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Presenting traveller preference heterogeneity in the context of agency theory: understanding and minimising the agency problem

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Abstract

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Disciplines

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Presenting traveller preference heterogeneity in the context of agency theory: understanding and minimising the agency problem

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ABSTRACT

In this paper agency theory has been used to interpret traveller preference heterogeneity in mode choice to understand agency problems. An agency problem is defined as a principal's dissatisfaction with the outcome of an agent's performance. Sydney statistical division travellers are considered as the *principal* and Transport for NSW (TfNSW) is treated as the *agent*. An agent performs the tasks that are delegated by the principal and thus a *metaphoric contract* is developed between them and travellers, for instance, show their satisfaction with the reliability and comfort of the transport service. TfNSW is expected to satisfy travellers' desired services. Therefore, it is imperative to analyse traveller preferences to understand their desires/demands. Random parameter logit models are employed to analyse the travellers' demand to explore travellers' dissatisfaction (the agency problem). The analysis reveals that this agency problem exists in the association between traveller and TfNSW because the probability of using a private car for transport is high. The preference for use of private transport is evidence of dissatisfaction of travellers with public transport. This paper identifies the dominant attributes of traveller preferences and then devises an approach to increase the use of public transport and reduce the agency problem.

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Agency theory; mode choice; logit model; traveller; transport for NSW

Introduction

From the context of transport management in Sydney, it is assumed that Transport for New South Wales (TfNSW) behaves in such way as to satisfy NSW travellers and provide a better transport service. The role of TfNSW, as an *agent*, is to maximise the utility of the travellers' (the *principal*) satisfactions within available resources by providing suitable modes of transport services. In order to understand the utility function of travellers towards mode choice, the TfNSW should have information about the nature of travellers' desires and expectations based on choice attributes both observed and latent. Thus, an inferred

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Table 1. Summary of extant research.

Issues/subjects	Methods used	Findings	Sources
Government support programs (GSPs) and academic entrepreneurship	Agency theory	The GSPs have an effect on reducing the agency problems in the relationship	Rasmussen and Gulbrandsen (2012)
Labour market	Agency theory and dichotomisation process	In the private sector, the principal is largely controlling the agents' activities via contemporary HRM systems and by tying wages to performance. On the contrary, the principal's lack of control over the agent's activities is noticed in the public sector	Cohen and Baruch (2010)
Capital planning and financing	Interview and principal-agent model	Hospital planning process should necessarily be informed by an explicit understanding of powerful groups (e.g. central government) involved and their divergent preferences and utilities to avoid agency problems	Thompson and McKee (2011)
Supply chain management	Agency theory and outcome-based and behaviour-based approaches	Agent-based factors such as information asymmetry, goal conflict, risk aversion of suppliers, length of relationship, and task characteristics, can be expected to influence how firms design and manage their quality management systems for supply chains	Zu and Kaynak (2012)
Risk management	Framework of agency theory	Empirical results indicate that purchasing organisations address various sources of supply risk by implementing management techniques that reduce the likelihood that detrimental events will occur. Firm size, purchases as a percentage of sales, and industry characteristics have also been found to influence the manner in which supplier behaviours are managed	Zsidisin and Ellram (2003)
Public transportation	Structural equation model	Public transportation offers low utility due to low degree of congruence between user preferences and service provided. Increased utility may increase new customers and thus agency relationship may improve	Andreassen (1995)
Managerial ownership	Logistics regression approach	The risk at lower level of managerial is significant and positive relations with managerial ownership concentration. This supports the hypothesis that a higher level of managerial ownership can reduce the agency conflict between external equity claimholders and managers	Ahmed (2009)
Organisational management	Mixed logit model	Agency theory and stewardship theory are not necessarily in conflict with each other but can be combined into a more general governance framework for non-profit organisations. Consequently, incentive structures that incorporate different types of objectives can facilitate the recruitment and retention of employees in non-profit organisations	Puyvelde, Caers, Bois, and Jegers (2013)
Doctor and patients' preferences	Logit model	GPs are not fully aware of patient preferences at an aggregate level. Even though GPs almost succeeded in predicting the rank order of preferences in the unforced choice, there is still room for improving the agency relationship in the organisation of general practice	Pedersen, Kaer, Kragstrup, and Hansen (2012), Scott and Vick (1999)

relationship is understood to exist between the 'traveller' and 'TfNSW'. Such a two party relationship is indicated in agency theory (AT).

AT, also known as the Principal-Agent or Principal AT/Model, describes the relationship between two or more parties in which one party is designated as the *principal* that

assigns another party, called the *agent*, to perform tasks on behalf of the principal (Jensen & Meckling, 1976; Moe, 1984; Ross, 1973). AT assumes that the agent has more information than the principal (Grammenos & Papapostolou, 2012), a condition that is known as *informational asymmetry*, and this adversely affects the principal's ability to monitor the agent's activities. Another assumption of AT is that both principal and agent act rationally and try to maximise their own interests, which ultimately results in a conflict of interest/choice that is referred to as *moral hazard* (Jensen & Meckling, 1976); that is the dilemma of acting against the interest of the principal as the agent tries to maximise its own interests. Since the principal does not have access to decisions that are made by an agent, it is unable to monitor whether the agent's action(s) are in their best interests. This is called *adverse selection or choice conflict*.

Because of the useful assumptions of AT discussed above, the theory is being applied to different fields (Kivisto, 2005). Table 1 summarises the contemporary research on AT in different sectors.

The research described in Table 1 shows that AT is being used in various fields including transportation. Examination of the relationship between traveller and transport service providers is rare in extant research. When travellers entrust their choice for safe, reliable, comfortable and cheap transport to the TfNSW, this creates a metaphorical contract, known as an *agency contract* (Anwar, Tieu, Gibson, Win, & Berryman, 2014), between travellers and the TfNSW. This contract is often characterised by an *agency problem* because mode choice is driven by a traveller's heterogeneous set of preferences which are not addressed adequately by the TfNSW. In most cases, the TfNSW performs its task well by aligning with government preference (such as a limited budget) although it is assumed that travellers' satisfaction and choice preference should be maximised by TfNSW.

In this study, *traveller preference* and *utility* are regarded as key indicators of the traveller–TfNSW relationship. Traveller preference is only one of the major choice functions that have a multitude of influences on TfNSW, but consideration of traveller preference in project design and implementation may reduce project failure. There are also a large number of actors, both internal and external, who affect the success or failure of a transport project (Anwar, 2013). This means that TfNSW may need to compromise with multiple sets of interests while it performs on behalf of the traveller and, therefore, choice conflicts may arise. The ability of TfNSW to resolve these conflicts will significantly affect its success or failure to overcome agency problem.

Likewise, utility is regarded as a key indicator of traveller satisfaction. The idea of an individual's utility function is expressed by the gain of satisfaction, which may be financial, social and/or psychic, in a mathematical form. These gains are called 'utility' from an economic point of view, and the idea of utility is that individuals tries to maximise their utility (i.e. gains) over the set of possible choice sets that are obtainable.

AT argues that agency problems arise from the informational asymmetries and choice conflict in the traveller and TfNSW relationship. AT considers this relationship as a contractual phenomenon (Jensen & Meckling, 1976), where the agent or TfNSW is to perform services on behalf of the travellers. Based on these assumptions, both principal and agent are rational economic entities and both are self-interested maximisers of their choice utility. The idea of a 'contract' in AT is introduced to recognise the necessary metaphorical agreement between the principal and the agent that specifies the obligations of each party. This implies that TfNSW is obliged to provide transport service as travellers demand. Accordingly,

traveller preference is an element that influences utility and needs to be analysed from the TfNSW point of view to achieve a balanced agency relationship (Anwar et al., 2014). Thus, in order to achieve a balanced agency relationship, considering traveller preferences in the planning and management process is imperative. According to the AT, if most of the people use public transportation (trains and buses only), the optimal condition is achieved. That means that to obtain a reliable agency relationship, an acceptable agency problem, public transport use should be higher than private car use.

In summary, travellers entrust their desires for reliable modes of transport to the TfNSW and assume that the TfNSW can be an effective agent to provide it. Limited access by the traveller to monitor the TfNSW's performance is observed and this causes choice conflicts. The TfNSW provides public transport, such as trains and buses, for the traveller and tries to accommodate customer expectations into the service. Travellers also have the opportunity to use their own cars (private transport). In this situation, a traveller makes choices between the use of their private car and public transport based on their utility maximisation concept, determined by choice preferences. Once travellers perceive the maximum utility, they choose that particular mode of transport. Based on their mode choice, whenever there is a low use of public transport it is likely that the TfNSW is not performing well enough to satisfy travellers' expectations; an agency conflict is created. In contrast, whenever there is a high use of public transport, the TfNSW is performing well enough to satisfy travellers' expectations and an agency conflict is avoided.

Research methodology

Data

The data source for this research was the cross-sectional 2010/11 household travel survey (HTS) data released in 2012. This was the largest and most comprehensive HTS of Sydney collected by the Bureau of transport statistics (BTS) of TfNSW. The BTS conducted a household questionnaire survey in three areas: Sydney, Newcastle and the Illawarra, and collected three types of data: Household, Person and Trip data. Later on the BTS created linked trip data that has not been used in this paper. For this present paper, only 'Sydney Statistical Division (SSD)' and 'person trip data' were considered for analysis. The HTS consisted of a face-to-face interview survey carried out every day from July to June of the financial year 2010/11. This collection method ensured high data quality and maximised response rates. Each respondent was requested to maintain a simple travel diary to record the details of all trips undertaken for the nominated last 24-h period. An interviewer then interviewed each respondent to collect the details of each trip. For further details about the HTS, its scope, coverage and methodology, please see Bureau of Transport Statistics (BTS, 2012).

Description of variables

Six latent variables (LVs) and 13 socio-demographic variables (SDVs) are evaluated in this paper to analyse traveller preference heterogeneity and to explore the association between traveller choice and service provided by TfNSW. LVs are: (i) comfort, (ii) convenience, (iii) safety, (iv) flexibility, (v) reliability and (vi) satisfaction and 20 indicators (Table 2) were set to explain them. Because of limited information in the HTS data-set, these indicators

Table 2. LVs and their indicators.

Latent variables	Label	Explained by (indicators) Anwar et al. (2014)	Definitions
Comfort	y_1	Enjoy time to read/relax on vehicle	Importance with 1, otherwise 0
	y_2	Stressfulness on vehicle	Importance with 1, otherwise 0
	y_3	Service slower	Importance with 1, otherwise 0
Convenience	y_4	Alternative mode availability	Importance with 1, otherwise 0
	y_5	Accessibility (does not go where required)	Importance with 1, otherwise 0
	y_6	Timetable availability	Importance with 1, otherwise 0
Safety	y_7	Safety response for mode used in 1st trip	perceived a safe trip with 1, otherwise 0
	y_8	Safety response for mode used in 2nd trip	perceived a safe trip with 1, otherwise 0
	y_9	Safety response for mode used in 3rd trip	perceived a safe with 1, otherwise 0
Flexibility	y_{10}	Fixed start and finish times at office – each day can vary	Importance with 1, otherwise 0
	y_{11}	Rotating shift (work flexibility)	Importance with 1, otherwise 0
	y_{12}	Roster shift (work flexibility)	Importance with 1, otherwise 0
Reliability	y_{13}	Variable hours (work flexibility)	Importance with 1, otherwise 0
	y_{14}	Frequency (travel mode, e.g. bus)	Importance with 1, otherwise 0
	y_{15}	Punctuality (for public transport)	Importance with 1, otherwise 0
Satisfaction	y_{16}	Faster (for public transport)	Importance with 1, otherwise 0
	y_{17}	Cleanliness (cleanliness inside vehicle)	Importance with 1, otherwise 0
	y_{18}	Travel time	Travel time in minutes
	y_{19}	Travel cost	Travel cost in Australian dollar
	y_{20}	Waiting time	Waiting time in minutes

are considered only to represent LVs in this paper. The 13 explanatory variables (objective attributes) are: annual income (in Australian dollars), age (in years), gender (1 if male, 0 otherwise), having children (0–14 years), car ownership, family size, full-time workers of household, travel time (in minutes), travel cost (in Australian dollars), waiting time (in minutes), trip rate (trips per person per day), trip purpose (1 if work, 0 otherwise) and distance travelled (in kilometres).

In HTS, the respondents (travellers) were asked about the reason for choosing a particular mode of transport (private or public) and some multiple answers were given. Travellers answered with the appropriate reason according to their experiences. For example, if 'enjoy time to read/relax on vehicle' was answered by a respondent as a reason for choosing a particular mode, it implied that the respondent views this indicator as important and, therefore, this indicator was marked 1 otherwise 0 (zero). In this way, y_1 – y_6 , y_{14} – y_{17} and y_{10} – y_{13} were determined by either 1 or 0.

The indicators y_7 – y_9 were used to represent safety. The travellers were asked about their experience travelling on the first three trips; whether they feel safe. There were five possible answers: (i) always; (ii) mostly; (iii) sometimes; (iv) rarely and (v) never. If the travellers answered (i) to (iii), it means they perceived the trip with the particular mode as safe. On the other hand, responses to (iv) and (v) indicate that the trip by this mode was thought to be unsafe. Therefore, if they responded to (i) to (iii), they perceived the trip to be safe, otherwise not. In this way, the indicators were marked for 1 if the respondents put a tick in (i) to (iii) otherwise 0 (zero).

Modelling issues

The analysis specifically investigates the influences SDVs and LVs on mode choice probability to explore the agency problem and devise an approach to minimise the problem.

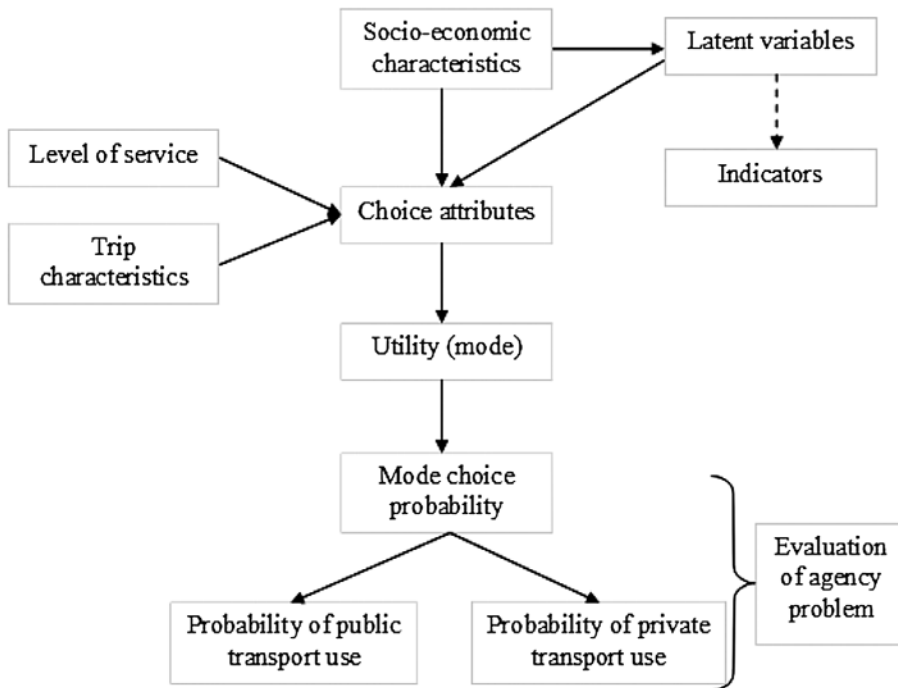


Figure 1. Structure of mode choice probability process.

Figure 1 describes the overall structure of the mode choice probability process for exploring the agency problem.

Econometric methods¹

There are two approaches available for incorporating LVs into the choice models (i) the *sequential approach* (also known as *two-step approach*), where the LVs are needed to be constructed before being included into the discrete choice model as regular explanatory variables (Ashok, William, & Yuan, 2002; Johansson, Heldt, & Johansson, 2006). Step 1 is the estimation of a MIMIC (multiple indicators and multiple causes) model; a type of regression model with a latent dependent variable(s). Step 2 is the estimation of a choice model with random parameters; information from the first step is incorporated in the second step; and (ii) the *simultaneous approach*, where both processes are performed simultaneously (Bolduc, Boucher, & Alvarez-Daziano, 2008).

Ben-Akiva et al. (2002) argue that results obtained using the second approach are more consistent and rational than the other approach but this second approach is not popular because of its complexity. Interestingly, the estimated results using both sequential and simultaneous approaches were not statistically different (Raveau, Alvarez-Daziano, Yanez, Bolduc, & Ortuzar, 2010) and this is motivation to employ the first approach in this study because it is not so cumbersome to use.

Modelling with LVs

A MIMIC model, that defines LVs appropriately, is estimated first where the LVs (η_{ijl}) are explained by characteristics (s_{ijr}) of the users (individuals), alternatives (mode alternative) and trip nature using the structural equation (Equation 1). As the analysts cannot collect data on LVs directly, indicators (y_{ijp}) are assigned to explain them through measurement using Equation (2):

$$\eta_{ijl} = \sum_r \alpha_{jlr} \times s_{ijr} + v_{ijl} \quad (1)$$

$$y_{ijp} = \sum_l \gamma_{jlp} \times \eta_{ijl} + \zeta_{ijp} \quad (2)$$

where i refers to an individual, j refers to an alternative, l is an LV, r refers to explanatory variables that belong to SDVs, and p refers to an indicator. α_{jlr} and γ_{jlp} are parameters to be estimated, while v_{ijl} and ζ_{ijp} are error terms with mean of zero and standard deviation to be estimated. The above specifications of the MIMIC model are not restricted to the estimation of parameters and the results of the model depend on the selected variables.

Specifications of the latent variable model

Factor analysis was employed to investigate the structural relationships in the MIMIC model (describes in Table 3) that guide the specification for computation of LVs (Figure 2 illustrates the results of this process) and results in the following set of equations.

$$\text{Comfort}_{ij} = \alpha_{\text{inc-com}_j} \times \text{Income}_i + \alpha_{\text{tco-com}_j} \times \text{Travel cost}_i + \alpha_{\text{wti-com}_j} \times \text{Waiting time}_i + \alpha_{\text{car-com}_j} \times \text{Car ownership}_i + \alpha_{\text{dt-com}_j} \times \text{Distance travelled}_i + \alpha_{\text{chi-com}_j} \times \text{Having children}_i + n_{\text{com},ij}$$

$$\text{Convenience}_{ij} = \alpha_{\text{age-con}_j} \times \text{Age}_i + \alpha_{\text{gen-con}_j} \times \text{Gender}_i + \alpha_{\text{car-con}_j} \times \text{Car ownership}_i + \alpha_{\text{wti-con}_j} \times \text{Waiting time}_i + \alpha_{\text{tr-con}_j} \times \text{Travel time}_i + \alpha_{\text{chi-con}_j} \times \text{Having children}_i + \alpha_{\text{inc-con}_j}$$

$$\text{Safety}_{ij} = \alpha_{\text{age-saf}_j} \times \text{Age}_i + \alpha_{\text{tr-saf}_j} \times \text{Trip rate}_i + \alpha_{\text{car-saf}_j} \times \text{Car ownership}_i + \alpha_{\text{dt-saf}_j} \times \text{Distance travelled}_i + \alpha_{\text{chi-saf}_j} \times \text{Having children}_i + \alpha_{\text{wti-saf}_j} \times \text{Waiting time}_i + n_{\text{saf},ij}$$

$$\text{Flexibility}_{ij} = \alpha_{\text{gen-flc}_j} \times \text{Gender}_i + \alpha_{\text{chi-flc}_j} \times \text{Having children}_i + \alpha_{\text{car-flc}_j} \times \text{Car ownership}_i + \alpha_{\text{tp-flc}_j} \times \text{Trip purpose}_i + \alpha_{\text{tp-flc}_j} \times \text{Trip purpose}_i + n_{\text{flc},ij}$$

$$\text{Reliability}_{ij} = \alpha_{\text{tti-rel}_j} \times \text{Travel time}_i + \alpha_{\text{wti-rel}_j} \times \text{Waiting time}_i + \alpha_{\text{fl-rel}_j} \times \text{Full time workers}_i + \alpha_{\text{car-rel}_j} \times \text{Car ownership}_i + \alpha_{\text{dt-rel}_j} \times \text{Distance travelled}_i + n_{\text{rel},ij}$$

$$\text{Satisfaction}_{ij} = \alpha_{\text{tti-sat}_j} \times \text{Travel time}_i + \alpha_{\text{tco-sat}_j} \times \text{Travel cost}_i + \alpha_{\text{wti-sat}_j} \times \text{Waiting time}_i + \alpha_{\text{car-sat}_j} \times \text{Car ownership}_i + \alpha_{\text{age-sat}_j} \times \text{Age}_i + n_{\text{sat},ij}$$

$$\begin{aligned} y_{y1,ij} &= Y_{y1,j} \times \text{Comfort}_{ij} + \zeta_{y1,ij} \\ y_{y2,ij} &= Y_{y2,j} \times \text{Comfort}_{ij} + \zeta_{y2,ij} \\ y_{y3,ij} &= Y_{y3,j} \times \text{Comfort}_{ij} + \zeta_{y3,ij} \\ y_{y4,ij} &= Y_{y4,j} \times \text{Convenience}_{ij} + \zeta_{y4,ij} \\ y_{y5,ij} &= Y_{y5,j} \times \text{Convenience}_{ij} + \zeta_{y5,ij} \\ y_{y6,ij} &= Y_{y6,j} \times \text{Convenience}_{ij} + \zeta_{y6,ij} \\ y_{y7,ij} &= Y_{y7,j} \times \text{Safety}_{ij} + \zeta_{y7,ij} \\ y_{y8,ij} &= Y_{y8,j} \times \text{Safety}_{ij} + \zeta_{y8,ij} \\ y_{y9,ij} &= Y_{y9,j} \times \text{Safety}_{ij} + \zeta_{y9,ij} \\ y_{y10,ij} &= Y_{y10,j} \times \text{Flexibility}_{ij} + \zeta_{y10,ij} \end{aligned}$$

$$\begin{aligned} y_{y11,ij} &= Y_{y11,j} \times \text{Flexibility}_{ij} + \zeta_{y11,ij} \\ y_{y12,ij} &= Y_{y12,j} \times \text{Flexibility}_{ij} + \zeta_{y12,ij} \\ y_{y13,ij} &= Y_{y13,j} \times \text{Flexibility}_{ij} + \zeta_{y13,ij} \\ y_{y14,ij} &= Y_{y14,j} \times \text{Reliability}_{ij} + \zeta_{y14,ij} \\ y_{y15,ij} &= Y_{y15,j} \times \text{Reliability}_{ij} + \zeta_{y15,ij} \\ y_{y16,ij} &= Y_{y16,j} \times \text{Reliability}_{ij} + \zeta_{y16,ij} \\ y_{y17,ij} &= Y_{y17,j} \times \text{Satisfaction}_{ij} + \zeta_{y17,ij} \\ y_{y18,ij} &= Y_{y18,j} \times \text{Satisfaction}_{ij} + \zeta_{y18,ij} \\ y_{y19,ij} &= Y_{y19,j} \times \text{Satisfaction}_{ij} + \zeta_{y19,ij} \\ y_{y20,ij} &= Y_{y20,j} \times \text{Satisfaction}_{ij} + \zeta_{y20,ij} \end{aligned}$$

Figure 2 follows the path to the results of α -vector matrix of structural equations described in Table 3 (which were estimated using the computer programme AMOS v.19). It is assumed that attributes which obtain a minimum .1 coefficient explain a particular

LV. For example, ‘comfort’ is explained by six (6) attributes of ‘car ownership’, ‘travel cost’, ‘having children’, ‘waiting time’, ‘distance travelled’ and ‘income’ of the traveller because all these attributes have at least a .1 coefficient (Table 3). Attributes that had a coefficient less than .1 were not used to describe an LV. The coefficient in the linear regression model (e.g. structural equation model) indicates the strength of impact/influence that causes an effect on the dependent variable. The t -value represents the significance. Strength is more associated with dependent variables to signify the influence and, therefore, a cut-off point was set to simplify the model.

These estimated matrix parameters using the MIMIC model were also used to quantify LVs that were incorporated in RPL models (Table 5) as explanatory variables. The alpha values in Table 3 are same for all alternatives. The choice of mode (i.e. alternatives) is the dependent variable and the factors described in Table 3 influence travellers in their mode choice decision-making process.

Hybrid discrete choice modelling

By maximising the utility (U_{ij}), individuals take a decision based on the assumption of random utility theory. It is also assumed that an analyst can only determine a representative portion (systematic component) of the utility (V_{ij}) function, therefore, an error term (ϵ_{ij}) for each alternative (Ortuzar & Willumsen, 2001) is required to be included in the function as a stochastic component. Mathematically, the utility function becomes:

$$U_{ij} = V_{ij} + \epsilon_{ij}, \quad (3)$$

where V_{ij} is a function of objective attributes X_{ijk} , such as travel time and cost, socio-economic and trip characteristics of the individual and k stands for all objective variables together.

Equation (4) is derived by including LVs in the utility function, where θ_{jk} and β_{jl} are parameters to be estimated:

$$V_{ij} = \sum_k \theta_{jk} \times X_{ijk} + \sum_l \beta_{jl} \times \eta_{ijl} \quad (4)$$

Only the alternative j is chosen, if the utility of alternative ‘ j ’ is greater than or equal to the utility of all other alternatives ‘ t ’ (all t includes alternative j) in the choice set C . This can be expressed mathematically with binary variables d_{ij} :

$$d_{ij} = \begin{cases} 1 & \text{if } U_{ij} \geq U_{it}, \forall t \in C \\ 0 & \text{other case} \end{cases} \quad (5)$$

As a sequential approach was used in this study, the discrete choice model is estimated with the MIMIC model’s structure and measurement Equations (1) and (2) (Ben-Akiva et al., 2002).

Specifications of the RPL model

Because of its ability to measure random taste variation and to allow an unrestricted substitution pattern and correlation among unobserved factors that help to address the limitations of initially innovated logit models, (e.g. multinomial (MNL) and nested logit (NL) models) the RPL model shows better performance. The standard deviations of random parameters

Table 3. MIMIC model results: a vector matrix of structural equations (t-values in the parenthesis).

LVs	Travel time	Travel cost	Waiting time	Age	Income	Family size	Gender	Car own-ership	No. child	Full time	Trip rate	Distance travelled	Trip purpose
Comfort	-.045 (-3.16)	-.212 (-3.86)	-.165 (-5.71)	-.011 (-2.91)	.121 (2.87)	-.002 (-3.01)	.061 (4.1)	.301 (6.12)	.202 (3.89)	.006 (2.01)	.038 (2.21)	.123 (3.81)	.021 (1.90)
Convenience	-.211 (-7.27)	-.102 (-1.71)	-.216 (-5.13)	-.125 (-2.21)	.156 (2.53)	-.002 (-2.76)	.126 (2.63)	.275 (5.48)	.189 (4.51)	.002 (1.67)	.117 (2.51)	.11 (2.63)	.131 (2.01)
Flexibility	-.092 (-3.47)	-.003 (-1.99)	-.066 (-1.89)	-.088 (-3.41)	.031 (1.90)	.022 (3.01)	-.102 (-2.13)	-.117 (-5.15)	-.131 (-5.31)	-.007 (-2.85)	.001 (2.13)	.013 (4.11)	.126 (4.20)
Safety	-.091 (-4.22)	-.012 (-3.04)	-.132 (-3.91)	-.21 (-4.67)	-.088 (-2.89)	.005 (3.64)	-.098 (-4.12)	-.219 (-7.72)	-.166 (-6.61)	-.008 (-2.44)	.112 (3.01)	.171 (3.69)	.041 (2.58)
Reliability	-.514 (-6.21)	-.011 -2.01	-.107 (-6.11)	-.042 (-1.89)	.031 (2.12)	-.005 (-2.11)	.012 (3.07)	.414 (4.56)	.003 (4.11)	.007 (2.12)	.016 (3.19)	.112 (3.12)	.009 (2.51)
Satisfaction	-.192 (-3.91)	-.166 (-6.21)	-.121 (-3.71)	-.142 (-5.11)	.032 (3.90)	-.008 (-2.12)	-.087 (-3.21)	.139 (5.11)	.092 (6.15)	.007 (5.16)	.097 (6.91)	.062 (5.33)	.068 (3.01)
<i>Model fit criteria</i>													
GFI	.963												
AGFI	.945												
NFI	.901												
CFI	.950												
RMSEA	.033												
Lower bound	.013 (90% CI of RMSEA)												
Upper bound	.048 (90% CI of RMSEA)												

Anwar et al. (2015).

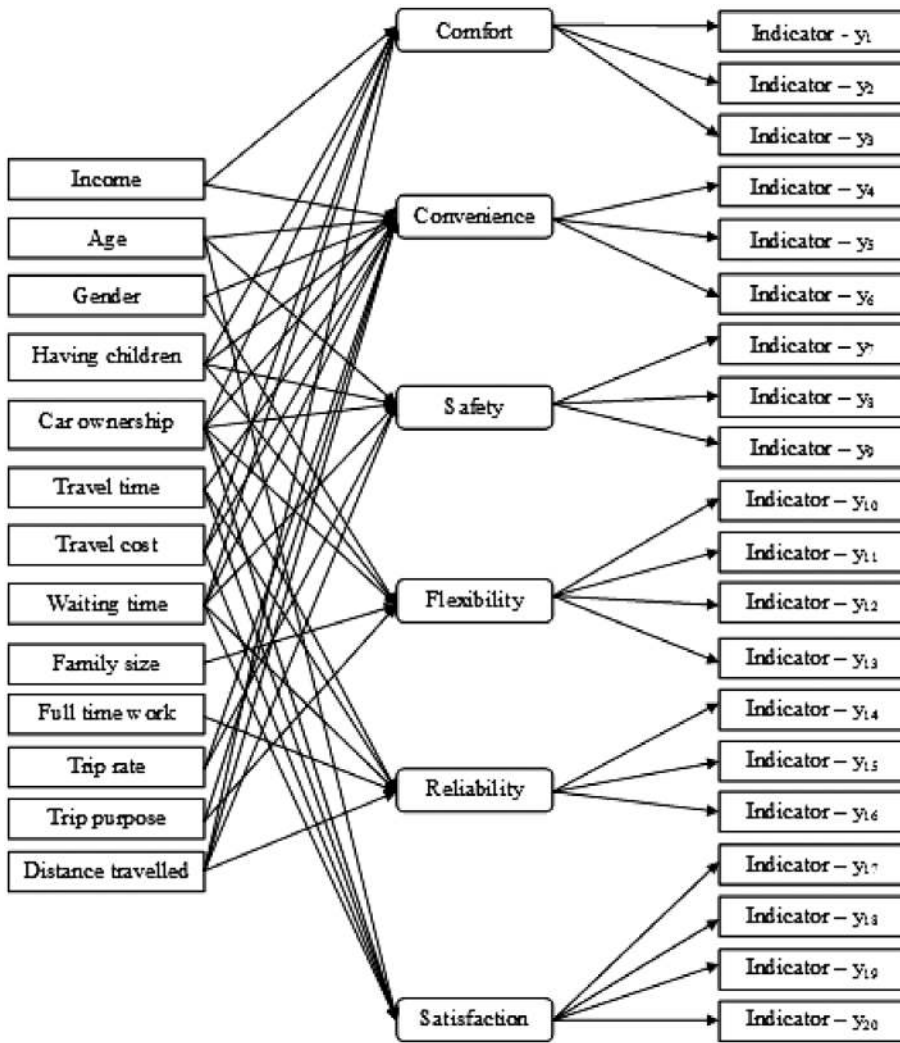


Figure 2. Latent variables model relationships.

in this model depict the degree of unobserved heterogeneity; and heterogeneity around the mean describes the interaction between random parameters and specified attributes.

According to Equation (3), the utility that an individual i receives from alternative j is denoted by U_{ij} , which is the sum of the systematic component V_{ij} and a stochastic component ε_{ij} and has a linear relationship.

Within a logit context a condition is imposed such that ε_{ij} is the independent and identically distributed (IID) extreme value type 1 (Gumbel Distribution). Initially, independence of irrelevant alternatives (IIA) property is also appeared in logit models such as MNL and NL models. These limitations (IID and IIA) should be taken into account in some way. For example, the stochastic component can be divided into two additive parts that are uncorrelated. One part is correlated and heteroskedastic among the alternatives and the other part is IID over alternatives and individuals

$$U_{ij} = x_{ij}\beta_j + (z_{ij}\delta_i + e_{ij}) \quad (6)$$

where x_{ij} is a vector of explanatory variables that are observed by the analyst; β_j is a vector of parameters to be estimated; z_{ij} is a vector of characteristics that can vary between individuals or alternatives, or both (there may be some common elements in both z_{ij} and x_{ij}); e_{ij} is a random term with zero mean that is IID over individuals and alternatives and is normalised to set the scale of utility; random variable (δ_i) is a vector of random terms with zero mean that varies over individuals according to the distribution $f(\delta|\Omega)$, where Ω are the fixed parameters of the distribution f .

In matrix form, it can be written as:

$$U = X\beta + (Z\delta + e) \quad (7)$$

If IIA exists, then $\delta = 0$ for all i and so utility U depends only on the systematic and IID stochastic portion of utility. Initially innovated logit models assume that IIA does not estimate $Z\delta$; thus δ is assumed as zero. Because of this, unobserved taste variations are not addressed in initially innovated logit models. Hence, by incorporating the effect of $Z\delta$ in the utility function, discrete choice models are able to accommodate those impacts and thus avoid the IIA assumption. These models estimate Ω (the parameters of the distribution of δ) as well as β .

To derive a RPL model from Equation (7), e is assumed to be a IID extreme value, while δ follows a general distribution $f(\delta|\Omega)$. If $\delta = 0$, it is MNL which has the IIA property. Estimation of the RPL generally involves estimating β and Ω . The choice probabilities depend on β and δ and the probability to select alternative j for individual i with conditional on δ is similar as the MNL model below:

$$P(j|\delta) = Lj(\delta) = \frac{e^{X_j\beta_j + Z_j\delta}}{\sum_{k \in J} e^{X_k\beta_k + Z_k\delta}} \quad (8)$$

As δ is not given, by integrating over all values of δ weighted by the density of δ , the unconditional choice probability for each individual can be obtained as below.

$$P(j) = \int_{\delta} \left[\frac{e^{X_j\beta_j + Z_j\delta}}{\sum_{k \in J} e^{X_k\beta_k + Z_k\delta}} \right] f(\delta|\Omega) \delta \quad (9)$$

i.e.

$$P(j) = \int_{\delta} Lj(\delta) f(\delta|\Omega) \delta \quad (10)$$

Models of this form are called RPL because the choice probability $Lj(\delta)$ is a mixture of logits with f as the mixing distribution. The RPL is characterised by accommodating heterogeneity as a continuous function of the parameters which are randomly and normally distributed.

Table 4. The y vector matrix of standardised regression weights of indicators (t-statistics in parenthesis).

Indicators	Regression weights				
	Group 1	Group 2	Group 3	Reliab.	Satis.
	<i>Comf.</i>	<i>Flex.</i>	<i>Safety</i>		
Indicator time to read/relax in the vehicle	.136 (5.59)	.007 (.141)			
Stressfulness in the vehicle	1.178 (4.89)	.141 (1.11)			
Slower service (in-vehicle longer travel time due to many stops during the travel)	-.056 (-3.84)	-.002 (-.04)			
Availability of alternative mode of transport	.201 (.152)	.239 (5.61)			
Accessibility (go where required)	.834 (1.21)	1.060 (7.12)			
Public transport timetable availability	.090 (.89)	.195 (4.44)			
Fixed start and finish times at work – each day can vary		-.201 (-7.10)	-.021 (-.98)		
Rotating shift at work		.992 (4.51)	-.717 (-.06)		
Roster shift at work		.331 (5.36)	-.215 (-1.01)		
Variable hours at work		.916 (6.12)	-.202 (-1.20)		
Safety response for mode used in 1st trip		.071 (.21)	1.250 (10.41)		
Safety response for mode used in 2nd trip		.010 (.11)	.970 (7.84)		
Safety response for mode used in 3rd trip		.069 (.09)	.870 (7.11)		
Frequency of bus or train				1.415 (7.11)	.213 (.12)
Punctuality of bus or train				1.517 (6.10)	.201 (.10)
Faster service (in-vehicle shorter travel time due to fewer or no stops during travel and platform)				1.211 (4.14)	.415 (.09)
Cleanliness on public transport and stops				.450 (.05)	.568 (3.84)
Travel time				-1.015 (-.10)	-1.212 (-6.74)
Travel cost				-.008 (-.84)	-.024 (-4.15)
Waiting time				-1.111 (-.76)	-1.512 (-6.14)
<i>Goodness-of-fit</i>					
GFI	.985	.989	.984		
AGFI	.978	.981	.971		
NFI	.911	.975	.901		
CFI	.931	.981	.990		
RMSEA	.036	.017	.039		
Lower bound	.000 (90% CI of RMSEA)	.000 (90% CI of RMSEA)	.017 (90% CI of RMSEA)		
Upper bound	.076 (90% CI of RMSEA)	.067 (90% CI of RMSEA)	.057 (90% CI of RMSEA)		

Regression weights of indicators representing LVs

In this paper, 20 indicators were selected to explain six LVs. Several groups of factor analytic models were examined to identify the weights of indicators to represent the LVs and the models were estimated using AMOS v.19 software. To understand the validity of the indicators that represent LVs there are exploratory analyses described in Table 4.

In group 1 in Table 4, the indicators representing *comfort* and *convenience* have been evaluated to check their validity. Six indicators were assumed to have significant impact on the variables *comfort* and *convenience*. After estimating the regressions weights, it was found that indicators have a significant effect on representing *comfort* and *convenience* variables.

The influence of stressfulness is higher on *comfort* while people travel, whereas *convenience* is highly dependent on accessibility of mode in their choice process. According to group 1 in Table 4, the regression weights of the first three indicators are higher and more significant than *convenience*. This indicates that these three indicators are more relevant to represent *comfort* rather than *convenience*. For the rest of the indicators in group 1, the regression weights are more relevant to *convenience* as they are statistically significant and have higher regression weights than *comfort*.

Other LVs in groups 2 and 3 can also be explained in a similar way and the overall acceptability of these weights was satisfactory. Evidence of an acceptable level was achieved through various goodness-of-fit criteria such as goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), normed fit index (NFI), comparative fit index (CFI) and root-mean-square error of approximation (RMSEA).

Results

Table 5 summarises the estimated results of RPL models. A number of SDVs and LVs were integrated in the models to observe the overall impacts of relevant attributes on traveller mode choice.

The analysis suggests that both models produce similar results when considering SDVs, but when LVs are included the importance of LVs exceeds those of SDVs. For example, findings from both the socio-demographic random parameter logit (SDRPL) model (that includes SDVs only) and the hybrid RPL (HRPL) model (that includes both SDVs and LVs) suggest that 'travel time' had a greater impact on traveller mode choice than 'travel cost'. Also, the effect of 'trip purpose' on mode choice was shown to decrease between SDRPL and HRPL and the same scenario was found for the effects of 'family size', 'full time workers' and 'trip rate'. An interesting outcome was the identified decrease in the effect of 'waiting time' on mode choice in the HRPL model. This finding is consistent with those of the BTS report (BTS, 2012) which suggests a growing uptake of public transport by travellers who appear to place less importance on waiting time. Unlike the SDRPL model, however, the HRPL model identified 'age' as a significant factor in mode choice, particularly in the case of elderly people who generally seek a comfortable or convenient mode of transport. Similarly, the effect of 'car ownership' is higher in the HRPL model which indicates that a car maximises the desired utility that may be induced by LVs rather than SDVs.

The importance of LVs to travellers is clearly observed in the HRPL models. All of them are statistically significant except the variable 'flexibility'. The variables with the highest

Table 5. Modelling results.

Attributes	SDRPL (t-values)	HRPL (t-values)
<i>Random parameter in utility functions</i>		
Travel cost (mean)	-3.14 (-4.15)	-2.09 (-3.00)
Travel cost (st.dev.)	.41 (3.11)	.70 (2.22)
Waiting time (mean)	-1.76 (-3.19)	-1.70 (-4.00)
Waiting time (st.dev.)	.03 (5.00)	.09 (3.94)
Age (mean)	-.111 (-.05)	-.091(-1.60)
Age (st.dev.)	.25 (1.891)	.49 (1.70)
Car ownership (mean)	1.86 (5.11)	1.94 (5.55)
Car ownership (st.dev.)	.01 (4.51)	.05 (3.55)
Having children (mean)	-1.77 (-4.11)	-1.81 (-5.01)
Having child (st.dev.)	.06 (4.00)	.09 (5.19)
Trip purpose (mean)	.071(3.01)	.062 (3.00)
Trip purpose (st.dev.)	.04 (3.12)	.02 (2.72)
Comfort (mean)		3.51 (8.79)
Comfort (st.dev.)		.11 (6.66)
Convenience (mean)		3.25 (5.46)
Convenience (st.dev.)		.02 (4.36)
Safety (mean)		5.51 (10.22)
Safety (st.dev.)		.09 (7.01)
Flexibility (mean)		.72 (.80)
Flexibility (st.dev.)		.03 (1.21)
Reliability (mean)		5.71 (9.01)
Reliability (st.dev.)		.01 (5.15)
Satisfaction (mean)		1.25 (3.00)
Satisfaction (st.dev.)		.10 (3.25)
<i>Non-random parameter in utility functions</i>		
Travel time	-1.20 (-4.10)	-1.13 (-4.64)
Gender	.40 (1.89)	-.214 (-2.01)
Income	1.99 (2.11)	1.46 (1.99)
Family size	.90 (1.12)	.89 (1.00)
Full time workers of HH	.94 (.56)	.93 (.07)
Trip rate	.89 (2.55)	.85 (2.70)
Distance travelled	-.81 (-2.22)	-.26 (-1.90)
<i>Mode constant</i>		
Car as a passenger (base)	0	0
Car as a driver	-2.09 (-3.00)	-2.56 (-10.0)
Train	-2.21 (-4.41)	-2.41 (-4.15)
Bus	-.15 (-4.89)	-.103 (-3.11)
<i>Heterogeneity around the mean</i>		
Travel cost: income	-.129 (-3.51)	-.011 (-4.11)
Waiting time: income	-.48 (-5.01)	-.033 (-4.15)
Age: Income	-.07 (-.98)	-.11 (-1.96)
Car ownership: income	.011 (2.91)	.61 (4.15)
Having child: income	-.1 (-3.16)	-.19 (-4.07)
Purpose: income	.001 (3.01)	.052 (3.11)
Comfort: income		.101 (4.21)
Convenience: income		.112 (3.80)
Safety: income		.51 (10.51)
Flexibility: income		.052 (1.80)
Reliability: income		.35 (9.10)
Satisfaction: income		.089 (4.11)
<i>Model statistics</i>		
Log likelihood function	-696.80	-576.53
McFadden pseudo R-squared	.28	.38
AIC	.0165	.0136
<i>Modal choice probability</i>		
Car as a driver	.720	.770
Car as a passenger	.204	.211
Train	.049	.020
Bus	.053	.033

impact in both years were 'safety' and 'reliability,' followed by 'comfort' and 'convenience.' Overall, the impact of LVs on mode choice was greater than the impact of SDVs.

As usual in model statistics, the values of McFadden pseudo R-squared are inflated from SDRPL which indicates that the HRPL is better for understanding the traveller mode choice heterogeneity. According to Akaike information criterion (AIC), HRPL represents the lower AIC which means that the predicted values using this model are closer to the real values compared to SDRPL model and the lowest AIC values signify the best model. Thus, HRPL models are better than SDRPL models in this case and the HRPL technique is more appropriate for interpreting the relationship between travellers and TfNSW.

An inferred relationship between traveller and TfNSW

According to the results above, some of the attributes (such as travel time and comfort) are influential on the traveller decision-making process and TfNSW is able to adjust or control some of those attributes to meet traveller expectations. An interaction in such a way between service providers and users reflects a relationship indicated in AT. Furthermore, travellers (the principal) provide their satisfactory or unsatisfactory feedback or opinions to TfNSW about the available services which are treated as delegated tasks for TfNSW (agent).

As suggested by the results described in Section 3, travellers demonstrate their expectations for safe, reliable, comfortable and convenient journey considering LVs whereas, according to SDVs, travellers expect reasonable costs, and less travel and waiting time for trips. Although travellers explicitly state their preferences, public transport use is substantially lower than car use which indicates *goal/choice conflict* (also called *moral hazard*). Again, information asymmetry also exists in the traveller and TfNSW relationship. For example, once LVs are included in the model, the SDVs (e.g. waiting time, travel time) become less influential (in terms of coefficients) on the decision made by travellers. Thus, travellers have more information than does the TfNSW about the attributes of their (travellers) utility function and only travellers possess information about the importance that they attach to this utility which contributes to *information asymmetries*.

Transport service should reflect these preferences and used by TfNSW in the public transport service to improve the agency problem. At the same time, most travellers use private cars to enjoy expected trips. In this situation, travellers take the mode – either public transport (e.g. train, bus) or private transport (e.g. car) – that maximises the satisfactory condition or utility. TfNSW has the experiences and skills to provide the satisfactory or expected services but due to internal constraints, such as limited budget, traveller may be provided with unsatisfactory services and an agency problem arises. In the other words, TfNSW wants to reduce the cost of the transport services and seeks to provide maximum utility for the users with the minimum cost. In contrast, travellers expect optimal service (i.e. customer focused) to assure the effective contract and, as a result, expenses for TfNSW may increase eventually. Hence, reducing cost is treated as maximisation of TfNSW's utility and getting optimal/expected service from TfNSW is maximisation of traveller's utility i.e. satisfaction.

Travellers are not in a position to be aware, at a reasonable level, about the implementing phase of mode service undertaken by the TfNSW and this leads to choice conflicts as indicated in AT. Thus, TfNSW may be directly influenced by other related stakeholders such as politicians, administrators, and transport companies, and the traveller's direct participation

Table 6. Forecasting changes in traveller mode choice.

Mode	Base year mode share in %		Predicted changes ^a					
			Scenario 1 (S1)		Scenario 2 (S2)		Scenario 3 (S3)	
	SDRPL	HRPL	SDRPL	HRPL	SDRPL ³	HRPL	SDRPL	HRPL
Car as a driver	72.0	77.0	-.07	.21	-1.00	-.85	-.54	-.32
Car as a passenger	20.4	21.1	.33	.17	.95	.52	.64	.35
Train	4.9	2.0	-.04	.08	-.08	-.01	-.06	.04
Bus	5.3	3.3	-.08	-.04	.51	.48	.22	.22

^aChanges are the differences in the probabilities between changed and unchanged conditions.

in TfNSW's project finalising stage is limited (Anwar, 2013). Therefore, choice conflicts occur and ultimately agency problems arise.

The reason behind choice conflicts has been identified through RPL models. In these models, various choice attributes are analysed and interpreted and the models summarise the dominant attributes (such as travel time, waiting time, comfort, safety) which are eventually travellers' expectations of the service. Based on these expected attributes, the mode choice probability is calculated. In this present research, the probability of private transport use was found to be the highest indicating travellers' dissatisfaction with existing public transport service and an agency problem. Therefore, increasing public transport use may be an option to reduce the agency problem.

A pathway to agency problem improvement in transport services

Travel demand forecasting and policy evaluation methods have not been discussed in the last decade to the same extent as the estimation of hybrid discrete choice models. This forecasting method is used in this paper to investigate how to minimise the agency problem.

According to the specifications of the MIMIC model, change in the explanatory variables should cause changes in the LVs. These changes may have an impact on the MIMIC model as well as on the utility functions in the choice model. Due to the changes in utility function, traveller mode choice probabilities are affected accordingly. The changes in the choice forecasting probabilities may be caused by the variations in explanatory variables related to SDVs. The changes in the explanatory variables s_{ij} and the tangible attributes X_{ijk} may affect the choices implicitly through the LVs or the alternative utilities by which the changes in choice probabilities may be observed.

The changes in traveller choices, which are associated with the overall transport system in a city, are allied with changes in SDVs. Again, the changes in SDVs contribute to construct the psychological (i.e. LVs) mindset of human beings and, eventually, the LVs impact on mode choice to influence the overall structure of trips. Thus, the transport forecasting context is an interrelationship among various observed and unobserved factors related to the transport management system. It is understood that traditional mode choice models (without LVs) are not generally sensitive to policies which affect the transport management system. Policies are associated with the changes to the management system which, in turn, may have an impact on the observed mobility structure of the travellers. Thus, the LVs would be able to capture transport system changes because the explanatory variables are related to demographics as well as the alternatives included in the MIMIC model to

evaluate the traveller motivational process. This is an important measure to be considered when forecasting changes using the estimated models.

On the basis of the empirical case presented in this study, three hypothetical scenarios are tested (i) increase in income by 10% for all respondents (S1); (ii) decrease in travel cost and waiting time by 10% for public transport (S2) and (iii) implementing both (i) and (ii) concurrently (S3). The variation of income affects directly: (i) the LV, as income is an explanatory variable in the MIMIC model and (ii) the utility functions, due to inclusion of it in the utility functions. These scenarios are modelled to observe the increase of public transport use which avoids the agency problem.

Table 6 presents the base year market shares, which are estimated by each model under no-change conditions along with market share changes predicted by the estimated models considering three hypothetical scenarios.

The forecast changes do not have the same direction for all modes. Three scenarios have been considered here to understand the predicting policies. For S1, the variations in the HRPL model have a positive direction for all modes except the bus. According to the SDRPL model under the same scenario, only train use is increased. Increasing income may contribute to increase in the usage of public transport though only bus usage is forecast negatively with a nominal coefficient value in the forecasting model. The reason may be that the people who have adequate income do not like to be exhausted by self-driving and are happy to use public transport. Another example may be brought to mind here: the cost of travel by train to Sydney Airport is very expensive and the cost may motivate people to use their car despite the train being a very convenient way to travel to the airport. Therefore, increasing income may have an influence on the decision to take the train rather than the car. This indicates that increasing an individual's income may prompt the travellers to travel by train. This is an interesting finding to help policy-makers.

As per Scenario 2, the probabilities of train and bus use are increased in both the SDRPL and HRPL models. This implies that reduced travel cost and waiting times are helpful in reducing travel by car. Furthermore, it is observed that the predicted changes to train and bus use probability are the highest in the SDRPL model of S2, compared with other scenarios. When service is frequent enough, people may not perceive waiting as much of a burden (Iseki, Taylor, & Miller, 2006). When people know the service schedule with a high degree of certainty, they can adjust their arrival to a transit facility to reduce waiting time (Evans, 2004; Reed, 1995). By providing on time operation of the transit service, people can reduce waiting time. Due to its readily available schedules and more dependable service, people generally perceive waiting times for commuter trains less burdensome than waiting times for irregular bus services (Evans, 2004). Therefore, reduction in the uncertainty (or increase in reliability) in waiting time is likely to reduce the disutility (or increase the utility) of transit service (Reed, 1995).

In Scenario 3, the SDRPL model shows that probabilities of car use, both as a driver and as a passenger, are reduced while the conditions of S1 and S2 are implemented concurrently. On the other hand, the probability of train usage is higher than the HRPL model as increasing 'individual income' and reduced travel cost and waiting time are included together.

Additionally, as expected, the HRPL model in S1 predicts an increase in private modes of travel due to increasing income as a changed condition, while the other HRPL models in S2 and S3 forecast a decrease in private modes because of inclusion of reduced travel cost and waiting time as a changed condition. This may indicate that the hybrid RPL models

are effectively more sensitive, as expected, but this higher sensitivity does not imply just a simple amplification of the effects involved. Consequently, the importance of including LVs in the choice models is even clearer.

It is understood that increasing income, reducing travel costs and waiting times have the ability to attract travellers to public transport rather than to private modes of transport and results in minimising the *agency problem*. After implementing these hypothetical scenarios, it is found that the probability of private transport use has been reduced to a reasonable level and the probabilities of public transport (train and bus) use have been increased to some extent (Table 6). It confirms that integrating traveller choice preferences in transportation planning helps to improve the traveller and TfNSW relationship by reducing the *agency problem*. Therefore, it can be concluded that traveller-demand oriented changes in relevant attributes can minimise the *agency problem* in the relationship.

Conclusions and policy responses

The contribution of this study is threefold. *Firstly*, it argues the applicability of AT to the provision of transport services; which is a new dimension to present traveller preference in the traveller choice process. *Secondly*, it models the LVs and SDVs separately and concurrently to explore their influences of choice attributes on traveller decisions and by which the relationship between traveller and TfNSW is addressed. *Thirdly*, it demonstrates the mode choice probability analysis as an approach to reduce the agency problem.

The analysis of the traveller-TfNSW relationship is relevant for transport policy formulation. As described, the relationship is addressed by the traveller choice preferences. If the heterogeneity in traveller choice is fully understood, the relevant organisation i.e. TfNSW would be able to provide satisfactory service for the users. Therefore, the nature of the demand and behaviour of travellers should be included in the transport policy for the policy to be worthwhile.

This study finds that the travellers of the SSD are inclined to use private cars rather than use public transport and this indicates TfNSW's dearth of awareness about travellers' utility functions and choices. To avoid the agency problem, policy responses should pay more attention to the traveller utility functions. It is well validated by this research that transport policy-makers should recognise traveller utility functions at the policy formulation level. As well, this study clarifies the nature of traveller preference attributes, which form the traveller utility function, in the relationship between traveller and TfNSW. The study identifies the attributes of the traveller-TfNSW relationship that are most important to travellers. Thus, the attributes that are most important to travellers should influence policy finalisation.

Furthermore, the behavioural findings and modelling techniques have direct policy and planning interventions in future transport management. *Firstly*, as LVs are found as significantly important in travel behaviour, ignoring them in the planning process could result in serious errors in public transport management. Therefore, to achieve the set objectives fixed by TfNSW and transport planners systematic attention to LVs is required in transportation planning and policies. *Secondly*, integrating the LVs in the relationship between travellers and TfNSW reduces the *agency problem* because of the understanding that comes from more realistic descriptions of travellers' decision-making.

In order to minimise the agency problem, reducing some SDVs such as travel cost and waiting time has a significant effect on switching private transport use to public transport

use. This type of SDVs constitutes the LVs and, eventually, LVs lead to traveller behaviour changes. It is also observed that increasing income works to reduce private car use. This research evaluated three hypothetical scenarios, which could be helpful in reducing the agency problem in the relationship between travellers and TfNSW. It was found that in the hypothetical scenarios the probability of car use was decreased and this is the key motivation to minimise the agency problem in the relationship. However, the response of the TfNSW towards travellers' desires is highly complex because people of different socio-economic backgrounds have different expectations. This paper simplifies the response mechanism by examining ways to decrease the agency problem that helps transport policy-makers to incorporate the findings of this study into future policies.

Note

1. The authors employed econometric methods similar to those that have been used by Anwar et al. (2014).

Disclosure statement

No potential conflict of interest was reported by the author.

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