Mode Choice Behavior on Bangkok Worker

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Abstract: Transportation has played an important role in supporting people's life through the movement activity and it can be considered as one of the most basic human needs. It generates economic growth and social activities due to the increasing of the people's travel demand. The demand of transport services is derived from the demand due to other needs, Kanafani (1983). Transportation planning and modeling is necessary to manage well transportation system which is associated with productivity in urban area. One of important stages in transportation modeling is modal split analysis. This paper examines mode choice behavior on Bangkok worker where the objective is to check whether the disutility of transport (travel time and travel cost) meets the general hypothesis. Multinomial logit model as one of discrete choice approaches is employed to describe travel patterns and mode choice for worker living in Bangkok. Biogeme v1.8 was used for the model estimation.

Keywords: Mode Choice, Worker, Multinomial Logit, and Bangkok.

1. INTRODUCTION

Transportation has played an important role in supporting people's life through the movement activity and it can be considered as one of the most basic human needs. People need transportation to fulfill their needs such as health, food, education, and others. It generates economic growth and social activities due to the increasing of people's travel demand. The demand of transport services is derived from the demand due to other needs, Kanafani (1983). Transportation planning and modeling is necessary to manage well transportation system which is associated with productivity in urban area. One of important stages in transportation modeling is modal split analysis. The terms "mode usage," "mode choice," or "modal split" are often used to describe the people's decisions regarding their travel means.

The study of the choice of transport mode by an individual is important for several reasons: the cost-benefit analysis of long-term investment in transport infrastructure, such as the effects on the well-being of the population by developing existing networks or increasing capacity on certain roads; the development of incentive policies for the use of certain modes of transport , including public transport, but also vehicles with clean energy (as greenhouse gases); the development of intermodality; the development of carpooling, congestion management policies, De Lapparent (2005).

Several research on mode choice behavior were conducted in Bangkok. Sanit (2013) developed a location and mode choice decision mechanism analysis of multi-worker household in Bangkok, Thailand. This research aims to investigate the factors involved in

household choices decisions of multi-worker households who are more constrained in selecting residential location, workplace location and travel choice than one-worker households, with particular emphasis on the role of transport factors. Sakpongsatorn (2010) showed that most of the residents are the high income group and automobile dependent, while the BTS shares about 33% of all trips made by condominiums residents in the study of travel behavior of condominium resident along the railway and BTS. In this paper, the objective is different to that of previous research in Bangkok.

Working trip purpose is one of particular interests to many analysts and policymakers to understand trip maker behavior. This purpose is related to peak-period where many transportation problems occur. This paper examines mode choice behavior of a work trip for employees in Bangkok Metropolitan Area. The development of mode choice models can reflect the current travel behavior of Bangkok's workers and present the mode share across socio-demographics. The objective of this paper is mainly to check whether the disutility of transport (travel time and travel cost) meets the general hypothesis. The data were collected using face-to-face interview method (distributing questionnaire to respondents) during a two-month period from November-December 2014. 376 workers participated in the survey.

Multinomial logit model as one of discrete choice approaches is employed to describe travel patterns and mode choice for worker living in Bangkok. The estimation was typically based on the statistical principle of likelihood maximization and statistical measurement. Biogeme v1.8 was used for the model estimation.

2. METHODOLOGY

2.1 Study Area

Bangkok Metropolitan Region (BMR), Thailand, covers the large core so-called Bangkok Metropolitan Area (BMA) and five surrounding areas, namely Nonthaburi, Pathumthani, Samut Prakarn, Samut Sakorn, and Nakorn Pathom. BMR has undergone rapid urbanization and industrialization since 1960. In this paper, Bangkok Metropolitan Area is selected as the study area.

In 2012, 5,673,560 populations live in BMA and this area contributes around 30.16 % of the country's GDP. This shows that BMA is a major economic center of the country, where every economic activity can be found in various areas such as high-density business districts, high-density residential areas, heavy industrial estates, etc. Map of Bangkok as shown in figure 1.

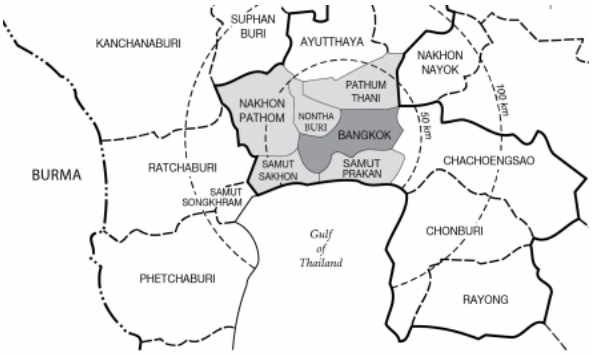

Figure 1. Bangkok City and surrounding area

2.2 Data Collection

As regards the research objective, worker's data such as personal information and trip pattern have to be provided to make an analysis. This type of data is obtained by conducting worker travel behavior survey in Bangkok Metropolitan Area.

Questionnaire quality plays an important role in order to collect worker travel behavior in the study area. The length of questionnaire and small number questions are taken into account to deal with the accuracy of respondent responses. Employing designed questionnaire, primary data collection is started by conducting pilot survey with face-to-face interview method. There were 20 persons who work in Din Daeng districts became pilot survey respondents. Many comments and critics are found during this stage related to questionnaire contents. It improves questionnaire quality for conducting the real worker travel behavior survey.

Finishing pilot survey with questionnaire improvement, next stage is conducting worker travel behavior survey in the chosen locations. Data collected from different categories of employees in Bangkok Metropolitan Area .Working purpose trip was taken from 3 categories of employees i.e., Government, private company and State-owned enterprise employees as shown in Table 1. The business activities are located at center of the city. These data may identify the current worker travel behavior and also reveals factors effecting the selection of modes.

Table 1. Respondent Types

Number	Respondent types	Locations
1	Government	Police Office Phaholyothin, Siriraj Hospital, Statistical office, Food and Drug administration
2	Private company	Gosoft, CPAC, TEAM Consulting Engineering and Management, Plan for Kids, Thai Osnor, DTAC, Tawee Mongkol Construction, Shinawatra Tower 2, Prince Palace Hotel, Sam Sen, ITCHYFEET THAI,
3	State-owned Enterprise	Mass Rapid Transit Authority of Thailand, TOT Public Company, Keatnakin Bank

A convenient sample of 376 employees was interviewed in Bangkok Metropolitan Area. Random sampling method was implemented for sampling technique. This number of sample is considered as sufficient by considering the precision, confidence level, and expected prevalence. Smith (2013) suggests the formula to determine the sample size (without finite population correction). The formula is shown below.

$$n = \frac{Z^2 P(1-P)}{d^2}$$

where,

n : sample size
Z : Z statistic for a level of confidence
P : Expected prevalence or proportion
(If the expected prevalence is 20%, then P = 0.2), and

d : Precision (If the precision is 5%, then d = 0.05)

By using 95% confidence level, expected prevalence of 0.3 and precision of 5%, it is resulted 323 sample size of respondents. Thus the number of sample of 376 respondents was considered sufficient. Since sample size (n)/ worker number (N) is less than 0.05, it is not necessary to use finite population correction factor in determining sample size.

2.3 Theoretical Approach

This research uses random utility concept, so the true utilities of the alternatives are considered random variables. Probability of alternative chosen is defined as the probability that it has the greatest utility among the alternative available. The utility function consists of attributes and coefficient as on the equation below.

$$U_{nj} = V_{nj} + \varepsilon_{nj} \quad (1)$$

where,

V_{nj} : which is the measurable part of the utility that the analyst can capture considering the different attributes of the alternatives and the taste parameters across the individuals, Train (2009).

ε_{nj} : which includes the part of the utility not measured by the analyst related to unobserved attributes, the unobserved heterogeneity of respondents and observational errors, Hess (2011).

Further equation can be developed into following equation:

$$V_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ... + \beta_n X_n \quad (2)$$

where,

V_i : Utility function of the alternative i

$X_1 ... X_n$: Attributes

β_0 : Model constant

$\beta_1 ... \beta_n$: The coefficient value of attributes

The model coefficients value represent the degree of relative importance attached to each product attribute. The model constant represents a basic bias towards or against the options. The random utility used to reflect unobservable elements of choice behavior, by including error term in the utility equation. The random element implies that the utility is related to the probability of a respondent giving a certain response rather than directly to the response itself (Pearmain and Swanson, 1991).

Multinomial Logit Model (MNL) is employed to make an analysis. This is the simplest and most popular practical discrete choice model, McFadden (1978). In this case, the probability of choosing the alternative j is increasing with V_j . For sake of estimation, one has to transform the satisfaction index, which can take any real value so that it is restricted to the unit interval and can be interpreted as a probability. The multinomial logit model is obtained by applying such a transformation to the V_{js}, Croissant (2010). More specifically, we have:

$$P_1 = \frac{eV_1}{eV_1 + eV_2 + eV_3} \quad (3)$$

$$P_2 = \frac{eV_2}{eV_1 + eV_2 + eV_3} \quad (4)$$

$$P_3 = \frac{eV_3}{eV_1 + eV_2 + eV_3} \quad (5)$$

The two characteristics of probabilities are satisfied:

$$0 \le P_j \le 1 \forall_i = 1,2,3$$

$$\sum_{j=1}^{3} P_j = 1$$

2.3.1 Attributes used in the models

The attributes used in the logit models were selected according to given dataset. The model is developed based on various attributes along with socio demographic characteristics, which is perceived to influence the individual choices. These attributes consist of level of service characteristics and mode specific variable. The level of service characteristics namely travel time and travel cost. The other attribute is mode specific constant or alternative specific constant (ASC). The alternative specific constant for an alternative explains the average effect of all factors that are not included in the model. In the logit modelling, alternative specific constant is preferred to use since the result of the calibrated data of disaggregate model using mode specific attributes is better and represents the travel behavior of the population compared to those estimated using generic variables. Train (2009) explains that if there are *i* alternatives, at most *i*-1 alternative specific constant can be used in the model, with one of the constant normalized to zero. In this research, for the mode choice context and the population of Bangkok city the global choice-set consist of 3 alternatives such as Motorcycle, Car and Public Transportation. Here Public Transportation includes Bus, Van, Taxi, BTS Skytrain and MRT. So there will be 2 alternative specific constants and the remaining is set to zero. The possible equation for this research can be shown below.

$$Vi = \beta o + \beta tt TT + \beta tc TC \quad (6)$$

where,

β_o : Alternative Specific Constant (ASC)
β_{tt} : beta parameter for travel time to be estimated
β_{tc} : beta parameter for travel cost to be estimated

The utility functions using BIOGEME are presented below.

U_{mc} (Motorcycle) = BETA_TT * MC_TT + BETA_TC * MC_TC
U_{car} (Car) = ASC_CAR * one + BETA_TT * CAR_TT
+ BETA_TC * CAR_TC
U_{pt} (Public Transport) = ASC_PT * one + BETA_TT * PT_TT
+ BETA_TC * PT_TC

Attribute of travel time and travel cost is related to working purpose trip from home to office. Travel time by car and motor cycle means in-vehicle travel time while travel time by public transport is walking time + waiting time + in-vehicle travel time. As regards travel cost, public transport cost is fare that is paid by respondent. Travel cost by car is cost of fuel + parking + toll and travel cost by motorcycle includes fuel cost and parking cost.

3. DATA ANALYSIS

3.1 Respondents' Characteristics

Table 2 shows the descriptive statistics of respondents' characteristics. The respondents were mostly female (62%), ages between 21-30 years (40.2 %), university graduated (91.2 %), private company and state-owned enterprise (75 %), low income (72.3 %). 57.4 percent of the respondents own one car, while 92.3 percent of the respondents do not own motorcycle. Dwelling respondents are mostly located in Bangkok with 76.3%. 39.4 percent of the respondents use car as primary mode for commuting, followed by using bus (30.9 %), motorcycle (12%), train (7.4 %), walking (6.4%), taxi (3.2%) and bicycle (0.8 %).

Table 2. Social-Demographic Charactertistics of The Respondents

CHARACTERISTIC		OBSERVATION		CHARACTERISTIC		OBSERVATION	
Gender	Male	143	38.0%	**Car Ownership**	No Car	131	34.8%
	Female	233	62.0%		1 Car	216	57.4%
Age	≤ 20	6	1.6%		2 Car	26	6.9%
	21 – 30	151	40.2%		> 2 Car	3	0.8%
	31 – 40	109	29.0%	**Primary Mode**	Walking	24	6.4%
	41 – 50	67	17.8%		Bicycle	3	0.8%
	> 50	43	11.4%		Motorcycle	45	12.0%
Education	Junior H School	8	2.1%		Car	148	39.4%
	Senior H School	25	6.6%		Bus	116	30.9%
	University	343	91.2%		Train	28	7.4%
Type of occupation	Government Employee	94	25.0%		Taxi	12	3.2%
	Private Company	282	75.0%	**Home Location**	Bangkok	287	76.3%
Income	< 20,000 Baht	272	72.3%		Samut Prakan	12	3.2%
	20,001 - 40,000 Baht	89	23.7%		Samut Sakhon	4	1.1%
	> 40,000 Baht	15	4.0%		Nonthaburi	51	13.6%
Motorcycle Ownership	No Motorcycle	347	92.3%		Pathum Thani	19	5.1%
	1 Motorcycle	21	5.6%		Nakhon Pathom	2	0.5%
	2 Motorcycle	3	0.8%		Ratchaburi	1	0.3%
	> 2 Motorcycle	5	1.3%				

Source : worker travel survey, 2014

3.2 Travel mode chosen by workers

The following figure reveals the transport mode selection based on respondent gender. Female workers tend to use car as the main of transportation mode. In male worker's case, the domination of car use is also significant. Bicycle has the lowest contribution on male and

female's transport mode for working purpose.

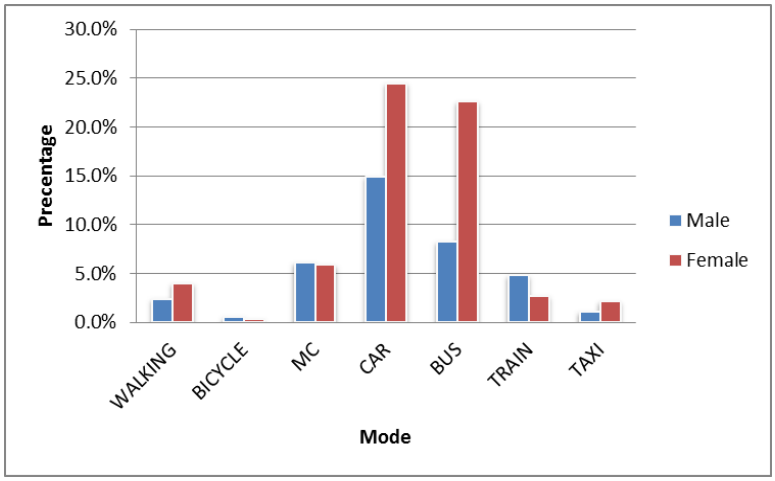

Figure 2. Gender wise mode selection

The highest number of respondent is between 21 and 30 year of age. From this age, 15% of respondents use bus, followed by car, train, motorcycle and non-motorized transportation.

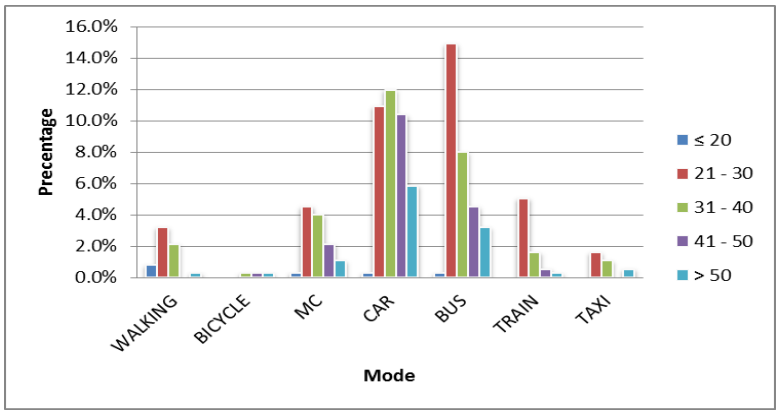

Figure 3. Age wise mode selection

The respondents are distributed by three income levels; low income, middle income and high income level. Low income level contributes significantly to the use of bus; it is approximately 17% of respondents. The use of car is dominated by middle income worker.

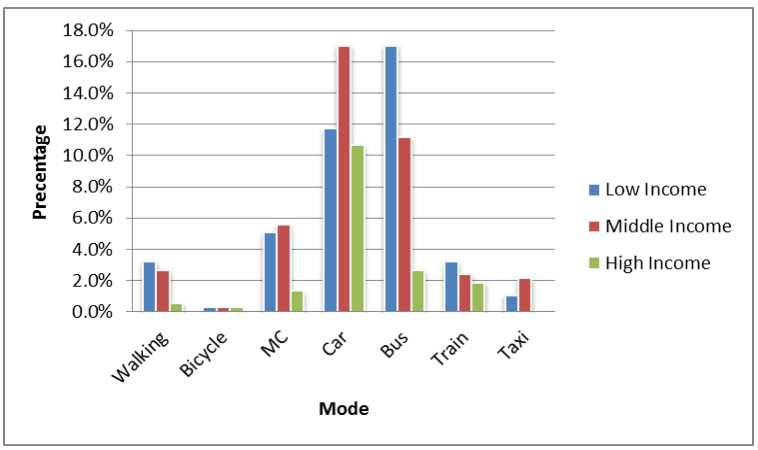

Figure 4. Income wise mode selection

3.3 Model Estimation

The authors used Biogeme v1.8 for the model estimation. The development of Biogeme has been motivated by the need to estimate the parameters of these new models from real data, Bierlaire (2009). The first version of Biogeme, released in 2001, was designed to estimate the models from the family of Multivariate Extreme Value (MEV) models (called "Generalized Extreme Value" models by McFadden (1978))**.** The version 0.7, released in 2003, introduced random parameters in the models, so that the parameters of mixtures of MEV models could be estimated. Originally designed for the courses and research at the Ecole Polytechnique Fédérale de Lausanne (EPFL), Biogeme is now widely used in the research community.

This section describes the analysis of dataset with multinomial logit (MNL) model. The result from Biogeme simulation of full dataset consists of 376 observations and 4 numbers of estimated parameters using simple MNL as below

Table 3. Model estimation result

Independent Variable	Value	t score
Asc_Car	5.00	5.56
Asc_Pt	4.35	5.96
Travel time	-0.0213	-4.97
Travel cost	-0.0314	-4.08
Number of estimated parameters: 4		
Rho-squared: 0.967		
Adjusted rho-squared: 0.945		

Source: Biogeme V.1.8 Result

The result indicates that all of the attributes have correct sign as priori belief. The parameters which are categorized as disutility for people have negative sign as expected and it concludes people want to minimize these attributes in order to get more benefits.

The result of t-statistic values is considered acceptable, it is shown that all of coefficients and constants have values on the range of confidence level of 95%, which is on the range of t-test <-1.96 and t-test >1.96. This results means all of the estimated parameters are statistically significant. The value of adjusted rho squared is considered high, the value is around 0.9. This is used as measurement of goodness of fit for the model to check how well the MNL model fits the data.

The positive value for alternative specific constant for car (Asc_Car) is considered high compared to alternative specific constant for public transportation. Asc_Car is valued more than Asc_Pt since it has predominance characteristics valued by respondents. Car is the highest proportion of transportation mode which is chosen by respondents; hence they feel more familiar with the service.

3.4 Variation across socio-demographics

The first segmentation usually used is based on gender. In general, the coefficients estimated from this model were found to be statistically significant except beta travel cost (beta_tc) for male worker. Furthermore, from the result it can be concluded that the estimation in line with the priori of choice mode modeling that all signs of the estimated coefficients regarding the service attribute such travel time and travel cost to be negative as refers to disutility.

Table 4. Model estimation result (Gender group)

Independent Variable	Female		Male	
	Value	t score	Value	t score
Asc_Car	5.00	2.19	5.00	2.13
Asc_Pt	4.26	4.81	4.43	2.19
Travel time	-0.022	-3.55	-0.032	-2.24
Travel cost	-0.034	-3.56	-0.008	-0.28

Source: Biogeme V.1.8 Result

The model is segmented into groups of income, low, medium, and high income worker in Table 5. Low income group involves respondents with income level less than 20,000 baht, medium level consist of income level between 20,000 up to 40,000 baht, and income over 40,000 baht is categorized in high income worker. From this category, the result does not represent good model. It is showed by insignificant t score. It may be caused by lack of respondent number in each model. However there is still negative sign in beta travel cost (tc) and travel time (tt) which is in line with aggregated model where people want to minimize these attributes in order to get more benefits.

Table 5. Model estimation result (Income group)

Independent Variable	Low income		Middle income		High income	
	value	t score	value	t score	value	t score
Asc_Car	0.964	0.43	4.72	3.31	5.00	0.00
Asc_Pt	-0.970	-0.64	5.00	2.23	1.29	0.38
Travel time	-0.275	-28.75	-0.017	-2.62	-0.036	-1.43
Travel cost	-1.06	-11.62	-0.035	-2.48	-0.045	-1.03

Source: Biogeme V.1.8 Result

From age variation below, in general it is shown that the estimated coefficient of travel time and travel cost statistically insignificant for all levels of age, expressed by t score. The unexpected sign occurred in the travel cost attribute (41 – 50 year of age) which is expected to be negative as refers to disutility for respondents.

Table 6. Model estimation result (Age group)

Independent variable	21 - 30		31 – 40		41 - 50	
	value	t score	value	t score	value	t score
Asc_Car	4.81	3.01	5.00	3.06	5.00	0.00
Asc_Pt	5.00	3.91	5.00	5.52	5.00	5.17
Travel time	-0.038	-1.45	-0.021	-0.55	-0.04	-1.29
Travel cost	-0.017	-0.60	-0.110	-0.54	0.008	0.19

Source: Biogeme V.1.8 Result

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4. CONCLUSION

A mode choice model was developed for work trip in Bangkok city. Travel time and travel cost are employed to create worker's mode choice formulation in this study. This work trip is essentially an attempt to identify the various variables that influences the mode choice behavior of employees. The analysis was conducted through a comprehensive study of travel pattern and variation across socio-demographic, principally with the logit model.

- The Multinomial logit model for mode choice analysis of work trips was examined. The significant deterministic variables include the total travel time and travel cost for each mode of transport. Travel time and travel cost which are categorized as disutility for people have negative sign as expected and it concludes people want to minimize these attributes in order to get more benefits.
- 39.4% of workers chose car for their working purpose trip.
- The highest proportion of female (25%) and male (15%) workers uses car in working trip.
- In term of age, bus is significantly used by 21 – 30 year of age which is up to 15%.
- 17% of low income worker contributes in the use of bus as primary mode for working trip. It reveals that car ownership is still low in this worker level.
- Walking and bicycle is less popular among workers for their transportation mode.

4.1 Suggestion

From the analysis, suggestions are shown as follows;

- Almost 40% of Bangkok workers choose car for their working purpose trip. This number results in bad traffic in Bangkok. Thai government should introduce and/or implement more public transportation service to reduce percent of the usage of car.
- The proportion of female and male uses car shows that female workers are more likely to use car for working trip than male workers. The possible explanation could be because of the low safety level in public transportation. The government can improve security level of public transportation. The subsidy for female passengers should be introduced.
- There should be some special services for the elderly in public transportation to incentive the workers who are over 31 to choose public transportation.
- Thai government can introduce the divided lane for bicycles for safety purpose.

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