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UNDERSTANDING COMMUTERS MOBILITY NEEDS AND PROMOTION OF PUBLIC TRANSPORT

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Understanding Commuters Mobility Needs and Promotion of Public Transport

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CHAPTER 1 Introduction

1.1 Rationale

Promotion of public transport is one of the key measures for providing sustainable mobility in cities. It is naturally perceived that the movement of large amount of commuters would be best accommodated by public transport, to gain movement efficiency (able to carry a large amount of demand with less consumption of resources such as land area, energy, etc.). This is also true for growing cities where more population and travel demand are expected while the existing traffic congestion is yet to be solved. The promotion of public transport can be done in several ways, both engineering and management actions. The promotion includes the provision of higher capacity public transport system (such as the introduction of new rail transit, bus rapid transit or BRT), the integration of existing public transport systems (rail, feeder, bus, water transport), the regulation and promotion of information transport (motorcycle taxi, passenger vans, etc), the economic measures such as price incentive. Apart from higher quality of services, the promotion of public transport has two broad demand implications: 1) to shift (or divert) its demand from other modes to ride on public transport, especially from regular motorists, and 2) to attract new trip makers (induced) or even those in the next generation to use public transport. The promotion of public transport can also target to those who are at the developed area near the public transport system and thus making the “captive” riders from these land development. With all these demand and use, public transport will become the main transport mode in the city, making the best use of resources (energy, land) and produce less undesirable impact (pollution, GHG), making the cities mobile and productive and bringing the sustainability to urban travel and living.

It is evident that many cities around the world are losing public transport patronage and Bangkok is one of them. In many cities, public transport patronage is decreasing while the mode share on private vehicle usage is increasing. This evident implies several matters. First, the future of urban mobility is not sustainable. The number of patronage is decreasing while the number of, say, private vehicle motorist is increasing. The road transport will become busier to accommodate greater amount of travel, causing more problems on roads. Secondly, the unpopular public transport makes lower quality of public transport services, since public transport generally requires an amount of riders to gain sufficient revenues and stay in operations. With less demand, it is feasible to improve operational services, or expand the coverage of the services. From Bangkok transport statistics, the popularity of public transport is decreasing. Even though a new rail transit can draw many riders and the number of passengers continues to increase, the degree of the increase in the ridership is not as high as expected. Thus, the decline of public transport patronage will call for urgent actions to attract more demand for existing and future public transport services.

It is a need to understand the needs of commuters for travel in order to better promotion and attraction of people to use public transport. Despite the availability and introduction of many

public transport services around the world, many trip makers are not selecting public transport as their choice of travel. This can be postulated that these services cannot fulfill their requirement of their travel. It is also unfortunate that most of the planning or study conducted before the implementation of a public transport service normally presume many of basic requirements in traveler's behaviors. Using the conventional study methodology, most studies aim to capture the amount of demand based on aggregate (quantitative) methods, without studying the real needs for travel. Moreover, the demand is then fitted in the predetermined public transport service attributes.

It is a need to study a proper way to conduct the survey to understand the needs of commuters and travel behaviors. The study on the travel behaviors that could imply the needs for public transport is prerequisite for the better promotion of public transport usage. It is believed that the understanding on people needs for travel (commute) and the decision to select a public transport mode is vital part of the success of promotion of public transport. In this research, the study to understand the real needs of people on their mobility and how public transport could fit in their needs are conducted. The travel behaviors are believed important to understand the needs of travelers. With focus on travel behaviors, many "internal" factors are carefully investigated. The research aims to find the reasons behind the selection of mode(s) of travel, their constraints, the decision mechanism, as well as the linkage between attitudes and behaviors.

1.2 Objectives

The objectives of this research are as follows:

1. To examine the commuters' behaviors and constraints/requirements for their travel.
2. To investigate perception of existing public transport systems.
3. To identify the attitudes toward transit.

1.3 Methodology

Broad methodology for this research is described below:

- Review and summary of basic theories used for the study
- Identify target group and target area
- Data collection design and survey
- Analyses
- Implications

Detail on the methodology will be presented with corresponding literature in the subsequent chapter.

CHAPTER 2 Literature Review

Since the aim of the research is to gain the understanding on travel decision on mode selection and the linkage between their needs and travel behaviors, the study must be carefully determined to portray all these requirements. The study now focuses on the adoption of psychological as well as choice theory to investigate the factors affecting the travel decision, especially the choice for traveling mode. With this prerequisite, few quantitative techniques are introduced to determine all internal factors behind the decision. These are for examples revealed preference (actions), attitudes, travel constraints, decision mechanism, desirable service attribute, and potential use of public transport. The results from analyses should not only gain the answers for the understanding on travel needs, but also the implications to public transport promotion and the self-evaluation on the goodness of the findings.

This chapter provides literature review as well as the selected methodology to be reviewed and used in this study. The literature review focuses on the fundamental knowledge needed for this study, including theories and past research studies. Then the proposed methodology of the research is presented. Literature review and study plan are also presented for data collection and analyses activities. The reviewed theory, study approach, and analysis techniques are presented in order to ascertain the outcomes of the study can meet the research objectives.

The explanation on literature review and study plan is shown according to the study methodology as described below:

- Review and summary of basic theories used for the study
- Identify target group and target area
- Data collection design and survey
- Analyses
- Implications

2.1 Review and summary of basic theories used for the study

Some related theories and their applications in the field of public transport are reviewed. The instances of these theories include revealed preference, attitudinal survey, traditional determination on public transport demand, behavioral, social, and psychological theories. This study applies the previous work in the area of traveler behavioral research by several authors.

The understanding on attitudes and factors affecting travel (mode) choice decision. Several past researches are reviewed in order to obtain the factors affecting the travel decision and their significance. The work by Beirao (2007); Stradling (2002); Stradling, (2007). Provides a good example of the tested variables.

The explanation of travel behaviors. Several behavioral theories to explain a traveler's intention to choose a mode are reviewed. In this study, few theories are mentioned and followed. The Theory of Planned Behaviors (TPB) is widely accepted and used in a field of psychology and this theory has also been used to explain traveler's choice (See Piriyawat, 2010) The University of California at Davis conducted few research papers pinpointing the behaviors of travelers in choosing the mode of travel by looking at their attitudes, liking, and desired mobility (See Redmond, 2000; Curry, 2000; Choo, Collantes and Mokhtarian, 2005). This part aims at finding the relationship of travel behaviors (or intention to use a particular mode) with many constraints as well as traveler's intrinsic characters such as lifestyle, attitude, preference, etc.

The theory of planned behaviors (TPB) is widely used in psychology fields and first introduced to transport in Thailand by (Piriyawat et. al. 2008) the theory offers the consideration of attitudes in individual's decision. The theory proposes that the human behaviors is influenced by Behavioral Intention which are derived from three main factors; namely Attitudes (AT), Subjective Norm (SN), and Perceived Behavioral Control (PBC). The Theory of planned behaviors are shown in Figure 2.1

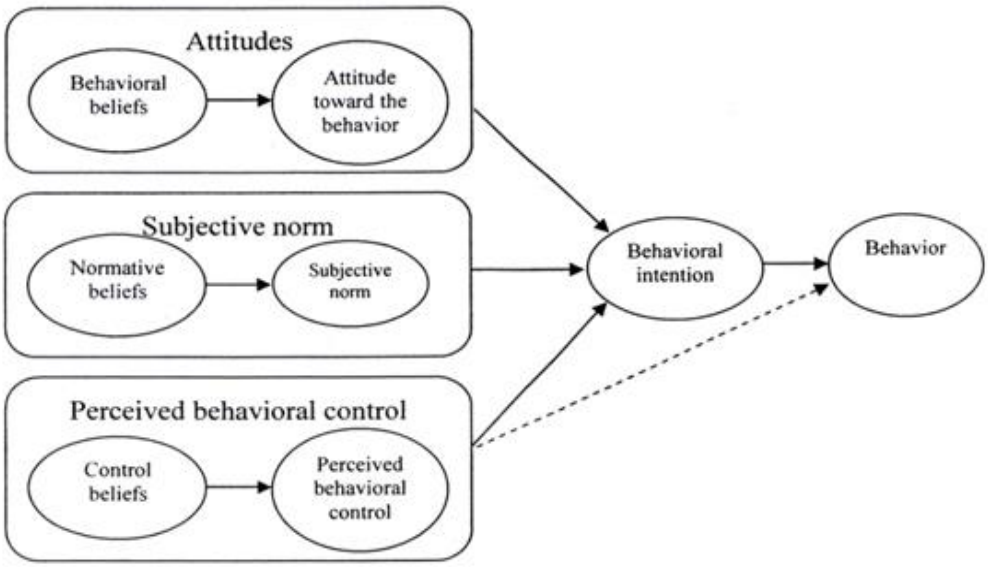


Figure 2.1 the Theory of Planned Behaviors (TPB) (Ajzen, 2006)

2.1.1 Review of the Theory of Planned Behaviors (TPB)

Authors	Results
Aberg (2002)	Aberg examined TRB's theory and efficient of Structural equation modeling (SEM) analysis. The result insisted the suitability of TRB to explain behavior of the sample related to attitude (Released behavior comes from attitude change). In addition, the result extremely assured the efficient of appreciate SEM in order to analyze to explain variables in model, and was able to examine consistency between model and hypothesis.
Bamberg, Ajzen and Scmidt (2003b)	They insisted accuracy of TRB's theory by SEM analysis in order to apply Mode Choice Analysis. The result found implementation of technology, norm in life style, and perception of travel behavior control affecting attitude to select bus transportation. Moreover, the analysis confirmed consistency among models and hypothesis of research referring TRB's theory.
Anable (2005)	Anable studied psychology theory and attitude to identify community characteristic by TRB's theory reference. E-Mail survey focused in the north-east Britain was the technique for data collection. The result found inconsistency between attitudes. In fact, behavior was the danger in attitude in order to select mode of travel such as ability to alter habit of using only personal car which are captive riders.
Ching-Fu Chen and Wei-Hsiang Chao (2011)	They studied and found the methodology in order to reduce using personal car and propose the policy to promote public transportation. The study considered sufficiency of demand based on theory integration such as Theory of Planned Behaviors (TPB), Technology Acceptance Model (TAM), and familiarity behavior. Kaohsiung in Taiwan was the case study using 200 personal car drivers and 202 motorcyclists as the sample to collect data by questionnaire survey. Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) were analyzed techniques. The result found negative effects of intention to use public transportation. While other variables in TPB and TAM, the result indicated familiarity in the opposite side. Therefore, this research could be guideline to promote the new public transport system and to understand what the factors which users require to use more public transport system in order to protect environment and solve sustainable pollution problems in the future.

The TPB can be used to explain travelers' behaviors. Nonetheless, it is noted that the theory clearly states three factors which may not cover all possible matters that an individual consider/feel in their travel decision. Moreover, the contents in each factors need to be studied. In transport study, other researchers also study the relationship between travel occurrence and their attitudes and other intrinsic factors. For example, Ory and Mokhtarian (2009) proposed the factors influencing the travel, and most of these variables are subjective and dependent on travelers' lifestyles, attitudes, objective mobility and others. The construction on relationship between the travel and profound factors are shown in Figure 2.2

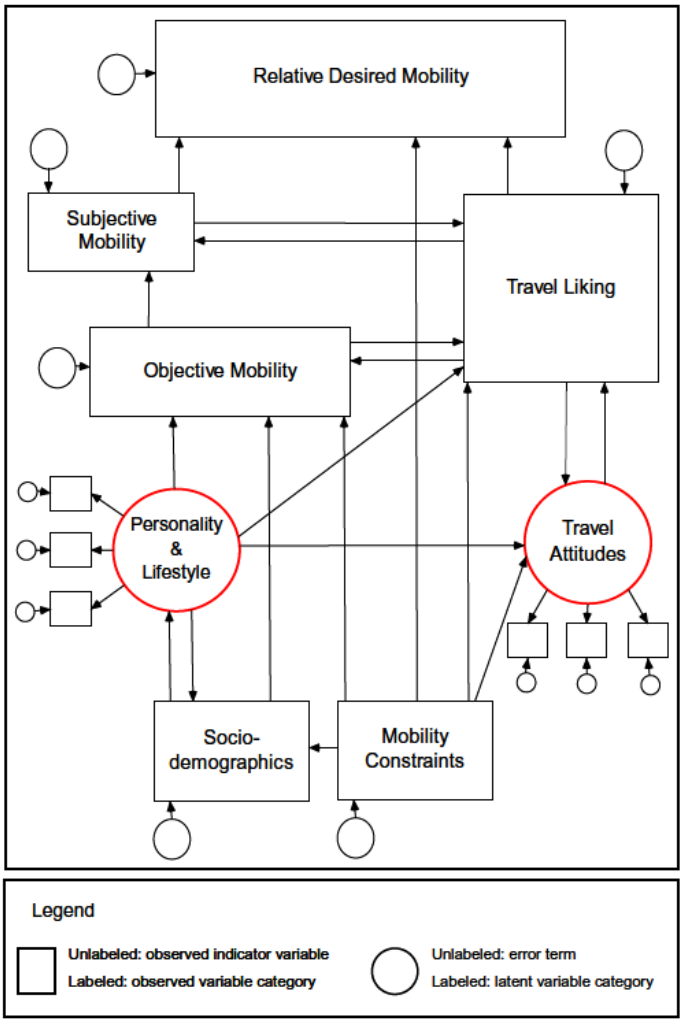


Figure2.2 Conceptual Model for Relationship between Mobility (Travel) and other factors (Ory and Mokhtarian, 2009)

Modeling of travel behaviors. Recent researches incorporate these behavior explaining factors in a widely used approach in choice modeling. The choice model has been used in transport for more than 30 years, especially to model mode choice. The detail on choice model can be found in Ben- Akiva and Lerman (1985). In 1999, a notable paper by Ben-Akiva et.al (1999) addresses the improvement of traditional choice model by adding "latent" variables in the model. This school of thoughts has been carried over by many recent researches (See Hurtubia et.al. 2010, Timme et.al. 2008).

Ben-Akiva (1999) explained the integration of latent variables in choice models. Few possible ways to incorporate the latent variables are shown in Figure 2.3

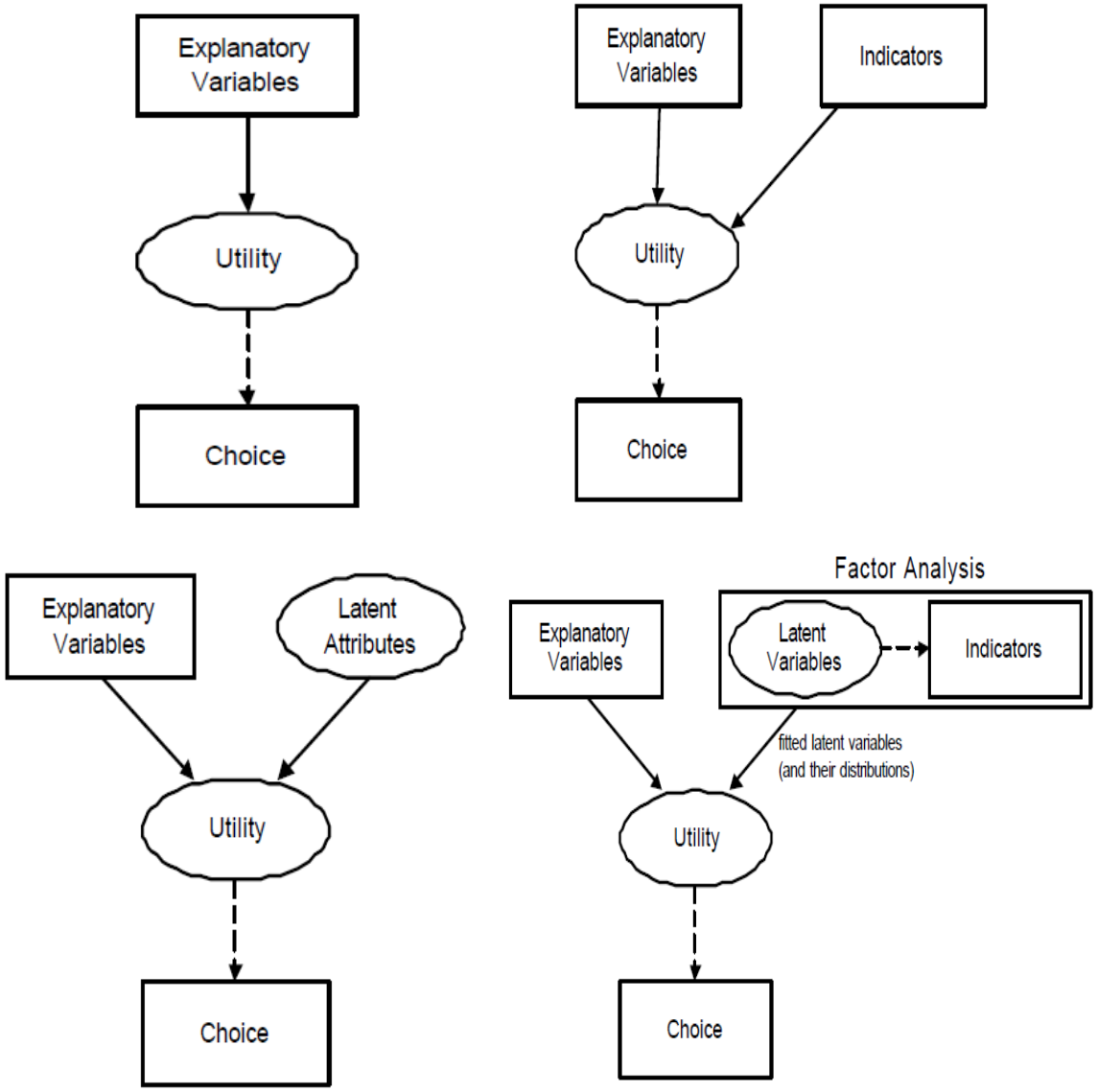


Figure 2.3 Possible ways to integrate latent variables in choice model

(Ben – Akiva et al., 1999)

2.1.2 Review of Choice Models

Authors	Results
Sirisophonsilp (2011)	1,321 Samples / Questionnaire interview / SP Data The result found influenced variables for mode choice includes travel time, cost, revenue, sex, and age of travelers.
Hurtubia et.al (2010)	1,124 Samples / Questionnaire interview / SP Data The result found models which integrate hidden variables in attitude could better explain behavior of travelers than without considering attitude factors travelers models.
Johansson et.al (2005)	4,000 Samples / Post questionnaire / RP Data The result found time and cost factor significantly affect to select mode of travel, whereas; hidden factors having importance in the model are elastic of service and comfort factors.
Beirao (2007)	119 Samples / Deep interview / RP Data - According to public transport user, factors of time, cost, convenient, lack of data, and inaccessibility affect travelers unable to use public transportation. - For personal car users, time, car use addict, convenient, and social status could not decrease car users, but dependence for travel and carefulness in environment could decrease car users.
Halden (2003)	356 Samples / Post questionnaire / RP Data - The result showed 3 factors affecting mode choices; 1. Hard Factor such as cost, travel time, or reliability in travel time 2. Soft Factor such as convenient, comfort, or safety 3. Complementary Factor such as life style, supporting, budget, or tax.
Dirk Temme et.al (2008)	907 Samples / Questionnaire interview / RP Data - The result found models integrated latent variables are interested because they could better explain behavior of travelers than original models including only characteristic variables. However, models integrated latent variables are difficult in typical statistic programs analysis. Thus, more complex analyzed models are necessary to use.

2.2 Target group and Target Area

After expert meeting in December, 2010, the target group and target area are proposed. The target group is general travelers who are commuting within Bangkok, with focus in two groups: who currently travel by private vehicles and who currently travel by public transport). The target area is not fixed (due to a data collection technique), but this study aims to divide the total samples into two main areas. This is to ensure the variety of the captured behaviors and to be able to see the difference of the behaviors of travelers in the two area (geographical and travel characteristics effect).

2.3 Design of Data Collection and Survey

This study focused on the questionnaire survey by using mail-back with the total of 800 collected samples. In survey plan, more than 2000 mails were planned to distribute all two areas; as a result, the questionnaire could be delivered in the mailbox of each house in each area and was also handed to passer-by in the study area.

2.4 Analyses

In the study several analyses are planned:

1. The analyses to disclose the understanding on traveler's decision. The descriptive statistics on samples are analyzed to show the general perception, attitudes, preferences, and barriers to choose a transport mode. Then factor analysis is performed to explore the dimension of variables used in travel decision. Factor analysis is a tool used to distill our many correlated observed variables into a smaller number of relatively uncorrelated fundamental dimensions. The factor analysis can give some understandings on the strengths (or relevancy) of each variable in explaining the happenings. More detailed analyses on the relationship among the variables are performed by structural equation modeling (SEM). Then the cluster analysis is performed. Based on the finding from the previous analyses, the traveling decision can be classified by clusters. The study looks for the possibility of explaining the travel behaviors (decision) by individual attitudes, lifestyles, or other variables. These analyses can help explain the unique characteristics by cluster (groups).The last analysis to explain the behaviors is the structural equation modeling (SEM).The SEM is the construction of relationship of variable behind the decision to the intention or behavior (decision). The SEM can be applied to explain the behaviors of several theoretical hypotheses (Planned behavior by (Ajzen, 2006; Redmond and Mokhtarian, 2001b) The results of the analysis can show the importance of each variables in travel decision.

2. Modeling on travel behaviors. Traditionally, the travel decision (i.e. mode choice) is modeled using choice model (s). Many forms of choice model have been studied and used in practice. Nonetheless, most traditional and practical models employ quantitative and alternative specific variables to describe the attributes of two competing modes. Many researchers, notably (Ben - Akiva et.al.1999), have proposed the inclusion of attitudinal or "latent" variables, to reflect better behavioral manners of travelers in perceiving the modes and travel decision. The inclusion of this kind of factors is not easy since it deals with "latent variables" which are not directly measured. Few ways to include the latent variables in a choice model are proposed. This study also plans to

develop such a model to illustrate the benefits of the incorporation of such variable in model accuracy. The detail on Integration of Choice and Latent Variable Model (ICLV) will be elaborated in the final report.

2.5 Implication

The results of the analyses are interpreted to yield a more understanding on how commuters' making decision for travel, specifically, the factors influencing the selection of public transit, and thus how the authority could prepare the service to meet commuters' needs.

The findings from the research are expected to give several answers:

- The original knowledge on commuters' needs is realized. Many conventional methods of acquiring knowledge on mode selection are used in practices. For example, home interview method to gain basic characteristics of travelers and travel. Most surveys seek out existing travel and their mode selection. This study focuses on the obtainment of more behavioral insights, such as attitude, travel constraints, and travel environments. Moreover, many reasons on their travel needs are captured, and these can be directly related to their reasons for mode selection. The commuters' survey starts with no presumption on their travel needs, thus gaining wider understanding on their requirement if they would ride a public transport.

- Perception and attitudes of commuters' toward public transport services can be identified. The perception and attitudes are proofed to have strong relationship with behaviors (intentions).

- Hopefully, the results from the study can identify potential public transport service characteristics that best suit commuters' needs.

- The methodology and results from this research can be used by many academics as well as practitioners to conduct the similar study to promote public transport. To academics, the learning on commuters' decision and the linkage between attitudes and behaviors can be used for pinpoint the importance success factors for public transport promotion. The learning for methodology can give academics the experience on the design of study of similar matters. To practitioners, the interpretation of the results of the study gives the suggestion on how to be more successful in public transport services.

- The research's ultimate goal is to discover a proper way to attract people to use public transport. With the understanding on basic travel behaviors, and the decision to select a mode, the research could lead to the direction to promote the public transport to commuters and the acceptability to the services. Valuable recommendation can be

made to authority to properly prepare the public transport services according to the real needs.

At the end of the study provides Summary of research. The summary will sum up the advancement in research methodology on the travel behaviors as well as the practical methodology to gain understanding on travel behaviors which will help the authority to better promote public transport. The summary on practical methodology which should be conducted for future demand study can also be addressed.

CHAPTER 3 Research Methodology

3.1 Overview of the methodology

To yield the objective of understanding the traveler's behaviors and attitudes, the questionnaire survey as proposed as the instrument for collecting both basic characteristics and attitudes of travelers. The obtainment of the attitudinal data through interview survey requires careful scrutiny on the target group selection, survey methodology, questionnaire used, so that the reliable data can be gathered and the analysis can yield the leading conclusion. Then two main analysis methods were proposed to determine the understanding of the travelers' attitude toward the use of public transport. First, the Structural Equation Modeling following the Theory of Planned Behaviors (TPB) were carried out to demonstrate the relationship and influence of attitudinal factors on mode shift. Secondly, the choice modeling was carried out to determine the propensity of mode switch from private to public transport due to several personal, travel, and attitudinal factors.

To complete the entire study, the research methodology is divided into several steps as seen in Figure 3.1.The study started with the literature review. The past studies can guide many aspects in this study: factors influencing traveler's behaviors, proper survey methods, analysis techniques and their interpretation, the travel behavioral conclusion from the previous studies for comparison, etc.

Then the study selected the area to collect the travelers' data. Since this study focuses on the Bangkok commuters who have typical work trip pattern (from home to work in the morning and from work to home in the afternoon), the study paid more attention on to study the relationship between attitudes and characteristics of the travelers more than to expand the determination of population attitudes of all Bangkok travelers. The bias which the selection of study area tries to avoid is the person characteristics and travel pattern and conditions. The study selected the area of survey so that a variety of persons can be interviewed and the proportion of the respondents in each category which is carefully chosen as close as what have seen in the field. For example, the proportion of male/female of public transport riders/drivers is determined at sites and the interview was carried out to yield the closest proportion of the gender seen at site. The concern on travel pattern is the lengths of travel and quality of service of the public transport services. The selection of study area may cause biases to this travel pattern. Thus, the selection of the study site would be necessary to make sure that the samples have a variety of the travel patterns, in term of the distance of travel on access, egress, and main mode, the quality of services on public transport, the choice set of each travelers in choosing public transport is also carefully studied.

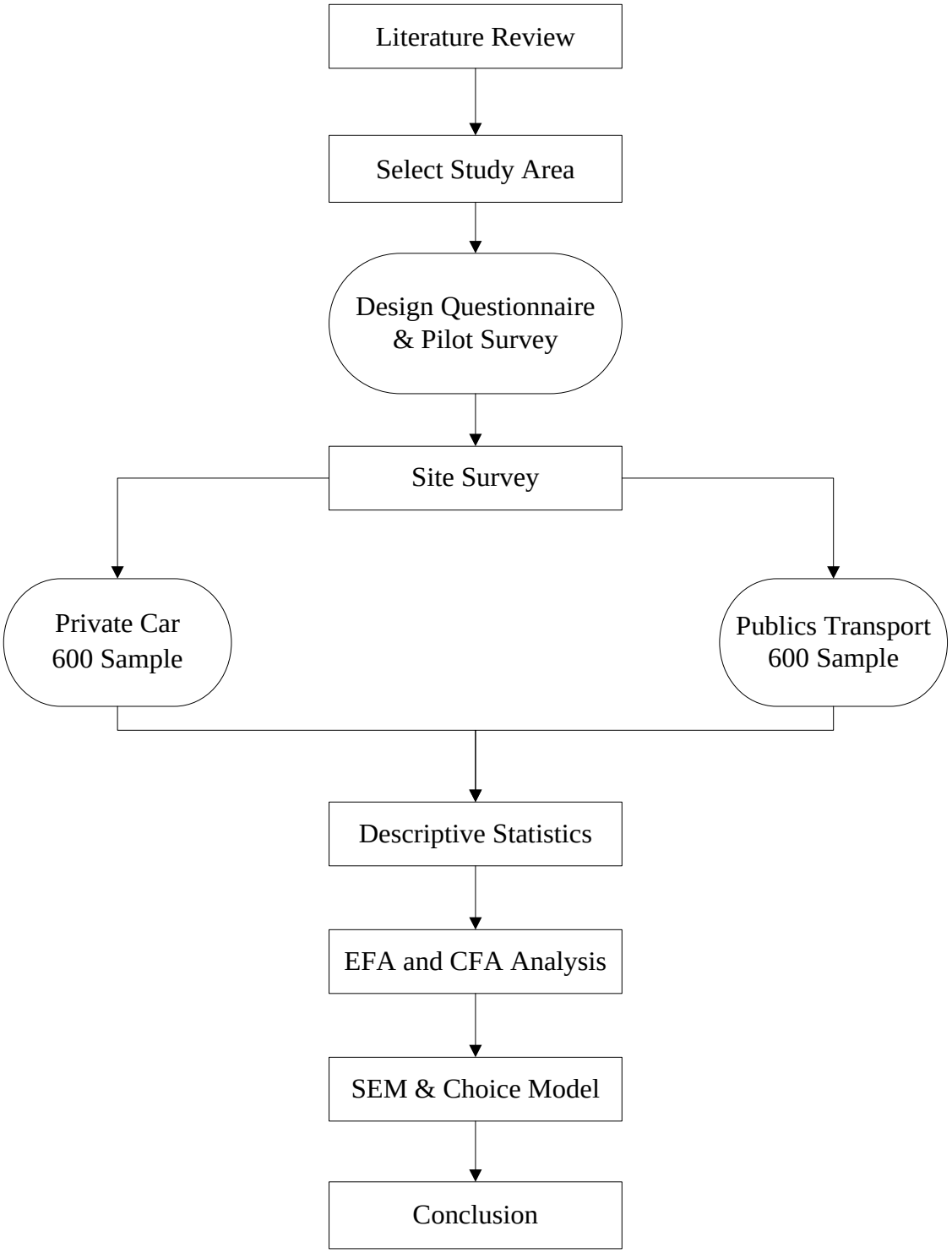


Figure 3.1 Research methodology

The development and testing of questionnaire is of importance. The questionnaire is the instrument to measure the attitudes of travelers. It is very important that the respondents comprehend the questions, and reflect the answers as close as they have thought in mind. A lot of time that the questions can be misleading and the respondents are unable to express their true attitudes. The questionnaires were developed, pilot-tested, and the explanation of the

understanding to the questions was verbally discussed with the surveyors. The questions were then adjusted to give the most accurate questions for particular answers. The best questions would give the same understanding to all travelers in the same way.

Once the questionnaire was designed and tested, the main survey was conducted. In this study, the quota sampling was carried out, with the planned number of samples for travelers with cars and for public transport riders of 600 and 600 samples. The quota sample would give the sufficient amount of samples for most statistical analysis purpose.

The analyses in this study included the descriptive analysis, the explanatory and confirmatory factor analyses, the Structural Equation Modeling, and the Choice Modeling. The descriptive analyses explain the data and determine the odds that may occur in the database. The basic statistics can also be compared with the secondary data or to judge the reasonability of the data, for example, the amount of travel, the length of travel, etc. Many checking can be done in the descriptive analysis, for example, how the respondents answer attitude data.

Then the Explanatory and Confirmatory Factor Analysis were carried out. In the study, many attitudinal questions were asked to samples. The questions were designed to reflect travelers' attitude in many dimensions. Most of questions asked about psychological factors behind travel and lifestyles. To better understanding on the relationship and how people consider these factors in the mode choice decision, the number of factors can be reduced through explanatory factor analysis. The analysis gives the combined relationship on what factors are considered together. The reduced number of factors will result from the explanatory factor analysis. On the other hand, the Confirmatory Factor Analysis tries to confirm that the "predetermined" relationships among factors are statistically valid. In this study, from the literature and from the construction of questions, many factors are designed to be correlated to the dependent variables. Nonetheless, the miscomprehension of the questions and the inaccurate answers of questions (scale) may cause the lesser degree of relationships among the preset variables. The confirmatory factor analysis will show the credibility of the relationships among these variables. The statistical test will confirm that all the relationships among variables are valid for the further analysis.

It is noted that this study focus the travelers in Bangkok. Bangkok has also had a variety of travel choices, especially public transport. It was planned in the study to capture as many kinds of public transport and access modes as possible, although the study did not attempt to the stratefy the data collection by these sub-modes. Rather, the study diversed the data collection points so that various public transport and access modes could be obtained. The key benefit of the data collection diversification was that the various quality of service by competitive modes (private vs public transport) and thus the variety of relative competitiveness between two modes could be obtained.

3.2 Target Group in the Study

The target group of this study was defined to be the Bangkok travelers who normally travel to work on two existing modes:

- People who normally travel by private cars (ride or drive on private cars).
- People who normally take a form of public transport to work.

3.3 Sample Size

To obtain statistical significance of the conclusion, the number of samples must be large enough and contain variety of travel behaviors. From previous studies, many researchers have suggested a rule-of-thumb for sample size to be larger than 400 samples. The objectives of getting a large number of data are two folds. One is that we would need at least a number of samples to construct meaningful relationship in the statistical analyses (factor analysis, choice modeling). The other is to capture the variation of travel pattern as well as attitudes on mode selection. The more variety on the traveler's and attitudes, a better construction of the relationship to represent a wide variety of behaviors. The previous studies similar to this study do not report a specific number of samples to be collected. Mainly the number of samples depends on the budget and time. It is suggested, however, that the collected data must pass some hypothesis testings such as goodness-of-fit to see if the samples can represent the actual population behaviors. Aroian and Norris (2001) stated that the sample size of 200-500 samples may be sufficient for factor analysis, structural equation modeling, and logit modeling.

In this study, the total number of 1,200 samples were planned to be collected. Therefore, each group of targets would be interviewed for approximately 600 samples.

3.4 Data Collection Method

The data (samples) of the study were collected using face-to-face interview method. Since the study required a number of samples for each regular mode usage, a choice based sampling was performed. The interviewers went out to preselected locations and interviewed the respondents. The locations determined the existing mode choice of travel. For example, the interview at rail transit station would be likely to get respondents who ride the rail transit system. The interview at the park-and-ride facility would get a number of samples who drive their own cars but connect to public transport.

The interviewers would then select a respondent by accidental sampling method. The interviewer would select the respondent at his/her convenienct, however, he/she was also instructed to get the samples reflecting the actual population of travelers in the locations. For example, he should select male/female, age of the travelers similar to the distribution of travelers' characteristics he had seen at the site. Moreover, the interviewer should not limit himself

at one location in the area. He should walk around to intercept the respondents in the entire preselected area

3.5 Analysis Methods

Three analysis methods were planned in the study:

3.5.1 Descriptive Statistical Analysis

The first analysis was the Descriptive Analysis which was used to describe the basic features of data used in the study. The analysis reveals the basic characteristics of travelers, travel patterns, and the summary of attitudes. Moreover, the descriptive analysis presents statistics in a simpler form, making it easy to understand the entire samples.

As the attitudes of travelers in this study were measured in a sematic scale, the descriptive statistics provide the summary of the attitudes, such as mean, standard deviation. The attitudes can then be compared or interpreted easily.

3.5.2 Factor Analysis

The factor analyses were performed in this study in two ways:

- Explanatory factor analysis, EFA
- Confirmatory factor analysis, CFA

3.5.2.1 Exploratory factor analysis, EFA

Exploratory factor analysis is the technique to explore and identify the factors that could explain the relationship among variables. The technique is known as a variable reduction method since it detects and combines effects of several variables into group(s). The analysis can thus reduce the number of variables in the relationship or group variables with similar effect into a smaller number of (new) variables. The new variable is called “factor score”. The analysis demonstrates the relationship among variables under study, including the determination of “correlation”. The correlation can indicate the direction of the relationship, such as the positive correlation indicates that two variables are positively correlated while the negiave correlation means the two variables are negaitively (or inversely) correlated. The final result from the explanatory factor analysis provides a set of factor score that could explain the relationship between a reduced number of variables and their degree of correlation. The factor score is quantitative or can be measured in a numeric scale.

After explanatory factor analysis, factors that are interrelated with the corresponding variable(s) are determined. A number of factors are grouped and thus the total numbers of factors are reduced. The new factors can be used for further analysis, such as Regression, Analysis

of Variance (ANOVA). Therefore, the EFA is popular in reducing number of factors under consideration and widely used in many areas of study such as education, marketing, medical etc. (กัลยา, 2553)

The EFA is known for its principle as factor reduction technique. In other words, the technique seeks the relationship among the variables under consideration and the convert the original factors into a new variable by linear combination. The technique tries to preserve the effect of the original factors but combines all the effect into a new variable, thus the new number of factors is reduced.

The equation used for explanatory factor analysis to estimate the factor j can be written

$$F_j = W_{j1} X_1 + W_{j2} X_2 + \ldots + W_{jp} X_p + e \quad (3.1)$$

Where; X_j = variables to be included in factor j

W_j = coefficient of j

Moreover, the relationship of variable X_i which are formed in a Linear Combination of the Factor can be expressed as:

$$\left.\begin{aligned} Z_1 &= L_{11} F_1 + L_{12} F_2 + \ldots + L_{1m} F_m + e_1 \\ Z_2 &= L_{21} F_1 + L_{22} F_2 + \ldots + L_{2m} F_m + e_2 \\ &\vdots \\ Z_p &= L_{p1} F_1 + L_{p2} F_2 + \ldots + L_{pm} F_m + e_p \end{aligned}\right\} \quad (3.2)$$

Where; Z_i = variable X_j (Standardized); j = 1, 2, …, p

p = number of variables

m = number of factors; m < p

F1, …, Fm = Common Factors

e = errors

L_{ij} = Coefficient called “Factor Loading”

Factor Loading or coefficients are the coefficient of correlation (r) since the variable X_j are stansardized to be Z_j. The value of Factor Loading is between -1 and +1 and this Factor Loading is used to determine which factor to be included by this variable (กัลยา, 2553)

To perform EFA involved in 5 main steps as follows:

Step 1 Examination of relationship among variables

If two or more variables have a strong correlation with significance, then it is reasonable to peform EFA. If no correlation is not found or with statistical insignificance, then no further EFA may be performed. Two ways to correlation checking can be done as follows:

Method 1 Examination on coefficient of correlation. A matrix of coefficient of correlation is determined then a correlation for each pair of variables is found.

- If the coefficient of correction has the value close to -1 or +1, then it implies that the correlation between two variables are strong. These two variables should be included in the same (new) factor

- If the coefficient of correlation has the value close to 0, then it implies that the two variables do not have (strong) correlation. The two variables should be grouped into different factors. Moreover, if there is no correlation with any other variable, then one variable may be excluded from the factor loading.

Method 2 Examination on Kaiser - Meyer - Olkin (KMO) Statistics. KMO is the indicator for examining the appropriateness to be included in the factor loading. This statistic is common for justifying the inclusion on such variable in the EFA analysis. The detail on the interpretation of this statistic will be elaborated in detail in the analysis section.

Step 2 Factor Extraction

The objective of the factor extraction step is to find the number of factors that represent all variables under consideration. A common and widely used method of factor extraction is “Principal Component Analysis” or PCA. In this step, a Factor loading is determined for each variable. The factor loading is important in determining which variables should be included in the same factor. The value of factor loadings can simply justify the inclusion of such as variable in the factor; if the factor loading is close to -1 or +1, then it implies strong correlation and the variable should be included in the factor. However, if the factor loading is not as large as-1 or +1, then the factor rotation should be performed and the variable will be considered again.

Step 3 Factor Rotation

In case that the factor loading is difficult to justify (the value is not close to -1 or +1), the factor rotation should be performed. The objective of the Factor Rotation is to alter the factor loading so that the factor loading for a particular variable is seen whether the variable should be included in the factor or not. The factor rotation ascertains the correlation between the variable and the factor. Two main methods of factor roatation are normally employed:

Method 1 Orthogonal Rotation. The rotation still keeps the factors to be independent to each other. Several sub-methods are available in most of statistical analysis packages:

- Varimax is the technique to determine the minimum number of variables to be included in the factor. In other word, it selects variables which have high factor loading for the factor. This method is the most popular method for factor rotation.
- Quartimax is the technique to determine the number of factors that could be explained by each variable.
- Equamax is the technique that combines the principles of Varimax and Quartimax.

Method 2 Oblique Rotation. The rotation may be not perpendicular to each other or the rotation may not be independent to each other. It may create a larger or smaller number of factor loading.

Step 4 Calculation of Factor Score

When several variables are grouped into factors, then a factor score can be computed for each (new) factor. The new factor can be a representative of all variables containing in that factor. The factor score can be expressed by

$$F_{ik} = W_{i1} Z_{1k} + W_{i2} Z_{2k} + \dots + W_{ij} Z_{jk} ; \quad (3.3)$$

$k = 1, 2, \dots, n$ and $i = 1, 2, \dots, m$

where:

Z_{jk} = variable j (Standardized) making up to factor k

n = number of samples

m = number of factors

W_{ij} = coefficient or Loading Factor of variable j in factor i

F_{ik} = Factor Score of factor i for the case k

Step 5 Statistical Testing and Naming of the Factor

The determination of Kaiser – Meyer - Olkin (KMO) statistic can be used to justify the appropriateness of the factors. The KMO is calculated from equation 3.4

$$\text{KMO} = \frac{\sum r_i^2}{\sum r_i^2 + \sum (partial\ correlation)^2} \quad (3.4)$$

Where; r = coefficient of correlation; $0 \leq \text{KMO} \leq 1$

- If the value of KMO is small (approaching 0), then the factor analysis may not be suitable for applying it with the data

- If the value of KMO is large (approaching 1), then factor analysis is sutiable for applying it to this set of data
- In general, if the value of KMO < 0.5, the data may not be used for factor analysis

Once the new factors are invented, the names of new factors can be given. The names should reflect the variables containing in each factor. The name should be easy to understand and reflects the representation of all variables in the factor.

3.5.2.2 Confirmatory factor analysis, CFA

Confirmatory Factor Analysis or CFA is a statistical analysis that tests the hypothesis on theory and relationship among variables. The relationships between variables must be hypothesized in advance and the CFA checks if the hypothesis is valid. In other words, the test ascertain the degree to which the evidence from the data (such as answers from questions) conforms to the predetermined postulation. (นงลักษณ์ 2542)

Principles of Confirmatory factor analysis, CFA

CFA is a relationship test between other observed variables (specified factor) and hidden variables (factors). Users are necessary to have this basic theory or sufficient database and have to know what observed variables include in latent variables. This analysis could help to analyze quality of psychology tools because it assures the accuracy of generated models. Consequently, CFA is the most important in specifying scope and study direction. The methodology of analysis, which is similar to SEM, could be divided in 3 aspects.

1. **CFA** is able to check whether each question is correct in specified theoretical component and specified models relate to collected data. These checking could use statistic study to measure. The researchers have to generate questions following the theory as well as accurate check of empirical data (questions). Actually, relationship between question and theoretical component is among empirical data (covariance of questions), and could examine and insist whether generated models are much or less related to each other.
2. **CFA** is able to estimate reliability in order to decrease measurement error from analyzed result. Reliability estimation is constant check of weight component and measurement error when data is collected in time difference and sometimes.

3. **CFA** is able to compare component structure of measurement more than 2 groups of sample in the same time. It checks whether component structure of measurement is constant when it is implemented in different sample to insist same component in each component structure or measurement characteristic. In addition, it could examine transition or invariance of component structure between samples. (Bollen, 1989)

Confirmatory factor analysis data characteristic

Requirement of Affirmative component analysis data characteristic

- Should be continuous value and normal distribution data
- Should have more amount of data

Although CFA requires massive data at least 100-200 samples, because of studying 3 components in this model from scenario, massive samples probably get unsuitable result or unreliability statistic data. Therefore, more samples (200-400) are more suitable and necessary to contribute complex relationship or various variables model. (Hair et al., 2010)

Initial arrangement to analyze confirmatory factor

There are 2 initial arrangements for analysis.

1. Initial arrangement for statistical analysis (Hair et al., 2010)

    - All data should be analyzed by normal distributions and linear Relationships between in each pair of variables.
    - Error might not relate to latent variables, and has independence from other errors, and has normal distributions.
    - Sample has asymptotic distributions which must specify sufficiently; otherwise, risk of error might be occurred.

2. Initial arrangement for parameter estimation

    - No single or group questions definitely explain other question in sample, and question must not be complex. (Bollen, 1989)
    - Question must have polynomial normal distribution. (West, Finch and Curan, 1995)

Step of Confirmatory Factor Analysis (CFA)

CFA step is similar to structural equation model analysis (SEM), but different in variable interrelationship specification. CFA could analyze by 5 steps following.

Step 1 Specific model specification

This step specifies relationship in hypothesis model specified by theory or prediction of the researcher which is importance for CFA. Mueller (1996) recommended that the researcher should have generated various alternative models before analysis.

Step 2 Model identification

This step identifies at least 3 observed variable per 1 latent variable called “Three Indicator Rule”. By this rule, one indicator as reference or latent variable to be standard value is specified, and 1.00 is the value of parameter of variable. Various indicators in one latent variable could indicate various visions of latent variable characteristic. In addition, more questions model could more accurate analyze, give precise parameter, and correct observed variable (Marsh et al., 1998). Therefore, more variables model tends to generate more consistent empirical data than a few variables model. As a result, amount of variables which are appropriate to the model or reference theory should be defied.

Step 3 Parameter estimation

Parameter estimation is an analysis how to solve structural equation in order to estimate parameter value (นงลักษณ์ วิรัชชัย, 2542) by the software “AMOS”. This analysis has to lead attitude data in each variable and grope to check accuracy from Cronbach’s (α) coefficient for appropriate analysis in order to integrate variables in one representative measurement. Cronbach’s (α) coefficient value should be 0.70 or more than 0.65 to integrate in one variable. (กริช แรงสูงเนิน, 2554)

Step 4 Evaluating the Data-Model Fit

Various statistic values are considered in this step. Firstly, estimated parameters are examined whether they are reasonable and based on expected theory. Nevertheless, these cases might be occurred from specific data of incorrect component model.

- Backward parameter such as positive value of weight component in spite of negative value according to theory
- Too less or unsuitable value parameter such as variance of negative value component or more than one correlation between component
- More than 2 or normal situation standard error
- Negative, close to 0, or more than 1.00 accuracy value of observed variable

Consequently, the index for consistency measurement of various models needs to be checked because model might have reasonable parameter component, but evaluation might not follow by theory (Mueller, 1996). The index including statistic values; Chi-Square, Relative Chi-Square, GFI, AGFI, CFI, RMR, and RMSEA which are explained in previous section, is implemented to evaluate model consistency.

Step 5 Model Modification

Since component model is not probably consist to empirical data from statistic value due to inconsistency relationship in model specification with the reality, parameters are able to be modified

by hypothesis model and modified test result by the Modification Indices (MI). This tool could add or delete one parameter for consistency of data which depends on decision (นงลักษณ์ วิรัชชัย, 2542). Relationship between modified observed and latent variable in model has to be reasonable and in line with expected theory in scope. After parameter is modified, examination between component model and new grope of sample is the next step. Consequently, in case of sufficient data, it is divided to 2 sets; one set is for model development, and another one is for model examination.

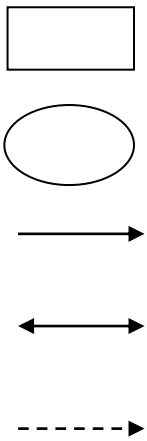
3.5.2.3 Structural Equation Modeling, SEM

SEM presents variables relationship between (1) test estimation as well as characteristic test and (2) model test of direct and indirect effects between observed and latent variable. In addition, SEM is different in error measurement and correlation acceptance when compared to other methods (Hair et al., 2010).

Another obvious difference between SEM and other techniques is ability of multi-regression of equations estimation at the same time. Each equation is separated, but has still relationship. SEM is defined as structural model, but is not separated to analyze relationship among dependent variables which has many variables as well as latent variable generated in one relationship characteristic (Hair et al., 2010).

SEM Component

Both SEM and CFA have the same basic component in exogenous and endogenous variables. Two kinds of variables include observed or independent variable, and latent or dependent variable. Observed variable is variable designed to collect questionnaire survey data, whereas; latent variable factor is defined and generated by integrated variables collected from questionnaire survey data. Latent variable could not measure value by itself, but it is necessary to have observed variable which is component of each that latent variable to measure. The principal symbols (นงลักษณ์ วิรัชชัย, 2542; กริช แรงสูงเนิน, 2554) could represent in Figure 3.2



is observed variable which directly measure

is latent variable which could not directly measure

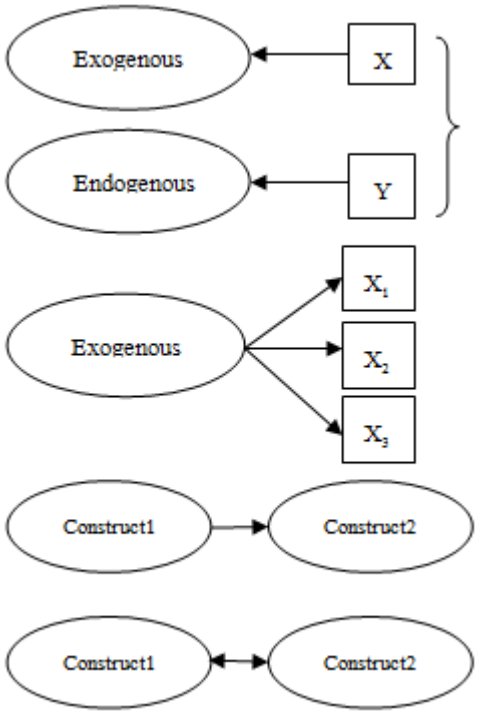
is variable which is the origin of arrow will directly change (cause) from variable which is the destination arrow (Result)

is 2 variables which are the destination of arrow have correlation

is variable which is the destination of arrow will directly change (cause) from variable which is the destination arrow (Result), but it is not significant in empirical test

Figure 3.2 the symbols in SEM (Source: Hair et al., 2010)

General pattern of relationship in SEM



is one observed variable effecting latent variable
Specification

- Observed exogenous variable represented by X
- Observed endogenous variable represented by Y

is various variables indicating latent variable

is structural relationships

is correlational relationships among latent variables only exogenous variables

Figure 3.3 General pattern of relationship in SEM
(Source: Hair et al., 2010)

There are 2 minor component models including measurement and structural model. Measurement model is able to measure for exogenous and endogenous measurement model. Exogenous variable in the part of observation needs to identify error (e) in all variables because variable obtained from questionnaire could not directly measure to 100%. Input of error could reflect on the accuracy of those variables to latent variables. Endogenous variable also needs to identify error (e) for how to predict value of variable is incorrect. Component of SEM could show in Figure 3.4.

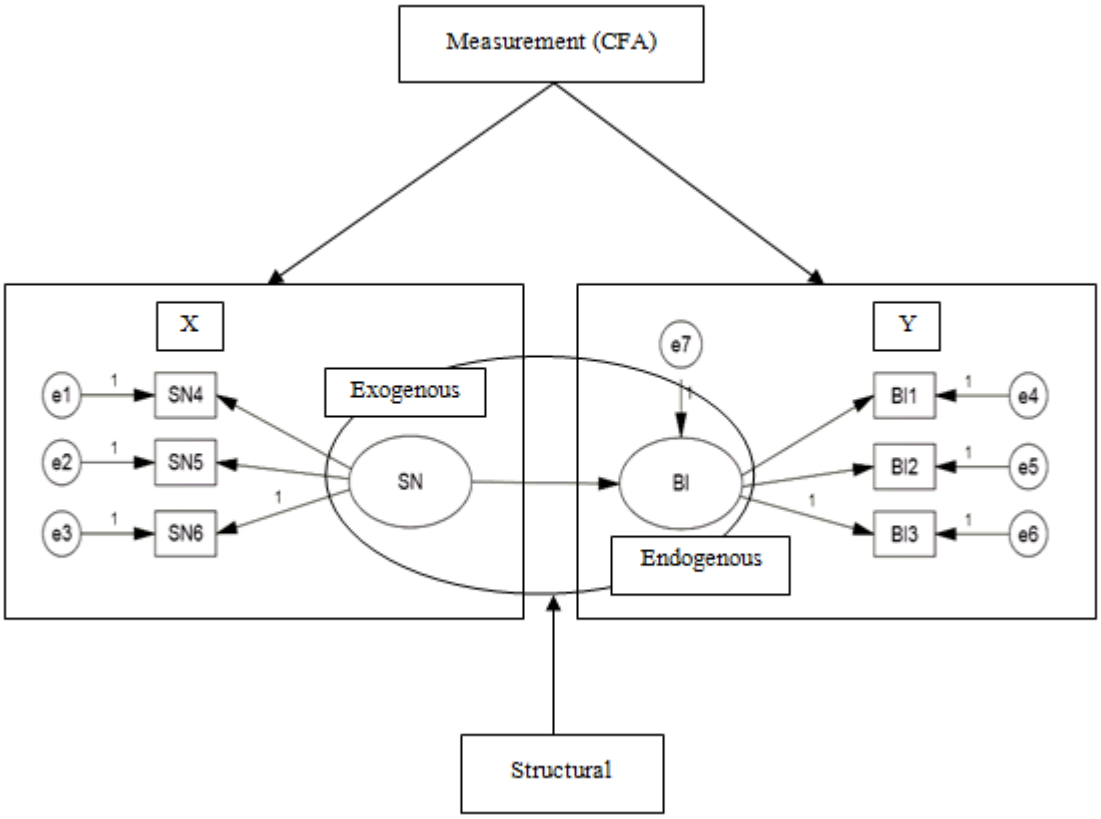


Figure 3.4 Component of SEM
(Source: Adjusted by Hair et al., (2010)

Implementation of SEM in travel behavior study

SEM implementation is able to study various travel behaviors by the sorts using in the current research (สุรเมศวร์ พิริยะวัฒน์, 2550).

- SEM could lead Dynamic Travel Demand Modeling to analyze continuous data of time series, and could determine analysis error as well as relationship among variables.

- SEM could lead Activity-Based Travel Demand modeling to analysis data and activities generating trips by direct relationship between density of population in area and travel demand.

- Driver Behavior explains driver behavior especially in accident. Currently, SEM is populated to explain both in direct and indirect relationship of accident factors. Moreover, it is able to obviously determine cause of accident.

- Attitudes, Perceptions and Hypothetical Choices are applied to check attitude hypothesis and travel behavior as well as variables related to complex model better than other methods.

- SEM could lead Organizational Behavior and Values to apply relationship analysis in order to solve truck congestion for cargo operator policy evaluation. In addition, occurred problem is co-analyzed by operator attitude and toward other operators.

- Travel Demand Modeling using Cross-Sectional Data are implemented to develop model to explain relationship between car using behavior and car ownership. Both distance and car ownership data could co-analyze instead of using step by step.

Structural Equation Modeling (SEM) Process

SEM could explain relationship between observed and latent variables whether they conform to collected data. CFA analysis is the same as SEM analysis, but CFA is different in examination and insisting data related theory among variables. To understand the basic of SEM, before implementation to analyze, 6 stages of process in order to generate model could be defined as follows:

Stage 1 Latent and observed variables specification
Stage 2 Relationship specification
Stage 3 Study and estimation method design
Stage 4 Suitability of measurement model evaluation
Stage 5 Structural relationship specifications
Stage 6 Suitability and compatibility evaluation

The flow chart of SEM process could represent in Figure 3.5.

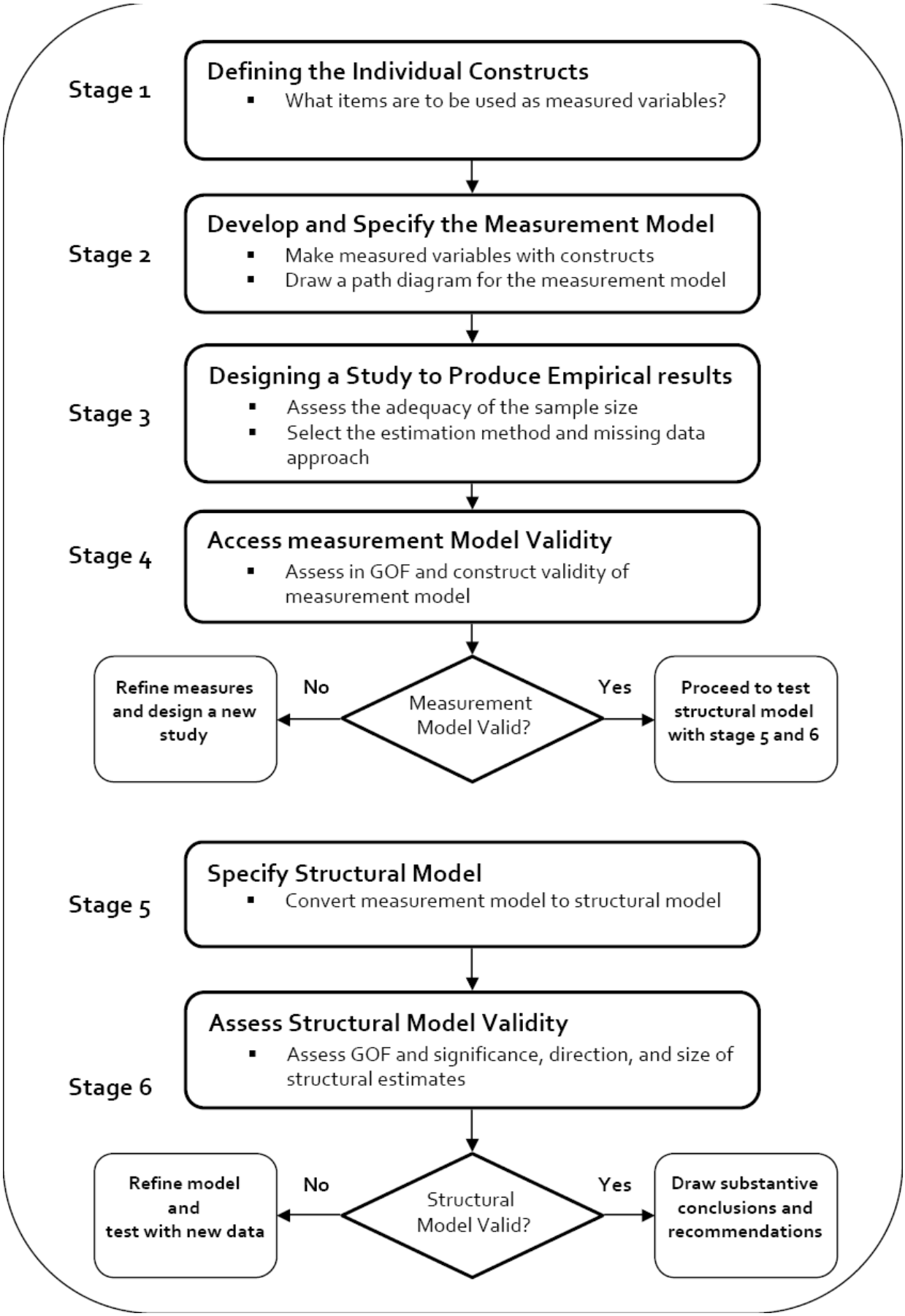


Figure 3.5 Six-stage processes for SEM
(Source: Adjusted by Hair et al., 2010)

Stage 1 Latent and observed variables specification

It is an importance in study because it reflect on truth and accuracy to measure considering important parts including

- Latent and observed variable analysis need to have reserved theory in order to specify each suitable question as well as sort of measurement (e.g. Likert Scales).
- Latent and observed variable may be generated by previous research.
- Indicators must be examined whether they are suitable to the study, if they don't calibrate before collecting realistic data.

Stage 2 Relationship specification

This stage specifies relationship of various variables effecting to each other by leading related theory and research to be the scope in order to generate hypothesis model as shown the relationship of this in Figure 3.6.

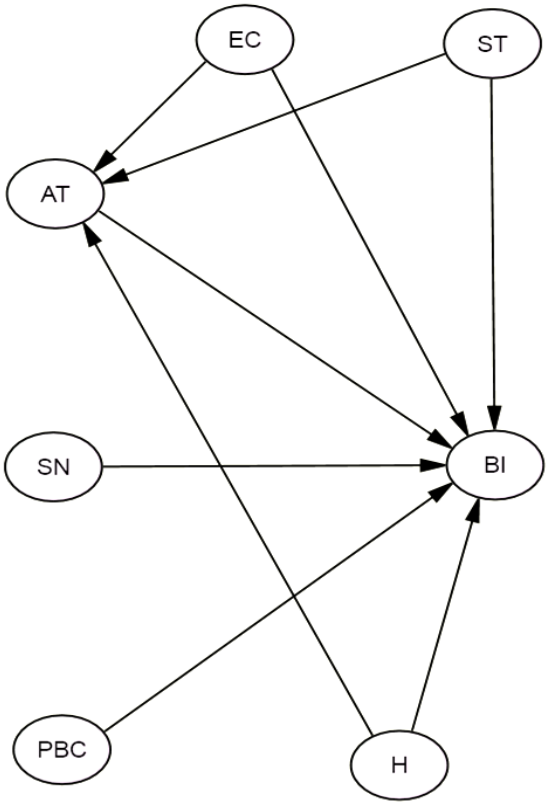


Figure 3.6 Hypothesis model of this research

Figure 3.6 is hypothesis explaining what factors effect intention to change to use public transportation. The hypothesis is attitude in public transportation (AT), complying with people or social (SN), and behavioral control perception (PBC). Three factors are basic effecting intention to change to use public transportation, but in literature review, other factors such as habitude (H),

environment care (EC), and social status (ST) may also effect to intention to change to use public transportation or attitude in public transportation.

Stage 3 Study and estimation method design

When specifying latent model as well as relationship among variables, the next step is study design consideration and estimation technique which has issues include (Hair et al., 2010);

Study design consideration and estimation

- Sample size should have sufficient amount of data when comparing with other general analysis, but SEM is able to know how many sample sizes are appreciate by 5 considerations including Multivariate normality, Estimation technique, Model complexity, Amount of missing data, and Average error variance.

- If data deviate from hypothesis (Multivariate Normality) to solve normal deviation, one parameter which has 15 dataset must be specified to reduce at least random error.

- Estimation technique, which is popular and efficient analysis, is Maximum Likelihood Estimation (MLE). If there are not problems in hypothesis, MLE is elastic method to estimate similar and the best model (Kaplan, 2000).

- In case of non-complex model, SEM is able to use less sample sizes, but in case of more observed variables, more sample sizes need to use. Hair et al (2010) recommended that one latent variable should have had at least 3 questions for approval measurement.

- If there is missing data, SEM test is complex. Consequently, adding sample size before analysis could prevent problems.

- Average Variance Extracted (AVE) is variance average which control variance of questionnaire in latent variable. More than 0.5 are appreciating value (Hair et al., 2010).

Stage 4 Suitability of measurement model evaluation

Examination or evaluation of obtained analysis is to develop specified model. Both CFA and SEM examine accuracy or evaluate similar model. Examination could be divided 3 minor steps.

Stage 4.1 Coefficient and sign are examined whether they are reasonable and conform to hypothesis. Moreover, R-Square is implemented to examine reliability of model.

Stage 4.2 Model is examined suitability by checking how generated model conform to evident data. This minor step is divided in 3 methods.

1. Evaluation of absolute fit indices, which analyze how theory conforms to data, includes chi-square statistics (χ^2), Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Root Mean Square Residual (RMR), and Root Mean Square Error of Approximation (RMSEA).

2. Comparative Fit Index (CFI) is used to compare between hypothesis model and null model.

3. Another measure for testing is Chi –square statistic comparing the tested model and the independent model with the saturated model (CMIN/ DF) which can be used in software called AMOS.

Stage 4.3 This minor stage analyzes error of residual analysis and model modification index. It thoroughly evaluates harmony level by doing after all harmony testing of model whether the result conform to analyzed data.

In all 3 minor steps have statistic explanations are;

- Chi-Square Statistics, χ^2 is statistic value testing hypothesis which has 0 value of harmony. If it has more value, harmony is significantly different from 0 that means implemented model does not conform to analyzed data. On the other hand, if it has less value, model has harmony to data. More chi-square value compared with degree of freedom (df), needs to calibrate model and then newly analyzes until it decreases. Actually, hypothesis model has harmony with data, and chi-square should not differ from degree of freedom (Golob, 2003).

- If there are more samples to identify fraction of χ^2/df or CMIN/DF, the result reports higher chi-square than less samples. To solve sensitivity, chi-square and degree of freedom are implemented to consider model combined with chi-square. Generally, fraction of χ^2/df being less than 2 is good result (Hair et al., 2010), or it being less than 3 is still approval result (นงลักษณ์ วิรัชชัย, 2542).

- Goodness of Fit Index (GFI) is an appreciate test of model using software called AMOS". GFI is similar to Coefficient of Determination (R^2) which is similar to explain variance of model compared with all variance value. This index value is between 0 and 1, and does not relate to sample size. GFI value closing 1.00 means model has harmony with analyzed data. Generally, more than 0.90 value of GFI is able to approve (Kline, 1998).

- Adjusted Goodness of Fit Index (AGFI) is bringing degree of freedom, amount of variables, and sample size to calibrate value. AGFI has also property to GFI.

- Root Mean Square Residual (RMR) is a statistic explaining residual average value from comparing between harmony of model and analyzed data. If RMR close to 0, model has harmony to analyzed data. Generally, less than 0.10 value of RMR is able to approve (Kline, 1988).

- Model Modification Indices is a statistic value for each parameter which equal to decreased chi-square when specifying parameter conforming to chi-square. Parameter should be independence or relive controlled constraint that parameter. Alternative model index has useful for adapted model decision to be in harmonious with analyzed data.

- Comparative Fit Index (CFI) is an index which compares research model how it has harmony more than freedom. Actually, more than 0.95 value of CFI, which is able to approve, is appreciate model. Due to its non-sensitivity in complex model, it is popular to implement (Hu and Bentler, 1999).

- Root Mean Square Error of Approximation (RMSEA) is an index which demonstrate appreciate model conforming to people or not. RMSEA try to solve complex problem of model and sample size. RMASEA value should be less than 0.07 (Hair et al., 2010), and in majority, it is analyzed in CFA or model comparison.

- Standard Errors and Correlations of Estimations are used in case of non-significant estimation that there are major standard errors and insufficiently suitable model.
- Multiple Correlations and Coefficients of Determination should not have more than 1 value called maximum value which means analyzed model is correct.

Stage 5 Structural relationship specifications

This stage is relationship linking among latent variables required to examine hypothesis already explained in step 2, but there is a difference in CFA and SEM analysis. CFA is the test finding relationship among observed variables, but SEM is relationship among latent variables. This research specifies CFA pattern as shown in figure 3.7.

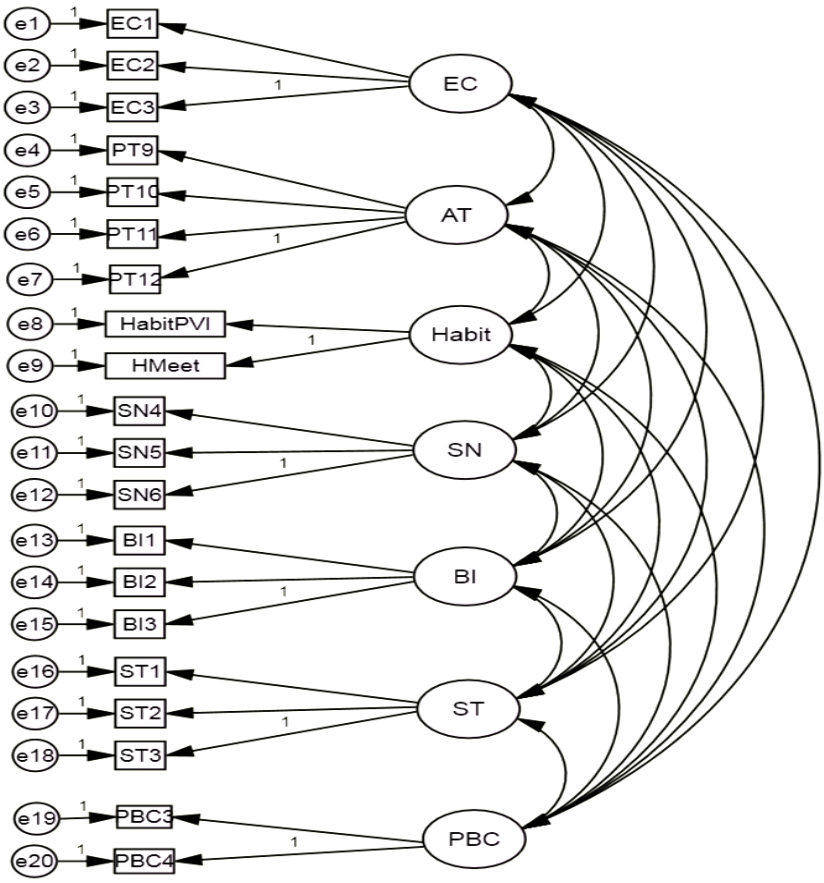


Figure 3.7 Analysis relationship pattern of CFA

Stage 6 Suitability and compatibility evaluation

This is the last stage of SEM. In major analysis needs to generate various models, but the researcher know how model is suitable model and which is more accurate or reliable. Each model evaluate appreciate itself as shown in step 4 what consideration are. Comparison of model consider different result of χ^2 or $\Delta\chi^2$, and Degree of Freedom or Δdf.

From this chapter, process in this research was understood both in study, sample size, data survey, implemented variables, or analysis technique specification for the result following the objectives. In addition, detail in this research was also understood for application to collect data in other study scope using questionnaire, and was able to decrease errors from collecting data. The next chapter had been analyzed basic characteristic of sample size being private car users to work.

a. Questionnaire Design

The questionnaire contains all necessary questions to receive the attitudes and facts about travelers, travel, the psychological thoughts on mode selection, and other environments for travel. In this study, the questionnaire is divided into 7 parts namely

Part 1 Socio-economic and personal characteristics of travelers. The questions include gender, age, number of members in household, average monthly income, types and number of auto ownership, driver license status. The questions are also specific for travelers who drive private cars or ride public transport. The specific question in this Part describing the current type of travelers (by mode of travel) is shown below:

1. Have no car. Must travel by public transport (only)
2. Have a car(s) in household but decide to go (to work) by public transport
3. Have a car(s) in household but need to share with household member. Must travel by public transport on the day when no car is available
4. Drive (to work). Drive alone and drive from home-work-home
5. Drive (to work). Drive regularly with member(s) in the household sharing the same car
6. Drive (to work). But park on the way and connect to public transport.

If the respondents choose the answer 4 or 5, then the respondents are currently “private car users”. If the respondents choose the answer 2, 3, and 6, then the respondents are “public transport riders”. It is noted that the respondents who answer 1 are classified as “captive riders”, and the data from these group of respondents may be excluded from the analysis since these people do not have their choice of travel.

Part 2 Travel characteristics and the selection on mode of travel. The questions aim to find the present mode usage, the purpose of travel, and the frequency of travel. Some key specific questions are shown below:

Q 1. How many days in a week that you travel from home to work ..... days/week

Q 2. Apart from work trip, how many days do you go out of home for personal, shopping, and seeing friends ..... days/week and what is your means of travel

Q 2.1 Personal and Shopping (HabitPVI)

❍ Drive or ride on private car ❍ Public transport ❍ Both private and public transport

❍ Walk/Bicycle

Q 2.2 Meet friends (HMeet)

❍ Drive or ride on private car ❍ Public transport ❍ Both private and public transport

❍ Walk/Bicycle

Q 3. What are means of travel to work in the past 3 months

Q 3.1 Drive or ride on private car

❍ Never ❍ Rarely ❍ Sometimes ❍ Often ❍ Always

Q 3.2 Public Transport (All kinds)

❍ Never ❍ Rarely ❍ Sometimes ❍ Often ❍ Always

Q 4. Which means of travel that you use for getting out of your home in the past month? (can answer more than 1 answer; please answer all means used)

❍Private car (driver) ❍ Private car (rider) ❍Walk ❍ Public van ❍ Bus

❍Motorcycle taxi ❍ Skytrain or Subway ❍ Motorcycle ❍Bicycle ❍ Train ❍ Boat

It is noted that Question 2 to 4 capture the “habit” of travelers on mode usage. The habit is defined as the captiveness of the current mode of travel. If a traveler uses the same mode all the times (never use any other mode for working as well as other purpose travel, then the traveler would have a strong habit of captiveness (or may generally called as addicted to a mode). Several questions can confirm the habit of the travelers as well as be used as the consistency check of the answers.

At the end of Part 2, a question is asked to respondent about the intention to use a transport mode other than the private car (CarBI). This question pulls out the respondent’s first impression on the mode switching. The question is strategically placed here, as it is the first question about the attitude (opinion), and the respondent is believed to report his/her quick impression. The choice answers are either a) Impossible, b) May be, and c) Possible. This question can be used to observe an instant and spontaneous response on the mode switching preference. This question can also be used to check the consistency of the answer (about mode switching) with other questions.

Part 3 Attitudes toward mode of travel (private and public transport). The questions ask the respondent to rate the quality of services, perceived opinion on transport modes. The respondents are requested to rate in 9-point scale (Likert scale) on both private and public transport on the same questions.

Thus, the comparisons between opinions on the two modes can be seen. The answer ranges from 1 = totally disagree to 9 = totally agree and 5 is a neutral answer.

The attutides toward travel mode usage are asked to the respondents for both private and public transport modes. These attitudes can be viewed as perception and expression of the service quality of a specific means of transport. The questions pinpoint 8 categories of perception on modes, as shown in Table 3.1. The questions are 9-point likert scale. With the same questions being asked to both private and public transport service, one can obtain the difference in the attitudes toward the services by both modes for each attribute category.

Table 3.1 Perception of service quality in 8 categories by modes of travel

Category	Variable	
	Private vehicle	Public transport
Easiness to travel with luggage	PV1	PT1
Easiness to travel with young children	PV2	PT2
Protection from sunlight or rain	PV3	PT3
Waiting time and transit	PV4	PT4
Cost saving	PV5	PT5
Stress from travel	PV6	PT6
Privacy	PV7	PT7
Availability (Can travel at any time)	PV8	PT8

Moreover, the overall expression of service quality are asked on 4 categories; namely, safety, convenience, reliability, and overall service quality for the two modes. The 4 categories are selected after general caharacteristics of transport modes, as shown in Table 3.2. The respondents are asked to rate the current perception of each mode service quality. The attitudes are answered in the 9-point sematic scale as well.

Table 3.2 Overall service quality by two modes

Category	Variable	
	Private vehicle	Public transport
safety	PV9	PT9
convenience	PV10	PT10
raliability	PV11	PT11
Overall quality of service	PV12	PT12

Next, the attitude on the mode switching from Private vehicle to Public transport is obtained through three questions. The questions aim to obtain attitudinal scale of intention to shift the mode. As the mode switching is not really happening, the questions obtain “behavioral intention” which is believed to lead to actual mode change in the near future. The questions are shown in Table 3.3. The questions target to degree of intention to switch to public transport

(from private vehicle), the intention to reduce private vehicle usage, and intention to switch to public transport for the next travel. It is noted that all three questions capture different categories of the behavioral change (degree of mode switch intention, the leaving of the current mode (private

car), and the time frame on the mode switch. Since these questions are important and reflect the desirable outcomes of the consideration, the answers from these questions will be analyzed together with other questions to display the consistency of the answers.

Table 3.3 Behavioral Intention to switch modes

Question	Variable	Meaning
I have strong intention to switch to Public transport	BI1	Obtain response on mode switching from Private vehicle to Public transport
I have strong intention to reduce Private car usage	BI2	
I have intention to use Public transport for my next travel	BI3	

Subsequently, several questions are listed in the same table, asking the respondents on Subjective Norm (SN), Attitudes (AT), and Perceived Behavioral Control (PBC). These questions target on several element of travelers opionions, and attitudes. These questions are mainly used for more detailed analysis on unobserved factors that influence travelers' decision. More specifically, these questions are exogeneous variables in the Theory of Planned Behaviors (TPB). The questions are listed in Table 3.4 -Table 3.6 for subjective norm, attitude, and perceived behavioral control, respectively.

Table 3.4 Subjective Norm

Question	Variable	Meaning
If my close friends/relatives use private car, I will use it, too.	SN1	Influence of surrounded people on individual decision
People surrounded me support me to use private car	SN2	
Family and friends surrounded me think that using private vehicle does not impact society	SN3	
If people close to me use Public transport, I will use it too.	SN4	
People surrounded me support me to use Public transport	SN5	
Family and friends surrounded me think that using Public transport is good for society	SN6	

Table 3.5 Attitudes of travelers

Question	Focus	Variable	Meaning
I am a punctual person	Personal	PN1	Personal characters/liking
I like driving		PN2	
I give importance to environment such as recycle	Environmental and Social concern	EC1	Degree of concern to environment and social matters by traveler
I want to use Public transport since it makes city livable		EC2	
I want to use Public transport since it reduces traffic congestion		EC3	
For me, car is the important, must have, and must use it	Attitudes toward car	ST1	Liking on car and car usage
For me, car show social status		ST2	

I want to own a car		ST3	
I want to use Public transport if the service is better	Perception on modes Public transport	PERC1	Liking on public transport
During traffic congestion, I prefer sitting in private car to public transport		PERC1	

Table 3.6 Perceived Behavioral Control

Question	Variable	Meaning
When I travel by car, it is difficult to find parking	PBC1	Difficulty to travel by car and public transport by individuals
I find it difficult to drive a car to work	PBC2	
I find it difficult to ride public transport to work	PBC3	
I find it difficult to travel from my house to transit stop	PBC4	

Part 4 Data on travel by private vehicle. This part of questionnaire obtains the travel characteristics by private vehicle. Data include distance of travel, provision of parking at working place, travel time (morning and afternoon) from house to working place, and cost.

Part 5 Data on travel by public transport. This part of questionnaire obtains the travel characteristics by public transport. The respondent is asked how he/she travels from home to working place by public transport. Data include mode use from home to transit station, main transit mode, and mode use from destination transit station to the working place. Along with each section of travel, travel time (including the waiting time), cost, and satisfaction on the mode are also collected. Most of answers are quantifiable data except the satisfaction answer ranges from 1 = totally disagree to 9 = totally agree and 5 is a neutral answer.

It is noted that, since each respondent travels by either private vehicle or public transport, either answers from Part 4 or Part 5 represents actual travel and the other is the estimates by traveler. Although the data on one mode is estimated, as the traveler may not use it often, we believe that the estimates on travel characteristics would give a close value to the reality and reflect traveler opinion (satisfaction). Then, Part 4 and Part 5 can also be used for comparing different characteristics of travel by the two modes.

Part 6 Factors deterring travelers from using Public transport. This part of questionnaire obtains the reasons why the traveler would not like to use public transport. In case of regular Public transport riders, these questions still ask them what factors that deter them on riding. The answers are ranking from 15 choices of common factors/reasons. The 15 possible choices come from early pilot projects. The respondents are asked to rank the most important factors ranking 1-5, in which 1 is the most important factor for them. The choices are listed below:

Travel in long distance	Travel time is long	Feel unsafe from crime
Difficult to make connection	Travel time is unreliable	Difficult to travel with family
Cannot carry lot of belongings	Bad service	Inconvenience on transit vehicle
Family discourage on usage	Exposed to sunlight and rain	Does not have privacy
Cannot go to many places	Cost of travel	Feel unsafe on accidents

Part 7 Choices for travel adaptation. This question is for only private vehicle users and targets to collect traveler's response to change and choice of their travel adaptation. With the scenario that the private vehicle users face a situation that they must change their mode of travel (such as high fuel cost, more congestion) the respondents are asked how they adapt their travel. The answers are 5 rankings from 7 possible choices. The choices are;

Reduce travel by private vehicle by reducing activities outside home
Try more walking and bicycle
Work at home (and use internet) more
Reduce the distance of travel by linking many activities to one trip
Change the travel to less congested period
Do more carpooling
Use Public transport

4.1 Steps for Data Collection

Before the actual data collection, the researchers must prepare for the readiness and pilot-test on the data collection activities. To ascertain that the data collection is carried out without any practical problem, several steps are conducted before the actual field data collection take place.

1. Site survey on appropriate sites for data collection

Before specifying the areas for data collection, several preliminary sites were surveyed. The survey gave the researchers an actual conditions of the sites, travelers who normally pass the sites, and existing modes in the area(s). The sites around Bangkok were surveyed and listed. Possible descrition of each site and possible data collection problems were also noted.

2. Specifying Data Collection Sites

Once several sites were surveyed and short-listed, then the actual data collection sites were selected. Since the objective of the study is to learn about Bangkok travel bahaviors with various travel characteristics, few sites were selected to be the data collection sites for this study. The main reason is that a variety of travel behaviors (and also attitudes toward the mode selection) can be captured by these sites. The sites represent a wide variety of mode choice set, especially the modes for public transport connection. The sites are mainly the interconnection between modes, and thus we can get a wide variety of travel conditions such as distance of access, mode usage, etc. Note that the selected sites are not normally Origin or Destination of the travel, and the study does not attempt to compare the characteristics and attitudes of travelers between the sites of data collection. The data collection at transfer point reduces a bias on trip distance and choice of mode usage. The bias is further reduced by selecting sites with various land-use patterns and distance to downtown area. Finally, the selected sites for data collection in this study included District of Pathumwan, Phranakorn, HuayKwang, BangKapim Jatujak, Bangkhen, SuanLuang, and PhraKhnanong as illustrated in Figure 4.1

Figure 4.1 Areas of Data Collection

(Map from http://www.panteethai.com/maps/province/bangkok.jpg)

The main reason that these sites were selected as the data collection sites in this study is that all 8 sites have a variety in travel modes and these areas contain much of economic and education activities. The areas are densely populated and lots of commercial activities. The variety of attitudes toward travel was also expected in these sites.

3. Formal Permission to conduct the data collection in the areas

Once the areas of data collection were finalized, the letter requesting the permission to conduct the survey was issued to several potential area of data collection. Mainly, the data collection took place at private facilities, such as the skytrain station, near the private commercial buildings, etc. The letter stated the objective of the study, the target group, time and date of data collection responsible persons and contact detail.

4. Interviewer Briefing and Pilot test

Before going to the sites and collect data, all interviewers must be trained and pilot-tested. The briefing elaborated the planning on the data collection activities, the detail on steps and procedures of data collection. The instruction was carefully given to all interviewers even in the fine detail such as place and time of appointment, proper dress, codes of conduct, the proparation on equipment, budget , and transportation to the data collection sites.

5. Data Collection Activities at the preselected sites

Field data collection activites were planned on the following dates. Even well-prepared data collection, some practical difficulties were still experienced. The summary of the problems at sites was listed below:

Table 4.1 Place and Time of Data Collection

Date	Place	Problems
8/05/2011	Ramkhamhang University	Some respondents did not pay much attention on answering the questions. Some did not read (or listen to) the questions thoroughly before answering the questions. The interviewers must separate all samples out and some samples were not used for further analysis
9/05/2011	Mochit Skytrain Station	
13/05/2011	Ekamai	
18/05/2011	Silom	
22/05/2011	PhraNakhon District	
28/05/2011	Bangkhen District	
2/06/2011	HuayKwang District	

6. Interview method

In this study, the questionnaire is the tool for collecting travelers data, thus the obtainment of the data from travelers were arried out through interview. First, the interviewers (surveyors) were trained. Then when going out for the data collection, the interviewers selected the respondents by accidental sampling method. Although less statistical meaning for population representation, the accident sampling provides easy-to-manage data collection and the interviewers can reduce the bias through their careful selection of samples. Moreover, the number of samples can be managed due to time and budget requirements. Each interviewer was assigned a number of samples he/she needed to collect. An instruction was given to all interviewers to spread out throughout the area (sites) of study.

7. Data Collection Actitivities (Pictures)

Figure 4.2 Data collection activities

CHAPTER 5 Data Analysis

After the field data collection was carried out, the next task was the creation of database and preliminary data analysis. This chapter explains the preliminary analysis of data to illustrate the characteristics of samples that are obtained from the field. The analyses were divided into few matters. First, the description of the socio-economic data of samples was presented. Then the travel characteristics were determined. The travel characteristics included mode usage, the number of days of travel (demand), time and cost of travel. After that, the summary on attitudes toward the travel mode, and opinion of the selection of modes were presented.

5.1 Socio-economic characteristics of samples

The socio-economic characteristics of the samples were presented in Table 5.1.

Table 5.1 Socio-economic characteristics of the samples

Category	Private vehicles (N=557)		Public transport (N=573)	
	Frequency	Percent (%)	Frequency	Percent (%)
Gender				
Male	306	54.9%	303	52.9%
Female	251	45.1%	270	47.1%
Age (years)				
< 25	102	18.3%	229	40%
25-40	355	63.7%	295	51.5%
41-55	82	14.7%	43	7.5%
> 55	18	3.2%	6	1%
Monthly income (Baht)				
≤ 10,000	63	11.3%	229	40%
10,001-20,000	246	44.2%	237	41.4%
20,001-30,000	117	21.0%	79	13.8%
30,001-40,000	62	11.1%	11	1.9%
> 40,000	79	12.4%	17	3%
Education				
Less than Bachelor's	121	21.7%	180	31.4%
Bachelor's	346	62.1%	362	63.2%
Higher than Bachelor's	90	16.2%	32	5.4%
Whether travel pattern changes during school session				
Yes	111	19.9%	196	34.2%
No	446	80.1%	377	65.8%
Work time constraint				
Must be punctual	367	65.9%	381	66.5%
Flexible	190	34.1%	192	33.5%
Number of vehicles in household (vehicles)				
1	230	41.3%	315	55%
2	173	31.1%	179	31.2%
3 or more	154	27.7%	79	13.7%

From Table 5.1, the both private and public transport user samples have similar number of males and females in the sample set. The majority of travelers are between 25-40 years of age and

have Bachelor's degree education. Most of them need to be at work on-time (no flexible hours). The major income group of travelers is 10,000-20,000 baht per month but a considerable number of public transport rider samples have income lower than 10,000 baht. One quick finding from the descriptive analysis is that the lower income ride public transport riders, comparing to the private vehicle drivers/riders. Most of samples do not change their travel pattern during the school session.

5.2 Travel Characteristics of samples

Table 5.2 reports that the travel characteristics of samples. On average, both private and public transport users go to work 5-6 times a week. They go for personal and seeing friends approximately 1-2 times a week.

Table 5.2 Travel characteristics of private and public transport users

Travel Demand (days/week)	Private vehicles (N=557)		Public transport (N=573)	
	Mean	Standard Deviation (SD)	Mean	Standard Deviation (SD)
Go to work	5.32	0.718	5.32	0.743
Go for personal/see friends	1.80	1.122	1.91	1.096

5.2.1 Traffic Characteristics associated with personal and shopping

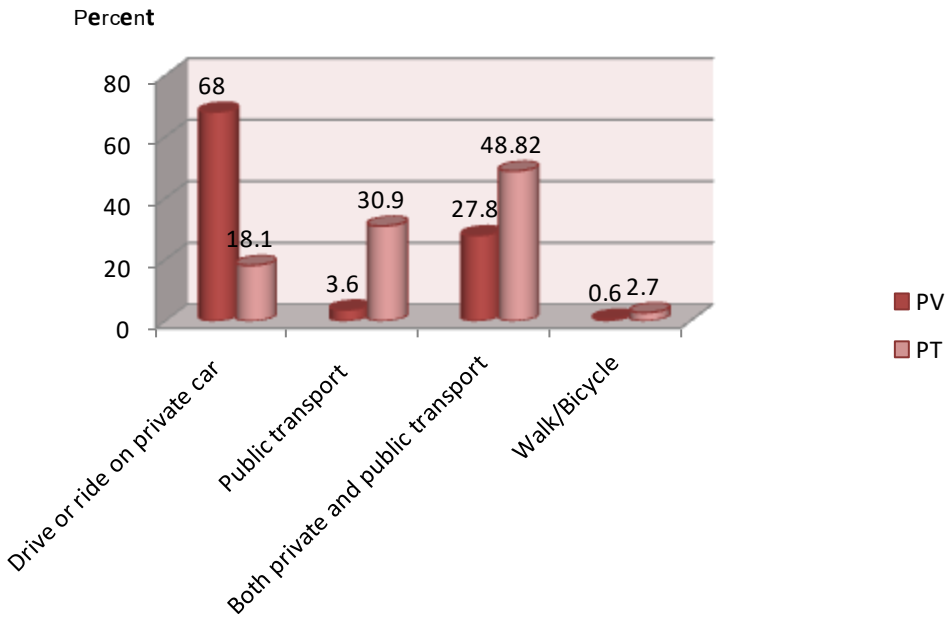


Figure 5.1 Mode usage for personal and shopping trips

Figure 5.1 displays that the samples who regularly go to work by private vehicles would also go to personal/shopping by private vehicles. From the Figure, 67.7 percent of samples this group would take private cars to shopping. While the regular public transport riders to work would take both private and public transport to personal/shopping. It is implied that the many of regular

public transport riders (47.6 percent) also regularly use both private and public vehicles at last for personal and shopping trip. It shows that the private vehicles may be an important means of transport for going to personal/shopping trips where the public transport may not be convenint or available.

5.2.2 Travel Characteristics associated with seeing friend

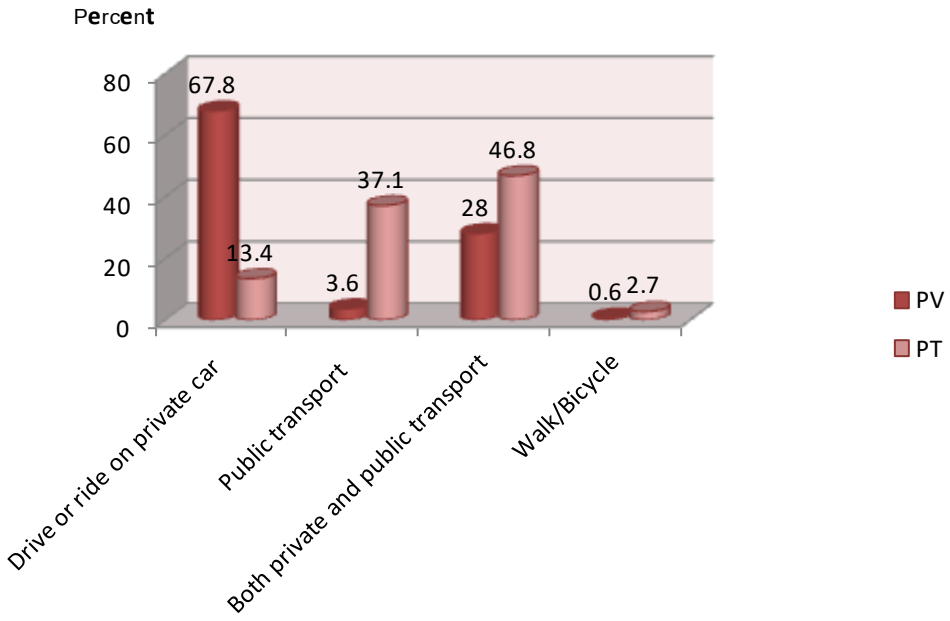


Figure 5.2 Mode usage for seeing friends

Figure 5.2 has a similar trend as Figure 5.1 the samples who regularly use private cars to work would also use private cars to see friends (66.6 percent). For the group of samples who ride public transport to work may use either private or public transport to see friends. This accounts for 47.9 of the total number of public transport to work riders.

5.3 Attitudes on Mode Usage by private and public transport users

This section reports the answers on attitudes toward travel, social-related opinion, and environments of travel. The attitudes focus on the difficulties on choosing and/or traveling on a mode and the intention to switch modes or change any behaviors. The summary of the results are shown in Table 5.3

Table 5.3 General Attitudes of travelers

Indexes	Private car users (Average)	Public transport users (Average)	Statistic value t
I am a person with high punctuality.	7.15 (1.798)	6.89 (1.764)	2.27
I feel like driving.	7.04 (1.718)	6.34 (1.872)	6.25
I am featured on the environment such as recycled paper separation.	6.82 (1.568)	6.59 (1.628)	2.29
I want to use public transport because it can help the city is more livable.	6.20 (1.833)	6.68 (1.612)	-4.37
I want to use public transport because it can reduce traffic congestion.	6.32 (1.951)	6.96 (1.636)	-5.69
Car has importance in my life. I require it.	7.07 (1.617)	6.27 (1.806)	7.44
Car is a symbol of social status.	6.10 (2.074)	5.94 (2.039)	1.22
I must have a car when suitable time arrived.	6.83 (1.794)	6.76 (1.824)	0.61
I will travel by public transport if there is better service.	6.91 (1.781)	7.28 (1.772)	-3.38
I am willing to use the car more than public transport in traffic congestion period.	6.51 (2.148)	5.78 (2.117)	5.4

Remark: ( ) is standard deviation

5.4 Differences in Perceptions on transport modes by current private vehicle and public transport users

The questions asked the samples to respond the perception on two modes (private vehicle and public transport) in a rating scale. The differences in the perceptions in the same category can be determined and interpreted. In each question, the sample was asked to rate the perception on one mode in the scale from 1 to 9. (1 is totally disagreed and 9 is totally agreed). The direct comparison of each question reveals the quantitative difference in perception (attitudes) toward the use of the two modes in that category.

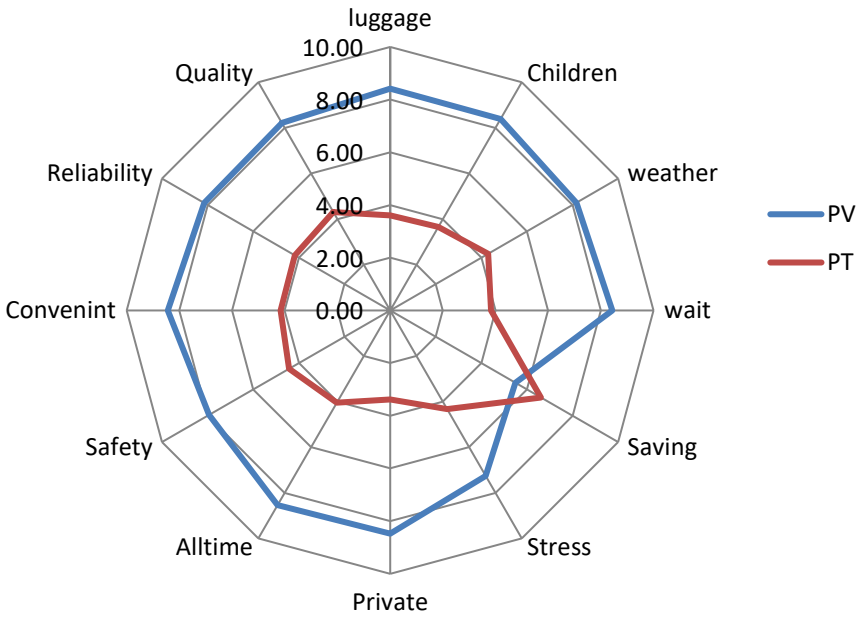


Figure 5.3 Attitude of car users to private car and public transport

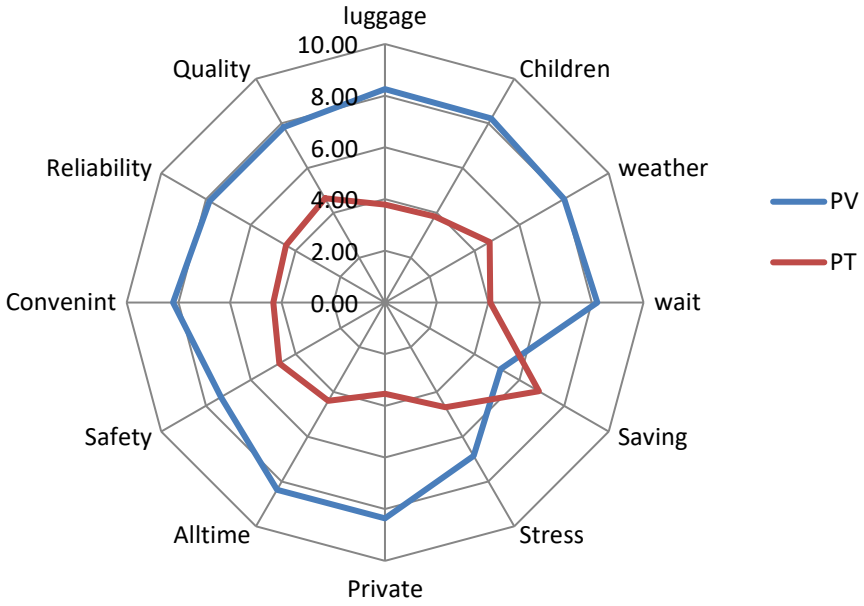


Figure 5.4 Attitude of public transport users to private car and public transport

5.5 Traveler characteristic

This topic showed the details and statistic values as well as details of traveler sample both of car and public transport users.

Table 5.4 Travel characteristic of travelers

Data	Car users	Public transport users
Distance from home to office (km)	19.5	16.6
Parking lot (%)		
Yes	90.7	84.6
No	9.3	15.4

In table 5.4 found car user group took average distance (19.5 km) from home to office farther than public transport user group (16.6 km). In addition, in majority, both 2 groups had parking lot in their office.

5.6 Public transport travel methods

This topic analyzed public transport travel methods of its users. In questionnaire was divided to 3 sections; travel from home to public transport station (origin), origin station to destination station, and destination station to destination (office). Each section in each mode of travel demonstrated in table 5.5.

Table 5.5 traveling data of public transport sample

Sections	Car users (%)	Public transport users (%)
Section 1 From home to origin station		
Walk	35.0	30.2
Motorcycle Taxi	39.1	30.0
Bus	7.9	15.9
Van	3.4	5.1
Motorcycle Taxi+Bus	6.8	8.9
Motorcycle Taxi+Van	3.9	3.5
Prvate Car	3.1	4.9
others	0.7	1.6
Section 2 from origin to destination station		
BTS	21.4	13.6
Subway	11.0	11.7
van	20.7	16.9
Bus	37.9	50.3
Taxi	5.4	4.9
others	3.6	5.2
Section 3 From destination station to office (destination)		
Walk	49.4	44.5
Motorcycle Taxi	22.4	23.0
Bus	9.7	15.5
Van	5.4	4.4
Motorcycle Taxi+Bus	5.7	6.3
Motorcycle Taxi+Van	3.2	2.8
Prvate Car	1.8	1.6
others	1.8	1.9

In table 5.5, in section 1, percent traveling of two groups of users had similarity in top 3 ranking; motorcycle taxi, walk, and bus respectively as shown in figure 5.5.

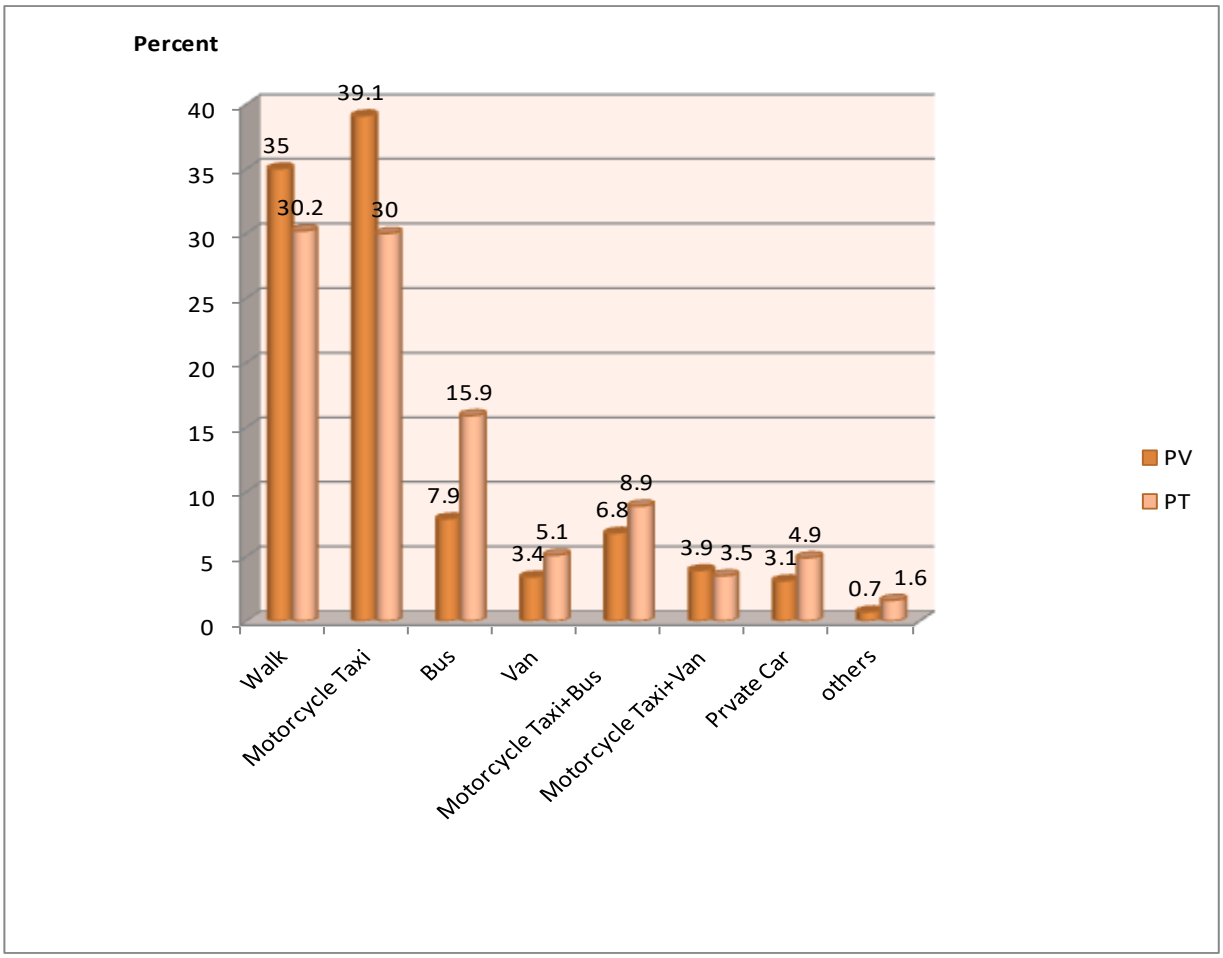


Figure 5.5 Traveling from home to origin station of public transport in each mode

In section 2, percent of traveling of two gropes of users had difference in top 3 ranking; bus (37.9%, 50.3%), BTS (27.4%, 13.6%), and van (20.7%, 16.9%) respectively as shown in figure 5.6.

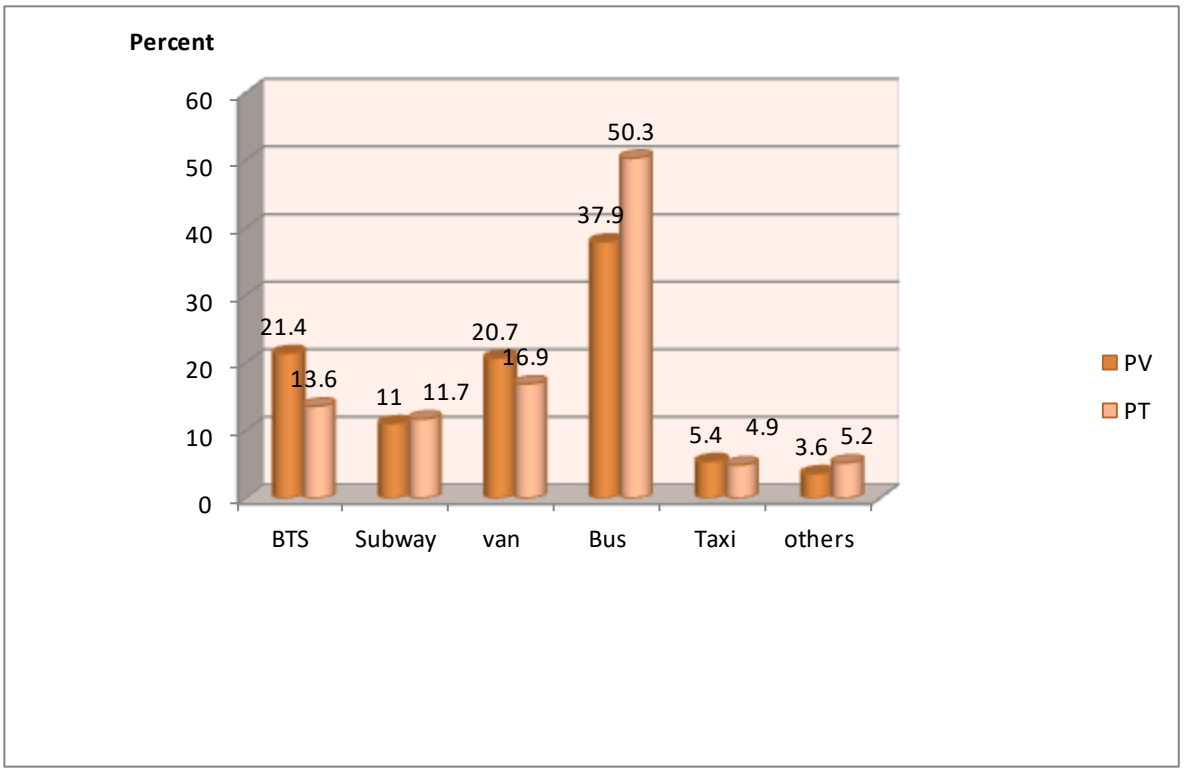


Figure 5.6 Traveling from origin to destination station of public transport in each mode

Figure 5.7 demonstrate travel method of two gropes of users in section 3. It found percent of traveling in top 3 ranking; walk, motorcycle taxi, and bus respectively.

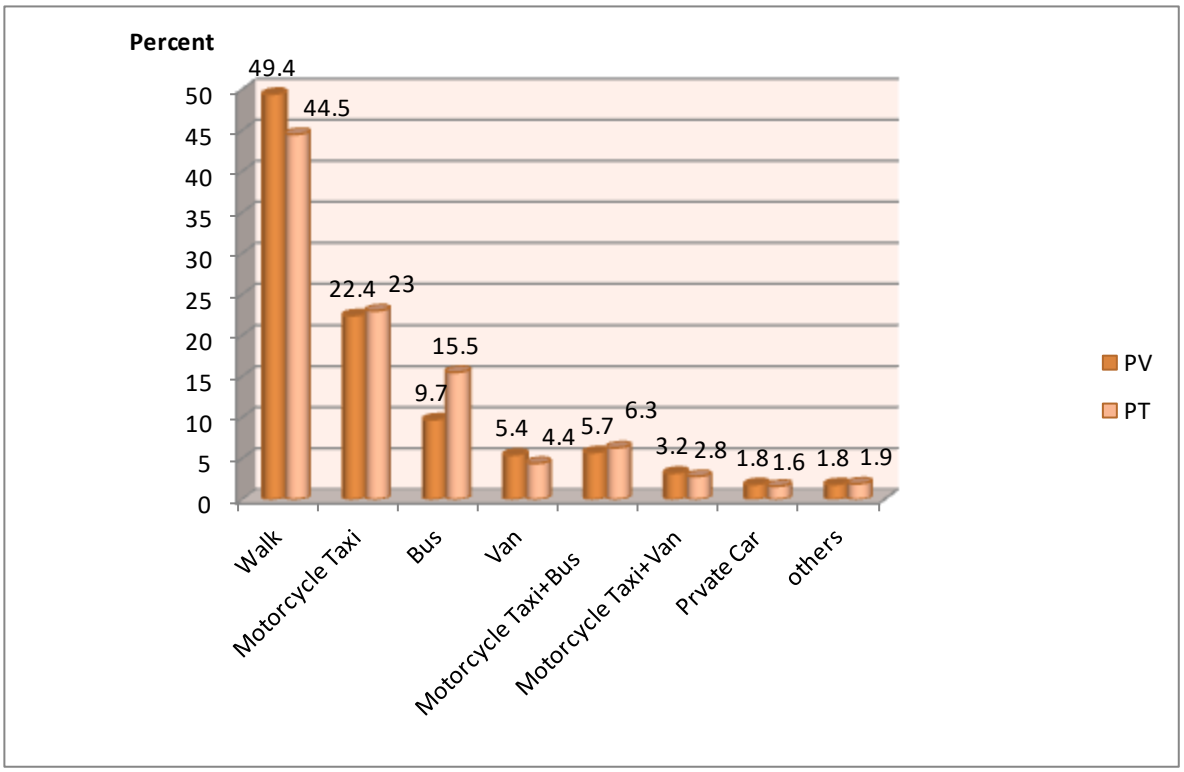


Figure 5.7 Traveling from destination station to office (destination) of public transport in each mode

5.7 Satisfaction in each section in case of using public transportation

Satisfaction of travelers in each section in case of using public transportation was calculated by current attitude of traveler evaluation from questionnaire as the analysis shown in table 5.6.

Table 5.6 Satisfaction in each section in case of using public transportation

Satisfaction	Car users	Public transport users	t value
Satisfaction in section 1	5.90 (2.091)	6.27 (1.873)	-3.15
Satisfaction in section 2	5.93 (1.992)	6.30 (1.93)	-3.15
Satisfaction in section 3	5.99 (1.932)	6.52 (1.771)	-4.81

Remark: () is standard deviation

Travel time

Table 5.7 Travel time of travelers (minute/day)

Current travel pattern	Using car	Using public transport
Car users	88 (2.20)	131 -(0.15)
Public transport users	83 (2.20)	132 -(0.15)

Remark: () is t value

By travel time analysis found current car travelers took 88 minute per day to travel in case of using car, but they took 131 minute per day in case of using public transport. According to public transport users, they took 83 minute per day in case of using car, but they took 132 minute per day in case of using public transport.

Travel cost

Table 5.8 Travel cost (Baht/day)

Current travel pattern	Using car	Using public transport
Car users	254 (7.56)	107 (4.12)
Public transport users	203 (7.56)	91 (4.12)

Remark: () is t value

By cost analysis found current car travelers paid 254 Baht per day to travel in case of using car, but they paid 107 Baht per day in case of using public transport. According to public transport users, they paid 203 Baht per day in case of using car, but they paid 91 Baht per day in case of using public transport.

5.8 Reasons and factors effecting private car users reject to use public transport

In this topic found the most factors effecting car user change to use public transport by the question “which factors do you reject to use public transport or walk/ride the bicycle” Interviewees had to arrange factors ranking 1 to 5. The first ranking was the most effected factor. In figure 5.8 demonstrate the result of the most effected factors which people reject to use public transport. The result found traveling in long distance was the most effected factor, travel time was the second, difficulty and inconvenient in public vehicle was the next factors. Distance, travel time, and quality of service, which are inefficient, are not able to convince car users to use public transport that conform to previous analysis.

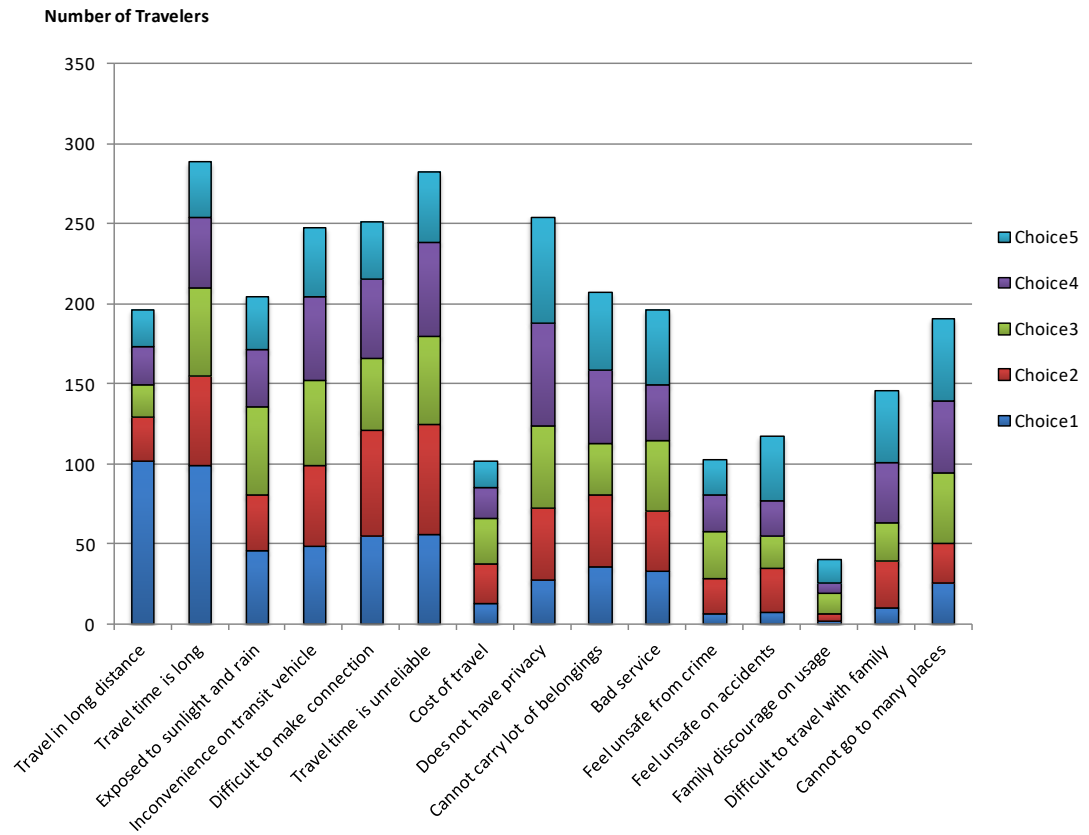


Figure 5.8 Effected factors ranking of car users do not use public transport

5.9 Traveling change examination by alternative specification of private car users

When identifying effected factors, behavior changing of private car users traveling was proposed how mode of traveling change without private car by the question” Which methods will you select to do if you need to change behavior due to some reason (increased oil price, more traffic congestion)”, and interviewees had to arrange answers in ranking 1 to 5. This question was able to examine how much private car travelers change to use public transport as shown in figure 5.9.

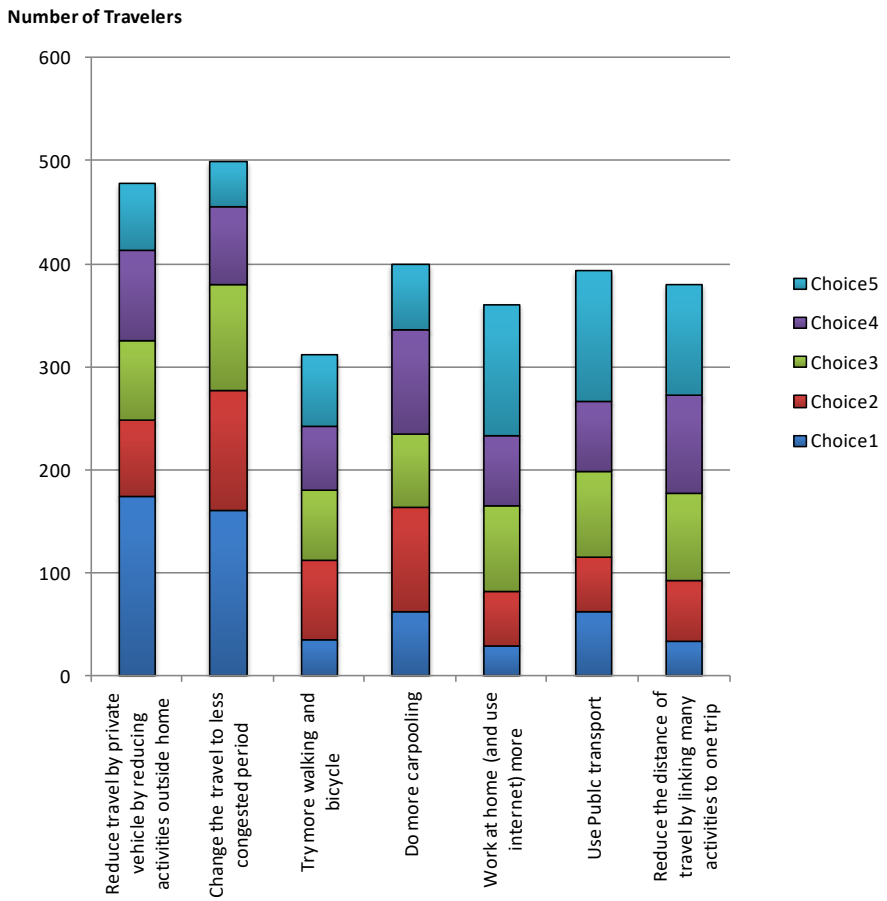


Figure 5.9 Behavior changing to use public transport

By the result in figure 5.9, if travelers need to change travel behavior, outside home activity reduction was the most answer they selected. Less traffic congestion period traveling was the second answer. More carpooling, using public transport, trying to walk or ride the bicycle, decreasing distance to travel, doing various activities in one trip, and working at home were the next answers respectively.

CHAPTER 6 CFA and SEM

By literature review in chapter 2, Ajzen's theory, The Theory of Planned Behavior (TPB), is able to well explain and predict intention to change behavior. This research applied this theory to specify scope for model generation. Ajzen identified 3 variable effecting intention including travel attitude, social conformance, and behavioral control perception. In chapter 5 examined data reliability of each variable both in theory and related research study. In addition, generated models from hypothesis were insisted by Confirmatory Factor Analysis (CFA) technique using software "AMOS" combined with SPSS Version 18 as the analysis tool.

6.1 Reliability examination

Reliability examination considers how all observed variables of latent variables conform to interrelationship in each observed variable using coefficient of Cronbach alpha (Cronbach's α). In majority research, data from questionnaire is examined whether it is sufficiently reliable before analysis. Confirmatory Factor Analysis (CFA) and Structural Equation Model (SEM) which have high Cronbach's coefficient value, mean latent variables are able to more explain variance of each observed variable. Generally, 0.60 value of coefficient could be approved (Clare, Kylie and Jo, 2006); moreover, more than 0.70 value is appreciate (Hair et al., 2010). Nevertheless, high value does not mean precious measurement; therefore, Construct Reliability and Average Variance Extracted (AVE) need to be examined.

6.1.1 Confidence generation by variable amount alteration and reduction principal

There are 2 steps to explain how to generate confidence in variables.

Step 1 lead results from questions in all observed variables in same latent variables to put in software "SPSS" for reliability examination. Cronbach's α value is used by combination with one-factor congeneric model to check. If analysis detects high value (> 0.60), it concludes that all variables have reliability. Moreover, one-factor congeneric model also checks how factor loading has more or less value and whether it is reasonable for cutting non-reasonable variables out.

Step 2 Variables elimination is divided in 2 methods

(1) Consider Cronbach's alpha value if it is more or less than 0.60. In case of less than 0.06, Cronbach's Alpha if item deleted value is considered for cutting inessential and non-reasonable variables. In case of more than 0.06, all variables are able to be implemented if there are reasonable and no excessive amount of variables. Table 6.1 (a) shows Cronbach's alpha if item deleted value for consideration to cut variables. Value of Cronbach's Alpha between 0.43-0.60 must be cut off. However, if Cronbach's Alpha values in each latent variable are not different, another method is more considered.

(2) Consider Cronbach's Alpha values in each latent variable which are not different and less than 0.60. This method might use one -factor congeneric model to more examine by Modification Index (M.I.) being a value for defect model examination as shown in table 6.1 (b).

Table 6.1 Example of cutting amount of variables consideration by perception latent variables (PBC) to difficultly travel

Variables	Cronbach's Alpha If Item Deleted	Cronbach's Alpha
PBC1	0.368	0.43<0.60
PBC2	0.447	
PBC5	0.356	
PBC2	0.325	
PBC5	0.374	

(a)

	M.I.	Par Change
PBC5 <--- PBC1	47.659	0.292
PBC5 <--- PBC2	9.066	0.105
PBC1 <--- PBC5	47.725	0.291
PBC1 <--- PBC2	9.236	0.106
PBC2 <--- PBC5	8.997	0.154
PBC2 <--- PBC1	9.152	0.156

(b)

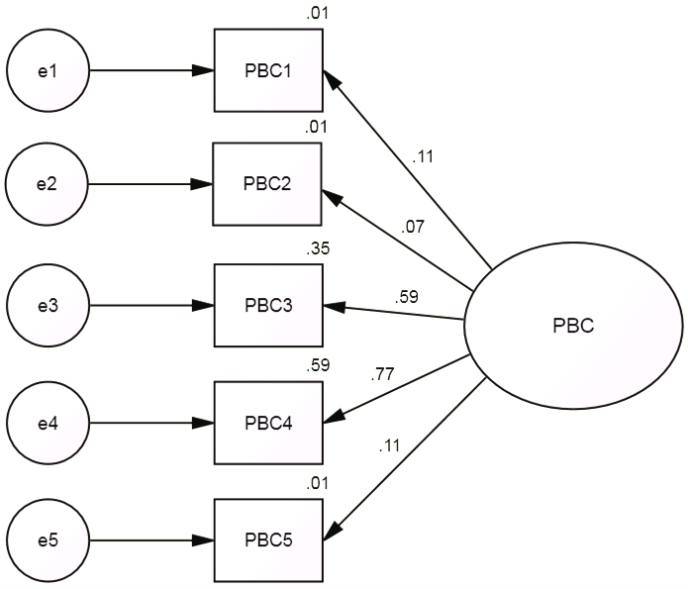


Figure 6.1 CFA Analysis by one-factor congeneric Model
(Example of defect perception to travel)

By table 6.1 (b), to cut variables by maximum M.I. value, found cutting variables between PCB1 and PCB5 must consider factor loading which one has less value. In figure 6.1 identifies value of factor loading of these variables equal 0.11 and very high value of M.I. which needs to cut them off. PCB2 is one of variable which has low factor loading value and is not reasonable; as result, it needs to be cut. Method from this figure is able to process by loop until Cronbach's αvalues are more than 0.60, and it is a basic filter variables method before leading to CFA. Nevertheless, it should have at least 3 observed variables to explain one latent variable (Hair et al., 2010).

In conclusion, 5 PCB variables is able to cut 3 variables which have only PCB3 and PCB4 because implemented question to ask might be various; as a result, Cronbach's Alpha value might be less than specification.

6.1.2 Cronbach's α analysis result

This research evaluated attitude effecting travel pattern of current public transport which differed from Ajzen evaluating attitude by person. Moreover, it also added group of variables in Environment Carefulness (EC), Social Status (ST), and habit to travel to consider. These 3 variables effected and were able to better explain intention to change public transport using.

By all questions to ask in questionnaire in 9 groups already explained in chapter 3, all of variables were examined reliability where variables or questions could explain latent variables and whether they were reliability for deep analysis. The result of analysis could represent in table 6.2.

Table 6.2 the result of reliability of Cronbach's αexamination

Measures	No. of Item	Cronbach's α
Service quality attitude Public transport (AT)	4	0.93
Subjective Norm (SN)	3	0.74

Perceived Behavioral Control (PBC)	2	0.63
Behavioral Intention Public transport (BI)	3	0.93
Environmental concern (EC)	3	0.77
Habit or Familiarity (HABIT)	2	0.89
Status (ST)	3	0.71
Personal characters (PN)	2	0.43
Perception on modes (PERC)	2	0.24

In table 6.2, Cronbach's α value of all variables except Personal characters (PN) and Perception on modes (PERC), are between 0.63-0.93 which exceeded 0.7 in majority. Totally, collected data have reliability, but there are obstacle in 2 groups of variables are; Cronbach's α value of PN equal to 0.43 and RERC equal to 0.24. They are a few values compared with specification being more than 0.60. Consequently, the researcher considered cutting these variables off because of a few values and confusing in interviewee's answers and misunderstanding in interviewer's questions. Without cutting these variables might be effect in the next analysis, not reasonable, and not capability to explain behavior.

6.2 Confirmatory Factor Analysis CFA)

After Cronbach's α value is already examined, the next step is confirmatory factor examination between observed variable and latent variable generated by The Theory of Planned Behavior (TPB). In addition, CFA examines whether generated model from hypothesis is constant, insists to reflection of latent factors, and conforms to collected data from questionnaire.

6.2.1 Confirmatory factor approval consideration principal

Muliti – Factor Congeneric Model is analyzed. It is difference of SEM analysis and additional confirmatory factor considerations includes;

1. Construct Reliabiliy or CR indicates reliability and accuracy of latent variable. Its appropriate value should be 0.70; whereas, 0.60 is only approval (Hair et al., 2010).

$$CR = \frac{\left(\sum_{i=1}^{n} L_i\right)^2}{\left(\sum_{i=1}^{n} L_i\right)^2 + \left(\sum_{i=1}^{n} e_i\right)} \quad (5.1)$$

Where L_i = Summary of Standardized Factor loadings, SFL

E_i = Error variance in each variable

n = Amount of questions in each group of variable

2. Average Variance Extracted (AVE) Controls variance of questions in Construct which is appropriate value equal to 0.5 (Hair et al., 2010).

$$AVE = \frac{\sum_{i=1}^{n} L_i^2}{n} \quad (5.2)$$

Where L_i = Summary of Standardized Factor Loadings, SFL

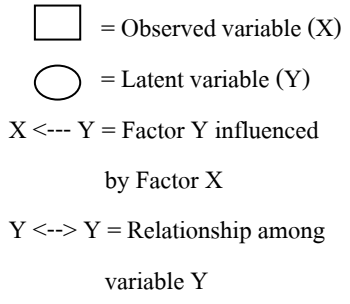
n = Amount of questions in each group of variable

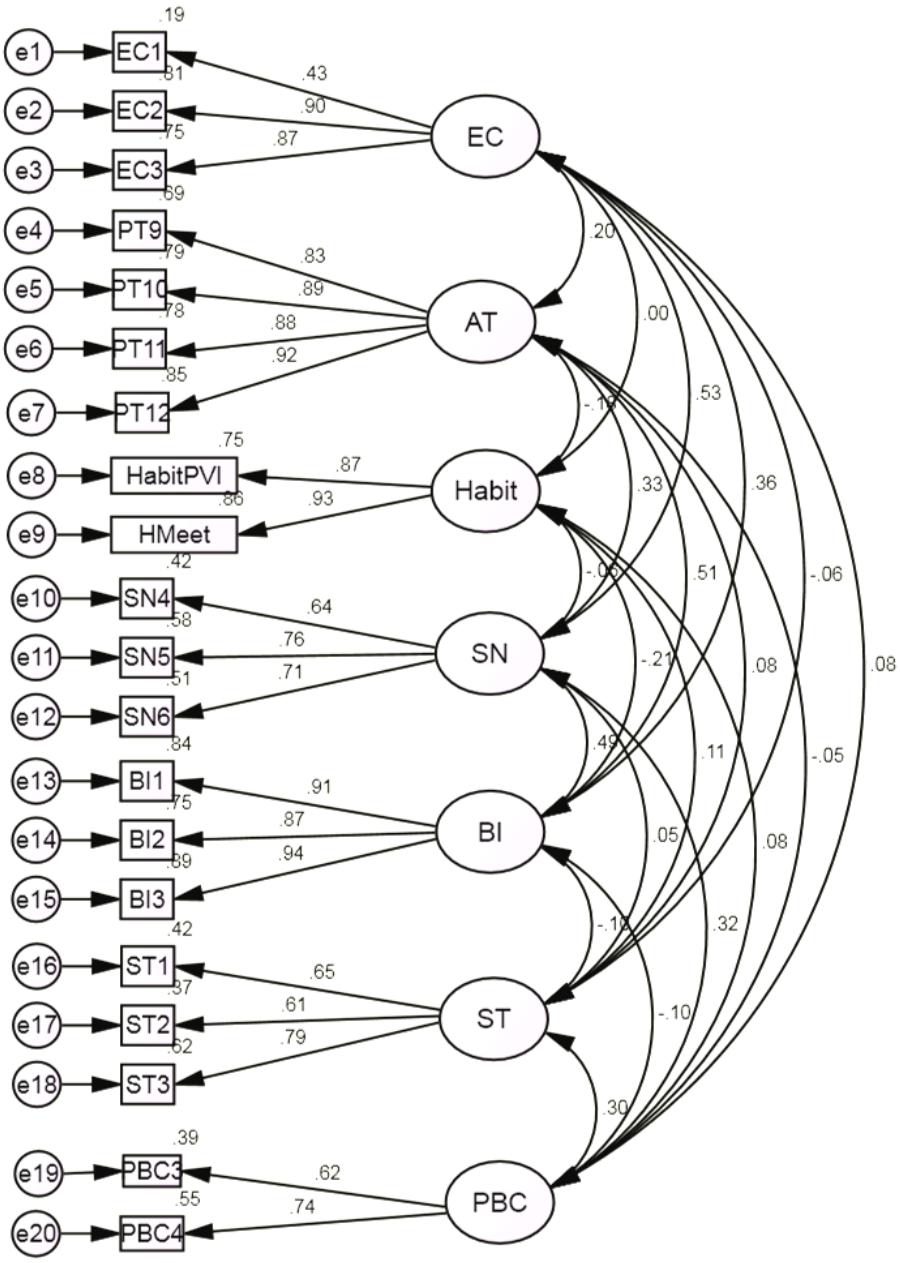
6.2.2 Confirmatory Factor Analysis (CFA) result

This analysis examined and used group of attitude variable in various patterns included; (1) differential attitude between using private car and public transport, and (2) Attitude in only private car users in safety, comfort, and service quality. The result found 2 first patterns did not effect and have significant to be intention variable indicator to use public transport, but pattern (3) attitude in only public transport was able to indicate and had significance to explain using public transport intention. The result of analysis was demonstrated in table 6.3.

Table 6.3 CFA analysis result

Construct	Item	SFL	Error variance	CR	AVE
Service quality attitude Public transport (AT)	PT9	0.83	0.69	0.80	0.78
	PT10	0.89	0.79		
	PT11	0.88	0.78		
	PT12	0.92	0.85		
Subjective Norm (SN)	SN4	0.64	0.42	0.75	0.50
	SN5	0.76	0.58		
	SN6	0.71	0.51		
Perceived Behavioral Control (PBC)	PBC1	0.62	0.39	0.66	0.47
	PBC2	0.74	0.55		
Behavioral Intention Public transport (BI)	BI1	0.91	0.84	0.75	0.83
	BI2	0.87	0.75		
	BI3	0.94	0.89		
Environmental concern (EC)	EC1	0.43	0.19	0.73	0.58
	EC2	0.90	0.81		
	EC3	0.87	0.75		
Habit or Familiarity (HABIT)	HabitPVI	0.85	0.75	0.66	0.80
	HMeet	0.93	0.86		
Status (ST)	ST1	0.65	0.42	0.75	0.47
	ST2	0.61	0.37		
	ST3	0.79	0.62		





$\chi^2 = 315.235$ ($df = 149$, $p < 0.000$), $\chi^2/df = 2.116 < 3$ $GFI = 0.946 > 0.90$, $CFI = 0.972 > 0.95$, $RMSEA = 0.045 \leq 0.050$)

Figure 6.2 proposed CFA model analysis (Standardized Coefficients)

In table 6.3 CR values are between 0.66-0.80. Some of variable groups are less than 0.7, but they are more than 0.6. Approval AVE values are between 0.47-0.83. Totally, variable groups have reliability and accuracy as well as good AVE value, but AVE for perception in difficulty to travel and in Social status (ST) equal to 0.47 being lower than standard specification value (0.5). Furthermore, variance of error in each variable or other variables being uncontrollable, have more error effecting reliability; however, conformation analysis result among components or latent variables from software "AMOS" as shown in figure 6.2, find χ^2= 315.235, df = 149, χ^2/df = 2.116, RMSEA = 0.045, GFI = 0.946,CFI = 0.972. Although, AVE values are less than 0.5, other statistic tests are able to say as good models.

By examination using Cronbach's αand CFA, concluded that models and other statistic tests were in specification, but AVE values of perception of difficulty and social status are a few lower than specification being approval. In addition, correlation among latent variables was not in high level not being similar meaning in each latent variable. These variables included; Environment Carefulness (EC1, EC2, and EC3).

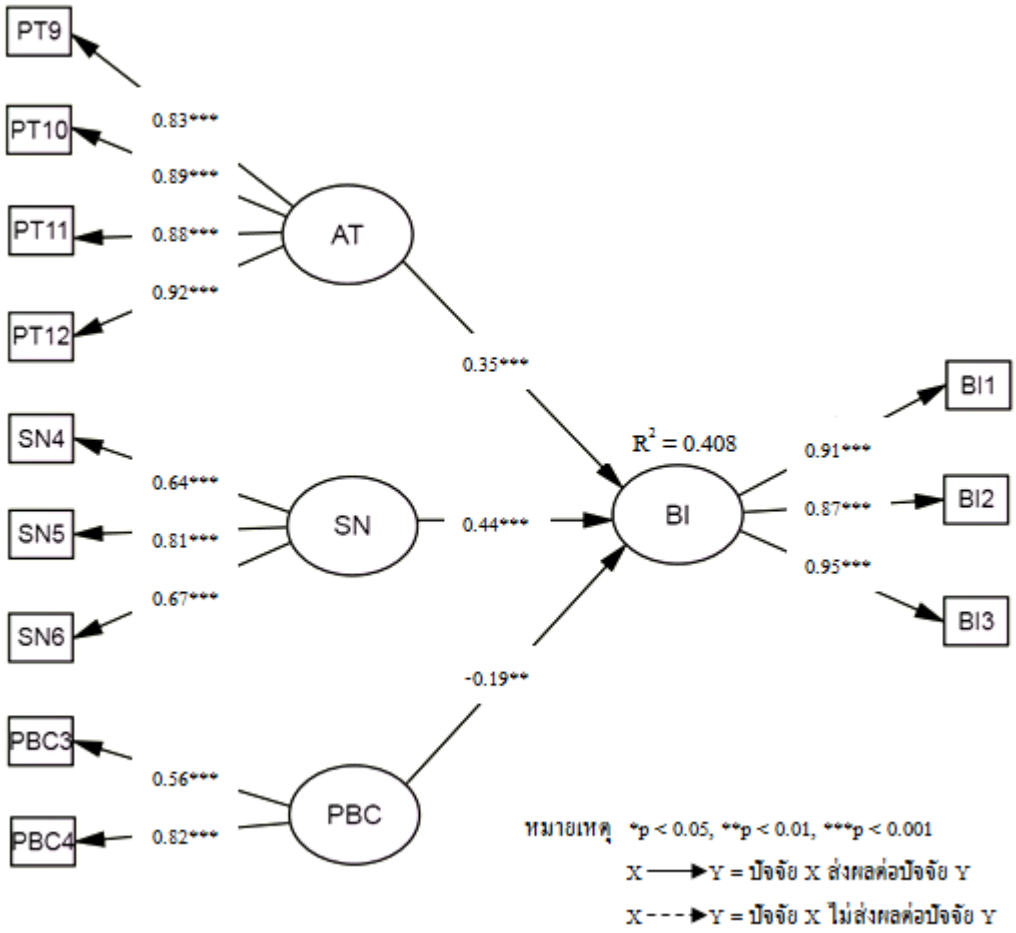
All of things in this chapter are able to insist that generated latent variables conform to indicate questions and theory used to be the scope of study. In this chapter could lead variables to analyze SEM and explain factors effecting intention to change public transport using. Another observation is why CFA must have correlation among latent variables explaining relationship between couple of latent variables. Correlation should not be exceed 0.8 by theory because if it has too more value, it means couple of variables are the same meaning, similarity to indicate, and able to eliminate or cut one of variable off (กริช แรงสูงเนิน, 2554).

6.3 Structural Equation Modeling (SEM) for Behavioral Intention

After the constructs are developed, the structural relationships between constructs are also developed. The behavioral intention can be explained by three latent variables: attitude (AT), subjective norm (SN), and Perceived behavioral control (PBC). Also, HABIT is also introduced in the alternate models. The SEM focuses on explaining causal relationship between BI and other latent variables. The degree of coefficient indicates the influence of those constructs to the examined variable BI. The proposed SEM models for Behavioral Intention to switch from private vehicle to public transport are illustrated in the visual diagram in Figure 6.3.

6.3.1 Theory of planned behavior (TPB) hypothesis models analysis result

By CFA and TPB, being the scope of hypothesis specification, the result of analysis by basic SEM is shown in figure 6.3.



χ^2= 74.871 (df =48, p<0.008), χ^2/df = 1.560<3 GFI = 0.978 >0.90, CFI = 0.993>0.95, RMSEA = 0.032 ≤ 0.050)

Figure 6.3 TPB models analysis result (SEM1) presented by Standardized Coefficients (N=557)

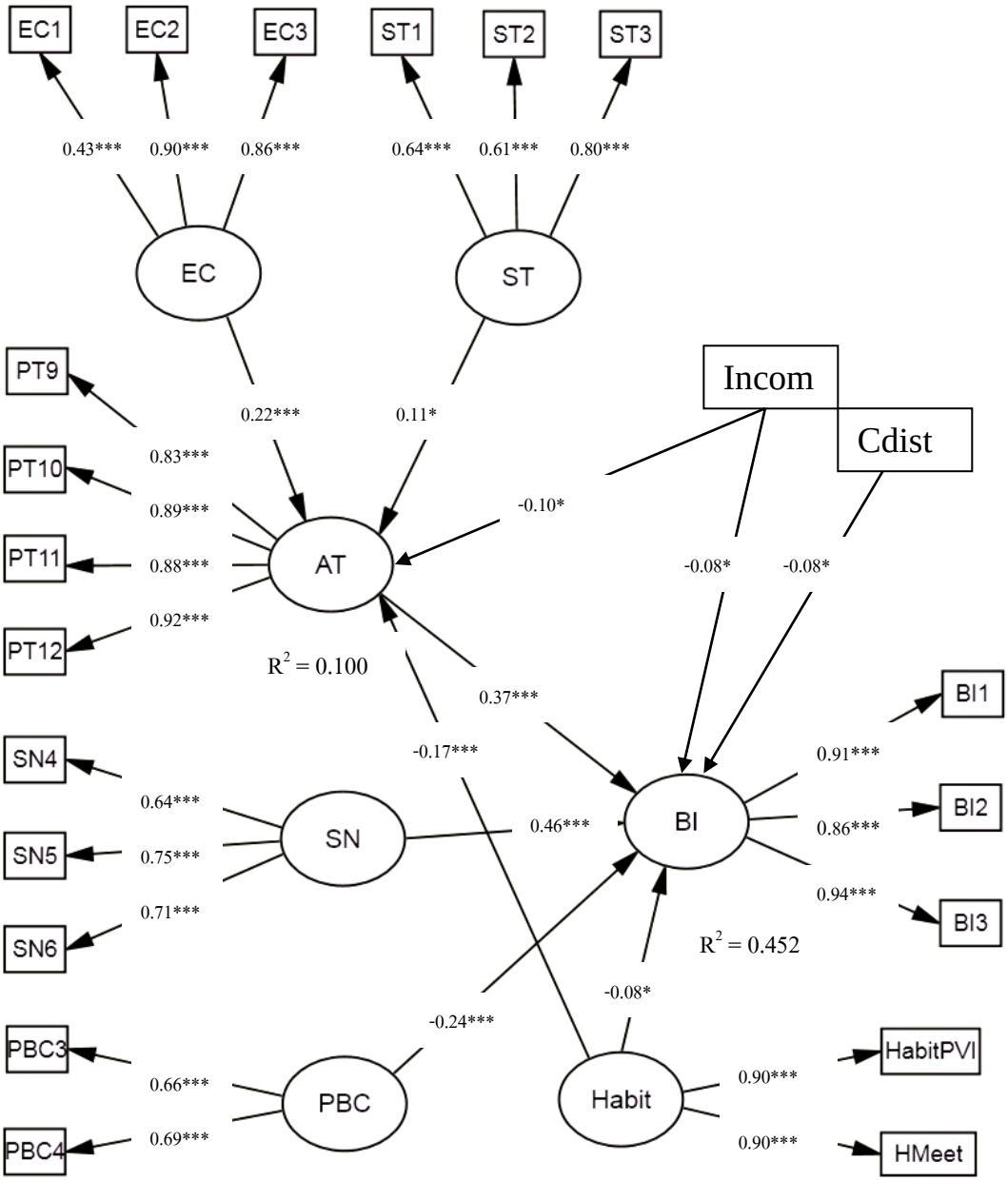
In figure 6.3 all indicated variables have significant value (p<0.001) and have 3 latent variables effecting Behavioral Intention (BI) including Attitude (AT), Subjective Norm (SN), and behavioral control (PBC). BI and SN have positive relationship, but PBC has negative relationship for intention. All 3 factors effected to intend to use public transport. SN was the most effected factors (0.44). That means if people or society think public transport using is a good thing or closing people use public transport, private car users could change and have intention to use public transport. AT was the second effected factor (0.35). That means if quality of service of public transport is good, safe, punctual, and comfortable, private car users could change and have intention to use public transport. Nevertheless, the negative factor, PBC (-0.19) means people have difficulty to travel by public transport such as more sections traveling or long distance.

The result in statistic testing generated model suitability as shown in figure 6.2 find χ^2=74.871 (df =48, p<0.008), χ^2/df=1.560 < 2 GFI = 0.978 > 0.90, CFI = 0.993 > 0.95, RMSEA = 0.032 ≤ 0.050). All indicators are in specified criterion and in figure 6.3, the value of R^2 = 0.408

that means this model is able to explain intention to change public transport using to 40%. By TPB model analysis could insist and summarize generated model have conformation to implemented theory and high data reliability.

6.3.2 Hypothesis model analysis result by adding socio-economic variable

From literature review found socio-economic variables effecting intention to change travel mode; therefore, they were considered in this research such as income, time, vehicles, cost, and distance. The analysis result found only income and distance effecting intention, but the value of them were less (-0.08) that means more income and long distance to travel, this grope of people is less to change public transport using. In addition, factor of income effecting attitude to public transport, the value of it was also less (-0.10) that means if quality of service is good, more income people may reject to use public transport. This result of this model was similar to all of models, and after statistic value examination, for generated model appropriate test as shown in figure 6.4, found $\chi^2 = 385.986$ (df =180, $p < 0.000$), $\chi^2/df = 2.144 < 3$, GFI = 0.941 > 0.90, CFI = 0.966 > 0.95, RMSEA = 0.045 ≤ 0.050). All of indicators are in specified criterion, and the result of R^2 (0.452) was the most value in 4 models that means this model could explain intention to public transport using to 45%.



หมายเหตุ *p < 0.05, **p < 0.01, ***p < 0.001

X ⟶ Y = Factor X effect to factor Y

X - - → Y = Factor X effect to factor Y

χ^2 = 385.986 (df =180, p<0.000), χ^2/df = 2.144<3 GFI = 0.941>0.90, CFI = 0.966>0.95, RMSEA = 0.045 ≤ 0.050)

Figure 6.4 Model analysis result by adding socio-economic variables (SEM4) presented by Standardized Coefficients (N=557)

CHAPTER 7 CONCLUSION

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