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ANALYSING DRIVER COMPREHENSION OF FORMATS FOR PRESENTING TRAFFIC INFORMATION ON VARIABLE MESSAGE SIGNS

– TOWARDS STATED PREFERENCE APPROACH FOR TRAVEL BEHAVIOUR RESEARCH

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Master of Philosophy

THE HONG KONG POLYTECHNIC UNIVERSITY

2000

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DECLARATION

I hereby declare that the thesis entitled "Analysing driver comprehension of formats for presenting traffic information on variable message signs – towards stated preference approach for travel behaviour research" is original and has not been submitted for other degrees or the like in this University or any other institutes. It does not contain any material, partly or wholly, published or written by others, excepts those references quoted in the text.

Lai Ka-Hung
April 2000

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ABSTRACT

Abstract of thesis entitled "Analysing driver comprehension of formats for presenting traffic information on variable message signs – towards stated preference approach for travel behaviour research", submitted by Lai Ka-Hung for the degree of Master of Philosophy at The Hong Kong Polytechnic University in April 2000.

Providing drivers with real-time dynamic traffic information by Variable Message Signs (VMSs) has been developed as an important initiative in traffic management of highways. The success of a VMS system highly depends on the quality of the messages as drivers' route choice behaviour will be affected by the available traffic information. Some messages do have much more influence than others, especially when they are presented in a particular format. To produce optimal operation, appropriate formats for presenting traffic information should be carefully selected to adopt users' need. The effectiveness of the system will be reduced if users misinterpret the contents of the messages. However, much attention has been given in the literature to forecast the use or penetration of VMSs, while proportionate attention has not been given to predict how drivers will respond to information presented in different formats.

Analysis of driver route choice behaviour is a difficult task and the condition will be much more complicated if traffic information is also provided to drivers. The level of inter-relationship between the information in different formats cannot be measured explicitly by conventional methods. This study attempted to examine driver comprehension and en-route choice behaviour in response to traffic information that was presented in three formats, namely; Numerical format (presenting travel time in a number), Words format (presenting congestion level by description) and Signal format (indicating congestion level by number of switch-on-signals). A stated preference (SP) survey with well-designed attributes regarding traffic conditions and comprising a total of 475 successful cases was conducted to measure drivers' utilisation for travelling on two designated routes. SP techniques provide data on the underlying priorities that determining drivers' behavioural intentions. Discrete

choice analysis was employed to develop binary logit models with respect to drivers' preference in different circumstances. Each driver was expected to choose the route that generated the highest utility to he or she. If this was not the case, the choice could be considered irrational. When a driver selected the route, which he or she had the highest utility, his or her behaviour could be quantified and expressed with a utility function. The overall utility of drivers for travelling on the routes could therefore be affected by their comprehension of the message formats.

The vector-valued variables employed in the utility functions were addressed by well-defined attributes. The explanatory variables employed in the models including those refer to respondents' socio-economic background and those characterising the transport network. To demonstrate the explanatory power of the models, respondents were also grouped into different categories regarding their familiarity with the road network and listening propensity to radio traffic news. It was understood that drivers' perception process affected their utilisation of the travel conditions of the routes. Drivers had different trade-off attitudes to the time and costs related attributes when they were influenced by identical traffic information which was presented in different formats. It was concluded that drivers had different comprehension and perception mechanism to the formats for presenting traffic information on VMS system. The message formats could induce certain bias towards a route in one's decision-making process.

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NOTATION

The following symbols are used in this paper:

e	=	2.718281828;
D	=	dummy variable for socio-economic or travel characteristics;
D_{RC}	=	road conditions dummy variable;
C	=	error term.
E	=	total expense on Route A or Route B;
JT	=	journey time for a single journey;
P	=	probability;
U	=	utility;
X	=	attribute;
α	=	alternative specific constant;
β	=	coefficient;
ξ	=	random error term;
Σ	=	summation;

Subscripts

K	=	threshold value; and
$1, 2, 3, 4, i, j, k$	=	positive integer indices.

1 - INTRODUCTION

1. INTRODUCTION

1.1 Study Background

Traffic congestion causes serious and adverse effects to the community in terms of economy, traffic accidents and environmental quality. It is generally accepted that depending only on the construction of more transport infrastructures to alleviate traffic congestion is inappropriate. From demand and supply point of view, solving the problem by implementing traffic measures for better management of the road system is highly regarded as a more economic and effective alternative. Similar to other major cities in the world, traffic congestion is anticipated as a major issue in the Hong Kong Special Administrative Region (HKSAR). The phenomenon cannot be left to find its own equilibrium. With the rapid development of information technology, the HKSAR government realises that there is a great potential in the application of modern technologies to maximise the capacity of the road network by providing real-time information to road users to better control traffic. Providing commuters with up-to-date traffic information about the best routes to any destination is one of the important applications of the technologies. Messages can be given by roadside variable message signs (VMSs), or ultimately by in-vehicle map/ message systems to assist drivers to make decision on their travel routes. The government is now studying the feasibility of applying some cost-effective new technologies to the road network in the HKSAR (Transport Bureau of the HKSAR Government, 1998).

1.2 The problem

Keeping drivers well informed of the latest traffic conditions is considered as an effective way to utilise the efficiency of existing road networks; or even as a means to alleviate traffic congestion. The arguments suggest that, if drivers can make use of traffic information and are able to make better choices in their routings, the capacity of the road network will be maximised. The experiences of previous studies, such as the researches

carried out by Ben-Akiva *et al.* (1991), Schofer *et al.* (1993), Polak and Jones (1993), Conquest *et al.* (1993), Khattak *et al.* (1993, 1997), Polydroropoulou *et al.* (1994), Bonsall (1995a), (and amongst the others) concluded that drivers' route choice behaviour would be affected by traffic information.

The influence of traffic information on an individual's diversion behaviour involves numerous interacted factors. These interactions not only act among drivers themselves, but also act between drivers and the information provided. In order to improve the opportunities of managing traffic flows on highway systems by providing relevant information, it inevitably needs to take into account the high level of interaction between these factors. It is essential to have a better understanding of the nature of the corresponding factors and the inter-relationship among them. In the past two decades, many researchers conducted studies on the appraisal of numerous interacted factors that might influence driver behaviour. For example, Tsuji *et al.* (1985), Mahmassani and Jayakrishnan (1991), Koutsopoulos *et al.* (1994), developed simulation models to investigate relationships between these interacted factors and drivers' behaviour. Caplice and Mahmassani (1992) took into account the influence of arrival time on commuter behaviour. Zhao *et al.* (1995) carried out an analysis regarding travel time information.

No matter which aspect these researchers concentrated on, human factor - the psychology of decision making of drivers – must always be considered. It is because traffic flows can be simply considered as the aggregation of individual decisions. Drivers' decision making can be conceptualised as their perception on the information provided. Such process can be hypothesised to be affected by many factors, including those referring to drivers' characters, their understanding of the message, their pervious experience on the information, and the accuracy of the information describing the travel conditions of the routes. This process may be explained by Figure 1.1. When traffic information or instructions are provided in a subjective manner, two problems arise: Do drivers understand the message? and What are their sequential actions after they have received the information?. Without doubt, the format for presenting information is one of the interacted

factors that affect drivers' decision-making. The subjective impression on the provision of information may not really be helpful to drivers, possibly because the relevant and accurate information has been put into an inappropriate format. Road users will have a demand on the information only if they understand the message content and find it is useful.

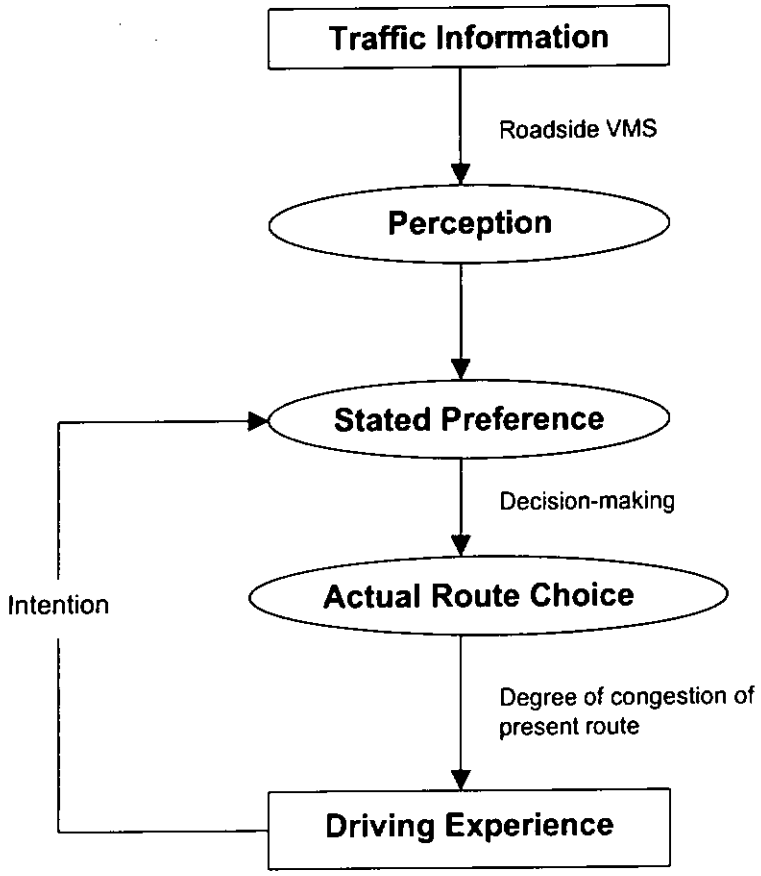

Figure 1.1 Conceptual framework of driver perception process of traffic information

Driver comprehension of the formats for presenting traffic information should be an important topic to the authorities that want to provide traffic information to drivers by using VMS. It is because even the most sophisticated VMS application may be unsuccessful if it is unable to understand drivers' perception mechanism and their behavioural responses in advanced. In spite of many analytical works involved modelling of drivers' responses and actions to traffic information, efforts offered for establishing behavioural models to explore

driver responses to information presented in different formats on VMS appears limited. One of the factors is VMS systems are still not widely used.

1.3 Variable Message Sign

VMS has a large display screen which displays a range of text messages or signals about real-time traffic conditions, such as traffic congestion, weather-related road conditions, and notification of construction ahead (Benson, 1996). In the mid-1980s, the provision of dynamic information by roadside electronic VMSs was deployed. Roadside VMS systems are currently deployed in some countries, such as the United Kingdom, the United States, Japan, the Netherlands, Australia and France. Considering the gradual popularity of VMSs, the system is reputed to be an effective and important means in modern traffic management of highways. In fact, as mentioned by Emmerink *et al.* (1996), there is a great potential for the development of VMS system in providing traffic information to drivers. It is a relatively economical alternative for the very sophisticated and expensive onboard navigation system.

VMS is not only a tool for highway managing authorities to offer instructions for controlling traffic flows but also a service to drivers in assisting them to make decisions. Drivers can make use of the provided information and choose the best routes to their destinations to avoid travelling on the traffic congested roads, based on their perception on the message. Because of the display function of VMS systems, highway managers can design the message contents, as well as the formats for presenting the traffic information, according to their own measurements and understanding of the travel conditions.

A good format should allow the presented traffic information to be easily seen, read, understood, and memorised. It is most important that the actual meaning of the message conveyed by the managing authorities to drivers should be clearly perceived without the possibility of misinterpretation. Road users may argue about the subjective judgement of the managers and suspect the effectiveness of the system. It is apparent that a rational driver requires as much accurate information as possible before a decision is made. Drivers will

not be content with just being informed of the travel conditions; they seek to understand the message. For VMS systems to be successful applied, appropriate message formats should be carefully designed.

1.4 Assessment Methods

Evaluation of the performance of a VMS system is always accomplished by the following methods:

- reveal drivers' preferences of an existing system through personal interviews and/or group discussions;
- carry out "before and after" field-monitoring for the deployment of a dynamic information system; and
- observe driver behaviour by computerised route choice simulator experiments.

For "Reveal preference" and "Before and after field-monitoring" methods, observations on existing behaviour may not vary sufficiently for the establishment of accurate statistical models for evaluation. The variables can be multi-collinear, so that accurate measurements of the importance of the different factors, such as drivers' socio-economic background and travel characteristics, will not be obtained. These two approaches are therefore unable to quantify and isolate the impact of those interacted factors which affect drivers' decision-making. As the variables are not under control, the observed behaviour may reflect factors that are not of interest to the researchers. In addition, the fluctuation of the level of traffic congestion will introduce difficulties for on-site observations. For "Simulator experiment" method, a complicated computer system must be developed. Large amount of geographical and transport data of a highway network are required for computer program set-up in advance. In fact, data-collecting works with respect to these three approaches are generally time and resources consuming.

'In the HKSAR, using VMS system to provide drivers with real-time traffic information about the best route is completely a new traffic management measure. VMSs, as the one shown in Figure 1.2, are currently deployed at the Lantau Link to show warning words and instructions only. It is very different to the VMSs which are functioned for showing dynamic traffic information. A real-time traffic information VMS in Japan is shown in Figure 1.3 for comparison.

Figure 1.2 A VMS currently deployed at the Lantau Link in the HKSAR

A better understanding of driver comprehension of the message formats is an important aspect for the HKSAR to achieve a successful operation of the system. It is not easy for the government to afford a new VMS system for experimental purpose. Just simply asking drivers' degree of preference and understanding of the presentation formats seems too crude for evaluating the effectiveness of different message formats.

Figure 1.3 A real-time information VMS in Japan

This report presents a study which using stated preference (SP) techniques to assess the impacts. The techniques offer an alternative and effective solution to the problems that will be encountered in the assessment if the aforesaid conventional methods are applied. SP techniques can provide good information on drivers' responses and travel behaviour in a very reasonable cost, as well as the opportunities for researchers to carry out "experiment". This study adduced the influence of three common formats for presenting information on VMS.

1.5 Stated Preference Techniques

SP methods are survey techniques widely used for market research and are primarily used to gather market information. In the last twenty years, SP techniques have been developed rapidly and become an integrated part of the transport forecasting methodology. It has generally proved that SP techniques could provide reasonable and valid results for various types of experimental designs, response tasks and analysis techniques. SP methods are very useful to predict travel behaviour because a hypothetical choice context can be built for

testing works, provide that the SP experiment can yield realistic and unbiased statement of behaviour. One of the common applications of SP techniques is to test respondents' reactions to significant change in travel conditions, which cannot be observed at present. SP approaches are designed to forecast demand for new, unique or hard to measure services. The strength of a SP approach is its ability to gain information on hypothetical situation, where conventional revealed preference methods are not suitable. SP techniques can expand the ability of transport planners to forecast future trends (Pearmain *et al.*, 1991).

In this study, an experimentally oriented SP survey was conducted to obtain numerous drivers' behavioural responses under hypothetical circumstances. Respondents' utilisation on different formats for presenting information on VMSs was examined and quantified, by developing behavioural models. "Utility" represents the satisfaction an individual enjoys when spending his or her resources on different things (Pearmain *et al.*, 1991). In this study, "Utility" implies an overall value attached to the choice on the designated routes by a driver. Under a hypothetical circumstance as if a VMS system was introduced to a highway, respondents selected their preferred alternative routes with the assistance of traffic information that was presented in different formats. An empirical analysis consisting of discrete choice models to quantify respondents' route choice behaviour was carried out using the results of the SP experiment. The utility functions were developed in terms of several well-defined attributes as well as some dummy variables. By comparing the different utility functions, it is possible to have insights into driver response to the different formats for presenting information. Although this study is performed in an exploratory way only, it is believed that whether the potential of a VMS system can reaches the expected target is highly dependent on drivers' understanding of the traffic information.

Take into account the HKSAR situations, the advantages for assessing the effectiveness of message formats by applying SP techniques are:

- the choices offered to respondents can be controlled to ensure data is of sufficient quality to develop good quality statistical models;

- the effects of variables of interest can be isolated from the effects of the other factors;
- SP techniques provide the "only practical basis" for conducting evaluation for the completely new information system; and
- good quality behavioural model can be developed in a more efficient way as respondents are asked to response for a number of imaginary cases.

1.6 Structure of this Study

Following this introductory section, the next section reviews the literatures on this topic accordingly. During the last two decades, though VMS systems have substantially been used for influencing drivers' route choice, there is little consensus as to the information formats. Section 3 describes the objectives, research methodology and attribute data use in this study. In order to quantify the effectiveness of VMSs with different message formats, binary logit models have been developed by using the data obtained from a SP experiment. Section 4 reports the SP surveys conducted in February and March 1998. The analysis and findings are presented in Section 5. The results show that traffic information presented in different formats can induce certain bias towards a route choice in one's decision-making process. Conclusions are drawn in the last section.

2 – THE LITERATURE

2. THE LITERATURE

During the last two decades, many researches have been carried out to examine the influences of VMS information on driver behaviour were carried out. It is possible to obtain rich empirical data and ideals to gain more insights into the substantial application of this technology in assisting drivers to make better decisions. However, few studies focused especially on the impact of formats for presenting information.

As stated in the introductory section, the most common methods to evaluate the influence of the message formats are (i) reveal preference, (ii) field monitoring and (iii) simulator experiments. With respect to the findings of some recent studies, these approaches are briefly described in this section.

For the reveal preference method, Catchpole *et al.* (1995) carried out individual interviews and group discussion sessions with drivers, to test their responses to a variety of message formats from the "Drive Time" system which operate at the Melbourne's South Eastern Arterial since July 1995. The aims of the individual interviews and group discussion sessions were to collect drivers' individual options with respect to the designated formats and to find out the inter-effects among drivers themselves respectively. The results showed that quantitative labels describing traffic were the format more readily understood by drivers in the short term. However, in the long term, this format would become less useful to drivers who became familiar with the system. Signs showing journey time provided the information would probably be most useful to drivers in the long term. Benson (1996) conducted a survey of more than 500 motorists in a suburban complex outside the Washington D.C. area to reveal motorist attitudes towards the content of the VMS system of northern Virginia. He concluded that demographic variables have little influence on driver attitudes about VMS system, except for those drivers with a higher level of education. Polydoropoulou *et al.* (1996) developed combined report and SP models to test travellers' en-route responses to the advanced traveller information systems, ATIS, in California Bay Area. Their works indicated that travellers were more likely to respond to

specific quantitative delay information. Shirazi *et al.* (1988) collected commute characteristics, factors affecting route change, and commuters' attitudes towards improved traffic information for continuous radio reporting, electronic freeway message signing, and a traffic information telephone number. It was targeted on commuters in the Los Angeles area where various forms of traffic information currently used at the time a telephone survey was carried out.

Highway managers also carry out direct on-site observations to obtain data with respect to drivers' responses. Ramsay, Catchpole and Luk (1997) performed an evaluation of the Freeway Information System at the Melbourne's South Eastern Arterial with extensive user interviews and accident analysis. The results showing that the format for presenting information on the system was well understood by drivers and the system could influence drivers' decision-making and behaviour. However, field monitoring method does not measure the various factors that affect driver behaviour quantitatively. It is very difficult to identify the influencing intensity of the various interacted factors on drivers' decision-making process individually as it is almost impossible to isolate the impact of these interacted factors. In addition, this method is only suitable for revealing the performance of a current existing VMS system. During the planning stage of developing such a system, valuable experiences from studies in overseas could be taken as useful references, however, direct adoption of the findings from foreign to develop a local VMS system may not be appropriate. It is due to the fact that the driving habits, cultural/economic background and lingual expression of the local and foreign drivers are very much different.

Computer simulator experiments for examining the impact of VMS message formats on driver behaviour is another method. The systems can simulate various driving environments and travel conditions to test driver decision. Bonsall (1995b) developed a computer route choice simulator to investigate the impact due to a range of possible VMS messages. Drivers tended not to use those non-advised routes. In other words, some messages were more effective than the others in influencing driver behaviour. To investigate driver behaviour in response to VMS message formats by using simulators is not a easy task as

there are many constraints exist in terms of expense, sophisticated technology and resources. In addition, data collecting process of these experiments is very time consuming.

Considering the constraints of the aforesaid methods, this study is to derive a framework of quantitative analysis on driver comprehension of format for presenting traffic information on VMS by using SP techniques and discrete choice analysis. Previous researches offered direct effort to quantify the effects of VMS formats for presenting information regarding driver behavioural issues empirically was meagre. For better understanding the literature, it is valuable to review those studies which are somewhat relevant to this topic. Most of these studies discussed are addressed to examine driver responses to traffic information, especially involving an implementation of behavioural models.

Mahmassani and Jayakrishnan (1991) developed a modelling framework to analyse the effect of in-vehicle real time information strategies on the performance of a congested traffic corridor. The results illustrated the effect of the fraction of users equipped with in-vehicle navigation systems on overall system performance by the modelling simulation. Caplice and Mahmassani (1992) investigated the effects of radio traffic information by applying a binary logit model using the data obtained from a mail survey. They observed that elder drivers and female drivers have listening propensity to radio. They also found that drivers not only would change their routes, but also switched their departure time. Bonsall (1992) considered the use of an interactive route choice simulator to investigate the influence of route guidance advice on drivers' route choice. The findings revealed that the influence depended on the extent of guidance advice was corroborated with other factors, including the quality of the information as well as driver familiarity with the road network. He also made comments on some approaches for modelling the route choice related to the context of guidance. Yang *et al.* (1993) made use of a neutral network concepts to build a model for the simulation on drivers' route choice behaviour. Polak and Jones (1993) investigated the effects of pre-trip information on travel behaviour. A logit model was developed based on the data collected from a stated preference survey. The initial results from the study indicated that respondents accepted the approach and the system was able to

provide useful quantitative data on the key parameters of information acquisition process. Khattak *et al.* (1993) applied a multinomial logit model to the factors which influence driver diversion and return choice behaviour. They also provided advice on the specific design implications of Advanced Traveller Information Systems. Zhao *et al.* (1995) developed a stated preference model to examine car commuter's route choice behaviour in response to traffic information, which was assumed to be provided with two types, in other words, travel time and travel time with marginal errors. Lotan (1995) explored route choice behaviour of familiar and unfamiliar drivers reacting to traffic information. An approximate reasoning model and a multinomial logit model were used to analyse the data collected through a driver simulator. He drew a conclusion on the unfamiliar driver category that might exhibit more uniform distribution of choices, while the familiar driver category would have clear preference among the alternative routes. Hato *et al.* (1995) took into account the influence of traffic information on drivers' route choice by introducing inertia variables to a behavioural model. They found that reliability of the information affected more on commuters than on those who went shopping. Emmerink *et al.* (1996) analysed the impact of both radio traffic information and VMS information on route choice behaviour of drivers, with different personal and travel characteristics, by using several types of Discrete Choice models. The analysis also revealed that the impacts of radio traffic information and VMS information on the behaviour were very similar. Mokhtarian and Salomon (1997) using a binary logit model to analyse the preference data obtained from 628 employees of the City of San Diego. The examination of the hypothesis of drivers to telecommute and constraints on facilitators of telecommuting was estimated. The results demonstrated the importance of attitudinal measures over socio-demographic ones, as the same demographic characteristics would have different effects on preference for different people.

3 – THE STUDY OBJECTIVES AND METHODOLOGY

3. THE STUDY OBJECTIVES AND METHODOLOGY

The HKSAR is an international city with extremely high population density. As other major cities, congestion is an evident. The implementation of real-time information VMS system is being considered by the government as one of the possible means to alleviate traffic congestion (Transport Bureau of the HKSAR Government, 1998). VMS systems are used to display the instant travel conditions of the road network to assist drivers to choose the best routes to their destinations. However, Hong Kong drivers not have experience of a real-time VMS system. Although the overseas experience in deploying such a system is beneficial and constructive, it cannot be taken as an adequate basis for us to understand Hong Kong drivers' en-route choice behaviour under this circumstance. This is probably due to differences in language, style of expression, traffic and geographic conditions between the HKSAR and the other cities. In addition, as described in the literature review section, only a few researches assessed empirically driver behavioural responses to different formats for presenting information on VMSs. Prior to introduce the system here, an insight on Hong Kong driver comprehension of the VMS message formats is valuable. Because of some technical, political and monetary reasons, an evaluation of the performance of a VMS system for improving the traffic conditions in the HKSAR remains largely an academic exercise.

3.1 Objectives

Based on the travel conditions and driving environment of the highway system in the HKSAR , this study is to address the following issues:

- to demonstrate the use of SP techniques to test driver comprehension of formats for presenting traffic information on VMSs;

- to assess the influences of the three common designated message formats on Hong Kong drivers' en-route choice. Respondents' socio-economic background and travel characteristics are regards as elements in the utility functions; and

- to examine, in particular, the impact of the factors radio listening propensity and road network familiarity of drivers on drives' attitude towards different message formats.

3.2 Methodology of this Study

Provide drivers with real-time travel information by means of VMSs is a completely new issue in the HKSAR. As VMS systems showing up-to-date travel information about the best routes to a destination has not yet been installed at present, it is impossible to carry out a direct observation on drivers' behaviour to test the influence of the message formats. Respondents must be questioned about their likely responses in a hypothetical situation. However, the constraints and difficulties described in the introductory section for developing a computer simulator are not easily solved. This study employed experimental oriented SP approach. The computation was based on mathematical models of decision-making and the theory of discrete choice analysis. The strength of SP approach is its ability to gain information on hypothetical situation, where conventional revealed preference methods are not suitable.

In this study, it was assumed that there was a VMS system informing respondents with instant travel information. SP exercises asked respondents to state their preferences between two designated routes under different hypothetical circumstances as if identical traffic information was presented to drivers in different formats. Taking into account respondents' trade-offs between the two designated routes in the SP exercises, the utility functions for the behavioural models in terms of the some well-defined attributes of the alternative routes could be established.

Discrete choice analysis is a branch of econometrics which has considerable development in the last twenty years within the general context of the random utility theory. The theory assumes that people are able to calculate some metric of preference, which economists and social researchers refer to as utility, for each possible alternative. People will choose the alternative with the highest utility. The random utility approach attempts to find a formula for this utility in terms of well-defined attributes of the alternative. However, it also allows for the fact that there will be random effects.

3.3 Survey Approach

For a study eventually to forecast choice behaviour in current or further scenarios, it is necessary to frame the survey experiment in realistic choice context (Bradely and Kroes, 1990). To provide a sense of realism to respondents, the SP experiment was designed for a trip from Tsuen Wan, located at the outermost edge of Kowloon urban area to Central (the central business district on Hong Kong Island) with the presence of a VMS system. For the attribute data to produce better explanation, it is necessary to base the SP choice context as closely as possible on a travel choice which respondents are actually made. In the SP exercises, respondents were assumed to travel from Tsuen Wan to Central under hypothetical situation. Traffic information was provided by a VMS system with different message formats for presentation. Usually, almost all drivers choose one of the following routes when they actually travel from Tsuen Wan to Central. The routes were named as Routes A and B in this study. The details are shown in Figure 3.1 and are listed as follows:

Route A

Tsuen Wan → Tsuen Wan Road → Kwai Chung Road → Western Kowloon Corridor → Tong Mi Road Flyover → Ferry Street → Gascoigne Road → Chatham Road North → Hong Chong Road → Cross Harbour Tunnel (CHT) → Gloucester Road → Harcourt Road → **Central**

Route B

Tsuen Wan → Tsuen Wan Road → Route 3 → Western Harbour Crossing (WHC) → Route 7 → Connaught Road → Harcourt Road → **Central**

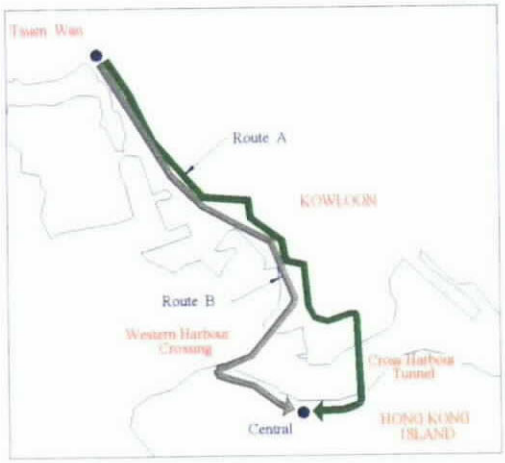

Figure 3.1 The designated routes in the SP experiment

For Route A, drivers travel on local roads and through the Cross Harbour Tunnel (CHT), which is known to be one of the most congested roads in the HKSAR. For Route B, drivers travel on a section of the expressway Route 3, and the Western Harbour Crossing (WHC), the third tolled tunnel connecting Kowloon to Hong Kong Island. Although a trip on Route B has the advantage of a shorter journey time, the expenses are higher. It was expected that drivers would have trade-offs between journey time and expenses along the routes.

The two routes have been chosen because:

- both routes are well known to drivers;

- both routes have approximately 17km;
- both routes include a cross-harbour tunnel connecting Kowloon to Hong Kong Island, where the expenses are different; and
- the travel conditions of the two routes are significantly different.

In this study, three common presentation formats of traffic information were examined. They are (i) Numerical format – shows the estimated journey time in minutes; (ii) Words format – describes the level of congestion by words; and (iii) Signal format – indicates the level of congestion by numbers of switch-on-signals. Their appearances are illustrated in Figures 3.2, 3.3 and 3.4.

Figure 3.2 Numerical format for presenting estimated journey time

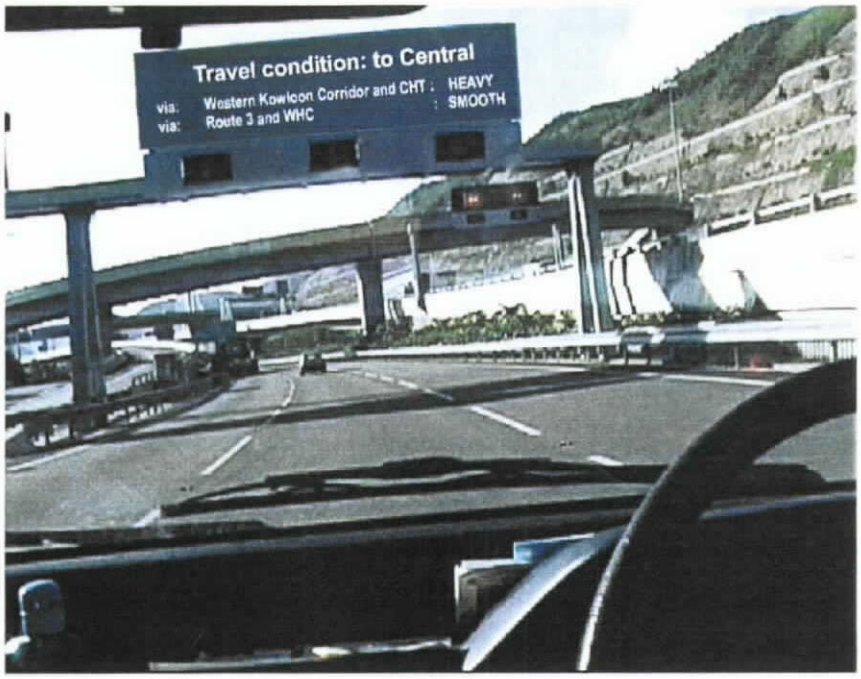

Figure 3.3 Words format for presenting travel conditions

Figure 3.4 Signal format for presenting congestion level

These types of message formats are very common for VMS systems. The first two formats can be found in many cities, such as the Freeway Information System at Melbourne's South Eastern Arterial (Ramsay *et al.*, 1997) and the VMS system in northern Virginia (Benson, 1996). The third one is a presentation format that is currently used at Tuen Mun Road, a highway with daily traffic flows of 106,000 vehicles (Transport Department, Government of the HKSAR, 1997). Traffic signboards with signal indicators are located at designated points along the road to indicate traffic congestion level if a traffic accident occurs ahead. A traffic signal board currently installed at Tuen Mun Road is shown in Figure 3.5.

Figure 3.5 Traffic signal board at Tuen Mun Road

3.4 Determining Attributes and Attribute Levels

In order to examine driver comprehension and behavioural response to different formats for presenting information by developing utility functions, it was essential to find out respondents' trade-offs of selected attributes in the SP exercise. Since the definition and measurement of the attributes were affected by the experience and expectations of drivers, it was necessary to ensure that the variables presented were those perceived to be realistic to drivers. In addition, it was important to ensure that the variables presented were clearly understood by respondents and they were supplied with the same background information. Referring to the content of real-time traffic information presented on the VMS systems in Australia (Catchpole *et al.*, 1995 and Ramsay *et al.*, 1997) and the United Stated (Benson, 1996), traffic information expressed in journey time or level of congestion was taken as one attribute in the SP experiment. For building up a picture of how possible time savings could off-set cost increases, the total travel expense for the trip combining tunnel toll and petrol cost, was chosen as the other attribute.

Attribute: journey time

The fundamental principle behind the choice of attribute values is to ensure that the values offered, whilst under hypothetical circumstance, are reasonable. In this sense, it is essential to concentrate on actual journeys which respondents have made, and to assume that all external aspects of the design are equal.

In this study, in order to present situations which broadly correspond with respondents' experience and make the SP choice context closely related to the conditions, selection of attribute values for journey times was based on the results of on-site measurements. The attribute: Journey Time was defined as the total time spent getting from the specified origin, the roundabout of Tuen Mun Road/ Tai Chun Road/ Tsuen Wan Road, to the specified destination, Jardin House at Central. The total time spent for travelling on the designated

routes (Routes A and B) were measured ten times for each time period as follows during typical weekdays in December 1997.

- peak period: 0730 hours – 1030 hours
- non-peak period: 1300 hours – 1600 hours

The journey times for the trips on Route A were found with a range from 25 to 65 minutes, and those for Route B were measured around 15 to 20 minutes. The wide range of the journey time for travelling on Route A was mainly due to the significant fluctuation of the congestion level of the local roads and the CHT during peak and non-peak periods.

Attribute: total expense for the trip

Total cost for the trip refers to the total out-of-pocket expenses for travelling on the designated routes, including the tunnel toll and petrol cost. By measuring these expenses for several types of private vehicles, a range of the generally required expenses were estimated. The estimation did not directly make reference to commercial vehicles because the expenses would always paid by the employers and the respondents' thoughts regarding the possible time savings on offsetting the cost increases might be affected. The toll charges of the CHT and the WHC in 1998 for different types of vehicles (Transport Department, Government of the HKSAR, 1998) are enclosed in Appendix A. Based on the definition, a trip on Route A would cost about HK$ 20 to HK$ 40; and that for Route B about HK$ 40 to HK$ 60.

Attribute: road conditions dummy

A direct comparison was made on the aforesaid attributes, journey time and total cost, by translating them to monetary units to estimate their demand effects. According to Pearmain *et al.* (1991) and Milton and Arnold (1995), however, it was not sensible to include only these two attributes, as this would make the experiment too transparent and simple, which

would invite attempts at "policy bias". The concept of "road conditions of the routes" was therefore incorporated in the utility functions as the third attributes to avoid such a bias in the SP exercises.

Attribute levels

As suggested by Pearmain *et al.* (1991), it may caused some items being ignored because respondents will experience fatigue in answering the SP exercise for too many attributes or levels. For a better handling of the survey data and to simplify the complicate analytical tasks, only three levels were set for each attribute in the final design of the SP experiment; where the levels were defined as the differences between Route A and Route B, using the following utility function:

$$U_A - U_B = \beta_1(JT_A - JT_B) + \beta_2(E_A - E_B) + \beta_3 D_{RC1} + \beta_4 D_{RC2} + \beta_i D_i + C \qquad (1)$$

where:

A, B stand for choice for Route A and choice for Route B respectively;

U = utility of a route;

JT = journey time for a single journey;

E = total expense on Route A or Route B;

D_{RC1} = road conditions dummy 1;

D_{RC2} = road conditions dummy 2;

D_i = dummy variable for socio-economic or travel characteristics;

$\beta_{1,2,3,\ldots,i}$ = coefficients; and

C = error term.

In this study, each alternative in the SP exercises was presented as a full set of attributes, including the traffic information, total expense and road conditions. The levels of the attributes for each alternative were defined in a statistically efficient manner, such that the

responses could be analysed, or decomposed as a function of these different levels. The attribute levels used to construct the hypothetical route choices in the SP exercise were based on an experimental design, by using the data according to people's actual experience. As described by Pearmain *et al.* (1991), for experimental design by using revealed data, correlation among the attribute levels is always a problem.

In the design, the values attached to the attribute levels were carefully selected so that they should not only cover the range of the valuations that had been on-site measured, but also varied independently form one another to avoid multi-collinearity. This ensured that the effects of each attribute level upon responses were easily isolated. Considering the difference between the journey time and total expenses for travelling on the designated routes, which obtained in actual on-site measurement, numerous trial tests were carried out to examine the singularity of different combinations in terms of the levels of each attribute by using SP experiment design package BINMSTER. A set of values (attribute difference) attached to the attribute levels with considerably insignificant correlation was gained.

There were originally 27 combinations for the SP exercises in total. By testing the singularity of the attribute levels for each format for presenting information, 9 SP games were finally designed to test respondents' trade-offs of the routings. The details of singularity test for the final trial is enclosed in Appendix B.

Three different "road conditions" - poor, fair and good - were incorporated and presented as two dummy variables in the utility functions, which known as road conditions dummy variables 1 and 2 in the SP experiment. "Good road conditions" was defined as few heavy vehicles and without road works. "Fair road conditions" was defined as many heavy vehicles and without road works; and that for "poor road conditions" was many heavy vehicles and with road works.

The values attached to the attribute were defined by considering the range of the measured valuations of the attributes and the results of the value of time (VOT) estimation for the

attribute combinations. The determined VOTs of the final set parameters defining a wide range of VOT, from HK$ 0.125/minute to HK$ 2.5/minute, it was assumed that competitive trade-off decisions were allowed and the values attached to the attributes could present trade-offs that cover the range held by each respondent. Table 3.1 illustrates the values attached to attribute levels to the routes.

Table 3.1 Values attached to attribute levels of alternatives for Routes A and B

Number	Journey time (minutes)			Total expense (HK$)			Road conditions	
	Route A	Route B	Difference	Route A	Route B	Difference	Route A	Route B
1	25	15	10	20	45	-25	Good	Good
2	30	20	10	30	55	-25	Poor	Good
3	30	20	10	25	40	-15	Good	Good
4	35	15	20	20	45	-25	Fair	Good
5	55	15	40	20	45	-25	Good	Good
6	30	20	10	35	40	-5	Fair	Good
7	60	20	40	25	40	-15	Poor	Good
8	35	15	20	35	40	-5	Good	Good
9	60	20	40	40	45	-5	Good	Good

3.5 Conversion of the Attributes

The relationships between attribute level for different descriptions of travel conditions between Numerical and Words formats were counter checked with traffic conditions detailed by radio traffic news. A conversion of the measured journey times on the routes and the corresponding descriptions of travel conditions from radio news was made. The descriptions of travel conditions were set into a four-level-description. Accordingly, the number of switch-on-signal (for Signal Format) to indicate the travel conditions was also set at four levels. The conversion of the attributes is shown in Table 3.2.

Table 3.2 Conversion of attributes for Numerical, Words and Signal formats

Numerical format (Number)	Words format (Description)	Signal format (Switch-on-signal)
up to 20 minutes	Smooth	-- -- --
From 21 to 30 minutes	Medium	O -- --
From 31 to 40 minutes	Heavy	O O --
More than 40 minutes	Congest	O O O

In the SP experiment, although traffic information was presented in different formats, the messages were assumed to represent identical travel conditions to respondents in the SP exercises. The simplified way of conversion described in Table 3.2 based on a subjective impression on the relationship of the attribute levels only. Respondents' understanding on the attribute values for one format with the other two formats might be very different. This limitation of the conversion mainly due to peoples' different impression and reliability towards different message formats. Nevertheless, it reflected the subjective judgements that would possibly made by the authorities.

Respondents would have their own trade-offs of the SP exercises based on the values of the attributes. Drivers' route choice behaviours were calculated by using discrete choice analysis, to obtain utility functions with respect to the principle of utility maximisation. When a driver selected the route which he or she had the highest utility among the provided alternatives, his or her behaviour was modelled at the time the choice was made. It was expected that driver's choice indicate not just preference, but also behavioural response and action taken. Therefore, respondents were asked to state their strength of preferences on one route from the alternatives in the SP games.

Samples of the SP exercise for each format for presenting information are shown in Figure 3.6. Bearing in mind that the message contents presented by each format are identical.

In addition, the SP exercises presented to respondents included a dummy question for simple rationality check. In other words, the attributes for one option with higher cost, longer journey time and less favourable road conditions in the dummy question. If a respondent chose the worse option, the interviewer would ask the respondent to reconsider it. If the respondent insisted, the interviewer would ask for reasons and carried on with the rest of the interview. Such built-in rationality test could let the interviewers facilitate respondents' understanding of the SP task.

Numerical format:

Route	Route A	Route B
Estimated journey time (minutes)	35	15
Total expense for the trip (HK$)	20	45
Road conditions of the route	Fair	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Words format:

Route	Route A	Route B
Description of congestion level	Heavy	Smooth
Total expense for the trip (HK$)	20	45
Road conditions of the route	Fair	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Signal format:

Route	Route A	Route B
Number of signals on	O O --	-- -- --
Total expense for the trip (HK$)	20	45
Road conditions of the route	Fair	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Figure 3.6 A sample of the SP exercise for each message format

3.6 The Questionnaire

The questionnaire of the SP experiment had three parts. The first part was the introductory section; it consisted screening questions for gathering respondents' basic information. This part collected the micro-level data of drivers, not only their socio-economic background, such as age, gender, education level, income, but also their travel characteristics on the designated routings, such as trip purposes, frequency of listening to radio traffic news, frequency of travel on the routes, usual choice between the routes. During asking respondents about their background information, the interviewer would take the opportunity

to explain the attributes of the route options. There were a total of nine SP games and one dummy question as simple rationality checking in the second part of the questionnaire. From respondents' trade-offs of the attributes of the SP games, utility function regarding drivers' en-route behaviour could be developed. The third part are attitudinal questions for obtaining respondent's perception and degree of their understanding of the three designated formats. To avoid presentation bias (Bradely and Kroes, 1990), the placement of the order of pairwise choices in the SP games for different formats was randomised. This facility can help to avoid order or learning effects that may occur when certain game-sets are always asked in the same order. A set of the questionnaire is enclosed in Appendix C.

4 – DATA COLLECTION

4. DATA COLLECTION

4.1 Stated Preference Survey

For a SP survey, the best way is to intercept the potential respondent for a personal face-to-face interview. The pilot and main surveys for this study were therefore conducted by contacting respondents in personal interviews. SP analysis for this study was based on information collected from the interviews with drivers.

4.2 Pilot Surveys

There are two main objectives in undertaking pilot surveys. Firstly, it is to test the wordings and concepts contained in the SP exercises. Secondly, the data of the survey are used to test the reasonableness of the values used in the design of the SP exercise. In addition, it offers an opportunity for the interviewers to become familiar with the environment and be aware of the potential problems which may occur.

Two pilot surveys were conducted. The first pilot survey was carried out with potential respondents selected randomly in the campus of The Hong Kong Polytechnic University with respect to their driving experiences at the designated routes. During the survey, a total of 54 interviews was carried out, of which, 49 could be used for analysis. The statistical analyses on the data collected in the first pilot survey suggested that in general respondents understood the content of the questionnaire. They all passed the rationality check and gave trade-offs of the different scenarios based on hypothetical travel conditions. Some respondents indicated that it would be better to know the appearance of the VMS system. In order to provide a visual stimulation to respondents for better description of their situation, pictures showing the appearances of the VMSs with different presentation formats were prepared. Some respondents indicated that they have favouritism on one of the presentation formats. Therefore, two questions regarding drivers' preferences and degree of

understanding on the formats were incorporated in the questionnaires for the second pilot and main surveys.

A second pilot was conducted in the central business area to test the revised questionnaire. Similar to the first pilot survey, respondents were also recruited randomly. A total of 37 responses were obtained. According to the findings from the second pilot survey, only minor amendments on the wordings of the questionnaire were made. It was pleased that most respondents seemed to maintain interest throughout the interview, despite the length of the questionnaire. It was a significant point of the survey. The results of the second pilot survey confirmed the appropriate approach of the SP experiment.

4.3 Main Survey

Sampling

Since SP techniques are a special type of market research method, obtaining sufficient samples for each category for analysis is very important. From some previous studies (e.g. Bradley and Kroes, 1990), it is understood that there is an unwritten law in transport SP research that the minimum acceptable sample is 30 to 50 respondents in each market segment for a model to be estimated. However, although around 30 interviews per market segment are considered "sufficiently large" to ensure that the Central Limit Theorem can be applied, it is generally agreed that larger samples are required. Pearmain and Swanson (1991) suggested that samples of 75 - 100 would be appropriate. This provided a guarantee to collect statistically significant samples for each segment.

For an efficient and convenient aggregation of the individual cases in accordance to drivers' personal and travel characteristics for the analysis, different segments were established regarding to the variables of the models. The quantity controls on the segments took into account the variables regarding respondents' socio-economic background and characterising the transport network, such as the age, gender, monthly income and driving experience on the designated routes.

In fact, SP techniques provide a particularly data efficient method of undertaking surveys. Each respondent can be presented with a set of alternative scenarios and be questioned about their choices in each case, thus yielding multiple responses from each interview undertaken.

Since it was expected that people with common socio-economic background and travel characteristics might likely have similar reactions to the designated travel attributes, the individual responses might be aggregated and used to calculate statistically significant predictions of behaviour for each segment of the survey sample. However, it was not easy to define the target sample size and to obtain data for the actual driver population using the two routes, with the designated origin and destination, unless a complicate O-D survey was performed. It was necessary to intercept potential drivers at their workplaces, residential areas and public locations, and to invite them to participate the survey. This method of recruiting respondents was felt to be the most appropriate for this type of survey, in which the overall sample was grouped into smaller segments with similar characteristics.

In view of the travel characteristics of Hong Kong drivers, it was most difficult to obtain sufficient samples for respondents with considerably driving experience on Route B among the segments. In this study, a minimum target number of 75 was therefore set for this segment to ensure reliable estimation.

The number of responses obtained per individual market segment and the heterogeneity of respondents' characteristics ensured that all the travel groups were represented and analysed. As long as sufficient observations were achieved within each segment (minimum 75 samples), the total sample did not have to be typical of the population as a whole. The assumption made was that, within each segment, respondents had enough in common with each other to allow valid statistical conclusions to be drawn from their responses. This quantity control method is a typical way of SP sampling in market research.

Fieldwork

The fieldwork was undertaken in February and March 1998. Potential respondents were contacted randomly in car parks, workplaces and public areas of some residential developments and asked a brief, in respect to their personal and travel characteristics to their suitability for the designated segments. Interviewers would provide clarification if respondents raised queries during the interview. Each interview lasted about 20 minutes and the survey achieved 603 interviews, which 552 were successfully completed. Only those respondents who passed the logic and rationality tests were chosen to be included in the valid samples. After rigorous checking to discard illogical responses before the analysis, the sample size was reduced from 552 at the end of the fieldwork to 475, giving a validity rate of 86%. The data were then used for analysing the influences of different message formats on drivers' route choice decision-making processes.

5 – ANALYSIS AND FINDINGS

5. ANALYSIS AND FINDINGS

5.1 Characteristics of Respondents

As discussed in the Methodology section, the number of responses for each segment regarding in accordance to the respondents' socio-economic and travel characteristics was ensured significant for analysis. Due to the application of the quantity control method, "sufficiently large" sample sizes for each segment were achieved. Although the sample sizes for each segment for the variables were "controlled", a count on the samples collected gave a full picture of the data to be analysed, and thus a better understanding of the results of the analysis carried out in the next section. Firstly, with reference to socio-economic background, it was found that all respondents were in employment and 68% of respondents were male. A relatively high percentage, about 76 %, was in the below 40 age group. About 48% had attained a tertiary education. In terms of occupation, "Professional/Managerial", "Service Worker" and "Self-employed" work groups accounted for 75% of the sample, with 35%, 23% and 17% of respondents respectively belonging to these work groups. Over 52% reported that their monthly income was above HK$ 30,000 (in 1998 prices). Just over half of respondents, 51% had a regularly listen propensity to the radio to obtain traffic news.

Secondly, with reference to travel characteristics of the designated routes, 37% of respondents drove to work choosing either of the two routes. About 56% using either of the route during peak hour. Likely due to the different toll charges of the two cross-harbour tunnels, more than 83% of respondents chose Route A rather than Route B under the existing circumstances. The tolls of the CHT ranged from HK$ 4 to HK$ 30 and that for the WHC ranged from HK$ 15 to HK$ 95 (in February 1998 prices) respectively (Transport Department, Government of the HKSAR, 1998). The respondents' driving frequencies on routes A and B were very different: 63% usually drove on Route A for at least once a week; but only 18% did so for Route B. More than 76% of respondents said that they were very or quite familiar with the travel conditions of Route A, only 55% however gave the same responses for Route B.

A summary of the personal and travel related characteristics of the valid samples is given in Table 5.1

Table 5.1. Personal and travel characteristics of respondents for total valid samples

Characteristics	%	Characteristics	%
Age (year)		*Personal monthly income (HK$)*	
18-25	30	Less than 20,000	22
26-39	46	20,000-29,999	26
40 or above	24	30,000-39,999	36
		40,000-49,999	7
Gender		50,000 or above	9
Male	68		
Female	32	*Time at which the trip is made*	
		Peak period	56
Education level		Non-Peak period	44
Tertiary	48		
Non-Tertiary	52	*Driving experience on Route A*	
		Less than once a week	37
Occupation		Once or more a week	63
Self-employed	17		
Professional/Managerial	35	*Driving experience on Route B*	
Clerical and related	15	Less than once a week	82
Service worker	23	Once or more a week	18
Manual worker	8		
Retail	2	*Driver perceived understanding of the travel conditions of Route A*	
Trip purpose		Very understand	48
Work	37	Quite understand	28
Others	63	Not understand	24
Listening to radio traffic information		*Driver perceived understanding of the travel conditions of Route B*	
Regularly	51	Very understand	14
Sparse	11	Quite understand	41
Sometimes	38	Not understand	45
		Preference on the routes under existing circumstance	
		Route A	83
		Route B	17

Sample size: 475 respondents

It indicates that it includes respondents with a broad range of socio-economic and travel-making characteristics. However, the distribution of each variable across the sample might not exactly reflect that of the driver population using the two routes. In fact, as stated in the

previous section, the distribution does not need to be a proportionate representation of the population.

Seven factors were incorporated in the questionnaire to test respondents' perceived level of the importance of the factors in making route choice decision. Respondents were asked to rank the factors. The scale of 1 to 7 is in ascending order which means that "1" is the most important and "7" is the least important. Most respondents ranked travel time, level of congestion and level of congestion were the most, second and third important factors respectively, and petrol cost as the least important one. Table 5.2 summarises the 475 respondents' ranking on the importance of the factors that influencing their decision-making on route choice.

Table 5.2 Respondents' ranking on the importance of the factors on route choices

Factor	*Proportion (share %) for ranking:*							*Total (%)*
	1	*2*	*3*	*4*	*5*	*6*	*7*	
Travel time	43	16	31	10	0	0	0	100
Level of congestion	12	59	16	6	3	3	1	100
Tunnel toll	37	9	23	7	11	9	4	100
Petrol cost	0	7	6	6	12	16	53	100
Understanding of the travel conditions	3	4	9	17	47	10	10	100
Distance of route	2	1	14	23	12	44	4	100
Road conditions	3	4	1	31	15	18	28	100
Total (%)	100	100	100	100	100	100	100	
Sample size: 475 respondents								

5.2 Analytical Method of Stated Preference Experiment

Making use of the data obtained in the SP exercises, the analysis was based on mathematical models of decision-making. Discrete choice analysis was employed to develop behaviour models to examine drivers' responses to the three designated formats for presenting traffic information on VMS systems quantitatively. As discussed in the Methodology section, the SP experiment in this study was a choice between two options based on a hypothesis. It was expected that there exist trade-offs among the attributes: total expenses, overall time saving and road conditions of the two designated routings.

Respondents' trade-offs between the two designated routes in the SP exercises were transacted to produce utility functions, regarding the behavioural models, by discrete choice analysis. According to Ben-Akiva and Lerman (1985), it is impossible to obtain a discrete choice model that can always succeed in predicting the chosen alternatives by all respondents. The concept of random utility was therefore adopted in the analysis of this study. The strength of preference, for simplicity, was converted to a reasonable distribution of probability. Five levels of probability values were chosen based on the five-point-semantic-scale of the questionnaire. The five sets used to represent drivers' attitude towards choosing Route A or Route B were: (i) Definitely choosing Route A, (ii) Probably choosing Route A, (iii) Undecided in choosing Route A or Route B, (iv) Probably choosing Route B and (v) Definitely choosing Route B. The conversion of the probabilities to the semantic scale for drivers to choose Route B is shown in Table 5.3.

Table 5.3 Conversion of Preference to Choice Probability

Strength of preference	*Scale*	*Choice probability for Route B*
Definitely choose Route A	1	0.01
Probably choose Route A	2	0.25
Undecided	3	0.50
Probably choose Route B	4	0.75
Definitely choose Route B	5	0.99

Considering the works carried out by Ben-Akiva and Lerman (1985), for the estimation of travel choice models with typical disaggregate model, the route choice processes for respondents were modelled by binary logit formulation in this study. Ben-Akiva and Lerman (1985) stated that a choice was considered as an outcome of a sequential decision-making process. Many factors affected drivers' decisions on changing a route, such as route attributes, drivers' socio-economic background and travel characteristics. In addition, according to Ben-Akiva *et al.* (1991), the factors which affecting drivers' route choice behaviour basically depend not only on travel information, but also on drivers' socio-economic characteristics and travel habit. These factors might have effect on drivers' perception process, and these should be included in the specification of the logit model. Some personal and travel-related factors in the analysis were incorporated in the analysis in

order to obtain a better explanation of the models. The utility functions for each message format were therefore developed with the various factors reflecting the respondents' socio-economic and travel characteristics as dummy variables.

From the concept of "random utility", a utility function is considered as a random variable including a deterministic part and a stochastic part. The deterministic part is explained by the designated attributes of the alternatives, respondents' socio-economic characteristics and travel-related variables. The stochastic part typically presents other unobservable elements that cannot be known. That means, there may be some effects which vary across the population but about which we do not have information either because we are unaware of them or because we cannot capture them. It is traditional to incorporate the expected value of the stochastic part into the alternative specific constant (the Constant, refer to the bias of the alternative) of a utility function and leave a stochastic term with an expected value of zero. The general form of the utility function regarding respondents' attitudes towards the three formats for presenting information, which assumes a Gumbel distribution in this study, is:

$$U_{ij} = \alpha_j + \sum_{k=1,K} \beta_{jk} X_{ijk} + \xi_{ij} \qquad (2)$$

where:

U_{ij} = utility of alternative j for individual i.

α_j = alternative specific constant for alternative j;

β_{jk} = coefficient for attribute k for alternative j;

X_{ijk} = attribute k for alternative j, individual i; and

ξ_{ij} = random error term for alternative j for individual i.

From Bradley *et al.* (1990), the general form of the probability function for a logit model is as follows:

$$P_{ij} = \frac{e^{U_{ij}}}{\sum_{j=1,J} e^{U_{ij}}} \tag{3}$$

where:

P_{ij} = the probability of individual i choosing alternative j; and

U_{ij} = the utility of alternative j for individual i.

The probability function applied in this study for the binary logit models is as follows:

$$\ln \frac{1 - P_B}{P_B} = U_A - U_B \tag{4}$$

Where:

A, B stand for choice for Route A and choice for Route B respectively;

P = choice probability; and

U = utility of a route.

It was assumed that the utility functions estimated across samples which were as homogenous as possible with respect to preference structures, and thus the survey samples were segmented as far as possible into groups which were expected to have similar behaviour.

Applying the data obtained in the SP experiment, for each of the designated formats, driver behaviour was expressed quantitatively by a utility function. The relationship among the attributes in each utility function regarding respondents' attitudes towards the three formats for presenting information was generally assumed linear in parameters. The coefficients for attributes represented the contributions of different variables to utility, in which the logarithm of the probability ratio was set as the dependent variable. In this study, the overall utility of a driver travelling on the designated routes could be raised either by a

lowering of cost or a saving in journey time. The relative values of the coefficients were used to derive VOTs of respondents.

By binary logit formulation, the interviewees' responses were transferred into response variables that measured the utility differences between the two options. To make comparison on driver comprehension of different message formats, the response variables with respect to Words and Signal formats were same as that for Numerical format. However, there might be an uncertainty for applying this transformation to those utility functions that were established for Words and Signal formats. Readers should caution the limitation of this simplified method of transformation, as respondents' preferences on different message formats might be very different. It was difficult to apply the transformation directly without considering any prerequisite. The limitation of transformation mainly due to peoples' different impression and reliability on different message formats.

In the analysis, the variables were grouped in respect to the sets of the designated attributes, drivers' socio-economic background, travel characteristics and driving experience on the designated routings as follows:

Designated attributes

- Journey time (independent variable in a quantitative form);
- Total expense (independent variable in a quantitative form);
- Road conditions dummy 1 (indicator variable in a qualitative form);
- Road conditions dummy 2 (indicator variable in a qualitative form);

Socio-economic background

- Age (dummy variable in a qualitative form);
- Gender (dummy variable in a qualitative form);

- Education level (dummy variable in a qualitative form);
- Monthly income (dummy variable in a qualitative form);

Travel characteristics

- Trip purpose (dummy variable in a qualitative form);
- Time at which the trip is made (dummy variable in a qualitative form);

Driving experience on the designated routings

- Driving experience on Route A (dummy variable in a qualitative form); and
- Driving experience on Route B (dummy variable in a qualitative form).

To interpret the results, the following points regarding the deployment of the variables in the analysis should be noted.

- According to the method suggested by Milton and Arnold (1995), road conditions dummy variables 1 and 2 were set as 0 if road conditions for both Routes A and B were presented as "good". Variables 1 and 2 were given by 1 and 0 respectively if road conditions of Route A was "fair" and Route B was "good". For case of road conditions of Route A as "poor" and Route B as "good", Variables 1 and 2 were assigned as 0 and 1, respectively.
- Age dummy variable had value of 1 if driver was younger than 40-year-old; and value of 0 otherwise.
- Gender dummy variable had value of 1 for male driver; and value of 0 for female.
- Education level dummy variable had value of 1 if driver attained a tertiary education; and value of 0 otherwise.
- Monthly income dummy variable had value of 1 if the monthly income of driver was HK$ 30,000 or above; and value of 0 otherwise.

- Trip purpose dummy variable had a value of 1 for commuting driver; and value of 0 otherwise.
- Time at which the trip is made dummy variable had value of 1 if driver travelled during peak periods; and value of 0 otherwise.
- Driving experience on Route A dummy variable had value of 1 if driver travelled on Route A at least once a week; and value of 0 otherwise.
- Driving experience on Route A dummy variable had a value of 1 if driver travelled on Route B at least once a week; and value of 0 otherwise.
- Value marked with an asterisk, *, is statistically insignificant at 99% level.
- Value marked with two asterisks, **, is statistically insignificant at 95% level.

The four designated attributes, together with eight potential variables regarding respondents' socio-economic and travel characteristics, were initially tested for the models. Information on "Time at which the trip is made" was originally incorporated. However, attempted to include this variable in the analysis provided low levels of significance for it in all models. For the cases with or without this variable, similar results for each model were obtained. This offered an empirical validation of the models though this variable was dropped. It was therefore neglected in the final set of assessments. The final models were specified with 11 variables which are as follows:

- Journey time (independent variable in a quantitative form);
- Total expense (independent variable in a quantitative form);
- Road conditions dummy 1 (indicator variable in a qualitative form);
- Road conditions dummy 2 (indicator variable in a qualitative form);
- Age (dummy variable in a qualitative form);
- Gender (dummy variable in a qualitative form);
- Education level (dummy variable in a qualitative form);
- Monthly income (dummy variable in a qualitative form);
- Trip purpose (dummy variable in a qualitative form);
- Driving experience on Route A (dummy variable in a qualitative form); and

- Driving experience on Route B (dummy variable in a qualitative form).

For simplicity, a transformation of a five-point-semantic-scale on the choice probability in logit formulation was applied. The utility functions with respect to the different formats for presentation were obtained by using ordinary least squares regression programs, in which the logarithm of the probability ratio was set as the dependent variable. The models developed based on the simplifying assumptions in this study are certainly useful for comparing driver response under different message formats only, further consideration should be given to attempt the use of such models for forecasting.

5.3 Results

Three models were attempted for simulating the decision-making process with respect to drivers' response to Numerical, Words and Signal formats for presenting traffic information on VMS. They are named as Model-Number, Model-Words and Model-Signal in this paper, accordingly. The details of the regression outputs for all models are shown in Appendices D1 to D24. Table 5.4 shows the respective estimated coefficient, together with their corresponding *t*-statistics for the models.

Sign of coefficients of variables

The distribution of the signs attached to the coefficients of the variables was consistent for the three models. There was a similar tendency for the effects of the selected variables on driver comprehension of the different message formats.

The coefficients of all variables were negative, except the driving experience on Route A dummy variable and the Constant. In the analysis, as the utility differences between the options for the two routes were measured, higher values of the journey time and cost as well as poor road conditions would generally lead to lower utilities and they were less preferred. Therefore, as expected, the coefficients for journey time, total expense and the

two road conditions dummy variables of the SP exercises were found to be negative. The negative signed socio-economic and travel-related variables imply that these factors also tended to have negative effects on the usage of Route A. Conversely, drivers with more travelling experience of Route A, seem to have a higher inclination to choose that route although they were influenced by the real-time traffic information. Considering this together with drivers' travelling experience of Route B, it appeared that the influences were due to driver developed habits along the routes. The positive sign of the Constants also indicated that respondents' choices had certain unobservable bias towards Route A.

Coefficient estimation

The significance of some variables in determining driver decision-making was somewhat less certain. For Model-Number, the education level variable was insignificant at 95%. For Model-Words, gender was marginally insignificant at 95% and trip purpose was insignificant even at 95%. In the case of Model-Signal, monthly income and trip purpose were found marginally insignificant at 99%, and gender was insignificant at 95 %. As these variables were not statistically insignificant in all models, they were not dropped from the final set of analysis. Therefore, comparison of the three models was therefore able to be made.

For the variables which were highly significant in statistical terms, it was considered that the values of the coefficients for road conditions dummy 2 were higher than that for road conditions dummy 1 in all models. It was not beyond our expectation that the former reflects a greater difference in road conditions. It should give a higher influence on drivers' decision-making than the latter.

The influence of driving experience was also an interesting point worth mentioning. In this study, it was expressed as the driving experience of the designated routes. Both the variables driving experience of Route A and driving experience of Route B were

statistically significant for all models. These parameters affect drivers' choice in a more effective way when they were presented in Numerical format than in Words format or Signal format. The reason for this was not yet clear; it might well be because of driver familiarity with the travel conditions in the road network. Past driving experience of a route seem to have a greater influence on decision-making; which was in response to information presented in Numerical format rather than in Words format or Signal format.

In the SP exercise, respondents were asked to make choices between the two designated routes as if traffic information was provided by a VMS system with different formats for presenting traffic information. The choices were based on the values of the defined attributes. In other words, the individuals were given not only choices between the designed attributes: time, expense and road conditions - but also between the routes that they habitually travelled. Respondents' bias towards a certain route was presented by the Constant (the bias term) that reflected the effects of the omitted factors. The Constants of the utility functions for Model-Words and Model-Signal were of values 4.516 and 4.619 respectively. However, Model-Number gave a lower value of 2.093. This suggested that the bias factors might have a higher influence on driver reaction to information presented in Words and Signal formats, rather than that in the case of Numerical format. One of the probable explanations for this might be drivers had lower inclination to choose Route B in response to the messages presented in Words or Signal formats than in Numerical format.

Value of time and validity of SP responses

VOTs of drivers, derived by the relative values of the coefficients for time and cost, for the Model-Number, Model-Words and Model-Signal were in Hong Kong dollars (HK$) 1.99/min, 2.15/min and 2.28/min respectively. It indicated that drivers had different trade-off attitudes towards information presented in different formats regarding time and expense. Drivers had the lowest values of time when they were influenced by the traffic information which was presented in Numerical format. It might be due to Numerical format provided the most precise description of travel conditions in which drivers were generally

more certain about their journey time. They therefore less willing to spend money to shorten their travel time although some drivers might not familiar with the system. For respondents had higher VOT towards a message format, their shift behaviour to the alternative route, which comparably with shorter journey time and more expense, would occur earlier. Respondents had the highest VOT and thus the highest intention to shift from Route A to B when they were influenced by the traffic information which was presented in Signal format. They had lowest VOT in the case for Numerical format.

Table 5.4 Coefficient estimated for binary logit models of route choices, figures in parentheses ( ) are *t*-statistics

Variable	*Model-Number*	*Model-Words*	*Model-Signal*
Journey time (minutes)	-0.145	-0.209	-0.210
	(-66.438)	(-109.087)	(-110.086)
Total expense (HK$)	-0.073	-0.097	-0.0916
	(-22.674)	(-34.061)	(-32.545)
Road conditions dummy variable 1	-0.369	-0.430	-0.316
	(-5.263)	(-6.996)	(-5.178)
Road conditions dummy variable 2	-1.205	-1.623	-1.421
	(-16.985)	(-26.108)	(-23.011)
Age	-0.614	-0.320	-0.285
	(-8.171)	(-4.862)	(-4.358)
Gender	-2.354	-0.1408**	-0.075*
	(-3.698)	(-2.524)	(-1.345)
Education level	-0.099*	-0.251	-0.373
	(-1.550)	(-4.469)	(-6.682)
Monthly income	-0.197	-0.176	-0.123**
	(-3.082)	(-3.145)	(-2.221)
Trip purpose	-0.485	-0.090*	-0.016**
	(-6.096)	(-1.294)	(-0.235)
Driving experience on Route A	0.740	0.279	0.234
	(9.074)	(3.911)	(3.297)
Driving experience on Route B	-0.452	-0.181	-0.387
	(-5.830)	(-2.662)	(-5.735)
Constant	2.093	4.516	4.619
	(15.478)	(38.124)	(39.250)
Summary statistics			
R^2	0.5753	0.7754	0.7774
Adjusted R^2	0.5742	0.7749	0.7768
Number of respondents	475	475	475
Number of observations	4275	4275	4275

As the other SP studies, the validity of SP responses is a critical issue in this study; while SP is often the only economic way to test new services and concepts, its reliance on hypothetical scenarios may raise doubts regarding validity. The primary test of validity, in

the absence of field tests/ demonstrations, is the reasonableness and theoretical consistency of the results and interpretation. The range of the values of time obtained in this study agreed with the recent survey results conducted for the calibrated models in the HKSAR (Wilbur and Hyder, 1998). As stated in the pervious section, stated preferences might be good indicators of actual reported choices. The consistency of the HKSAR calibrated models' results and our findings positively confirmed our study approach. It gave support for the use of stated preference responses to provide insights into diversion behaviour. The validation of the findings in this study certainly could further come from field monitoring and tests of the operation of a VMS system in the territory.

As familiarity with the road network was a special factor that not easy to be defined, a further examination of the effects of drivers' familiarity with the road network were carried out based on respondents' driving experience on the designated routes in the next section.

5.4 Effects of Familiarity with the Road Network

In order to provide a sensation of realism, two existing routes, which are well known to Hong Kong people, have been incorporated in the SP exercises to test drivers' perception process. As mentioned previously, a compound factor named "familiarity with road network" was elicited. Lotan (1995) mentioned that familiarity could not easily be classified as an issue belonging to one of the aforesaid factors regarding respondents' socio-economic background or travel characteristics, or even other circumstance like weather conditions, peak hour periods. Familiarity is not independent of route and travel factors although naturally it should be considered as a kind of drivers' socio-economic background because it induces interactions on drivers' socio-economic background with route attributes and travel characteristics. Take into account the interactions, familiarity with road network might probably cause bias in this study as respondents might develop habits along one of the designated routes. A separate test was carried out to further examine the influential power of travelling experience on the route choice behaviour. Driver familiarity with the travel conditions was therefore categorised into the following three groups:

- unfamiliar with the travel conditions of both routes;
- familiar with the travel conditions of one of the routes; and
- familiar with the travel conditions of both routes.

For simplicity, drivers' travelling experience on Routes A and B defined their network familiarity. Based on the data collected, it was assumed that drivers were classified as familiar with the travel conditions of a route if they travelled on that route at least once a week. Table 5.5 summarises the valid sample sizes, personal and travel characteristics of respondents of the three categories.

The models were specified by the following variables, for the three categories with respect to respondents' familiarity with the routes.

- Journey time (independent variable in a quantitative form);
- Total expense (independent variable in a quantitative form);
- Road conditions dummy 1 (indicator variable in a qualitative form); and
- Road conditions dummy 2 (indicator variable in a qualitative form).

The utility functions for driver route choice behaviour in response to traffic information presented in the three designated display formats were estimated. Table 5.6 summarises the results of the coefficient estimated, together with the corresponding *t*-statistics, for the models with respect to drivers' road network familiarity.

Similar to the results obtained previously, as expected, negative signs of the variables and positive signs of the Constants were found, for the models in each category. That meant there was unobservable bias towards using Route A by respondents. As discussed, this phenomenon might be due to Hong Kong drivers' propensity to use Route A.

Table 5.5 Personal and travel characteristics of respondents of the three categories regarding route familiarity

Characteristics	*Unfamiliar with the travel conditions of both routes*	*Familiar with the travel conditions of one of the routes*	*Familiar with the travel conditions of both routes*
	Proportion (%)	*Proportion (%)*	*Proportion (%)*
Age (year)			
18-25	32	30	28
26-39	67	34	33
40 or above	1	36	39
Gender			
Male	55	68	95
Female	45	32	5
Education level			
Tertiary	65	35	47
Non-tertiary	35	65	53
Occupation			
Self-employed	8	20	25
Professional/Managerial	49	23	34
Clerical and related	23	13	2
Service worker	17	21	39
Manual worker	2	16	0
Retail	1	7	0
Personal monthly income (HK$)			
Less than 20,000	38	18	0
20,000-29,999	35	23	15
30,000-39,999	17	44	55
40,000-49,999	8	9	1
50,000 or above	2	6	29
Trip purpose			
Work	9	55	62
Others	81	45	38
Time at which the trip is made			
Peak period	14	77	87
Non-Peak period	86	23	13
Preference on the routes under existing circumstances			
Route A	72	99	66
Route B	28	1	34
Sample size for each category:	**172** respondents	**216** respondents	**87** respondents
Total sample size: **475** respondents			

The estimated coefficients of the variables, for the utility functions concerning drivers' route choice behaviour in response to the three formats for presenting traffic information, were all statistical significant in 99% level of confidence. That might imply that the designated attributes of the SP experiment for the three formats had significant effects on respondents' decision making process for the three road network familiar or unfamiliar groups.

Table 5.6 Coefficient estimated for the utility functions of drivers' route choices for categories regarding route familiarity, figures in parentheses ( ) are *t*-statistics

Variable	*Unfamiliar with the travel conditions of both routes*			*Familiar with the travel conditions of one of the routes*			*Familiar with the travel conditions of both routes*		
	Model-Number	*Model-Words*	*Model-Signal*	*Model-Number*	*Model-Words*	*Model-Signal*	*Model-Number*	*Model-Words*	*Model-Signal*
Journey time (minutes)	-0.140 (-37.863)	-0.204 (-57.488)	-0.206 (-61.772)	-0.146 (-45.784)	-0.211 (-80.110)	-0.209 (-78.427)	-0.155 (-28.282)	-0.216 (-49.462)	-0.217 (-45.727)
Total expense (HK$)	-0.062 (-11.362)	-0.092 (-17.668)	-0.084 (-16.975)	-0.083 (-17.580)	-0.100 (-25.787)	-0.097 (-24.554)	-0.072 (-8.909)	-0.095 (-14.736)	-0.094 (-13.387)
Road conditions dummy 1	-0.330 (-2.785)	-0.390 (-3.432)	-0.339 (-3.181)	-0.329 (-3.217)	-0.357 (-4.230)	-0.241 (-2.814)	-0.547 (-3.119)	-0.691 (-4.939)	-0.456 (-2.993)
Road conditions dummy 2	-1.339 (-11.169)	-1.505 (-13.118)	-1.322 (-12.250)	-1.100 (-10.649)	-1.800 (-21.082)	-1.357 (-15.635)	-1.200 (-6.766)	-1.416 (-10.005)	-1.777 (-11.536)
Constant	1.327 (9.229)	3.825 (27.796)	4.052 (31.324)	1.669 (13.474)	4.243 (41.456)	4.280 (41.136)	1.546 (7.267)	4.157 (24.497)	4.179 (22.631)
Summary statistics									
R^2	0.5302	0.7239	0.7478	0.5846	0.8034	0.7963	0.5597	0.7940	0.7646
Adjusted R^2	0.5300	0.7232	0.7472	0.5838	0.8029	0.7959	0.5575	0.7929	0.7634
Number of respondents	172	172	172	216	216	216	87	87	87
Number of observations	1548	1548	1548	1944	1944	1944	783	783	783

Considering each category with respect to route familiarity, consistent distribution pattern of coefficient values of the variables for the models were observed. It exhibiting no significant different between the responses of drivers, who were familiar or unfamiliar with the travel conditions, of the two designated routes. As mentioned in the previous section,

one interesting factor attributing drivers' route choice decisions turned out to be the Constants (the bias terms) corresponding to the inherent preferences to Route A, or might be the CHT. That was unrelated to the attribute levels set for the alternatives in the SP exercises. The values of the constants obtained for Model-Words and Model-Signal were very close, but that for Model-Number was obviously different and had a smaller value. It seem that respondents reacted to Words and Signal presentation formats with similar inherent preferences (a priori preference) towards Route A, but very different to that with Numerical format. Based on the coefficients which were associated with the received information, it was probably to say drivers' wills to choose Route B was lower when they perceived information presented in Words and Signal formats than that in Numerical format. The findings were consistent with that for the original sample size.

The estimated VOTs for the models are shown in Table 5.7. It was noted that the pattern of the VOTs obtained for respondents who were unfamiliar with both routes was different to that for the other two groups as well as the whole sample size. In this case, respondents who unfamiliar with the travel conditions of both routes had the lowest value of time when they were influenced by the traffic information in Words format.

Table 5.7 VOTs estimated for respondents with respect to route familiarity

Value of time (HK$ / minute)								
Unfamiliar with the travel conditions of both routes			*Familiar with the travel conditions of one of the routes*			*Familiar with the travel conditions of both routes*		
Model-Number	*Model-Words*	*Model-Signal*	*Model-Number*	*Model-Words*	*Model-Signal*	*Model-Number*	*Model-Words*	*Model-Signal*
2.25	2.22	2.45	1.76	2.11	2.15	2.15	2.27	2.31

5.5 Effects of Listening Propensity

At present, traffic conditions on heavily congested road sections are broadcast every 30 minutes during peak periods. It is expected that some drivers take into account the broadcast information in their decision-makings. Although radio traffic information is not

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provided in a real-time form as on VMS, it also aims to help drivers choose the best route and, therefore, make better utilisation of the road network. Emmerink *et al.* (1996) indicated the existence of a significant positive correlation between radio traffic information and VMS traffic information (in respect to Route Information Amsterdam). Drivers who were influenced by radio traffic information were also more likely to be influenced by VMS traffic information. The two systems were used in a similar way by road users. Broadcasting could be considered as a format for presenting traffic information. It should be included in the analysis, as there might be a strong interaction between listening propensity to radio traffic information and a particular VMS message format. To give a useful interpretation of the influence of the listening propensity to radio traffic information on driver perception process, in addition to the behavioural model comprising the 475 successful interviewed cases, the valid samples were further divided into the following categories:

- drivers who listen to radio traffic information regularly; and
- drivers who sparse listen to radio traffic information.

This reduced the number of valid samples from 475 to 240 for the former category and 235 for the latter. Table 5.8 summarises the personal and travel characteristics of respondents in respect to the categories with different listening propensity.

Behavioural models for respondents' attitudes on VMS message formats were developed for the two categories. Table 5.9 reports the three sets of results calculated by binary logit formulation. The variables were found with expected negative signs in all sets of results. As discussed in the previous section, drivers would choose a route with a shorter journey time, financially economical and better road conditions. However, the sign of the Constant for each model was significantly positive. It might once again be explained by drivers' habits. Possibly, the drivers preferred Route A than Route B in their route choice.

Table 5.8 Personal and travel characteristics of respondents for the categories regarding listening propensity

Characteristics	*Regularly listen to radio traffic information*	*Sparse listen to radio traffic information*
	Proportion (%)	*Proportion (%)*
Age (year)		
18-25	34	25
26-39	32	61
40 or above	34	14
Gender		
Male	75	61
Female	25	39
Education level		
Tertiary	38	58
Non-Tertiary	62	42
Occupation		
Self-employed	16	18
Professional/Managerial	37	32
Clerical and related	8	21
Service worker	29	17
Manual worker	9	6
Retail	1	6
Personal monthly income (HK$)		
Less than 20,000	22	22
20,000-29,999	23	20
30,000-39,999	38	29
40,000-49,999	2	13
50,000 or above	15	1
Trip purpose		
Work	44	29
Others	56	71
Time at which the trip is made		
Peak period	72	39
Non-Peak period	28	61
Driving experience on Route A		
Less than once a week	15	59
Once or more a week	85	41
Driving experience on Route B		
Less than once a week	66	97
Once or more a week	34	3
Preference on the routes under existing circumstances		
Route A	87	79
Route B	13	21
Sample size for each category:	240 respondents	235 respondents
Total sample size: 475 respondents		

When considering the corresponding coefficients estimated for the variables, it was observed that only the variable road conditions dummy 1 of Model-Number for the case "regularly listen to radio traffic information" and Model-Signal for the case "sparse listen to

radio traffic information" were insignificant at a 99% level. This indicated that, to some drivers with different listening propensity to radio traffic news, a slight difference in road conditions (for the case of road conditions dummy 1) might not definitely affect their decision-making processes based on the information presented in Numerical format or Signal format. It was obviously that drivers with different travel characteristics would have some variations in their comprehension of the formats for presenting traffic information. Nevertheless, the distribution pattern of the coefficients obtained for the variables with respect to the three models among each set of categories (all samples, regularly and sparse listen to radio traffic information) showed that the relationship of the three models regarding the three categories was consistent.

Table 5.9 Coefficient estimated for the utility functions of drivers' route choices for categories regarding listening propensity, figures in parentheses ( ) are *t*-statistics

	All samples			*Regularly listen to radio traffic information*			*Sparse listen to radio traffic information*		
Variable	*Model-Number*	*Model-Words*	*Model-Signal*	*Model-Number*	*Model-Words*	*Model-Signal*	*Model-Number*	*Model-Words*	*Model-Signal*
Journey time (minutes)	-0.145 (-64.761)	-0.209 (-107.798)	-0.210 (-108.177)	-0.148 (-45.867)	-0.208 (-79.849)	-0.213 (-81.218)	-0.143 (-45.795)	-0.210 (-73.239)	-0.207 (-72.561)
Total expense (HK$)	-0.073 (-22.101)	-0.097 (-33.659)	-0.092 (-31.981)	-0.071 (-14.861)	-0.101 (-26.303)	-0.100 (-25.916)	-0.076 (-16.464)	-0.092 (-21.599)	-0.083 (-19.664)
Road conditions dummy 1	-0.369 (-5.130)	-0.430 (-6.914)	-0.316 (-5.088)	-0.224* (-2.173)	-0.596 (-7.134)	-0.441 (-5.261)	-0.517 (-5.166)	-0.261 (-2.834)	-0.188* (-2.062)
Road conditions dummy 2	-1.205 (-16.556)	-1.623 (-25.800)	-1.421 (-22.612)	-1.075 (-10.292)	-1.732 (-20.518)	-1.662 (-19.587)	-1.338 (-13.219)	-1.511 (-16.226)	-1.175 (-12.719)
Constant	1.522 (17.446)	4.076 (54.042)	4.179 (55.464)	1.587 (12.671)	4.107 (40.581)	4.226 (41.540)	1.457 (12.005)	4.044 (36.207)	4.131 (37.298)
Summary statistics									
R^2	0.5523	0.7697	0.7691	0.5476	0.7865	0.7907	0.5592	0.7550	0.7495
Adjusted R^2	0.5518	0.7694	0.7689	0.5467	0.7861	0.7903	0.5584	0.7546	0.7490
Number of respondents	475	475	475	240	240	240	235	235	235
Number of observations	4275	4275	4275	2160	2160	2160	2115	2115	2115

The estimated VOTs for the models are shown in Table 5.10. The values obtained were in HK$ between 1.88/min and 2.50/min, which agreed not only with the recent survey results conducted for calibrated models in the HKSAR (Wilbur and Hyder, 1998), but also agreed with the previous findings in this study. Drivers' trade-off behaviour of the experimental variables was reflected by the values of the obtained VOTs. The different trade-off behaviour of drivers indicated that they had different comprehension of the formats for presenting traffic information. The pattern of the VOTs obtained for respondents who regularly listen to radio traffic news was different to that for those drivers who sparse listening to the radio traffic news and the whole sample size. Respondents had listening propensity to radio traffic had the lowest VOT when they were influenced by the traffic information in Words format and thus lowest intention to shift to Route B. The finding clearly outlined the VMS information format could induce bias in one's decision-making process.

Table 5.10 VOTs estimated for respondents with respect to listening propensity

Value of time (HK$ / minute)								
All samples			*Regularly listen to radio traffic information*			*Sparse listen to radio traffic information*		
Model-Number	*Model-Words*	*Model-Signal*	*Model-Number*	*Model-Words*	*Model-Signal*	*Model-Number*	*Model-Words*	*Model-Signal*
1.98	2.17	2.29	2.09	2.05	2.12	1.88	2.29	2.50

6 - CONCLUSION

6. CONCLUSION

6.1 Conclusions

Several aspects of driver comprehension of formats for presenting traffic information on VMS have been discussed in the context of Hong Kong drivers' route choice behaviour. Experimentally oriented SP exercises with well-designed attributes were used to evaluate drivers' trade-off attitude (willingness to divert) in response to real-time information presented in different formats, under hypothetical situations. Based on the data obtained, an examination of three common formats - Numerical format, Words format and Signal format - had been made by developing mathematical models which were expressed as utility functions together with some explanatory variables. The explanatory variables employed in the models included the factors referring to respondents' socio-economic background and those characterising the transport network.

Take into account the expected signs of the coefficients, the reasonableness and statistically significance of the relevant variables, the consistency of the estimated VOTs and the results of a recent study conducted in the HKSAR (Wilbur and Hyder, 1998), the models were validated empirically. It gave a strong motivation for the appropriateness of the experimentally oriented behavioural models in this study.

It was found that there was similar tendency for the effects of the selected variables on driver comprehension of the different message formats. The findings not only supported our expectations about respondents' rationality of their route choices according to the attributes but also positively confirmed the study approach. It supported the use of stated preference responses to provide insights into drivers' diversion behaviour and to quantify their responses to information presented in different formats.

To demonstrate the explanatory power of the models, the assessment also focused on the responses of drivers who with (i) different degree of familiarity with the travel conditions of

the designated and (ii) different listening propensity to radio traffic news. In fact, the SP data in this study provided a great deal of rich information on respondents including socio-economic and travel characteristics. Presumably it would allow complex models to be developed than those currently reported in this study. It would be interesting, for example, to see whether there is any effect of message formats on the decision-making of drivers of different of age, gender or education level in further studies. In addition, the samples can be further classified according to the homogeneity of drivers in psychology terms. Drivers who sharing similar pattern of perceptions to travel time information can be summarised as risk-averse, risk-neutral and risk-prone. Based on Zhao *et al.* (1995), a risk-averse driver's perceived travel is larger than the provided travel time information. A driver is said to be risk-neutral or risk-prone if his or her perceived travel time is equal to or smaller than the provided travel time information respectively.

Based on the findings, it is possible to conclude that drivers have different comprehension of the formats for presenting traffic information on VMSs. The results explain the fact that driver route choice behaviour is actually dependent not only on the traffic information itself, but also on their perception of the information. Drivers' utilisation of the travel conditions of the routes was affected by their perception processes. They had different trade-off attitudes to time and costs related attributes; and thus had different VOTs (with respect to the journey time and total expense) in their route choices when they were influenced by identical traffic information, which was presented in different formats. It was generally found that when drivers were influenced by VMS information presented in Signal format and were opting for an alternative route, which comparably with shorter journey time and more expense, they would likely shift to that route earlier than in the cases of the other two designated formats.

As mentioned in the previous section, one interesting and important factor attributing drivers' route choice decisions was the Constants (the bias terms) which corresponding to the inherent preference for an option that was unrelated to the attribute levels set for the alternatives in the SP exercise. For the three sets of results presented in this study, the

values of the Constants obtained for Model-Words and Model-Signal were very close, but that for Model-Number was obviously different and smaller. It seems that respondents reacted to Words and Signal presentation formats with similar inherent preferences (a priori preference) towards the option, but very differently to Numerical format. The results of this study also indicated that drivers had a higher inclination to choose the fast and expense alternative route when receiving messages in Numerical format.

The results of this study showed that the overall utility of drivers travelling on the designated routes could be affected by presenting identical traffic information in different formats. Highway managers and VMS designers need to take such findings into account. This aspect is particularly important for those authorities, such as the government of the HKSAR, who are interested in providing drivers with up-to-date traffic information to assist them to choose best routes during their trips (Transport Bureau of the HKSAR, 1998).

6.2 Recommendations

To have better management of highways, good communication with drivers, by means of the provision of instant traffic information, is generally considered as an essential need. Using VMS systems is a relatively economical way to provide real-time information to influence drivers' decision-making on route choices. However, a lot of results of the previous studies have been publishing concerning the markets for advanced traffic information systems and their incorporation into control strategies, not enough work has been done to predict what driver responses will be. The effectiveness of a VMS system is reduced if the information provided is open to misinterpretation. It is therefore particularly important to have more insights into driver comprehension and reaction to formats for presenting traffic information. The work undertaken in this study is only one of numerous ways to examine the effects. Further study of this topic, in order to enrich the understanding of the impact of the varieties of formats for presenting traffic information on driver

behaviour, is highly recommended. There are more possibilities for further research and discussion. Efforts could be dedicated to study topics, such as:

- interaction of traffic information provided in different languages;

- driver reaction to traffic information presented in different formats, considering the views raised, for example, by participants in a focus group type of study;

- driver perception of the reliability of information presented in different formats because drivers usually take into account the real congestion conditions with the traffic information provided; and

- the effects of delay information provided in different formats on drivers' behavioural inertia when drivers facing unexpected congestion.

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APPENDICES

Appendix A

Toll charges of Western Harbour Crossing (WHC) and Cross Harbour Tunnel (CHT) in January 1998

Vehicle type	WHC toll in January 1998 (HK$)	CHT toll in January 1998 (HK$)
Light goods vehicle	45	15
Medium goods vehicle	65	20
Heavy goods vehicle	95	30
Extra axle for goods vehicle	30	10
Private car/ Taxi	30	10

Source: Transport Department of the HKSAR, Internet web-site homepage: http://www.info.gov.hk/td/transp07.htm.

Appendix B

Singularity test for attributes

```
0    THE FULL FACTORIAL DESIGN IN LEVEL FORM IS :

          1        111
          2        112
          3        113
          4        121
          5        122
          6        123
          7        131
          8        132
          9        133
         10        211
         11        212
         12        213
         13        221
         14        222
         15        223
         16        231
         17        232
         18        233
         19        311
         20        312
         21        313
         22        321
         23        322
         24        323
         25        331
         26        332
         27        333
  CORRELATION MATRIX FOR THE LEVELS OF THE DESIGN

%GM          1.000
V1/2        -0.383  1.000
V1/3        -0.439  0.269  1.000
V2/2        -0.383  0.118 -0.067  1.000
V2/3        -0.439 -0.067 -0.154  0.269  1.000
V3/2        -0.383 -0.176  0.269  0.118 -0.067  1.000
V3/3        -0.383  0.118 -0.067 -0.176  0.269  0.118  1.000

              %GM     V1/2    V1/3    V2/2    V2/3    V3/2    V3/3

 VARIABLE LEVEL1 LEVEL2 LEVEL3 LEVEL4 LEVEL5 LEVEL6
```

1 THE VALUES YOU ARE USING FOR THE VARIABLES ARE

VARIABLE	LEVEL1	LEVEL2	LEVEL3	LEVEL4	LEVEL5	LEVEL6
1	10.00	20.00	40.00			
2	-25.00	-15.00	-5.00			
3	1.00	2.00	3.00			

0 THE CHOSEN DESIGN IN LEVEL FORM IS :

1	2	3
	111	
	113	
	121	
	132	
	212	
	231	
	311	
	323	
	331	

0 THE ACTUAL VALUES ON THE CARDS ARE

	1	2	3
1	10.00	-25.00	1.00
2	10.00	-25.00	3.00
3	10.00	-15.00	1.00
4	10.00	-5.00	2.00
5	20.00	-25.00	2.00
6	20.00	-5.00	1.00
7	40.00	-25.00	1.00
8	40.00	-15.00	3.00
9	40.00	-5.00	1.00

0CORRELATION MATRIX WITH VARIABLE VALUES

	%GM	VA01	VA02	VA03
%GM	1.000			
VA01	-0.534	1.000		
VA02	0.500	-0.113	1.000	
VA03	-0.517	0.010	0.205	1.000

Appendix C

Questionnaire of stated preference survey

The Hong Kong Polytechnic University

Survey on Drivers' Responses to Traffic information

We are conducting a survey for The Hong Kong Polytechnic University to study Hong Kong drivers' responses to traffic information. Thank you for answering some questions about your route choice. All information will be treated in the strictest confidence and will be used only for academic researching purposes.

Part I

Background Information

At first, we would like to have your background information.

1. Age (years): __ 18-25 __ 26-39 __ 40-59 __ 60 or above
2. Gender: __ Male __ Female
3. Education level: __ Tertiary __ Secondary __ Primary
4. Occupation:
   - __ Student
   - __ Self-employed
   - __ Professional/ Managerial
   - __ Clerical and related
   - __ Service worker
   - __ Manual Worker
   - __ Retail
   - __ Other (please specify)_____
5. Monthly Income (HK$):
   - __ below 20,000
   - __ 20,000-29,999
   - __ 30,000-39,999
   - __ 40,000-49,999
   - __ 50,000 or above
6. Listen to radio traffic information regularly: __ Yes __ No

Route Choice from Tsuen Wan to Central – a case study

The two available routes from Tsuen Wan to Central with approximate travel distance are listed below: **[Refer to Figure 1]**

Route A	Route B
Tsuen Wan > Tsuen Wan Road > Kwai Chung Road > Western Kowloon Corridor > Tong Mi Road Flyover > Ferry Street > Gascoigne Road > Chatham Road North > Hong Chong Road > Coss Harbour Tunnel > Gloucester Road > Harcourt Road > Central	Tsuen Wan > Tsuen Wan Road > Route 3 > Western Harbour Crossing > Route 7 > Connaught Road > Harcourt Road > Central

Do you familiar with the travel conditions of these routes?

Route A:	1) Very familiar	2) Quite familiar	3) Not familiar
Route B:	1) Very familiar	2) Quite familiar	3) Not familiar

Which route you prefer? (please circle the appropriate block)

Route A	Route B

Do you use either of these routes for working purpose?

Always	Sometimes	Few

When do you usually travel on these routes:

Peak period	Non-peak period

(Peak period - from 7:30am to 10:30am and from 4:30pm to 7:30pm)

How often this trip do you make per week?

Route A:	1) at least one time per week	2) less than one time per week
Route B:	1) at least one time per week	2) less than one time per week

How do you account the importance of the following factors in your route choice? Please rank.

Factor:	Ranks
Travel time	
Congestion level	
Tunnel toll for the trip	
Cost for petrol	
Familiarity of the travel condition of the route	
Distance of the route	
Driving quality of the route	
Other (please specify):	

Part II Stated Preference Games

Suppose there is a variable message sign (VMS) tells you the instant traffic information about the aforesaid two routes in Part A. The following questions indicate the travel conditions of the two routes before you decide to drive on which one of them. Each question gives you information of the routes under different hypothetical situations. Please look at each scenario carefully and tell us your preference on the routes. (please circle you answer)

*In the following section, please note that "**estimated journey time**" refers to the total journey time for the trip and "**total expense for the trip**" refers to the total expenses, including the tunnel toll and petrol cost. The "**road conditions**" in the games is defined as follows:*

Road Conditions	*No. of heavy vehicles*	*Road works*
Good	Few	No
Fair	Many	No
Poor	Many	Yes

Numerical format: The VMS presenting the estimated journey time (minutes) in the form of a number [Refer to Figure 2]

Game 1

Route	Route A	Route B
Estimated journey time (minutes)	25	15
Total expense for the trip (HK$)	20	45
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 2

Route	Route A	Route B
Estimated journey time (minutes)	30	20
Total expense for the trip (HK$)	30	55
Road conditions of the route	Poor	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 3

Route	Route A	Route B
Estimated journey time (minutes)	30	20
Total expense for the trip (HK$)	25	40
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 4

Route	Route A	Route B
Estimated journey time (minutes)	30	20
Total expense for the trip (HK$)	40	15
Road conditions of the route	Fair	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 5

Route	Route A	Route B
Estimated journey time (minutes)	35	15
Total expense for the trip (HK$)	20	45
Road conditions of the route	Fair	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 6

Route	Route A	Route B
Estimated journey time (minutes)	55	15
Total expense for the trip (HK$)	20	45
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 7

Route	Route A	Route B
Estimated journey time (minutes)	30	20
Total expense for the trip (HK$)	35	40
Road conditions of the route	Fair	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 8

Route	Route A	Route B
Estimated journey time (minutes)	60	20
Total expense for the trip (HK$)	25	40
Road conditions of the route	Poor	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 9

Route	Route A	Route B
Estimated journey time (minutes)	35	15
Total expense for the trip (HK$)	35	40
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 10

Route	Route A	Route B
Estimated journey time (minutes)	60	20
Total expense for the trip (HK$)	40	45
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Interviewer:

If the respondent answers "Definitely choose A" in all cases, ask:
You have stated that you will definitely choose Route A in all cases under all circumstances. Can you tell us why?

If the respondent answers "Definitely choose B" in all cases, ask:
You have stated that you will definitely choose Route B in all cases under all circumstances. Can you tell us why?

Words format: The VMS presenting the travel conditions by words [Refer to Figure 3]

If the information is presented in a format of description, please tell your preference of your choices. Please note that there are four descriptions for presenting the travel conditions of the routes, they are:

- Smooth
- Medium
- Heavy
- Congest

Game 1

Route	Route A	Route B
Description	Medium	Smooth
Total expense for the trip (HK$)	30	55
Road conditions of the route	Poor	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 2

Route	Route A	Route B
Description	Heavy	Smooth
Total expense for the trip (HK$)	35	40
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 3

Route	Route A	Route B
Description	Medium	Smooth
Total expense for the trip (HK$)	40	15
Road conditions of the route	Fair	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 4

Route	Route A	Route B
Description	Heavy	Smooth
Total expense for the trip (HK$)	20	45
Road conditions of the route	Fair	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 5

Route	Route A	Route B
Description	Medium	Smooth
Total expense for the trip (HK$)	20	45
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 6

Route	Route A	Route B
Description	Medium	Smooth
Total expense for the trip (HK$)	35	40
Road conditions of the route	Fair	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 7

Route	Route A	Route B
Description	Medium	Smooth
Total expense for the trip (HK$)	25	40
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 8

Route	Route A	Route B
Description	Congest	Smooth
Total expense for the trip (HK$)	25	40
Road conditions of the route	Poor	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 9

Route	Route A	Route B
Description	Congest	Smooth
Total expense for the trip (HK$)	20	45
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 10

Route	Route A	Route B
Description	Congest	Smooth
Total expense for the trip (HK$)	40	45
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Interviewer:

If the respondent answers "Definitely choose A" in all cases, ask:
You have stated that you will definitely choose Route A in all cases under all circumstances. Can you tell us why?

If the respondent answers "Definitely choose B" in all cases, ask:
You have stated that you will definitely choose Route B in all cases under all circumstances. Can you tell us why?

Signal format: The VMS presenting the estimated congestion level by signal lights [Refer to Figure 4]

If the information regarding the congestion level is indicated by signal lights as follows (four conditions),

No light on: -- -- --
One light on: O -- --
Two lights on: OO --
Three lights on: OOO

Please tell your preference of your choices. Please note that more the signal lights are switched on, the higher the level of congestion on the route.

Game 1

Route	Route A	Route B
Number of signals on	O O O	-- -- --
Total expense for the trip (HK$)	25	40
Road conditions of the route	Poor	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 2

Route	Route A	Route B
Number of signals on	O O --	-- -- --
Total expense for the trip (HK$)	20	45
Road conditions of the route	Fair	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 3

Route	Route A	Route B
Number of signals on	O -- --	-- -- --
Total expense for the trip (HK$)	25	40
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 4

Route	Route A	Route B
Number of signals on	O -- --	-- -- --
Total expense for the trip (HK$)	40	15
Road conditions of the route	Fair	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 5

Route	Route A	Route B
Number of signals on	O O O	-- -- --
Total expense for the trip (HK$)	20	45
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 6

Route	Route A	Route B
Number of signals on	O O O	-- -- --
Total expense for the trip (HK$)	40	45
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 7

Route	Route A	Route B
Number of signals on	O -- --	-- -- --
Total expense for the trip (HK$)	35	40
Road conditions of the route	Fair	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 8

Route	Route A	Route B
Number of signals on	O -- --	-- -- --
Total expense for the trip (HK$)	20	45
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 9

Route	Route A	Route B
Number of signals on	O O --	-- -- --
Total expense for the trip (HK$)	35	40
Road conditions of the route	Good	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Game 10

Route	Route A	Route B
Number of signals on	O -- --	-- -- --
Total expense for the trip (HK$)	30	55
Road conditions of the route	Poor	Good

Definitely choose A	Probably choose A	Undecided	Probably choose B	Definitely choose B

Interviewer:

If the respondent answers "Definitely choose A" in all cases, ask:
You have stated that you will definitely choose Route A in all cases under all circumstances. Can you tell us why?

If the respondent answers "Definitely choose B" in all cases, ask:
You have stated that you will definitely choose Route B in all cases under all circumstances. Can you tell us why?

PART III Perception and Understanding of the Presentations

At last, please state your preference on the three different formats for presenting traffic information on the VMSs as mentioned above. Please rank the order of your preference.

Format	*Style of presentation*	*Ranks*
Numerical	Presenting the estimated journey time in a number	
Words	Presenting the travel conditions by description	
Signal	Presenting the level of congestion by signal lights	

What is your degree of understanding of the contents of the three different formats for presenting traffic information on the VMSs. Please circle your answer.

Numerical format:	A) Fully understand	B) Quiet understand	C) Not understand
Words format:	A) Fully understand	B) Quiet understand	C) Not understand
Signal format:	A) Fully understand	B) Quiet understand	C) Not understand

Thank you very much for your response.

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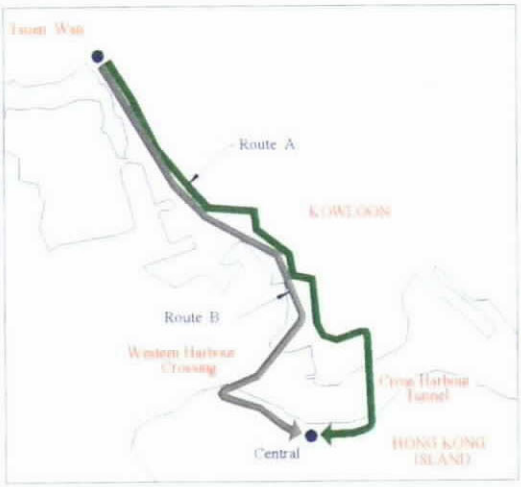

Figure 1 - The designated routes in the SP experiment

Figure 2 - The Numerical form for presenting traffic information on VMS

Figure 3 - The Words form for presenting traffic information on VMS

Figure 4 - The Signal form for presenting traffic information on VMS

Appendix D1

Summary output for logit model for preliminary test: Model-Number

Regression Statistics	
Multiple R	0.758477238
R Square	0.57528772
Adjusted R Square	0.574091909
Standard Error	1.775506081
Observations	4275

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	12	18199.02238	1516.585198	481.0857411	0
Residual	4262	13435.62189	3.152421842		
Total	4274	31634.64427			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.086438287	0.137315061	15.19453345	8.07146E-51	1.817229306	2.355647268	1.817229306	2.355647268
Journey time	-0.145399219	0.00218872	-66.43116917	0	-0.149690249	-0.141108189	-0.149690249	-0.141108189
Total expense	-0.073342162	0.003235025	-22.67127981	1.5597E-107	-0.079684495	-0.066999829	-0.079684495	-0.066999829
Road conditions 1	-0.369208907	0.070165194	-5.261995075	1.49503E-07	-0.506769203	-0.23164861	-0.506769203	-0.23164861
Road conditions 2	-1.204935877	0.070948604	-16.98322187	1.20549E-62	-1.344032063	-1.06583969	-1.344032063	-1.06583969
Age	-0.609159194	0.07782676	-7.827117496	6.25234E-15	-0.761740146	-0.456578242	-0.761740146	-0.456578242
Gender	-0.231668444	0.065255919	-3.550152183	0.000389166	-0.359604006	-0.103732882	-0.359604006	-0.103732882
Education level	-0.09723252	0.064564456	-1.505975979	0.132147447	-0.223812454	0.029347415	-0.223812454	0.029347415
Monthly income	-0.193303945	0.064948712	-2.976255262	0.002934319	-0.320637221	-0.065970669	-0.320637221	-0.065970669
Trip purpose	-0.473063227	0.090691159	-5.216200022	1.91301E-07	-0.650865096	-0.295261357	-0.650865096	-0.295261357
Time at which the trip is made	-0.023490738	0.08896364	-0.264048755	0.791755117	-0.197905771	0.150924294	-0.197905771	0.150924294
Experience on Route A	0.748914645	0.088772881	8.436299874	4.43057E-17	0.574873599	0.922955691	0.574873599	0.922955691
Experience on Route B	-0.452107163	0.077615912	-5.824928809	6.13467E-09	-0.604274744	-0.299939582	-0.604274744	-0.299939582

Appendix D2

Summary output for logit model for preliminary test: Model-Words

Regression Statistics	
Multiple R	0.880594905
R Square	0.775447387
Adjusted R Square	0.774815142
Standard Error	1.555641789
Observations	4275

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	12	35617.78207	2968.148506	1226.496813	0
Residual	4262	10314.13111	2.420021376		
Total	4274	45931.91317			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.524913024	0.120311076	37.61011184	1.3983E-267	4.289040702	4.760785345	4.289040702	4.760785345
Journey time	-0.20917429	0.001917687	-109.0763728	0	-0.212933954	-0.205414627	-0.212933954	-0.205414627
Total expense	-0.09653505	0.002834426	-34.05806069	4.3873E-225	-0.102092	-0.0909781	-0.102092	-0.0909781
Road conditions 1	-0.430073257	0.061476505	-6.995733698	3.05076E-12	-0.5505992	-0.309547314	-0.5505992	-0.309547314
Road conditions 2	-1.622813986	0.062162903	-26.10582681	1.709E-139	-1.744685627	-1.500942345	-1.744685627	-1.500942345
Age	-0.32754221	0.068189324	-4.803423608	1.61333E-06	-0.461228773	-0.193855647	-0.461228773	-0.193855647
Gender	-0.145927437	0.057175155	-2.552287574	0.010736394	-0.258020495	-0.033834378	-0.258020495	-0.033834378
Education level	-0.253732011	0.056569317	-4.485329261	7.47176E-06	-0.364637311	-0.142826711	-0.364637311	-0.142826711
Monthly income	-0.180137864	0.056905989	-3.16553434	0.001558894	-0.291703218	-0.068572509	-0.291703218	-0.068572509
Trip purpose	-0.105808742	0.079460701	-1.331585822	0.183067538	-0.261593069	0.049975584	-0.261593069	0.049975584
Time at which the trip is made	0.032007019	0.077947103	0.410624866	0.68136827	-0.120809869	0.184823907	-0.120809869	0.184823907
Experience on Route A	0.266665643	0.077779966	3.428461791	0.000612765	0.11417643	0.419154856	0.11417643	0.419154856
Experience on Route B	-0.181186144	0.068004586	-2.664322426	0.00774341	-0.314510525	-0.047861764	-0.314510525	-0.047861764

Appendix D3

Summary output for logit model for preliminary test: Model-Signal

Regression Statistics	
Multiple R	0.881718705
R Square	0.777427875
Adjusted R Square	0.776801205
Standard Error	1.545342099
Observations	4275

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	12	35551.01891	2962.584909	1240.570742	0
Residual	4262	10178.00634	2.388082202		
Total	4274	45729.02526			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.602450268	0.119514513	38.50955131	1.1026E-278	4.368139624	4.836760911	4.368139624	4.836760911
Journey time	-0.209703964	0.00190499	-110.0814115	0	-0.213438736	-0.205969193	-0.213438736	-0.205969193
Total expense	-0.091631979	0.00281566	-32.54369966	1.0859E-207	-0.097152137	-0.086111821	-0.097152137	-0.086111821
Road conditions 1	-0.31619568	0.061069477	-5.177638546	2.35071E-07	-0.435923638	-0.196467723	-0.435923638	-0.196467723
Road conditions 2	-1.420903195	0.061751331	-23.01008201	1.5599E-110	-1.541967941	-1.29983845	-1.541967941	-1.29983845
Age	-0.271235338	0.067737852	-4.004191597	6.32893E-05	-0.404036781	-0.138433896	-0.404036781	-0.138433896
Gender	-0.064559075	0.056796606	-1.136671358	0.255739602	-0.175909981	0.046791831	-0.175909981	0.046791831
Education level	-0.367145034	0.056194779	-6.533436758	7.18307E-11	-0.477316046	-0.256974023	-0.477316046	-0.256974023
Monthly income	-0.114662007	0.056529223	-2.028366956	0.042584868	-0.225488703	-0.003835312	-0.225488703	-0.003835312
Trip purpose	0.014316518	0.078934602	0.181371894	0.856084303	-0.140436381	0.169069418	-0.140436381	0.169069418
Time at which the trip is made	-0.062261552	0.077431026	-0.804090486	0.421389566	-0.21406666	0.089543557	-0.21406666	0.089543557
Experience on Route A	0.258514068	0.077264996	3.345810921	0.000827523	0.107034465	0.40999367	0.107034465	0.40999367
Experience on Route B	-0.387029639	0.067554337	-5.729160475	1.07886E-08	-0.519471297	-0.254587981	-0.519471297	-0.254587981

Appendix D4

Summary output for logit model of route choice: Model-Number

Regression Statistics	
Multiple R	0.7585
R Square	0.5753
Adjusted R Square	0.5742
Standard Error	1.7753
Observations	4275

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	11	18198.802587	1654.436599	524.929021	0
Residual	4263	13435.841684	3.151734		
Total	4274	31634.644271			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.09274737	0.13520551	15.47827000	0.00000000	1.82767421	2.35782054	1.82767421	2.35782054
Journey time	-0.14539922	0.00218848	-66.43841871	0.00000000	-0.14968978	-0.14110866	-0.14968978	-0.14110866
Total expense	-0.07334216	0.00323467	-22.67375389	0.00000000	-0.07968380	-0.06700052	-0.07968380	-0.06700052
Road conditions 1	-0.36920891	0.07015754	-5.26256931	0.00000015	-0.50675419	-0.23166362	-0.50675419	-0.23166362
Road conditions 2	-1.20493588	0.07094086	-16.98507522	0.00000000	-1.34401689	-1.06585487	-1.34401689	-1.06585487
Age	-0.61444880	0.07519616	-8.17127942	0.00000000	-0.76187240	-0.46702520	-0.76187240	-0.46702520
Gender	-0.23544112	0.06366560	-3.69808996	0.00021996	-0.36025883	-0.11062341	-0.36025883	-0.11062341
Education level	-0.09931037	0.06407612	-1.54988112	0.12124428	-0.22493290	0.02631217	-0.22493290	0.02631217
Monthly income	-0.19655233	0.06376600	-3.08239994	0.00206651	-0.32156688	-0.07153777	-0.32156688	-0.07153777
Trip purpose	-0.48458739	0.07949027	-6.09618501	0.00000000	-0.64042968	-0.32874509	-0.64042968	-0.32874509
Experience on Route A	0.73963520	0.08151165	9.07398183	0.00000000	0.57982995	0.89944044	0.57982995	0.89944044
Experience on Route B	-0.45224832	0.07760560	-5.82752162	0.00000001	-0.60439569	-0.30010096	-0.60439569	-0.30010096

Appendix D5

Summary output for binary model of route choice: Model-Words

Regression Statistics	
Multiple R	0.8806
R Square	0.7754
Adjusted R Square	0.7749
Standard Error	1.5555
Observations	4275

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	11	35617.374020	3237.943093	1338.242184	0
Residual	4263	10314.539152	2.419549		
Total	4274	45931.913172			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.5163167	0.1184641	38.1239175	0.0000000	4.2840653	4.7485680	4.2840653	4.7485680
Journey time	-0.2091743	0.0019175	-109.0870106	0.0000000	-0.2129336	-0.2054150	-0.2129336	-0.2054150
Total expense	-0.0965350	0.0028341	-34.0613822	0.0000000	-0.1020915	-0.0909786	-0.1020915	-0.0909786
Road conditions 1	-0.4300733	0.0614705	-6.9964160	0.0000000	-0.5505874	-0.3095591	-0.5505874	-0.3095591
Road conditions 2	-1.6228140	0.0621568	-26.1083728	0.0000000	-1.7446737	-1.5009542	-1.7446737	-1.5009542
Age	-0.3203349	0.0658852	-4.8620136	0.0000012	-0.4495043	-0.1911656	-0.4495043	-0.1911656
Gender	-0.1407870	0.0557824	-2.5238602	0.0116434	-0.2501496	-0.0314245	-0.2501496	-0.0314245
Education level	-0.2509009	0.0561421	-4.4690323	0.0000081	-0.3609686	-0.1408331	-0.3609686	-0.1408331
Monthly income	-0.1757118	0.0558704	-3.1449902	0.0016724	-0.2852469	-0.0661768	-0.2852469	-0.0661768
Trip purpose	-0.0901066	0.0696476	-1.2937499	0.1958219	-0.2266523	0.0464390	-0.2266523	0.0464390
Experience on Route A	0.2793092	0.0714187	3.9108681	0.0000934	0.1392914	0.4193271	0.1392914	0.4193271
Experience on Route B	-0.1809938	0.0679963	-2.6618168	0.0078012	-0.3143020	-0.0476856	-0.3143020	-0.0476856

Appendix D6

Summary output for binary model of route choice: Model-Signal

Regression Statistics	
Multiple R	0.8817
R Square	0.7774
Adjusted R Square	0.7768
Standard Error	1.5453
Observations	4275

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	11	35549.474872	3231.770443	1353.403331	0
Residual	4263	10179.550387	2.387884		
Total	4274	45729.025258			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.6191723	0.1176864	39.2498425	0.0000000	4.3884458	4.8498989	4.3884458	4.8498989
Journey time	-0.2097040	0.0019049	-110.0859751	0.0000000	-0.2134386	-0.2059693	-0.2134386	-0.2059693
Total expense	-0.0916320	0.0028155	-32.5450488	0.0000000	-0.0971519	-0.0861121	-0.0971519	-0.0861121
Road conditions 1	-0.3161957	0.0610669	-5.1778532	0.0000002	-0.4359187	-0.1964727	-0.4359187	-0.1964727
Road conditions 2	-1.4209032	0.0617488	-23.0110359	0.0000000	-1.5419629	-1.2998435	-1.5419629	-1.2998435
Age	-0.2852553	0.0654527	-4.3581905	0.0000134	-0.4135766	-0.1569340	-0.4135766	-0.1569340
Gender	-0.0745585	0.0554162	-1.3454271	0.1785589	-0.1832030	0.0340861	-0.1832030	0.0340861
Education level	-0.3726523	0.0557735	-6.6815275	0.0000000	-0.4819974	-0.2633072	-0.4819974	-0.2633072
Monthly income	-0.1232718	0.0555036	-2.2209691	0.0264054	-0.2320877	-0.0144558	-0.2320877	-0.0144558
Trip purpose	-0.0162280	0.0691904	-0.2345405	0.8145767	-0.1518771	0.1194212	-0.1518771	0.1194212
Experience on Route A	0.2339191	0.0709499	3.2969643	0.0009854	0.0948205	0.3730178	0.0948205	0.3730178
Experience on Route B	-0.3874038	0.0675499	-5.7350726	0.0000000	-0.5198368	-0.2549708	-0.5198368	-0.2549708

Appendix D7

Summary output for logit model regarding route familiarity (unfamiliar with both routes): Model-Number

Regression Statistics	
Multiple R	0.728154685
R Square	0.530209246
Adjusted R Square	0.528991382
Standard Error	1.805288016
Observations	1548

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	5675.468997	1418.867249	435.3602421	3.07E-251
Residual	1543	5028.737018	3.259064821		
Total	1547	10704.20601			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.326571476	0.14374613	9.228571764	8.75223E-20	1.044613057	1.608529894	1.044613057	1.608529894
Journey time	-0.140026102	0.003698257	-37.86272807	2.0728E-222	-0.147280243	-0.13277196	-0.147280243	-0.13277196
Total expense	-0.062108742	0.005466188	-11.36234957	8.6585E-29	-0.072830685	-0.051386799	-0.072830685	-0.051386799
Road conditions 1	-0.330124281	0.118557395	-2.784510242	0.005426333	-0.562674928	-0.097573633	-0.562674928	-0.097573633
Road conditions 2	-1.339051771	0.119881114	-11.16983092	6.52446E-28	-1.574198896	-1.103904645	-1.574198896	-1.103904645

Appendix D8

Summary output for logit model regarding route familiarity (unfamiliar with both routes): Model-Words

Regression Statistics	
Multiple R	0.850827668
R Square	0.723907721
Adjusted R Square	0.723191993
Standard Error	1.728019968
Observations	1548

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	12080.70799	3020.176998	1011.42779	0
Residual	1543	4607.479795	2.98605301		
Total	1547	16688.18779			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.824605745	0.137593659	27.79638091	3.3593E-138	3.554715415	4.094496074	3.554715415	4.094496074
Journey time	-0.203504734	0.003539968	-57.48773045	0	-0.210448391	-0.196561077	-0.210448391	-0.196561077
Total expense	-0.09244286	0.00523223	-17.66796484	9.16096E-64	-0.102705894	-0.082179826	-0.102705894	-0.082179826
Road conditions 1	-0.389529896	0.113483026	-3.432494806	0.000613862	-0.612127154	-0.166932637	-0.612127154	-0.166932637
Road conditions 2	-1.505336418	0.114750088	-13.11839012	2.37684E-37	-1.730419022	-1.280253814	-1.730419022	-1.280253814

Appendix D9

Summary output for logit model regarding route familiarity (unfamiliar with both routes): Model-Signal

Regression Statistics	
Multiple R	0.864774521
R Square	0.747834972
Adjusted R Square	0.747181271
Standard Error	1.624661152
Observations	1548

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	12078.48413	3019.621032	1144.002174	0
Residual	1543	4072.785314	2.639523859		
Total	1547	16151.26944			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.052247891	0.129363709	31.32445669	3.939E-167	3.79850063	4.305995151	3.79850063	4.305995151
Journey time	-0.205592778	0.00332823	-61.77239835	0	-0.212121111	-0.199064445	-0.212121111	-0.199064445
Total expense	-0.083503155	0.004919273	-16.97469578	2.19956E-59	-0.093152321	-0.073853989	-0.093152321	-0.073853989
Road conditions 1	-0.339409406	0.106695216	-3.181111771	0.001496299	-0.548692357	-0.130126455	-0.548692357	-0.130126455
Road conditions 2	-1.321622503	0.10788649	-12.25012045	5.41446E-33	-1.533242143	-1.110002863	-1.533242143	-1.110002863

Appendix D10

Summary output for logit model regarding route familiarity (familiar with one route): Model-Number

Regression Statistics	
Multiple R	0.764614054
R Square	0.584634652
Adjusted R Square	0.583777787
Standard Error	1.743210162
Observations	1944

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	8293.380625	2073.345156	682.294874	0
Residual	1939	5892.197657	3.038781669		
Total	1943	14185.57828			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.668926394	0.123861621	13.47412042	1.27037E-39	1.426010358	1.91184243	1.426010358	1.91184243
Journey time	-0.145899311	0.003186674	-45.78419134	0	-0.152148982	-0.139649641	-0.152148982	-0.139649641
Total expense	-0.082800677	0.004710046	-17.57958831	2.62972E-64	-0.092037968	-0.073563386	-0.092037968	-0.073563386
Road conditions 1	-0.328604174	0.102157262	-3.216650152	0.001318339	-0.528953863	-0.128254485	-0.528953863	-0.128254485
Road conditions 2	-1.10004336	0.10329787	-10.64923564	8.92398E-26	-1.302629996	-0.897456723	-1.302629996	-0.897456723

Appendix D11

Summary output for logit model regarding route familiarity (familiar with one route): Model-Words

Regression Statistics	
Multiple R	0.896320595
R Square	0.803390609
Adjusted R Square	0.80298502
Standard Error	1.440610118
Observations	1944

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	16443.46068	4110.865171	1980.798559	0
Residual	1939	4024.118218	2.075357513		
Total	1943	20467.5789			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.243444471	0.102360753	41.45577637	1.6291E-269	4.042695699	4.444193242	4.042695699	4.444193242
Journey time	-0.21096282	0.002633507	-80.10719369	0	-0.216127624	-0.205798016	-0.216127624	-0.205798016
Total expense	-0.100376206	0.00389244	-25.78747838	2.4979E-126	-0.108010016	-0.092742396	-0.108010016	-0.092742396
Road conditions 1	-0.357150098	0.084424006	-4.23043295	2.44111E-05	-0.522721522	-0.191578674	-0.522721522	-0.191578674
Road conditions 2	-1.799667319	0.085366618	-21.0816283	5.36892E-89	-1.967087384	-1.632247255	-1.967087384	-1.632247255

Appendix D12

Summary output for logit model regarding route familiarity (familiar with one route): Model-Signal

Regression Statistics	
Multiple R	0.892378689
R Square	0.796339725
Adjusted R Square	0.79591959
Standard Error	1.464329679
Observations	1944

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	16257.26902	4064.317254	1895.439258	0
Residual	1939	4157.722872	2.144261409		
Total	1943	20414.99189			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.280044408	0.104046116	41.13603233	1.8399E-266	4.07599032	4.484098497	4.07599032	4.484098497
Journey time	-0.209938227	0.002676867	-78.42683991	0	-0.215188069	-0.204688385	-0.215188069	-0.204688385
Total expense	-0.097147182	0.003956529	-24.55364118	3.7888E-116	-0.104906682	-0.089387682	-0.104906682	-0.089387682
Road conditions 1	-0.241471648	0.085814043	-2.813894334	0.004943912	-0.409769196	-0.0731741	-0.409769196	-0.0731741
Road conditions 2	-1.356697046	0.086772175	-15.63516241	5.464E-52	-1.526873672	-1.18652042	-1.526873672	-1.18652042

Appendix D13

Summary output for logit model regarding route familiarity (familiar with both routes): Model-Number

Regression Statistics	
Multiple R	0.748145049
R Square	0.559721014
Adjusted R Square	0.557457369
Standard Error	1.899974176
Observations	783

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	3570.414584	892.603646	247.265349	5.6245E-137
Residual	778	2808.503656	3.609901871		
Total	782	6378.91824			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.545917023	0.212716881	7.267486309	8.92144E-13	1.128350172	1.963483874	1.128350172	1.963483874
Journey time	-0.154780328	0.005472716	-28.28217932	1.3912E-121	-0.165523362	-0.144037294	-0.165523362	-0.144037294
Total expense	-0.072067554	0.008088917	-8.909419236	3.58777E-18	-0.087946235	-0.056188872	-0.087946235	-0.056188872
Road conditions 1	-0.547291412	0.175442353	-3.119494242	0.001878444	-0.891687731	-0.202895092	-0.891687731	-0.202895092
Road conditions 2	-1.200210014	0.177401205	-6.76551219	2.61225E-11	-1.548451593	-0.851968436	-1.548451593	-0.851968436

Appendix D14

Summary output for logit model regarding route familiarity (familiar with both routes): Model-Words

Regression Statistics	
Multiple R	0.891060746
R Square	0.793989252
Adjusted R Square	0.792930071
Standard Error	1.515696479
Observations	783

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	6888.566031	1722.141508	749.6254993	3.9294E-265
Residual	778	1787.327265	2.297335816		
Total	782	8675.893296			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.157047313	0.169694005	24.49731388	1.10846E-98	3.823935098	4.490159528	3.823935098	4.490159528
Journey time	-0.215942579	0.004365836	-49.46190607	2.0717E-242	-0.224512789	-0.207372368	-0.224512789	-0.207372368
Total expense	-0.095088693	0.0064529	-14.73580777	1.57884E-43	-0.107755845	-0.082421541	-0.107755845	-0.082421541
Road conditions 1	-0.69127855	0.139958406	-4.939171351	9.60682E-07	-0.966019278	-0.416537822	-0.966019278	-0.416537822
Road conditions 2	-1.415984351	0.141521072	-10.00546656	2.98043E-22	-1.693792618	-1.138176083	-1.693792618	-1.138176083

Appendix D15

Summary output for logit model regarding route familiarity (familiar with both routes): Model-Signal

Regression Statistics	
Multiple R	0.874432712
R Square	0.764632568
Adjusted R Square	0.763422453
Standard Error	1.649436625
Observations	783

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	6876.339128	1719.084782	631.867515	1.2139E-242
Residual	778	2116.658839	2.720641181		
Total	782	8992.997967			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.179115402	0.184667255	22.63051677	1.61952E-87	3.816610444	4.541620359	3.816610444	4.541620359
Journey time	-0.217250208	0.004751063	-45.72664874	1.1561E-222	-0.226576626	-0.20792379	-0.226576626	-0.20792379
Total expense	-0.094009841	0.007022283	-13.38736172	6.23689E-37	-0.107794702	-0.080224981	-0.107794702	-0.080224981
Road conditions 1	-0.455823612	0.152307882	-2.992777557	0.002851961	-0.754806572	-0.156840652	-0.754806572	-0.156840652
Road conditions 2	-1.776590637	0.154008433	-11.53567119	1.57023E-28	-2.078911806	-1.474269469	-2.078911806	-1.474269469

Appendix D16

Summary output for logit model regarding listening propensity (all samples): Model-Number

Regression Statistics	
Multiple R	0.74314152
R Square	0.552259319
Adjusted R Square	0.55183989
Standard Error	1.821297191
Observations	4275

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	17470.5271	4367.631775	1316.692558	0
Residual	4270	14164.11717	3.317123459		
Total	4274	31634.64427			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.522427739	0.087266568	17.44571566	6.81425E-66	1.351339849	1.693515628	1.351339849	1.693515628
Journey time	-0.145399219	0.002245168	-64.7609546	0	-0.14980092	-0.14099752	-0.149800917	-0.140997522
Total expense	-0.073342162	0.003318458	-22.1012778	1.4177E-102	-0.07984807	-0.06683626	-0.079848067	-0.066836258
Road conditions 1	-0.369208907	0.071974787	-5.12969783	3.0308E-07	-0.51031695	-0.22810087	-0.510316945	-0.228100868
Road conditions 2	-1.204935877	0.0727784	-16.5562292	1.01252E-59	-1.34761942	-1.06225234	-1.347619417	-1.062252336

Appendix D17

Summary output for logit model regarding listening propensity (all samples): Model-Words

Regression Statistics	
Multiple R	0.877301163
R Square	0.769657331
Adjusted R Square	0.769441554
Standard Error	1.574093505
Observations	4275

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	35351.83372	8837.95843	3566.899726	0
Residual	4270	10580.07945	2.477770364		
Total	4274	45931.91317			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.075956442	0.075421924	54.04206391	0	3.92809022	4.223822664	3.92809022	4.223822664
Journey time	-0.20917429	0.001940433	-107.7977663	0	-0.212978548	-0.205370033	-0.212978548	-0.205370033
Total expense	-0.09653505	0.002868045	-33.65882795	1.6892E-220	-0.102157912	-0.090912188	-0.102157912	-0.090912188
Road conditions 1	-0.430073257	0.062205688	-6.913728854	5.42094E-12	-0.552028778	-0.308117736	-0.552028778	-0.308117736
Road conditions 2	-1.622813986	0.062900227	-25.79981112	1.5781E-136	-1.746131166	-1.499496806	-1.746131166	-1.499496806

Appendix D18

Summary output for logit model regarding listening propensity (all samples): Model-Signal

Regression Statistics	
Multiple R	0.876977869
R Square	0.769090182
Adjusted R Square	0.768873873
Standard Error	1.572545551
Observations	4275

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	35169.74436	8792.436089	3555.516937	0
Residual	4270	10559.2809	2.472899509		
Total	4274	45729.02526			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.179072146	0.075347755	55.46379143	0	4.031351334	4.326792958	4.031351334	4.326792958
Journey time	-0.209703964	0.001938524	-108.1771141	0	-0.213504481	-0.205903448	-0.213504481	-0.205903448
Total expense	-0.091631979	0.002865225	-31.98072648	2.2082E-201	-0.097249312	-0.086014647	-0.097249312	-0.086014647
Road conditions 1	-0.31619568	0.062144515	-5.088070621	3.77263E-07	-0.438031271	-0.19436009	-0.438031271	-0.19436009
Road conditions 2	-1.420903195	0.062838372	-22.6120308	5.0506E-107	-1.544099106	-1.297707285	-1.544099106	-1.297707285

Appendix D19

Summary output for logit model regarding listening propensity (regulaly listen to radio traffic news): Model-Number

Regression Statistics	
Multiple R	0.739984756
R Square	0.547577439
Adjusted R Square	0.546737676
Standard Error	1.857766713
Observations	2160

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	9001.832368	2250.458092	652.0615257	0
Residual	2155	7437.545381	3.451297161		
Total	2159	16439.37775			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.586728153	0.125227422	12.67077228	1.53785E-35	1.341148898	1.832307409	1.341148898	1.832307409
Journey time	-0.147775065	0.003221813	-45.8670473	0	-0.154093254	-0.141456876	-0.154093254	-0.141456876
Total expense	-0.070767284	0.004761983	-14.8608845	1.24264E-47	-0.080105848	-0.06142872	-0.080105848	-0.06142872
Road conditions 1	-0.224432404	0.103283734	-2.172969507	0.029891223	-0.426978634	-0.021886173	-0.426978634	-0.021886173
Road conditions 2	-1.074863144	0.104436919	-10.29198447	2.76645E-24	-1.279670847	-0.870055442	-1.279670847	-0.870055442

Appendix D20

Summary output for logit model regarding listening propensity (regulaly listen to radio traffic news): Model-Words

Regression Statistics	
Multiple R	0.886843413
R Square	0.78649124
Adjusted R Square	0.786094936
Standard Error	1.501541684
Observations	2160

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	17897.82477	4474.456192	1984.565669	0
Residual	2155	4858.722109	2.254627429		
Total	2159	22756.54688			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.107424132	0.101215181	40.58110728	5.8123E-268	3.908934469	4.305913795	3.908934469	4.305913795
Journey time	-0.207928655	0.002604034	-79.84868193	0	-0.213035337	-0.202821972	-0.213035337	-0.202821972
Total expense	-0.101237609	0.003848877	-26.30315185	1.788E-132	-0.108785512	-0.093689705	-0.108785512	-0.093689705
Road conditions 1	-0.595554605	0.083479174	-7.134169808	1.32421E-12	-0.759262785	-0.431846425	-0.759262785	-0.431846425
Road conditions 2	-1.731915032	0.084411237	-20.51758854	1.34261E-85	-1.897451049	-1.566379015	-1.897451049	-1.566379015

Appendix D21

Summary output for logit model regarding listening propensity (regulaly listen to radio traffic news): Model-Signal

Regression Statistics	
Multiple R	0.889211036
R Square	0.790696266
Adjusted R Square	0.790307767
Standard Error	1.509175529
Observations	2160

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	18542.12465	4635.531162	2035.26046	0
Residual	2155	4908.251228	2.277610779		
Total	2159	23450.37587			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.225835994	0.10172976	41.5398208	1.469E-277	4.026337208	4.425334779	4.026337208	4.425334779
Journey time	-0.212568768	0.002617273	-81.21766533	0	-0.217701412	-0.207436123	-0.217701412	-0.207436123
Total expense	-0.100256532	0.003868445	-25.91649297	3.8724E-129	-0.107842809	-0.092670256	-0.107842809	-0.092670256
Road conditions 1	-0.44139134	0.083903583	-5.260697164	1.57716E-07	-0.605931814	-0.276850867	-0.605931814	-0.276850867
Road conditions 2	-1.661759962	0.084840384	-19.58689809	9.4384E-79	-1.828137565	-1.495382358	-1.828137565	-1.495382358

Appendix D22

Summary output for logit model regarding listening propensity (sparse listen to radio traffic news): Model-Number

Regression Statistics	
Multiple R	0.747817099
R Square	0.559230414
Adjusted R Square	0.558394832
Standard Error	1.781387495
Observations	2115

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	8495.294085	2123.823521	669.270415	0
Residual	2110	6695.750371	3.173341408		
Total	2114	15191.04446			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.45675923	0.121349601	12.00464786	3.65477E-32	1.21878188	1.694736581	1.21878188	1.694736581
Journey time	-0.142972824	0.003122046	-45.79459334	0	-0.149095433	-0.136850214	-0.149095433	-0.136850214
Total expense	-0.075971825	0.004614523	-16.46363685	2.17255E-57	-0.085021314	-0.066922336	-0.085021314	-0.066922336
Road conditions 1	-0.51706576	0.100085426	-5.166244302	2.61309E-07	-0.713342174	-0.320789347	-0.713342174	-0.320789347
Road conditions 2	-1.337776114	0.101202901	-13.21875264	2.19597E-38	-1.536243995	-1.139308233	-1.536243995	-1.139308233

Appendix D23

Summary output for logit model regarding listening propensity (sparse listen to radio traffic news): Model-Words

Regression Statistics	
Multiple R	0.868916338
R Square	0.755015603
Adjusted R Square	0.754551178
Standard Error	1.639524102
Observations	2115

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	17479.76412	4369.94103	1625.698352	0
Residual	2110	5671.762884	2.688039282		
Total	2114	23151.527			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.043819227	0.111685749	36.20711931	1.0969E-223	3.82479355	4.262844904	3.82479355	4.262844904
Journey time	-0.210446428	0.002873417	-73.23907751	0	-0.216081455	-0.204811402	-0.216081455	-0.204811402
Total expense	-0.091732436	0.004247038	-21.599154	1.22157E-93	-0.100061256	-0.083403617	-0.100061256	-0.083403617
Road conditions 1	-0.261071029	0.092114977	-2.834186563	0.00463796	-0.441716684	-0.080425375	-0.441716684	-0.080425375
Road conditions 2	-1.511391641	0.09314346	-16.22649231	6.86602E-56	-1.694054243	-1.328729039	-1.694054243	-1.328729039

Appendix D24

Summary output for logit model regarding listening propensity (sparse listen to radio traffic news): Model-Signal

Regression Statistics	
Multiple R	0.865746294
R Square	0.749516645
Adjusted R Square	0.749041795
Standard Error	1.626005867
Observations	2115

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	16692.79586	4173.198966	1578.428356	0
Residual	2110	5578.618621	2.643895081		
Total	2114	22271.41448			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4.131313323	0.110764875	37.2980452	2.608E-234	3.91409356	4.348533085	3.91409356	4.348533085
Journey time	-0.206778207	0.002849725	-72.56075103	0	-0.212366772	-0.201189643	-0.212366772	-0.201189643
Total expense	-0.082823925	0.004212021	-19.66370353	3.52565E-79	-0.091084072	-0.074563778	-0.091084072	-0.074563778
Road conditions 1	-0.188336283	0.091355469	-2.06157645	0.039370308	-0.367492474	-0.009180091	-0.367492474	-0.009180091
Road conditions 2	-1.174921817	0.092375472	-12.71898039	9.203E-36	-1.356078326	-0.993765308	-1.356078326	-0.993765308