行政院國家科學委員會補助專題研究計畫 ■ 成 果 報 告 □期中進度報告

駕駛人對高速公路實施電子計程收費之接受度、願付價格及其路線移轉行為之影響

計畫類別：■ 個別型計畫　　□ 整合型計畫
計畫編號：NSC97－2410－H－366－016－SSS
執行期間：　97　年　8　月　1　日至　98　年　7　月　31　日

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中　華　民　國　98　年　9　月　10　日

駕駛人對高速公路實施電子計程收費之接受度、願付價格及其路線移轉行為之影響

The Acceptance and willingness to pay of electronic distance-base charging on freeway drivers and their effects on switching behavior

ABSTRACT

In order to alleviate traffic delay and consider equity principle, the electronic distance-based charging strategy will be implemented overall on freeway in Taiwan. Since drivers' opinions and willingness-to-pay for this charging strategy may greatly affect their route switching behavior, this research attempts to discuss drivers' behavioral reactions with considering their viewpoints under various distance-based charging rates. A research framework is proposed and five types of information, which including distanced-based charging rates, willingness-to-pay, latent variables, socioeconomic and travel characteristics, are incorporated into behavioral modeling process. According to the empirical study, the questionnaire survey was conducted to collect 1,071 valid samples from freeway drivers living in northern, midst, and southern of Taiwan. The estimated ordered probit model indicates that drivers living in northern of Taiwan would more accept and comply with higher charging rate than other areas. Drivers having higher willingness-to-pay would unlikely switch routes under various distance-based charging rates. As expected, higher charging rate (NT1.2/km and NT$1.5/km) would lead drivers switching routes even though they could accept this strategy. Drivers would be likely switching routes in the shorter distance of alternatives route, especially for those who toll-free in toll-distance-based phase. Moreover, results reveal that several travel and socioeconomic characteristics are also significant to explain drivers' switching behavior in the models.

Keywords: distance-based charging rate, route switching behavior, ordered probit model

1.INTRODUCTION

Tolls on freeways are collected by vehicle types and most charged manually at mainline tollbooths in Taiwan until now (*1*). Since tollbooths on freeways are located approximately every 40 km in Taiwan, more than 50 percent of freeway users are toll-free, especially in metropolitan areas. Besides the unfairness issue of user payment, heavy traffic congestion and considerably delays would occur at tollbooths during daily peak hours as well. For alleviating traffic delays and taking the principle of equity into account, Taiwan Area National Freeway Bureau will completely execute electronic toll collection (ETC) system on freeway by distance-based charging strategy in December 2012. The implementation of free-flow ETC on freeways, constructed gantries with sensors installed between interchanges, would lead vehicles equipped with the on-board unit (OBU) and an IC card to pay toll without stopping. The ETC system would also facilitate the implementation of value pricing (or called congestion toll) (*2*-*3*).

Many countries have always considered road pricing strategy as promising attempts to solve urgent traffic problems in urban area (*1*, *4*). Since all drivers should be charged on freeway in distance-based charging phase, however, road pricing would result in paying more extra travel costs especially for those who are toll-free in toll-based charging phase. Therefore, it is found that drivers' will respond to road pricing by altering routes, departure time, modes, or giving up their trips (*4*-*8*). Due to the strategy of electronic distance-based charging on freeway will be implemented in Taiwan, it should be paid much attention to drivers' potential diversion reactions for the benefit of reducing traffic volumes on freeway. However, the level of distance-based charging rate would consequently influence the degree of diversion. Whether drivers will pay the tolls would also impact on their route switching behavior (*9*). Based on the purpose of congestion management, how to set up distanced-based charging rate from drivers' real opinions should be a great concern.

Besides, several researches indicated that acceptance of strategy is assumed to be a significant factor influencing effectiveness of the implementation of road pricing strategy (*4*, *10*-*12*). But higher acceptance is not necessarily accompanied higher compliance to charging rate. Thus, the effectiveness of the distance-based charging strategy depends greatly on drivers' acceptance, willingness-to-pay (WTP), and compliance toward it. These are the critical factors for successful implementation of distance-based charging strategy. Hence, for realizing drivers' route switching behavior more explicit, this research explores drivers' perception and attitude factors (i.e. latent variables) toward distance-based charging strategy both on positive (e.g. acceptance) and negative (e.g. switching intention) side. The factors that may influence drivers' route switching behavior are identified by review of the literatures could be grouped into several categories, such as pricing rates, information types, latent variables, travel characteristics, socioeconomic characteristics, and environmental situations, etc. (*13*-*21*)

The objective of this research is to evaluate changes of freeway drivers' route switching behaviors in response to various distance-based charging rates. This study proposes an analysis framework to incorporate latent variables, socioeconomic and travel characteristics in the behavioral model under various distance-based charging rates to explain drivers' stated route switching behavior. The analysis methodologies include a stated experimental design, factor analysis and discrete choice modeling. The empirical study can provide an understanding of drivers' behaviors and gain policy implications for distance-based charging strategy.

The remainder of this paper is organized as follows. The research framework and methodology are proposed in Section 2. Section 3 presents the results of an empirical study, which describes data collection, statistical summary and factor analysis. Thereafter, the model estimations and managerial implications are drawn. The conclusions and future research directions are concluded in the final section.

2. RESEARCH FRAMEWORK AND METHODOLOGY

2.1 Research Framework

For exploring the effects of distance-based charging rate on drivers' route switching behavior, the research framework and methodology is proposed as shown in Figure 1. The questionnaire survey method is used to collect the data more detailed for fully analyzing drivers' route switching behavior. And the distance-based charging rates are designed using the stated preference method. Thus, most available and significant information should be considered, which generally contain five types of information: drivers' willingness-to-pay for distance-based charging strategy, socioeconomic characteristics (e.g. age, income), travel characteristics (e.g. trip purpose, resident area), latent variables (e.g. strategy acceptance, switching intention), and stated route switching behavior under various distanced-based charging rate (e.g. NT$1.0/km, NT$1.2/km).

In order to accommodate the numerous explanatory variables, drivers' route switching behavior with distance-based charging strategy should be discussed further by using discrete choice model to interpret their behavioral reactions. Since the drivers' stated response on route switching is of degrees rather than just "yes" or "no", it would be inappropriate to use the multinomial logit or other binary models because these models do not account for the ordering of the dependent variable. Therefore, while the dependent variable is discrete and with order, it would be more appropriate to use the ordered probit model than other logit or regression models. Thus, we choose the ordered probit to construct the switching behavioral model in this research.

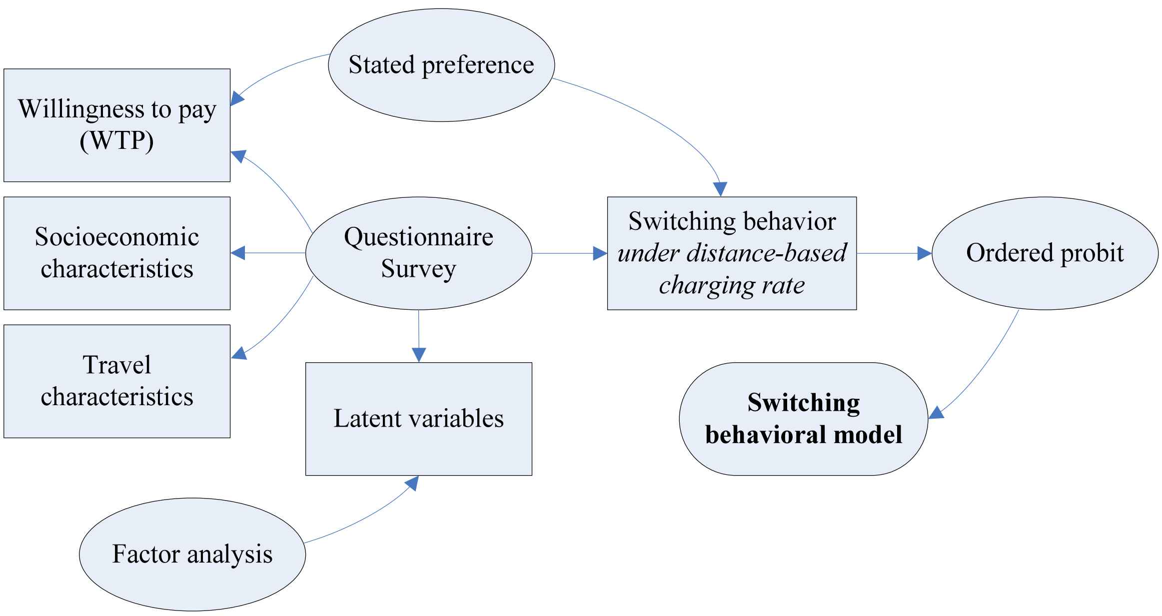


FIGURE 1 Research framework and methodology.

For taking drivers' internal concern into account, drivers' perception and attitude (i.e. latent variables) for distance-based charging strategy would also be considered in the model. Since discrete choice model is unable to measure these latent variables, factor analysis approach would be applied to extract latent variables into this behavioral research. Then, these latent variables are transferred into explanatory variables for drivers' route switching behavioral model. Latent variables will be taken as input data into the following ordered probit model. In addition to the latent variables, stated switching behavior, willingness to pay, socioeconomic and travel characteristics are also entered into the ordered probit model as explanatory variables. Finally, drivers' route switching behavioral model would be estimated. Based on the modeling results, it is possible to differentiate drivers' behavioral reaction between these distance-based charging rates and explore potential factors.

2.2 Stated Preference Experiment

The respondents were assumed to ride a car on the regular route (i.e. freeway), and they had to decide whether or not switching to the alternative route (i.e. non-toll roads) while encountering various distance-based charging rates on freeway. Because of the average tolls was approximately NT$0.7~1.5/km in toll-based charging phase, the distance-based charging rates were set four categories, which are NT$0.8/km, NT$1.0/km, NT$1.2/km, and NT$1.5/km.

Since the respondents decide whether switch or not probably based on the tolls they should pay on freeway and the distance they would drive on the alternative route, distance scenarios were hypothesized for diversion decision in this questionnaire. To prevent too many hypothetical distance scenarios would lead respondents confused, it was assumed that respondents would encounter shorter distance (i.e. *ScenarioI*, formerly toll-free in toll-based charging phase) and longer distance (i.e. *ScenarioII*, formerly need to pass through one tollbooth in toll-based charging phase). Two hypothetical scenarios are compared in Table1.

Respondents had to determine their likelihood of perceptions and attitudes toward the implementation of distance-based charging strategy on a five-point Likert scale. According to the drivers' route switching behavior under hypothetical scenarios and charging rates, a stated preference choice set was presented to respondents who should decide whether they would switch to the alternative route or not on ordered choice. The responses of switching tendency were also rated on a five-point Likert scale with a positive statement and classified to five degrees as "strongly unlikely", "unlikely", "undecided", "likely", and "strongly likely".

TABLE 1 Comparison with two hypothetical scenarios

Characteristics	*ScenarioI*	*ScenarioII*
Driving distance		
Distance of the freeway	15 kilometers	30 kilometers
Distance of the alternative route	shorter distance (15 minutes travel time would be wasted for switching)	longer distance (30 minutes travel time would be wasted for switching)
Charged tolls on freeway		
In toll-based charging phase	toll-free	pass through one tollbooth (one times charged NT$40 for a car)
In distance-based charging phase	charged by distance-based charging rate (NT$0.8 per km, NT$1.0 per km, NT$1.2/km, and NT$1.5/km)	charged by distance-based charging rate (NT$0.8 per km, NT$1.0 per km, NT$1.2/km, and NT$1.5/km)

2.3 Ordered Probit Model

The ordered probit model was developed by McKelvey and Zavoina (1975), which is always used for the discrete-valued dependent variable taking more than two values and natural ordering (*22*). Researchers often treat ordinal dependent variables as if they were interval. In principle, the decision of respondents in the ordered probit model does not follow the rule of utility maximization. Likert scales on surveys ask respondents whether they strongly agree, agree, have no opinion, disagree, or strongly disagree with a statement (*23*).

In modeling, we assume the willingness to switch route -- y_i^* is the unobserved variable (latent variable) and y_i^* is expressed as (*24*-*26*):

$$y_i^* = \beta x_i + \varepsilon ,$$

where y^* is the dependent variable coded as 0, 1, 2,…, *J*, β is the vector of coefficients, x_i is the vector of independent variables, and ε is the error term, normally distributed with mean 0 and variance 1.

The dependent variable is observed as the likelihood to route switching as follows:

$$\begin{aligned} &y = 0 \ \text{ if } \ y^* \le 0, \\ &y = 1 \ \text{ if } \ 0 \le y^* \le \mu_1, \\ &y = 2 \ \text{ if } \ \mu_1 \le y^* \le \mu_2, \\ &\quad \vdots \\ &y = J \ \text{ if } \ \mu_{J-1} \le y^*. \end{aligned}$$

where the threshold values μ are the unknown parameters to be estimated with β, assuming that ε is normal.

The following probabilities result from the normal distribution:

$$\begin{aligned} &\Pr ob[y = 0] = \Phi(-\beta x) \\ &\Pr ob[y = 1] = \Phi(\mu_1 - \beta x) - \Phi(-\beta x) \\ &\Pr ob[y = 2] = \Phi(\mu_2 - \beta x) - \Phi(\mu_1 - \beta x) \\ &\quad \vdots \\ &\Pr ob[y = J] = 1 - \Phi(\mu_{J-1} - \beta x) \end{aligned}$$

Hence, the Probability function is written as

$$\Pr ob[y_i = j] = \Phi(\mu_j - \beta x_i) - \Phi(\mu_{j-1} - \beta x_i), j = 0,1,\ldots J,$$

where Φ is the cumulative standard normal distribution function.

The log likelihood function is the sum of individual log probabilities specifically as

$$L = \sum_{j=1}^{J} \sum_{y=j} \log(\Phi(\mu_j - \beta x_i) - \Phi(\mu_1 - \beta x_i)) .$$

The ordered probit model includes two sets of parameters. The constant and other threshold parameters indicate the range of normal distribution associated with specific values of explanatory variables. The remaining parameters represent the effect of changes in each explanatory variable on the underlying scale. These parameters indicate the relative importance of each variable in determining the likelihood to switch routes.

3. EMPIRICAL STUDY

3.1 Data

A questionnaire with a stated preference survey was conducted to collect the data on freeway drivers' socio-demographic, travel characteristics and choice preferences. The data were collected from on-line questionnaire and interview survey in Northern, Midst, and Southern area of Taiwan. A total of 1,071 valid questionnaires were returned during October, 2008. The survey characteristics are given in Table 2. More than forty percent of respondents are living and commuting in northern of Taiwan (41.74%), nearly quarter in midst of Taiwan (22.04%), and 36.23% of respondents are living and commuting in southern of Taiwan. The percentage of trip purposes are working (18.49%), business (20.07%), social (25.58%), and recreational (35.85%) respectively. According to the socioeconomic characteristics of respondents, more than sixty percent of respondents are males (64.52%), between the ages of 25 and 44 (62.28%), college and graduate school (66.67%) educational level, and most, personal incomes are between 20~60 thousands per month (79.08%).

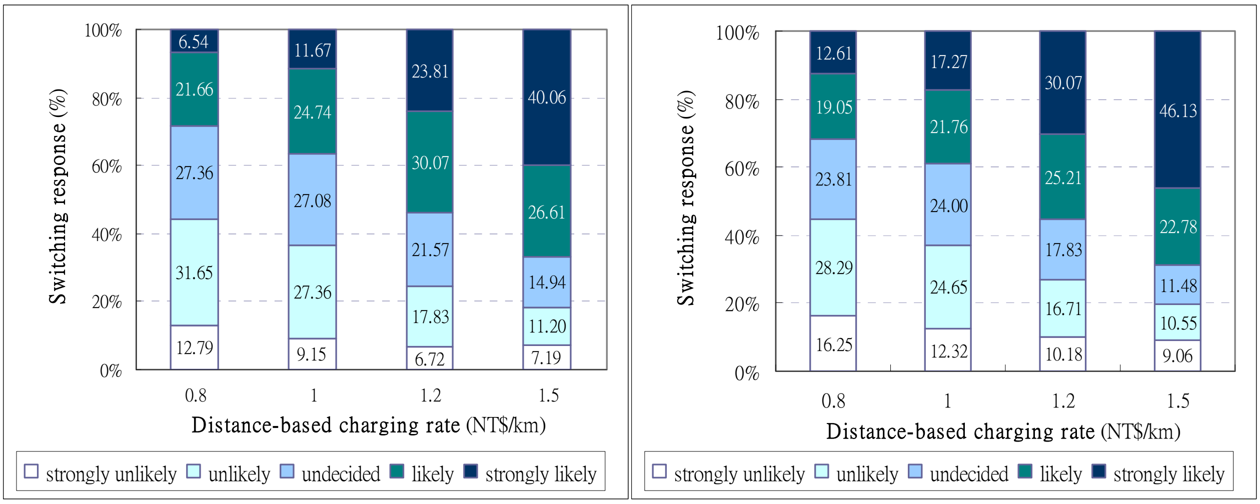
TABLE 2 Statistical summary

Characteristics	Samples	Distribution	Characteristics	Samples	Distribution
Resident area			*Age*		
northern of Taiwan	447	41.74 %	18 ~ 24 years old	87	8.12%
midst of Taiwan	236	22.04%	25 ~ 34 years old	305	28.48%
southern of Taiwan	388	36.23%	35 ~ 44 years old	362	33.80%
Trip purpose			45 ~ 54 years old	222	20.73%
working	198	18.49%	> 55 years old	95	8.87%
business	215	20.07%	*Monthly income*		
social	274	25.58%	< NT$ 20 thousands	140	13.07%
recreational	384	35.85%	NT$ 20~40 thousands	354	33.05%
Gender			NT$ 40~60 thousands	335	31.28%
male	691	64.52%	NT$ 60~80 thousands	158	14.75%
female	380	35.48%	> NT$ 80 thousands	84	7.84%
Level of education					
high-school	357	33.33%			
college	424	39.59%			
graduate school	290	27.08%			

3.2 Switching Response

Respondents' stated route switching response toward four distance-based charging rates under two distance scenarios are shown in FIGURE 2. It revealed that charging higher distance-based rate to drivers would induce more diversion probabilities. Besides, comparing with two distance scenarios, the shorter distance of the alternative route is, the more probabilities they would switch to the alternative route. Therefore, the percentage of the respondents that would likely to switch route in *ScenarioI* is consequently larger than *ScenarioII*.

In *ScenarioI*, formerly toll-free in toll-based charging phase, more than half of the respondents expressed their willingness to switch routes when they should be charged NT$1.2 per kilometer. Even nearly 70 percent of the respondents indicated their propensities of diversion while paying NT$1.5/km charging rate. Due to the length of alternative route in *ScenarioII* is longer than *ScenarioI*, the respondents would unlikely switch to the alternative route.



ScenarioI ***ScenarioII***

FIGURE 2 Switching responses under various distance-based charging rates.

3.3 Factor Analysis

In order to incorporate significant drivers' cognition and attitude into switching behavioral model, two latent variables were extracted by the processing of principal factor analysis and the results were summarized in Table 3. Each rotated factor was composed of measurement variables to be considered with factor loadings ≥0.45. Based on the minimum factor loading criterion and order of extraction, two factors were extracted. *FactorI* represented the construct of acceptance toward distance-based charging strategy, and was composed of three measurement variables $x_1\sim x_3$. *FactorII*, which was labeled as the switching intention, was appeared to measure the intention of switching to alternative route or modal, and was consisted of x_4 and x_5.

The value of Cronbach's alpha was calculated for the scale items to ensure the internal consistency. The reliability of each construct was assessed by using Cronbach's alpha lager than 0.6 or 0.7 (*27-28*), which is the recommended level in exploratory research. In this survey, the values of Cronbach's alpha ranged from 0.694 to 0.755 that indicating the scales are internally consistent and reasonably free of measurement error. The factor (i.e. latent variables) would be consequently taken as explanatory variables, and then incorporated into the switching behavioral model.

Table3 Factor analysis results

Factor	Measurement variable	Factor loadings	Cronbach's alpha if item deleted	Cronbach's alpha
FactorI Strategy acceptance	x_1	0.858	0.608	0.755
	x_2	0.845	0.634	
	x_3	0.752	0.765	
FactorII Switching intention	x_4	0.818	0.538	0.694
	x_5	0.811	0.546	

4. SWITCHING BEHAVIORAL MODEL

4.1 Operation of Explanatory Variables

Since the stated behavioral responses have a natural ordering, the ordered probit formulation would be appropriate to model the likelihood that a respondent would switch routes while paying the distance-based charging rate. The main objective of this modeling process is to determine which distance-based charging rates are significant, and to investigate whether the latent variables about perceptions or attitudes of drivers would have influence on their route switching behavior. The model is also important in investigating the explanatory variables and their levels on the propensity to switch routes.

Two distance scenarios with four distance-based charging rates are modeled separately. In these models, five sets of explanatory variables are considered (shown in Table4). The first is willingness-to-pay for distance-based charging strategy, the second is the dummy variables that represent various distance-based charging rates, and the third is the latent variables that extracted from principal components analysis previously. Moreover, travel and socioeconomic characteristics of respondents are also considered in the models.

Drivers' willingness-to-pay for distance-based charging strategy was considering as a variable in the models. Various distance-based charging rates entered into the models as dummy variables. This effort would enable the identification of what are the significant charging rates that are considered effective to the respondents. Since the NT$0.8/km charging rate is taken as the base rate in the models, the dummy variables CR_1~CR_3 are equal to zero representing NT$0.8/km. The charging rate on NT$1.0/km, NT$1.2/km, and NT$1.5/km are represented by the dummy variables CR_1~CR_3 equaling to 1 separately. The latent variables strategy acceptance and switching intention, which positively or negatively affect drivers' route switching behavior, are also regarded as significant explanatory variables in the switching behavioral model. The latent variables are entered into the models via the factor analysis process in which the factors are transferred into variables.

The travel characteristics of respondents are taken into consideration in the models. The trip purpose of a respondent who has often taken the freeway also entered into the models as dummy variables. A trip to work is considered as the basis of trip purposes in the models, so the dummy variables $TP_1 \sim TP_3$ are equal to zero representing the working trip. The trip purposes involving business trips, social trips, and recreational trips are represented by the dummy variables $TP_1 \sim TP_3$ equaling to 1 separately. In addition, driving frequency, numbers of tollbooth pass through, experience of encountering congestion, and familiarity with the alternative route are also taken into account. Experience of encountering congestion and the familiarity with the alternative route are expressed by using five scales of degrees. The socioeconomic characteristics of respondents are also considered in the models, including gender, age, educational background, and monthly income. All of these characteristics are transferred into dummy variables then entered into the behavioral models.

Table4 Explanatory variables

Category	Variable	Definition
Willingness-to-pay	WTP for distance-base charging	NT$0~1.5/km
Distance-based charging rate	Dummy variable CR_1	1 if NT$1.0/km, 0 otherwise
	Dummy variable CR_2	1 if NT$1.2/km, 0 otherwise
	Dummy variable CR_3	1 if NT$1.5/km, 0 otherwise
Latent variable	Strategy acceptance	0~4 represent degrees of acceptance, 4 if extremely acceptable
	Switching intention	0~4 represent degrees of switching, 4 if most likely to switch
Travel characteristics	Trip purpose	
	Dummy variable TP_1	1 if business-trip, 0 otherwise
	Dummy variable TP_2	1 if social-trip, 0 otherwise
	Dummy variable TP_3	1 if recreational-trip, 0 otherwise
	Resident area	
	Dummy variable A_1	1 if midst of Taiwan, 0 otherwise
	Dummy variable A_2	1 if southern of Taiwan, 0 otherwise
	Driving frequency	1 if a commuter, 0 otherwise
	No. of tollbooth pass through	0 if toll-free, 1 otherwise
	Experience of encountering congestion	0~4 represent degrees of congestion, 4 if extremely crowed
	Familiar with alternative routes	0~4 represent degrees of familiarity, 4 if extremely familiar
Socioeconomic characteristics	Gender	0 if female, 1 if male
	Age	=0, if 18 ~ 54 yrs old; =1,if > 55 yrs old
	Educational background	0 if college or technical training, 1 if graduate school
	Monthly income	=0, if < NT$ 40 thousands; =1, if > NT$ 40 thousands

4.2 Estimation Results

In the estimation process of the behavioral models, five sets of variables are input. The models relating to respondents' route switching behavior with *ScenarioI* and *ScenarioII* are presented in Table 5, and most explanatory variables are statistically significant in these ordered probit models. It is important to note that the signs of coefficients are shown in the models, because they may have different effects on the probabilities of respondents' route switching behavior.

As expected, respondents would obviously maintain their regular routes when they drive in the longer distance (i.e. *ScenarioII*) than in the shorter distance (i.e. *ScenarioI*). It means that the higher benefit for saving travel time on freeway to be considered, the less route switching probabilities would be. Respondents who have higher willingness-to-pay would unlikely switch to the alternative route.

The models illustrate various rates of distance-based charging strategy. The estimated coefficients of the dummy variables CR_1, CR_2, and CR_3, correspond to charging rate NT$1.0/km, NT$1.2/km, and NT$1.5/km respectively. The respondents value the charging rates and make their diversion decision based on whether the rate could be affordable. All charging rate dummy variables appeared to be significant, which means that respondents would more likely switch routes when they should be charged NT$1.0/km~NT$1.5/km than NT$0.8/km. Under these two distance scenarios, the higher rates is charged, the more likely the respondents are willing to switch routes. Respondents are most likely to switch from freeway especially in NT$1.5/km charging rate. And the switching probability in *ScenarioI* is larger than *ScenarioII* because of the distance of alternative route concern.

The results show that the latent variables would have positive or negative effects on respondents' route switching behavior. If the distance-based charging strategy is more acceptable for respondents, they would reduce their propensity to switch routes. But the strategy acceptance does not have great negative effect upon their switching behavior due to its magnitude of estimated coefficient. Furthermore, the effect of latent variable switching intention is larger than the strategy acceptance on switching probability. It reflects that higher acceptance of strategy is not necessarily equal to higher intention of payment. While the switching intention toward distance-based charging strategy increase, respondents would be likely to switch routes on the road.

Relating to the trip purpose, respondents on business trips would be less likely to switch routes than those on trips to work when they face the distance-based charging strategy implemented on freeway. It could be attributed to the tolls does not always paid by themselves while traveling across tollbooths. But respondents on social trips or recreational trips would be more likely to switch routes. Since the social trips or recreational trips often occur in off-peak hours, the identity of these trips is more flexible than that of trips to work. Hence it appears that respondents on these trips would have higher likelihood of switching routes while charging distance-based rate on freeway.

Respondents who reside at the midst and southern of Taiwan would be more likely to switch routes than those at northern area. It is probably because that people living in northern area are used to user payment. Besides, since commuters who having higher frequency usage on freeway should be charged more travel cost, they would more likely switch to the alternative route. Respondents who always need to pass through tollbooths are more likely switching routes. According to the magnitude of estimated coefficients of these characteristics, respondents who experience more congestion incidents and familiar with alternative routes would apparently show their willingness to switch routes especially in shorter distance (*ScenarioI*).

Finally, the results show that among the socioeconomic characteristics, several variables also appeared to be significant in the models. Respondents are younger (< 55 years old), lower level of education, or more monthly income (> NT$ 40 thousands) might be less likely to switch routes. The causes might be attributed to their inherent personal characteristics.

The estimated coefficient for the constant term is positive but smaller than the value 2, refers to the five-point Likert scale is the "undecided" degree for switching, and it indicates that respondents would be unlikely to switch to the alternative route while only paying NT$0.8/km toll rate. Since all the values of threshold μ on the *ScenarioII* are smaller than the ones on the *ScenarioI*, respondents would hardly switch to the alternative route while traveling longer distance.

4.3 Managerial Implications

Drivers' route switching behavior is typically influenced by their acceptance and switching intention toward the distance-based charging strategy. Specifically, the positive latent variable, switching intention, exert great impacts than drivers' acceptance toward distance-based charging strategy. It indicates that even drivers agree the benefits of distance-based charging strategy, their behavioral reactions still influence mainly by considering whether the charging rate is affordable especially for formerly toll-free drivers. While the distance-based charging rate is too high to pay, drivers would prefer switch routes than keep driving on freeway.

If the implementation of distance-based charging strategy on freeway is mainly to diminish the traffic loading during peak hours especially in metropolitan area, the traffic manager should focus on setting higher rate for shifting unnecessary traffic flows in order to overcome congestion problems. However, too many traffic flows shifted from freeway may induce local traffic getting worse, the traffic manager should weigh this matter carefully by evaluating the percentages of diversion under different charging rates. Furthermore, the traffic manager should provide higher charging rate for peak period travel depending on diverse demand for different trip purposes since their differential usage of freeway is in temporal or spatial distinction.

According to the research results, drivers who lived in northern of Taiwan would less likely switch routes than other residential area. The traffic manager could set applicable distance-based charging rate depending on implemented area, meanwhile, it would be contributive simulate distinct proportion of diversion. But the probability of route switching would be also restricted by the distance of alternative route, the shorter distance would result in more diversion appearances. If traffic manager would like to enhance the likelihood of drivers' route switching, the nearby alternative route should be offered to substitute for freeway.

TABLE 5 Estimation Results of Ordered Probit Models

Variables	Parameter estimate (*t*-value)	
	ScenarioI	***ScenarioII***
Willingness-to-pay		
WTP for distance-base charging	-0.042 (0.000)***	-0.001 (0.765)
Distance-based charging rate		
Dummy variable CR_1 (1 if NT$1.0/km, 0 otherwise)	0.223 (0.000)***	0.194 (0.000)***
Dummy variable CR_2 (1 if NT$1.2/km, 0 otherwise)	0.622 (0.000)***	0.541 (0.000)***
Dummy variable CR_3 (1 if NT$1.5/km, 0 otherwise)	0.977 (0.000)***	0.902 (0.000)***
Latent variables		
Strategy acceptance	-0.059 (0.000)***	-0.091 (0.000)***
Switching intention	0.139 (0.000)***	0.135 (0.000)***
Travel characteristics		
Trip purpose		
Dummy variable TP_1 (1 if business-trip, 0 otherwise)	-0.127 (0.028)*	-0.162 (0.004)**
Dummy variable TP_2 (1 if social-trip, 0 otherwise)	0.065 (0.321)	0.198 (0.002)**
Dummy variable TP_3 (1 if recreational-trip, 0 otherwise)	0.079 (0.210)	0.203 (0.001)***
Residential area		
Dummy variable A_1 (1 if midst of Taiwan, 0 otherwise)	0.239 (0.000)***	0.186 (0.000)***
Dummy variable A_2 (1 if southern of Taiwan, 0 otherwise)	0.251 (0.000)***	0.156 (0.000)***
Driving frequency (1 if a commuter, 0 otherwise)	0.093 (0.075)*	0.084 (0.100)*
No. of tollbooth pass through (0 if toll-free, 1 otherwise)	-0.334 (0.000)***	-0.216 (0.001)***
Experience of encountering congestion (0~4 represent degrees of congestion, 4 if extremely crowed)	0.057 (0.004)**	0.025 (0.199)
Familiar with alternative routes (0~4 represent degrees of familiarity, 4 if extremely familiar)	0.036 (0.046)*	0.069 (0.000)***
Socioeconomic characteristics		
Gender (0 if female, 1 if male)	0.005 (0.894)	0.000 (1.000)
Age (=0, if 18 ~ 54 yrs old; =1,if > 55 yrs old)	0.032 (0.622)	0.538 (0.000)***
Educational background (0 if college or technical training, 1 if graduate school)	-0.193 (0.000)***	-0.374 (0.000)***
Monthly income (=0, if < NT$ 40 thousands; =1, if > NT$ 40 thousands)	-0.006 (0.869)	-0.117 (0.001)***
Thresholds		
Constant	1.482 (0.000)***	0.622 (0.000)***
μ_1	0.920 (0.000)***	0.792 (0.000)***
μ_2	1.591 (0.000)***	1.364 (0.000)***
μ_3	2.437 (0.000)***	2.047 (0.000)***
Summary statistics		
Log likelihood at zero $L(0)$	-3217.90	-3294.94
Log likelihood at convergence $L(\hat{\beta})$	-3685.41	-3766.86
Adjusted likelihood ratio index $\bar{\rho}^2$	0.127	0.125
No. of observations	1,071	1,071

*** denoted a significant path at p-value<0.001; ** denoted a significant path at p-value<0.01; * denoted a significant path at p-value<0.1.

5.CONCLUSIONS AND RECOMMENDATIONS

An on-line questionnaire and interview survey are conducted in the three major metropolitan areas of Taiwan to explore the effects of various distance-based charging rates on drivers' route switching behavior. This paper proposed an analysis framework to incorporate possible causal factors into switching behavioral model via ordered probit approach. Since drivers' opinions would greatly influence the effects of the distance-based charging strategy, this paper takes drivers' latent variables and willingness-to-pay into account. The empirical study demonstrates that higher charging rate (i.e. NT$1.2/km and NT$1.5/km) would lead drivers increase their willingness to switch routes from freeway, even though they have higher acceptance of distance-based charging strategy. For formerly toll-free drivers, they would be more likely switching especially in shorter distance of the alternative route. Besides, drivers who living in northern of Taiwan (e.g. Taipei metropolitan) are used to accept this equity strategy and further comply with the charging rate instead of switching routes from freeway.

Although this research explores several types of relevant factors and absolutely enhances the explanatory abilities of behavioral model by considering latent variables, it does not mean that the findings can explain all drivers' real diversion decisions. The primary reason is that drivers' decision making process should be more complicated in the real situation, and there would be many unmeasurable variables referring to inherent concerns in drivers' mind without incorporating in these behavioral models. Some limitations relating to travel situation or traffic condition may not be completely considered in these proposed models as well. So the behavioral models established in the study could not completely explain drivers' actual behavior about route switching decision. Thus, future research could collect more relevant explanatory variables and latent variables relating to behavioral decision in order to explicitly explain drivers' real route switching behavior and effectively enhance the explanatory abilities of the behavioral models.

Relating to hypothesized distance scenarios and charging rates, there are few situations simulated by the SP design in this study. To analyze the effects of distance-based charging rates under driving condition for traffic management purpose, other scenarios of charging rates or travel condition could be simulated and considered into the proposed model. Thus, the traffic manager can predictably evaluate drivers' behavioral responses in advance using stated preference method.

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