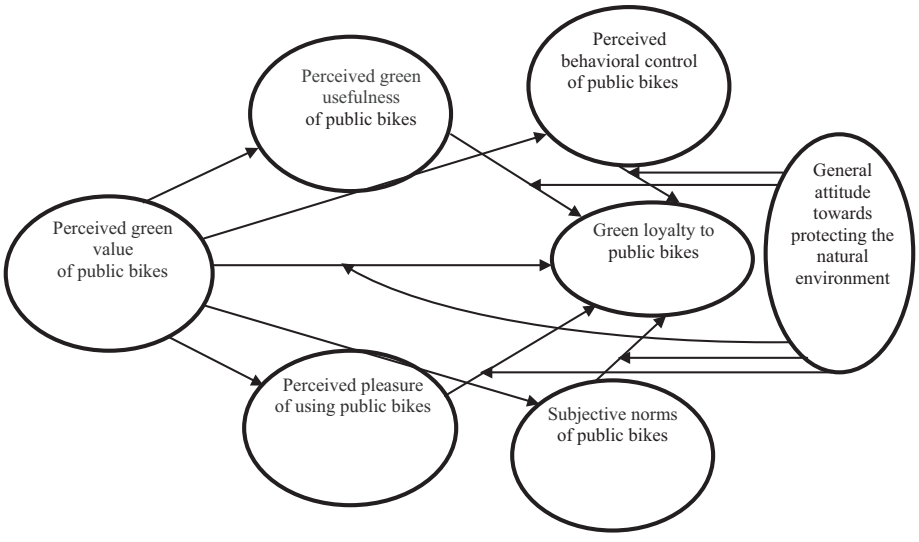

Fig. 1. Theoretical framework of the modified TAM and TPB for public bike usage.

Table 1
Demographic characteristics.

Characteristics	Number		Ratio		Characteristics	Number		Ratio	
	U	N	U	N		U	N	U	N
Gender					*Occupation*				
Male	122	127	46.74%	48.66%	Business	79	75	30.27%	28.74%
Female	139	134	53.26%	51.34%	Public Servant	54	49	20.69%	18.77%
Age (in years)					Manufacturing and Engineering	67	71	25.67%	27.20%
<18	21	18	8.05%	6.90%	Student	43	39	16.48%	14.94%
18–24	58	61	22.22%	23.37%	Other	18	27	6.90%	10.34%
25–34	63	65	24.14%	24.90%					
35–44	89	83	34.10%	31.80%					
45–65	30	34	11.49%	13.03%					
Education					*Main Travel Model*				
High school	82	78	31.42%	29.89%	Walking	11	13	4.21%	4.98%
College/University	118	124	45.21%	47.51%	Private Bicycle	7	10	2.68%	3.83%
Graduate Institute	61	59	23.37%	22.61%	Motorcycle	67	62	25.67%	23.75%
Monthly Income ($US)					Car	28	24	10.73%	9.20%
<344	40	37	15.33%	14.18%	Bus	61	59	23.37%	22.61%
345–1034	112	121	42.91%	46.36%	Rapid Transit System	73	75	27.97%	28.74%
1035–1724	69	61	26.44%	23.37%	Taxi	8	11	3.07%	4.21%
1725–2413	23	27	8.81%	10.34%	Other	6	7	2.30%	2.68%
>2414	17	15	6.51%	5.75%					

Note: U: users, N: non-users.

3.2. Dimensions

The public bike system is perceived as a new transportation technology from the commuter's perspective because, to become a member and to use the system, it is necessary to use the RFID sensor panel and intelligent card. The TAM and TPB are the most significant psychological models of new technology usage, and thus the sustainable modified TAM and TPB and a moderator of general environmental attitude were applied in this study to form items of each variable and to analyze the measurement and structural results of the structural equation modelling (SEM) (Koller et al., 2011; Verhagen et al., 2012; Huijts et al., 2014). The questionnaire was designed using a five-point Likert scale from 1 to 5, where 1 denotes high disagreement while 5 denotes high agreement. The use of a five-point Likert scale is common and acceptable in academic research related to the TAM and TPB, and has been used in numerous prior published papers (Chen et al., 2007; Greaves et al., 2013; Huijts et al., 2014; Chen, 2016). The questionnaire comprises seven variables in the modified TAM, TPB and a moderator. In addition, a number of items also elicited the participants' demographic information, including their age, annual income, gender, and level of education.

Exploratory factor analysis (EFA), confirmatory factor analysis (CFA) and structural equation modeling were applied for scale development purposes (Churchill, 1979; Gerbing and Anderson, 1988). An EFA is performed to obtain scale purification, and enables the identification and purification of the latent constructs of path analysis via an iterative process. A factor is retained if its eigenvalue is greater than 1.0, and the factor loadings of the items in each factor are greater than 0.5 (Hair et al., 2010). After deleting unsuitable items, the eigenvalues indicated a seven-factor solution explaining 74.27% and 72.33% of the variance of the scale, and the communality of each item was relatively high, ranging from 0.515 to 0.803 and 0.505 to 0.744 for users and non-users, respectively. The EFA results of the seven variables and their associated items are described in Table 2.

3.2.1. Perceived green value of public bike use

The studies of Ashton et al. (2010) and Verhagen et al. (2012) address the definition of perceived green value, which is the set of attributes associated with the environmental consciousness value of public bikes, which could create positive word-of-mouth and increase reusing intentions. The ideas of Patterson and Spreng (1997) were used to measure this construct. The evaluation includes four statements: (PGV1) I consider that YouBike's environmental functions have much value for me; (PGV2) I consider that YouBike's environmental performance corresponds to my expectations; (PGV3) I consider that YouBike has more environmental concern than other forms of transportation; and (PGV4) I consider that I utilize YouBike because it is environmentally friendly.

3.2.2. Perceived pleasure to use public bikes

Sweeney and Soutar (2001), Mathwick et al. (2001) and Moon and Kim (2001) consider perceived pleasure to use as an intrinsic belief or motive, which is formed from an individual's experiences of enjoyment and escapism when using public bikes. The ideas of Sweeney and Soutar (2001) and Mathwick et al. (2001) were used to assess perceived pleasure to use, which includes three statements: (PPU1) I consider that the experience of using YouBike is interesting; (PPU2) I consider that riding YouBike makes me relaxed; and (PPU3) I consider that using YouBike makes me forget my troubles temporarily.

Table 2
Factor structure and loadings for EFA.

	Perceived green value		Perceived pleasure to use		Green loyalty		Perceived green usefulness		Subjective norms		Perceived behavioral control		General attitude toward protecting the natural environment	
	U	N												
PGV1	0.876	0.842												
PGV2	0.822	0.786												
PGV3	0.749	0.756												
PGV4	0.817	0.693												
			U	N										
PPU1			0.798	0.703										
PPU2			0.777	0.750										
PPU3			0.717	0.598										
					U	N								
GL1					0.563	0.544								
GL2					0.523	0.679								
GL3					0.600	0.649								
							U	N						
PGU1							0.743	0.589						
PGU2							0.707	0.724						
PGU3							0.636	0.706						
									U	N				
SN1									0.783	0.698				
SN2									0.738	0.687				
SN3									0.830	0.657				
											U	N		
PBC1											0.565	0.787		
PBC2											0.606	0.814		
PBC3											0.519	0.585		
													U	N
GA1													0.639	0.649
GA2													0.678	0.718
GA3													0.711	0.813

Note: U: users, N: non-users; using principal component analysis and orthogonal rotation (varimax) with Kaiser normalization; Loadings below 0.30 are not shown; Total variance extracted by the seven factors for users and non-users = 74.27% and 72.33%.

3.2.3. Green loyalty to public bikes

Green loyalty is interpreted as the degree of reuse intention due to a powerful environmental motive and sustainable commitment to public bikes (Forgas et al., 2012; Chou et al., 2014). The ideas of Chou et al. (2014) were adopted for green loyalty, which consists of three statements: (GL1) I will reuse YouBike owing to its environmental functions; (GL2) I prefer using YouBike to other transportation owing to its environmental performance; and (GL3) I will continue to utilize YouBike because it is environmentally friendly.

3.2.4. Perceived green usefulness of public bikes

Perceived green usefulness is the extent to which an individual believes that public bikes will add to the environmental performance in some part of his/her life within an organizational context (Chen and Chao, 2011; Verhagen et al., 2012). The ideas of Chen and Chao (2011) and Cheng and Huang (2013) were used to evaluate this construct. There are three statements: (PGU1) I believe that using YouBike's environmental performance can improve traffic quality; (PGU2) I believe that using YouBike's environmental functions can make me healthier; and (PGU3) I believe that the quality of the living environment improves after using YouBike.

3.2.5. Subjective norms of public bikes

Subjective norms are defined as the perceived social pressure one feels regarding whether or not to engage in a usage behavior such as riding public bikes (Ajzen, 1991). This construct is based on Chen and Chao (2011), and the evaluation of subjective norms consists of three statements: (SN1) People who influence my behavior think that I should use YouBike; (SN2) People who are important to me will encourage me to use YouBike; and (SN3) Using YouBike will become a symbol that I support environmental issues for the people I know.

3.2.6. Perceived behavioral control of public bikes

Ajzen (1991) deemed perceived behavioral control as the perception that one has the ability to acquire the related resources when, for example, exercising by using a public bike; it is also the set of control beliefs of obtainable technique, resources and chances for performing a behavior such as using public bikes. This construct refers to Wan et al. (2014) to eval-

uate perceived behavioral control. The evaluation includes three statements: (PBC1) I have the relative resources, techniques and knowledge of using YouBike; (PBC2) It is convenient for me to use YouBike; and (PBC3) It is easy for me to use YouBike.

3.2.7. General attitude toward protecting the natural environment

General attitude toward protecting the natural environment refers to the degree to which an individual feels a positive or negative perception related to a pro-environmental orientation (De Groot and Steg, 2010; Koller et al., 2011). These items are based on De Groot and Steg (2010) and Koller et al. (2011), and the three criteria are: (GA1) I think that protecting the natural environment is a wise decision for me; (GA2) I think protecting the natural environment is satisfactory for me; and (GA3) I think that protecting the natural environment is worth encouraging.

4. Results

We performed SEM using AMOS 18.0, as earlier studies have successfully applied SEM to make crucial contributions to the environment and transportation fields (Fyhri and Klæboe, 2009; Chan and Bishop, 2013; Tang et al., 2013; Carreira et al., 2014). Following Anderson and Gerbing (1988), the data were analyzed in two procedures. First, the CFA was explored through the convergent and discriminant validity and the factor loadings of the measurement model. Second, the path coefficients and significance between the constructs of the structural model were also computed. The findings are discussed as follows.

4.1. The measurement model

The descriptive statistics, correlation analysis and the results of the discriminant and convergent validity are presented in the following.

4.1.1. Evaluation of common method variance, reliability and multivariate normality

The correlation coefficient testing proved that there are positive and significant relationships among the seven constructs in Table 3. The factor analysis for the accumulation percentage of explained variance exhibits that each construct can be classified into only one factor, as shown in Table 4. Since we administered two pretests of the questionnaire before providing it to the participants, the content validity of the data is hence appropriate.

In addition, Harman's one-factor test was performed to estimate the existence of common method variance (CMV) (Podsakoff et al., 2003). There are 22 items in the seven constructs. First, these 22 items were analyzed using exploratory factor analysis and the analysis of unrotated principal components to decide the number of factors. Second, the factor that accounted for the greatest variance for the estimated constructs was identified. Seven constructs were found in the exploratory factor analysis. If a general factor can interpret the major part of the covariance between the dimensions, CMV is confirmed to be true (Malhotra et al., 2006). In this research, the eigenvalues of the seven constructs are all greater than 1.0, rather than being a single factor. Nevertheless, the seven constructs constitute 74.27% and 72.33% of the overall variance,

Table 3
Correlations of the constructs.

Constructs	A		B		C		D		E		F		G
A. Perceived green value	–												
	U	N											
B. Perceived pleasure to use	0.292**	0.225**	–										
			U	N									
C. Green loyalty	0.384**	0.349**	0.599**	0.512**	–								
					U	N							
D. Perceived green usefulness	0.291**	0.372**	0.505**	0.492**	0.543**	0.487**	–						
							U	N					
E. Subjectivenorms	0.260**	0.276**	0.447**	0.501**	0.581**	0.591**	0.458**	0.554**	–				
									U	N			
F. Perceived behavioral control	0.370**	0.298**	0.516**	0.540*	0.599**	0.471**	0.588**	0.493**	0.470**	0.452**	–		
											U	N	
G. General attitude toward protecting the natural environment	0.295**	0.469**	0.712**	0.628**	0.602**	0.634**	0.613**	0.537**	0.522**	0.532**	0.595**	0.430**	–

Note: U: users, N: non-users; * shows the significant influence.
** $p < 0.01$.

Table 4
Factor analysis of this study

Constructs	Number of Indicators		Number of factors		Accumulation percentage of explained variance	
	U	N	U	N	U	N
A. Perceived green value	4	4	1	1	71.35	65.32
B. Perceived pleasure to use	3	3	1	1	74.66	71.00
C. Green loyalty	3	3	1	1	68.05	70.67
D. Perceived green usefulness	3	3	1	1	69.19	63.49
E. Subjective norms	3	3	1	1	74.32	71.48
F. Perceived behavioral control	3	3	1	1	65.50	67.55
G. General attitude toward protecting the natural environment	3	3	1	1	80.14	77.69

Note: U: users, N: non-users.

and the most important factor only interprets 20.87% and 16.12% of all the variance for users and non-users, respectively. For this reason, no expansion factor was found in the analysis. That is, there is no status of CMV in this article.

For the measurement analysis, we applied assessment methods to confirm the reliability and validity of the six constructs. The estimation of the reliability was computed via the factor loadings of each dimension's individual items. The factor loadings of all items of the six variables manifested in Table 5 are influential. The other estimation of reliability is Cronbach's α. The Cronbach's α coefficients are listed in Table 5. Generally, the common threshold of Cronbach's α coefficients is near 0.7 (Hair et al., 2010). Here, the ranges of Cronbach's α coefficients of users and non-users are as follows: 0.73–0.87 and 0.71–0.82. Since the Cronbach's α coefficients of all six dimensions are higher than 0.7, the reliability estimation is fitting. For multivariate normality, this work applies the Mardia coefficient to test the situation, and the coefficient should be smaller than $p\,(p+2)$, where p is the number of observed variables (Bollen, 2014). The Mardia coefficients of users and non-users are 110.89 and 154.86, respectively, which are both less than 399 ($p\,(p+2) = 19\,(19+2) = 399$), and the Mahalanobis distances have no obvious differences between observations. There is thus no existence of outliers in the data, hence corresponding to multivariate normality. However, it is also crucial to examine whether the validity of the measurement model is accepted, as is discussed in the following.

4.1.2. Multicollinearity

AMOS was used to examine the multicollinearity status among dimensions. The data manifested no proof of multicollinearity. From the regression analysis, the variance inflation factor (VIF) was implemented to assess the scope of one

Table 5
The descriptive statistics, factor loadings, Cronbach's α coefficients of the constructs and AVEs.

Constructs	Items	Mean		Standard deviation		Factor loadings of each variable		Cronbach's α		CR		AVE		Square root of AVE	
		U	N	U	N	U	N	U	N	U	N	U	N	U	N
A. Perceived green value	PGV1	4.23	4.04	0.68	0.68	0.89	0.85	0.87	0.82	0.86	0.83	0.61	0.55	0.78	0.74
	PGV2					0.84**	0.82**								
	PGV3					0.69**	0.70**								
	PGV4					0.73**	0.57**								
B. Perceived pleasure to use	PPU1	3.92	3.44	0.68	0.60	0.86	0.69	0.82	0.80	0.84	0.80	0.64	0.58	0.80	0.86
	PPU2					0.89**	0.88**								
	PPU3					0.62**	0.72**								
C. Green loyalty	GL1	3.91	3.59	0.64	0.66	0.78	0.81	0.74	0.77	0.76	0.80	0.52	0.58	0.72	0.76
	GL2					0.51**	0.57**								
	GL3					0.88**	0.85**								
D. Perceived green usefulness	PGU1	3.87	3.62	0.69	0.65	0.62	0.64	0.77	0.71	0.78	0.74	0.55	0.51	0.74	0.71
	PGU2					0.80**	0.72**								
	PGU3					0.78**	0.67**								
E. Subjective norms	SN1	3.69	3.44	0.71	0.66	0.81	0.72	0.83	0.80	0.83	0.80	0.61	0.57	0.78	0.75
	SN2					0.76**	0.73**								
	SN3					0.78**	0.80**								
F. Perceived behavioral control	PBC1	3.82	3.26	0.71	0.75	0.61	0.75	0.73	0.76	0.75	0.76	0.52	0.52	0.72	0.72
	PBC2					0.67**	0.74**								
	PBC3					0.80**	0.68**								

Note: U: users, N: non-users; $*$ shows the significant influence.
** $p < 0.01$.

independent variable being involved with another. The VIF value is a common judgment of multicollinearity (Hair et al., 2010). A VIF value should be smaller than or equal to 10, and tolerance should be greater than 0.1 if there is no multicollinearity between independent variables (Asher, 1983). The ranges of VIFs of the five independent variables of users and non-users are 1.19–1.85 and 1.00–1.66 respectively, confirming that there is no further proof of multicollinearity.

4.1.3. Evaluation of validity

The average variance extracted (AVE) is applied to compute the discriminant validity (Fornell and Larcker, 1981), and can estimate the extent of variance produced by the variable through its items as a result of the assessment errors. Discriminant validity is the extent to which a construct with its items is different from another one with its items (Bagozzi et al., 1991). To correspond to the threshold of discriminant validity, the square root of AVE should be greater than the correlation coefficients between all the dimensions in the framework. For instance, the square roots of the AVEs of perceived green value and perceived pleasure to use of users are 0.78 and 0.80, which are greater than the correlation coefficient, 0.29, between the two constructs, as shown in Table 3. The example shows that there is clear discriminant validity between the two constructs.

Besides, the square roots of all AVEs in Table 5 are more than all the correlation coefficients between the dimensions in Table 3. That is, the discriminant validity of this model is obvious. In addition, if the AVEs of the constructs are more than 0.5, all factor loadings are more than 0.5, and each composite reliability (CR) exceeds 0.6, then the convergent validity of these dimensions is fitting (Fornell and Larcker, 1981; Hair et al., 2010). The extents of AVEs of the six dimensions of users and non-users are 0.52–0.64 and 0.52–0.58, as can be seen in Table 5. These values all exceed 0.5. Consequently, the convergent validity of these data is acceptable. It can therefore be inferred that the discriminant validity, composite reliabilities and convergent validity in this study are all acceptable according to the empirical data. Moreover, nomological validity was also tested to identify how well the latent dimensions relate with the theoretical constructs (Churchill and Iacobucci, 2002). This framework and the contents of the dimensions were developed based on the related theories and empirical results. As can be seen in Table 3, it was found that the dimension contents were significantly positively related with the variables (Davis, 1989; Ajzen, 1991; Teo et al., 1999; Moon and Kim, 2001; Hair et al., 2010). Hence, the nomological validity of the framework is also obvious.

4.2. The structural model

This section presents the fit statistics for the structural model of the multi-group analysis, the direct and indirect effects among dimensions, and the results of all of the hypotheses.

4.2.1. Direct effects

The fit assessment of the structural model of the multi-group analysis explains that the fitness of the structure is acceptable after adjustment of the modification indices (GFI = 0.920, RMSEA = 0.034, NFI = 0.915, CFI = 0.966, Chi square ratio = 1.602). The fit statistics are all acceptable, with GFI and NFI both greater than 0.9, CFI exceeds the recommended 0.95, and the chi square ratio falls within the recommended range of 1–3. The empirical model can therefore be interpreted as having an excellent fit (Carmines and McIver, 1981; Marsh et al., 1988; Hu and Bentler, 1999; Little et al., 2002; Hair et al., 2010). RMSEA ranging from 0.01 to 0.05 is considered preferable (Browne and Cudeck, 1993; Hair et al., 2010), and thus the RMSEA in this model is acceptable. Some coefficients of the hypotheses examined are positive and significant, only one path is not significant for users, and two paths are not supported for non-users, as shown in Table 6. More paths in the model do not apparently improve the fitness, and the covariance residuals of the dimensions are close to zero. In the multi-group

Table 6
Results of the structural model for users and non-users.

Path	Effect		Coefficient		Result	
	U	N	U	N	U	N
PGV to PPU	+	+	0.35**	0.29**	Supported	Supported
PGV to PGU	+	+	0.36**	0.46**	Supported	Supported
PGV to SN	−	+	0.33**	0.36**	Supported	Supported
PGV to PBC	+	+	0.46**	0.39**	Supported	Supported
PGV to GL	+	+	0.13*	0.16*	Supported	Supported
PPU to GL	+	+	0.39**	0.36**	Supported	Supported
PGU to GL	−	+	−0.06	0.09	Not supported	Not supported
SN to GL	+	+	0.17*	0.43**	Supported	Supported
PBC to GL	−	+	0.36**	0.06	Supported	Not supported

Note: PGV: perceived green value, PPU: perceived pleasure to use, GL: green loyalty, PGU: perceived green usefulness, SN: subjective norms, PBC: perceived behavioral control; +: a positive effect, −: a negative effect; U: users, N: non-users; ∗ shows the significant influence.

* $p < 0.05$.

** $p < 0.01$.

analysis, the chi-square test was used to measure the model estimates, and the results prove that they are not significantly different (χ^2 difference = 16.2; $p > 0.05$).

Fig. 2 shows that perceived green value has greater effects on green loyalty via perceived behavioral control and perceived pleasure to use than via subjective norms ($0.33 * 0.17 < 0.35 * 0.39 < 0.46 * 0.36$). Consequently, the complete model of the modified TAM model and TPB for users is shown in Fig. 2. Since most paths and all t values are supported and significant, and only one path is not significant for the framework, the findings can be interpreted as showing that stronger perceived green value not only considers users' or consumers' strong sense of environmentalism, but also propels the dimensions of perceived pleasure to use, subjective norms, perceived behavioral control and perceived green usefulness, while perceived behavioral control has the second most important influence on green loyalty. The findings also indicate that perceived pleasure to use is the main variable for managing consumption relationships and affecting green loyalty to public bikes from the significant path coefficients shown in Fig. 2. The quantitative implications are that perceived pleasure to use, subjective norms and perceived behavioral control can positively produce green loyalty to public bikes. Moreover, the data support the above statements and exhibit that perceived pleasure to use, subjective norms and perceived behavioral control have a powerful effect on green loyalty to public bikes.

For non-users, seven paths and their t values are supported and significant, while two paths are not effective, as shown in Table 6. The tests completely support H1, while H2 and H3 are partly significant, as shown in Fig. 3. The comparison between users and non-users indicates that subjective norms are the most important variable for green loyalty for non-users, while perceived green value also has a direct effect on green loyalty, and H1 is completely significant for both users and non-users.

It is interesting that perceived green usefulness shows no effect on green loyalty for either users or non-users. The reasons for this may be that: (1) public bikes are regarded as a short-distance transit mode; and (2) the bike infrastructure and access are neither sufficiently widespread nor convenient. These two conditions are likely to be the main reasons why perceived green usefulness cannot produce the interviewees' sustainable loyalty to public bikes. Users' feelings of enjoyment have a stronger influence on their sustainable loyalty, and the opinions of relatives and friends are more influential for non-users in the modified TAM and TPB. This result is similar to Koller et al. (2011), but the current work focuses on the loyalty of sustainability for public bike usage based on a sustainable modified TAM and TPB. Furthermore, perceived behavioral control has a meaningful effect on green loyalty only for users.

4.2.2. Indirect effects

This study also found that perceived pleasure to use, subjective norms, and perceived behavioral control are the mediative dimensions between green loyalty and perceived green value. The three effects of a bootstrapping test between perceived green value and green loyalty for users and non-users of the public bike system are listed in Table 7. Zero is not included between the lower and upper values of the two methods for the total, direct or indirect effects, so the three effects are significant between the two variables (Shrout and Bolger, 2002; Hayes, 2013). These results suggest that strengthening riders' perceived green value, perceived pleasure to use, subjective norms and perceived behavioral control can influence their green loyalty because of the significance of the mediative effects. Increasing users' feelings of enjoyment and non-users' advice from relatives and friends so as to develop their green loyalty to use public bikes is thus a critical goal.

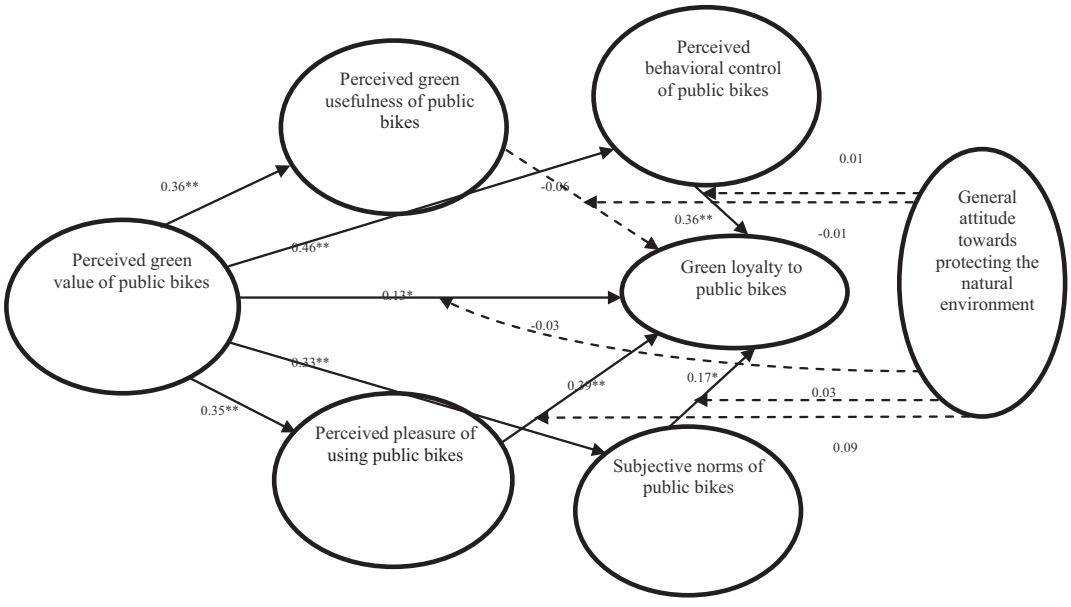

Fig. 2. The modified TAM model and TPB of the full model for users. *Note:* * shows the significant influence. $^{*}p < 0.05$; $^{**}p < 0.01$.

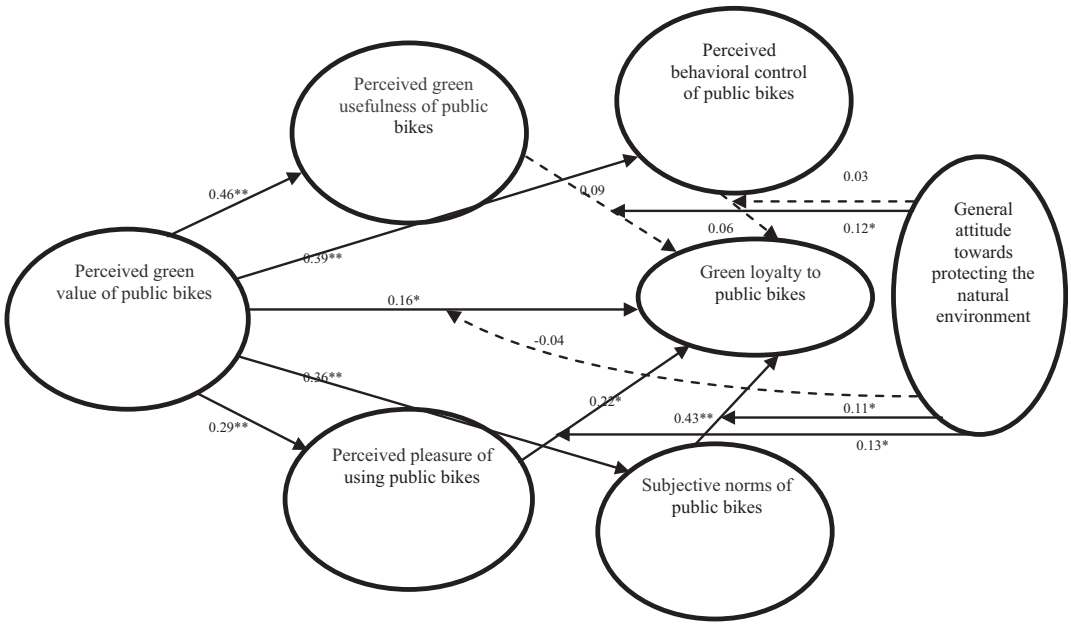

Fig. 3. The modified TAM model and TPB of the full model for non-users. *Note:* ∗ shows the significant influence. $^{*}p < 0.05$; $^{**}p < 0.01$.

Table 7
Results of the bootstrapping test between perceived green value and green loyalty

Effects between perceived green value and green loyalty	95% confidence interval of bias-corrected method		95% confidence interval of percentile method	
	Lower	Upper	Lower	Upper
Total effects	U 0.30	0.78	U 0.32	0.81
	N 0.30	0.59	N 0.30	0.60
Direct effects	U 0.04	0.32	U 0.05	0.32
	N 0.06	0.27	N 0.06	0.27
Indirect effects	U 0.24	0.53	U 0.24	0.54
	N 0.17	0.46	N 0.14	0.42

Note: U: users, N: non-users.

Table 8
Results of GA moderation for users and non-users.

Between	Effect		Coefficient		Result	
	U	N	U	N	U	N
PGV and GL	–	–	−0.03	−0.04	Not supported	Not supported
PPU and GL	+	+	0.09	0.13*	Not supported	Supported
PGU and GL	–	+	−0.01	0.12*	Not supported	Supported
SN and GL	+	+	0.03	0.11*	Not supported	Supported
PBC and GL	+	+	0.01	0.03	Not supported	Not supported

Note: PGV: perceived green value, PPU: perceived pleasure to use, GL: green loyalty, PGU: perceived green usefulness, SN: subjective norms, PBC: perceived behavioral control, GA: general attitude toward protecting the natural environment; +: a positive effect, –: a negative effect; U: users, N: non-users; ∗ shows the significant influence.

* $p < 0.05$.

4.3. The moderation results of users and non-users

The general attitude toward protecting the natural environment is established to test the moderation effectiveness of green loyalty via subjective norms, perceived pleasure to use, perceived behavioral control, perceived green usefulness, and perceived green value for public bikes, as listed in Table 8. The moderation extents are ineffective between the five constructs and green loyalty for users ($\Delta R^2 = 0.001$, $\beta = 0.030$, and $p > 0.05$; $\Delta R^2 = 0.008$, $\beta = 0.094$, and $p > 0.05$; $\Delta R^2 = 0.000$,

$\beta = 0.013$, and $p > 0.05$; $\Delta R^2 = 0.000$, $\beta = -0.007$, and $p > 0.05$; $\Delta R^2 = 0.001$, $\beta = -0.034$, and $p > 0.05$). The data explain that the attitude of protecting the natural environment does not have effective power to influence users' norms from relatives and friends, perceived enjoyment, perceived behavioral control, environmental usefulness, or perceived green value on green loyalty, as shown in Fig. 2. This study indicates that environmental attitude can moderate the path between subjective norms, perceived pleasure to use, perceived green usefulness and green loyalty for non-users ($\Delta R^2 = 0.010$, $\beta = 0.101$, and $p < 0.05$; $\Delta R^2 = 0.015$, $\beta = 0.127$, and $p < 0.01$; $\Delta R^2 = 0.012$, $\beta = 0.116$, and $p < 0.01$), which means that a stronger attitude can reinforce the relationships between these three variables and green loyalty for non-users. However, this influence is not obvious for usage ability or for perceived green value influencing green loyalty, as shown in Fig. 3 ($\Delta R^2 = 0.001$, $\beta = 0.033$, and $p > 0.05$; $\Delta R^2 = 0.001$, $\beta = -0.040$, and $p > 0.05$), and shows that attitude is not a moderator between perceived behavioral control, green perception and green loyalty for non-users.

5. Discussion

Governmental policies can constantly provide new forms of green transportation and push to have them accepted by consumers or users so as to improve the environment and to correspond to the prevailing green thinking. This work therefore addresses six concepts from the green modified TAM and TPB, and explores their causal relationships in the context of public bikes. Green loyalty was found to be the later construct produced by the other five preceding dimensions.

The findings show that public bike users' perceived green value, perceived pleasure to use, perceived behavioral control and subjective norms are positively connected to their green loyalty, and perceived green value could also directly generate the three constructs: perceived behavioral control, subjective norms, and perceived pleasure to use. From the empirical results, public bike riders' feelings of enjoyment have a greater influence on their green loyalty, and suggestions from relatives and friends for non-users are more critical in the modified TAM and TPB.

Consequently, the relevant managerial implications are that governmental policies should invest more resources in raising users' perceptions of public bikes being fun and enjoyable via improved facilities, by simplifying the use of the system, and by increasing the chances to use the bikes so as to enhance users' environmental awareness and loyalty to long-term green behaviors. These implications can also be seen in the lower factor loadings of users' perceived behavioral control and perceived pleasure to use. Policies could encourage citizens to recommend this environmentally-friendly travel mode to their friends, relatives and social contacts, and emphasize the fun and relaxation experienced when riding the bikes, which could then result in greater green loyalty on the part of non-users. Because perceived behavioral control and subjective norms still reveal significant positive effects on users' green loyalty, government policies should consider both dimensions, such that the strengthening of support for relatives and friends and of the usage methods and techniques of public bikes can continue developing the sustainability of the earth. For non-users, the encouragement of relatives and friends or others' recommendations and judgments is more crucial than perceived pleasure to use for green loyalty.

Furthermore, the implementation of such policies would achieve an effect of different customer segments from the different moderation influences of users and non-users. The relationships between the five constructs and green loyalty are not positively moderated via the general attitude toward protecting the natural environment for users. The analysis shows that the attitude of protecting the environment does not have an influential impression on users, who in fact focus on more realistic usage perceptions in the modified TAM and TPB. The moderation findings also show that this attitude can strengthen the effectiveness of the feelings of fun or enjoyment, environmental usefulness, and support of friends for non-users of public bikes. In fact, this attitude is more obvious for non-users because they may have an ideal expectation of protecting the natural environment before using the public bike system. The moderation results of protecting the environment have a more significant increase for non-users. From the analysis, governmental policies can increase related advertising to emphasize the importance of protecting the natural environment to evoke non-users' positive feelings, usefulness enhancement, and advocacy by influential people to attract sustainable usage loyalty. Ideally, policies should focus on how to strengthen users' actual usage perceptions such as perceived pleasure to use and perceived behavioral control of the public bike system.

Some theoretical implications of this study are worth discussing: (1) the correlation of the fourth indicator of perceived green value is lower, meaning that non-users perhaps do not consider public bikes to be more environmentally-friendly than other forms of transportation; (2) the correlations and means of the second indicator of green loyalty are lower, meaning that users and non-users may want to decrease their use of other forms of transportation, but the decrease is not obvious; (3) the correlations and means of the first indicator of perceived green usefulness are lower, showing that neither public bike users nor non-users have sufficient confidence in the system improving the traffic environment because it may not decrease their usage of other forms of transportation; (4) the correlations and means of the third indicator of perceived pleasure to use are lower, meaning that both users and non-users can feel interested and relaxed when using this form of transportation, but it is not apparent that they can forget their troubles while riding the bikes; (5) the correlations and means of the first indicator of perceived behavioral control are lower, meaning that users and non-users think the usage knowledge and techniques should be enhanced when using public bikes; (6) the correlation of the third indicators of perceived behavioral control is lower, meaning that non-users think that using the system may not be so simple; and (7) the true enjoyable experiences of users and adopting the viewpoints of influential others for non-users are obvious in the data.

Although this article mainly discusses the relationships between green consciousness and green loyalty for the modified TAM and TPB, perceived pleasure to use is in fact a much stronger dimension than the others, as can be seen in Figs. 2 and 3.

However, the main contribution of this study may differ from those of other research. For example, one study focused on the perception of benefitting the environment which can lead to individuals having an obvious propensity to purchase organic wines; however, perceived green usefulness had no effect in that study (Olsen et al., 2012). The current study found that perceived behavioral control has critical effects on green use loyalty for users, but Barber et al. (2014) argued that consumers are often less willing to pay more money for environmentally-friendly products through a controlled auction experiment.

In this investigation, most of the participants were women, which is similar to the prior study of Beecham and Wood (2014), which revealed via Recency–Frequency (RF) segmentation that female users prefer using streets with slower and better traffic, and cycle routes slightly offset from major roads. Our results are also consistent with the findings of Handy et al. (2014), whose review of studies indicated that distance, bike infrastructure, bike access, bike equipment, cost and social environment are critical usage factors for cycling. The results of this study reveal that bike infrastructure quality, cost and access can influence perceived green usefulness, perceived behavioral control, perceived green value, and perceived pleasure to use, and that social environment can influence subjective norms. Hence the significant contributions are similar to those of these two studies.

Other studies have also performed SEM analysis and found that environmental cues had greater effects than non-environmental cues on interest in luxury restaurants, and perceived pleasure apparently influences behavioral intentions (Hyun and Kang, 2014). An analysis of satisfaction with travel revealed that high levels of satisfaction would be obvious for people using bikes in an urban area (Friman et al., 2013). Positive emotions and travel satisfaction revealed much stronger significant effects than negative emotions on usage loyalty of a mid-distance bus transportation service (Carreira et al., 2014). Positive consumer attitude and peer pressure were also found to have greater influences on intention to purchase sports shirts that were transported using energy efficient fuel (Schniederjans and Starkey, 2014). Service availability of perceived behavioral control, government actions regarding subjective norms, and positive environmental awareness have all been found to significantly affect acceptance intentions of sustainable public transport (Khoo and Ong, 2015). Positive attitudes toward cycling and interest in bicycle usage have more effects on intention to use bike-sharing for holiday cycling (Kaplan et al., 2015). All of these studies make similar contributions via SEM analyses regarding sustainable consciousness, positive emotions and the influence of others' suggestions on both users and non-users.

When people make a consumption decision between equipment attributes and greenness, they are likely to respect real attributes rather than greenness (Darnall et al., 2008). The implications of this are that governmental policies could supply public bikes that offer a high level of pleasure value to create greater green loyalty to the bikes. For the supported hypotheses, it is also suggested that governmental policies heighten users' and non-users' perceived pleasure to use, subjective norms, and perceived behavioral control as attributes of public bikes, which is similar to Darnall et al.'s (2008) recommendation. Nevertheless, this study found that perceived green value can generate perceived pleasure to use, subjective norms, and perceived behavioral control in many cases of public bike systems.

It should be noted that this study highlights three further areas of research. First, only the usage experience of public bikes was explored; therefore, further research can assess the user behaviors of other forms of green transportation and compare their findings. Second, future work can use different external variables such as the service quality dimension. Third, since this study explored the hypotheses using questionnaires, only cross-sectional findings were arrived at; the data could not manifest the dynamic results in different periods of public bike use through vertical sectional analysis. It is thus suggested that future investigations can use a vertical sectional approach to study the paths between the six constructs for public bikes over a period of time. These theoretical contributions could generate crucial enlightenment in the area of green transportation psychology.

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