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MODELING OF TRANSPORTATION BEHAVIOR FOR COERCIVE MEASURES FOR CAR DRIVING IN KUALA LUMPUR

Abdullah Nurdeen[1], Riza Atiq O. K. Rahmat[1] and Amiruddin Ismail[1]
[1]Department of Civil and Structural Engineering, Faculty of Engineering, University Kebangsaan Malaysia,
43600 UKM Bangi, Selangor Darul Ehsan, Malaysia
E-mail: kamba@vlsi.eng.ukm.my

ABSTRACT

The rapid increase of car ownership associated with inadequate public transport has largely contributed to increase traffic congestion, accidents and environmental pollution. A policy proposed to improve public transport and control car ownership simultaneously has become necessary for solving the problems the objectives of this research are to develop mode choice models to expressing car users and public transport users' behavior and investigate their response to scenario of a reduction in bus and train travel time and travel cost. In this paper, a survey of 1200 car, bus and train users was conducted in Kuala Lumpur city center. A binary logit model was developed for the three alternative modes, bus, train and car. It was found that travel time, travel cost, gender, age, income level and car ownership are significant in influencing car users' mode choice behavior. The probability of car drivers shifting to public transport was also examined based on a scenario of a reduction in bus and train travel time and travel cost. Reduction of total travel time and travel cost for the bus and train mode emerges as the most important element in a program aimed at attracting car users towards public transport and away from car mode.

Keywords: public transport policy, car reduction, logit model, mode choice, model shift.

INTRODUCTION

Malaysia's rapid growth in population, economy and motorization has resulted in the number of registered motor vehicles increasing by 8,321,517 over the 13-years period from 1990 to 2003. In other words, there was a general increase of 54.6% for all motor vehicle registration in Malaysia. The rise in population and motorization, however, has led to an increase in road traffic accidents and casualties. These problems have prompted the Malaysian government to undertake various studies to address this problem. One of these studies was the shift of transportation mode from private car to public transportation (Bus and Train) in Malaysia (Riza UKM, 2004). The study targeted to evaluate policies and strategies that can help to formulate, model shift of transportation mode from private car to public transportation in Malaysia, to formulate the modeling of possible model shift from private car to public transportation and to predict the future model shift. The current paper is a part of the research that has focused on model shift initiatives.

To date, research efforts have focused primarily on modeling modal shift from private car to public transport. Many cities have attempted to restrict the use of private cars in favour of public transport (Mackett, 1994). Such policies exist in France (Harrison *et al*., 1998), Germany (FitzRoy and Smith, 1998), Britain (Mackett, 1994; Harrison *et al*., 1998), Netherlands (Ploeger and Baanders, 1995; Cheung and Hoen, 1996), Romania (Marshall and McLellan, 1998), Australia (Black, 1996), Asian countries (Shimazaki *et al.*, 1994; Land Transport Authority, 1996) and Canada (Schimek, 1996).

This study describes modeling of transportation policies to formulate, model shift from private car to public transport for all trips and school trips. The survey data collected from Kuala Lumpur city center were used to develop the models. The explanatory variables included in the models were demographic, socio-economic characteristics of individuals, trip characteristics, and mode attributes. A binary logit model was used to identify factors that are significant in determining the choice of transport and to predict the probability of a change in bus and train ridership with respect to various travel times and cost.

MATERIALS AND METHODS

A questionnaires study was carried out in selected urban areas of the Kuala Lumpur City Center to determine reasons for travelers' mode choice from among three transport modes: private cars, bus and train. The survey area was selected because of its high car ownership and use and the availability of public transport (bus and rail). A total of 1200 questionnaires[1] were collected over a period of 5 months from (1 April to1 September 2005). The questions addressing car, bus and train users were addressed contained only in the revealed preference survey and pertained to demographic, socio-economic characteristics and mode attributes. The respondents were requested to report their current travel situation by answering a set of questions. These questions were categorized into: (1) Questions on respondent's current travel modes and associated attributes such as current travel mode available to the respondent, his/her current travel mode and associated travel time, cost, and access approach. The respondents were encouraged to report information on other travel mode attribute values.

[1]*The questionnaire is available from the authors upon request.*

(2) Traveler's personal information relating to travel mode choice such as age, income, gender, occupation, education, total number of household members, and number of vehicle ownership in the household. Some of the questions in this section were categorized. For instance, the income of respondents consisted of five levels with equal intervals.

For car users, the questionnaire addressed both revealed and stated preferences. The survey information included socio-economic characteristics of individuals, trip information of individuals, and attitudes and perceptions on travel and policy measures.

Socio-economic information included household income, individual's income, age, gender, vehicle ownership, and total number of members in household, occupation and education level. Trip information of individuals included the purpose of the trip, mode of travel, total travel time and travel cost etc.

A binary logit model was developed for three alternatives namely, bus, train and car, with the aim of comparing the utility of these travel modes and to identify the factors that would influence car users to move from traveling by car to choosing the public transport alternative. In these models, model car and bus, the dependent variable was "1" if the commuters' traveled by bus and "0" for car use and model 2 car and train the dependent variable was "1" if the commuters' traveled by train and "0" for car use. The explanatory variables were: age, gender, income, travel time, travel cost and car ownership. Some of the explanatory variables such as age, income per month and gender were categorized. For instance, the income was categorized as; <RM 1000, RM 1001-2000, RM 2001-3000, RM 3001-4000, >4001 (1 US Dollar = RM 3.65) while gender was categorized as 0 for male and 1 for female. Age was also categorized as; 16-29, 30-44, 45-60 and >60.

RESULTS AND DISCUSSION

Modeling car users switching behavior

Binary Logit models were developed on a hypothetical choice stated preference survey of car users in Kuala Lumpur to predict the effect of a road insurance increase on mode switching behavior. Stated responses to an increase in the legal age for driving from the current 18 years to 23 years scenario obtained from a survey sample of 250 car users conducted were correlated with demographic and socio-economic variables to determine their influence on mode switching behavior. The Binary Logit model was used to evaluate the general effect of policy variables on mode split. For this model, the dependent variable was 1 if the commuters switched and 0 otherwise. Four major factors that affect car users switching behaviors included in the model were: age, gender, vehicle ownership, education and income. The results of mode switching behavior were compared with the revealed preference results.

Age

Table-1 showed the effect of the legal age for driving from the current 18 years to 23 years on car users switching behavior against age. The results showed that age is significant in explaining mode-switching behavior. The odds ratio increased by approximately 2.8 times from older users compared with young users. In other words, the older users are likely to switch more than two times compared to the younger users.

Gender

Table-1 showed the effect of legal age for driving from the current 18 years to 23 years on car users switching behavior against gender. The results indicated that resistance to switching is the same among male and female users. The odds ratio of 5% showed that males were about 5% more likely to switch compared to females. Cross tabulation results are also in agreement with the model results.

Car ownership

Car ownership of the household is also a major factor that determines the choice of mode of transport. The results from the survey indicated that an increase in car ownership in the household is likely to decrease resistance to a mode change. Resistance to switching was found to be higher among respondents whose household vehicle ownership is one, while respondents from households that owned two to three and more than three vehicle, are less resistant to a mode change. The results of the binary model also showed significance, the negative sign of the coefficient indicates that an increase in car ownership in the households is likely to decrease resistance to switching from motorcycle to private car.

Income

Table-1 showed the effect of legal age for driving from the current 18 years to 23 years on car mode switching behavior against income. Income which is the major influencing factor of mode choice emerged as a strong explanatory variable in the model. The odds ratio increased 2.396 from low income (RM 1000) to higher income (>RM 2000). It indicates that car users who earn monthly income of more than RM 1000 are twice likely to switch to other safe modes compared with those earning less than RM 2000 monthly.

Table-1. License age increase switching behavior in relation to age, gender, car ownership and income (cross tabulation and estimated parameter) (n = 250).

Cross Tabulation					
Age (years)	**%**	**Switch**	**%**	**No change**	**Total**
18-19	43.75	35	56.625	45	80
20-21	100.0	67	0	0	67
22-23	92.23	95	7.69	8	103
Gender	**%**	**Switch**	**No change**	**%**	**Total**
Male	65.38	107	34.61	56	163
Female	97.14	85	2.35	2	87
Car Ownership	**%**	**Switch**	**%**	**No change**	**Total**
1 car	62.2	53	37.8	32	85
2-3 cars	32.4	24	67.6	50	74
> 3 cars	14.2	13	85.7	78	91
Income	**%**	**Switch**	**%**	**No change**	**Total**
Low income	63.1	69	36.9	40	109
High income	92.2	130	7.8	11	141
Estimation results for binary logit model (n = 250)					
Constants	Coefficients	S.E	Sig	Odd ratio	
Age	1.021	0.318	0.001	2.77	
Gender	-2.971	1.100	0.007	0.051	
Car ownership	-0.633	0.277	0.020	0.531	
income	0.874	0.405	0.041	2.396	
Constant	1.777	0.530	0.096	5.97	
(-2)log likelihood	60.43				

Mode choice model between car and bus

A binary logit model for all trips was developed for two alternatives namely, bus and car to explore factors affecting bus ridership and to predict the probability of a change in bus ridership with respect to various travel times and cost. The model examined the characteristics of bus and car trips such as travel time travel cost, demographic and socio-economic characteristics to determine the relative influence of demographic, socio-economic variables and mode attributes on mode choice behavior.

Table-2. Estimation results for binary logit models for car and bus (n = 951).

All Trips				
	β	S.E.	P-value	$Exp\ (\beta)$
Age	1.11	0.031	0.001	3.03
Gender	2.11	0.00	0.000	8.25
Travel time	-0.136	0.005	0.000	0.873
Travel cost	-0.033	0.032	0.000	0.97
Income	-0.712	0.002	0.000	0.490
Car ownership	-0.453	0.023	0.002	0.635
Constant	2.30	1.20	0.000	
Summary of statistics				
Model chi-square /Sig,	311.12			
(-2)log likelihood	199.78			
P-value for the Goodness of Fit Test. statistics	0.7			
Cox & Snell- R^2	0.64			
Nagelkerke	0.77			
Number of observations	951			

The estimated coefficients for travel time and travel cost for the bus mode (Table-2) were negative, implying that an increase in travel time and travel cost for the bus mode is likely to increase the probability of car users to continue choosing the car as the preferred transport mode. The likelihood of shifting car users to buses is improved if

reductions in travel time and cost can be achieved. In the model, demographic variables such as age, income, and gender were found to significantly explain mode choice behavior. For the gender factor, the model estimation suggests that if the gender is female the preference would be for bus use rather than car. The odds ratio increases by approximately eight times for females compared with males. For age factor, the result showed that an increase in age was likely to decrease car use, meaning that the elderly are more likely to ride on a bus rather than a car. The odds ratio increases about three times for older people compared with the younger commuters. For car ownership factor is negative, implying that an increase in car ownership for the bus mode is likely to increase the probability of a car users to continue choosing the car as the preferred transport mode.

In order to assess how well the model fits the data, Hosmer and Lemeshow Goodness-of-Fit test statistic was developed and a chi-square test from observed and expected frequencies was computed. As shown in Table-2, the model for all trips has a P-value of 0.7; confirms that the fit of the models are good. The models explanatory power, the two R-Square values indicate the model's strong explanatory power. The factors included in the model account for 90.1% of the variation for the Negelkerke, while Cox and Snellt can explain 77%. Classification matrices were calculated to assess whether the model fits the data and it was found that the model correctly classified about 93.7% of car cases and about 82% of the bus mode cases. The overall accuracy of the prediction model was 96.7%.

Probability Prediction

One of the most important uses of mode choice models is predicting the effects of policy measures. In order to promote greater use of public transport services, the study examined the probability of car users shifting to public transport based on a scenario of a reduction in bus travel time and travel cost. This was done by solving the binary logit equation for probability using the range of various travel time scenarios. The effects of other variables were controlled by keeping them constant (giving them the values mainly based on means). The mode share probabilities categorized by various levels of travel time and travel cost are shown in Figures 1, 2 and 3. The mode share probabilities categorized by various levels of travel time as shown in Figure-1. Mode choice probabilities ranged from 90% likelihood of car use with current bus total travel time per trip (60 minutes) to 5% likelihood of car use with a reduction in bus travel time per trip (15minute). At the same time, the probability of bus ridership increased from10% with current bus travel time of (60 minutes) to 95% of likelihood with a 15 minutes reduction in bus total travel time per trip. A 50:50 split may be achieved when the travel time are set at 40 minutes per trip for bus travel to all trips

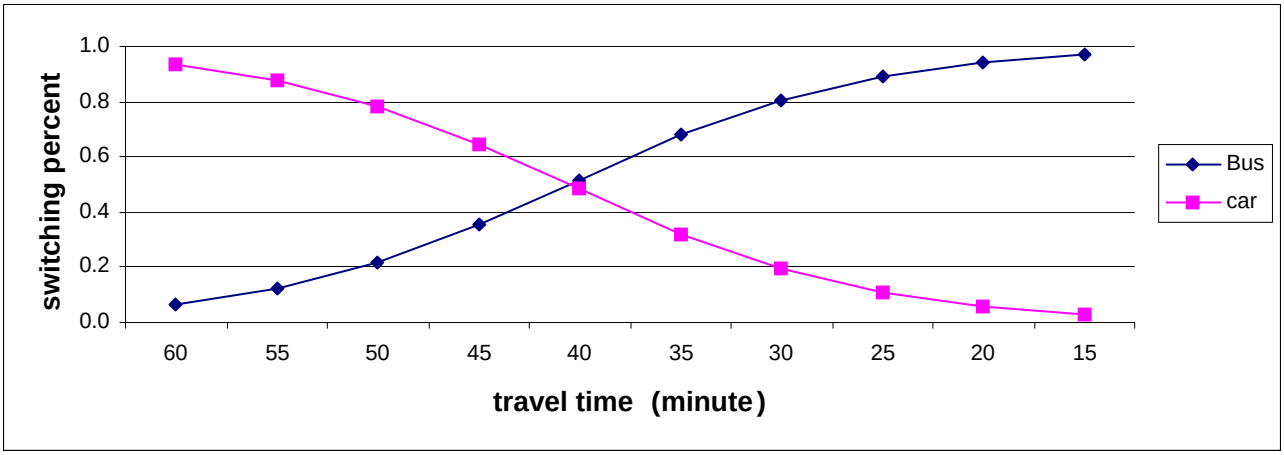

Figure-1. Effect of bus travel time reduction on car users' mode choice probability (all trips).

Mode choice model between car and train

The variables shown in Table-3 are all significant. Demographic and socio-economic variables are found to provide statistically intuitive results. In this model, typical demographic variables such as age, income, car ownership and gender were found to significantly explain mode choice behavior. Most of the coefficients have the expected sign. For the gender factor, the model estimation suggests that if the gender is female the preference would be for car use rather than train. The odds ratio increases by approximately 7.5 times for females compared with males. For age, younger people are more likely to use the train as opposed to car. The odds ratio increases about three times for younger people compared with the older commuters. The estimated coefficients for travel time, travel cost and car ownership for the train mode (Table-3) are negative, implying that an increase in travel time, travel cost and car ownership for the train mode is likely to increase the probability of a car users to continue choosing the car as the preferred transport mode to work. The likelihood of shifting car users to train are likely if reductions in travel time and cost could be achieved.

The models explanatory power, the two R-Square values indicate the model's strong explanatory power. The factors included in the model account for 92.77% of the variation for the Negelkerke, while Cox & Snellt can explain 78%. The overall accuracy of the prediction model was 94.0%.

Mode choice probabilities for travel cost ranged from 98% likelihood of car use with current train total travel cost (RM = 50) to 30% likelihood of car use with a reduction in weekly train total travel cost (RM = 15). At the same time, the probability of train ridership increased from 2% with current train total travel cost of (RM = 50) to 70% of likelihood with a (RM = 15) reduction in weekly train total travel cost.

Thus, by promoting the appropriate policy, in relation to travel time and travel cost, one could provide opportunities for mode shifts among car users, which in return, will reduce their exposures and therefore, the risk of injury.

Table-3. Estimation results for binary logit models for car and train (n = 912).

All Trips				
	β	S.E.	P-value	$Exp\ (\beta)$
Age	1.08	.031	0.011	2.94
Gender	1.98	0.00	0.000	7.24
Travel time	-0.161	.005	0.000	0.85
Travel cost	-0.05	.032	0.005	0.95
Income	-0.823	.002	0.000	0.44
Car ownership	-0.765	.023	0.00	0.46
Constant	-0.1	1.20	0.000	
Summary of statistics				
Model chi-square /Sig,	288.67.			
(-2)log likelihood	180.15			
P-value for the Goodness of Fit Test. statistics	0.75			
Cox & Snell- R^2	0.78			
Nagelkerke	0.73			
Number of observations	912			

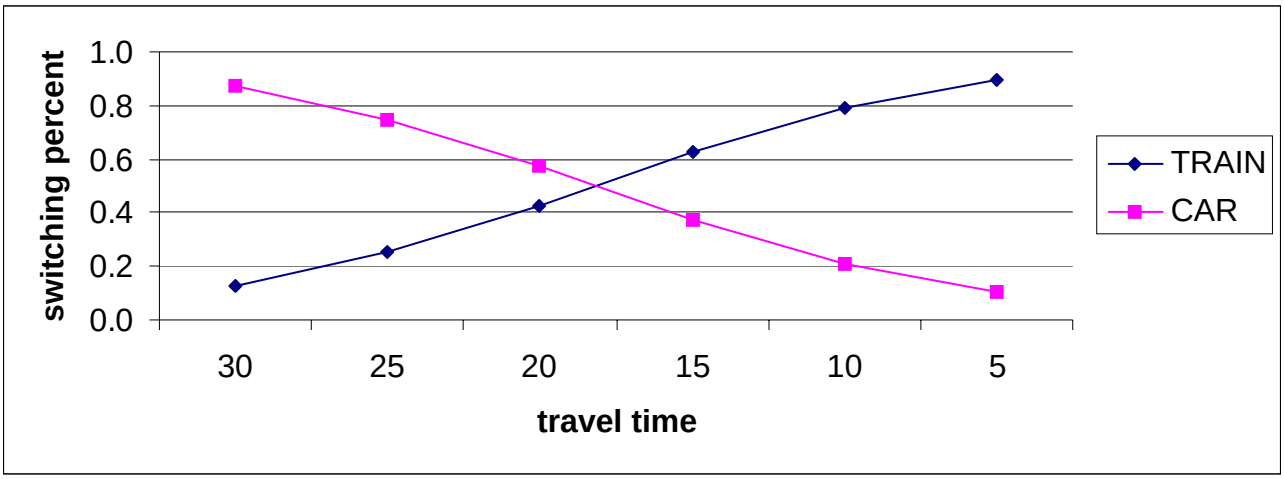

Figure-2. Effect of train travel time reduction on car users' mode choice probability (all trips).

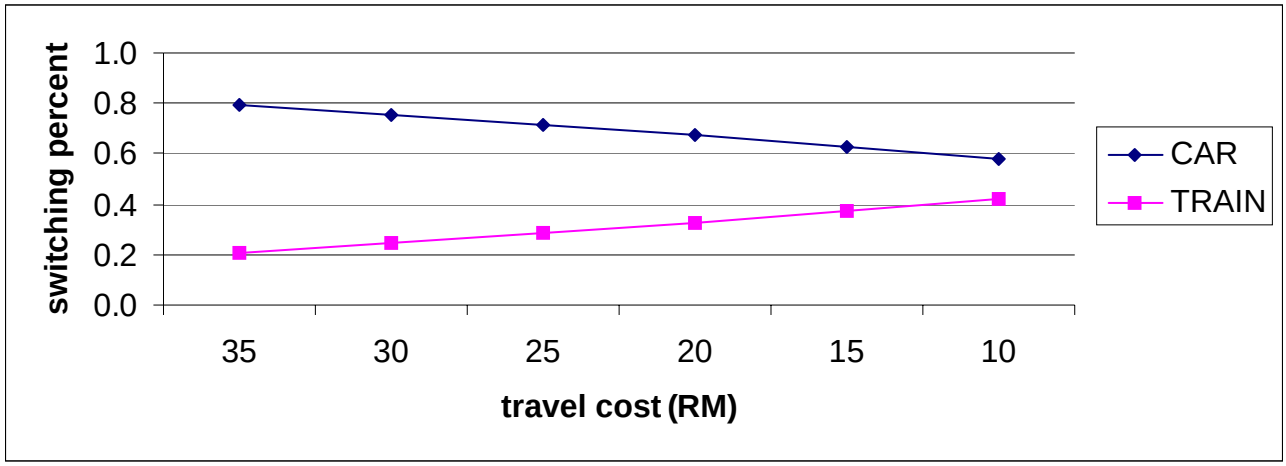

Figure-3. Effect of train travel cost reduction on car users' mode choice probability (all trips).

CONCLUSIONS

In order to promote greater use of public transport for all trips, this study examined the effect on car use if total bus and train travel time and travel costs were reduced. This was understood by solving the binomial logit equation for probability using several options of travel time and cost scenarios. The results suggest that travel time and travel cost are characteristics that determine why car use is a favored modal choice. In order to promote greater use of public transport and less dependence on car, an efficient public transport system is clearly needed. Higher capacity transit systems, use of bus lanes, bus gates, and ITS systems are among initiatives that could be implemented to improve the public transport system. The use of traffic restraint policies such as in France (Harrison *et al*., 1998), Australia (Black, 1996), Area Licensing in Singapore (Geok 1981) or London Road Pricing (Litman 2005) could further enhance a policy that promotes public transport; a policy that is moving towards a more sustainable transport system compared with total dependence on private vehicles. In summary, the most effective means of encouraging a switch from car to safer mode of transport is through reduced bus travel time.

In light of the above discussions, some reflection is necessary in relation to the modal split model for developing and newly developed countries. Although the tendency is more towards shifting to public transport, this has proven unsustainable, long-term, in the developed countries. As such, promoting a shift from car to an efficient public transport system would be advocated as a model in a sustainable transport policy in highly car-registered countries such as Malaysia. Although, in the short-term, the introduction of a comprehensive public transport system will require government infrastructure funding, such a system is sustainable and will result in higher road crash cost saving. Developing countries should not repeat the mistakes of earlier industrialized countries.

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