World Conference on Transport Research - WCTR 2016 Shanghai. 10-15 July 2016

Influence of psychological factors on mode choice behaviours: Case study of BRT in Khon Kaen City, Thailand

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Abstract

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Keywords: Theory of Planned Behavior, Latent Variables, Bus Rapid Transit and Mode Choice Behaviors.

1. Introduction

In traditional choice models, individual travel mode choice is modeled both as a function of individual characteristics of the decider such as age, gender, income and attributes of the travel mode choice alternatives such as travel time, travel cost etc. Travel mode choice is conceptualized as a function of these solely directly measureable variables. (Temme, Paulssen and Dannewald, 2007)

However the recent work in choice models has emphasized the importance of the explicit treatment of psychological factors affecting decision-making. (See, for example, Koppelman and Hauser, 1979; McFadden, 1986a; Ben-Akiva and Boccara, 1987; Ben-Akiva, 1992; Ben-Akiva et al., 1994; Morikawa et al., 1996) (Ben A-kiva, 1997). A guiding philosophy in these developments is that the incorporation of psychological factors leads to a more behaviorally realistic representation of the choice process, and consequently, better explanatory power and can help to understand the decision process underlying modal choice. (Ben A-kiva, 1997; Domarchi, Tudela and Gonzalez, 2008).

The meta-analysis of psychological factors affect mode choice reveals that variable derived from the Theory of Planned Behavior (TPB) and habit displayed large effect on behavior (Gardner and Abraham, 2008). The TPB is a widely used behavioral decision theory that has received good empirical support in applications to a variety of domains (see, for example, Bamberg, Ajzen and Schmidt, 2003; Long, Choocharukul and Nakatsuji, 2010; Ching and Wei, 2011; Chen and Lai, 2011; Donald, Cooper and Conchie, 2014). The TPB explains that travel behaviour is determined by three rational determinants: attitude, subjective norm and perceived behavioral control. In contrast to rational determinants, some researchers argued that habitual behaviour has stronger influence on behavior intentions (Verplanken et al., 1998; Chen and Lai, 2011)

In Khon Kaen, Thailand, the Bus Rapid Transit System (BRT) is planned to operate to solve traffic problems in the city. It is a new system which has specific lanes, uses NGV energy that will provide environmental friendly, convenient and standard service. There are 5 routes of BRT run cover urban area of Khon Kaen City and has feeder system along BRT stations (show in Figure1.) (SATIENNAM, T. et al., 2013). In the figure 1, the red line of BRT is used as the main route transit service in the north-south of highway.
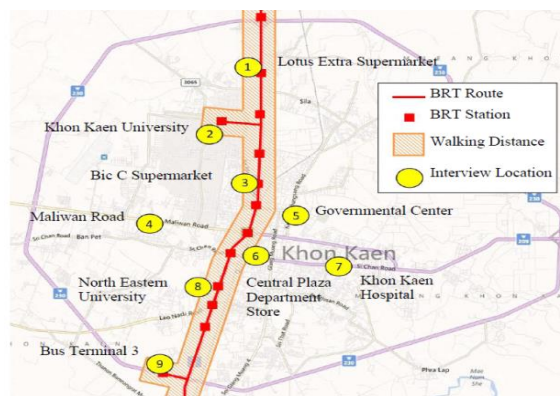

Fig. 1. Bus Rapid Transit planning location in Khon Kaen City

This study, therefore, utilized the TPB to explain the intention of using BRT in the selected study area of Khon Kaen city, Thailand. As well as, integrated latent variables (some TPB and habit) together with service attributes as explanatory variables, in order to explore the effects of psychological factors on mode choice behavior of choosing Bus Rapid Transit (BRT) system.

2. Review

2.1. Mode choice with latent

Recent advances in modeling discrete choice can be incorporated unobservable psychological factors such as a desire for flexibility in addition to directly observable variables such as individual characteristics in choice models. (Ben-Akiva et al., 1994) Extending choice models with latent variables like value or attitudes can lead to a more realistic representation of the choice process taking place in the consumer's "black box" and should thus provide greater explanatory power (Domarchi, Tudela and Gonzalez, 2008). In the area of choice modeling, researchers have used various techniques in an effort to explicitly capture psychological factors in choice models. One frequency used approach is to first perform factor analysis on the indicators, and then use the fitted latent variables in the utility, as shown in Figure2. (See, for example, Prashker, 1979; Ben A-kiva, 1997)
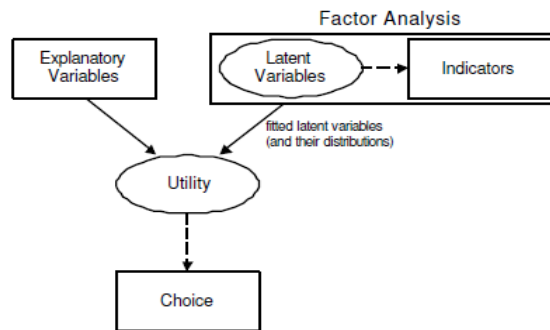

Fig. 2. Sequential Estimation: Factor analysis followed by a choice model. (Ben A-kiva, 1997)

2.2. Psychological Factors Influencing Mode Choice Behavior.

The meta-analysis of 23 unique dataset which measured car use behavior and/or intentions revealed that variable derived from TPB and habit on behavior displayed large effect on behavior (Gardner and Abraham, 2008). Recent research works as shown in Table 1 also support these findings.

Table 1. Psychological factors influencing mode choice behaviour .

Name	Objective	Technique	Variables	Findings
Bamberg, Ajzen and Schmidt (2003)	Investigate an intervention—introduction of a prepaid bus ticket on increased bus use among college students.	SP/RP	TPB and Past Behavior	PBC and past behavior were found to a strongly influence students' intentions to take the bus to the campus.
Domarchi, Tudela and Gonzalez (2008)	Examine the effect of psychological factors combine with socio-economic, in order to obtain information about the traveller and chosen mode.	RP	Attitude, Habit and affective appraisal	The attitudinal variables had a strong influence on mode choice as well as strong habit highly influenced to mode use.
Carrus, Passafaro and Bonnes (2007)	Examined the role of attitude, subjective norm, perceived behavioral control, habit etc. in prediction of using public transport instead of car to go to work.	RP	attitude, subjective norm, perceived behavioral control, habit etc.	Past behaviour and desire were highly factor to predict intention to use public transport instead of car to go to work.
Long, Choocharukul and Nakatsuji (2010)	Study to the motorcyclist's intentions to use future urban rail transport in Phnom Penh, Cambodia.	SP	TPB include Social and Economic factors	PBC and attitude were the factors to predict intention of using future sky train.
Chen and Chao (2011)	Study the switching intentions toward public transit by private vehicle users	RP	TPB, Technology Acceptance Model	The habitual behavior of private vehicle use hinders an

	(both car and motorcycle users).	(TAM) and Habit	individual's intention to switch from a car or motorcycle to public transit.
Chen and Lai (2011)	Explore the effects of rational and habitual factors on mode choice behaviors in a motorcycle dependent region.	RP	TPB include Social and Economic factors	Psychological (rational and habitual) factors have stronger influences on mode choice behaviors than socio-economic factors, and furthermore that habitual factors explain traveler mode choice behaviors better than rational ones.
Tyrinopoulos and Antoniou (2013)	Investigate the variables that affect to the habitual modal choices of commuters and reasons that discourage them from using public transport service.	RP	Habit, socio-economic factors and latent variables	The main factor affecting to habit of using public transport is availability of parking space. In contrast the crowding is factor that most discourage from the use of public transport.
Donald, Cooper and Conchie (2014)	Study (TPB) model within the domain of transport mode choice and identified the most important factors impacting on participants drove or used public transport to commute to work.	RP	TPB and habit	TPB variables (attitude, subjective norm and PBC) influenced use of both transport modes indirectly through their effects on intention and habit.
Jaensirisak and Pongmesa (2015)	Investigate the possibility of integrating road pricing with Bus Rapid Transit (BRT) to alter mode choice behaviour.	SP	Habitual behaviour and captive attitude	Most private vehicle users had habitual behaviour and captive attitude on their mode however, if BRT system is integrated with road pricing measures it will reduce habitual behaviour and captive attitude.

2.3. The Theory of Planned Behavior

The Theory of Planned Behavior (TPB) was developed from the Theory of Reasoned Action (TRA) by Icek Ajzen, 1991. Principle of TPB is human behavior affected via their intention. The intention was affected from 3 factors including attitude towards the behavior, subject norm and perceived behavioral control as shown in Figure 2. **Attitude towards the behavior** is determined by behavior beliefs that are the overall person's general feeling to their behavior. **Subject norm** is determined by normative beliefs that are person's perceptions from people who are important to them think he should or should not perform behavior. **Perceived behavioral control (PBC)** is determined by Control beliefs that are feeling difficult or easy to perform behavior.
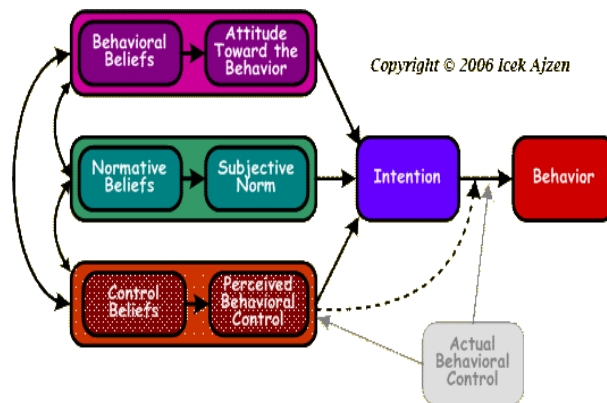

Fig. 3. Framework of TPB

2.4. Habit

Habitual behaviour identified in the choice of private vehicle travel affect the selection changes of travel patterns of private vehicles users (Jaensirisak and Pongmesa, 2015). Habits are characterized by three features: automaticity, situation constancy, and functionality (Verplanken and Aarts, 1999; Chen, Garling and Kitamura, 2004).

Verplanken and Aarts (1999) argued that habits are also functional in the sense that they are being performed for achieving a certain purpose. Habits are results of repeated experiences and under most cases, those experiences must be pleasurable to the individual performer, as otherwise, the individual will not want to perform it repeatedly if it is a painful experience (Chen, Garling and Kitamura, 2004). This is the origin of Verplanken's frequency-response habit measure.

3. Methodology

The questionnaire consists of three parts. Part 1 collects the respondent's socio-economic information. Part 2 measures the respondent's psychological factors including TPB's constructs and habitual constructs. Finally, part 3 contains details of travel time and travel cost about the mode of transport chosen for traveler.

3.1. Stated Preference design (Jaensirisak and Pongmesa, 2015)

Stated preference (SP) techniques are based on the presentation of hypothetical scenarios that are plausible and realistic to respondents. Each scenario represents a package of different attributes. The design process of an SP experiment can be summarised in four steps:

(a) Selection of a set of attributes. The characteristics of the hypothetical scenarios are represented by attributes that influence preferences.

(b) Specification of the number and magnitude of the attribute levels. Variations of the attribute values across scenarios need to be large enough for respondents to trade-off, otherwise they may be ignored.

(c) Experimental design – combination of the attribute levels. Design of the hypothetical scenarios is based on an experimental design which is usually fractional factorial rather than complete factorial. A complete factorial design contains all possible combinations of the attribute levels. A great advantage of the fractional factorial design is that the number of scenarios can be dramatically reduced from the full factorial design, while it still ensures that the main effects of the attributes are independent from the significant interaction effects, so that the main effects can be estimated efficiently.

(d) Design of response measurement. Respondents are asked to state their preferences towards each scenario. These responses are able to provide information based on how individuals evaluate the attributes in the designed scenarios.

In addition to the SP experiment, other components are also needed in a survey, for example questions gathering individuals' actual travel situations relevant to the study context, questions about the attributes of existing alternatives, questions about attitudes to alternatives, and personal details. These additional data are useful in analysis of SP data and explanation of the behavioural responses.

In this study, total cost and total time of vehicle use, travel time on BRT, and BRT fares were used as the attributes in the SP experiment. Levels of the attributes were selected according to possible values of travel time on BRT and BRT fares. A combination of the attribute levels included nine scenarios presented to respondents. For each observation, respondents were asked to choose their current travel mode or BRT. Three SP experiments were designed for private vehicle user (car and motorcycle groups) and existing public transport user.

3.2. Theory of Planned Behaviour design

The TPB standard direct measurements according to Ajzen (2006) and Jillian J Francis et al. (2004) involve measuring of four constructs including attitude, subjective norm, and perceived behavior control and intention. There are total 16 items for the measurement of 4 constructs as follow:

Attitude Attitude towards the behavior was measured by four items: ''For me to using BRT would be: bad/good, unpleasant/pleasant, support/unsupported and harmful/beneficial." Cronbach's alpha was 0.819.

Subjective norm Subjective norm was measured by four items. This can be measured in 2 kinds. The first kind is descriptive norm which concerns perceptions of others' use of BRT. It was measured by 1 item: "Most of people who are important to me intend to use BRT". The second kind is injunctive norm which concerns the perceptions of important people want he/she to use BRT. It was measured by 3 items :"Most people who are important to me would support my using the BRT", "Most people in social expect me to use BRT" and "Most people who are important to me think that I should/should not use BRT." Cronbach's alpha was 0.719.

Perceived behavioral control (PBC) PBC was measured by four items. This can be measured in 2 kinds. The first kind of these measures is Self-efficacy. It was measure by 1 item: "I am confident that if I want to I could take BRT". The second kind measured Controllability. It was measured by 3 items: "For me, to take the BRT would be easy–difficult", "Whether or not I intend to take BRT is completely up to me", "My freedom to take the BRT is high–low." Cronbach's alpha was 0.740.

Intention finally, intention was measured by four items. "My intention to use BRT is strong–weak," "I intend to use BRT: likely–unlikely," "I plan to use BRT: likely–unlikely," "I will make an effort to use BRT." Cronbach's alpha was 0.928.

All these items are measured by using a five-point likert scale from 1; strongly disagree to 5; strongly agree. The four TPB constructs were calculated by the four corresponding item mean and used in subsequent analyses.

3.3. Habit design

Habits to use private vehicle were measured by response-frequency measures (Verplanken and Aarts, 1999; Chen and Chao, 2011; Chen and Lai, 2011). The respondent were asked to indicate which mode (i.e. motorcycle, car and public transport) they would choose for nine trips with different purposes, including work/study, meeting/contact work, visit friend, shopping, go to see the movies, eat in restaurant, engage in sports, go to the hospital, go outside city. The habits strength are measured from the frequency of the reported private vehicle trip (1-9).

3.4. Data collection and sample characteristics

The data collection was conducted from March to April 2015 by personal interviews at major places, such as educational institutions, department stores, bus terminals and government offices. The data set available for modelling purposes (incompletes were removed) contained 215 private car users, 220 motorcycle users, and 165 public transport users, making a total of 600 individuals, and 4,158 SP observations. Respondents' characteristic are shown Table 2.

Table 2. Respondent profile

Characteristics		Percent
Age (years)	Lower than 21	17
	21-30	71.4
	More than 31	11.6
Gender	Male	41.4
	Female	58.6
Income (Bath/month)	Lower than 5,000	20.6
	5,000-10,000	41.8
	More than 10,000	37.6
Career	Students	72.5
	Government officers	7.0
	Business persons	9.7
	Others	10.8
Distant from house to BRT station	Lower than 400m	22.5
	More than 400m	77.5
Travel mode use	Car	35.3
	Motorcycle	36.2
	Public transport	28.5

3.5. Modeling issues

The analytical model consists into 2 parts, first in order to determine the predictors of intention to use a BRT, hierarchical regression analysis are employed. Then a discrete choice model used to examine the effects of psychological factors of choosing BRT.

The linear regression model of BRT use intention (Int) is specified (Chen and Lai, 2011) as Equation 1.

$$Int = f(ATT, SN, PBC, H) \tag{1}$$

Where the independent variables, ATT, SN, PBC, and H denote attitudes, subjective norm, perceived behavioral control and habit, respectively.

Mode choice behaviour affected by the system features of travel time and cost was analyzed by the logit model. Each of the 600 respondents was presented with nine scenarios and asked to choose his/her own private vehicle (personal car or motorcycle) and public transport or BRT for their journeys to destinations. The utility functions for these responses were set as Equation 2.

$$V_{PC} = ASC_{PC} + t \cdot (Total\ TravelTime)_{PC} + c \cdot (Total\ Travel\ Cost)_{PC}$$
$$V_{MC} = ASC_{MC} + t \cdot (Total\ TravelTime)_{MC} + c \cdot (Total\ Travel\ Cost)_{MC}$$
$$V_{PT} = ASC_{PT} + t \cdot (Total\ TravelTime)_{PT} + c \cdot (Total\ Travel\ Cost)_{PT}$$
$$V_{BRT} = t \cdot (Total\ TravelTime)_{BRT} + c \cdot (Total\ Travel\ Cost)_{BRT} + Ps \cdot (TPBfactor) + h \cdot (habit) \tag{2}$$

The utility function for existing mode is set as a function of the alternative specific constant (ASC), travel time and travel cost. The ASCs are included in order to allow for a preference effect for one alternative over the others, all other things being equal. For the utility of BRT use is a function of travel time, BRT fare and latent factors consist of TPB factors and habit.

4. Results and discussion

Results of this study are presented in three parts. Firstly, respondent's psychological factors are reported in section 4.1 in order to explain the rational on each mode. Secondly, regression model was used to reveal the effect of psychological factors influencing intention to use BRT. Finally, in section 4.3, the BRT choice behaviors of existing private vehicle users (personal car users and motorcycle users) and existing public transport user were developed basing on the Stated Preference (SP) data. The utility functions of Logit models include service attributes as explanatory variables and psychological factors as latent variables.

4.1 Psychological factors

Table 3 reports the psychological factors. The four latent variables derived from TPB direct measure include attitude, subjective norm, perceived behavioral control, and intention to use BRT. For the attitude, it is found that all users think that BRT is good, pleasant, support, and beneficial (ATT: Mean= 4.07, SD= 0.53). For the subjective norm, they think that people who are important to them will use BRT and support them to use BRT (SN: Mean= 3.57, SD= 1.01). In term of the perceived behavioral control, they think that they have self-efficacy to use BRT and controllability over the use of BRT (PBC: Mean= 4.00, SD= 0.37). Finally, for the intention, it was found that all users intend to use BRT (INT: Mean= 3.64, SD= 0.49).

Comparing existing private vehicle users (personal car users and motorcycle users) and existing public transport users, this study found that the rating of TPB's variables of the public transport users were higher than those of private vehicle users. It should be noted that existing public transport in Khon Kaen city has a poor service and inconvenient (SATIENNAM, T. et al., 2013). These may presents a barrier to use the existing public transport. However, the BRT as a new alternate mode with good service will fascinate the existing public transport user to shift to BRT.

Considering habit variable, it is found that all users have a strong habit to use private vehicle in their daily life (Habit: Mean= 7.94, SD= 1.93). This is due to poor existing public transport service as afore-mentioned. Besides, motorcycle users are available as an affordable mean of transportation for all users. However, the habit of the public transport users is lower than those of private vehicle users. This implied that the private vehicle users are more captive to their vehicle than the public transport user.

Table3. Psychological factors

	All users (n=600)		Car (n=215)		MC (n=220)		PT (n=165)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Attitude (ATT)	4.07**	0.53	4.09**	0.66	4.06**	0.68	4.29**	0.69
Subjective Norm (SN)	3.57**	1.01	3.48**	0.73	3.61**	0.67	3.63**	0.63
Perceived Behavioral Control (PBC)	4.00**	0.37	3.77**	0.69	3.89**	0.63	3.96**	0.58
Intention (Int)	3.64**	0.49	3.54**	0.89	3.71**	0.79	3.86**	0.78
Habit_Private vehicle	7.94**	1.93	8.63**	1.16	8.32**	1.39	6.53**	2.55

**t-test is significant at the 0.01 level.

4.2 BRT use intentions

Regression model was estimated to examine intention to use BRT. Prior to the test of hypotheses, specific collinearity statistics between variables were checked. Correlations among latent variables are shown in Table 4. The independent variables with high correlation (r>0.5) (Gardner and Abraham, 2008) will not be used in the same model. From table 4, it is found that subjective norm and perceived behavioral Control factors have high correlation. Therefore only one factor would be added into the model.

Table4. Correlations between latent variables

	Habit_Private vehicle	ATT	SN	PBC	INT
Habit_Private vehicle	1				
Attitude (ATT)	-0.16[**]	1			
Subjective Norm (SN)	-0.08[**]	0.40[**]	1		
Perceived Behavioral Control (PBC)	-0.17[**]	0.41[**]	0.62[**]	1	
Intention (Int)	-0.19[**]	0.47[**]	0.71[**]	0.671[**]	1

** Correlation is significant at the 0.01 level.

In the block, attitude, subjective norm, perceived behavioral control and habit were inserted as predictors. The results of model without/and with habit variable are displayed in Table 5. The results show that the model (3) which considers attitude, subjective norm and habit can explain 56 percent of the variance for intention. The TPB factors had positively significant while habit on private vehicle had negative significant to intention to use BRT. It should be noted that the most important factors are subjective norm. This study provides support for the predictive of the TPB factors in relation to transport mode choice (Donald, I. J et al., 2014; Ching-Fu Chen., 2011; Nordfjaern, T. et al., 2014).

Table5. Effect of psychological factors on BRT use intentions

Variables	Model without habit variable, β		Model with habit variable, β	
	Model (1)	Model (2)	Model (3)	Model (4)
Attitude (ATT)	0.219**	0.236**	0.202**	0.230**
Subjective Norm (SN)	0.626**	-	0.623**	-
Perceived Behavioral Control (PBC)	-	0.573**	-	0.565**
Habit	-	-	-0.111**	-0.061**
Adjused-R^2	0.551	0.496	0.563	0.500

** Correlation is significant at the 0.01 level.

4.3 Mode choice model

The data from personal car (PC) users, motorcycle (MC) users and public transport (PT) users were analysed in base model (Table 6) and model with latent variables (Table7) respectively. These models demonstrate the effects of latent variables on mode choice bahaviour.

Table 6 is base model which considers only modal attributes (travel time and travel cost). The results showed the coefficients of travel time and travel cost have negative significant effect on mode choice. When everything else is equal, motorcyclist and public transport users prefer to use BRT than their existing mode (ASCs are negative sign). The personal car users, on the contrary, prefer to use their existing mode though it has not significant.

From Table 7, the analyses also showed that the model with latent variables is significantly better than the one without the variables. Model (1) and (2) includes TPB factors and habit, there are found that the effect of the attitude, perceive behavioral control and the habit are not significant in the models. Then only the subjective norm is taken into model (3). The results showed that the subjective norm has significant positive effects on BRT use behavior. This is confirming that the mode choice behavior was affected by the TPB variable especially from the perceived social norm.

Table6. Parameters of mode choice model for traveller without latent variables.

Variables	Model without latent variables, β	
	Coefficient	t-ratio
ASC_MC	-0.970*	-9.83
ASC_PC	0.233	1.64
ASC_PT	-0.925*	-12.00
Time	-0.146*	-26.13
Cost	-0.042*	-10.32
Observations	4,158	
ρ^2	0.619	
Log Likelihood	-2189.44	

Table7. Parameters of mode choice model for traveller with latent variables.

Variables	Model with latent variables, β					
	Model (1)		Model (2)		Model (3)	
	Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
ASC_MC	-1.050*	-2.79	-0.314	-0.90	0.125	0.55
ASC_PC	0.144	0.36	0.859*	2.324	1.315*	5.31
ASC_PT	-0.915*	-2.57	-0.207	-0.60	0.191	0.86
Cost	-0.042*	-10.30	-0.042*	-10.30	-0.042*	-10.32
Time	-0.146*	-26.11	-0.148*	-26.19	-0.148*	-26.23
Attitude	0.072	1.20	-0.050	-0.84	-	-
Subjective Norm	-	-	0.319*	5.17	0.305*	5.35
PBC	-0.013	-0.19	-	-	-	-
Habit_private vehicle	-0.038	-1.67	-0.034	-1.52	-	-
Observations	4158		4158		4,158	
ρ^2	0.619		0.622		0.622	
Log Likelihood	-2187.033		-2173.498		-2174.929	

5. Conclusion

Choice model usually assumes that travellers choose a travel mode basing on service attributes and their socioeconomic characteristics. Currently, some research found that psychological factors significantly influenced individual mode choice decision. These factors included in utility function could improve the developed mode choice models with higher correlation. Thus, this study integrates psychological factors according to Theory of Planned Behaviour and habit as latent variables together with service attributes as explanatory variables, in order to explore the effects of psychological factors on mode choice behaviour of choosing Bus Rapid Transit (BRT) system.

The planned BRT project in Khon Kaen city was selected as a case study. A total of 600 private vehicle and public transport users were randomly surveyed by a Stated Preference (SP) exercise and psychological questionnaire that measured a series TPB factors and habit to use private vehicle. Hierarchical regression analysis is employed to determine the latent predictors of intention to use a BRT. The BRT choice behaviours of existing private vehicle users (personal car users and motorcycle users) and existing public transport user were developed basing on the Stated Preference (SP) data. The utility functions of Logit models include service attributes as explanatory variables and psychological factors (Attitude, Subjective Norm, Perceived Behavioral Control, Intention and Habit) as latent variables.

The results showed that the TPB factors accounted for a significant part of the variance in the intention to use BRT. Intention of using BRT was determined by subjective norm and weak effect of habit on private vehicle. Moreover, the effects of the psychological factors influencing on mode (BRT) choice behaviors was affected by both of service attribute factors and perceived social norm. Some factor reflects personal car users are captive to their vehicle with little consideration of alternative modes. Therefore, the development of a public transport system needs to consider personal psychology factors affecting mode choice behaviour. The findings of this study would help to understand commuter's behavior and suggest for BRT planning in Asian developing countries where motorcycles and cars are dominant modes of travel.

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