

## THE USE OF STATED PREFERENCE TECHNIQUE TO MODEL MODAL CHOICES

Resdiansyah<sup>1,a</sup>

<sup>1</sup>Politeknik Enjinering Indorama, Purwakarta, Indonesia

<sup>a</sup>resdiansyah@pei.ac.id

### Abstract

Public transportation especially bus services in Kuching City, Malaysia are relatively old and most of the buses are in state of dilapidation. This gives a very bad image on Kuching city and poor perception especially from the tourists and local consumers. To achieve a sustainable public transport industry, the old buses need to be regenerated and replaced with modern buses. The aim of the study is to explore the consumer's travel behavior by employing modal choice modelling. Consequently, a study was conducted in Kuching City Area by using stated preference technique, analyzed and compiled by using SPSS.17 multiple linear regressions analysis. In this context, discrete choice analysis was used to examine the relationship between independent variables (travel time, waiting time, fares and comfort) and dependent variables (choice of respondent whether to consume old bus or choose new bus services). A total of 2000 respondents were interviewed. The findings showed that for the trips purpose, fares and comfortability were the primary factors that reflected the decision or behavior of the respondents asked. It was discovered that there is a significant relationship between the choice of the respondents and comfortability. For the trips purpose to school, recreation, shopping and others, most of the respondents preferred to opt for scenario 5 (travel time 20 min, frequency 20 min, fare RM 2.00, and the level of comfort is good with AC system) which gave the highest demand with the percentage of 75.4%, 55.1%, 70.3% and 69.1% respectively. On the other hand, scenario 3 (travel time 30 min, frequency 15 min, fare RM 2.00, and the level of comfort is good with AC system) was chosen for the purpose of working trips with the percentage of 50.5% respectively. Thus, it can be concluded that scenario 5 is the most appropriate condition to be implemented for the future bus services to serve the consumers in Kuching city subjected to a condition whereby the bus operators need to deliver a better, comfortable and reasonable fares bus services. It also appeared that longer travel time did not affect for the travelers choice at this stage. Hence, the study suggests that the local authority and the bus operators should establish a "quality partnership" and working together in order to come out with a much better and appropriate transport policy and schemes for the existing public transportation systems, especially bus services.

**Keyword:** Stated Preference Technique, Discreet Choice Anlysis, Modal Choice, Public Transportation

### Abstrak

Angkutan umum khususnya pelayanan bus di Kota Kuching sangat tua dan sebagian besar bus mengalami kerusakan memprihatinkan. Hal ini memberikan citra yang sangat buruk pada kota Kuching, Malaysia terutama dari para wisatawan dan konsumen lokal. Untuk mencapai industri transportasi publik yang berkelanjutan, bus tua perlu di regenerasi dan diganti dengan bus modern. Tujuan dari penelitian ini adalah untuk mengeksplorasi perilaku perjalanan konsumen dengan menggunakan pemodelan pemilihan moda. Akibatnya, sebuah penelitian telah dilakukan di Kota Kuching dengan menggunakan teknik Stated Preference yang dianalisis dan disusun dengan menggunakan SPSS.17 untuk analisis regresi linier berganda. Dalam konteks ini, analisis pilihan discrete digunakan untuk menguji hubungan antara variabel independen (waktu perjalanan, waktu tunggu, tarif dan kenyamanan) dan variabel terikat (pilihan responden apakah mengkonsumsi bus tua atau memilih layanan bus baru). Sebanyak 2.000 responden yang diwawancarai. Temuan menunjukkan bahwa untuk tujuan perjalanan, tarif dan kenyamanan adalah faktor utama yang mencerminkan keputusan atau perilaku responden yang diminta. Hal ini ditemukan bahwa ada hubungan yang signifikan antara pilihan responden dan kenyamanan. Untuk tujuan perjalanan ke sekolah, rekreasi, belanja dan lain-lain, sebagian besar responden lebih suka memilih skenario 5 (perjalanan waktu 20 menit, frekuensi 20 menit, tarif RM 2.00, dan tingkat kenyamanan yang baik dengan sistem AC) yang memberi sebuah permintaan tertinggi dengan persentase 75,4%, 55,1%, 70,3% dan 69,1% masing-masing. Di sisi lain, skenario 3 (perjalanan waktu 30 menit, frekuensi 15 menit, tarif RM 2.00, dan tingkat kenyamanan yang baik dengan sistem AC) dipilih untuk tujuan perjalanan bekerja dengan persentase 50,5% untuk masing-masingnya. Dengan demikian, dapat disimpulkan bahwa skenario 5 adalah kondisi yang paling tepat untuk diterapkan untuk layanan bus masa depan

untuk melayani konsumen di kota Kuching dengan syarat suatu kondisi dimana operator bus harus memberikan layanan yang lebih baik, layanan tarif bus yang nyaman dan wajar. Itu juga muncul bahwa waktu perjalanan lebih lama tidak mempengaruhi untuk pilihan wisatawan pada tahap ini. Juga didapati bahwa, studi ini menunjukkan bahwa otoritas lokal dan operator bus harus membangun "kualitas kemitraan" dan bekerja bersama-sama untuk keluar dengan kebijakan transportasi yang jauh lebih baik dan tepat dan skema untuk sistem transportasi publik yang ada, terutama layanan bus.

**Kata kunci:** Teknik Stated Preference, Analisa Pilihan Diskrit, Pilihan Moda, Angkutan Umum

## 1. Introduction

In Kuching City, Malaysia and the suburban areas, buses are the primary mode of public transportation system available. There are other types of public transport systems, namely taxis and vans. Currently, bus services in Kuching City Area are relatively old and most of the buses are in state of dilapidation. This gives a very bad image on Kuching City and poor perception especially from the tourists and local consumers. Thus, to achieve a sustainable public transportation industry, the old buses need to be regenerated and replaced with modern buses.

The aim of this study is to explore the travel behaviour by employing mode choice modelling. In this context, stated preference (SP) technique was used to evaluate the traveler's behaviour. Also, the study provides a simple overview of the design and implementation of stated preference techniques to estimate the importance of the mode attributes. SP techniques are very popular since it was applied, developed and accepted for the purpose on transportation behaviour study in the last three decades. In SP techniques, the study presented the methods of discrete choice analysis based on mathematical modelling to analyse the travel demand and travellers behaviour in order to come out with the best criteria for the implementation of new public transportation schemes.

### 1.1. Background of Public Transportation in Study Area

Briefly, public transportation in Kuching City area is only focusing on the buses, though there are other modes of public transportation such as taxis and vans. Taxis can be easily found outside the hotels or at the taxis stands. Fares are reasonable, but should always be agreed in advance. Vans can be found at the city centre adjacent to the India Street area. The fares are much cheaper compared to taxis. Generally, the service is quite similar to the taxis because they are operated independently.

However, vans do not serve the consumers who wish to travel within the city area of which buses and taxis are still the best option for this particular purpose. Bus services are the best option due to cheaper fares offered. Fares depend on the travel distance. Majority of the buses are not air-conditioned. On the other hand, there is no centralised and modernly built bus interchange in Kuching city. Most of the local bus terminals are separately located within the centre of the city area (adjacent to the waterfront, India Street and along the Gambier Street. Additionally, departure points also vary and depend on the destinations/zones served and individual bus operators. There are four major bus operators in Kuching which are namely Sarawak Transport Company (STC), Kuching Matang Transport Company (KMTC), Chin Lian Long Company (CLL) and Petra Jaya Transport.

### 1.2. Problem Statement and Objective

As a result of rapid changes and competitive in the modern industry, the companies survival in the public transport services is largely depends on their great extent of capability to increase the patronage and influence the motorist travelers to shift their modes of mobility from car to public transport system. Generally, the preliminary intention of this study is to provide answers to the following questions:

- a) How mode choice is affected by?
  - i. The level of services for both modes,
  - ii. Travel time,
  - iii. Waiting time, and
  - iv. Fares (cost),
- b) What are the travellers' behaviour characteristics that influence their decision making in selecting modes of transportation?

The main objective of this study is to determine and compare the travel behaviour of the existing and future bus passengers, in order to enhance its competitiveness and quality of services in the future. Specifically, the objectives of this study are arrayed as the followings:

- i. To describe the characteristics of the public transportation demand by developing a model using SP technique with respect to a various scenarios for both of the buses, hence evaluate it by using discrete choice analysis.
- ii. To evaluate the potential of the future exclusive and modern buses to cope with the current demand of the existing bus services in Kuching City area, where the results analysis is based on the journey purposes.
- iii. To identify the response of the bus passenger according to the level of services such as comfortability, waiting time, travel time and cost offered by the bus operators.

## 2. Conceptual Framework of the Study

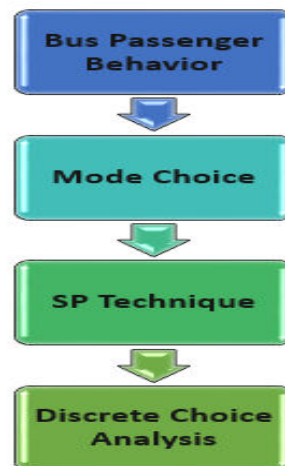


Figure 1: Conceptual framework of the study.

The general steps of the study processes are summarised in Figure 1. The conceptual framework described here is mainly focused on the study of the bus user's behaviour. Eventually, the study will create a model, which will represent and determine the significance attributes of bus passenger behaviour that effect mode choice. A mode choice can be viewed as an outcome from the above sequential decision-making process. Thereafter, stated preference technique will be used to obtain the primary data from bus passenger. Finally, in order to describe the mode choice model, the researcher proposed to use a discrete choice analysis.

## 3. Literature Study

### 3.1. Mode Choice

The choice of travel mode is probably the most important model in travel demand analysis. This is because the mode choice model is concerned with the trip-maker's behavior regarding the selection of travel mode [3]. Papacostas [3] also states that the reason underlying this choice varies between individuals, trip type, and the relative level of service and cost associated with the available modes. The objectives of mode choice models can be classified as:

- a. Aggregate: To estimate the number of proportion of trips from each zone to each zone by purpose that take any mode.
- b. Disaggregate: To estimate the probability that a particular trips from each zone to each zone by a specific individual will take mode.

But contemporary mode choice models are almost disaggregate model [4]. So, in this study, mode choice models are basically disaggregate mode choice model. Disaggregate as used here means that models are intended to describe the mode choice made by individuals rather than by large groups or zonal averages [5]. It is interesting to see how far we can get by using a series of mathematical techniques. To summarize, there is a number of mathematical models are used to predict mode choice. These generally attempt to estimate the probability of a trip-maker's movement will use a particular mode. Several mode choice models forms are used. This includes binary logit model, multinomial logit model, hierarchical logit model, multinomial logit model, choice by elimination and satisfaction, utility and disutility

function, probabilistic model and many other approaches. But, in this study the researcher will only focusing in binary logit model.

**3.2. Discrete Choice Analysis Theory**

A discrete choice analysis based on random utility theory, has been the backbone of transport planning since the 1970s [2]. It predicts a decision made by an individual (choice of mode, choice of route, etc.) as a function of any number of variables. The models are used when the consumption of one good rules out the consumption of another good, such as for example in travel mode choice situations [2]. As mention earlier, the models are a mathematical function, which predicts an individual’s choice based on the utility or relative attractiveness of competing alternatives. The model generally includes characteristics of the individual and relative attributes of competing choices.

**3.2. Binary Logit Model**

Although there are a number of mathematical utility function in discrete choice models, but the most basic mathematical utility function for the models are as follows [6]:

$$U = U(q_1, q_2, q_3), \text{ where,}$$

$$q_1 = \begin{cases} 1 & \text{If mode 1 is chosen,} \\ 0 & \text{Otherwise;} \end{cases}$$

$$q_2 = \begin{cases} 1 & \text{If mode 2 is chosen,} \\ 0 & \text{Otherwise;} \end{cases}$$

$$q_3 = \begin{cases} 1 & \text{If mode 3 is chosen,} \\ 0 & \text{Otherwise;} \end{cases}$$

and that only one alternative is chosen:

$$q_1 q_2 = q_1 q_3 = q_2 q_3 = 0.$$

For the purpose of this study, binary logit model was chosen since there were only two scenarios involved in the study. According to Ben-Akiva and Lerman [6], the derivation of any binary choice model is conceptually straightforward. The utility function for binary logit models are as follows:

$$P_1 = \frac{e^{V_1}}{(e^{V_1} + e^{V_2})} \dots\dots\dots(2.1)$$

Where; P1 = Probability of the passenger to choose one of the scenarios,  
 e = Exponential,  
 v = Variable.

**3.3. Stated Preference Technique**

SP techniques can be described as a “family” of techniques, which individual respondent’s statements about their preferences in a set of transports options to estimate utility functions [1]. It was designed to answer questions, which could not be answered with revealed preference (RP) techniques. This is due to the fact that it is often very difficult to undertake a “revealed preference” (RP) study and to derive meaningful results. Basically, RP techniques are based on the actual, observed behavior and applied in a real world condition. While SP technique are based on hypothetical and stated behavior. Laitila [7] states, SP technique have been applied and developed within empirical research on transportation behavior since the mid 70ties. And in spite of their known limitation and problems, SP based survey techniques have become an accepted part of the transport planning tool kit [8]. They also mention that SP techniques are implemented as stated-choice experiments, in which respondents are asked to choose between two or more alternatives described to them. Ortúzar and Willumsen [9] summarized the main features of SP technique as follows:

- a. It is based on the elicitation of respondent's statements of how they would respond to different hypothetical (travel) alternatives;
- b. Each option is represented as a 'package' of different attributes like travel time, price, headways, reliability and so on;
- c. The researcher constructs these hypothetical alternatives so that the individual effect of each attribute can be estimated;
- d. This is achieved using experimental design techniques that ensure the variations in the attributes in each package are statistically independent from one another;
- e. The researcher has to make sure that interviewees are given hypothetical alternatives they can understand, appear plausible and realistic, and relate to their current level of experience;
- f. The respondent state their preferences towards each option by either ranking them in order of attractiveness, rating them on a scale indicating strength of preference or simply choosing the most preferred option from a pair or group of them;
- g. The responses given by individuals are analyzed to provide quantitative measures of the relative importance of each attribute.

#### 4. Methodology

In this study, attributes are generally defined as the variables, which describe and define the differences between the alternatives. The attributes may involve travel time, waiting time (frequency), cost (in terms of fares), comfortability, safety, reliability, interchange, headway and others. However, the design is simple, where there were only four attributes chosen which were the travel time, waiting time (frequency), cost (in terms of fares) and comfortability. Alternatives were the existing and future buses of which the respondents should make their option. And the levels are the values of the attributes, which are shown in table.1.

**Table 1: Definition of levels for each attribute.**

<i>Attributes</i>	<i>Levels</i>	
Travel time (min)	Fast	20
	Medium/ Original	25
	Slow	30
Frequency (min)	Frequent	10
	Medium/ Original	15
	Infrequent	20
Fares (RM)	High	2.00
	Normal/ Original	1.60
Comfortability	High	Good
	Low/ Original	Poor

##### 4.1. Experimental design

At this stage, the researcher will design the way in which the options will be presented to the respondents and how they be allowed to express their preferences. The form of presentation of the alternatives will be easy to understand and within the context of the respondents experience and constraints. For simplicity, the experimental design considered only four attributes:

- a. travel time – varies (the three levels)
- b. waiting time (frequency) – varies (three levels)
- c. cost (in terms of fares) – varies (two levels)
- d. comfort –varies (two levels)

Thus, for a null factorial design, we need  $2 \times 2 \times 3 \times 3 = 36$  option of combinations. Finally, from 36 option of combinations, a certain number of scenarios has been defined and simulated as follows:

**Table 2:** Scenario Design

Scenario	Travel Time (min)	Frequency (min)	Fares (RM)	Comfort
Current Situation	25	15	1.60	Poor
I	25	15	2.00	Good
II	25	10	2.00	Poor
III	30	15	2.00	Good
IV	30	10	1.60	Poor
V	20	20	2.00	Good
VI	20	15	1.60	Poor

### 5. Modeling, Result and Discussions

The model development in this study has covered dependent variable and independent variable. Dependent variable is the choices of the respondent whether to choose the new bus services or resume the current bus services. Independent variables were fares, travel time, frequency (waiting time) and comfortability. Additionally, the models developed in the study were also based on the different consumers' trip purposes. The model is given by:

$$U = a_1 + a_2(T_C - T_N) + a_3(W_C - W_N) + a_4(F_N)$$

where;

$U$  = Utility function

$a_1$  = constant (independent variable)

$a_2$  = constant for travel time (dependent variables)

$a_3$  = constant for frequency (dependent variables)

$a_4$  = constant for fares (dependent variables)

$T$  = travel time

$W$  = frequency (waiting time)

$F$  = fares

$C$  = current bus

$N$  = new bus

SPSS 17.0 (multiple regression analysis method) was used to develop the models for different trips purposes, which are tabulated in table 3 below.

**Table 3:** Model Development

Journey Purpose	Model
School	$U = -4.947 + 0.028(T_C - T_N) + 0.020(W_C - W_N) + 2.708(F_N)$
Work	$U = -4.535 + 0.023(T_C - T_N) + 0.024(W_C - W_N) + 2.519(F_N)$
Social/Recreation	$U = -4.842 + 0.026(T_C - T_N) + 0.011(W_C - W_N) + 2.763(F_N)$
Shopping	$U = -5.002 + 0.033(T_C - T_N) + 0.011(W_C - W_N) + 2.790(F_N)$
Other	$U = -6.066 + 0.029(T_C - T_N) + 0.006(W_C - W_N) + 3.450(F_N)$

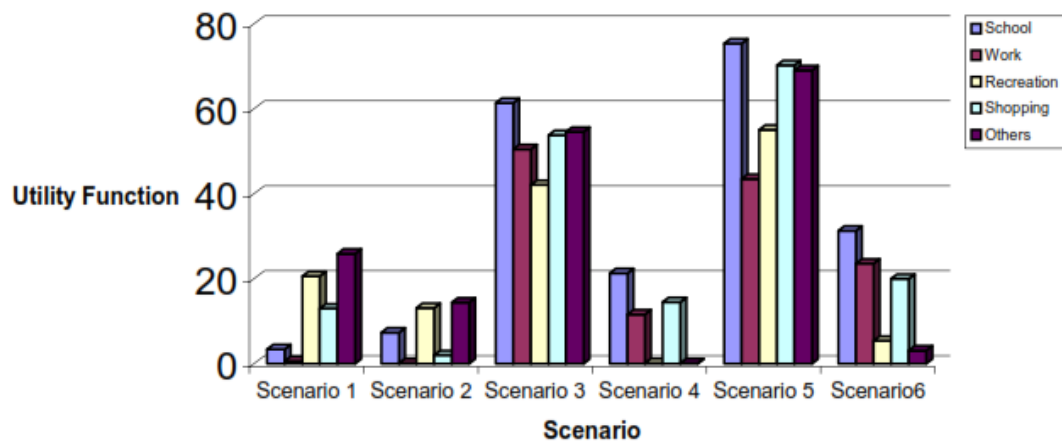


Figure 2. Model Application based on scenario

Figure 2 illustrates the summary of modelling results based on five different scenarios. The study revealed that most of the respondents preferred to choose scenario 5 except for working trips purposes where scenario 3 was chosen as the highest utility function. Thus, it can be concluded that the journey fares of the public transportation especially bus services influence the decision or behaviour of the respondents asked. It also appeared that comfortability influences the behaviour of the respondents in making their decision of choosing the new bus system. For scenario 3 in particular, it is impossible for the bus operators to deliver new buses with equal price and at the same time provide a greater comfortability. Consequently, it can be concluded that scenario 5 is the most appropriate condition to be adopted and implemented by the bus operators in time to come, where the bus operators should provide a better bus services which are comfortable with a reasonable fares. It appeared that longer travel time did not affect the bus passenger choice for the current condition of bus services in Kuching city area.

## 6. Conclusion and Recommendation

### 6.1 Conclusion

The study findings showed that for every trip purposes, fares and comfortability influence the decision making or behavior for most of the bus consumers asked. The probability for the new bus services scheme to compete with the current bus is generally very moderate. This is due to the fact that majority of the respondents asked have chosen a good level of services especially comfortable with a reasonable price (fares). In line with the study, significant relationship between the choice of the respondents and comfortability has been discovered.

### 6.2 Recommendation

Considering wider implications of the present findings, it seems necessary to conduct a more thorough and comprehensive study regarding the travel behavior of bus passengers, which also suggests that further studies should be conducted that involve all the public transportations users and the potential users (private car users). A bigger sample size would give further corroborative evidence about the behavior of the public transportations users. Future researchers should consider conducting studies in other locations in order to compare the findings. Consequently, a clearer understanding regarding the public transportations users' behavior could be achieved as a result. Importantly, the local authority and the bus operators should establish "quality partnership" and work together in order to successfully implement and achieve a better results for the public transports users which at the same time able to attract car commuters to change their mode of transportation to buses.

## References

- [1] Danielis R, Rotaris L. Analyzing Freight Transport Demand Using Stated Preference Data: A survey and a Research Project for the Friuli-Venezia Giulia Region. *Tranporti Europei*. 1999; Vol.13.
- [2] Nerhagen L. Mode Choice Behavior, Travel Mode Choice Models and Value of Time Estimation – A Literature Review. *CTEK, Dalarna University*. 2000; Vol.6. ISSN: 1400-1888

- 
- [3] Papacostas C.S, Prevedouros P.D. Transportation Engineering and Planning,. New Delhi: Prentice Hall of India, 3<sup>rd</sup> Edition. 2002
  - [4] Banks J.H. Introduction to Transportation Engineering, McGraw-Hill, 2<sup>nd</sup> Edition. 2002.
  - [5] Wright P.H. Ashford N.J. Transportation Engineering: Planning and Design. New York: John Wiley & Sons. 3<sup>rd</sup> Edition. 1989.
  - [6] Ben-Akiva M, Lerman, S.R. Discrete Choice Analysis. Massachusetts: MIT Press.1993
  - [7] Kristrom B, Laitila T. Stated Preference Methods for Environmental Valuation: A Critical Look. Sveriges lantbruksuniv. 2002.
  - [8] Stern E, Salomon I, Bovy P.H.L. Travel Behaviour: Spatial Patterns, Congestion and Modelling. Cheltenham: Edward Elgar Publishing Limited. 2002.
  - [9] Ortúzar J.D, Willumsen L.G. Modelling Transport. (2nd ed.). Chichester: John Wiley & Sons Limited. 1996