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ACCEPTANCE TENDENCIES AND COMMUTERS' BEHAVIOR UNDER DIFFERENT ROAD PRICING SCHEMES

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Road pricing, as one of the transportation demand management strategies, aims to influence people's long-term travel behavior through economical means. Under this strategy, reduction in traffic volumes is expected by applying charges to private mode users at times and places when and where congestion occurs. As a result, urban congestion can be relieved and traffic flows can be more evenly distributed to alternative modes, routes or times. In this paper, three road pricing schemes: fixed pricing, credit-based pricing, and differential pricing (peak and off peak), proposed or implemented in different countries, are investigated. A computer-aided survey was conducted at two locations in Taiwan to obtain commuters' socioeconomic characteristics, travel characteristics, attitudes on different schemes, and attitudes on incentive alternatives on different road pricing schemes. The data was then used to investigate the important and significant attributes that may affect the acceptance of different road pricing schemes and the travel behavior of car/motorcycle commuters in an Asian context. The results of this study can provide valuable insights into road pricing strategies to be regulated and implemented in the future.

KEYWORDS: Transportation demand management, road pricing, ordered probit, nested logit, motorcycle commuters

1. INTRODUCTION

Road pricing is regarded as one form of transportation demand management (TDM) strategies, because it is aimed to relieve traffic congestion through economic means, by charging users of congested roads, to achieve a more balanced distribution of traffic flows on alternative roads. First proposed by the economist Pigou, in 1920, road pricing aims to influence, or reduce, the traffic volumes through applying certain amount of additional charges for private transportation modes at times and places when and where they cause congestions. As a result, it is expected that congestions can be relieved and a re-distribution of traffic to alternate routes, modes or times. Road pricing works on the basic principle of internalizing the external costs produced by car users and to reflect monetarily the costs of accommodating them in the congested roads. These costs include the social cost of air and noise pollution caused by cars, and the congestion cost, due to the congested network caused by the heavy traffic flow (Hau, 2005).

Singapore and London are two major cities that have used road pricing successfully to relieve road congestions during peak periods. In this study, the possibility of applying road pricing as a way to combat traffic congestion in a typical urban area in Asia, like Taipei, and commuters' preferences and behavior under alternative road pricing schemes, will be the focus. As the economy in Taiwan continues develop and income rises, the demand and use of motorcycles and cars also increase. As a result, road networks in urban areas have become overly-congested during the morning and evening commuting periods, which are common among countries in Asia. Furthermore, the traffic situation has worsened over the last decade due to insufficient land area and over-saturated urban roads. Therefore, how to suppress the use of private modes of transport and promote the

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use of public transportation is an important issue that the government would have to deal with. Various TDM strategies, including inducements and restrictions, have been applied to alleviate traffic congestion in other countries. To identify alternative road pricing schemes suitable for areas like these, different road pricing systems currently in operation will be first reviewed, with the objective of providing strategic inputs in the formation of alternatives for the study.

Based on the results of the review, three alternative strategies of road pricing schemes are identified. They are: fixed; per-entry; and peak/off-peak differential charging mechanism. Commuters' acceptance of these three schemes and their behavior under each will be studied through stated preference surveys. Two fast-developing areas in Taipei, the Shinyi area and the Neihu science park, were selected as the sites for investigation as they are experiencing serious congestion during peak periods and therefore commuters traveling to and from these areas are good candidates for the study. A customized computer-aided survey instrument was used to collect commuters' socio-economic and trip characteristics, as well as their preferences on road pricing schemes and incentive programs. Information regarding the allocation of revenues gained from the operation of the system and commuters' behavior under various simulated road pricing schemes were also collected. Ordered probit was used to investigate commuters' levels of acceptance towards various road pricing schemes. Their relationships and impacts on commuters' travel behavior were studied through estimating multinomial logit and nested logit models. It should be noted that private commuters include car and motorcycle commuters, as there is a high proportion of commuters using motorcycles in Tawian, as in many Asian countries. Finally, conclusions and suggestions will be made with specific references to legislation, improvement of the schemes, and further studies.

2. BACKGROUND

A rich body of literature can be found on the topics of road pricing and congestion pricing. Hau (2006) discussed comprehensively the various congestion charging mechanisms used. Over the years, a number of studies have been conducted to examine the likely acceptance and effects of road pricing on traveler behavior, some of which are case studies of existing applications. One of the most recent articles by Hensher and Puckett (2007) gave an updated overview of developments in road pricing worldwide and pointed out that the question of whether to have road pricing, especially in the Western cities, "is not if but when and where." They also remarked that although Singapore has implemented road pricing for more than 30 years, London and Stockholm's experiences may be more relevant to most countries in the west. The following discussions will first give a brief introduction of road pricing in these three cities and other studies that look into the attitudinal and behavioral aspects.

2.1 Road pricing in London and Stockholm

The road pricing strategy has been implemented in a small part of the metropolitan area in London, UK, since 2003. The pricing area is around 21 square kilometers (1.3% of the metropolitan area), and the pricing time is from 7:00 AM to 6:30 PM, Monday to Friday (excluding holidays). The fixed pricing of UK£5 (US$9) is adopted and, after paying, cars have multiple entries into this area. According to the evaluation by Transport of London, vehicle-kilometers and delay per vehicle might have reduced by 10~15% and 20~30%, respectively, and the traffic volume dropped by 16%, far more than the original number estimated by the authority. However, the net financial revenue of UK£80 millions is only 60% of original estimate due to the over estimation of traffic flow entering this area and the under estimation of the operating cost.

Results on the trial runs for Stockholm's congestion pricing system have been encouraging, with reported reduction of traffic by more than 20% and the transit usage increased by more than 5%. Eliasson and Mattson (2006) presented their findings on the equity effects of congestion pricing through a case study for Stockholm. It was noted in their study that Stockholm has a good system of public transport especially in the inner city where there would be high charges during peak periods. They concluded that the net impacts of the congestion pricing scheme are greatly dependent upon the travel patterns prior to the scheme and how revenues are used. Loukopoulos et al. (2006) noted in their Stockholm study that the public's acceptability to road pricing is highly linked with the availability of public transport in the road pricing area.

2.2 Road pricing in Asia – Singapore

The road pricing system in Singapore, given its long history of operations, has been widely reported in a wide range of publications. Menon et al. (1993) gave a detailed overview of the road pricing system in Singapore, and highlighted the reduction in CBD traffic as a direct result of road pricing. Phang and Toh (1997) discuss the various restrictions that have been imposed on car owners in Singapore to control road congestion. As reported, an area licensing scheme, the earliest form of cordon-based road pricing system in Singapore, was first introduced in 1975. Since 1995, the Road Pricing Scheme (RPS) was implemented along Singapore's expressways and drivers were gradually becoming accustomed to road congestion pricing (Lam and Toan, 2006). All vehicles, except scheduled buses, police cars and emergency vehicles, are required to buy and display an RPS pass in order to drive pass the road pricing gantries in the city bound direction between 7:30~8:30 in the morning. As a consequence of the enormous manpower needed in the RPS system, the Electrical Road Pricing (ERP) system started operation in 1998 to replace the manual RPS. The road prices in the ERP system were differentiated according to such attributes as time, location, distance and traffic flow, which allows for the efficient control of travel patterns and behavior (Menon and Lam, 2000). The effects of road pricing on traffic in Singapore was studied by Olszewski and Xie (2006). Their conclusion after modeling choices of drivers before and after introduction of ERP suggests that congestion in Singapore is effectively controlled by variable pricing methods of ERP.

2.3 Attitudinal and behavioral studies of road pricing

In addition to these studies on actual implementation of road pricing schemes, many studies have examined the likely *acceptance* of such schemes in other countries. For example, survey results discussed in Ison's study (Ison, 2000) for the UK indicate that people agree that the implementation of road pricing would relieve traffic congestion in urban areas. However, 80% of them think that such road pricing would not be acceptable to the public. The results also show that the most important issue of concern to the public is how the revenue obtained from road pricing would be used. Similarly, Jakobsson et al. (2000) targeting car users in Göteborg, Sweden found that the acceptance of road pricing depends on the car user's perception of the fairness at the extra travel costs as well as the degree of infringement on the individual driver's freedom. Decreasing one's own car use has a direct effect on perceptional fairness and freedom infringement. Income and the expectation that others would also decrease car use are the two factors that determine one's own reduction in car usage. To gain more support for road pricing from the public, several studies indicated that the following factors should be taken into consideration: (i) compensation for low income people (Viegas, 2001; Santos and Rojey, 2004); (ii) consensus of law makers (Oberholzer-Gee and Weck-Hannemann, 2002); and (iii) social norms, personal expectations and perceived effectiveness (Schad and Schlag, 2003). Fujii et al. (2004) discussed a survey investigating whether the same effects held true in the Asian countries of Japan and Taiwan. Their results indicate that fairness plays the same role, but, infringement on freedom may be more important in Japan than in Sweden or Taiwan. Income had a stronger effect on acceptance in Taiwan than in Japan or Sweden. Schade and Baum (2007) based on reactance and dissonance theory studied 140 drivers on their reactions to road pricing. One important finding is that attitudinal responses to road pricing are strongly affected by whether drivers are convinced about the scheme.

While the literature on acceptance thus shows rather consistent results, research on implications of road pricing on travel behavior shows more mixed results. O'Mahony et al. (2000) showed that car use would decrease significantly if road pricing was practiced, although 55% of the respondents queried were against the road pricing policy. The advantage that people agreed on was "the travel time to destination decreases due to congestion being alleviated", while "unfairness" and "more taxes" were the two disadvantages cited. Potential problems after the implementation of road pricing were "lack of alternative modes of transport" and "public acceptance".

Other studies on adaptation in general, on the other hand, indicate that travellers first consider changing, if anything, those facets of their activity-travel pattern that require least effort (e.g., Loukopoulos et al., 2004; Albert and Mahalel, 2005; Choo and Mokhtarian, 2005; Shiftan and Golani, 2005). Thus, while a small percentage may change departure time or route, very few will change mode choice, let alone long-term choices (Arentze and Timmermans, 2007).

To summarize, the above review seems to suggest that while some of the factors or modeling results seem to be consistent, as Hensher and Puckett (2007) pointed out that the differences in political and governmental environment, as well as socio-economic conditions, have rendered a quite different situation in Asia when it comes to the implementation and the studies of its responses. To address this gap, the paper attempts to investigate commuters' acceptance tendencies and responses to different road pricing schemes through surveys conducted in an Asian country – Taiwan, and the results as reported in this paper can be considered as a pioneer work in this specific geographical and socio environment. Given the importance of public acceptance when road pricing is implemented in the real world, much attention is paid to the aspect of public acceptance in this study. Ordered probit models and nested logit models are used to investigate the factors for the acceptance tendency of different road pricing schemes and their effects on car/motorcycle commuters' behavior.

3. METHODOLOGY

3.1 Survey design

The country of Taiwan in Asia has a rapidly growing economy and population whose mobility is increasingly dependent on private transport, with cars and motorcycles being the main modes, although there is also availability of transit and efficient bus services in large cities such as Taipei, where traffic conditions can be considered as typical representation of Asian characteristics. In this study, two fast-developing areas in Taipei, the Shinyi area and the Neihu science park, are selected as the sites for investigation. These sites were chosen because they were experiencing serious congestion during peak periods and therefore commuters traveling to and from these areas became good candidates for the study. A customized computer-aided survey instrument was used to collect data from Oct 14 to Nov 5, 2004. The total number of useful samples was 272. The samples were selected randomly from the yellow book in both Shinyi area and Neihu science park and the survey was conducted face to face.

There are five parts in the survey conducted in this study, and they are: commuters' socioeconomic and trip characteristics; their preferences for road pricing schemes and incentive programs; information regarding the allocation of revenues gained from the operation of the system; and commuters' behavior under various road pricing schemes.

3.1.1 Socio-economic characteristics

Respondents were asked about the following socioeconomic data: gender; age; vocation; education; marital status; individual and household car ownership; individual and household income; and household members including those aged below 18.

3.1.2. Trip characteristics

The questions regarding trip characteristics are: residence and working locations; commuting distance; working hours; commuting experiences by public and private modes; and the most frequent mode used to commute. Commuting experiences by public include walking time of access and egress to stops (stations), fare, in-vehicle travel time of bus, transit, or both. Commuting experiences by private (car and motorcycle) include: travel times during peak and off peak; the number of stops in the morning commute; parking cost; travel cost (gasoline consumption); car ridership; and the traffic conditions of the most frequently used and occasionally used routes. It is noted that the travel cost measure is based on the distance that the commuter travels and the gasoline price per kilometer.

Moreover, Likert's nine scale questions regarding how positively or negatively private commuters perceive road pricing are also used. Ratings in both cases are made based on nine-point numerical scales with verbally defined endpoints and midpoints (1 = extremely disagree, 5 = neutral, 9 = extremely agree). For example, on the positive side, road pricing: reduces traffic congestion, saves travel time, reduces pollution, improves quality of life, better utilization of public transport and enhances user-pay policy. On the negative side, it is unfair to the poor, perceived as an additional tax, and deteriorates the socioeconomic activities in the planning area. Based on these points, commuters are asked to indicate whether they agreed.

3.1.3 Road pricing schemes

Road pricing schemes based on the ones that have been implemented or tested in other countries are proposed in this study. They are fixed pricing, credit-based pricing, and differential pricing (peak and off peak). For each scheme, the respondents have to answer their acceptance level of that scheme ranging from 1 (most unlikely to accept) to

5 (most likely to accept), and the acceptable highest price for car and motorcycle (there are five levels of suggested prices). The definition of different schemes is described more in details below:

Scheme F_P (Fxed Pricing): there are two fixed prices for car and motorcycle respectively. Drivers are only asked to pay once per day for entering the planned zone.

Scheme C_P (Credit-based Pricing): drivers are free to enter the planned area a certain number of times per month, and are asked to pay for entering the planned zone after exceeding their limit.

Scheme D_P (peak and off peak Differential Pricing): drivers are asked to pay more for the highest peak hour, and then the other peak hours (two hours before and after the highest peak hour), and then the off-peak hours. The pricing is different for car and motorcycle.

3.1.4 Commuters' choice behavior under different road pricing schemes

The attributes to be considered and trade-offs among the above alternatives are: walking/waiting time (W_time); in-vehicle time (IVT); pricing cost (RP_cost), gasoline cost (G_cost); parking cost (PK_cost); and fare (FARE). The alternatives used in the survey can be found in Table 1.

TABLE 1: Choice alternatives

Abbreviation	Meaning
P_D	Pay and Drive a car
P_M	Pay and ride a Motorcycle
D_AFR	Drive a car and use the Alternate Free Route
M_AFR	ride a Motorcycle and use the Alternate Free Route
B	take Bus
T	take Transit
B_T	take Bus and Transit

Table 2 presents the attribute levels of each alternative (some are hypothetical data and some are actual commuting data). It shall be noted that IVT is randomly generated by the computer and assigned to each alternative of private modes.

TABLE 2: Descriptions of attribute levels for different alternatives

	P_D and P_M	D_AFR and M_AFR	B, T and B_T
W_time	Actual data at both ends		Actual ingress/egress and waiting times
IVT	Base case: travel times in peak hours		Actual in-vehicle time
	-10%	+10%	
	-20%	+20%	
	-30%	+30%	
	-40%	+40%	
RP_cost	Based on chosen pricing schemes	0	0
G_cost	Proportionally decrease with travel times	Proportionally increase with travel times	0
PK_cost	Actual commuting data		0
FARE	0	0	Actual Fare

The design of levels of in-vehicle time in alternatives P_D and P_M are based on the results shown in other countries that the in-vehicle travel time on the pricing routes or intervals would be decreased due to the reduction of traffic flows. Therefore, there are five levels of in-vehicle time included: the same as the travel time of peak hour (+0%), 10%, 20%, 30%, and 40% less, respectively. It should be noted that when the in-vehicle time during the peak hour is shorter, the travel time in the peak hour is set to equal that in off-peak hours. On the other hand, the levels of in-vehicle times in alternatives D_AFR and M_AFR also have five levels, and they are: the same as the travel time of peak hour (+0%), 10%, 20%, 30% and 40% longer, respectively. It is assumed that commuters are willing to travel on free routes and periods regardless of their travel times. As for the public commuters (B, T and B_T), the in-vehicle times are based on the values provided by commuters in the survey.

3.2 Exploratory analysis

3.2.1 Socioeconomic characteristics

Most of the respondents are male (75%), 18-30 years old (54.8%) and married (64%). 38.6% of respondents work in service-related industries, and 30.9% in IT industries. The majority of respondents are college graduated (68.4%). The phenomenon of over representativeness of education in the level of college graduates is due to a higher and well educated (such as computer science or industrial engineers) expertise is the threshold for getting the jobs in both areas. In fact, the result is quite consistent with the distribution in real world. The average number of household members under 18 years old is 0.62. Most of the respondents (62.2%) have 4-6 members in the household, comparing to an average of 4.38. Individual income of most respondents is within 20,001-60,000 NT dollars (or NTD) (72.8%), with an average of 48,768 NTD. The average household income is 110,974 NTD. The average car ownership is 1.42 cars per household and 1.83 motorcycles per household, and 0.54 cars per individual and 0.83 motorcycles per individual.

3.2.2 Trip characteristics

60% of the respondents indicated Taipei city as their residence locations, and 53% of them have been living at their current locations for more than 10 years. In terms of commuting distances, 33% of the respondents commute 6-10 kilometers to their workplaces, and most of them have regular work schedules (75%). The departure times of the majority are 7-9 am (74.6%).

3.2.3 The likelihood of acceptance towards road pricing schemes and the associated prices

The likelihood of acceptance towards the three road pricing schemes is shown in Table 3. The result indicates that the likelihood of non-acceptance (including very unlikely and unlikely to accept) is greater than that of acceptance (including very likely and likely to accept), which is probably due to the fact that road pricing is not yet implemented in Taiwan and consequently people are more conservative about this policy. In addition, scheme three has a higher acceptance level than the other two schemes. The reason for this higher acceptance level could be that scheme D_P (peak and off-peak differential pricing) is more flexible and does not induce negative feeling of being imposed additional tax by the respondents. Their feelings are more like delaying entry time to prevent being charged and being charged less. It should be noted that there still exists a certain portion of respondents choosing the normal scale; hence, a large scale publicity campaign of this policy before implementation will be beneficial to increase the acceptance of road pricing.

TABLE 3: The likelihood of acceptance towards three road pricing schemes

Scheme	F_P		C_P		D_P	
acceptance	Frequency	(%)	Frequency	(%)	Frequency	(%)
Very unlikely	56	20.6	54	19.9	47	17.3
Unlikely	94	34.6	83	30.5	71	26.1
Normal	72	26.5	72	26.5	76	27.9
Likely	47	17.3	60	22.1	71	26.1
Very likely	3	1.1	3	1.1	7	2.6
Total	272	100	272	100	272	100

As for the willingness to pay in different schemes, motorcycle commuters are willing to pay an average 12.29 and 12.48 NTD in schemes one and two, respectively, whereas they are prepared to pay 10.59 NTD in the highest peak, 3.1 NTD in the other peak and they would not wish to pay in the off-peak. For car commuters, on average they are willing to pay 25.51 and 23.69 NTD in schemes one and two, respectively,, whereas they are willing to pay 21.59 NTD in the highest peak, 12.56 NTD in the other peaks and would not wish to pay in the off-peak.

3.2.4 Commuters' choice behavior

The commuters' choice behavior after presenting an SP design of road pricing is investigated in this study. As described in Table 1, there are at most seven alternatives that commuters can choose from. For example, some commuters may live far away from bus stops and transit stations, as such, B, T and B_T are not available to them. Table 4 shows that around 52%-60% of car commuters choose to drive on the road pricing routes, and 27%-35% choose to drive on the free alternative routes. As for the motorcycle commuters, 46%-50% drive on the road pricing routes, while 42%-47% drive on the free alternative routes. However, switching to public transport is rare. It can be shown that car commuters are less likely to switch their commuting mode, probably due to the larger influence of road pricing on motorcycle commuters.

4. ESTIMATION RESULTS

The acceptance of road pricing and the commuters' choice behavior under three road pricing schemes for private commuters including both car and motorcycle are investigated. Two types of models are established: ordered probit (OP) and logit models, including multinomial logit (MNL) and nested logit (NL).

TABLE 4: Commuters' choices under different road pricing schemes (number of commuters in parentheses)

Scheme	Commuters	P_D	D_AFR	P_M	M_AFR	B	T	B_T
F_P	Car (88)	53 60.2%	26 29.5%	3	3	1	1	1
	Motorcycle (153)	1	2	71 46.4%	72 47.1%	4	2	1
C_P	Car (88)	46 52.3%	31 35.2%	4	4	1	1	1
	Motorcycle (153)	1	2	74 48.4%	69 45.1%	4	2	1
D_P	Car (88)	53 60.2%	24 27.3%	4	3	1	1	2
	Motorcycle (153)	3	1	77 50.3%	64 41.8%	4	3	1

4.1 Ordered probit models

Ordered probit models are applied to analyze the acceptance tendency of different road pricing schemes for both car and motorcycle commuters. The dependent variable used in the models is the likelihood of accepting road pricing schemes (0 is the least likely while 4 is the most likely), and the explanatory variables include: socioeconomic characteristics; trip characteristics; and road pricing characteristics.

4.1.1 Acceptance tendencies of car commuters

Table 5 presents the model estimation results regarding the acceptance tendency of different road pricing schemes for car commuters. The results indicate the significant variables influencing the acceptance tendency of road pricing schemes. Car commuters with higher education levels are more likely to accept road pricing, probably due to a better understanding of road pricing. This is also true for the car commuters with higher income levels (those above the average income), which may be a reflection of their higher values of time. Commuters who own more than two cars are less likely to accept road pricing due to the high expense once road pricing is implemented.

As for trip characteristics, commuters traveling during am and pm peaks are more likely to accept road pricing, because of the resulted shorter travel times, and as a result, less likely of being late at the workplace. Car commuters once experienced longer in-vehicle travel times in public transport in their commutes before are less likely to accept road pricing, because of a lower likelihood of switching to public transport, which tends to have longer travel times after road pricing is implemented. Moreover, car commuters with longer travel times in the morning (including walking time from parking lots to workplace and travel times in the peak) are more likely to accept road pricing, probably hoping to be benefited in the form of shortened travel times.

The results also indicate that commuters willing to pay higher road pricing charges are more likely to accept the schemes. Two incentive variables (incentives 1 and 2) are found to be significant, that is, having a positive likelihood of road pricing acceptance. Both incentives are designed to provide feedbacks due to the road pricing revenue to public users. The first (incentive 1) is to reduce parking fees, while the second (incentive 2) is to offer discounted fares if public transport is used. They are more likely to accept road pricing if their attitudes towards these two incentives are more positive.

Finally, car commuters are more likely to accept road pricing if they perceive positively on road pricing, otherwise, it would be unlikely for them to accept road pricing. The common variables in the three road pricing schemes are "enhance user-pay policy" and "deteriorate the socioeconomic activities in the road pricing area".

TABLE 5: The acceptance tendency models of different road pricing schemes for car commuters

Explanatory variables	Models					
	F_P		C_P		D_P	
	Coef.	t values	Coef.	t values	Coef.	t values
Constant	-2.51	-3.22	-3.68	-3.43	-1.63	-3.04
Education level	--	--	0.46	1.66	--	--
Personal income>48 thousand (NTD)	0.09	2.01	--	--	--	--
Individual car ownership>2	-2.50	-2.37	-3.14	-2.54	--	--
Commuting in the morning peak	0.59	1.73	--	--	0.54	1.99
Commuting in the evening peak	0.91	3.11	--	--	--	--
In-vehicle time (transit+bus)	-0.02	-1.83	--	--	--	--
In-vehicle time (car)	--	--	0.03	3.49	--	--
Road pricing fee (car)	0.03	1.82	0.04	1.93	0.06	3.46
Attitude towards reduced parking fees	--	--	--	--	0.12	2.61
Attitude towards discounted fares	0.19	3.04	0.10	1.64	--	--
Reduce traffic congestion and save travel time	--	--	0.15	2.87	--	--
Reduce pollution and improve life quality	--	--	0.16	2.81	--	--
Fully utilize public transportation	--	--	0.18	2.62	--	--
Enhance user-pay policy	0.38	6.56	0.19	3.02	0.15	3.21
Being unfair to the poor people	-0.09	-1.43	--	--	--	--
Deteriorate the socioeconomic activities in the road pricing area	-0.15	-2.93	-0.09	-1.81	-0.09	-1.96
Threshold μ_1	2.09	9.51	1.47	8.41	1.11	7.34
Threshold μ_2	3.44	13.75	2.49	12.18	2.31	12.41
Threshold μ_3	5.43	11.03	--	--	3.86	10.8
LL(0)	-122.991		-121.588		-126.772	
LL(β)	-71.275		-82.744		-101.563	
ρ^2	0.42		0.32		0.20	
Observations	88					

4.1.2 Acceptance tendencies of motorcycle commuters

Table 6 presents the model estimation results regarding the acceptance tendency of different road pricing schemes for motorcycle commuters, with older ones being less likely to accept road pricing, probably due to their habitual behavior. The results also indicate that commuters willing to pay higher road pricing fees are more likely to accept the schemes. There are also two incentive variables (incentive 2 and incentive 3) found to be significant, both of which are associated with the re-distribution of the road pricing revenue to public users. Incentive 2 is to pay discounted fares when using public transport and incentive 3 is to improve public transport systems and services. Overall, commuters are more likely to accept road pricing if their attitude towards road pricing is more positive. The common variables in three road pricing schemes are "reduce traffic congestion and save travel time" and "being unfair to the poor people", which are quite different from those for the car commuters.

TABLE 6: The acceptance tendency models of different road pricing schemes for motorcycle commuters

Explanatory variables	Models					
	F_P		C_P		D_P	
	Coef.	t values	Coef.	t values	Coef.	t values
Constant	-1.01	-1.45	-0.24	-0.38	-0.62	-1.09
Age	-0.21	-1.74	-0.28	-2.39	--	--
Road pricing fee (motorcycle)	0.05	2.25	0.06	3.22	0.07	4.70
Attitude towards discounted fares	0.20	4.27	0.13	2.81	0.10	1.89
Attitude towards public transport improvements	--	--	--	--	0.15	2.81
Reduce traffic congestion and save travel time	0.21	4.86	0.15	3.64	0.09	2.05
Fully utilize public transportation	--	--	0.11	2.48	--	--
Enhance user-pay policy	0.19	4.15	--	--	0.15	3.28
Being unfair to the poor people	-0.11	-2.28	-0.13	-2.92	-0.17	-3.48
Threshold μ_1	1.632	11.50	1.309	10.95	1.287	10.30
Threshold μ_2	3.093	17.10	2.373	17.03	2.374	16.65
Threshold μ_3	5.435	12.49	4.068	14.16	4.537	14.53
LL(0)	-207.128		-215.195		-218.162	
LL(β)	-141.044		-170.155		-158.855	
ρ^2	0.32		0.21		0.27	
Observations	150					

The results shown in Tables 5 and 6 indicate that the variables that influence both motorcycle and car commuters are the road pricing fee, attitudes towards incentives and attitudes towards road pricing. The variables for incentives 1 and 2 have significant effects on acceptance tendency for car commuters, while incentives 2 and 3 have significant effects for motorcycle commuters. The reasons for incentive 2 being significant in both models is probably because people are more familiar with this incentive, which is similar to the existing strategy of charging discounted fares when users transfer between bus and transit. Incentive 1 is to reduce commuters' parking fees if they take public transport to work, which intuitively has a stronger effect on car commuters than motorcycle commuters. Finally, incentive 3, or improving public transport systems and services, is more attractive to motorcycle commuters since riding a motorcycle is not as comfortable as driving a car or taking the public transport.

The common variables in the three road pricing schemes for car commuters are "enhance user-pay policy" and "deteriorate the socioeconomic activities in the road pricing area", while the common variables in the three road pricing schemes for motorcycle commuters are "reduce traffic congestion and save travel time" and "being unfair to the poor people". The different common variables existing in car and motorcycle models indicate the different perceptions of important variables on road pricing acceptance for car and motorcycle commuters.

4.2 Commuters' choice behavior models

In the Nested Logit (NL) models, different structures (NL1, NL2 and NL3) were investigated, and they are shown in Figures 1 to 3 as follows. While the lowest levels of alternatives are the same for all three structures, the middle layers of alternatives are grouped differently.

The estimation results are shown in Table 7. After comparing the goodness-of-fit of models for different nest structures, the best model for the scheme F_P is the NL1 structure, while the best models for schemes C_P and D_P are the NL2 structure.

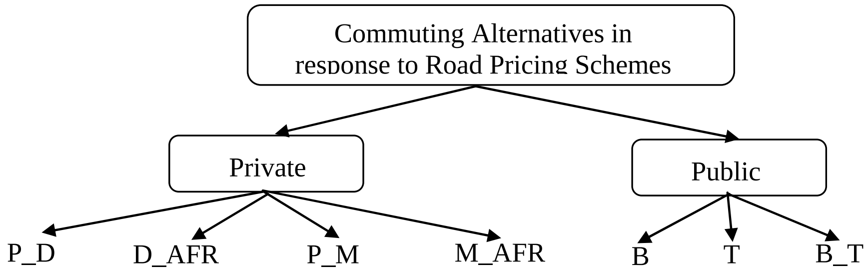

FIGURE 1: NL1 structure

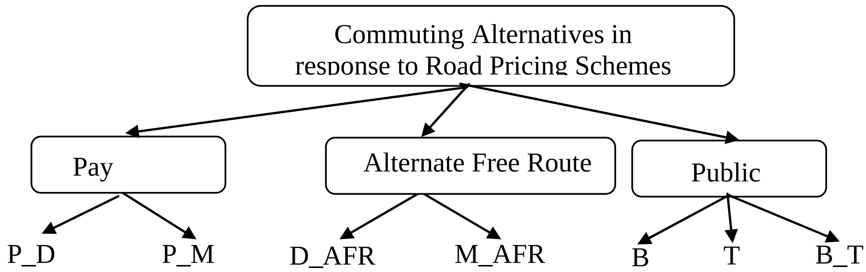

FIGURE 2: NL2 structure

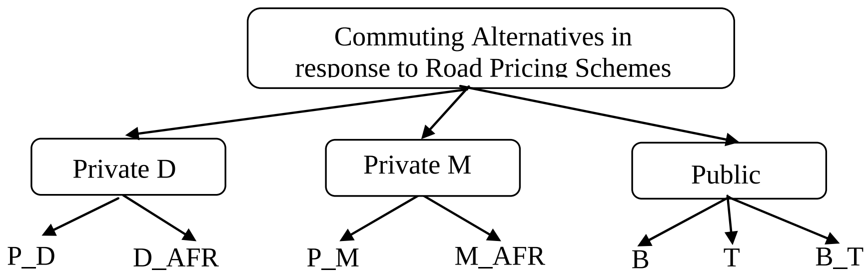

FIGURE 3: NL3 structure

The model performance of NL3 turns out to be statistically insignificant. The values are all within the range of 0 and 1 and the t-statistics are significant in the right direction. The likelihood ratio indicators ρ^2 are all greater than 0.5, again demonstrating that the models have a satisfactory goodness–of-fit. The non-nested likelihood ratio test is employed to compare MNL and NL models, and the results show that NL2 models for schemes C_P and D_P outperform the MNL models with 5% significance level. However, this is not the case for scheme F_P, which implies that for schemes C_P and D_P, there exists correlation among alternatives in each of the nests, while the alternatives are all independent.

The estimation results of better models for all three schemes are described as follows. The alternative B_T is taken as the base alternative. The results show that the generic variables, including travel cost, in-vehicle time and out-of-vehicle time, are significant variables to influence commuters' choice behavior. The negative signs of these coefficients indicate that the longer the travel time and the higher the cost, the less likely the alternatives would be chosen for all three schemes.

TABLE 7: The MNL and NL models for private commuters

Variables	Scheme F_P				Scheme C_P				Scheme D_P			
	MNL		NL1		MNL		NL2		MNL		NL2	
	Coef.	t values	Coef.	t values	Coef.	t values	Coef.	t values	Coef.	t values	Coef.	t values
Alternative specific constants												
Car (P_D)	*2.21*	*1.25*	3.01	1.42	-0.22	-0.25	*0.35*	*0.14*	-1.37	-1.33	*-3.21*	*-1.06*
Car (D_AFR)	*4.25*	*2.47*	5.09	2.41	0.37	0.48	*1.66*	*1.07*	1.59	1.28	*2.13*	*1.10*
Motorcycle (P_M)	*-0.80*	*-1.11*	-0.07	-0.05	-1.34	-1.54	*-1.87*	*-0.72*	-2.52	-2.58	*-4.60*	*-1.49*
Motorcycle (M_AFR)	*-0.40*	*-0.57*	0.37	0.28	-0.25	-0.37	*0.50*	*0.35*	-2.42	-2.50	*-2.77*	*-1.50*
Bus (B)	*-0.31*	*-0.55*	-0.03	-0.03	-0.23	-0.40	*0.22*	*0.17*	-0.62	-1.10	*-0.77*	*-1.03*
Transit (T)	*2.43*	*1.52*	3.87	1.20	-0.11	-0.17	*0.32*	*0.25*	-1.14	-1.56	*-1.29*	*-1.32*
Generic variables												
Out-of-vehicle travel time	*-0.06*	*-2.30*	-0.08	-1.90	-0.06	-2.31	*-0.08*	*-1.49*	-0.08	-2.64	*-0.09*	*-1.63*
In-vehicle travel time	*-0.03*	*-3.44*	-0.04	-3.35	-0.03	-3.41	*-0.03*	*-2.49*	-0.04	-3.63	*-0.04*	*-2.34*
Travel cost	*-0.01*	*-2.77*	-0.01	-2.25	-0.01	-2.30	*-0.01*	*-2.17*	-0.01	-3.31	*-0.01*	*-2.47*
Road pricing fee												
Car (P_D)	*0.04*	*1.64*	0.04	1.61	--	--	--	--	--	--	--	--
Motorcycle (P_M)	--	--	--	--	0.05	1.78	*0.09*	*1.58*	--	--	--	--
Socioeconomic characteristics												
Age (P_M)	--	--	--	--	--	--	--	--	0.86	2.10	*1.40*	*1.68*
Age (M_AFR)	--	--	--	--	--	--	--	--	0.93	2.25	*1.05*	*1.85*
Information (P_D)	--	--	--	--	--	--	--	--	1.10	1.87	*2.62*	*1.49*
Service (P_D)	--	--	--	--	--	--	--	--	1.37	2.38	*2.01*	*1.93*
Education level (P_D)	*-1.83*	*-2.38*	-1.84	-2.32	--	--	--	--	--	--	--	--
Education level (D_AFR)	*-1.97*	*-2.52*	-1.99	-2.45	--	--	--	--	-0.92	-1.81	*-1.07*	*-1.52*
Education level (T)	*-1.61*	*-1.92*	-2.32	-1.44	--	--	--	--	--	--	--	--
Marital (P_M)	--	--	--	--	-1.32	-3.33	*-2.79*	*-2.12*	--	--	--	--
Marital (T)	--	--	--	--	--	--	--	--	1.47	1.80	*1.73*	*1.42*
Income (P_M)	--	--	--	--	0.12	1.73	*0.26*	*1.61*	--	--	--	--
Trip characteristics												
Length of stay in current residence (P_D)	--	--	--	--	0.09	1.94	0.15	1.58	0.10	2.04	0.18	1.70
Working hour (P_D)	--	--	--	--	-1.35	-2.61	-2.55	-2.11	--	--	--	--
AM peak (P_D)	--	--	--	--	--	--	--	--	-1.09	-2.00	-1.89	-1.80
PM peak (D_AFR)	-1.47	-2.99	-1.45	-2.94	-1.45	-2.96	-1.70	-2.18	-1.49	-2.81	-1.91	-2.08

TABLE 7: The MNL and NL models for private commuters (continued)

Variables	Scheme F_P				Scheme C_P				Scheme D_P			
	MNL		NL1		MNL		NL2		MNL		NL2	
	Coef.	t values	Coef.	t values	Coef.	t values	Coef.	t values	Coef.	t values	Coef.	t values
μ_m												
private (pricing)	--	--	0.89	2.34	--	--	*0.46*	*2.31*	--	--	*0.50*	*1.91*
private (AFR)					--	--	*0.74*	*3.13*			*0.71*	*2.60*
public	--	--	0.66	1.71	--	--	*0.51*	*1.45*	--	--	*0.70*	*1.99*
LL(β)	*-229.20*		-228.87		-230.99		*-228.47*		-224.690		-223.141	
LL(0)	*-549.52*		-549.52		-493.17		*-493.17*		-493.57		-493.57	
ρ^2	*0.583*		0.584		0.532		*0.537*		0.545		0.548	
Observations	*268*		268		268		*268*		268		268	

In MNL for scheme F_P and MNL-NL2 models for scheme C_P, the positive signs of "road pricing fee" indicate that commuters are more likely to choose "pay and drive" and "pay and ride a motorcycle" as the "road pricing fee" indicated by commuters increases in schemes one and two. The reason that this variable is not significant in scheme three is probably because of differential pricing over time and, as a result, commuters could pay less eventually.

As for the socioeconomic characteristics variables, age, service workers, education level, and marital status are statistically significant to influence the commuters' choice behavior. Older commuters are more likely to choose P_M and M_AFR in scheme D_P. Employees in information industries are more likely to choose P_D in scheme D_P. Commuters with higher education levels are less likely to choose P_D, D_AFR and T. Married commuters are less likely to choose P_M and T, probably due to the need to car pool in their commutes.

The length of stay in current residence, work hour policy, and AM and PM peak commutes have significant effects on commuters' choice behavior. The longer the commuters live at the current residence, the more likely they would choose P_D in schemes C_P and D_P. The commuters with regular working hours are less likely to choose P_D in scheme C_P. The commuters traveling in AM and PM peaks are less likely to choose P_D and D_AFR, probably due to the fact that the pricing on car is much higher than the one on motorcycles. The other reason is that the travel cost would be higher during the peaks when traveling on alternate free, which may be longer, routes.

5. CONCLUSIONS

In this study, the acceptance tendency and responses to different road pricing schemes were studied through conducting behavioral surveys on a sample of commuters in Taiwan, one of the typical Asian countries that are considering road pricing as a solution to traffic congestion. Given the different social and political fabrics of Asian countries with their counter parts in the west, this study is targeted to look into how Asian commuters may accept or respond to road pricing, in their possibly unique ways. The work as reported can be considered as one of the pioneer studies conducted to investigate this particular aspect of road pricing, amid the rich body of literature already available on other parts of the world. The paper presented findings with an Asian context, especially the results obtained for both the car and motorcycle users. The latter form an important proportion of the overall road traffic in many Asian countries, including Taiwan, and its impacts have been largely neglected in most other studies dealing with data obtained from mainly developed countries. Methodologically, we applied ordered probit models to analyze the commuters' levels of acceptance towards various road pricing schemes. Their relationships and impacts on commuters' choice behavior were also studied through estimating multinomial logit and nested logit models. Several conclusions are highlighted as follows:

(I) The result indicates that the likelihood of non-acceptance (including very unlikely and unlikely to accept) was greater than that of acceptance (including very likely and likely to accept), which probably is due to the fact that road pricing has not been implemented yet in Taiwan and consequently, people are more reserved about this policy. In addition, scheme three had a higher acceptance level than the other two schemes. The reason for this higher acceptance level could be that scheme three (peak and off peak differential pricing) is more flexible and has no negative connotations of imposing additional tax. It should be noted that there still exists a certain portion of respondents choosing the normal scale; hence, a full advocacy of this policy before implementation will be beneficial to increase the acceptance of road pricing. This result seems echoing those obtained by Schade and Baum (2007) that people needs to be more convinced for them to perceive positively road pricing.

(II) Around 52-60% of car commuters choose to drive on the road pricing routes, and 27-35% choose to drive on the alternate free routes, while the proportions for motorcycle commuters are 46-50% and 42-47% respectively. However, switching to public transport is rare for both. Especially car commuters are found to be less likely to switch their commuting modes. This is most probably due to the larger influence of road pricing on motorcycle commuters.

(III) The common variables in the three road pricing schemes for car commuters are "enhance user-pay policy" and "deteriorate the socio-economic activities in the road pricing area", while the common variables in the three road pricing schemes for motorcycle commuters are "reduce traffic congestion and save travel time" and "being unfair to the poor people". The different common variables in car and motorcycle models indicate the different perceptions of important variables on road pricing acceptance for car and motorcycle commuters.

(IV) Generic variables, including travel cost, in-vehicle time and out-of-vehicle time are the significant variables influencing the commuters' choice behavior. The negative signs of these coefficients indicate that increasing travel time and cost would make it less likely for the alternatives to be chosen in all three schemes. Therefore, more reasonable pricing, traffic flow monitoring to maintain an improved level of service, and improvement in public transport accessibility are all key elements to achieve the following objectives: evenly distributing the traffic to alternate routes; alleviating traffic congestion, and increasing the ridership of public transport. These results appear to be in line with previous studies by other researchers.

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