

# Development of discrete choice model considering internal reference points and their effects in travel mode choice context

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**Abstract.** In the conventional travel behavior models such as logit and probit, decision makers are assumed to conduct the absolute evaluations on the attributes of the choice alternatives. On the other hand, many researchers in cognitive psychology and marketing science have been suggesting that the perceptions of attributes are characterized by the benchmark called “reference points” and the relative evaluations based on them are often employed in various choice situations. Therefore, this study developed a travel behavior model based on the mental accounting theory in which the internal reference points are explicitly considered. A questionnaire survey about the shopping trip to the CBD in Matsuyama city was conducted, and then the roles of reference points in travel mode choice contexts were investigated. The result showed that the goodness-of-fit of the developed model was higher than that of the conventional model, indicating that the internal reference points might play the major roles in the choice of travel mode. Also shown was that the respondents seem to utilize various reference points: some tend to adopt the lowest fuel price they have experienced, others employ fare price they feel in perceptions of the travel cost.

**Keywords:** Travel behavior; Reference points; Mental accounting theory; Travel mode choice; Discrete choice model

## 1. Introduction

In recent years, there has been a growing intersection between the transportation and the economic area of study. In microeconomic theory, there are two demand levels theory namely consumer demand and market demand. Recent behavioral research indicates that there is no simple explanation of how price might influence individual buyers’ purchase decisions, even in the transportation field, such as fuel price, parking fee, and toll fee. Private car (auto) and public transport (PT) are two transportation modes that still have an interchangeable high preference to use by most of urban dweller. In urban transport field, reducing private car and increasing public transport users is challenging. Travel cost and travel time are used as reference by the traveler.

The conceptualizations of reference price rely on a substantial body of behavioral literature that examines the relationship between new point information (i.e. actual price) and established reference point information (i.e. reference price) [1]. Several theories have been proposed in dealing with reference price such as prospect theory [2], mental accounting theory [3], and strategic reference point theory [4].



According to economic theory, the price is assumed to influence buyer choice due to price serves as an indicator of the purchase cost. Thus, it is believed that the buyer has perfect information concerning price and requires the satisfaction of comparable product alternatives (Kent B. Monroe). The study of prospect theory in transport mode choice for traveling has been extensively investigated by many researchers (e.g. Stated Preference Analysis Travel Choice [5], Identification of parameters for prospect theory model for travel choice analysis [6]. Applying behavioral economics in the design of travel information system [7]. A cumulative prospect theory approach to passengers behavior modeling: waiting time paradox revisited [8]. For the transport user, sometimes travelers drive a private car and using public transport, depend on the profitable value of vehicles. The focus of this study is to find out the alternative decision frames for a short-distance trip called reference points which have two different definitions, i.e., gain and loss. The value function is statistically estimated and tested within the context of the reference price. This research is concerned only for a short-distance trip like a shopping trip from a resident (origin) to central business district (CBD). The study aims to answer what kind of the travel mode will be used and how is the influence of internal reference price in choosing the travel mode?. This research presents some hypotheses related to internal reference price across the travel mode choice, especially in the short-distance trip. The following hypotheses are;

1. The effect of internal reference price on actual travel cost are greater than perceived travel cost for public transport.
2. The effect of internal reference price on perceived travel cost are greater than reservation travel cost for public transport.
3. Actual travel time are less than perceived travel time for public transport.
4. Perceived travel time are greater than reservation travel time for public transport.
5. Public transport user tends to adopt the lowest price as reference cost.

Everyone may have different internal reference price depend on the situation of travelers. Thus, data regarding individual internal reference price was collected. This study concern on internal reference price such as fair price, perceived price and reservation price of travel cost and travel time as a reference in a short-distance trip. The purpose of this study is to analyze the influence of internal reference price on the travel behavior of transport user at a short-distance trip. In order to know the influences of internal reference price, this study analyzes the data using binomial logit model approach based on prospect theory and mental accounting theory. Another basic element of prospect theory such as weight function is beyond the scope of this study.

This study is comprised of six sections. The second section presents a brief introduction to prospect theory. The third section provides methods; that is, data collection and procedure, survey instrument and data analysis. Developed model is presented in the fourth section. The result and discussion are proposed in the fifth section. Finally, the conclusion and suggestions for future research direction are given in the last section.

## **2. Literature review**

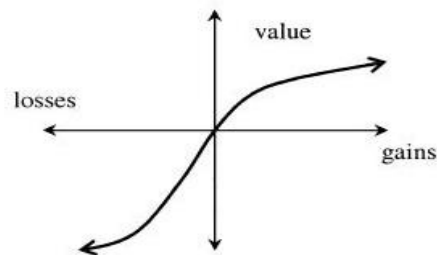
### **2.1. Prospect theory**

Prospect theory is concerned with risky choices “such as whether or not to take an umbrella and whether or not to go to war, which “are made without advance knowledge of their consequence” [9]. It is like whether or not to use a private car or public transport [10]. It is found through experiments that the choice depends on the position in which the decision maker is placed and, according to the position, whether they would have gain or lose by the perspective decision. The essence of prospect theory can be found in two scaling functions, that is, the value function and weight function, and in the reference point. The value function represents a prospect (i.e., possible outcomes and its consequences) in terms of the increase and decrease in the amount of asset from a reference point. The weight function, on the other hand, scales a prospect in term of probability associated with it [11]. The properties of the value function are showed in **Table 1**.

**Table 1.** Properties of the value function.

1	Defined on the deviation from the reference point.
2	Generally, concave for gains and convex for losses.
3	Steeper for losses than for gains.

Source: Kahneman and Tversky (1979), p .279. [2]

**Figure 1.** Value function.

Kahneman and Tversky propose the function form of the value function as

$$f(x) \begin{cases} x^\alpha & \text{if } x \geq 0 \\ -\lambda(x)^\gamma & \text{if } x < 0 \end{cases} \quad (1)$$

where  $x$  refers to the outcome expressed as deviation from zero-asset position, that is, reference point,  $\lambda$  is the scale parameter, and  $\alpha$  and  $\gamma$  are parameters of the value function in the gain region and loss region, respectively.

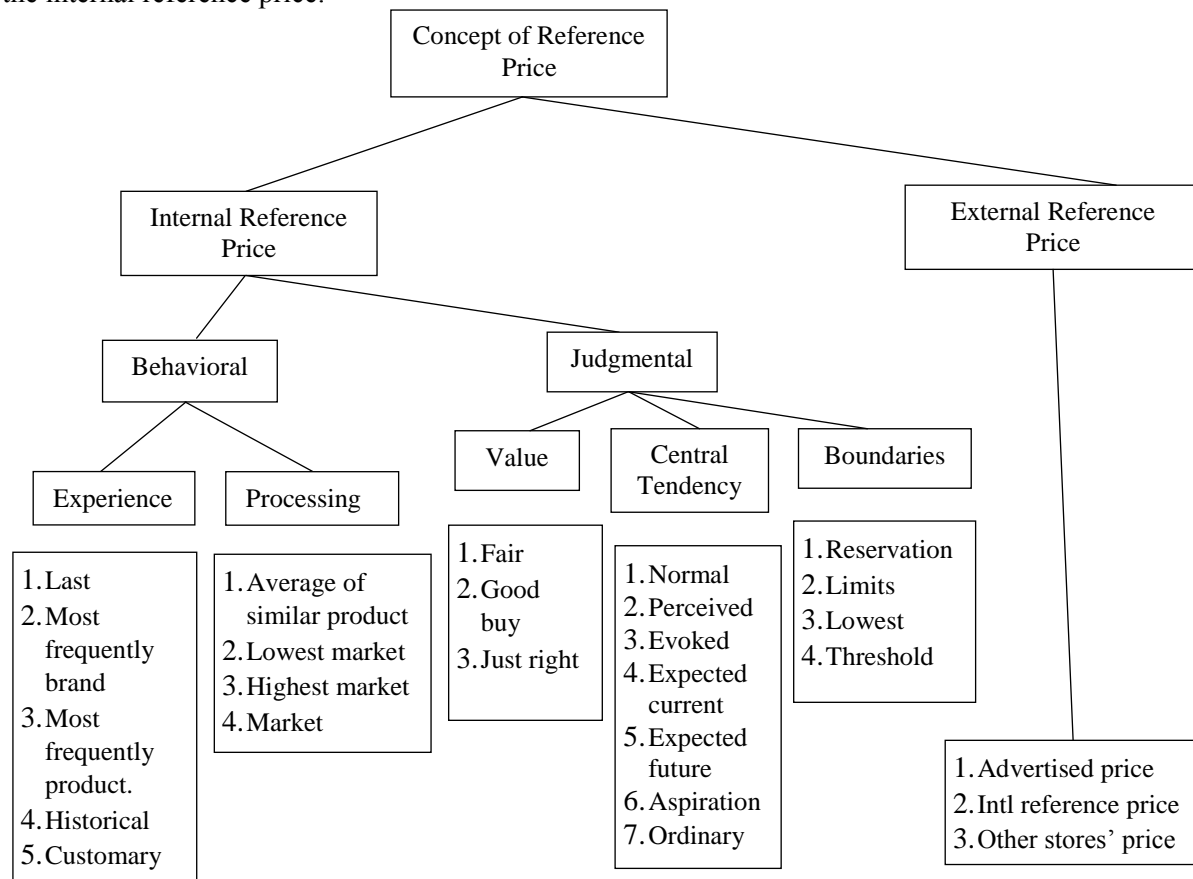
## 2.2. Reference price

The reference price is defined as the standard price considered by consumer when evaluating the actual price of the products to purchased, and it is based on the premise that consumers do not respond to prices absolutely, but only relative to the reference price [3]. The concept of a reference price asserts that consumers make decisions based on both actual and perceived price. In the transport field, it is recognized that car user behavior (travel behavior) is one of the main factors in transportation planning. Reference price might influence the perception or behavior of transport user to decide what kind of the travel mode will be used. The internal reference price and external reference price are various conceptualizations of the reference price. An internal reference price refers to a process that takes place internally, in the consumer's mind, by means of experience and judgment. Whereas, external reference price refers to information gathered from the environment, external to the person [1]. The following is detail for an internal and external reference price description.

### 2.2.1. Internal reference price.

The internal reference price is based on the past prices for the brand paid by consumer. It has some reference price such as fair price, reservation price, normal or standard price, aspiration price, market price, historical price, perceived price, and evoked price. The definition of some reference price has relationship each other. For instance, if someone wants to buy something/goods. They would negotiate a price to buy it. Before making a negotiation a reservation price, and fair price should be considered first. Reservation price is defined as the limit (i.e., the lowest/highest price she/he as a seller/buyer are ready to sell/buy) [12]. If the price is suitable (agree) among seller and buyer, that is a fair price. Actual price is a real price of commodity that can be sold and delivered immediately. Perceived price is the price in which a buyer can decide to buy a product. It has been claimed that the internal reference price concept has gained popularity in the literature and also provides more accuracy in

predicting consumer behavior [13]. The existence of the internal reference price is motivated by adaptation-level theory, which suggests that people adapt to the level of past stimuli on comparison with the adaptation level [14]. A consumer who concern for prices, are also more apt to pay close attention to, and stronger memory for, prices that they encountered in the past can be categorized as the internal reference price.



**Figure 2.** The concept of Reference Price.

### 2.2.2. External reference price

The external reference price is the price which consumer are not loyal to any one brand switch from brand to brand [15]. It is provided to the consumer through advertised price, international reference price and another stores' price. The advertised reference price is an offer price which can influence a consumer to buy something. Three basic external reference price formats are used in advertising: (1) comparing an advertised price with the seller's former price, (2) comparing an advertised price with the manufacturer's suggested retail price, and (3) comparing an advertised price with the price at competing [16]. Another external reference price is international reference price which reflects the price of the product in different countries. The international reference price is a part of external reference price in which the price of the product in various foreign markets using the transformable value is comparable to the local market's price. In the area of transport field, it is possible to apply the term of international reference price in a country, for example in determining the price of public transport ticket. Costumers would compare the observed point-of-purchases price with the reference price in order to implement prospect theory in the context of prices. A number of example regarding to the external reference price which related to the transport mode choice such as advertising discount fare are commonly used.

### 2.3. Reference point

The reference point is a zero-asset position from which the deviation measured each prospect as a gain or a loss [11]. It should be noted that the concept of a reference point has its roots in the psychology perception, and there is no formal theory available for formulating reference point [17]. Transport user will choose some alternative transport modes for traveling, such as car, bus, rail and bicycle. We assume that there are three relevant attributes of reference point: travel time, travel cost and convenience. Although the time and cost of the journey can be seen as losses in many travel situations, some travel choices could be still perceived as psychological gains if their cost and time are lower than those of other travel alternatives. At the travel cost, there are some variables associated with it, such as parking fee, toll fee and fuel price (gasoline price). Some people said that the fuel price is low and while others said expensive; it depends on an experience and their perception.

Thaler's (1985) model suggests that overall utility for a product can be conceptualized as function of acquisition utility (AU) and transaction utility (TU), where AU reflects the perceived value for the money or 'get' relative to 'give', and TU captures the consumer's reaction to relative price to the price compared to the expected price [18];

$$U = AU(p, \bar{p}) + \beta TU(p, p^*) \quad (2)$$

where;

$U$  ; The utility from a purchase

$AU(p, \bar{p})$  ; Acquisition utility, judged by comparing the actual price to be paid ( $p$ ) to consumer's value-equivalent price ( $\bar{p}$ )

$\beta TU(p, p^*)$  ; Transaction utility, judged by comparing the actual price to be paid ( $p$ ) to the consumer's expected price  $p^*$

$p$  ; Actual price

$\bar{p}$  ; Willingness to pay

$p^*$  ; Reference price

### 3. Methods

#### 3.1. Data collection and procedure

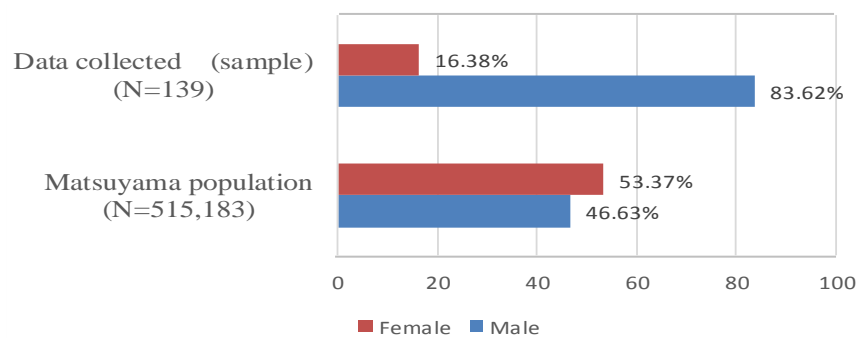
The data were collected in Matsuyama City, Ehime Prefecture, Japan. This study focuses on short-distance trip shopping, for example, resident to center business district such as Takashimaya, Okaido, and Gintengai. The questionnaire was addressed to transport users randomly selected in some points toward Matsuyama city officer. This questionnaire consists of 53 questions. It covers an economic term which applied in behavioral economics such as actual price, perceived price, and reserved price. By using binomial logit model, the data were analyzed to identify the reference point of travel time for public transport (PT), travel cost for public transport, and travel time for private car (auto). The respondents were asked to fill in the questionnaire sheet. The following illustrates about questionnaire sheet.

1. The questionnaire sheet describes what is the main transport mode they have used and how frequent it is. We asked them about how much is a reasonable price, fair price, reservation price and perceived price?. Moreover, reasonable price, fair price, reservation price, and perceived price serve as the reference price. Information obtained from questionnaires was analyzed by using binomial logit model in order to know the magnitude influence of internal reference price across the transport user in the short-distance trip.
2. Socio-economic and demographic characteristic, wherein surveyed respondents were asked about their gender, age, driver's license, monthly income, occupations, and zip code.

#### 3.2. Preliminary analysis

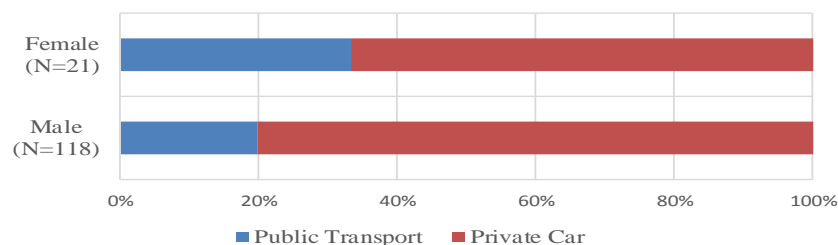
In the preliminary analysis, data were described prior to the analysis. Analysis started with statistical analysis of the data and briefly looked at some standard techniques for description and summarization

of data. Prior to application of these techniques, however, it is important to perform a data cleaning to ensure an appropriate analysis in the context of the study objectives. Matsuyama area is about 429.05 km<sup>2</sup>, Matsuyama is the capital city of Ehime Prefecture on the island of Shikoku in Japan and also Shikoku's largest city, with a population of 515,183 as of August 1, 2016, and the number of households is 235,178, as well as the number of man and woman is 240,254 and 274,929 respectively. The ratio between data collected (sample) and Matsuyama population is shown in **Figure 3**.



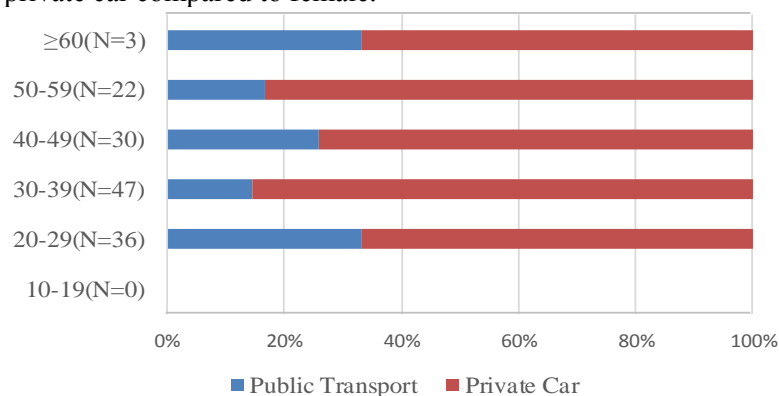
**Figure 3.** Data collected and Matsuyama population

**Figure 3** shows the population ratio of Matsuyama for female and male are 46.63 % and 53.37 % respectively. And the population ratio of the data is 16.38 % for female and 83.62 % for male. The following figures are mode choice distribution and analyzed base on the basic information of the respondent. It can be seen in **Figure 4**, **Figure 5**, and **Figure 6**. The figures describe the mode choice (public transport and private car) based on gender, age categorize, and characteristic of travel mode choice.



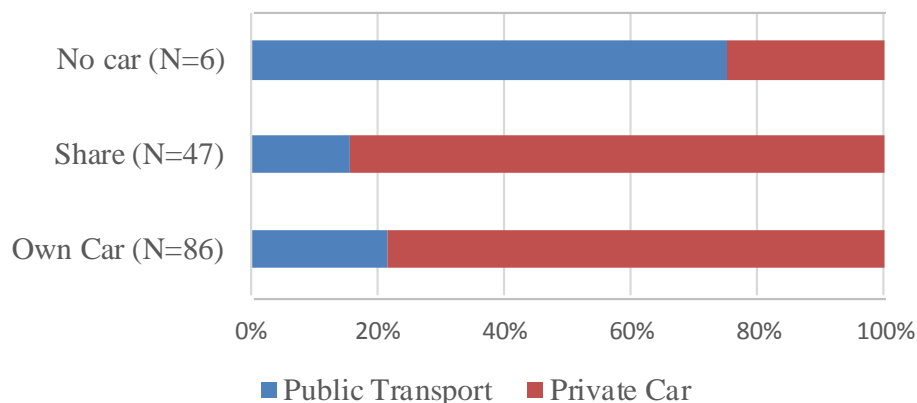
**Figure 4.** Mode choice based on gender.

**Figure 4** shows a diagram of the relationship between travel mode based on gender. We consider the figure to know how is preference of the travel mode of choice based on gender. It can be seen that male tend to use private car compared to female.



**Figure 5.** Mode choice based on age category.

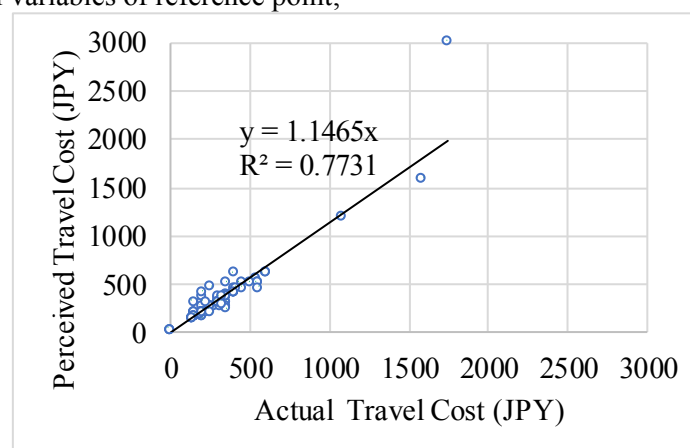
We had 139 data and distributed in six age categories. Our data is kinds of bias in terms of age category. **Figure 5** indicates the descriptive environment between age categories and mode choice. It shows that there are not people coverage less than 20 age and there are three people who are in  $\geq 60$  age category. It means that transport users are mainly in the 20-29 age category to 30-39 age category. It might occur since the data which already collected in Matsuyama city office mostly use private car. Whereas, private car user must to have car license. The results also indicate that travelers mostly use private car than public transport in this data.



**Figure 6.** Travel mode share correspondent to car ownership

The characteristic of transport user on travel mode choice is presented in **Figure 6**. This figure is considered to know the effect of car ownership on use public transport or private car usage. It shows that the transport user who has a car tend to use automobile and share mobile, compared to the public transport. It might be occurred due to the private car user is over estimate to the public transport. The possibility, they do not know the actual price of a ticket the public transport.

The correlations of several variables in terms of internal reference point are shown in **Figure 7**, **Figure 8**, **Figure 9**, and **Figure 10**. Those figures are obtained from the data analysis. It is also considered to know how the transport user feels about the variables of internal reference point. The following are several variables of reference point;



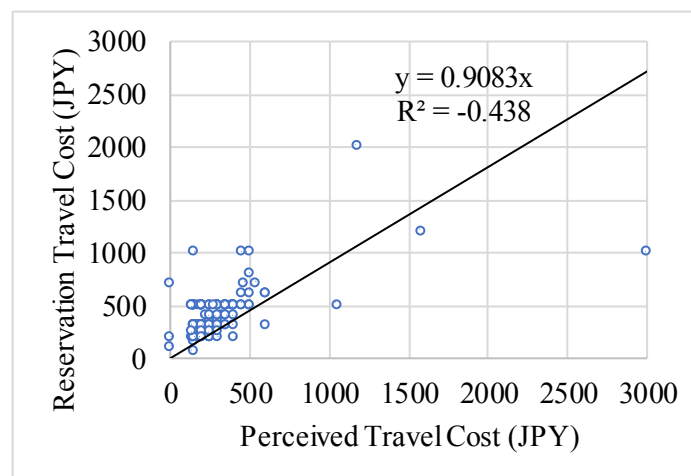
**Figure 7.** Actual travel cost-perceived travel cost.

**Figure 7** shows the correlation between actual travel cost and perceived travel cost. It is examined in order to know the perception of public transport user to the actual travel cost toward perceived travel cost, how they feel of the cost, whether the transport user is an overestimate or underestimate. The result shows that the perceived travel cost is greater than the actual cost. Therefore, it can be said that the transport user overestimates toward perceived travel cost.

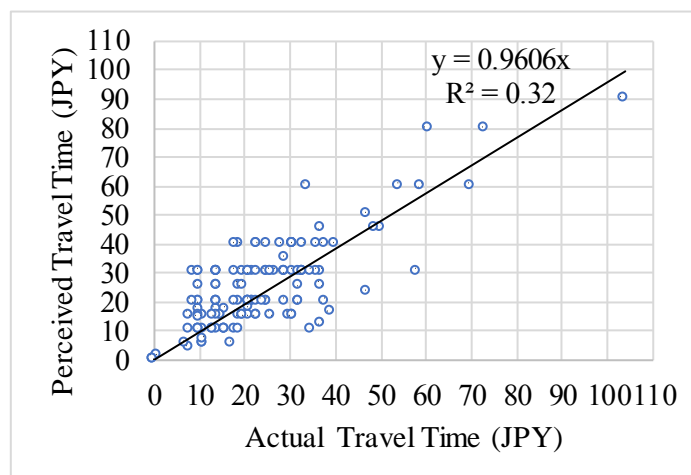


The correlation between perceived travel cost and reservation travel cost is depicted in **Figure 8**. It investigated how the public transport user feels in regard to the perceived travel cost toward reservation travel cost. The result indicates that perceived travel cost is greater than reservation travel cost. It means that the price in which a public transport user can decide to buy a ticket more than the highest price, which has a public transport.

In **Figure 9**, it shows the graph of the correlation between actual and perceived travel time. This figure is considered to know how the public transport user perception is. The figure indicates that actual travel time of public transport is quite similar to the perceive travel time. It means that the transport users feel that there is no different between actual and perceived travel time, so that it can be said that the traveler relish the condition.



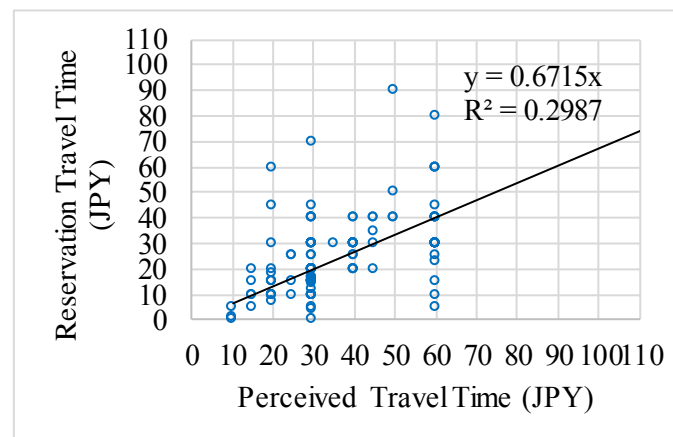
**Figure 8.** Perceived travel cost-reservation travel cost.



**Figure 9.** Actual travel time-perceived travel time.

The correlation between perceived travel time and reservation travel time as described in **Figure 10**. This analysis is performed in order to know how the public transport user feel is. The result indicates that perceived travel time is greater than reservation travel time. It can be said that the public transport users assume when they use public transport, the reservation travel time less than perceived travel time.





**Figure 10.** Perceived travel time-reservation travel time.

The description of the relationship between variables of travel time and travel cost is presented in **Table 2** and **Table 3**.

**Table 2.** The relationship between variables of travel cost.

Relationship between Variables	Number of samples	Share (%)
$TC_{pt}^{fair} < TC_{pt}^{percep} < TC_{pt}^{reserv}$	27	24.1
$TC_{pt}^{reserv} > TC_{pt}^{percep} = TC_{pt}^{fair}$	24	21.4
$TC_{pt}^{fair} < TC_{pt}^{reserv} < TC_{pt}^{percep}$	18	16.1
$TC_{pt}^{fair} < TC_{pt}^{percep} = TC_{pt}^{reserv}$	12	10.7
$TC_{pt}^{percep} < TC_{pt}^{fair} < TC_{pt}^{reserv}$	7	6.2
$TC_{pt}^{reserv} < TC_{pt}^{fair} < TC_{pt}^{percep}$	7	6.2
$TC_{pt}^{percep} < TC_{pt}^{reserv} < TC_{pt}^{fair}$	5	4.5
$TC_{pt}^{percep} > TC_{pt}^{fair} = TC_{pt}^{reserv}$	4	3.6
$TC_{pt}^{reserv} < TC_{pt}^{percep} < TC_{pt}^{fair}$	4	3.6
$TC_{pt}^{percep} = TC_{pt}^{fair} = TC_{pt}^{reserv}$	3	2.7
$TC_{pt}^{percep} < TC_{pt}^{fair} = TC_{pt}^{reserv}$	1	0.9
Total	112	100

**Table 2** shows the relationship between variables of travel cost. In the first row, it shows that the public transport fair is relatively expensive. On the other hand, some possibilities for using public transport might be occurred due to perceived travel cost for public transport is lower than reservation cost. The second case, fair cost of public transport is equal to the perceive cost, but lower than reservation cost. In this case, people also can use public transport. In the third, the fair travel cost is less than reservation cost, while perceived travel cost is greater than fair travel cost and reservation travel cost. It means that the perceived of public transport user is the highest. So, it is difficult to use public transport. At fourth case, the reservation travel cost of public transport is equal to the perceive travel cost but greater than fair cost. In the fifth row, fair travel cost exists between perceived travel cost and reservation travel cost but perceived travel cost less than reservation travel cost. It means that public transport user is an underestimate. The similar situation to the fifth case, in the sixth situation, but perceived travel cost is greater than reservation travel cost, so it can be said the public transport user is over estimate. The seventh case indicates that fair travel cost is greater than two conceptual internal reference point namely reservation travel cost and perceived travel cost. It can be said that the public transport users are dominant or still consistent to use it. Moreover, at the eighth case describes the relationship which reservation travel cost is equal to fair travel cost, but less than perceive travel

cost. It means that it is difficult to use the public transport. In the ninth case, fair travel cost is greater than two conceptual reference point. It means that people accurately use public transport. At the tenth, perceive travel cost and fair travel cost as well as reservation travel cost is equal. It can be said public transport users assume same for all attributes. The last case, perceived travel cost less than fair travel cost but same with reservation travel cost. It means that people have the possibility to use public transport

**Table 3.** The relationship between variables of travel time.

Relationship between Variables	Number of samples	Share (%)
$\begin{matrix} fair \\ pt \end{matrix} < \begin{matrix} percep \\ pt \end{matrix} < \begin{matrix} reserv \\ pt \end{matrix}$	41	36.6
$\begin{matrix} reserv \\ pt \end{matrix} > \begin{matrix} percep \\ pt \end{matrix} = \begin{matrix} fair \\ pt \end{matrix}$	31	27.7
$\begin{matrix} fair \\ pt \end{matrix} < \begin{matrix} percep \\ pt \end{matrix} = \begin{matrix} reserv \\ pt \end{matrix}$	17	15.2
$\begin{matrix} percep \\ pt \end{matrix} < \begin{matrix} fair \\ pt \end{matrix} < \begin{matrix} reserv \\ pt \end{matrix}$	9	8.0
$\begin{matrix} fair \\ pt \end{matrix} < \begin{matrix} reserv \\ pt \end{matrix} < \begin{matrix} percep \\ pt \end{matrix}$	7	6.2
$\begin{matrix} percep \\ pt \end{matrix} > \begin{matrix} fair \\ pt \end{matrix} = \begin{matrix} reserv \\ pt \end{matrix}$	5	4.5
$\begin{matrix} percep \\ pt \end{matrix} = \begin{matrix} fair \\ pt \end{matrix} = \begin{matrix} reserv \\ pt \end{matrix}$	1	0.9
$\begin{matrix} percep \\ pt \end{matrix} < \begin{matrix} reserv \\ pt \end{matrix} < \begin{matrix} fair \\ pt \end{matrix}$	1	0.9
Total	112	100

**Table 3** shows the relationship between variables of travel time for public transport. In the first row, it describes that the time of public transport fair is relatively long. In this situation, public transport users feel the perceived travel time is longer than fair travel time. On the other hand, they have some possibilities to use public transport because perceived travel time for public transport is shorter than reservation travel cost. The second case, the fair travel time of public transport is equal to the perceived travel time but lower than reservation time. In this case, people also can use public transport. At third case, the reservation travel time of public transport is equal to the perceived travel time but longer than fair time. It means the public transport user is over estimate to using public transport. In the fourth row, fair travel time existed between perceived travel time and reservation travel time but perceived travel time less than reservation travel time. It means that public transport user is an underestimate about travel time. In the fifth situation describes the fair travel time is less than reservation time, while perceived travel time is longer than them. It means public transport user consider to use public transport. The sixth case describes the relationship which reservation travel time is equal to the fair travel time but less than perceived travel time. It might be said that it is difficult to use the public transport user. At the seventh, perceived travel time and fair travel time as well as reservation travel time is equal. It can be said public transport user feels that they can choose any transport modes they need. The eighth row shows fair travel time is longer than two conceptual internal reference point namely reservation travel time and perceive travel time. It is also can be said the public transport users is dominant or still consistent to use it.

#### 4. Developed model.

The data were analyzed by using the binomial logit model. It is developed base on mental accounting theory and prospect theory. The following functional form for the value function fits the prospect theory in Equation (3);

$$f(x) \begin{cases} x^\alpha & \text{if } x \geq 0 \\ \lambda(x)^\gamma & \text{if } x < 0 \end{cases} \quad (3)$$

The binary logit model can be seen in Equation (4) [19].

$$P_n(i) = \frac{e^{V_{in}}}{e^{V_{in}} + e^{V_{jn}}} \quad (4)$$

$$U_c = \beta_0^c + \beta_1^c X_1^c + \beta_2^c X_2^c + \dots + \beta_k^c X_k^c \quad (5)$$

$$U_{pt} = \beta_0^{pt} + \beta_1^{pt} X_1^{pt} + \beta_2^{pt} X_2^{pt} + \dots + \beta_k^{pt} X_k^{pt} \quad (6)$$

$$\text{Car (c)} = \exp( b[1] + b[3]^*x[.,.] + b[4]^*x[.,.] + b[5]^*x[.,.] + b[7]^*x[.,.] ) \quad (7)$$

$$\text{Public Transport (pt)} = \exp( b[2] + b[3]^*x[.,.] + b[4]^*x[.,.] + b[5]^*x[.,.] + b[6]^*x[.,.] ) \quad (8)$$

The parameters are defined for each utility which used to the model such as  $b[1]$  = constant utility of car,  $b[2]$  = constant utility of PT,  $b[3]$  = coefficient parameter of cost,  $b[4]$  = coefficient parameter of time,  $b[5]$  = coefficient parameter of age,  $b[6]$  = coefficient parameter of gender,  $b[7]$  = coefficient parameter of license and  $U_c$  is utility of car as well as  $U_{pt}$  is utility of public transport.

The mental accounting theory is showed in Equation (9);

$$U_c = AU_c(p, \bar{p}) + \beta TU_c(p, p^*) \quad (9)$$

$$AU_c = \beta_2^c (TC_c - WTP_c) \quad (10)$$

$$TU_c = \beta_3^c (TC_c - RC_c) \quad (11)$$

$$U_c = \beta_0^c + \beta_1^c X_1^c + \beta_2^c (TC_c - WTP_c) + \beta_3^c (TC_c - RC_c) + \beta_5^c TT, \quad (12)$$

$$U_{pt} = \beta_0^{pt} + \beta_1^{pt} X_1^{pt} + \beta_2^{pt} (TC_{pt} - WTP_{pt}) + \beta_4^{pt} (TC_{pt} - RC_{pt}) + \beta_5^{pt} TT \quad (13)$$

The following is some cases of the probabilistic choice framework.

Case 1 (linear-in-parameter)

$$U_c = \beta_0^c + \beta_1^c X_1^c + \beta_2^c X_2^c + \beta_3^c X_3^c + \beta_4^c X_4^c \dots + \beta_k^c X_k^c \quad (14)$$

$$U_{pt} = \beta_0^{pt} + \beta_1^{pt} X_1^{pt} + \beta_2^{pt} X_2^{pt} + \beta_3^{pt} X_3^{pt} + \beta_4^{pt} X_4^{pt} \dots + \beta_k^{pt} X_k^{pt} \quad (15)$$

In this case, the utility function for all attributes of travel behavior is a linear parameter. The travel cost, travel time and the other attributes work in each variable. It is called conventional model.

Case 2 (non-linear parameter)

The utility function of linear-in-parameter to be a utility function nonlinear-in-parameter is developed by incorporating between prospect theory and binomial logit model using power function. The utility function can be expressed as follows;

$$U_{pt} = \alpha^{pt} + \beta_t^{pt} (TT_{per} - TT_{rp})^{\exp(\eta t)} + \beta_c^{pt} (TC_{per} - TC_{rp})^{\exp(\eta c)} + \gamma_t + \varepsilon, \quad (16)$$

if  $TT_{per} \geq TT_{rp}$  and  $TC_{per} \geq TC_{rp}$

$$U_{pt} = \alpha^{pt} + \beta_t^{pt} (TT_{rp} - TT_{per})^{\exp(\eta t)} + \beta_c^{pt} (TC_{rp} - TC_{perc})^{\exp(\eta c)} + \gamma_t + \varepsilon, \quad (17)$$

if  $TT_{rp} \geq TT_{per}$  and  $TC_{rp} \geq TC_{perc}$

Model A (Travel time for public transport, there are four models).

The utility function of the public transport  $U_{pt}$  of the loss frame which the fair travel time and reservation travel time as a reference point are;

$$U_{pt} = \alpha^{pt} + \beta_t^{ptloss} (TT_{per} - TT_{fair})^{\exp(\eta t)loss} + \beta_c^{pt} (TC_{per} - TC_{fair})^{\exp(\eta c)loss} + \gamma_t + \varepsilon, \quad (18)$$

if  $TT_{per} \geq TT_{fair}$  and  $TC_{per} \geq TC_{fair}$

$$U_{pt} = \alpha^{pt} + \beta_t^{ptloss} (TT_{per} - TT_{reserv})^{\exp(\eta t)loss} + \beta_c^{pt} (TC_{per} - TC_{reserv})^{\exp(\eta c)loss} + \gamma_t + \varepsilon, \quad (19)$$

if  $TT_{per} \geq TT_{reserv}$  and  $TC_{per} \geq TC_{reserv}$

The utility function of the public transport  $U_{pt}$  of the gain frame which the fair travel time and reservation travel time as a reference point are;

$$U_{pt} = \alpha^{pt} + \beta_t^{ptgain} (TT_{fair} - TT_{per})^{\exp(\eta t)gain} + \beta_c^{pt} (TC_{fair} - TC_{per})^{\exp(\eta c)gain} + \gamma_t + \varepsilon, \quad (20)$$

if  $TT_{fair} \geq TT_{per}$  and  $TC_{fair} \geq TC_{per}$

$$U_{pt} = \alpha^{pt} + \beta_t^{ptloss} (TT_{per} - TT_{reserv})^{\exp(\eta t)gain} + \beta_c^{pt} (TC_{per} - TC_{reserv})^{\exp(\eta c)gain} + \gamma_t + \varepsilon, \quad (21)$$

if  $TT_{per} \geq TT_{reserv}$  and  $TC_{per} \geq TC_{reserv}$

Model B (Travel cost for public transport, there are four models).

The utility function of the public transport  $U_{pt}$  of the loss frame which the fair travel cost and reservation travel cost as a reference point are;

$$U_{pt} = \alpha^{pt} + \beta_t^{ptloss} (TT_{per} - TT_{fair})^{\exp(\eta t)loss} + \beta_c^{pt} (TC_{per} - TC_{fair})^{\exp(\eta c)loss} + \gamma_t + \varepsilon, \text{ if } TT_{per} \geq TT_{fair} \text{ and } TC_{per} \geq TC_{fair} \quad (22)$$

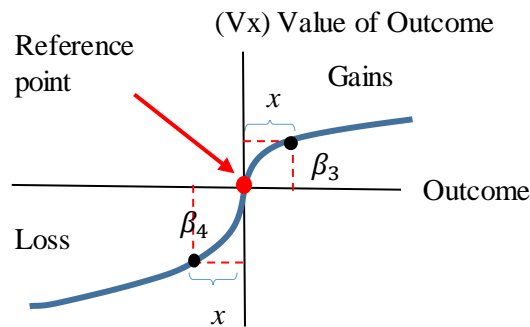
$$U_{pt} = \alpha^{pt} + \beta_t^{ptloss} (TT_{per} - TT_{reserv})^{\exp(\eta t)loss} + \beta_c^{pt} (TC_{per} - TC_{reserv})^{\exp(\eta c)loss} + \gamma_t + \varepsilon, \text{ if } TT_{per} \geq TT_{reserv} \text{ and } TC_{per} \geq TC_{reserv} \quad (23)$$

The utility function of the public transport  $U_{pt}$  of gain frame which the fair travel time and reservation travel time as a reference point are;

$$U_{pt} = \alpha^{pt} + \beta_t^{ptgain} (TT_{fair} - TT_{per})^{\exp(\eta t)gain} + \beta_c^{pt} (TC_{fair} - TC_{per})^{\exp(\eta c)gain} + \gamma_t + \varepsilon, \text{ if } TT_{fair} \geq TT_{per} \text{ and } TC_{fair} \geq TC_{per} \quad (24)$$

$$U_{pt} = \alpha^{pt} + \beta_t^{ptloss} (TT_{per} - TT_{reserv})^{\exp(\eta t)gain} + \beta_c^{pt} (TC_{per} - TC_{reserv})^{\exp(\eta c)gain} + \gamma_t + \varepsilon, \text{ if } TT_{per} \geq TT_{reserv} \text{ and } TC_{per} \geq TC_{reserv} \quad (25)$$

In the existing application of utility function, it is recognized that it has several attributes such as travel time, travel cost and conventional model. The travelers are affected by travel time or travel cost to choose the travel mode. This research is grounded by tracing the private car behavior and public transport behavior deeply, where  $TC_c$  is travel cost of the car,  $RC_c$  is reference cost of the car,  $TT_c$  is travel time of the car,  $RTT_c$  is reference travel time of the car,  $\varepsilon_c$  is Gumble distribution of the car. Also,  $\alpha$ ,  $\beta$ ,  $\eta$  and  $\gamma$  are variables of the value function in the gain and loss area. From the eight models, it will be obtained which is the better model or goodness-of-fit model. In the conventional model, the utility of a risky prospect is linear in outcome probabilities. By developing the model, the mental accounting theory can be employed into the transport field (travel behavior), which both gain frame and loss frame is separately created, where the reference point serves as asset position. The following is a figure of the reference point (non-linear parameter)



**Figure 11.** A Reference point (non-linear parameter).

## 5. Result and discussion

This study developed a travel behavior model base on the mental accounting theory. In conventional model usually employ the linear-in-parameter. In the mental accounting theory, researchers use the non-linear parameter. Travel time for public transport is presented in **Table 4**. By using Gaussian Software, we obtain the **Table 4**. The  $\theta_1, \theta_2, \theta_3, \theta_4$  are the satisfaction threshold of public transport.  $\beta$  AU loss is variable of acquisition utility in the loss area,  $\eta$  AU loss is transaction utility in the gain area, AIC is an Akaike's Information Criteria and  $\rho^{-2}$  is an informal goodness-of-fit measure.

For a binary choice model, the value of goodness-of-fit ( $\rho^{-2}$ ) must lie between 0 and 1 as well as the closer to one is a better. As we can see in **Table 4** that the better of goodness-of-fit is fair travel time because of its value closer to 1.

**Table 4.** Travel time for public transport.

Variables	Objective TT		Perceived TT		Reference Point			
					Fair TT		Reservation TT	
	Estimates	t-statistic	Estimates	t-statistic	Estimates	t-statistic	Estimates	t-statistic
$\theta_1$	-2.20	-7.70	-2.29	-7.86	-2.26	-8.36	-0.441	-1.79
$\theta_2$	-1.40	-5.45	-1.48	-5.67	-1.33	-5.71	0.352	1.45
$\theta_3$	-0.76	-3.14	-0.82	-3.39	-0.59	-2.85	0.96	3.77
$\theta_4$	0.59	2.32	0.55	2.14	1.24	4.66	2.36	7.59
$\beta$ AU loss	-2.47	-4.97	-2.45	-5.29	-2.94	-4.96	-0.17	-0.22
$\eta$ AU loss					-0.92	-3.19	-0.75	-0.13
$\beta$ TU gain					1.09	2.43	1.93	3.58
$\eta$ TU gain					-10.1	-0.08	-0.65	-1.47
Number of observations	110.00		115.00		115.00		115.00	
AIC	310.04		314.36		298.67		338.74	
$\rho^{-2}$	0.12		0.12		0.19		0.08	

By performing similar analysis at **Table 4**, we gain goodness-of-fit  $\rho^{-2}$  in **Table 5**. It is shown that the goodness-of-fit of travel cost for public transport is fair travel cost, because the highest value of  $\rho^{-2}$  is in fair travel cost, the value of  $\rho^{-2}$  is 0.21.

Travel time for the private car is shown in **Table 6**, it has three models. The First model is analyzed for average travel – minimum travel time, model 2 is analyzed for maximum-minimum travel time, and model 3 is analyzed for maximum-minimum travel time.

**Table 5.** Travel cost for public transport.

Variables	Objective TT		Perceived TC		Reference Point			
					Fair TC		Reservation TC	
	Estimates	t-statistic	Estimates	t-statistic	Estimates	t-statistic	Estimates	t-statistic
$\theta_1$	-1.73	-7.36	-1.83	-7.46	-2.43	-8.27	-0.33	-1.48
$\theta_2$	-0.80	-4.04	-0.87	-4.26	-1.32	-5.40	0.66	2.89
$\theta_3$	-0.22	-1.15	-0.27	-1.41	-0.60	-2.67	1.30	5.32
$\theta_4$	1.47	5.26	1.43	5.10	1.46	4.54	3.08	8.75
$\beta$ AU loss	-2.00	-3.77	-2.20	-4.01	-3.51	-4.97	0.00	0.00
$\eta$ AU Loss					-0.93	-4.02	2.54	0.04
$\beta$ TU gain					0.97	1.49	1.75	3.84
$\eta$ TU gain					-10.76	-0.03	-1.64	-2.63
Number of observations	110.00		110.00		112.00		112.00	
AIC	307.75		303.84		283.53		305.80	
$\rho^{-2}$	0.11		0.12		0.21		0.08	

There are three attributes in **Table 6**; average travel time, maximum travel time and minimum travel time. Then these attributes are formulated each other, thus it obtained three models.  $\beta_5$  and  $\beta_6$  are the variables of travel time for private car. By using Gaussian Software, it

can be obtained the value of goodness-of-fit of the model. As can be seen that the better model of goodness-of-fit is model 1 since the value is 0.24, which is closer to one.

**Table 6.** Travel time for private car

Variables	Reference Point					
	Model 1		Model 2		Model 3	
	AV-Min		Max-AV		Max-Min	
	Estimates	t-statistic	Estimates	t-statistic	Estimates	t-statistic
$\theta_1$	-2.79	-5.82	-2.07	-2.98	-36.16	-0.23
$\theta_2$	-1.79	-4.05	-1.15	-1.73	-35.21	-0.22
$\theta_3$	-1.00	-2.30	-0.40	-0.61	-34.44	-0.22
$\theta_4$	1.00	2.38	1.45	2.13	-32.56	-0.21
5	-6.05	-1.36	-0.50	-0.62	-34.96	-0.22
6	-0.20	-0.33	-1.03	-0.30	-4.30	-0.94
N observations	113.00		113.00		113.00	
AIC	276.16		290.17		285.82	
$\rho^{-2}$	0.24		0.20		0.21	

From the data analysis, it found a reference point for each model in travel time for public transport model, travel cost for public transport model, and travel time for the private car model. Which then the models were integrated. The integrated model is increasingly recognized as a tool to support transport policy. This study also identify which variable have the most influence on these models should be integrated. Furthermore, it is important to develop the multi choice mode, which kind will be predicted. Integrated model constitutes three combined attribute models; travel time for public transport, travel cost for public transport, and travel time for the private car. The Integrated models were presented in **Table 7**.

**Table 7.** Integrated Model

No	Variables	Estimates	t-statistic
1	$\theta_1$	-2.339	-8.105
2	$\theta_2$	-1.3705	-5.556
3	$\theta_3$	-0.5119	-2.404
4	$\theta_4$	1.2195	4.54
5	AU loss	-5.2442	-3.406
6	$\eta$ AU loss	-0.3595	-1.27
7	TU gain	1.0703	2.375
8	$\eta$ TU gain	-10.0936	-0.075
9	$\theta_1$	-2.5374	-7.891
10	$\theta_2$	-1.3196	-5.133
11	$\theta_3$	-0.4916	-2.146
12	$\theta_4$	1.4964	4.549
13	AU loss	-5.6977	-4.63
14	$\eta$ AU Loss	-0.5352	-2.718
15	TU gain	1.2326	1.982
16	$\eta$ TU gain	-10.76	-0.041
17	$\theta_1$	-2.7178	-5.383

18	$\theta_2$	-1.7617	-3.735
19	$\theta_3$	-0.921	-1.994
20	$\theta_4$	1.0103	2.262
21	5	-7.2779	-1.155
22	6	-0.064	-0.101
23	constants	-0.0235	-0.05
24	travel cost pt	0.363	1.974
25	travel time	0.0863	0.561
26	gender	0.2532	0.598
27	age30	0.5982	1.815
28	age50	0.3983	0.897
29	own pc	0.0009	0.003
30	frequency	0.165	0.367

**Table 7** shows the result of the integrated models. The variables were analyzed among each other. The value of variables obtained by analyzing the data trial and error for all variables until found best value. As can be seen in **Table 7** that the variables number 1 to 4 are satisfaction threshold of travel time for public transport, variables number 5 to 8 are acquisition utility and transaction utility in gains and loss area. Then, variables number 9 to 12 are satisfaction threshold of travel cost for public transport, variables number 13 to 16 are acquisition utility and transaction utility in gains and loss respectively. Hereafter, variables number 17 to 20 are satisfaction threshold of travel time for private car and variables number 21 to 22 are variable of travel time for private car. Variables number 23 is constant of the model. Finally, the variables number 24 to 30 are dummy variables of the integrated model. In this model travel time for public transport is not too significant but travel cost for public transport significantly affect the model because its value is greater than the level of significant (1.974).

## 6. Conclusion

This study investigated the decision-making process of travel mode choice based on the prospect theory and mental accounting theory. The conventional model of the utility function is affected by travel time, travel cost, and convenience as well as other attributes. Three attributes are utilized as a reference point such as reservation travel time, perceive travel time and the fair travel cost. According to the AIC (Akaike's Information Criteria) index and  $\rho^{-2}$  (Mac Fadden pseudo) which found the value of AIC and  $\rho^{-2}$  is 298,69 and 0.19 for fair travel time for public transport, the value of AIC and  $\rho^{-2}$  is 283.53 and 0.21 for fair travel cost for public transport, and the value of AIC and  $\rho^{-2}$  is 276.16 and 0.24 for average-minimum travel time for private car. By developing a model using mental accounting theory and prospect theory, the results showed that the fair travel time and fair travel cost are utilized as reference point for public transport user seem to be diminishing according to the gain and loss. The results also showed that the goodness-of-fit of the developed model is higher than that of the conventional model which means that the internal reference point might play the major roles in the choice of travel mode. Several limitations of this study provide research for the future study. First, given the importance of the reference point, the development of mental accounting theory in the transport field is recommended. Second, how to identify what kind of reference point is utilized for the evaluation of travel cost such as perceived transit fare and cost of the other travel mode. Third, how the effect of the reference point after implementing the transport policy whether it is stable, decrease or increase?.

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