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Influence of psychological factors in mode choice decision making: A structural equation modeling approach

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Abstract

This study investigates the influence of psychological factors in the mode choice of private or public transport among commuters. Theory of Planned Behavior (TPB) was adopted as a theoretical basis for incorporating the influence of psychological factors in mode choice decision making. TPB is a theory designed to predict and explain human behavior in specific contexts. Attitude, subjective norm, perceived behavioral control and intention are the factors considered in TPB. A questionnaire survey was conducted among 400 commuters in the city of Calicut, Kerala, India. Structural equation modeling was adopted to test the relations stated in the Theory of Planned Behavior. ‘Attitude’ was identified as the most significant factor influencing the intention to use public transit. The results of the study are useful to obtain a better understanding of mode choice behavior.

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Keywords: Theory of Planned Behavior; Mode choice behavior; Private and Public transport; Structural Equation Modeling.

1. Introduction

Vehicles are one of the major inventions that have a significant influence on human progress. Private vehicle usage has improved the ease of travel, in terms of flexibility of movement and door to door connectivity. With the improvement in economic growth of nations, affordability of private vehicles has increased and there is a significant hike in private vehicle ownership and usage especially in developing countries. The total number of registered motor vehicles in India has increased from 0.3 million as on 31st March, 1951 to about 159.5 million as on 31st March, 2012. The total registered vehicles in the country grew at a compound annual growth rate of 9.9% between 2001 and 2011 (TERI, 2015). A nation-wide study by the Ministry of Urban Development in 30 cities in India found that the

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share of public transport is declining and the two-wheelers constitute 60-70 percent of registered motor vehicles in most cities, as per 2001 figures (MoUD, Wilbur Smith Associates, 2008). However, increasing private vehicle usage has led to a plethora of problems such as road traffic congestion, depleting fuels, deteriorating environmental quality etc. One of the remedies to these problems is to promote public transport patronage, through enhancing public transit facilities. Hence, there is a necessity to identify the factors which can influence the mode choice of private and public transit modes in developing countries like India.

Mode choice models are commonly used to identify the influence of socio-demographic factors, service attributes etc. on the mode choice decision making (Fatima and Kumar, 2014, Redman et al., 2013, Satiennam et al., 2016, Aditya et al., 2017). The demand for public transit is influenced by factors such as fares, quality of service, income and car ownership (Paulley et al., 2006). Travel time, travel cost, gender, age, driving license holding, residential location, waiting time and number of transfers involved in using public transport, comfort etc. are the various socio-demographic and service attributes which are important and commonly used in most of the studies (Jou and Chen 2014, Satiennam et al., 2016; Aditya et al., 2017).

Recent works have proved the importance of attitudes and perceptions in determining the mode choice decision making. Beirao and Cabral (2007) identified the advantages and disadvantages of public transport, as perceived by people and also identified the motivations and barriers to public transport usage, based on the qualitative analysis of the data obtained from a questionnaire survey. The study concluded that public transit should be promoted as a positive experience. Redman et al., (2013) concluded that while service reliability and frequency are important public transit attributes in general, those attributes most effective in attracting car users are largely affective and connected to individual perceptions, motivations and contexts. Wang et al., (2013) examined the perceptions of public transit service performance, private car service performance and the level of importance of various attributes during commuting. Fu and Juan (2014) used a latent segmentation approach to segment the people based on their attitude and potential for transit usage.

Recent works in mode choice models have emphasized the importance of the explicit treatment of psychological factors in mode choice decision making (Kaewklunlong et al., 2017). Psychological factors can significantly influence the individual decision making process. Incorporation of the influence of psychological factors in mode choice decision making have proved to give better results and develop better understanding of mode choice behavior. Rastogi and Madhavan (2012) used structural equation modelling to assess the influence of the factor construct titled 'mode preference' on mode choice behavior of leisure travelers. Numerous psychological studies have examined interaction between attitude and behavior such as the Theory of Planned Behavior (TPB) by Ajzen (1991). The Theory of Planned behavior is a theoretical model to predict the human behavior, in which cognitive self-regulation is considered important. A central factor in TPB is the individual's intention to perform behavior. Intentions are indications of how hard people are willing to try, in order to perform behavior. According to TPB, performance of behavior is controlled by intention and perceived behavioral control (Ajzen, 1991). The intention is affected by three factors which include 'attitude', 'subjective norm', and 'perceived behavioral control'. Attitude is a person's favorable or unfavorable evaluation of a particular behavior under concern. Subjective norm is determined by a person's perceptions, from people who are important to them, about how he should or should not behave. Perceived behavioral control refers to people's perceptions of the ease or difficulty of performing the behavior of interest. The relationships in TPB are shown in Figure 1.

Anable (2005) used the Theory of Planned Behavior (TPB) to segment a population of day trip travellers into potential 'mode switchers' using cluster analysis. The work done by Chen and Chao (2011) was based on the Theory of Planned Behavior and it presented an integrated model by taking into account both rational and habitual variables for mode choice. Variables considered included 'attitude', 'subjective norm', 'perceived behavioral control' and 'intention' to use public transit. Idris (2015) studied the effect of psychological factors and the relative importance of attributes of the service in determining the mode choice behavior. Structural equation modeling was adopted to incorporate the effects of psychological factors in mode choice decision making.

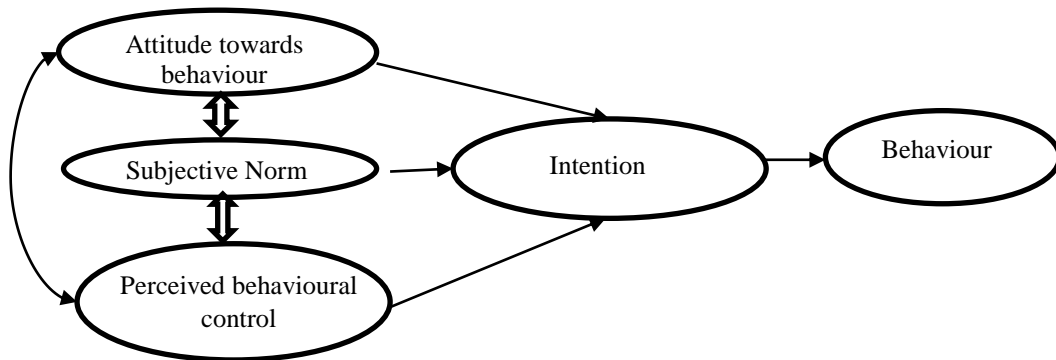


Fig. 1. Theory of Planned Behavior (Source: Ajzen, 1991)

Chowdhury and Ceder (2013) used the TPB to investigate the role of ‘perceived behavioral control’ in determining the traveller’s intention to use public transport routes with transfers, using structural equation modeling. Liu et al., (2016) used the TPB to evaluate the roles of policy acceptance and other factors in commuter’s transport mode decisions. Li et al., (2016) suggested that the TPB serves as a good predictor of the intention to competitive driving behavior. Structural Equation Modeling (SEM) was used to model the relation between the latent factors based on the TPB. Papaioannou and Martinez (2015) modeled binary choice between public transit and private car using structural equation modeling to examine the influence of accessibility and connectivity in mode choice. Thorhauge et al., (2016) derived the psychological factors on the TPB, estimated them based on structural equation modeling, and included them into discrete choice model for departure time choice. Kaewklungklom et al., (2017) examined the intention and choice behavior of using the newly introduced public transportation (BRT) in Asian developing countries. The study was based on the TPB and used psychological factors and habit as latent variables, along with service attributes such as travel time, travel cost etc. in mode choice equations. Among the latent variables considered in the study, ‘subjective norm’ was identified as the most important and significant variable.

From the literature review, it can be inferred that the psychological factors can significantly influence the mode choice decision. In an Asian developing country like India, the rate of private vehicle usage is increasing on an alarming rate and the government is focusing on suitable mode shift policies so as to increase the public transit patronage and thereby reduce private vehicle usage. The increasing trend of private vehicle usage in India calls for detailed studies to determine the factors which influence the mode choice of private and public transport modes. Very few works have addressed the influence of psychological factors in mode choice in Indian context. This study is adopted to develop detailed understanding of the influence of psychological factors in mode choice decision of private and public transport by using Theory of Planned Behavior (TPB) as a theoretical frame of reference. It is inferred that structural equation modeling can be used as an efficient tool to model the relations among the latent variables stated in the TPB. It is also observed that the influence of the factors considered in the TPB, varies among different studies (Kaewklungklom et al., 2017). This study is also useful to understand the relative importance of various psychological factors in mode choice behavior, in an Indian context.

2. Methodology

2.1. Study area

Calicut city, which is the third largest city in Kerala, India is taken as the study area. Calicut is one among the largest urban areas in the state. The city has a reasonably well developed transport infrastructure.

2.2. Design of questionnaire

Work place interview was adopted for the study, since the study focuses on the commuter trips. The method of data collection adopted for this study was face-to-face interview technique. Questionnaire was developed based on the factors influencing the mode choice identified from the literature review. Questionnaire was designed to collect household information, personal information and travel related information, in addition to the data on psychological factors. The ‘Theory of Planned Behavior’ was adopted as a theoretical foundation to consider the effects of psychological factors in mode choice of private and public transport. The TPB standard direct measurements involved measuring four variables including ‘attitude’, ‘subjective norm’, ‘perceived behavioral control’ and ‘intention’. A total of fourteen statements were used for the measurement of the above variables and the respondents were asked to rate the statements in a five point Likert scale i.e., ‘strongly disagree’, ‘disagree’, ‘neutral’, ‘agree’, ‘strongly agree’ and the corresponding scores were -2, -1, 0, 1 and 2 respectively. The statements used are given in Table 1. The format for these statements to measure data on psychological factors were designed based on experience from the literature review (Anable 2005, Idris et al. 2012, Kaewklungklom et al. 2017). But, it was subjected to several modifications after conducting several pilot studies. The direct application of such statements developed from literature review was not effective in capturing data from the study area.

‘Attitude’ towards public transit was measured by four statements. These statements were intended to measure the positive attitude of the commuter towards public transit, i.e., whether he perceives public transit to be beneficial / easy/ favors the use of public transit and whether he is satisfied with the existing facilities. The ‘attitude’ towards private vehicle was also measured since the positive attitude towards public transit may not be the sufficient to determine their intention to use public transit. These statements for attitude towards private vehicle capture the dependency of the commuter towards private vehicle and also the perceptions on safety in using private vehicle. Subjective norm is a social factor, which refers to the perceived social pressure to perform or not to perform the behavior under concern, i.e., the use of public transit. Subjective norm was measured by a single statement which is based on the perception of commuter regarding any restrictions from family or society towards using public transit for daily commutation. Perceived behavioral control was measured by three statements which were intended to collect the perceptions on easiness or difficulty in using the public transit. Intention is a factor which concerns about how hard people are willing to try in order to perform the behaviour and it was measured by two statements which captures the strong intention to use public transit.

Table 1. Statements used to measure the psychological factors

Statements	Psychological factor
1. I like travelling by public transit (S1)	Attitude towards public transit (PT attitude)
2. I think public transit can sometimes be easier than driving (S2)	
3. For me to use public transit is beneficial (S3)	
4. I am satisfied with the public transit facilities (S4)	
1. I need a car/ two-wheeler to do many things I like to do (S5)	Attitude towards private vehicle (PV attitude)
2. I feel that travelling by a car/two-wheeler is safer than by bus (S6)	
3. I feel that getting to work without a car/ two-wheeler is irritating (S7)	
4. I think that owning a car/two-wheeler is a symbol of prestige (S8)	
1. Most people who are important to me would support me using public transit(S9)	Subjective norm
1. I am confident that if I want to I could take the public transit(S10)	Perceived behavioral control
2. For me to take the public transit would be easy (S11)	
3. Whether or not I intend to use the public transit is completely upto me (S12)	
1. I will make an effort to use public transit (S13)	Intention
2. My intention to use public transit is strong (S14)	

After assigning the values for the responses given by the respondents, corrections for Leniency and Central tendency errors were applied. Leniency error is the tendency of an interviewee to give higher or lower preference about the characteristics. Central tendency error is the tendency of an interviewee to give the preference as average and not to use the extremes. Leniency error can be found out by subtracting mean of all single ratings from the mean of the individual rater. Central tendency error is determined by subtracting standard deviation of all single ratings from the standard deviation of the individual rater. The first four statements were used to measure the transit favoring attitude of the people and the latent factor is termed as ‘PT attitude’. The next four statements were used to measure the ‘private vehicle favoring attitude’ of the people and the latent factor is named as ‘PV attitude’.

2.3. Data collection and Sample Characteristics

Data collection through face-to-face direct interview was carried out in the city of Calicut from March to April 2018. Only work trips were considered for the study, since the study focuses on the commuter trips. About 450 samples were collected and after data cleaning, 50 samples were rejected and the data obtained from 400 respondents were used for detailed analysis and modeling. Simulation research has shown that with a good model and multivariate normal data, a reasonable sample size is about 200 cases (Boomsma,1998, Hox and Bechger,1999). So, the sample size of 400 is justifiable for the purpose of modeling. The data was subjected to preliminary analysis for household information, personal information and travel related information. The average household size of the sample was 4.31. The average vehicle ownership per household was 1.74. About 67.75% of the sample had vehicle for exclusive use and 76.25% of the sample had driving license. The respondent characteristics are shown in Table2.

Table 2. Respondent characteristics

Characteristics		Percent
Age	Lower than 26	13.5
	26 to 40	43.5
	Above 40	43
Gender	Male	62.75
	Female	37.25
Career	Government employee	71.5
	Private employee	23
	Daily wages	4.25
	Business	1.25
Personal monthly income	Less than Rs.20,000	35.5
	Rs.20,000 to Rs.50,000	50.75
	Above Rs.50,000	13.75
Travel mode	Bus	48
	Car	14.25
	Two-wheeler	37.75

2.4. Categorization of sample based on TPB factors

As given in Table 1, the first four statements are used to identify the attitude of respondent towards public transport. So, average of ratings for the first four statements gives the ‘transit favoring’ (PT attitude) score for a particular respondent. Likewise, scores for other factors such as ‘Private vehicle dependent’ (PV attitude), ‘subjective norm’, ‘perceived behavioral control’ and ‘intention’ are also calculated. The average scores for the factors calculated for the whole sample are given in Table 3.

Table 3. Average scores for the latent factors

TPB factor	Transit favoring attitude (PT attitude)	Private vehicle dependent attitude (PV Attitude)	Subjective norm	Perceived behavioral control	Intention
Average score for the sample	0.42	-0.37	0.75	0.78	0.98

From Table 3, the average score values for the factors except ‘private vehicle dependent attitude’ (PV attitude) are found to be positive. This implies that, the sample have a positive evaluation of transit service, and have good support from society to use public transit, and they perceive it as easy to use. Based on the average scores for the whole sample, categorization of the sample was done. A person with a score for perceived behavioral control greater than 0.78 is considered to perceive public transit as easy to use and is given the group name as ‘PT-Easy’, while those with score less than 0.78 is considered to perceive public transit as difficult to use and is given the group name as ‘PT-Difficult’. Similarly, for ‘intention’, if the score of a respondent is greater than the 0.98, the person is considered in the group of ‘High intention’ to use the public transit, otherwise as ‘Low intention’ to use the public transit. For, subjective norm, if the score is greater than 0.75, the respondent is included in the group of ‘Good support’ from society to use public transit, else, in the group of ‘Poor support’ to use public transit. To find out the dominant travel attitude of a respondent, deviation from the weighted average is calculated, i.e., his/her scores corresponding to the two travel attitudes, ‘transit favoring’ and ‘private vehicle dependent’ are subtracted from its respective average scores. Then, the maximum value of deviation among these two travel attitudes is identified. This is identified as the dominant travel attitude of particular respondent. Figure 2 through Figure 5 show the categorization of the sample, based on the TPB factors.

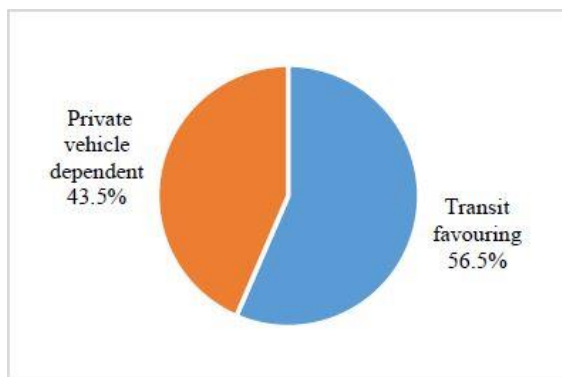


Fig. 2. Attitude

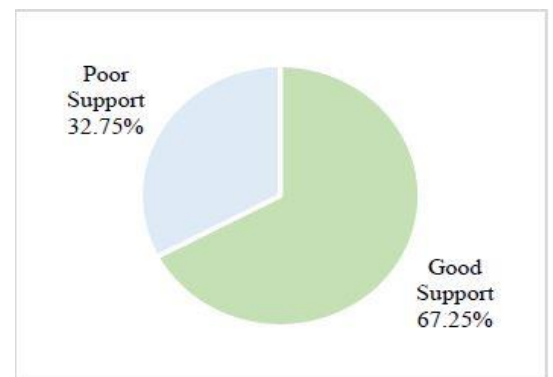


Fig. 3. Subjective norm

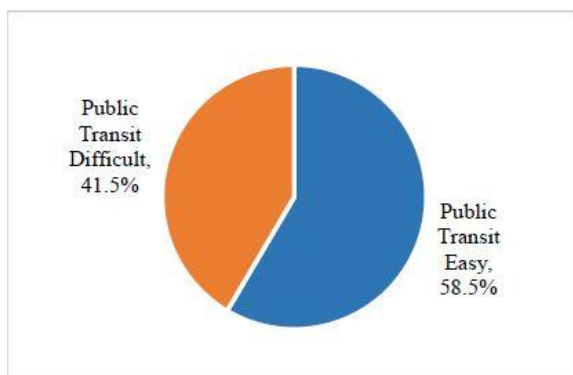


Fig. 4. Perceived behavioral control

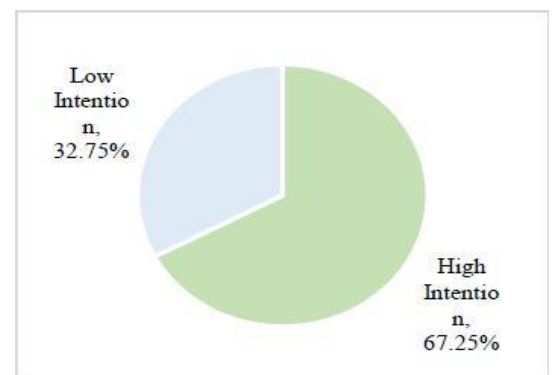


Fig. 5. Intention

Figure 2 show that 56.5% of the sample has transit favoring attitude. Bus users contributed to only 48% of the sample, while 56.5% of the sample has transit favoring attitude. This shows that a significant portion of the private vehicle users have a transit favoring attitude and if adequate public transit facilities are provided, there is a possibility of attracting private vehicle users towards the public transit. A similar trend is observed for all the three factors ‘subjective norm’, ‘perceived behavioral control’, and ‘intention’. This suggests that society is having positive attitude about the use of public transit facilities.

3. Structural equation modeling

In order to assess the influence of the psychological factors in mode choice of private or public transport modes and to test the validity of the relations in the Theory of Planned Behavior, a Structural Equation Model (SEM) formulation was used. SEMs can handle indirect and multiple relations (Papaioannou and Martinez, 2015) and the response variable in one regression equation may appear as a predictor in another equation. SEM can be viewed as a combination of factor analysis and regression or path analysis. The latent variables are modeled by specifying a measurement model and a structural model. The measurement model represents the relationships between the latent variables and the corresponding observed indicator variables. A structural model specifies the relationships among the latent variables.

A structural model is developed for the whole sample of 400 respondents. Confirmatory factor analysis is done as the modeling is based on the stated relations in the Theory of Planned Behavior. The latent variables include attitude, subjective norm, perceived behavioral control and intention. Attitude towards public transit and private vehicle are measured separately by using two variables- ‘PT attitude’ and ‘PV attitude’ respectively. The mode of travel for work trip of the respondent was known in advance. The variable mode choice behavior was used as a binary variable, which takes the value ‘1’ for public transit user and ‘0’ for private vehicle user. The observed indicator variables are represented as S1, S2, and S3 etc. The structural model developed for the sample is shown in Figure 6 and the unstandardized regression weight estimates, along with standard error and critical ratio are tabulated in Table 4. The level of significance is based on the critical ratio of the regression estimate. Thus, when critical ratio values are greater than or equal to 2.58, it indicates a 99 percent level of significance (Biswas et al., 2006, Hox and Bechger, 1999).

Table 4 . Regression weight estimates

Dependent variable	Independent variable	Estimate	Standard Error	Critical Ratio
Intention	<--- PT attitude	0.276	0.077	3.577
Intention	<--- PV attitude	-0.490	0.061	-7.966
S1 (Likes travel by public transit)	<--- PT attitude	1.000		
S2 (Public transit easier than driving)	<--- PT attitude	1.037	.280	3.703
S4 (Satisfied with transit facilities)	<--- PT attitude	0.153*	0.153	1.002
S5 (Need a private vehicle for daily works)	<--- PV attitude	1.000		
S6 (Private vehicle safer than transit)	<--- PV attitude	1.018	.124	8.187
S7 (getting to work without private vehicle is irritating)	<--- PV attitude	1.333	.152	8.760
S8 (Private vehicle is a symbol of prestige)	<--- PV attitude	0.417	0.090	4.613
S10 (Confident to use transit service)	<--- PBC	1.000		

S12 (Independent decision making in using transit)	<---	PBC	0.640*	0.576	1.111
S13 (Make effort to use transit)	<---	Intention	1.000		
S14 (strong intention to use transit)	<---	Intention	1.171	0.069	16.850
Mode choice behavior	<---	PBC	0.257*	0.231	1.110
Mode choice behavior	<---	Intention	0.630	0.092	6.882

* Not significant at 99% level of significance

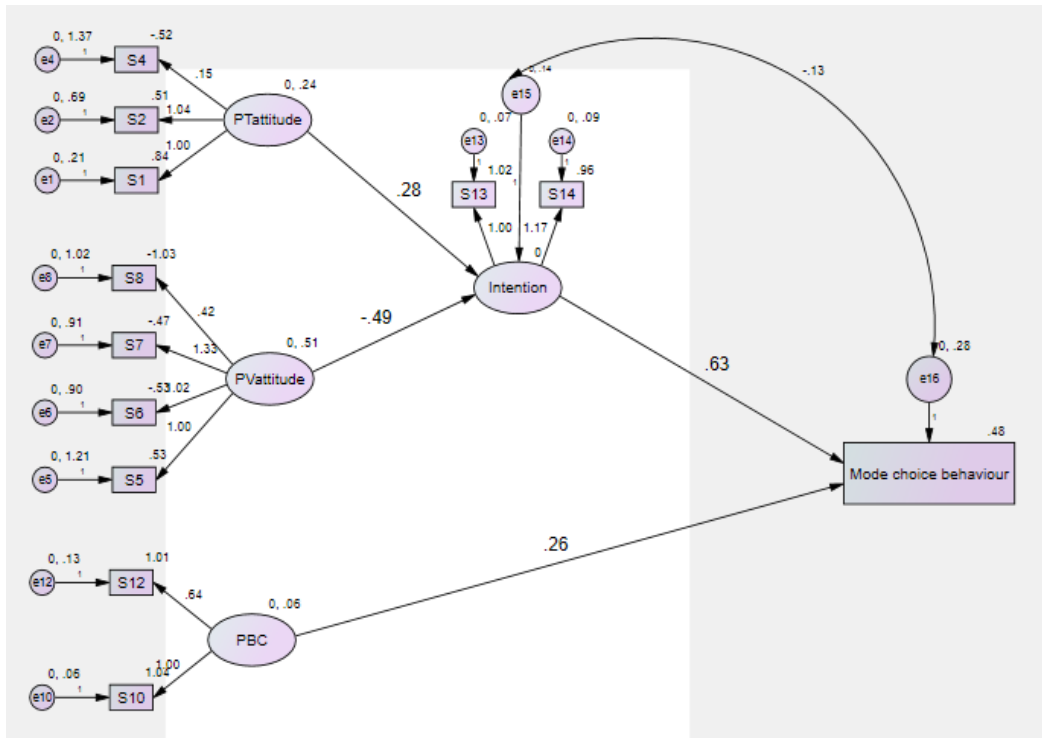


Fig. 6. Structural model with latent variables

4. Discussions

The various relations stated in the TPB are tested in the structural model. Intention to use public transit is a significant factor in mode choice behavior. Intention has a positive relation with mode choice behavior, which implies that as intention to use public transit increases, the mode selected will be public transit. Two kinds of attitudes were measured - positive attitude towards public transit (represented by ‘PT attitude’) and the positive attitude towards the private vehicle (represented by the variable ‘PV attitude’). The ‘PT attitude’ has a positive significant influence on the intention to use public transit. It implies that as the transit favoring attitude of the people increases, the intention to use public transit increases. The ‘PV attitude’ has a negative significant influence on the intention to use public transit. This implies that as the private vehicle dependency of people increases, the intention to use public transit decreases. Comparing the magnitudes of regression weight estimates, the influence of ‘PV attitude’ (-0.49) has stronger influence on the intention to use public transit as compared to the ‘PT attitude’. This implies that even if a person considers public transit more easy to use than driving by self or likes using public transit, but he considers private vehicle as very important for his daily works, their intention to use transit will be less.

The latent variable ‘subjective norm’ is excluded from the model, since the influence on the intention is not significant and the regression coefficient is near to zero. The latent variable ‘perceived behavioral control’ has no significant influence on the intention to use public transit. The relation between the PBC and the mode choice is positive, but insignificant. Even though this relation is not significant, the PBC is retained in the model considering the model fit. Statements S3 and S11 are excluded from the model, since the regression coefficients are not significant and nearly approached zero and their removal improved the model fit. All the statements are significantly influenced by the latent variables, except S4 and S12. As per the model, the ‘attitude’ is the most significant factor influencing the intention to use the public transit.

Commenting on the model fit, the model has a chi-square value of 204.579 with degree of freedom as 50. The relative chi-square value is obtained as 4.092, which is less than the acceptable threshold of 5. The Normed Fit Index (NFI) value is obtained as 0.829, while the Comparative Fit Index (CFI) value is obtained as 0.863. Values of NFI and CFI closer to one indicate good model fit. The Parsimonious Normed Fit Index (PNFI) value is 0.628, which is slightly above the acceptable limit of 0.5. The Root Mean Square Error of Approximation (RMSEA) value is 0.088, which indicates a mediocre model fit (Browne and Cudeck, 1992, Ambak et al., 2011, Idris et al., 2012).

5. Conclusions

Travel mode choices are influenced by socio-demographic characteristics, attributes of the trip and trip maker, service attributes of the mode etc. Psychological factors also have significant influence on the mode choice of private or public transport. This study tested the relations stated in the Theory of planned Behavior in determining the mode choice behavior. Categorization of the sample based on TPB factors is useful for identifying the composition of sample based on the psychological factors. The variables considered were attitude, subjective norm, perceived behavioral control and intention to use public transit. The relative importance of the variables, vary among different studies. This study revealed the importance of ‘attitude’ in determining the mode choice behavior. The private vehicle favoring attitude was found to have a stronger influence on the intention to use public transit as compared to that of public transit favoring attitude of the people. Thus, it can be concluded that improvement of public transit facilities alone will not result in an increased mode share of public transit. Introduction of policies which restrict the use of private vehicles like congestion charging, parking pricing etc. are also needed to reduce the dependency of people on private vehicles and make them shift to improved transit facilities. Subjective norm and perceived behavioral control were not significant in determining the intention to use public transit. Intention to use public transit has a positive significant influence on the mode choice behavior of selecting public transit, while the influence of perceived behavioral control is insignificant. The results from the structural equation modeling can be useful to develop advanced mode choice models using latent variables. Although social factors or personal information are not studied in this research, it is suggested that it is considered in the future work.

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