CONJOINT ANALYSIS FOR INDIVIDUALS' PURCHASING BEHAVIOR OF ETC IN-VEHICLE TRANSMITTERS

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In Japan, an electronic toll collection system (ETC) is now already operating. This system, which enables drivers to automatically pay tolls without stopping the car, is expected to bring various benefits including smoother traffic at tollgates and more convenience for drivers owing to the cashless system. However, up to now, only few percentages of vehicles in Japan are installed with in-vehicle transmitters. Therefore, promoting the use of transmitters is particularly required. The objective for this research is to explore which promotion program and which features of ETC transmitter motivate a driver to purchase the device. In order to fulfill this objective, conjoint choice experiments were conducted using Internet-based questionnaire survey. Experimentally controlled combinations of four attribute levels, namely, price of unit, discount rate of toll fee, reduction of waiting time at toll gate, and distance-based toll, called profiles, were presented to respondents for evaluation. Respondents had to choose their most prefer transmitter profile from choice. In addition, several subjective evaluation questions were asked in order to group respondents with the same tastes into the same segment. Finally, latent class choice model was adopted for model formulation. The results show that reduction of transmitter's price can contribute greatly to promoting the use of transmitters.

Key Words: *Interactive survey, Conjoint analysis, ETC transmitter, Stated preference survey, Latent class model*

1. INTRODUCTION

Electronic Toll Collection (ETC) is the use of various technologies to allow the toll collection process to be automated in such a way that customers do not have to stop and pay cash at a tollgate. ETC service was started in Japan on March 30, 2001 with several aims: to alleviate traffic congestion near tollgates; to enhance convenience of drivers by eliminating the need to handle cash; and to reduce management cost. It is planned that the ETC system in Japan will handle complicated toll systems in which amounts of charge are changed according to the type of vehicle and distance traveled.

However, based on data up to 7 May 2002, only 241,206 cars in Japan are equipped with ETC transmitters[1). This number accounts for approximately 0.003 percent of total cars (70 million cars based on data in year 2001) in Japan[2). From this incredibly low percentages of number of cars equipped with transmitters, if flexible toll fee systems such as distance-based toll fee system in which amounts of charge are calculated based on the distance traveled by driver are implemented, very few percentages of total cars in Japan can utilize this system. By this problem, it is important to understand individuals' purchasing behavior of transmitters in order to promote the use of them.

Usually, diffusion process of new product is predicted by Bass model. However, Bass model using aggregate level data does not allow researcher to examine individual purchasing intention. Therefore, the model that uses individual level data like random utility model was chosen for this research. In addition, due to the small percentages of ETC transmitter users, it is difficult to collect reveal preference data. Therefore, experimentally control combination of attribute levels of ETC transmitter are formed here to ask respondents. Respondents have to state their preference by choosing one of transmitters.

Interactive internet-based survey program was developed for data collection. Since, we would like to capture taste variation among car users. Therefore, in addition to conjoint choice task several subjective evaluation questions were asked in order to group respondents with the same tastes into the same segments. Latent class choice model was adopted for model formulation.

The paper is organized as follows. We begin with design of a choice experiment and data collection in chapter 2. Next, in chapter 3, the latent class choice model is applied to stated choice data of transmitters. Estimation results and discussions are shown here. In addition, elasticities of probability and policy evaluation results are also illustrated. Finally, the conclusion and future research direction are provided in chapter 4.

2. EXPERIMENTAL DESIGN AND DATA COLLECTION

(1) Attributes and Levels of ETC transmitters

Since, in this research, we pay attention to individuals' purchasing behavior of ETC transmitters from the viewpoint of government not from the viewpoint of transmitter selling company. Therefore, most of attributes are attributes that government is interested and manageable not attributes of transmitter itself. Four attributes that are selected in stated choice experiment are as follows:

1. Price of unit (yen): 25000, 30000, 35000, 40000
2. Discount rate of toll fee (%): 10, 20, 30, 35
3. Reduction of waiting time at tollgate (minutes): 1, 2, 4, 8
4. Distance-based toll system: yes, no

All attributes have four levels except distance-based toll system, which has only two levels. (1) Price is a price of transmitter. At present (June, 2002), the market price of a transmitter is around 30,000 to 50,000 yen. (2) Discount rate of toll fee is a discount rate that is given to only transmitter user. (3) Reduction of waiting time at tollgate is amount of time that respondents could save at tollgates if they install transmitter comparing with no transmitter case. (4) Distance based toll system is a toll rate system that depends on travel distance rather than fixed rate (described below).

(2) Definition of Distance-based Toll Fee System

Currently, toll roads in Japan are classified into three types under the Road Law as national expressways, urban expressways, and general toll roads. In the first two types of toll road, national expressways are constructed and managed by the Japan Highway Public Corporation (JH). Urban expressways are built and managed by the Metropolitan Expressway Public Corporation (MEPC), Hanshin Expressway Public Corporation, and Designated Urban Expressway Public Corporation in their respective regions.

The target of this research is car-holders in Kanto region of Japan. Therefore, we consider urban expressways that are constructed and managed by MEPC and national expressways that are managed by JH.

At present, the toll rate system that applied by JH is depends on distance. However, for the Metropolitan Expressways, a flat-rate toll system for three toll rate areas (Tokyo, Kanagawa and Saitama routes) and two vehicle types has been adapted. Since a flat-rate toll system simplifies toll collection, saves time for toll collection and requires no exit gates.

This research would like to explore the impact after distance-based toll system is introduced to the Metropolitan Expressways. Since, the present flat rate toll system for Tokyo area, which is the target for our study, is 700 yen. Therefore we set maximum fee of distance-based toll system to be 700 yen. By this maximum rate, drivers who usually use Tokyo Routes do not lose their benefit. We expect that this toll system can promote the use of transmitters.

Toll fee is set to minimum 200 yen within 5 km and then increases linearly with distance at rate 33.33 yen/km until maximum at 700 yen. By this new toll system, Tokyo routes' users can pay toll fee cheaper than present system in case that they travel less than 20 kilometers or just equal to the present system in case that they travel more than 20 kilometers.

(3) Design of Choice Experiments

The choice experiment presented three alternatives to a respondent:

1. A hypothetical transmitter option A
2. A hypothetical transmitter option B
3. None option (choosing none of these two transmitters)

The set of attributes and levels described in section 2.1 was used to create profiles (combination of attribute levels) of transmitter. First, one option in each choice question was constructed by using $4^3 \times 2$ orthogonal main effects design to create 16 transmitter profiles. Second, these sixteen profiles were then paired with their foldover to create sixteen choice sets[3)]. A *foldover* is a mirror image of the original design; i.e., replace each 0 by 1, and each 1 by 0. This approach guaranteed orthogonality within and between two transmitter options in the different choice sets[4)]. Next, a third choice option of choosing nothing was added to each pair. Then, the choice sets that one profile is superior to another on every attribute were removed. Therefore sixteen profiles were reduced to fourteen profiles. Since fourteen choice sets are still too large for a respondent to answer, we randomly assigned 4 choice sets to each respondent for evaluation. Each respondent therefore evaluated four pairs of descriptions of transmitter plus the option of choosing neither transmitter.

(4) Questionnaire Survey

An internet-based survey was conducted from June 14, 2002 to June 21, 2002. Total time for collecting data is one week. We hired E-Com Research Company to conduct the survey. The research company recruited samples by sending electronic mails to all members registered with the company. In this survey, we allowed only car owners who live in Kanto region (composed of Tokyo, Saitama, Gunma, Chiba, Kanagawa, Tochigi and Ibaraki prefecture) in Japan could answer this survey. Of the 579 who answered, 538 returned usable surveys (an effective response rate of 93 percent). This rate is quite high since we wrote JavaScript to check whether respondents answer all questions before proceeding to the next page. Some data cannot be used since they closed window before answering all questions and some respondents do not have their own cars.

The internet-based survey is composed of 5 main pages. Page1 is a questionnaire with questions about respondents' experience of using toll road and other information related with ETC transmitter. Page 2 consists of five point scaled subjective rating questions about opinion towards transmitter. Page 3 is an explanation page about the effect of transmitter diffusion. Page 4 is a centerpiece of the survey, which is a stated choice question. Surveyed respondents are asked to evaluate one choice set at a time and to choose among three alternatives, two are transmitter' profiles and one is choosing nothing. This process is undertaken four times. The distinction of this survey from other stated choice experiments[5)-7)] are that, first, previous answer table are shown accompanying with choice task. Respondents can also change their answers in confirm page after they answered all questions. Second, saving table that showed amount of money respondents could save from each profile according to their previous answers about their frequency and distance of using the expressway is also presented on the computer screen. By providing more information, respondents can make a decision more consistently and easily. Page 5 is a small questionnaire about individual characteristics (gender, age, marital status, occupation and income). Pilot test indicated that the survey requires approximately 5 minutes to conduct and can be completely self-administered.

(5) Sample Characteristics

Due to the survey method (internet survey), first we are afraid that most of respondents are young. However, the range of age is wider than expected. The majority of respondents are between 20 and 60 years of age (95%). Some respondents are between 60 and 69 (5%). Percentage of male and female response to this survey is approximately the same. The largest income group (32%) has income more than 9 million yens per year. The other smaller income groups, which are 3-4.9, 5-6.9, 7-8.9 million yens per year, are equally represented (18%, 22%, 21% respectively). Approximately half of the respondents, 44%, are office worker and 26% are homemaker. All of them have their own car. 59% of respondents answer that they are familiar with ETC transmitter. 40% answer that they have ever heard this word. Only 1% answer that they do not know ETC transmitter.

About experience of using expressways, most of them are not frequent users. More than half, 62%, answer that they use expressways 1-2 times per month (27%) or few months one time (35%). Frequent users are accounting for 24%: almost everyday (4%), 3-5 days per week (6%) and once a week (14%). Average monthly toll fee that respondents answered is approximately 4,100 yen per month. And the main purpose of using expressways is recreation (66%). People who answer that they already installed transmitter is only 3%. Contrast with car navigator that is quite wide spread in Japan, about one-third responded that their car already equipped with it. A high percentage of total respondents (about 43%) chose option three (not buy any transmitter).

3. MODEL ESTIMATION

(1) Specification of models

Suppose the utility (or preference) of alternative $i \in C_n$ for individual n belongs to latent segment s $(s = 1, \ldots, S)$, which is unknown to the analyst, is defined as

$$U_{in|s} = \beta_s X_{in} + \upsilon_{in|s} \qquad (1)$$

where β_s is a utility parameter row vector for segment s, X_{in} is a column vector of alternative and individual characteristics, and $\upsilon_{in|s}$ is an error term. Assuming that the distribution of the error terms ($\upsilon_{in|s}$) is IID Gumbel with scale factor μ_s, then the conditional choice probability of choosing alternative $i \in C_n$ (the choice set) is a Multinomial Logit (MNL) model:

$$P_{in|s} = \frac{e^{\mu_s \beta_s X_{in}}}{\sum_{j \in C_n} e^{\mu_s \beta_s X_{jn}}} \qquad (2)$$

Since, when we observe a randomly selected individual from the population, we are unable to observe their segment membership. Instead, suppose we can observe a latent segment membership scoring function, as follows:

$$Y_n = \gamma Z_n + \upsilon_n \tag{3}$$

where γ is parameter row vector, Y_n is a latent membership scoring function, Z_n is observed perceptual and attitudinal indicator column vector of the individual, and υ_n is an error term.

Define a latent membership indicator I_n is related to Y_n as follows:

$$I_n = \begin{cases} 1 & Y_n \le \tau_1 \\ 2 & \tau_1 \le Y_n \le \tau_2 \\ \vdots & \vdots \\ S & \tau_{S-1} \le Y_n \end{cases} \tag{4}$$

where $\tau_s\ (s = 1,\ldots,S-1)$ are cutoff parameters to be estimated. These τ_s define the range of Y_n that lead to classification of respondents into each latent segment. It should be note that in order to construct s classes $S-1$ cutoff parameter is needed to be estimate.

From expression 3, the error term υ_n is assumed to be independently logistic distributed across individuals, so that the cumulative density function is

$$G(\upsilon_n) = \left[1 + \exp(-\upsilon_n)\right]^{-1}, -\infty < \upsilon_n < \infty \tag{5}$$

Therefore, the segment membership probabilities, $W_{ns} = \Pr(I_n = s), s = 1,\ldots,S-1$, can be calculated as:

$$W_{ns} = \Pr(I_n = s) = \begin{cases} G(\tau_1 - \overline{Y}_n) & s = 1 \\ G(\tau_2 - \overline{Y}_n) - G(\tau_1 - \overline{Y}_n) & s = 2 \\ \vdots & \vdots \\ 1 - G(\tau_{S-1} - \overline{Y}_n) & s = S \end{cases} \tag{6}$$

where $\overline{Y}_n = \gamma Z_n$ (see expression 3). By assuming that error term υ_n is logistic distributed, the class membership model W_{ns} is the familiar ordered logit model.

Then the unconditional probability of observing n choosing $i \in C_n$ can be expressed in terms of the two probability defined above:

$$P_{in} = \sum_{s=1}^{S} P_{in|s} W_{ns} \tag{7}$$

By specification of the model explained above, it imposes an ordinal relationship among the latent segments: membership in higher-order segments implies higher values of Y_n, and vice versa.

We adopted the model that is similar to Swait, and Sweeny (2000)'s model. However, the definition of latent membership scoring function is different. Swait and Sweeny (2000) use value orientation VO_n as an indicator Z_n for dividing individual into segment. However, in our case, attitude towards having transmitter (AH) and attitude towards benefit of transmitter (AB) was used instead and both variables are calculated from principal component analysis (PCA), which will be explained later.

In parameter estimation process, there are two main points that care should be taken. First, it is not possible to estimate scale factors $\mu_s, s = 1,\ldots,S$ and utility parameters in the model $\beta_s, s = 1,\ldots,S$ simultaneously[3), 8), 9)]. Some possibilities for dealing with this problem are as follows:

1. constrain scale factors to be equal but let utility parameters vary across segments (i.e., estimate $\beta_1,\ldots,\beta_s$ and set $\mu_1 = \cdots = \mu_s = 1$);
2. force utility parameters homogeneity but let scale parameters vary across segments (i.e., estimate $\beta_1 = \cdots = \beta_s = \beta$ and $\mu_1,\ldots,\mu_s$, by normalizing $\mu_1 = 1$).

Each of these possibilities reflects the different behavioral assumptions concerning taste heterogeneity and error term variance within latent segments. In first possibility, it represents hypothesis that taste parameters differ between latent segments, but they have equal variance of error terms. Alternatively, in second possibility, tastes are assumed homogenous across segments, but they are heterogeneous in terms of error variance. Second, only ($S-2$) of the cutoff parameters $\tau_s, s = 1,\ldots,S-1$ are actually identifiable, so one of them must be arbitrarily fixed (e.g. $\tau_1 = 0$). In our model, we set $\tau_1 = 0$.

We shall explain you about variables used in latent membership scoring function (Y_n). In addition to choice task, respondents also were asked several questions about their opinion towards transmitter as we already explain in section 2.4. Some variables are selected to form Z_n (see **Table 1**). In these set of questions, respondents had to rate their opinion in 5-point scale from strongly agree to strongly disagree. These five-scaled data was then subjected to

Table 1 Item list of questions that used for latent membership scoring function

1.	Do you think you are a person who is interested in a new product such as car navigator or ETC transmitter?
2.	Do you think next time when you buy a new car you would like to install transmitter in your car too?
3.	Do you think if your surrounding people such as members in your family or your friends buy transmitter, you would like to buy it too?
4.	Since now very few people have transmitter, do you think you have a sense of superiority of owning transmitter?
5.	Do you think your surrounding people agree with your decision of buy transmitter?
6.	Do you think ETC transmitter will become highly widespread in near future or not?
7.	Do think by using ETC transmitter, you are more comfortable since you do not need to open a car window?
8.	Do think by using ETC transmitter, you can considerably reduce waiting time at tollgate?
9.	Do you think ETC diffusion can contribute to an improvement of environmental condition such as reduction of air pollution?

factor analysis using principal component analysis method (PCA) to yield the underlying factor structure.

By using principal component analysis method, two major factors were found, accounting for 53% of the variation. Factor 1 is composed of items 1-6. Factor 2 is composed of items 7-9. From the descriptions of questions in each factor, we would like to label factor 1 as attitude towards having transmitter (AH) and factor 2 as attitude towards benefit of transmitter (AB). Factor score of factor 1 (AH) and factor score of factor 2 (AB) were used as Z_n in model 3 to explain latent segment membership.

(2) Estimation Results

The utility functions for the choice given segment model are each specified with an alternative-specific constant for none option, price, discount rate of toll fee, reduction of waiting time and distance-based toll system. All of these variables are attributes of conjoint choice task.

Table 2 presents two base models, which will be used to compare with latent class choice model. The first base model is simple multinomial logit model (MNL), assuming a single segment in the population (i.e. *S=1*). We shall call this model the *naive model* (NM). In this model, we incorporated only the attributes that we used in conjoint choice task (4 attributes) and one none option constant. This model's explanatory power is somewhat low ($\bar{\rho}^2$=0.087) as can be seen by the goodness-of-fit statistics. In spite of the low explanatory power of the model, the signs of parameters are correct and their significance levels are generally high except reduction of waiting time variable and none option constant (constant of option 3 which is choosing none of transmitter profiles). In first based model, we did not incorporate any variable about personal attribute. Therefore, we shall incorporate this in the second base model by including two factors deriving from PCA (AH and AB) in the specification of the MNL utility function. This model also maintains the assumption of having one segment. We shall name this second base model the *base attitude model* (BAM). It is clear that the addition of AH and AB in the utility functions of transmitters is statistically significant. The likelihood ratio test ($\bar{\rho}^2$) increases from 0.087 to 0.143. Both attitude parameters are significant and all are of the correct sign, which is positive. It is mean that person that has high value of AH and AB trends to buy transmitter, which conforms to our intuitive.

Since number of segments is unknown to model estimator. We shall utilize the Akaikes Information Criterion (AIC) and the Consistent Akaikes Information Criterion (CAIC) as a criterion for selection of the number of segments[8), 10)]. Both AIC and CAIC based on the log likelihood at convergence (LL). AIC encourage parsimonious model selection by penalizing log likelihood improvements due to larger number of parameters. CAIC is similar to AIC but sample size is also considered as well as number of parameters. The model with the smallest AIC and/or CAIC is selected. It should be noted that, besides these statistics, analyst judgment should also direct the decision. The AIC and CAIC for this model is calculated as

$$AIC = -2(LL_s - K_s) \quad (8)$$

$$CAIC = -2LL_s + (4S-1)(\ln(2N)-1) \quad (9)$$

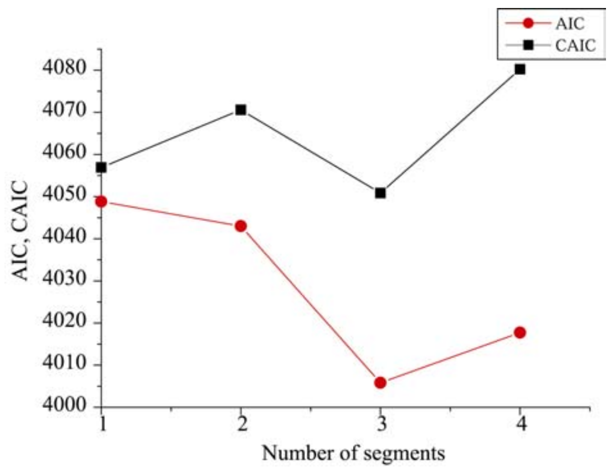


Figure 1 Number of segments selection

Table 2. Estimation results for the naïve and base attitude models

	Naïve model (NM)		Base attitude model (BAM)	
Parameters	Estimate	t-ratio	Estimate	t-ratio
Utility function				
None option constant	-0.123	-0.6	-0.159	-0.8
Price	-0.694	-11.3	-0.698	-11.3
Discount rate of toll fee	0.530	13.4	0.533	13.4
Reduction of waiting time	-0.002	-0.2	-0.002	-0.1
Distance-based toll system	0.597	8.9	0.602	8.9
Attitude towards having transmitter			0.771	14.8
Attitude towards benefit of transmitter			0.164	3.5
Summary statistics				
Log likelihood (random choice)	-2364.2		-2364.2	
Log likelihood at convergence	-2152.9		-2017.4	
No. of parameters	5		7	
AIC rho squared	0.087		0.143	
No. of sample	2152		2152	

where LL_s is the log likelihood at convergence for a model with S segments, K_s is the number of parameters for a model with S latent segments, S is number of segments, and N is number of sample.

We then estimated the latent class choice model for different numbers of latent segments, ranging from two to four *(S=1,…,4)* and graphed AIC and CAIC (**Fig. 1**). According to **Fig. 1**, AIC and CAIC reaches a minimum at *S=3*. Therefore, we selected the three-segment solution as the best model to express utility parameter heterogeneity among segments (see **Table 3**). It is observable that CAIC for 2-segment solution is inferior to the 1-segment solution. Swait and Sweeny (2000)[8] also found similar result and stated that this happened once the penalty for number of parameter is accounted for.

We would like to compare base attitude model (BAM) (**Table 2**) with 3-segment latent class model (**Table 3**), which are non-nest. Thus, normal likelihood ratio test statistics cannot be used. Modified Likelihood Ratio Test (MLR) is applied here for comparison of these two models[11]. Calculated MLR value is 26.9, which is more than 1.35. Therefore, it is safe to conclude that 3-segment latent class model is superior to BAM.

From the estimation result (**Table 3**) we obtained the following estimated latent segment membership scoring function:

$$\bar{Y}_n = 5.981 AH_n + 3.107 AB_n, \quad (10)$$

and cutoff parameters ($\tau_1 = 0$ and $\tau_2 = 4.251$). Both AH and AB in latent segment membership scoring function are significant. The latent class model predicted the 3 segments' size as 48.9%, 27.0%, and 24.3%, which are the predicted segments' size for segment 1, 2 and 3, respectively. It is not surprise that the biggest group (about half portion of all sample=48.9%) is segment 1, which is the group with lowest AH and AB values. Low AH and AB values mean that segment1 has negative attitude towards having and benefit of transmitter. People belonged to this group do not want to purchase transmitter. This is also consistent which the real situation now that very few percentages of total cars in Japan are already equipped with transmitters. The second and the third-sized groups are segment 2 and 3 respectively. This reflects the fact that the smallest segment is the segment that people have a positive attitude towards having and benefit of transmitter (high value of AH and AB).

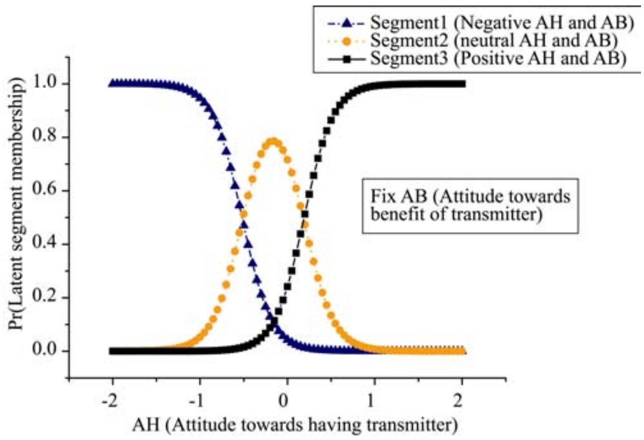


Figure 2 Latent segment membership probabilities as a function of AH

Table 3. Estimation results for the latent segment model (3 segment solution)

	Segment 1		Segment 2		Segment 3	
Parameters	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio
Utility function						
None option constant	1.083	2.9	-0.133	-0.2	-2.370	-5.5
Price	-0.616	-5.4	-0.589	-3.1	-0.851	-7.2
Discount rate of toll fee	0.598	7.8	0.489	4.4	0.530	7.3
Reduction of waiting time	0.025	1.0	-0.067	-1.3	0.009	0.4
Distance-based toll system	0.667	5.1	0.294	1.3	0.750	5.8
Predicted segment size	48.7%		27.0%		24.3%	
Class membership function						
Attitude towards having transmitter	5.981	2.0				
Attitude towards benefit of transmitter	3.107	2.0				
Cutoff Parameters						
τ_1	0					
τ_2	4.251	-1.8				
Summary statistics						
Log likelihood (random choice)	-2364.2					
Log likelihood at convergence	-1984.9					
No. of parameters	18					
AIC rho squared	0.153					
No. of sample	2152					

Fig. 2 depicts how the estimated segment membership probabilities (equation 3) behave as a function of attitude towards having transmitter (AH) and the cutoff parameters, for a fixed level of attitude towards benefit of transmitter (AB).

As shown in **Fig. 2** and due to ordinal nature of the segments, low values of AH_n and AB_n lead to a high probability of membership in segment 1 and large values in AH_n and AB_n lead to a high probability of membership in segment 3. Intermediate values of AH_n and AB_n result in high probability of membership in segment 2.

Table 3 suggests that price of transmitter has a significant negative effect in all segments, while reduction of waiting time is not significantly different from zero for all segments. The reason may be that the levels of reduction of waiting time were set to be so low (1, 2, 4, and 8 minutes) and each level is not different so much. The respondents may feel that the reduction of waiting time is less important than other attributes (price, discount rate of toll fee and distance-based toll fee system). To illustrate this, let us compare 2 transmitter options. For sake of simplicity, we will compare only 2 attributes. One with 8 minutes reduction of waiting time (highest) and price 40,000 yen. Another option with reduction of waiting time 2 minutes and price 30,000 yen. Respondents may feel that the time that they can save (6 minutes) has less importance than a huge amount of money they can save (10,000 yen).

For segment 1, **Table 3** informs that utilities are based on all three attributes except reduction of waiting time, which is not statistically significant for all segments. This segment has a positive value for alternative specific constant of the none option, which means that this segment exhibits a high probability of choosing none. This is consistent with the fact that this group has "negative attitude towards having and benefit of transmitter".

Price has the greatest negative impact on the second segment, which is quite common for all segments. Although, in segment1, distance-based toll has a greatest impact, the distance-based toll's coefficient is only 0.051 different from price's coefficient. Interestingly, for this group distance-based toll is not statistically significant, while it is strongly significant for segment 1 and 3. It implies that distance-based toll system policy has less effect for this group of people. Again, alternative specific constant for none option is not significant for this group. This can be interpreted that members in this group do not exhibit more or less probability of choosing none, which leads us to suggest that this is the "Neutral attitude towards having and benefit of transmitter" segment of population.

In contrast with segment 1, segment 3 manifests a low probability of choosing none (none option constant<0) and is the smallest of the three (constituting 24.3% of the sample). This makes segment 3 conformable with the "positive attitude towards having and benefit of transmitter" segment of population. All price, discount rate of toll fee and distance-based toll are significant for this segment.

(3) Policy Evaluation

To know the extent to which the probabilities of choosing transmitter change in response to a change in some observed factor entering utility function, average elasticities are calculated by using sample enumeration method. The elasticity of P_{in} (probability that individual n choosing alternative i) with respect to x_{ink}, the k variable entering the utility of alternative i, is

$$E_{X_{ink}}^{P_{in}} = \frac{\partial P_{in}}{\partial X_{ink}} \cdot \frac{X_{ink}}{P_{in}} \qquad (11)$$

In order to calculate average elasticities, first, the elasticities are calculated for each individual on the basis of the individual's characteristics and the characteristics of the alternatives as faced by the individual. Secondly, the average elasticity for alternative i with respect to X_{ink} is then average across sample size. Average elasticities of P_{in}, $i = 1, 2$, with respect to variable entering the utility of alternative i are shown in **Table 4**.

From the **Table 4**, the elasticity of probability of choosing transmitter with respect to price is the largest among other variables. It implies that the percent change in price contributes greatly to a percent change in the probability of choosing that alternative. Hence, the three possible policies for promoting usage of transmitter should be (1) reducing the price of transmitter (2) increasing the discount rate and (3) implementation of distance-based toll fee system. These three policies are arranged in order from the most effective policy to the less effective one.

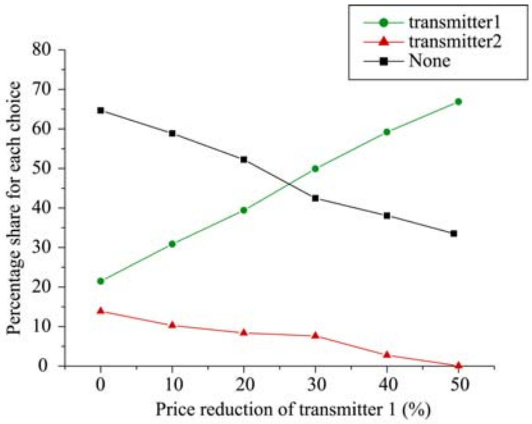
To illustrate the effect of 3 policies explained above, two policy scenarios were simulated here.

1. The price of transmitters are reduced from 10%, 20%…up to 50 % from normal price for all the samples.
2. The discount rate of toll fee are increased from 10%, 20%…up to 50 % from normal discount rate for all the samples.

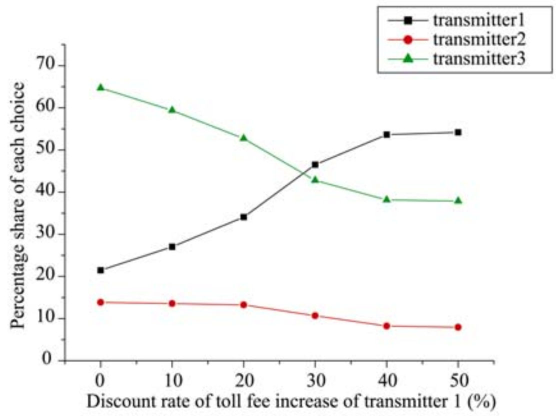
We assume the relatively large changes here, though it cannot be implemented in the real situation. Expressway company may not offer such a huge discount rate or company cannot reduce the price of transmitters. The main point, which we would like to show here, is the effect after the policy has been implemented.

For the reason that Both transmitter option 1 and option 2 are hypothetical choice options, which are not identical for all respondents, we shall demonstrate the effect of change in price and discount rate only for the transmitter option1. The effect of price reduction of transmitter option1 to percentage share for each choice can be seen in **Fig. 3**. Noticeably, transmitter's price reduction is an effective policy. Reducing in price about 10% can increase option1 market share approximately 10% also. When price of transmitter option 1 is 50% off, no one buy transmitter option2.

Similarly, the effect of a discount rate increment of transmitter option1 to percentage share for each choice can be observed in **Fig. 3**. There is a dramatically increase in probability of choice option 1, when discount rate of option 1 increase from 10% to 40%. For discount rate more than 40%, it is almost no effect to probability (all lines flatten out).



(a) Effect of reduction in price of transmitter 1 to market share



(b) Effect of increase in discount rate of toll fee of transmitter 1 to market shar

Figure3 Policy scenarios

4. CONCLUSIONS AND FUTURE RESEARCH DIRECTION

This study analyzed individuals' purchasing behavior of ETC in-vehicle transmitter. In order to fulfill this objective, an interactive Internet-based, self-administered stated preference survey and ordered logistic latent class choice model were utilized and explained here.

Ordered logistic latent class choice model is adopted to divide respondents into segments based on their attitude towards having (AH) and attitude towards benefit of transmitter (AB). As a basis for comparison, we also estimate trinomial logit model with AH and AB (Base attitude model) and without AH and AB (Naïve model). The result shows that the base attitude model is much improved from naïve model and latent class model yields improved fit beyond the base attitude model. Therefore, it could be concluded that AH and AB is a useful basis for this segmentation. The estimated parameters indicated that reduction of waiting time is not statistically significant for all 3 segments. In contrast with coefficients of price, which have a high value and significant for all three segments.

In addition, elasticities of choice probability with respect to 4 main attributes (price, discount rate of toll fee, reduction of waiting time and distance-based toll) are calculated. Three policies for promoting the use of transmitter are introducing here: (1) reducing the price of transmitter (2) increasing the discount rate of toll fee and (3) implementation of distance-based toll fee system. Reducing the price of transmitter is the most effective one. It could result to high increase in probability for purchasing transmitter. Finally, policy evaluation of reducing transmitter's price and increasing the discount rate of toll fee are also presented.

For future research direction, first, due to the data collection method, only people with access to the Internet were able to participate in this survey. As a result, some bias is likely in the sample. Other survey method is highly motivated for data improvement for the future research. Even the sample is not intended to be necessarily representative of the population at large. However, this likely bias was not a main concern for this limited study. This research is a first attempt to acquire better understanding about attributes that affect the purchasing behavior of ETC transmitter. The survey tool developed and analysis results could form the basis and highlight the direction for further research study.

Second, this research considered taste heterogeneity among individual by divided respondents into latent segments dictated by model itself. We assumed that the unobserved factors that affect decision-makers are independent over the repeated choice. As a result, each choice situation by each respondent is treated as a separate observation. The model that allows repeated choices by each sampled decision-maker such as mixed logit model should be estimated and compared with latent class choice model.

REFERENCES

1) *Web page of Japanese Ministry of Land, Infrastructure and Transport Road Bureau ITS.* http://www.mlit.go.jp/road/ITS/index.html. Accessed June 1,2002.
2) *Web page of Japan automobile federation*. http://www.jaf.or.jp. Accessed June 1,2002.
3) J.Louviere, J., Hensher, D. A. and Swait, J. D. *Stated Choice Methods: Analysis and Application*, Cambridge University Press, 2000.
4) Conlon, B., Dellaert, B. G. and van Soest, A. *Combining and Comparing Consumers' Stated preference ratings and choice response*. Tilburg University, Center for Economic Research, November 2000.
5) Adler, T., Ristau, W. and Falzarano, S. Traveler Reactions to Congestion Pricing Concepts for New York's Tappan Zee Bridge. *Transportation Research Record 1660*, 1999, pp. 87-96.
6) Greene, W. H. and Hensher, D. A. *A latent class model for discrete choice analysis: Contrasts with mixed logit*. Working paper, Institute of Transport Studies. April 2002.
7) Saelensminde, K. Stated Choice Valuation of Urban Traffic Air Pollution and Noise. *Transportation Research Part D*, Vol.4, 1999, pp.13-27.
8) Swait, J. and Sweeney, J. C. Perceived value and its impact on choice behavior in a retail setting. *Journal of Retailing and Consumer Services*, Vol.7, 2000, pp. 77-88.
9) Swait, J. A structural equation model of latent segmentation and product choice for cross-sectional revealed preference choice data. *Journal of Retailing and Consumer Services*, Vol.1, No. 2, 1994, pp. 77-89.
10) Bozdogan H. Model Selection and Akaike's Information Criterion (AIC): The General Theory and Its Analytical Extensions. *Transportation Research Record 1660*, Vol. 52, 1987, pp. 345-370
11) Horowitz, J. L., Koppleman, F. S. and Lerman, S. R. *A self-Instructing Course in Disaggregate Mode Choice Modeling.* U.S. Department of Transportation, Washington, D.C., 1986.