MODELLING MULTIMODAL PASSENGER CHOICES WITH STATED PREFERENCE

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ABSTRACT

Redland Shire Council has recently started the implementation of an Integrated Local Transport Plan (ILTP) that aims to reduce the car dependency by enhancing the usage of alternative modes of transport. A multi mode choice model is required that can forecast the travel behaviour across the region in order to achieve the targets set in ILTP. This paper presents the findings of a state-of-the-art literature review done on mode choice modelling and outlines the development and calibration of a model to investigate the travel behaviour of Redlands' residents.

The present study attempts to develop a nested logit model and calibrate it using data obtained from a stated preference (SP) survey to be conducted in the Shire. The model development will consider all the vital attributes of the travelling modes used in the study area including various public transit access modes. The possibility of combining SP and *revealed preference* (RP) data to calibrate the model using joint-estimation method will be further assessed.

It is expected that the outcomes of the research will assist policy makers in the areas of public transport planning and the development of network for public transport access modes including walkways and cycleways.

Keywords: Nested logit modelling, stated preference, public transport, access modes, sampling

1. INTRODUCTION

The South East Queensland (SEQ) region of Australia covers around 1% of the state's total area, yet contains almost two-thirds of Queensland's entire population (Queensland Government 2000). The rising urban sprawl in the region inflates the demand for better public transport system and improvement in the infrastructure. Keeping this in mind, all the local councils of the region have started implementing the Integrated Local Transport Plan (ILTP) that primarily focuses on the creation of an ecologically sustainable transport system.

Redlands is a shire in South East Queensland with a population of 111'500 and an annual growth rate of 4.8% (RSC 2001). One of the major thrusts of the ILTP, planned by Redland Shire Council (RSC), is to reduce the car dependency and increase the share of other more sustainable forms of travel such as walking, cycling and public transport. However, in order to bring other forms of transport in the level capable of competing with car, it is necessary to substantially improve the transport infrastructure and facilities related to these modes. This can be done by serious planning and capital outlay in the public transport sector.

However, before starting the implementation to achieve these objectives, one would certainly like to be sure, in what conditions (level of infrastructure, facilities, cost, level of comfort, safety, security etc) an individual would like to think about adopting other travelling modes than a car. In other words, RSC is interested to identify those potential measures that can be put into practice in order to attract a substantial number of car users to adopt public transport to fulfil their travelling needs.

This research is being conducted in order to develop a comprehensive understanding of the current travel behaviour of the residents of the shire and to forecast the usage of various travelling modes under different scenarios. The primary aims of the research are to conduct a travel survey in order to gather responses of the residents of the shire and then, to calibrate a passenger mode choice model using this data.

This paper presents the findings of a state-of-the-art literature review focussing mainly on the choice behavioural modelling framework planned for the research along with the designing of a travel survey to be conducted in the shire. This survey is supposed to enquire the people regarding their day-to-day travel and contain questions regarding the choice of a travelling mode under various virtual scenarios. These types of surveys generally contain questions regarding the respondent's behaviour to pick a travelling mode under numerous hypothetical conditions and are generally regarded as *stated preference* (SP) surveys. Further, the possibility for adding *revealed preference* (RP) data, information about actual travelling of an individual, to the calibration process of the model will be further assessed. The method for estimating a mode choice model by using both SP and RP data simultaneously is generally known as joint-estimation method. Further details of the method can be found in Bradley and Daly (1992).

2. MODEL DEVELOPMENT

A behavioural model is defined as one which *represents the decisions that* *consumers make when confronted with alternative choices* (Ortuzar and Willumsen 1994). Therefore, the traveller must decide whether to make a trip, where and when to go, which route to take, and which mode to select. These decisions are made on the basis of the terms upon which the different travel modes are offered, i.e. the travel times, costs, and service levels of the competing alternative travelling modes. The models that tend to represent the travel behaviour of the individuals when provided with a discrete set of travelling alternatives are commonly known as *discrete choice models*.

These discrete choice models are mostly based on the *theory of utility maximisation* which visualises the individual as selecting that travelling mode which maximises his or her utility. The *utility* of an alternative is defined as the attraction associated to a particular travelling mode from an individual for a specific trip (Abraham and Hunt 1998).

As a matter of computational convenience, the mathematicians generally represent utility as a linear function of the attributes of the journey weighted by the coefficients which attempt to represent their relative importance as perceived by the traveller. Therefore, one possible representation is given by Southworth (1980) as,

$$U_{mi} = \theta_1 x_{mi1} + \theta_2 x_{mi2} + \ldots\ldots + \theta_k x_{mik} \quad (1)$$

where,

U_{mi} is the net utility function for mode *m* for individual *i*;

$x_{mi1}, \ldots, x_{mik}$ are *k* number of attributes of mode *m* for individual *i*; and

$\theta_1, \ldots, \theta_k$ are *k* number of coefficients (or weights attached to each attribute).

The choice behaviour can be modelled using the random utility model which treats the utility as a random variable, i.e. comprising of two distinctly separable components: a measurable conditioning component and an error component. Therefore,

$$U_{mi} = V_{mi} + E_{mi} \quad (2)$$

where,

V_{mi} is the systematic component (observed) of utility of mode *m* for individual *i*; and

E_{mi} is the error component (unobserved) of utility of mode *m* for individual *i*.

Generally, the difference between the socioeconomic characteristics of similar groups of individuals is usually ignored by the transport modellers in order to reduce the level of complexity of the model. Therefore, the systematic component of the utility can be treated as a function of attributes of available modes only and a single utility function can be visualised to exist for all individuals (Ortuzar 1996). Similarly, the error component of the utility can also be considered independent of socioeconomic characteristics for the same reason. Assuming that the error component has zero mean and an extreme value distribution (Kilburn and Klerman 1999), the net utility function can be given as:

$$U_m = V_m + E_m \quad (3)$$

Thus, if there are *M* number of total travelling modes available, the probability of an individual selecting mode *m*, such that $m \in M$, will be based on its associated utility function U_m, such that,

$$U_m \geq U_i \quad (4)$$

where,

U_m represents utility of travelling alternative *m*; and
U_i represents utility of any travelling alternative in the set of available travelling modes.

Summarising the theory of utility maximisation presented in equation 4, every alternative associates a certain utility with itself determined by its various attributes and the individual is supposed to select the alternative possessing highest utility. This is the basic idea used in the development of all the discrete travel choice models.

3. MODEL SPECIFICATION

An individual's behaviour in selecting a mode of travel is a result of the trade-off between the attributes of available transport alternatives. The travel modes that are used generally involve walking, cycling, auto (private transport) and transit modes (public transport).

The decision for selecting walking and cycling modes for travelling generally inculcates one major factor, the travelling distance (Hoogendoorn and Bovy 2004). Therefore, an individual will only consider these modes when the travelling distance is significantly small. Hence, they are treated as minor travelling modes; thus, paving the way for auto and transit to be referred to as the major modes in almost all of the study areas.

A transit trip is generally composed of several discrete phases, mainly including the trip from origin to transit access point, travelling through the transit mode to the transit stop, and then taking the trip to the destination. In some cases, the transit trip may require some additional stages. Normally, the first and the last travelling modes used by an individual for the transit trip are classified as *access modes*.

Access modes usually consist of various categories of motorised and non-motorised travelling modes. They may include non-motorised travelling alternatives such as walking or cycling as well as motorised modes like *park `n ride* (drive private vehicle to transit station and park), *kiss `n ride* (be driven to transit station and dropped off), dropped off from a bus (feeder bus), train, ferry etc.

For the study area of Redlands, various essential travelling modes, including access modes, and their associated attributes have been figured out. Figure 1 shows the structure of these modes that suits the multi modal environment of the study area (this structure can change during the period of research).

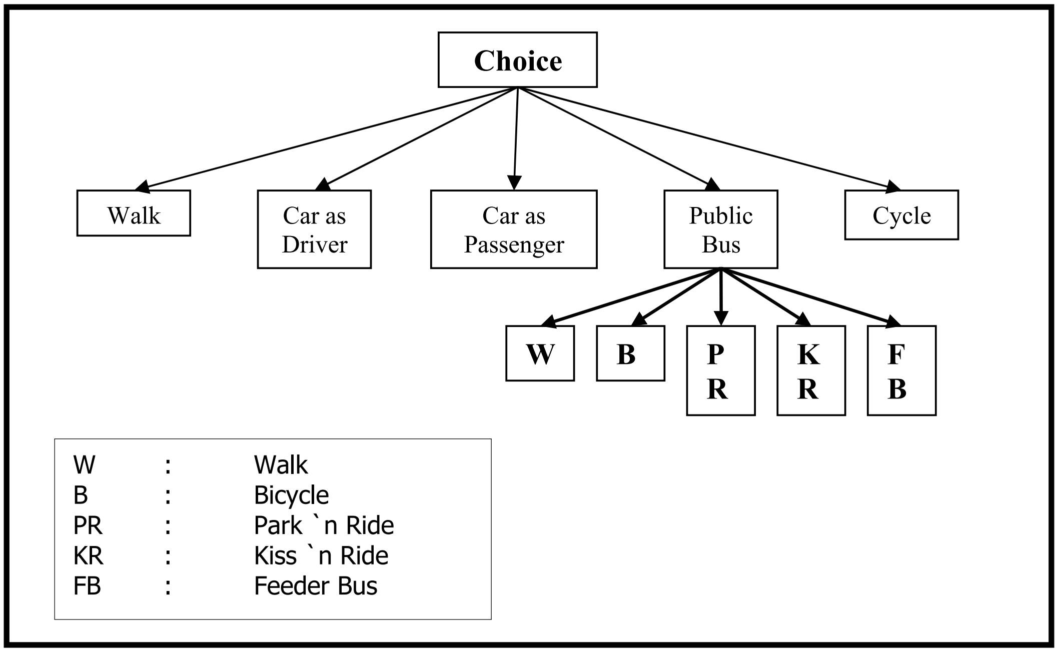

Figure 1 Model Specification for Redlands

The model structure shown in Figure 1 clearly shows that the contemporary multinomial logit models have to be preferred instead of their binary counterparts. Additionally, the use of simple multinomial logit models will raise of the issue of correlation (For details, see Koppelman and Wen (1998)). Thus, the proposed model structure for the research contains nested or tree logit models since they can flexibly relax the constraints of the multinomial logit models by allowing *correlation* between the utilities of the alternatives in common groups. The detailed literature regarding the theoretical framework and calibration techniques of nested logit models can be found in McFadden (1986) and Ortuzar (2001).

4. STATED PREFERENCE SURVEY

The next major tasks after model development and model specification are to design an SP instrument and conduct the survey in the study area. The physical design for the survey is chosen to be *Computer Assisted Personal Interviewing* (CAPI) as it has recently proved to have a higher response rate as that of other questionnaire forms (Wermuth et al. 2003).

The design of the instrument possesses immense significance since its highly responsible for a standard response rate of the survey. Therefore, it is vital that a standard survey designing software should be selected in order to develop the questionnaire. The software selected for designing SP surveys for this research is WinMint. Further details regarding the software are provided in section 4.2.

4.1 Data Sampling

Before designing the survey, the issue of generating a sample from the target population needs to be resolved. The segmentation for the sample is planned to be done according to the types of trips the travellers make (work, education, shopping etc) in the study area using *stratified random sampling*. The main reason for selecting this sampling method is due its capacity to include different strata of people along with maintaining randomness in the sample; thus contributing to minimum bias (Hensher 1994). The mathematical framework of this method, along with various examples, is presented in detail by Richardson et al. (1995).

4.2 Instrument Design

The physical form of the survey instrument selected for this research is commonly known as Computer Assisted Personal Interviewing (CAPI). The selection of CAPI has following main reasons:

- Personal interviewing with the respondents has higher probability of increasing the response rate (Louviere et al. 2000);
- Interactive designs in CAPI make the survey attractive for the respondent and flexible for the interviewer; and
- Making use of the latest technology in order to replace the orthodox method of paper-and-pencil questionnaires.

WinMint has been selected for designing SP survey instrument in this research. It is a standard questionnaire designing software with the power of developing various stated preference surveys in a highly interactive manner. The detailed programming structure and data coding methodology can be found in HCG (2000). Figure 2 shows an example of WinMINT using the stated preference questions to compare the attributes of two different train services under hypothetical scenarios. These sorts of hypothetical questions will be part of the survey instrument of this research that will tend to observe the respondents' behaviours towards using various travelling modes.

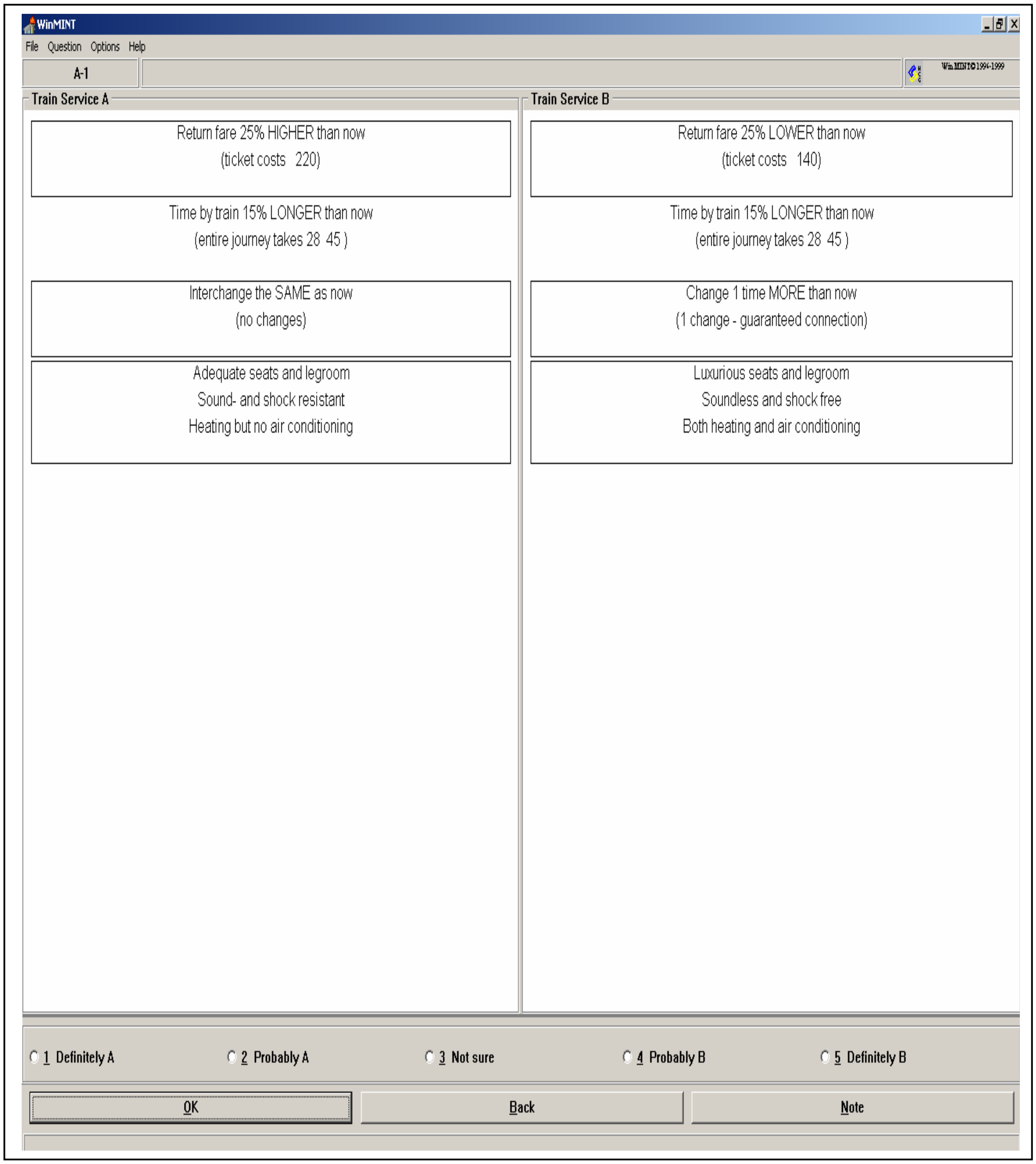

Figure 2 Stated Preference Example using WinMINT

5. SUMMARY & FUTURE RESEARCH

In this paper, we have presented the findings of the literature review undertaken with the aim of developing and calibrating a travel mode choice model for Redlands using stated preference (SP) surveys. For the part of model development, the provisional model specification has been done (Figure 1) and the literature has suggested that nested logit model will be the apposite discrete choice model considering the multi modal travel environment of the study area. For the part of survey instrument designing, a standard SP software, WinMint, is being appraised.

The main goals for future are the conducting of an SP survey in Redlands and calibrating the model with respect to the collected data. Initially, a pilot survey is planned to be conducted after the survey instrument designing phase so that the credibility of the survey instrument can be scrutinized and the response rate can be critically assessed.

Further, after conducting the survey, data need to be recorded on the latest technological patterns and analysis need to be done for removing errors and bias. The model will be calibrated using ALOGIT (a mode choice model calibration software) and tested for validity. The level of functionality and coding details of this software can be found in HCG (1992). The possibility of estimating and validating the model again using the joint-estimation method will also be assessed.

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