Joint Implementation of Policies for Making the MRT Successful and Mitigating the Congestion in Jakarta

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Abstract

Traffic congestion in Jakarta is an emerging challenge. Although the policies have been implemented both discouraging private vehicles and improving public transport, the traffic jam is getting worse as conflicting fuel subsidy policy is implemented. This study reports empirical evidence on the trade-off effect between improvements in public transport services and fuel subsidy removal for a modal shift of private vehicle commuters in Jakarta. The data on stated preferences on the possibility of modal shift for private vehicle commuters in Jakarta are collected and analyzed by mixed logit models. With presence of road pricing at the (Central Business District) CBD in Jakarta, we find that joint implementation of policy scenarios through removal of fuel subsidy and road pricing is more effective to discourage people using cars or motorcycles. As the consequence, the new provision of mass rapid transit (MRT) will be effective to attract car and motorcycle commuters in any feasible range of service improvements.
Key words: MRT, policies mixed, utility, mixed-logit

1. Introduction

The capital city of Indonesia, a special administrative city of Jakarta Province (locally refers to DKI Jakarta), has been known to be one of the most congested cities in the world (Cunningham & Cunningham, 2010). The economic cost only for time losses of the congestion was modestly estimated to be 5.6 billion USD a year (Japan International Cooperation Agency, 2012) which accounts for approximately 5% of GRDP of DKI Jakarta (Statistics Indonesia, 2014a). Amid the serious situation, the growth rate of vehicles continues to be much greater than that of transport infrastructure provisions (Santos, Behrendt, Maconi, Shirvani, & Teytelboym, 2010).

Various efforts have been made to mitigate the congestion while addressing both the travel demand and supply. For example, the “3-in-1” regulation, in which only a car with more than three passengers, can enter the central arterial roads during peak hours has implemented since December 2003 (BAPPENAS & JICA, 2004). The bus rapid transit (BRT) known as TransJakarta has been introduced and expanded gradually and is presently operated in 12 corridors since 2004 (Transjakarta, 2013). The upgrading and revamp of the JaBoDeTaBek (Jakarta Bogor Depok Tangerang Bekasi) Railway System are also implemented to strengthen the inter-city public transport (Turner, 2012).

Despite such efforts, however, motorization has been prevailing with high growth rates of cars and motorcycles, driven fundamentally by the rapid economic growth and urbanization in DKI Jakarta (Statistics Indonesia, 2014b). During the last ten

years, number of registered passenger cars in DKI Jakarta has grown by 11.9% annually while that of motorcycles has grown much faster by 16.3%. The motorized passengers with cars and motorcycles dominantly share about 98% of transport mode choices, in which commuters are the largest subcategory in terms of trip purpose with 50% (Ministry of Economic Affairs & Japan International Cooperation Agency, 2012). In addition, the low-cost green cars (LCGCs) as subsidized compact and fuel-efficient cars, which are recently promoted by the government are making the congestion even worse as once an individual has purchased an automobile, there is a strong eagerness to use it for traveling (Chin & Smith, 1997).

Based on the utility theory, the transport mode chosen should give the highest value of expected utility (Noland, Small, Koskenoja, & Chu, 1998), as composite effect of all the influencing factors including physical and non-physical features. Making public transportation the most attractive requires giving the highest utility among the available transport options. The reliable, highly frequent, and comfortable public transport increase the utility (Beirão & Sarsfield Cabral, 2007; Redman, Friman, Gärling, & Hartig, 2013). Also, the availability of parking areas in the public transit system could enhance the use of public transport (Duncan & Cook, 2014), implying that connectivity with other transportation modes is important for public transport. However, the literature also pointed out multiple factors to robustly make the private vehicles being the most attractive transport mode for people to commute among the other transport modes, including comfort, flexibilities in time and route, speed and fulfilling various symbolic and emotional needs (Anable, 2005; Bergstad et al., 2011; de Groot & Steg, 2007; Hagman, 2003; Jensen, 1999; Redman et al., 2013; Steg, 2005; Widodo & Kidokoro, 2012).

As a consequence, it was concluded that the BRT could not successfully attract the vehicle commuters to shift but most of people from the other public transports (Kumar, Zimmerman, & Agarwal, 2012; Yagi & Mohammadian, 2008). Furthermore, vehicle commuters would shift to the BRT if the costs of using cars and motorcycles were higher by the means of policy interventions such as area pricing scheme to the central business district (CBD) (Yagi & Mohammadian, 2008).

It is then required to change the relative utilities between public transport and private vehicle use in a consistent manner. The government of Indonesia and city of Jakarta currently plan to introduce new Mass Rapid Transit (MRT) and emerging concerns exclusively concentrate on providing better services of the MRT in term of frequency, speed, and parking facilities to make a transit system more attractive (MRT Jakarta, 2013b). Yet, introducing MRT without sufficient simultaneous countermeasures to discourage vehicle commuters such as electronic road pricing (Yagi & Mohammadian, 2008), increasing fuel price or fuel subsidy removal (Elvik & Ramjerdi, 2014) would result in failure for solving the congestion.

In the literature, the standard approach to address expected behavioral changes in transportation mode choice is to study on the valuation of revealed preferences for different attributes of transport modes (D. A. Hensher, 2006; D. a. Hensher, 2008). Ito, Takeuchi, & Managi (2013) estimated the potential demand on the basis of how much people are willing to pay for alternative fuel vehicles under various refueling scenarios. It often includes contextual scenarios as external factors in the attributes of the choice sets, when choice experiments are employed. Alternatively, the background scenarios can be separated from the attributes in the choice sets, by which the cognitive burden is considered to be reduced for respondents (DeShazo & Fermo, 2002; Fischer et al., 2014; Zhao, Johnston, & Schultz, 2013). For example, Wouter Botzen and Van Den Bergh (2012) treat government compensation scenarios as contextual background, while attributes of flood probability and climate insurance are exclusively included in the choice sets.

In reference to Wouter Botzen and Van Den Bergh (2012), the present study employs the road pricing and the fuel subsidy removal as contextual policy scenarios and services of the planned MRT as attributes in the choice sets to primarily analyze revealed preferences of changes in transport mode for vehicle commuters in DKI Jakarta. Here, the contextual policy scenarios offer the pushing effects by discouraging vehicle commuters to use the private cars and motorcycles, whereas improvements of MRT services offer pulling effects by encouraging vehicle commuters to shift.

The main research questions of this paper are: 1) how is the future commuters' behaviors on transport mode choices once MRT successfully completed under different policy scenarios? 2) how big its benefits to increase economic value? Based on this research questions, the main objective of this research is to provide empirical evidence to quantify the scale of impacts of such policies to discourage vehicle commuters on the relative utilities for better policy making.

The remainder of the paper is organized as follows: Next section briefly explains Jakarta MRT development followed by the third section on methodological details including analytical model, the design of the questionnaire, and survey method. The section four reports empirical findings and the fifth section conclude the study.

2. Jakarta MRT Development Overview

Multiple benefits are expected for the development of MRT in Jakarta: to increase transport capacity of passengers; to reduce travel time, to mitigate air pollution; to reduce traffic accidents, and to improve the country's investment climate and consequently

further to enhance social and economic development (MRT Jakarta, 2013b). The development of MRT connecting the south and the north is divided into two stages of MRT construction. The first stage will connect from Lebak Bulus in the south to Bunderan Hotel Indonesia over 15.7 kilometers with 13 stations consisting of 7 elevated stations and 6 underground stations. Currently, it is under construction and scheduled to begin the operation by the end of 2016. The second stage will be further stretched from Bunderan Hotel Indonesia to Kampung Bandan with total length of 8.1 kilometers with eight underground stations and be completed in 2018. The MRT will be operated from 05.00 am to 00.00 am with every 8 minutes frequency (the headway), and the total travel time for the first stage is about 43 minutes with the speed at 30 kilometers per hour on average. In addition, the parking facilities are not available at all the MRT stations, but only in major stations. Each train will have six carriages with the capacity of approximately 250 passengers of each carriage. In the third-year operation, it is targeted to carry 412,000 passengers daily.

The total cost of the MRT construction is about 1.44 billion USD (MRT Jakarta, 2013b), of which 1.2 billion USD is financed by loan and the payment will be shared between Jakarta province budget (30%) and national budget (70%). The remaining 0.24 billion USD is shared between Jakarta Province budget (58%) and national budget (42%).

Although it is not possible in the near future, the current plan acknowledges the following needs in the long run; (1) the MRT will be integrated with the other public transport modes such as city buses, BRT, and JaBoDeTaBek railway system; (2) supporting facilities of adequate pedestrian and parking spaces at all MRT stations for park-and-ride system; (3) commercial and public buildings will be constructed near the MRT stations.

3. Research Method

3.1 Sampling Area

This study uses primary data, which are obtained from the survey for commuters with cars or motorcycles who have main activities in the CBD of Jakarta during the weekday. The MRT is planned to be constructed at the center of existing wider roads

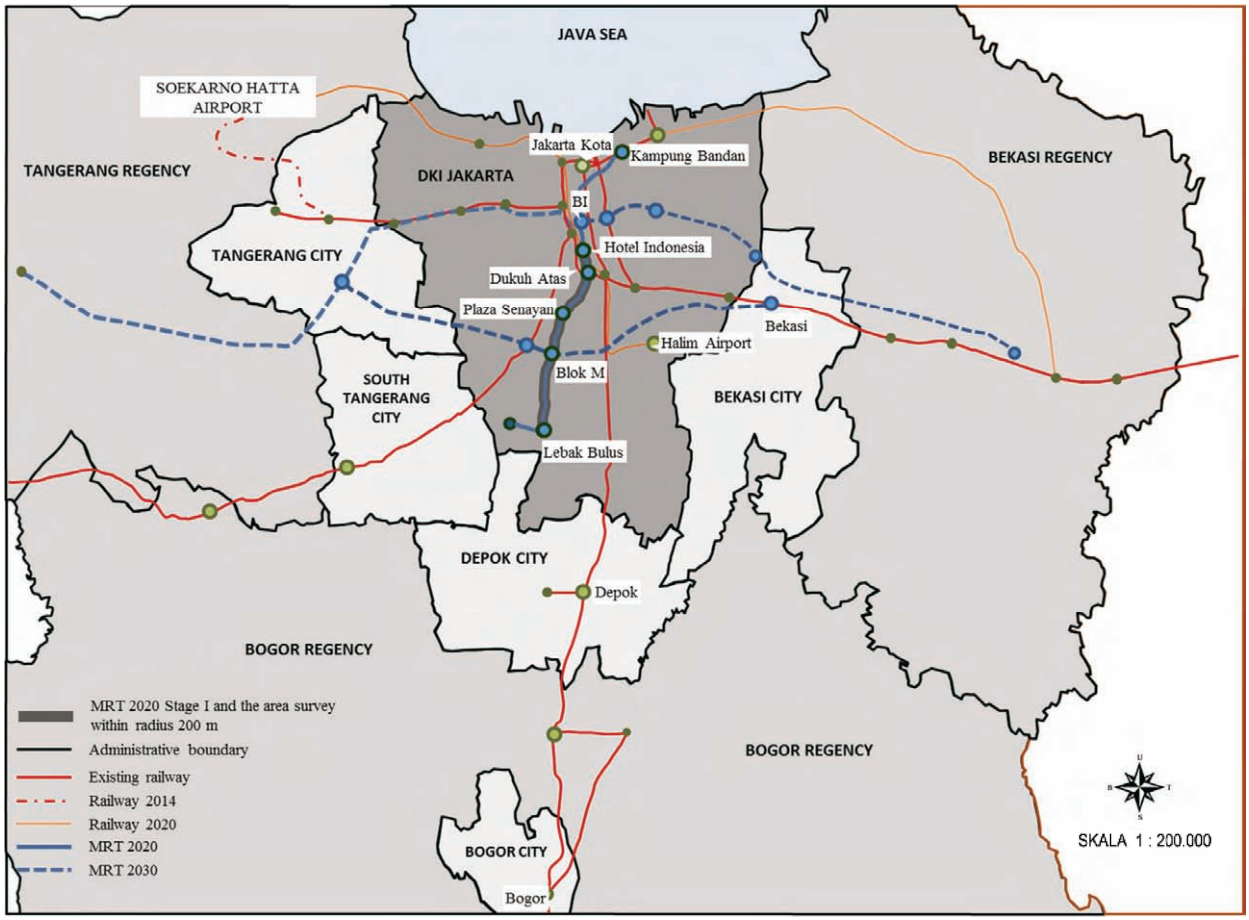

Figure 1. The map of study

Source: General Plan of Railway Network in JaBoDeTaBek 2014-2030,
Directorate General of Railway, Ministry of Transportation Indonesia, modified by author

and thus the sampling target of the survey is selected to be buildings along the roads from Lebak Bulus in South Jakarta to Hotel Indonesia in Central Jakarta shown in Figure 1.

The buildings include commercial business offices, governmental offices, schools, hospitals, restaurants, shops, super markets, etc. We focus primarily on the buildings in the first line directly facing to the roads with MRT since there are many residential buildings behind the first line. Although sampling area is in DKI Jakarta as places of daytime activities, residential locations of respondents vary over all satellite cities around DKI Jakarta, JaBoDeTaBek.

3.2 Selection of Attributes

In designing questionnaires of the choice experiment (CE), the selection of attributes is a crucial component because it will affect the respondent choices (Nguyen, Robinson, Kaneko, & Komatsu, 2013). As mentioned earlier, the attributes of choice set exclusively focus on services of the MRT, whereas other policies are treated as contextual policy scenarios. The attribute selection for this study utilize the existing findings from Focus Group Discussion (FGD) which was conducted by Jakarta Transportation Agency (MRT Jakarta, 2013a). The purpose of FGD was broadly to understand users' preference for services of MRT and their willingness to use MRT once it starts. Total respondents were 18 commuters including private vehicle users and public transportation users with different income levels. The conclusions from the FGD are that the commuters potentially want a faster public transportation than using their private vehicles, if short headway (high frequency) and parking areas for cars and motorcycles around the MRT close to their home are available. Other concerns such as comfort, safety, and accessibility to the MRT from their working place are found to be also important.

To incorporate the FGD findings, the attributes of choice cards in the questionnaires are comprised of headway, average speed, and parking availability. Yang and Sung (2010) used similar attributes, travel time, frequency and travel cost, in constructing a mixed-logit model to analyze the effects of new transport mode introduction on modal shift. Moreover, Mazzulla and Ebol (2006) measures the service quality attributes by using frequency, number of stations (bus stops), the comfort of the bus (seat availability), security and information. Other researches also employed frequency and comfort as the common factors when considering public transport as a viable alternative mode (i.e., Beirão & Sarsfield Cabral, 2007).

The first attribute is headway defined as a measurement of the time between train under consideration and the next train behind in the same traffic lane (Heidemann, 1990), that represents maximum waiting time at the station. The headway is one of the key elements in the public transportation users' satisfaction with service quality and in mode choice decisions (Luethi, Weidmann, & Nash, 2007). The current master plan of MRT designs the headway of MRT to be every 8 minutes on average. The improved services should be shorter and feasible headways compared to the current master plan. Therefore, the combinations of current and improved services are developed with three levels of headway (every 3 minutes, every 5 minutes and every 8 minutes). Speed is the second attribute that is defined as the time spent traveling between specified points (Redman et al., 2013). The speed attribute is somewhat related to the headway but not exactly same in terms of quality of services (Pucher, Park, & Kim, 2005). Similar to the headway scenarios, we consider three levels of speed to generate the choices, 30 kilometers/hour as in the current MRT master plan, 40 kilometers/hour and 50 kilometers/hour. The third attribute is parking availability with two cases: parking is partially available but not in all MRT stations as in the current plan and parking is available at all stations as an improved scenario. Another attribute used is the financial burden or indirect tax imposed on the MRT development. This financial burden is fundamentally defined by two ways: private burden and social burden. When it comes to future infrastructure development, we employed social burden in this study as fee of MRT is not announced and lots of costs are barred by non-users as much of tax revenue of DKI

Table 1. The attributes and levels of choice experiments

Attributes	Improved Services	Current Plan	Status Quo
Headway	Every 3 minutes Every 5 minutes Every 8 minutes	Every 8 minutes	Not shifting to MRT (using current mode, either cars or motorcycles)
Speed	50 kilometer /hour ≈ 31 minutes 40 kilometer /hour ≈ 35 minutes 30 kilometer /hour ≈ 43 minutes	30 kilometer /hour ≈ 43 minutes	
Parking availability in all MRT stations	Available Not available	Not available	
Financial Burden for the People	78 USD 65 USD 52 USD	52 USD	52 USD

Jakarta is collected from motor vehicle tax, which accounts for approximately 60% according to Sudjarwoko (2010). We estimate per capita social cost of the MRT construction as follows. The financial burden to construct the MRT is shared between national government and the government of DKI Jakarta by 55% and 45% respectively. When the 45% of total cost of the MRT construction is divided by total population of DKI Jakarta, we get 52 USD, which is used as baseline. Then we estimate additional costs of service improvements such as replacement of better trains, increase in number of trains and provisions of parking stations that found to be maximum 50% increase. With these considerations, we set 52 USD (current plan), 65 USD (25% increase) and 78 USD (50% increase), respectively. Table 1 explains the detail attributes and levels of the CE.

3.3 Experimental Design

The experimental design assigns combinations of values to the attributes to set a choice card that is shown to a respondent. There are maximum 54 (3x3x2x3) combinations of choice cards that can be generated. Due to constraints of budget and time, we decided to implement choice experiment at three times for each respondent and thus three different choice cards are at least required for each respondent. When we prepare different types of choice cards, we need more choice cards and accordingly more choice sets depending on how many choice sets are contained in each choice card. When we prepare three different types of combination for three choice cards, and each of the cards contains two choice sets, we need 9 choice cards and 18 choice sets.

Among the 54 combinations, we could reduce 18 choice sets randomly, while being logically acceptable and still fulfilling the orthogonality (D. A. Hensher, Rose, & Greene, 2005) that ensures zero correlation between attributes. The 18 choice sets are used with status quo conditions and the current plan of MRT development, which is a special case of 54 combinations to develop choice cards as shown in Figure 2 as an example. That is, each choice card contains four combinations of choice sets where the first and second choice sets are common (status quo and current plant), and the other two combinations are selected and paired from the 18 combinations. Thus, we created 9 different choice cards. Finally, we created has 3 groups of choice cards, namely types I, II and III.

To ask the respondent's preference for commuting mode, besides the main attributes it is also introduced the contextual policy scenarios, which are not treated as the attributes, but as external factors. As mentioned, there are two policy scenarios proposed, the road pricing and fuel subsidy removal. With two policy scenarios, it can develop three combinations including implementation of both policies together. In total, there are four scenarios with baseline policy where none of the two policies are implemented.

CHOICE CARD I

Select one either Status Quo, Current Plan, Option A or Option B

Attributes & Current Conditions	Status Quo (not change)	Current Plan	Option A	Option B
Frequency		Every 8 minutes	Every 8 minutes	Every 5 minutes
Average speed of MRT		30 km/hour ≈ ± 43 minute	40 km/hour ≈ ± 35 minutes	40 km/hour ≈ ± 35 minutes
Parking availability in all stations		Not available	Not available	Available
Financial burden for the people	520,000/ person or 2,080,000/ family (assumed 4 members/ family)	520,000/ person or 2,080,000/ family (assumed 4 members/ family)	650,000/ person or 2,600,000/ family (assumed 4 members/ family)	780,000/ person or 3,120,000/ family (assumed 4 members/ family)
I will use MRT or not change from current condition (check only ONE)	☐	☐	☐	☐

Figure 2. An example of a choice set

The suggested minimum required numbers of respondent are 75-100 for each segment of respondents (Kumar and Rao, 2006) and 50 for each alternative (Hensher et al., 2006), we set number of target respondents for each type to be 60 in total in this study. Since we have four policy scenarios, 15 respondents are assigned for each type. Furthermore, we have two subcategories of targets segment, car commuters, and motorcycle commuters. Therefore, finally we have 360 respondents consisting of 180 respondents for each segment as summarized in Table 2.

Table 2. The Allocation of Targeted Respondents

No	Policy Scenarios	Choice Set					
		Car			Motorcycle		
		Type I	Type II	Type III	Type I	Type II	Type III
1	No policy scenarios	15	15	15	15	15	15
2	RP (Road Pricing Policy)*	15	15	15	15	15	15
3	FS (Fuel Subsidy Removal Policy)**	15	15	15	15	15	15
4	JP (Joint Policies of Road Pricing and Fuel Subsidy Removal)	15	15	15	15	15	15
Total respondents of each Choice set groups		60	60	60	60	60	60
Total respondents based on the type of vehicles		180			180		
All respondents targeted		360					

*Road Pricing scenario is between 0.6 USD and 2.1 USD depend on the vehicle types
**Fuel price without subsidy assumes to be 0.9 USD per liter

3.4 Questionnaire structure

The questionnaire used in the survey is developed by four main parts and screening questions included at the beginning of questionnaires. There are two questions in the screening: the first screening question is to exclude any respondents who potentially give bias response due to their occupation in the transportation sector, and the second screening question is to make sure that the targeted respondents are either using cars or motorcycles to commute every day.

The first part of the questionnaire consists of questions about the current usage of transportation modes in general and their detail information of daily commuting behaviors. The second part has questions about willingness to buy new vehicles. The third part is a choice experiment of a possible change in their mode choice for daily commuting when new MRT is introduced. The last part is about respondents' profile (gender, age, education, occupation, personal income and household income). All the contents of questionnaires are almost identical except for the choice experiment part as explained earlier.

In the third part of the questionnaire, the hypothetical choice experiment, considering the experimental design explained above, makes the questionnaire created several versions based on three types of choice-set groups and four scenarios. Therefore, there are 9 versions developed and applied in the survey.

3.5 Pretest

Before doing the main survey, the pretest of the survey was conducted, and total samples are 24 respondents consisted of 12 respondents of car commuters and motorcycle commuters, respectively. Face to face interview is applied. The validity of questionnaires shows that among main variables concerned are correlated and significant at 1%. The reliability of questionnaires is calculated by using Cronbach Alpha, and the value is 0.909. Referring to these numbers, it can be concluded that the questionnaires are valid and reliable. It means that respondents could understand the questions of the questionnaires.

3.6 Estimation Methods

The choice experiment approach to analyzing the travel behavior change in response to hypothetical choice experiment is now widely used (Ortuzar & Willumsen, 2011). A choice experiment model is a stochastic alternative model that simultaneously infers alternative positions and the distribution of individual preference (Yang & Sung, 2010). The design of hypothetical choice experiment has to satisfy with three characteristics, namely being mutually exclusive, exhaustive and finite (Train, 2003). The alternatives being mutually exclusive mean that there is no possibility to choose beyond the alternatives given. The choice set is exhaustive if the decision makers allow to not choosing any of the alternatives provided. The alternatives being finite mean that they can be counted and finally be stopped counting. The discrete choice model usually satisfy with the third characteristic, since the attributes are nominal or ordinal type of data that gives finite number of choice alternatives.

Discrete choice models estimate their parameters under an assumption of decision maker's behavior in maximizing their utility towards some alternatives of choice set (Train, 2003). The discrete choice models are defined simply to explain the relationship between a set of explanatory variables and a choice, without to know exactly how the process of choice is made.

Deriving a basic choice model is equivalent to individual's choice measured from a probability of an alternative being chosen (D. A. Hensher et al., 2005). Each individual, labeled n faces J alternative of choice set. Each alternative would provide a specific

level of utility to the individual. The utility that the individual n gets from alternative J is represented by $U_{nj}; j = 1, ..., J$ alternatives. The utility is only recognized by the individual, but not by other people. The individual will choose one alternative, which gives the highest level of utility. In other word, this model shows that alternative i would be chosen if only if $U_{ni} > U_{nj}$ for all $j \neq i$. The individual's utility can be examined by measuring some attributes of choice alternatives, labeled x_{nj} for all j, and attributes related to characteristics and background of individuals, labeled s_n. Therefore it is possible to determine a utility function, as $V_{nj} = V(x_{nj}, s_n)$ for all j, explaining relation of these measured attributes to individual's utility. Since the utility function does not capture all part of utility, the utility can be composed as

$$U_{nj} = V_{nj} + \varepsilon_{nj} = V(x_{nj}, s_n) + \varepsilon_{nj} \tag{1}$$

The utility is set linear in parameters as expressed

$$U_{nj} = \beta' x_{nj} + \theta s_n + \varepsilon_{nj} \tag{2}$$

where ε_{nj} describes part of utility that cannot be explained by the utility function. The ε_{nj} called error terms, ε_{nj} for all j, are not known and treated as random. It can be set as a random vector $\varepsilon'_n = (\varepsilon_{n1}, ..., \varepsilon_{nj})$ that has a joint density function, denoted as $f(\varepsilon_n)$.

So, if the measurement of utility is from the sample but not population, the probability of individual n chooses alternative i can be stated as

$$Prob_{ni} = Prob\left[(V_{ni} + \varepsilon_{ni}) \geq (V_{nj} + \varepsilon_{nj})\right] \forall\, j = 1, \ldots, J; i \neq j \tag{3}$$

From equation (3), it can be written into

$$Prob_{ni} = Prob\left[(V_{ni} - V_{nj}) \geq (\varepsilon_{nj} - \varepsilon_{ni})\right] \forall\, j = 1, \ldots, J; i \neq j \tag{4}$$

It means that the probability of individual choosing alternative i is equal to the probability that the difference in the unobserved sources of utility of alternative j compared to i is less than (or equal to) the difference in the observed sources of utility associated with alternative i compared to alternative j after evaluating each and every alternative in the choice set of $j = 1, ..., i, ..., J$ alternatives. How to handle the information of ε_j associated with each individual, the utility maximization must be random. This step to consider for the unobserved elements of utility associated with each alternative. To cover this issue the assumption must be set to ensure that the sampled population resides along a bounded line and randomly assigned a location, or it is called the distributions. Different utility model has specific assumptions towards the distribution or density function of the error term and the correlation over the observed alternatives. By holding the ε_j as independently identically distributed (*i.i.d.*) assumption, the cumulative choice probability can be derived from equation (4).

$$Prob_{ni} = \int I(V_{ni} - V_{nj}) \geq (\varepsilon_{nj} - \varepsilon_{ni})\, f(\varepsilon_n) d\varepsilon_n \;\forall\, j = 1, \ldots, J; i \neq j \tag{5}$$

From equation (5) can be derived the general closed-form expression (Train, 2003) as expressed in equation (6). The probability of an individual n choosing i out of the set of J alternatives is equal to the ratio of the (exponential of the) observed utility index for alternative i to the sum of the exponentials of the observed utility indices for all J alternative, including the i_{th} alternative and it is formulated as:

$$Prob_{ni} = \frac{e^{V_{ni}}}{\sum_{j=1}^{J} e^{V_{nj}}} = \frac{e^{\beta'_{ni}}}{\sum_{j=1}^{J} e^{\beta'_{nj}}}; j = 1, \ldots, i, \ldots, J \tag{6}$$

The mixed logit model divides the density function of random terms, some portion of random terms follows to the specified distribution such as normal, lognormal, triangular, and other unobserved factor distributed *i.i.d.* extreme value. The choice probability of mixed logit model can be expressed by the following linear form (Train, 2003):

$$Prob_{ni} = \int \prod_{t=1}^{T} \left(\frac{e^{\beta x_{nit}}}{\sum_j e^{\beta x_{njt}}} \right) f(\beta) d\beta \tag{7}$$

The choice probability of mixed logit is a weighted average of the standard logit probability towards all possible values of parameter β and its respective probability density $f(\beta)$ as the weight factors. Parameter β can be determined to follow specific distribution e.g. normal, lognormal, uniform and triangular (D. A. Hensher et al., 2005). Due to this, the mixed logit remove the constraints in standard logit model by accommodating the heterogeneity of preference across different individuals, existing correlation among observed attributes, and inconstant pattern of substitution that release form the IIA property (Train, 2003). The parameters are estimated using maximum likelihood and using 1000 Halton quasi-random draws. For the Halton quasi-random draws, there is no magical number but by simulating the Halton number to get the stability of parameters estimated is needed, for

example 10, 25, 50, 100, 500, 1000 draws. The bigger the Halton draws the parameters estimated will be more stable. Each parameter can be estimated with the simulation of the equation (Train, 2003):

$$\beta_n = \frac{\int \beta_n \left[\prod_{t=1}^{T} P(choice\ j|x_{nt},\beta_n) g(\beta|\theta)\right] d\beta_n}{\int \left[\prod_{t=1}^{T} P(choice\ j|x_{nt},\beta_n) g(\beta|\theta)\right] d\beta_n} \tag{8}$$

where $g(\beta|\theta)$ is the distribution of β in the population, and θ is its vector of parameters.

Based on the utility function, it can generate the total willingness to pay for the improvement choices based on the compensating surplus welfare formulated as:

$$\Delta E(CS_n) = (1/\alpha_n)\left[ln\left(\sum_{j=1}^{J^1} e^{v_{nj}^1}\right) - ln\left(\sum_{j=1}^{J^0} e^{v_{nj}^0}\right)\right] \tag{9}$$

Where superscript 0 and 1 refer to before and after the change and $\Delta E(CS_n)$ considered as change of expected consumer surplus of individual n from alternative j; e is known as constant; V is utility; $\propto_n$ marginal utility of income of individual n (Train, 2009). So, it can be calculated the estimation of total economic value after MRT operated under certain scenarios.

3.7 Model Specification

The utility models of this study consist of four utility equations, describing basic alternative as the status quo condition, where people do not want to shift to MRT and three alternatives for people who want to shift to MRT. These three alternatives consist of a current plan of MRT provision and two improved services of MRT provision.

The utility model of basic alternative only includes constant, all policy scenarios and cost which is named by financial burden. This utility model is used as a based model because the main interest of this study is to measure how the policy scenarios can discourage the commuters in using private vehicles, either cars or motorcycles to shift to public transport, MRT.

The utility models of other alternative j contain all main attributes defined in the Hypothetical Choice Experiment (HCE). However, the attribute frequency and speed were transformed into lognormal because the assumption of both variables follows the lognormal function, not linear. The value of frequency and speed attributes is defined to be non-negative value. The other attributes are parking and cost. The parking is dummy variables. One, if the parking is available at all MRT stations and zero is otherwise. The attribute cost is the indirect tax that people have to pay to develop MRT. The increasing costs are assumed to be the better services of MRT provision compared to the current plan.

In the alternative j utility function, it is also incorporated some variables that are related and those are the current vehicle type used, travel time, and consumer attributes. In addition, to develop the model, it is indicated interactions of some variables especially the interaction to vehicle types. It is because, there is hypothesis that types of vehicles will give different responses and have different reasons regarding their behaviors in transport mode choices. The interactions, that are included into models, are between vehicle types and travel time and vehicle types and policy scenarios. The travel time of people who use cars and motorcycles is different. So, it is needed to know the interaction between them. Regarding the policy scenarios, since the charge of road pricing is different and depend on the vehicle types, the interactions between policy scenarios and vehicle types are also needed to be estimated. Another interaction is between attribute parking and people home addresses. It is assumed for some people who live closer to MRT stations, they do not need to park their vehicles compared to people who live farther.

Based on those assumptions and hypothesis, the model is specified below:

$$V_i^0 = ASC1 + ASC_{RP} \cdot RP + ASC_{FS} \cdot FS + ASC_{JP} \cdot JP + \overline{\alpha^0} \cdot cost^0 + \varepsilon_i^0 \tag{10}$$

$$\begin{aligned} V_i^j = {} & \alpha_i^1 \cdot headway_i^j + \alpha_i^2 \cdot speed_i^j + \alpha_i^3 \cdot parking_i^j + \overline{\alpha^4} \cdot cost_i^j + \beta_i^1 \cdot motorcycle_i + \beta_i^2 \cdot TT_i + \\ & \beta_i^3 \cdot employer_i + \beta_i^4 \cdot student_i + \beta_i^5 \cdot age_i + \beta_i^6 \cdot edu_i + \beta_i^7 \cdot male_i + \beta_i^8 \cdot \\ & familyincome_i + \beta_i^9 \cdot hhsize_i + \beta_i^{10} \cdot jakarta_i + \beta_i^{11} \cdot (motorcycle * RP)_i + \beta_i^{12} \cdot \\ & (motorcycle * FS)_i + \beta_i^{13} \cdot (motorcycle * JP)_i + \beta_i^{14} \cdot (motorcycle * TT)_i + \beta_i^{15} \cdot \\ & (parking * jakarta)_i + \varepsilon_i^j \end{aligned} \tag{11}$$

Table 3. Definition of Variable Used in the Utility Models and the Expected Signs

Code	Description	Expected sign
Dependent variable		
Chosen	1 if the alternative is chosen, 0 otherwise	NA
Explanatory- main attributes		
Headway	Headway of MRT, every 8 minutes, 5 minutes and 3 minutes. The headway was transformed into frequency per hour (60 minutes/headway) in lognormal form (random variable)	-
Speed	The Speed of MRT, 30 km/hour, 40 km/hour and 50 km/hour. The speed was transformed into lognormal (random variable)	+
Parking	Dummy variable 1 for parking available and otherwise (random variable)	+
Cost	Indirect tax imposed to the people to develop MRT or it is called financial burden, for the current plan is 52 USD, and the improved services are increased to be 65 USD and 78 USD.	-
Explanatory-exogenous variable (policy scenarios)		
RP	Road pricing implemented (random variable)	-
FS	Fuel subsidy removal implemented (random variable)	-
JP	Joint policy, RP and FS are implemented (random variable)	-
Explanatory-demographic, socio-economic variables		
motorcycle	1 motorcycle commuters; 0 car commuters	-
TT	Current travel time from home to the office	-
employer	1 if respondents are employers; 0 otherwise	+/-
student	1 if respondents are students; 0 otherwise	+/-
age	Age of respondents in years	-
edu	Education of respondents in years	+/-
male	1 if male, 0 female	+/-
familyincome	Average monthly income in USD	-
hhsize	The number of household members	+/-
jakarta	1 if respondent's home address is located in Jakarta; 0 otherwise	-
Explanatory-interaction between vehicle type and policy scenarios		
motorcycle*RP	Interaction between motorcycle and road pricing	-
motorcycle*FS	Interaction between motorcycle and fuel subsidy removal	-
motorcycle*JP	Interaction between motorcycle and joint policy	-
motorcycle*TT	Interaction between motorcycle and travel time	-
Explanatory-interaction between attribute and location		
parking*jakarta	Interaction between parking and respondent's home address	-

4. Results and Discussion

4.1 Respondents and Responses

The socio-demography of respondents covered in this research is described in Table 4. The proportion of male and female respondents is almost same for all respondents, but there is different to motorcycle commuters where males is much higher than females. Most of respondents are in the productive age that it can be seen from the average age in 33 years-old. The range of respondent age is between 20 years-old and 50 years-old. The motorcycle commuters are younger than car commuters on average. The education level of car and motorcycle commuters is also different, where car commuters have higher education level compared to motorcycle commuters. The average of personal income is about 454 USD. If it is compared with car and motorcycle commuters, the different income is about 209 USD. The average of the household income of car commuters is almost double of motorcycle commuters. It also shows that the distance between respondents' homes and offices between car and motorcycle commuters is not different. It is about 17 kilometer on average. Although the distance between car and motorcycle commuters is not different, but the travel time for car and motorcycle commuters is different. The travel time for motorcycle commuters is about 2.38 hours and this is faster than car commuters that need 38.6 minutes more. All these variables related to the households and

Table 4. Socio-Demography of Respondents

Total Sample	Car commuters	Motorcycle commuters	All respondents
	180	180	360
Gender (%) *Male/Female*	44/56	61/39	53/47
Average of Age/Standard Deviation/ minimum/ maximum (year)	33.8/7.9/20/50	32.6/7.9/20/49	33.2/7.9/20/50
Average of Education Level	14.6/2.4	12.9/2.4	13.7/2.4
Occupation (%) *Employer/Employee/Others*	31/58/11	22/68/10	27/63/11
Household Size (Median) *(person)*	4	4	4
Average Personal Income/ Standard Deviation *(In USD/Month)*	558.4/290.6	349.8/201.7	454.1/270.8
Average Household Income/Standard Deviation *(In USD/Month)*	971.1/275.0	650.0/312.4	810.6/334.9
Average Distance from Homes to Offices/ Standard Deviation *(kilometers)*	17.0/9.5	17.1/9.3	17.1/94
Average Travel time/ Standard Deviation *(hours)*	3.03/1.03	2.38/0.81	2.71/0.98

Source: Field survey, all respondents as base

individuals are all included in the models either as dummy or continues variables because these variables can affect the people behavior (Ben-Akiva, De Palma, & Isam, 1991).

Table 5 describes the description of attributes for improvement of MRT services for the total samples and differentiates between cars and motorcycle commuters. The Mean of headway is 6.17 minutes which is more frequent compared to the current plan that is 8 minutes. The mean of headway for car commuters is expected slightly to prefer more frequent compared to motorcycle commuters.

Table 5. Characteristics of the Attributes in the Model

Attribute	Unit	Car Commuters		Motorcycle commuters		All respondents	
		Mean	*Std* [a]	*Mean*	*Std* [a]	*Mean*	*Std* [a]
Headway	*minutes*	6.17	2.15	6.00	2.17	6.35	2.12
Speed	*kilometer per hour*	36.69	8.46	36.40	8.34	36.11	8.22
Parking	*1= available; 0= not available*	0.24		0.19		0.21	
Cost	*USD*	62.6	9.8	61.5	10.1	62.1	10.0
Sample size	*Number of respondents*	180		180		360	
Number of observations	*Number of responses*	540		540		1080	

[a] Std = standard deviation
Source: Field survey, all respondents as base

The average speed that respondents expected is about 36 kilometers per hour, and this is slightly faster compared to the current plan which is about 30 kilometers per hour. Currently, based on the calculation of the samples, the average speed for car and motorcycle commuters is 10.9 and 13.9 kilometers per hour respectively. Commuters expect that the MRT should be faster than the current condition. For the parking availability, the mean score is 0.21, and the car commuters expect higher than motorcycle commuters, meaning that the car commuters have a higher preference to park their cars in the stations. Based on the average for both car and motorcycle commuters, they expect to improve services with the consequence that they want to pay more for the current condition with the average is 62 USD. If it is compared, the car commuters want to pay about 63 USD, which is higher than motorcycle commuters, 61 USD.

4.2 The Choice Model

To estimate the parameters of utility models, it is utilized Nlogit software by generating the sample of random parameters by Halton number, setting to panel data with four utility equations, specifying the number of points in the simulation to 100, and a setting maximum number interaction to 200. Based on Hensher and Greene (2001), the Halton sequences provide greatly improved accuracy with fewer draws and computational time compared to standard pseudo-random sequences. In selecting the number of Halton draws, it is no magical number and it varies which depend on the model specification. Hensher (2001) concluded that a small number of Halton draws (as low as 25) can produce model fits and mean value of travel time savings almost indistinguishable. Using 100 Halton number draws for this research is more than enough to get the stability of parameter estimations.

Due to the specified model is mixed logit, setting the main attributes of the choice cards to be random is needed. For this model estimated, all the main attributes are treated to be random except the cost attribute. The cost attribute is treated to be fixed parameter. The random parameters should follow certain distributions. Selecting the distribution of the random parameters is essential to be arbitrary approximations to the real behavioral profile (Hensher and Green, 2001). They also mentioned, if the response parameter is to be a specific (non-negative) sign, the lognormal form is suggested. If the variable is a dummy, a uniform distribution is more appropriate. For this study, the attribute speed and headway should not have negative signs, so the lognormal

Table 6. The Parameters Estimated Of The Model Specification

Variables	Estimate	t-value
Main Attributes		
ASC	17.581**	2.376
frequency (R)	0.799***	2.666
speed (R)	1.257***	47.572
parking (R)	1.936***	7.317
Cost	-0.171***	-15.116
Policy Scenarios		
RP	-7.676**	-2.206
FS	-7.341**	-2.107
JP	-8.438**	-2.485
Demographic, socio-economic		
Motorcycle	1.965	0.429
TT	-1.325	-1.642
Employer	-2.436**	-2.048
Student	-2.577	-1.059
Age	-0.083	-1.199
Edu	0.584**	1.949
Male	1.257	1.225
familyincome	0.002	0.987
Hhsize	1.099**	2.273
Jakarta	-2.896**	-2.209
Interaction between vehicle type and policy scenarios		
motorcycle*RP	-2.779	-0.686
motorcycle*FS	-5.721	-1.352
motorcycle*JP	-8.078*	-1.910
motorcycle*TT	-4.061*	-1.684
Interaction between attribute and location		
parking*jakarta	-1.212***	-4.473
McFadden Pseudo-R2	0.178	
Chi-squared	533.848***	
Prob[ChiSqd > value]	0.000	

*** Significant at 1% level
** Significant at 5% level
* Significant at 10% level
(R) Random Variables distributed normally of Mixed Logit Model

distribution is applied. For parking attribute which is a dummy variable, the uniform distribution is used.

As shown in table 6, the parameter estimation for utility model is significant at 1% level with pseudo R2 about 0.17. According to parameter estimations, the cost has significant negative impact on private vehicle users' willingness to shift to public transport (MRT). The main attributes, speed, and frequency, have significant positive impacts on commuters' utility by choosing MRT to commute by 0.7999 and 1.257 points, respectively. The parking availability also provides significant positive impact to increase the commuters' utility to choose MRT by 1.936 point. It indicates that if the parking is available at all MRT stations, the commuters' utility will increase by 1.936 point. However, the parking has a significant negative impact if the commuters live in Jakarta by -1.212. For commuters who have homes in Jakarta, by providing parking, their utility is still increased but it is not as big as the people who live outside Jakarta. The utility of Jakarta's commuters by providing parking is only 0.724 point.

The interesting results are the policy scenarios that all have significant negative signs. Meaning that, by implementing these policies, it can discourage people to use their private vehicles. The impacts of road pricing and fuel subsidy removal are almost similar, but if these policies are implemented together, the impact is higher although it will not be a double. In addition the joint policy scenarios give much higher impact on motorcycle commuters, it is signed by the interaction between motorcycle and joint policy implementation has a significant coefficient.

There are four variables of demographic, socio-economic that have significant coefficients. The negative sign of coefficient of employer indicates that they do not prefer to use MRT for daily commuting. Surprisingly, the higher the education level of commuters, their preference to shift to MRT is bigger, and it is also happened to the families who have many members. But, for commuters who live in Jakarta, their preference is less than people who live outside Jakarta. The parking area at all MRT station is not so important for the Jakarta people. Meaning that, once they shift to use MRT, they do not want to drive their vehicles even only to the closest MRT stations.

4.3 The policy scenarios impacts people who stick on driving

Based on the model, it describes that the policy scenarios are effective to discourage people in using private vehicles, either cars or motorcycles and shift to public transport provided, MRT. Figure 3 depicts that the utility of car and motorcycle commuters is decreasing by introducing road pricing and fuel subsidy removal. The impacts of policy scenarios are similar to car and motorcycle commuters except the joint policy implementation that give the big impact on motorcycle commuters. The road pricing affects slightly bigger in reducing the utility for people who keep driving. As the expectation, the joint policy is the most effective policy to discourage people to use private vehicles, and it is expected to shift to public transport, especially for motorcycle commuters. By providing MRT and implementing policy scenarios, it seems effective to encourage people to use public transport. The figure shows how big the impacts of policy scenarios to discourage people from using private vehicles.

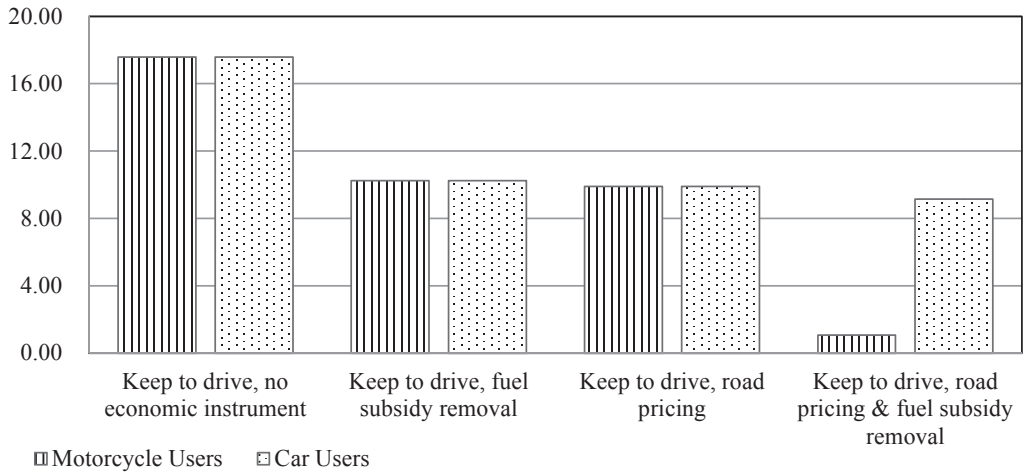

Figure 3. The Policy Impacts on Utility of Car and Motorcycle Commuters

From the utility, it can calculate the willingness to pay (WTP) to people who still want to use private vehicles for daily commuting. The meaning of WTP, in this case, is their willingness to pay more for the social cost imposes. The results show that without any policy instrument introduce, the car and motorcycle commuters want to pay about 73.6 USD more compared to the current social cost imposes, which is 52 USD. With the road pricing implemented, their willingness to pay is decreasing to 28.6 USD. This is similar to the implementation of fuel subsidy removal, where WTP of people also decreases to 30.5 USD. The

interesting is if the joint implementation of road pricing and fuel subsidy removal implemented, the WTP of car commuters is still positive, meaning that they are not affected by this joint policy implementation. But, the WTP of motorcycle commuters become negative. It means that the motorcycles commuters will be suffered if joint policy implemented.

4.4 The utility changes toward MRT service improvement

Figure 4 shows the changes in people's utilities by shifting to MRT for daily commuting. By shifting to the current plan, the start point of utility is at 5.02. The utility will shift to 6.95 by providing parking area at all MRT stations. By improving the speed and headway, it also will increase the utilities. However, the available parking at all MRT stations gives the higher impacts compared to the improvement of speed and headway. It can be caused the speed and headway that are offered better than the current public transport. The best service which are 3 minutes of headway, 50 km/hour of MRT speed and available parking at all MRT station give the highest utility for people who shift in using MRT.

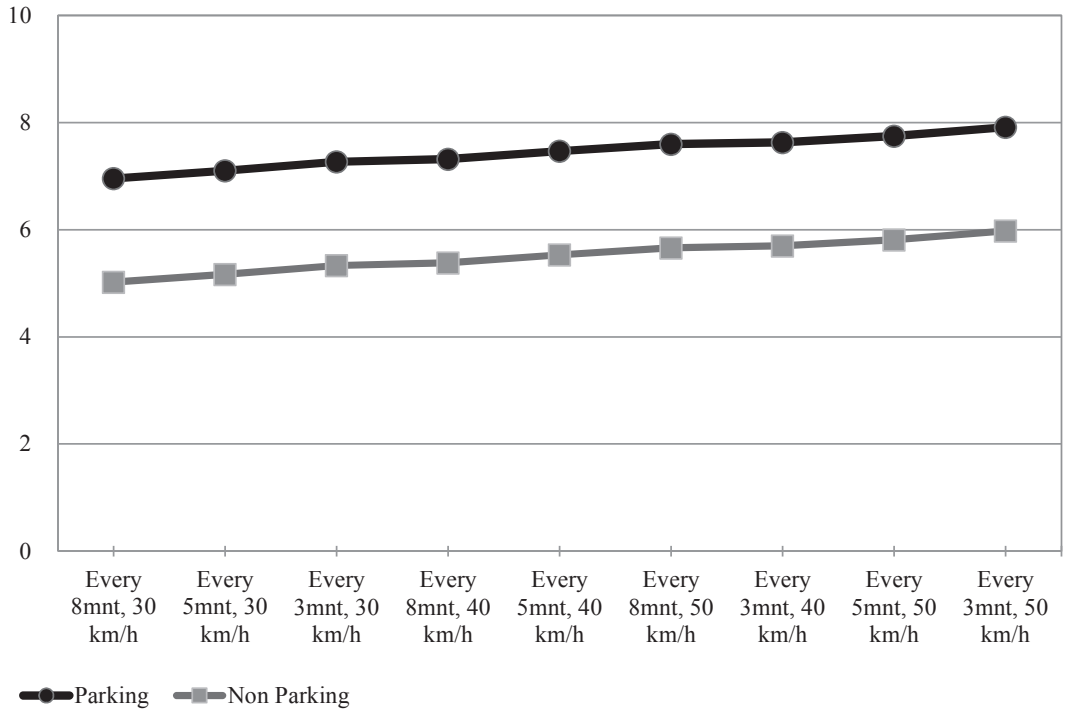

Figure 4. The Utility Changes by Shifting to MRT with Service Improvement

The WTP of people who want to shift to MRT is not affected by the policy scenarios because they already decided to use public transport. So, whatever the policy to burden the using of the private vehicle, it will not affect them. The base of WTP is the current plan of MRT development. By improving the services, the WTP of people in using MRT will increase. Table 7 describes the WTP of people who want to shift to MRT either to current plan or the improved services in term of speed, headway and also parking availability. From the table is shown that the highest WTP is the best services offered where headway is every 3 minutes, the speed is 50 km/hour, and parking areas are available at all MRT stations. The other information from the graph is that the parking attribute gives a bigger effect on the WTP. It can be seen by comparing the same headway and speed with and without parking where WTP has a big different. It seems the availability of parking areas at all MRT stations is important, since the public tranports are not well integrated yet. By having parking areas at MRT stations, commuters can follow the park and ride system, where the commuters can drive their cars or motorcycles from home to the stations and continue by using MRT to reach their workplaces.

Table 7. Summary of WTP by Shifting to MRT

Headway, Speed	WTP of the MRT Services	
	Parking is not available	Parking is available
Every 8mnt, 30 km/h	*0.00*	11.34
Every 8mnt, 40 km/h	2.12	13.45
Every 8mnt, 50 km/h	3.76	15.10
Every 5mnt, 30 km/h	0.86	12.20
Every 5mnt, 40 km/h	2.98	14.32
Every 5mnt, 50 km/h	4.62	15.96
Every 3mnt, 30 km/h	1.84	13.18
Every 3mnt, 40 km/h	3.96	15.29
Every 3mnt, 50 km/h	5.60	*16.94*

4.4 Economic value estimation

Successfully promoting MRT under certain policy scenarios and the improved services from the current plan give some benefits for people who want to shift to use MRT. After knowing each benefit of each potential MRT passenger on average, it can be calculated the total economic value estimation with different combination of the improved MRT services for both car and motorcycle commuters.

To calculate the total economic valuation for all commuters who use either cars or motorcycles for commuting and the workplaces are along the MRT will be operated, it should know the number of car and motorcycle population that have destination to this area. By using data from Ministry of Transportation of Indonesia c.q. Directorate of Urban Transport System who conducted traffic counting along this area to know the population of cars and motorcycles that enter this area. The data in 2011 for cars and motorcycles show 384,250 and 334,553 respectively. By estimating the proportion of car and motorcycle commuters who shift to MRT either to current and improved services from the model estimated, table 8 shows the estimated economic value of each combination chosen by respondents. The highest total economic value is about 498,879 USD for car commuters and 397,285USD and the combination is headway every 3 minutes, with speed 30 kilometer per hour and parking is available at all MRT stations.

Table 8. Economic Value Estimation by Shifting to MRT with the Improved Services

The Combination of the Improvement of MRT services	Total Economic Value (USD)	
	Car	Motorcycle
Every 8mnt, 40km/h, NP	39,930	31,085
Every 8mnt, 50km/h, P	428,816	345,292
Every 5mnt, 30km/h, NP	12,136	8,829
Every 5mnt, 40km/h, P	197,053	156,524
Every 5mnt, 50km/h, NP	186,362	148,184
Every 3mnt, 30km/h, P	498,879	397,285
Every 3mnt, 40km/h, NP	157,156	127,573
Every 3mnt, 50km/h, NP	161,689	130,781

km/h = kilometer per hour; mnt NP = Parking is not available; P = Parking is available;

However, from the model it can be calculated the percentage of commuters who do not want to shift to MRT which is about 24.2%. Although the policy scenarios can reduce their utility but the willingness to pay of the commuters who still want to use their own cars or motorcycles are still positive. Meaning that, the road pricing, or fuel subsidy removal, or joint policy implementation is still affordable. For example, the WTP of car commuters that still use cars for commuting is about 28.6 USD. It seems this amount is not high enough to discourage them in using cars. The positive value of WTP gives a sign that there is a potential economic value that government can generate from this group so that they choose the public transport, for example, by increasing the vehicle taxes, etc.

5. Concluding Remarks

This research has developed mixed logit model to simulate the people changing behavior once MRT completed and operated in Jakarta, Indonesia by using stated preference, which is obtained through survey along planned MRT route from Lebak Bulus to Kampung Bandan. The model developed in this research is not only including the main attributes related to the MRT services, where the services will be applied to current plan services and the improvement one, but also introducing the other policies that will be implemented together as the scenarios. The policies introduce in this research are the hypothetical scenarios, if there is no fuel subsidy and if the road pricing will be implemented in the CBD area. The main targeted respondents of this research are the car and motorcycle commuters who are working in the CBD area, and they commute daily.

Based on a model developed, it found that implementing mixed policies could be an effective way to change the people behavior to shift from cars or motorcycles to MRT. Implementing fuel subsidy removal or road pricing always decrease the commuters' utility by driving cars or motorcycles. Moreover, the joint policies implemented both, road pricing and fuel subsidy removal, give a higher impact to decrease the commuters' utility. In addition, by offering a new public transport, MRT, 75.8% of commuters want to shift to use MRT for commuting either to the current plan or the improved services. The alternative chosen to improve the MRT services should provide the parking areas at MRT stations since the alternatives with parking available always give the higher benefits for commuters.

The commuters will shift to use MRT if the operational costs of using cars or motorcycles are very expensive as caused by implementing no fuel subsidy and road pricing together. More than 75% of car and motorcycle commuters will shift to use MRT, and the coefficient of this variable is statistically significant. By implementing road pricing and removing fuel subsidy, it will hamper both private vehicle users especially motorcycle commuters. In term of demographic variables included in the models and other control variables, there are some different significant results between cars' and motorcycle commuters.

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