SITUATIONS OF OPTION : MODELLING WORKTRIP MODAL CHOICE IN KUALA LUMPUR

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abstract: The paper reports on a study undertaken by the author in Kuala Lumpur, Malaysia to attempt a better understanding of the mechanism of worktrip modal choice amongst local commuters. The model framework adopted relied upon Brog and Schwerdtfeger's premise that situative conditions of the user acts as a constraint making for the use of a particular mode of transport. Five logistic regression models were fitted to analyse the relationship between the various dependent variables and the selected socio-demographic variables for each situative condition. The conclusion is that a broader range of variables were influential at different stages of the choice process.

1. INTRODUCTION

Current patterns of use of transport modes in urban areas are the result of a large number of individual decisions. The worktrip serves as the link between an individual's place of residence and his workplace. Worktrips often represent the largest proportion of peak-hour traffic composition. Their effects on the performance of the urban transport system are significant. Peak-hour traffic determines, to a large extent, the required capacity of the infrastructure. Worktrip characteristics constitute an important element of urban travel patterns because of their essential nature and also because of their tendency to be subject to an asymmetric time-distribution. In addition, other activities may be performed during the course of the worktrip, for example, giving lifts to schoolchildren or even shopping. Restrictions upon work practices often meant that worktrips cannot be significantly altered in terms of timing of journeys. Hence, studies on worktrips could provide urban transport authorities with useful information on which to base their transport investment and pricing policies.

The urban transport problem is aggravated by the trend towards using private motorised modes of travel, predominantly the car, rather than by public transport. Public transport use is often seen as less convenient compared to the car. However, due to its greater efficiency in terms of people carried per unit of transport supplied, commuters need to be encouraged to use some form of public transport especially for peak-hour travel. This suggests that effective policies should be adopted to influence individual decisions on choice of transport mode. This necessitates the investigations of methods that may encourage the use of alternative modes to the private car, where viable alternatives exist.

The aim would be to isolate the prime variables influencing travellers' modal choice and then to so alter the characteristics of public transport modes available that they become relatively more attractive to travellers than private transport.

Various short-term and medium-term measures have been adopted aimed at modifying modal split. The measures undertaken ranged from the introduction of new public transport services, fare adjustments, bus priority schemes right up to restrictions in private vehicle movements. However, the effectiveness of these policies vary widely between urban areas and clearly they are not directly transferable to different situations. In order to effect a desired shift of modal usage towards public transport, it is essential to obtain a better understanding of the reasons which motivated the choice of private transport. Considerable knowledge has been obtained from the traffic studies carried out by consultants regarding the descriptive characteristics of travel demand, relating for example, to peak-hour traffic volumes on heavily used routes, even in the developing countries. What is lacking are attempts made towards understanding the reasons for travel behaviour. What is really needed is an understanding of the underlying socio-economic processes affecting individual choice decisions, expressed in terms of transport user behaviour.

The primary objective of the research described in this paper was to obtain a better understanding of the factors responsible for determining an individual's choice of travel mode for the worktrip in the context of Kuala Lumpur. The Federal Territory of Kuala Lumpur, the capital city of Malaysia, is located in the Klang Valley Region which is the most densely-populated region in Malaysia. A robust national economy and the rapidly-growing metropolitan population has meant that more roads has to be built to accommodate the growth in traffic. The rapid economic growth has also meant an increase in demand for public passenger transport. Bus public transport in Kuala Lumpur is faced with heavy demand, especially during peak-hours. The operators, which include some small undertakings with limited resources, have also had to cope with increasing operation costs. Before 1996, stage carriage buses provided the major means of public transport within Kuala Lumpur and the region. A lot of proposals have been made in order to cope with heavy public transport passenger demand since the 1980s. It was, however, only recently that a major policy shift went underway with the introduction of other public transport modes such as the Light Rail Transit, high-speed commuter rail services and the soon-to-be-implemented monorail service.

Recent consolidation of the bus-operating industry has now led to two operators, both subsidiaries of public-listed companies, running bus public transport services instead of the former eight smaller bus companies. In the case of the rail-based public transport services, two companies obtained concessionaires to provide two different Light Rail Transit systems. The newly -corporatised Keretapi Tanah Melayu Berhad , formerly the Malayan Railway, is providing a more regional passenger rail transport services. Another public transport service to be offered is the People-Mover Rapid Transit System, basically a monorail system offering an intra-urban service developed in conjunction with an integrated city-over-the-river multi-billion Kuala Lumpur Linear City development project.

Data for this study was obtained by conducting a worktrip travel survey in selected areas of Kuala Lumpur. The main theme of the survey centred on details of travel modes and the characteristics of their use for worktrips undertaken by the employees of industrial,

commercial and institutional establishments. Apart from journey details, the information collected included such aspects as circumstances under which a particular mode was used, access to private and/or public transport facilities and some transport system performance indicators. In this survey, the status of car availability of respondents was based upon an affirmative response to the question: 'Do you have a car/private van which you could have used, if you had wished, to travel to work, either as a driver or passenger, this morning?' This method of assessment was based on the assumption that the respondent would be in the best position to know his own situation as to whether he had access to a car or not.

This paper begins with a short review of the situation of option approach to explanation of modal choice behaviour first developed by Brog and Schwerdtfeger. In the next section, using the survey data, a model was estimated based upon the traditional treatment of modal choice as the relationship between modal type used and a few selected independent variables. In the fourth section, the modal choice situation was broken down into particular situative conditions. Different variables were found to be influential at various stages of the modal choice decision-making processes. The conclusion to be drawn from the analysis is that a much broader range of variables were influential in determining the circumstances leading on to actual modal use.

2. MODEL FRAMEWORK

The main hypothesis of this study is that an individual traveller's choice of mode for the worktrip is determined by situative conditions within which the choice was made. This hypothesis leaned heavily upon the theoretical framework developed by Brog and Schwerdtfeger (1977). Brog and Schwerdtfeger reported that a situation of option is essentially determined within three basic dimensions; firstly, supply of transport alternatives; secondly, socio-demographic determinants; and thirdly, subjective attitudes. Firstly, the dimension of supply of transport alternatives refer to the availability of public transport for travel and individual transport facilities (in the form of the possession of driving licence and car) respectively. In attempting to explain a modal choice decision, one needs to differentiate between transport users according to whether public transport users had a car available or whether reasonable public transport facilities (as regards journey time and costs) are available for car users. In other words, one needs to ascertain whether a real alternative is available. For some private motorists, they may be completely unaware that public transport exists between their homes and workplaces. Hence, no careful evaluation of alternatives to the private car is made.

Secondly, we are also concerned with identifying material constraints which make for the use of a particular modal type. The socio-demographic determinants, referred to as the material constraints, could frequently limit an otherwise subjective situation of option. Examples of material constraints for the use of the private car includes the necessity of using the car at work, irregular working hours at the workplace which may prevent or make the use of public transport difficult, the necessity of performing extra activities at work or on the worktrip , or health reasons such as physical disabilities. On the other hand, the two main material constraints making for the use of public transport are that the (although in principle, available) family car is being used by other household members and the unavailability of suitable parking facilities at the workplace. Knowledge of the available transport alternatives is also acknowledged by Brog and Schwerdtfeger as a constituent

feature of the situation of option. In their research, Brog and Schwerdtfeger found that private car users were frequently unaware of public transport routes and stops, and in many cases there is total ignorance of public transport connecting services.

Thirdly, we should also isolate travellers who have no subjective possibility of choice, that is, those who may have personal prejudices against an alternative mode of transport. Thus, the third dimension identified is that of subjective attitudes. Comparison between public and private modes often proved decisively in favour of the private car. There seems to be a contrast in images between the two in terms of sense of ownership, relative freedom of use, prestige and comfort. The private car was often seen as a time-saving mode, no time was spent waiting and changing which were subjectively felt to last much longer especially in bad weather, freedom from fixed routes and timetables, convenience with no crowding and certainty of a seat, and its use involves prestige and pleasure of driving. For private car users, there was little willingness to transfer to the use of public transport.

Brog and Schwerdtfeger noted that there is a final group of travellers for whom, both objectively and subjectively, the use of either mode is equally possible. They include the commuters who use private cars despite their knowledge of actual alternative modes of transport available, and even though their choice is not restricted by material or personal reasons. They are referred to as the 'car-fixated' group. Then there are the commuters who abstain from using the private car, despite its availability and even though they are not under material or personal pressures to use public transport. They are known as the 'abstainers' group. As far as Brog and Schwerdtfeger were concerned, this group forms the real object of enquiry into the parameters of user behaviour.

Figure 1 shows the framework for modal choice explanation as put forward by Brog and Schwerdtfeger to illustrate the need for a thorough knowledge of the individual situation which leads to the choice of mode of travel. In their example of the modal choice between private car and public transport by commuters, the individual situation of option is defined by various factors arising from the three basic dimensions described above. Figure 1 helps to determine for every individual traveller whether firstly, he has an objective possibility of choice, secondly, whether he is subject to material constraints, thirdly, whether he is adequately informed about the objectively available alternatives, and finally, whether he considers all alternatives to be subjective possibilities of choice or not. Figure 1 shows that causal explanations for the modal choice of individuals can be detected at every stage of the decision-making process, that is, situative conditions act as a constraint making for the use of a specific mode of transport.

This meant that for the individuals concerned they would frequently be unresponsive to policy measures which do not aim at the limiting conditions precisely. Brog and Schwerdtfeger suggested that reductions of public transport fares or travelling times would be deemed irrelevant for those individuals who do not have any public transport facilities on their origin/destination routes, or those who are dependent upon the use of their private car at the workplace due to professional material constraints. On the other hand, it could also be determined which individuals would gain new choice options if certain policy measures are instituted. Brog and Schwerdtfeger thus had made an important step towards the formulation of a policy-sensitive model. The author decided to adopt the model structure into the scheme of study as the model appears to be fundamentally sound and easily applicable.

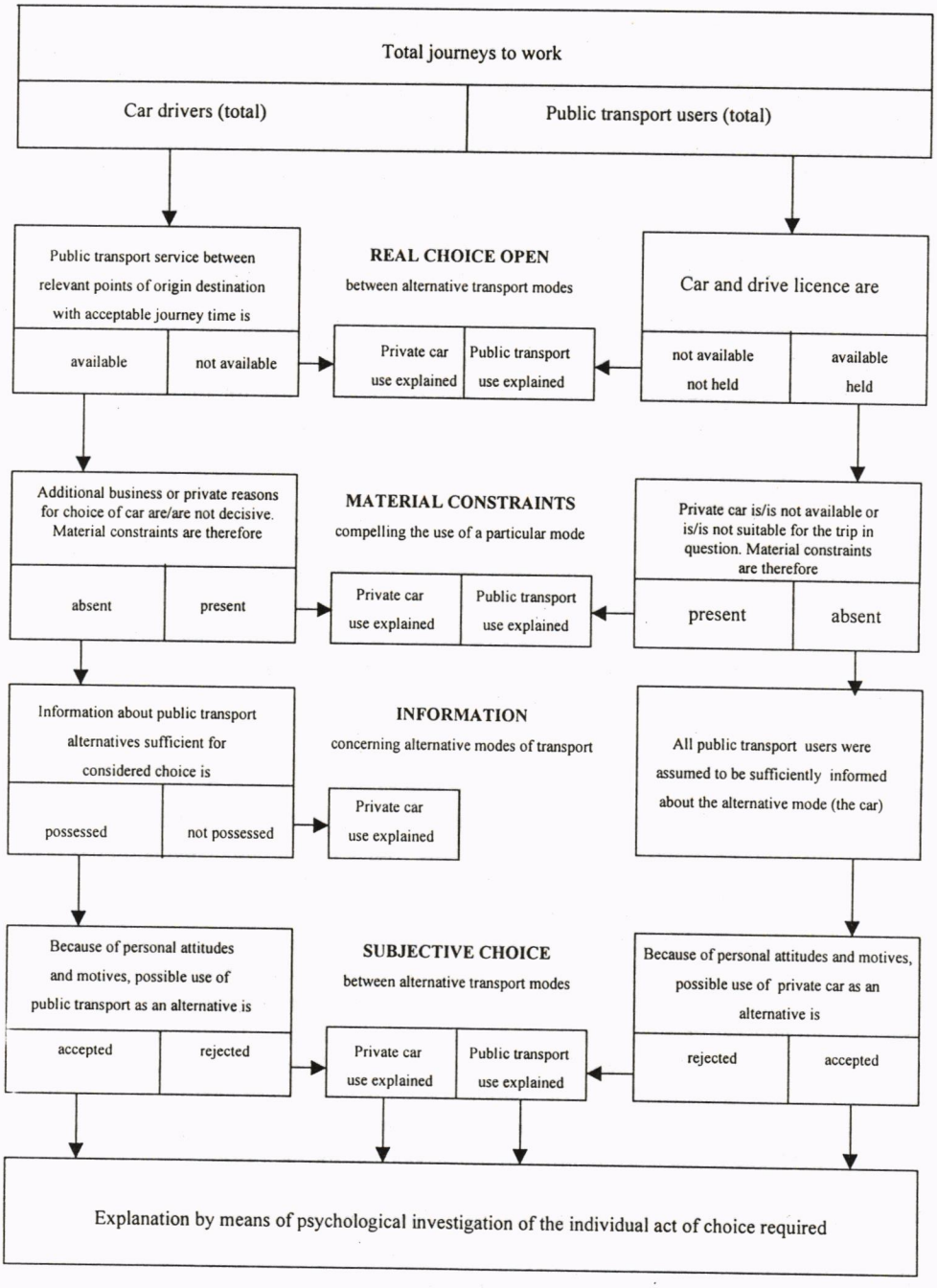

Figure 1 Explanation of modal choice by reference to individual situations of option

Source: Brog and Schwerdtfeger, 1977

Using the empirical findings of the worktrip travel survey, the main hypothesis was tested by breaking it down into a number of specific questions. This author then proceeded to determine the variables influential at the three main stages of the situative condition model. On the basis of their significance, the variables were selected and later incorporated into models aimed towards explaining particular situations of option. In the next section, five logistic regression models were fitted to analyse the relationship between the various dependent variables (one for each model) and the selected independent variables for each situative condition. The five models were selected after a number of trial runs with various versions of the model in order to find the model of best or most reasonable fit.

Finally, in this section, the variables which were used to indicate the various situations of options would be identified. Regarding objective freedom of choice, variable GOTCAR [car available] would indicate whether a car was available for use for the worktrip while variable BUSAV [bus available] would indicate whether a suitable bus service was available for the worktrip between the relevant points of the individual's trip movements. Variables which yielded information regarding the presence or absence of material constraints were NOTUSE (not used) and PRFCAR (prefer car). Variable NOTUSE refer to the reason offered by a particular respondent regarding the non-use of the available car for his/her worktrip. On the other hand, PRFCAR refer to the main reason identified by the respondent for choosing the private car over the available bus service for his/her worktrip. Both variables NOTUSE and PRFCAR were used again to identify subjective freedom of choice as certain responses selected by the respondents would indicate whether they had subjectivity of choice.

Using the model structure adopted, ultimately all individual users would fall into groups depending upon their situations of options (refer Figure 2). In Figure 2, the modal choice situations of group types are differentiated by either rectangular or oval enclosures. The oval enclosures represent the groups of respondents whose modal choice decision has been explained. Table 1 gives the breakdown by number of respondents for each group type. Taking the case of private car users, 673 respondents were in a position of having objective freedom of choice to decide between using the car for the worktrip or opting instead for the available public transport service. Group 1 therefore comprised of choice users of private transport unlike the 151 respondents in Group 0 who were captive users of the private car as they had no alternative public transport service to choose from. The evidence before us shows that while only 18 per cent (151/824) of private car users were captive users of their mode, 85 per cent (840/990) of public transport users were captive users of their respective public transport mode. It indicates that an overwhelming majority only used public transport due to the unavailability of the private car for their use.

Although 673 respondents were considered as choice users at the first stage, 503 of them had to contend with using the private car due to material constraints associated with the use of the available bus service. Only 170 respondents as represented by Group 10 had no material constraints making for the use of the private car. The final stage relating to subjective freedom of choice indicate that all 170 respondents had no subjective freedom to choose the use of public transport due to their attitudes towards the public transport service.

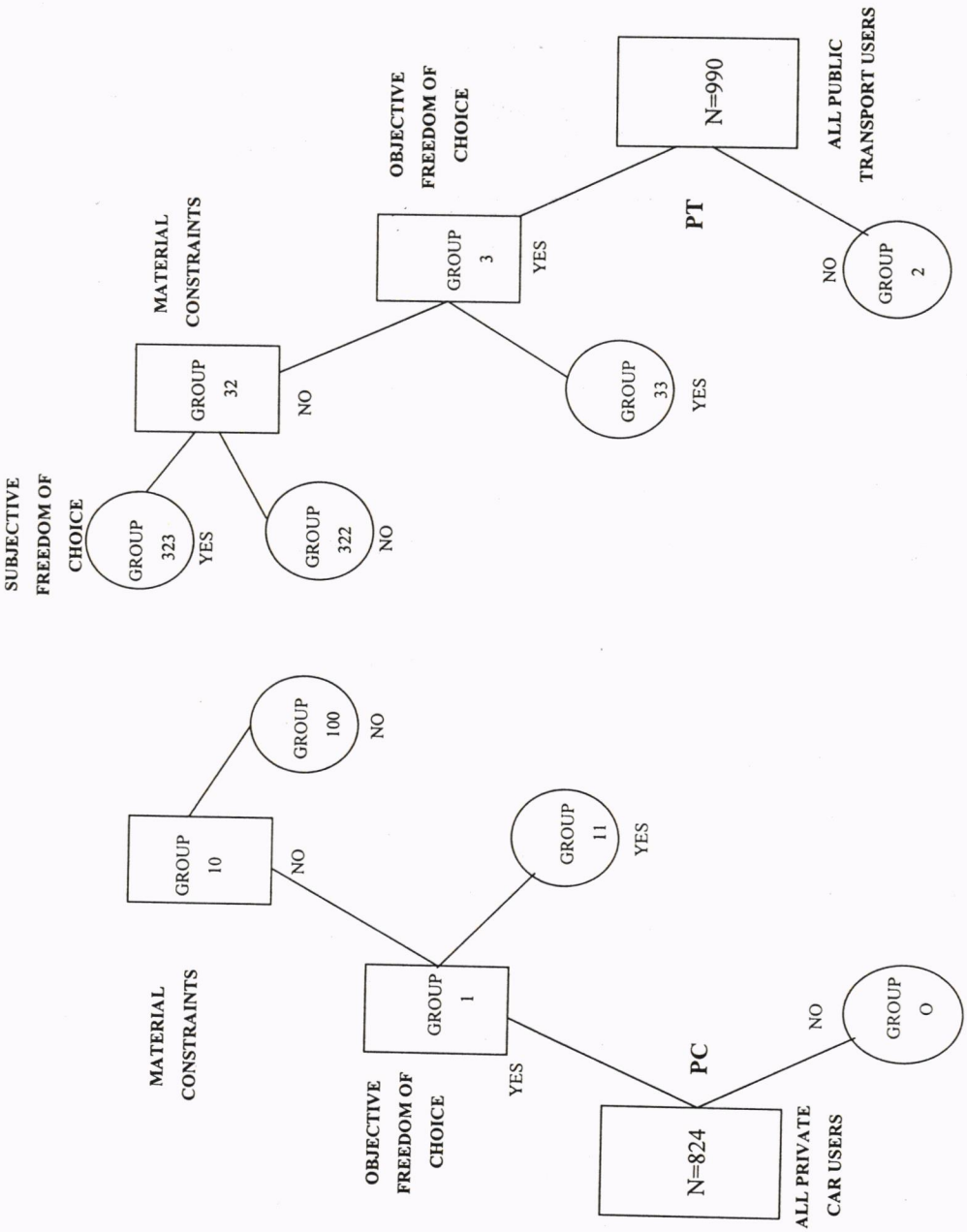

Figure 2 Model of situations of modal choice (by group types)

Table 1 Number of respondents by group type

Private Car Users	(N=824)	Public Transport Users (N=990)	
Group Type	Number of respondents	Group Type	Number of respondents
GROUP 0 - Users with no objective freedom of choice (no alternative public transport service)	151	GROUP 2 - Users with no objective freedom of choice (no alternative car available)	840
GROUP 1 - Users with objective freedom of choice (can use either car or bus)	673	GROUP 3 - Users with objective freedom of choice (can use either bus or car)	150
GROUP 11 - Users with material constraints associated with use of available bus service	503	GROUP 33 - Users with material constraints associated with use of available car	128
GROUP 10 - Users with no material constraints	170	GROUP 32 - Users with no material constraints associated with use of car	22
GROUP 100 - Users with no subjective freedom to choose public transport due to their attitudes	170	GROUP 322 - Users with no subjective freedom to choose the car because of attitudes towards using the car	11
		GROUP 323 - Users who have subjective freedom in choosing to use the car but abstain	11

On the other hand, a total of 990 respondents were public transport users. Only 150 of them had objective freedom of choice to decide between using the available car or public transport mode for the worktrip. In contrast, Group 2 comprised of 840 respondents who had no car availability status, hence determining their modal choice status. Group 33 comprised of 128 respondents who faced material constraints in using the available car while 22 respondents had no material constraints. Out of these 22 later respondents, 11 had no subjective freedom in choosing between the two modal types due to their attitudes

towards using the private car. The other half professed to having subjective freedom of choice towards using private transport but still abstained from using the available car for their worktrip. Group 323 may be considered as the private transport abstainer's group.

It is interesting to note that all 170 respondents who were choice users of the private car mode and had no material constraints attached to the use of public transport expressed the lack of subjective freedom in their choice of mode (i.e. group 100). It should also be noted that 85 per cent of public transport choice users (i.e. 128/150) had to resort to the use of public transport due to the presence of material constraints in using the private car.

3. WORKTRIP MODAL CHOICE:TRADITIONAL ANALYSIS

According to the framework of modal choice outlined above, a given situative condition is determined by a quite specific set of variables. In order to determine a particular situation empirically, data relating to the socio-demographic structure of the individual, and to a certain extent his household, as well as subjective attitudes, is required. The worktrip travel survey yielded the variables which were required in the quantification of the model. The travel survey questionnaire had been organised in sections with only 1 section common to all respondents. 21 variables, mostly socio-demographic ones, were derived from the general section. The second section, Section A, was meant for those users who had travelled to work by private cars/vans, either as drivers or passengers. Eleven variables were derived from Section A. All bus public transport users had to complete Section B of the questionnaire which contributed 14 variables.

It is hypothesised that the socio-demographic characteristics affect the outcome of the situative conditions mentioned above (refer Table 1). Crosstabulations of two variables were carried out whereby the row variables in each case comprised of the socio-demographic characteristics while the column variables were the categories associated with the situative conditions. The row percentages were selected to gather information regarding the relationship between the two variables. Other statistical indices used to assess the relationship between chosen variables include the Pearson chi-square, Goodman and Kruskal's lambda and the Pearson correlation coefficient.

In the first instance, thirteen socio-demographic variables were cross-tabulated with the mode used by the respondents in their worktrips. The modal types considered was limited to two, that is, private motorised and public motorised transport. All but one of the thirteen variables had an observed significance level of 0.0000. Since the observed significance level is very small, the hypotheses that the socio-demographic characteristics and modal type are independent are rejected. However, the lambda values obtained showed that only variable GOTCAR (representing car availability status of respondent) was of substantial help (0.51889) in predicting the modal use type represented by variable MODE as the dependent variable. Other variables that were of some help in predicting MODE were MCAR (representing household car ownership) (lambda value = 0.29201) and WAGE (representing monthly salary/wage of respondent) (lambda value = 0.25287). In terms of the value of the Pearson correlation coefficient, the largest value of 0.55379 is obtained by variable GOTCAR which indicate the possibility of a linear relationship between the two variables GOTCAR and MODE. Pearson's r was also quite substantial (0.41115) for variable WAGE except that the relationship is a negative one.

Variables GOTCAR, MCAR and WAGE were selected as the most significant factors influencing modal usage and would be incorporated into the logistic regression model.

A more rigorous technique is then adopted to analyse the relationship between a particular dependent variable and the several independent variables which had been identified as being significant. The logistic regression technique selected here is a common method used to model relationships between the binary response variable and several explanatory variables which may be categorical (discrete) or continuous. The logit model examines relationship between dependent and independent variables by analysing the expected odds of a dependent variable as a function of independent variables. An odds is the ratio of the frequency of being in one category and the frequency of not being in that category. The logarithm of the ratio of the two frequencies is called a logit. In logit models, the logit, or log odds, that the dependent variable has a specified value is a linear function of the independent variables. An appeal of the logistic transformation of the dependent variable is that it transform the problem of predicting probabilities within a (0, 1) interval to the problem of predicting the odds of an alternative being chosen within the range of the entire real line (from minus infinity to infinity) (refer Hensher and Stopher, 1979). In the modelling exercises below, the aim would be to locate the best fit to the observed data guided by the adopted theoretical framework. The logit regression analyses were run on SAS statistical package using the CATMOD (categorical modelling) procedure.

In the first instance, the logistic regression model is used to analyse the relationship between the modal type used in the worktrip (whether private or public transport) and the selected independent variables a, b and c (i.e. GOTCAR, MCAR and WAGE) respectively. The GOTCAR variable is a binary variable with value 1 if `car was available for use for worktrip' and a value of 2 if otherwise. Variable WAGE represents the monthly salary of the respondent. Variable WAGE has three categories; the first category represents a monthly salary of RM (Malaysian Ringgit) 400 or below, the second category represents RM 401-800 while the third category represents a salary of RM 800 or above. The third variable MCAR represents the number of motorcars owned by the respondent's household, again with three categories. The first category represents zero car ownership, the second represents 1-car households while the third category represents multiple-car-owning households. The model specified is in the form y=a c b*c which indicates that only the main effects of a and c and the interaction effect between variables b and c are to be included as parameters. The maximum-likelihood analysis of variance table shows that the model specified fits since the likelihood-ratio goodness-of-fit test is non-significant. It shows that variables GOTCAR and WAGE were significant factors with respect to the type of mode used for work travel. The interaction between variables MCAR and WAGE is also significant (refer Table 2).

The positive coefficient of a in the table of estimates shows that the first level of GOTCAR (which refers to car-available status) has a larger probability of using the car than the second level of GOTCAR (i.e. no-car-availability status). This meant that respondents who have a car at their disposal are more likely to travel by car than those who do not. On the other hand, the negative coefficient associated with the first level of c (monthly wage of RM400 or below) meant that they have a smaller probability of using the car than the third level of variable WAGE (RM800 and above). In other words, high-income respondents are more likely to use the car than other categories of respondents.

Table 2 Maximum likelihood analysis of variance table

Source	DF	Chi-square	Probability
Intercept	1	2.42	0.1199
a (GOTCAR)	1	124.16	0.0000
c (WAGE)	2	70.46	0.0000
b *c (MCAR*WAGE)	4	55.83	0.0000
likelihood ratio	9	3.22	0.9549

Table 3 Analysis of maximum likelihood estimates

Effect	Parameter	Estimate	Standard Error	Chi-square	Probability
Intercept	1	1.0496	0.6749	2.42	0.1199
a	2	2.5693	0.2306	124.16	0.0000
c	3	-2.0875	0.6993	8.91	0.0028
	4	-0.6721	0.6925	0.94	0.3318
c*b	5	2.3018	0.3377	46.46	0.0000
	6	-1.2374	0.2357	27.57	0.0000
	7	1.5679	0.3137	24.99	0.0000
	8	-0.8642	0.1879	21.15	0.0000

In the overall analysis of car use, the results indicated that car availability status of respondents was the major determinant of using the car for work travel. Results show that car availability at the individual level is more significant than the household car ownership variable in influencing the use of mode of travel to work. The survey data revealed that 97.3 per cent of respondents in a car-available situation had used the car to make the worktrip either by driving or as passengers. This finding generally conforms with a finding from a much-earlier study by Lucarotti (1977) in Cambridge, United Kingdom that the rate of use of cars, when they are available, varied relatively little. As an example, although the level of car availability ranged between 32 per cent (for women in the lowest occupational group) and 98 per cent (for men in the highest occupational group), the rate of use only varied between 83 per cent to 93 per cent.

4. WORKTRIP MODAL CHOICE: SITUATIVE OPTIONS

In this section, an attempt was made to classify individuals according to their respective socio-demographic situations and to explain their worktrip patterns of behaviour in the context of these situations. This analysis fits into the theoretical framework explained in Table 1. The models would determine the variables influential at the three main stages of the situative condition model; i.e. firstly, supply of transport alternatives (factors determining car availability for public transport users and factors determining bus availability for private transport users); secondly, socio-demographic determinants (factors

determining presence of material constraints for use of car and likewise, the bus); and, thirdly, subjective attitudes towards use of car.

4.1 Bus availability model

Based upon the crosstabulation between socio-demographic characteristics and bus availability status (variable BUSAV) of respondents, it was found that eight out of eleven variables had an observed significance level larger than 0.02. Only the observed significance level for variables ORGN (worktrip origin) and MCAR (household car ownership) are smaller than 0.01 which meant that the hypotheses that the two socio-demographic variables and bus availability status are independent can be rejected. It is postulated that trip origin of respondents might determine the likelihood of respondents having an alternative public transport service in the sense that certain areas are more likely than others to have a public transport service. It is likely that respondents from multiple-car-owning households would opt to live in areas that have poor public transport service as these respondents were not likely to depend upon public transport as their means of travel to work. Attractiveness of residential location is deemed to be more important than the consideration of public transport availability. The Pearson correlation coefficient obtained for variable MCAR is 0.10411. The positive value associated with Pearson's r suggest that respondents from multiple-car-owning households are less likely to have access to an alternative public transport service.

In this case, the logistic regression model is used to determine the relationship between bus availability status of respondent and the selected independent variables a and b (i.e. ORGN and MCAR respectively). The ORGN variable represents the zone of worktrip origin represented by three categories (i.e. the first category refers to the central zone, the second category refers to both the inner and intermediate zones while the third category refers to the external zone. The bus availability model specified was of the form y= a b which indicates that only the main effects of a and b were to be included. The maximum-likelihood analysis of variable table shows that the model specified fits since the likelihood-ratio goodness-of-fit test is non-significant (i.e. having a value of 0.4177) (refer Table 4). Referring to the maximum-likelihood estimates table, the negative coefficient associated with the first level of a (which refers to central zone-originated worktrip) meant that those who originated from the central zone had a smaller probability of having a bus transport service as an alternative compared to those originating from inner-intermediate and external zones (refer Table 5).

The positive coefficient associated with the first level of MCAR is not significantly different from 0 at the 0.10 significance level. On the other hand, the positive coefficient associated with the second level of MCAR (which refers to one-car owning households) meant that respondents from such households have a larger probability of having an alternative public transport service than the third level of MCAR (i.e. multiple-car-owning household). The third coefficient associated with variable MCAR is negative as all the three coefficients have to add up to zero.

Table 4 Maximum likelihood analysis of variance table

Source	DF	Chi-square	Probability
Intercept	1	38.77	0.0000
a (ORGN)	2	8.99	0.0112
b (MCAR)	2	16.37	0.0003
likelihood ratio	4	3.91	0.4177

Table 5 Analysis of maximum likelihood estimates

Effect	Parameter	Estimate	Standard Error	Chi-square	Probability
Intercept	1	1.0439	0.1676	38.77	0.0000
a (ORGN)	2	-0.5641	0.2393	5.56	0.0184
	3	0.4257	0.1604	7.04	0.0080
b (MCAR)	4	0.0297	0.2222	0.02	0.8936
	5	0.3835	0.1441	7.08	0.0078

4.2 Car availability model

Crosstabulation between socio-demographic characteristics and car-availability status of respondents (GOTCAR) showed that both variables LESEN (number of driving licences owned by respondent's household) and MCAR (household car ownership) have an observed significance level of 0.0000. The LESEN variable refers to the number of driving licences owned by the respondent's ho'sehold. The LESEN variable has three categories, that is, the first category refers to the none-licence-holding households, the second represents 1-licence-holding households while the third category represents mulitple-licence-holding households. Both the hypotheses that LESEN and GOTCAR and MCAR and GOTCAR respectively are independent can be rejected. Likewise the observed significance level for WAGE (0.0073) is small enough for the hypothesis that WAGE and GOTCAR are independent to be rejected. Referring to the Pearson correlation coefficient, the largest value obtained is 0.63215 for variable MCAR which might indicate the possibility of a linear relationship between MCAR and GOTCAR. The negative value associated with Pearson's r indicates that these respondents from non-car-owning households were likely to find themselves in a position of no-car-availability for the worktrip and the reverse is true for respondents from multiple-car-owning households. Pearson's r was also quite substantial for variable LESEN (-0.35906) and the relationship is a negative one whereby respondents from multiple-licence-holding households were more likely to have a car available for the worktrip compared to those respondents from non-licence-holding households. Therefore, all three variables, MCAR, LESEN and WAGE were selected as significant factors influencing car availability status.

The logistic regression model is used in this case to analyse the relationship between the car availability status of the respondent and the selected independent variables a, b and c (i.e. MCAR, LESEN and WAGE respectively). The car availability model specified was of the form y=a which indicates that only the main effect of a was to be included. The analysis of variance table shows that the model specified fits as the likelihood-ratio goodness-of-fit test is non-significant (i.e. having a value of 0.6924). Thus variable a (MCAR) was a significant factor influencing car availability status of respondents.

Referring to the maximum-likelihood estimates table, the negative coefficient associated with the first level of a (which refers to non-car-owning household) meant that those respondents from the household type had a smaller probability of having a car available as an alternative compared to those respondents from one-car-owning or multiple-car-owning households.

Table 6 Maximum likelihood analysis of variance table

Source	DF	Chi-square	Probability
Intercept	1	44.57	0.0000
a (MCAR)	2	64.51	0.0000
likelihood ratio	13	10.02	0.6924

Table 7 Analysis of maximum likelihood estimates

Effect	Parameter	Estimate	Standard Error	Chi-square	Probability
Intercept	1	-1.7180	0.2573	44.57	0.0000
a (MCAR)	2	-3.8730	0.4832	64.25	0.0000
	3	1.8565	0.2691	47.61	0.0000

4.3 Public Transport Use Constraints Model

From the crosstabulation between socio-demographic characteristics and the status categories (that is whether constraints are present or absent) of public transport use (referred to as variable MATCON) , it was found that all but one of the eleven variables had observed significance levels greater than 0.05. Only the observed significance level for variable POSN (0.0044) is small enough for the independence hypothesis to be rejected. It is thus inferred that variable POSN (representing respondent's position in the household whether as head of household (first category), wife to head of household (second category) or ordinary member as the third category) has an influence over the presence or otherwise of material constraints in the use of public transport. Referring to the Pearson correlation coefficient, the largest value obtained is 0.12375 for variable POSN. The positive value associated with Pearson's r suggest that respondents who are head of household were more likely to face material constraints in using public transport than other members of the

household. Whether the presence of material constraints were more imaginary than real could not be determined. Based upon the Pearson's correlation coefficients, both variables POSN and WAGE were selected for incorporation into the logistic regression analysis.

In this instance, the logistic regression model is used to analyse the relationship between the presence or absence of public transport use constraints referred to as variable MATCON and the selected independent variables a and b (i.e. POSN and WAGE respectively). The model specified was of the form y = a b which indicates that only the main effects of a and b were to be included in the model. The maximum- likelihood analysis of variance show that the model specified fits as the likelihood goodness-of-fit test is non-significant (i.e. with a value of 0.7366). From the maximum-likelihood estimates table, the positive coefficient associated with the first level of A (which refers to the head of household status) meant that the heads of households had a larger probability of facing material constraints in the use of public transport than do the other two categories of respondents. The negative coefficient associated with the second level of variable b meant constraints in the use of public transport. that those earning between RM 401-800 have a smaller probability of facing material constraints in the use of public transport.

Table 8 Maximum likelihood analysis of variance table

Source	DF	Chi-square	Probability
Intercept	1	27.26	0.0000
a (POSN)	2	6.82	0.0331
b (WAGE)	2	5.16	0.0760
likelihood ratio	4	2.00	0.7366

Table 9 Analysis of maximum likelihood estimates

Effect	Parameter	Estimate	Standard Error	Chi-square	Probability
Intercept	1	1.8404	0.3525	27.26	0.0000
a (POSN)	2	0.3340	0.1381	5.85	0.0156
	3	-0.0626	0.1288	0.24	0.6268
b (WAGE)	4	-0.6521	0.3928	2.76	0.0969
	5	-0.8092	0.3572	5.13	0.0235

4.4 Private Car Use Constraints Model

The crosstabulation between socio-demographic characteristics and the status categories (i.e. whether constraints are present or absent) of private car use constraints (referred to as variable USECON found that the majority of the variables had observed significance levels greater than 0.0000. The smallest observed significance level is 0.1207 for variable MCAR, followed by 0.1440 for variable LESEN. Pearson correlation coefficient values obtained were also small. The largest value of 0.15934 obtained was for variable LESEN

followed by 0.09596 obtained by variable POSN. Positive values of Pearson's r were recorded for both variables LESEN and POSN. The positive value associated with Pearson's r for variable LESEN indicates that those respondents from non-licence-holding households were likely to be those with material constraints in using private car. Variables LESEN and POSN were selected for incorporation into the selected model.

Here, the logistic regression model is used to analyse the relationship between the presence or absence of private car use constraints referred to as variable USECON and the selected independent variables a and b (i.e. LESEN and POSN respectively). The model specified was of the form y= a b which indicates that only the main effects of a and b were to be included in the model. The maximum-likelihood analysis of variance table shows that the model specified fits as the likelihood-ratio goodness-of-fit test is non-significant (i.e. with a value of 0.9249). From the maximum-likelihood estimates table, the positive coefficient associated with the first level of a (which corresponds to non-licence-holding household) meant that respondents from such households had a larger probability of facing material constraints in the use of the private car than do the other two categories of respondents.

Table 10 Maximum likelihood analysis of variance table

Source	DF	Chi-square	Probability
Intercept	1	72.84	0.0000
a (LESEN)	2	.	.
b (POSN)	2	2.05	0.3586
likelihood ratio	2	0.16	0.9249

Table 11 Analysis of maximum likelihood estimates

Effect	Parameter	Estimate	Standard Error	Chi-square	Probability
Intercept	1	4.2288	0.4955	72.84	0.0000
a (LESEN)	2	3.3795	.	.	.
	3	-0.9673	0.3906	6.13	0.0133
b (POSN)	4	1.0157	0.7125	2.03	0.1540
	5	-0.6095	0.4920	1.53	0.2154

5. CONCLUSION

A summary of the findings is attempted in this concluding section. Firstly, if the situation of modal choice was treated traditionally, it was found that variables GOTCAR, WAGE and the interaction effect between the variables WAGE and MCAR were influential factors in determining whether an individual travelled by private motorised transport or public transport. Nearly 85 per cent of those respondents who were in the car-available category travelled by private transport. The other 15 per cent who had although claimed that they had a car available at their disposal, chose or for various reasons, had to travel by

other public motorised or non-motorised modes. It must be remembered that the measure of availability adopted in this research is based on the perception of the respondent. It could be said then that the availability of a car is crucial to its use.

Secondly, the modal choice situation had been broken down into particularly situative conditions. It was found that different variables were influential for particular situative conditions. Variables ORGN (worktrip origin) and MCAR (household car ownership) were significant factors determining the bus availability status of respondents. It was expected that variable ORGN would influence bus availability as the residential location of respondent was important in deciding whether bus public transport was available as not all areas are well-served by public transport. What was surprising perhaps was that variable MCAR had a significant effect on bus availability status. The effect is indirect in the sense that those respondents who owned their own transport may not be too bothered to choose residential locations which are well-served by public transport.

Variable MCAR was the most significant factor determining the car availability status of respondents. The survey data revealed that 45 per cent of the respondents had a car available which they could have used for their worktrip, compared to 53 per cent who did not, and another 2 per cent who were uncertain of their status. Out of those who comes from non-car-owning households, 93 per cent did not have a car available while 7 per cent claimed that they had a car available for their worktrip. The majority of such respondents in this group actually travelled as car-passengers. As for those from one-car-owning and multiple-car-owning households, 88 per cent and 90 per cent respectively claimed they do not have access to the use of a car. Hence, a significant proportion of members of car-owning households do not have a car available as the car was being used by another member of the family who has priority to its use over them.

As regards to material constraints in using a particular mode, variable POSN was found to be significant in influencing the presence or absence of material constraints in using the available public transport service. It could be inferred that individuals in certain positions of responsibility within the household structure tended to travel by private transport as they might need to perform worktrips of such nature that are not limited by schedule or route constraints of a public transport service. It was found that heads of households were generally more disadvantaged in terms of car demand constraints as opposed to other status groups. This meant that while improvements in public transport service would remove most of the supply characteristic constraints, it would not be able to remove car demand constraints which particularly afflict the heads of households.

This finding relates to the work of V. Oster Jr who investigated the use of workplace-related trips to visit non-work destinations in order to obtain savings in time and money cost in travel. This suggest that account should be taken not only of the 'objective' transport components, which an individual faces, but also the characteristics of the way of life (family, job) which rule the organisation of time and space by the individual. As heads of households, these individuals bear great responsibilities and that might explain why they were more constrained to use their car more than others.

The conclusion that could be drawn from this analysis is that a much broader range of variables were influential at different stages of the decisionmaking process rather than the usual and limited influences of variables such as GOTCAR and WAGE upon modal

choice. Modal usage rates are dependent upon opportunities available to a particular traveller, each with their own situation of modal choice. Most travellers would attempt to maximise their opportunities to private transport access while, some travellers, might unwittingly through residential location choice, minimise their opportunities to public transport.

This study has built upon the theoretical framework devised by Brog and Schwerdtfeger to aid the understanding of the modal choice process. It has attempted, with the aid of logit models, to identify influential variables in each situative modal choice option. In conclusion, the author would stress that the model attempted here is mainly an explanatory model though future researchers might wish to refine it into a predictive model. In order to do that, researchers would have to think about estimating the value of key variables such as car availability/bus availability at some future time.

The study has however revealed, using the revealed-preference approach, that the available car is almost invariably used whenever possible for the worktrip. Household car ownership was, to a large extent, instrumental in determining car availability status of the individual and it also has been shown, albeit indirectly, to have an indirect effect upon the status of public transport availability.

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