DESIGN OF A COMPUTER BASED SURVEY INSTRUMENT FOR MODELLING MULTIMODAL PASSENGER DEMAND

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ABSTRACT

This research is being undertaken with the aim of developing a comprehensive understanding of the current travel behaviour of the residents of Redland Shire, South East Queensland. A unique computer based stated preference (SP) travel survey is being conducted in the study area to determine the current modal split and to calibrate a nested logit model to forecast the future travel behaviour. This paper focuses on the new design of the computer based survey instrument that dynamically generates interactive random SP designs.

The design considers all the significant travelling modes currently used in the study area including various transit access modes and also involves hypothetical travelling modes for future use. The use of the instrument in a pilot survey is discussed together with the model specification component of the study. A data collection strategy for generating the sample randomly has also been presented. The plan proposes the market segmentation to be done on the basis of stratified random sampling.

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

Keywords: Stated preference, nested logit modelling, future transport planning, access modes, transit, public transport

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1. INTRODUCTION

Redland Shire is part of South East Queensland with a population of 111,500 with an annual growth rate of 4.8% (RSC 2001). The urban growth in the region inflates the demand for better public transport system and improvement in the infrastructure. Redland Shire Council started implementing the Integrated Local Transport Plan (ILTP) that primarily focuses on the creation of a more sustainable transport system by reducing car dependency and improving the infrastructure for public transport and environmental friendly modes such as walking and cycling.

This research is being conducted in order to develop a comprehensive understanding of the current travel behaviour of the residents of the shire. The primary objectives of the research are to conduct a SP travel survey in order to gather responses of the residents of the shire and to calibrate the nested logit model in order to forecast the passenger travel demand.

This paper focuses on the unique design of the computer based survey instrument and discusses its ability to randomly generate various hypothetical SP scenarios. The survey asks people about their day-to-day travel and generates SP comparison games based on the information provided by the respondents. The strategy outlined for generating the sample for the survey is also discussed.

2. STUDY AREA PROFILE

The study area for the research covers the southern parts of Redland Shire as the northern region has already been studied under the TravelSmart study (Queensland Government 2004b). Figure 1 shows the map of the study area showing five suburbs of the Shire that are part of the study area namely Thornlands, Redland Bay, Victoria Point, Mount Cotton and Sheldon.

Figure 1 Suburbs included within the Study Area

Although these suburbs form 30% of the total population of Redland Shire, they do not have regional rail network access since the nearest station lies in Cleveland. Around 70% of the residents of these suburbs use car for work (Australian Bureau of Statistics 2002) and other purposes as the bus services are not frequent as well (Queensland Government 2004a).

The research aims to examine the current travel profile of residents making trips to Brisbane city (or using the city corridor) by screening them with virtual mode switching scenarios. Further, it also aims to capture the local travel behaviour (trips within the Shire) by evaluating the population's level of sensitivity towards each attribute of the common travelling modes.

3. MODEL DEVELOPMENT

The literature reveals that the decision to select a particular mode can be equated mathematically in the form of utility functions. The *utility* of an alternative is defined as the attraction associated with a particular travelling mode from an individual for a specific trip (Abraham and Hunt 1998). As a matter of computational convenience, the utility is generally represented 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*.

For this research, the difference between the socioeconomic characteristics of similar groups of individuals is ignored 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 (level-of-service variables) 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:

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

Therefore, equation 1 is modified to be given as,

$$U_m = \sum_{k=1}^{K} \theta_k x_{mk} \quad (4)$$

The model specification for the project is based on the types of trips that people generally make for their day-to-day travel. These trips are broadly classified according to their purposes namely work, shopping, education and other trips. The set of *other* trips refers to various different travel activities such as recreation, sports, health, etc.

Since the research aims to determine the complete travel profile of the population of the study area, both all-the-way and access modes are included in the model specification as shown in Figure 2.

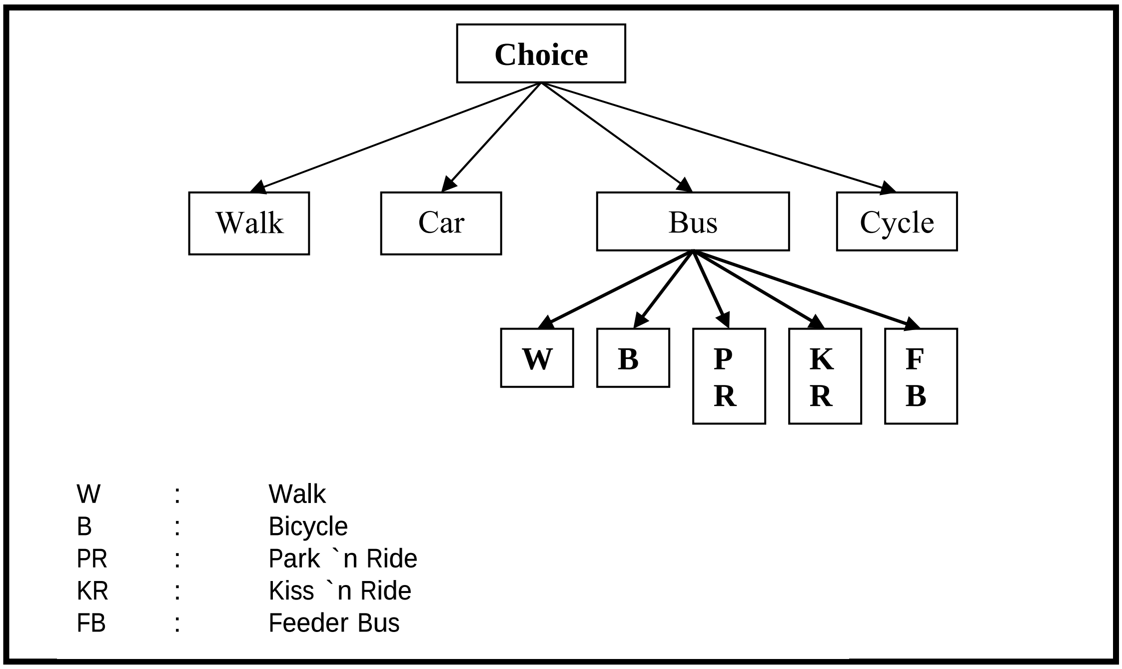

Figure 2 Model Specification

For the model illustrated in Figure 2, contemporary multinomial logit model has to be used instead of its binary counterpart. Thus, the proposed model structure for the research contains nested logit model since it can relax the constraints of the simple multinomial logit model 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. SURVEY INSTRUMENT DESIGN

The physical design of the survey instrument is chosen to be *Computer Assisted Personal Interviewing* (CAPI) since it is the current state-of-the-art in stated preference (SP) surveys. The survey instrument has been designed considering the different types of trip purposes in mind. It begins by gathering an individual's *revealed preference* (RP) travel information regarding the travelling mode he/she selects for a certain trip. Based on this data, the instrument is programmed to present the respondent with a particular set of stated preference (SP) games. The use of laptops (notebooks) has enabled the feature of generating dynamic SP games which would not have practical using the usual paper-and-pencil surveys, where a fixed set of SP games is generally presented irrespective of user's details.

From a statistical perspective, it is considered that revealing more variability in the options presented to the respondent is better. In other forms of survey designs, such as paper-and-pencil surveys, the same limited set of options is generally presented to all the respondents as it would be too costly to prepare separate designs for each respondent (Martin and Manners 1995). The software selected for programming the CAPI tool is WinMint (a standard software used for SP survey designing). The level of functionality and coding details of the software can be found in HCG (2000).

Each survey is based on the specific trip (work, shopping, education, other) that a respondent makes on regular basis. The SP survey part of the instrument generates eight virtual comparison games between the attributes of the mode currently being used by the respondent with that of an alternative mode. The *alternative* mode can be a hypothetical mode such as bus on busway, cycling on cycleway etc. The respondent then makes a decision and selects one of the modes based on the importance that he/she associates to the attributes of each mode. Figure 3 presents an example of WinMINT using an SP game to compare the attributes of *car* and *bus on busway* under hypothetical scenarios

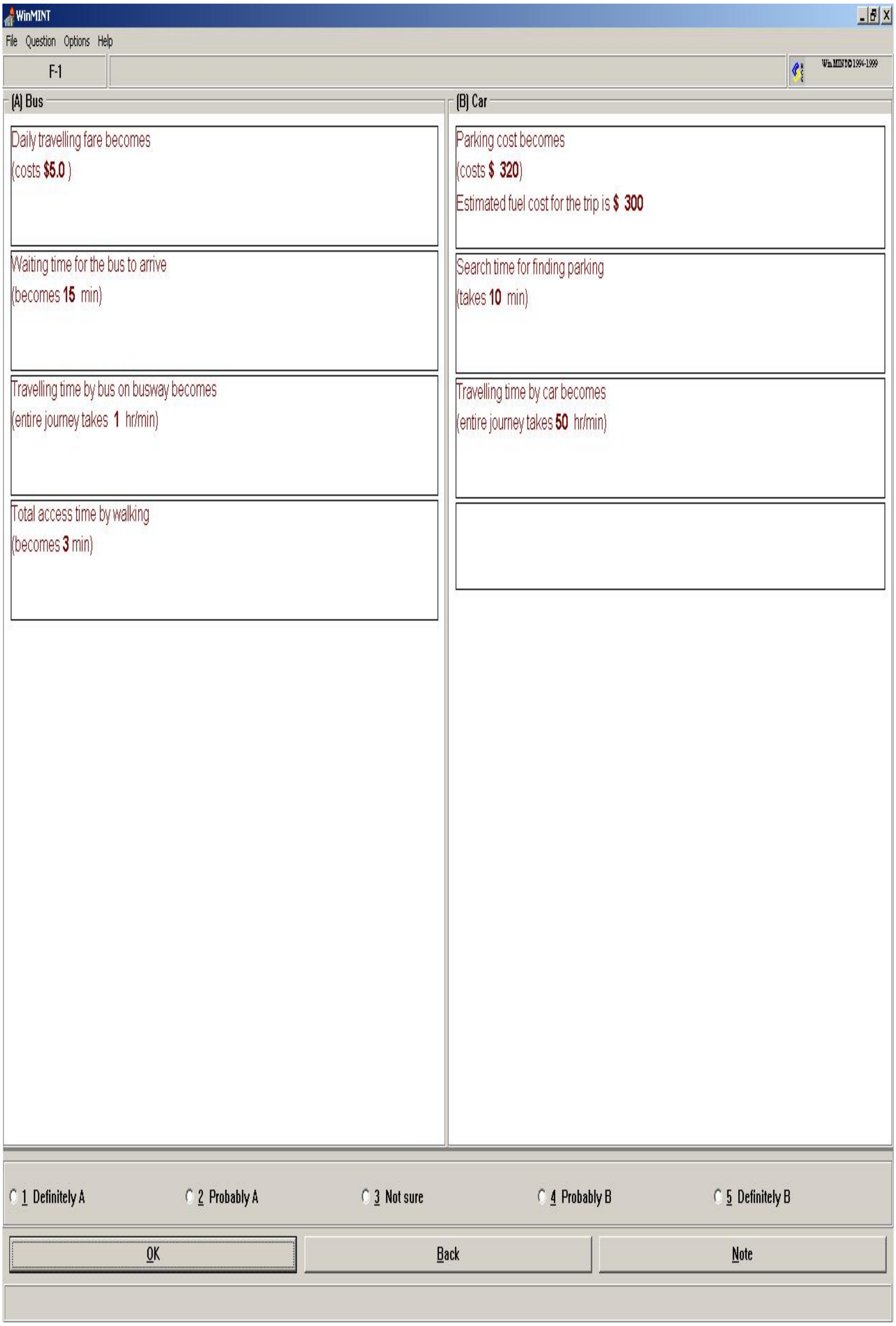

Figure 3 Example of a Stated Preference (SP) Comparison Game

5. DATA COLLECTION STRATEGY

A strategy for generating the survey sample has recently been finalised following the successful completion of a pilot study. The plan proposes that market segmentation to be done using *stratified random sampling*. A detailed framework of the method is given in Ampt et al. (1985).

In the pilot study, around 25 respondents, generated totally randomly, were interviewed forming around 10% of the size proposed for the main survey (a sample size of 250). The pilot survey has helped in scrutinising the design of the instrument and has assisted in assessing the response rate from the residents. Each respondent represents an *m* number of unique response identities for *m* number of unique trips that he/she regularly makes. In this manner, the travel profile of each trip of the respondent can be determined respectively. The survey is currently being conducted at respondents' households, workplaces or educational institutions. The respondents are contacted through telephone, e-mail, fax, etc asking for their interest in participating in the study. The respondents showing positive willingness to participate in the study form the members of the survey sample. The stratification is done on the basis of the population of the suburbs of the shire.

SUMMARY AND FUTURE RESEARCH

The purpose of this research is to develop an understanding of the travel behaviour of the residents of the study area which can be useful from the perspectives of public transport planning and development of walkways and cycleways. In this paper, we have presented the design of the survey instrument along with a model specification in order to analyse the travel behaviour of the target population. The model specification has been done on the basis of the types of trips and the survey sample is being generated in such a way as to get a representative sample from all the suburbs within the study area.

The survey instrument has been designed using CAPI method in order to make the SP experiment more relevant and interesting for the respondent. Further, the use of computer for surveying has given us a lot of advantages over non-computer surveys such as automatic branching to different questions, customised queries and answer categories for virtually each respondent, answer range and logic checks, and automatic data coding and storage.

The main goal for near future is to finish the main survey implementation in Redland Shire. After collecting the data, various statistical analysis and model estimation are planned in order to determine the sensitivities of each attribute of the travelling modes. For this purpose, a mode choice model calibration software ALOGIT has been selected. The level of functionality and coding details of the software can be found in HCG (1992).

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