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Exploring agency relationship in transport service sector by analysing traveller choice behaviour

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Keywords

choice, traveller, analysing, behaviour, sector, exploring, service, transport, relationship, agency

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Abstract

Examining travellers' preferences for mode choices to understand a relationship between *traveller* and *transport for New South Wales (TfNSW)* from the perspective of agency theory (AT) is the main focus of this paper. This paper emphasises on latent and traditional objective attributes to assess the mode choice process within the agency relationship as indicated in AT as a method by which the utility of the principal (traveller) can be maximised. It is found that the probability of car use is significantly higher than public transport due to mismatch between traveller expectations and present transport services and it indicates an existence of agency problem in this services. Finally, some arguments have been identified to minimise this problem. Thus, the contribution of this research is three-fold: *firstly*, the application of agency theory's utility and implications in traveller choice behaviour; *secondly*, the demonstration of scale to which attributes influence traveller mode choice to shape the agency relationship within transport mode services; and *finally*, a pathway for the improvement of agency relationship in transport mode services.

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1. Introduction

This paper interprets traveller choice behaviour and transport services in a different perspective using agency theory (AT) which is a novel idea in transportation research. The additional insight of this perspective is developing models to understand the expectation of service users (i.e. principal) and how Transport for New South Wales (TfNSW) can be effectively monitored by the service users too. Design of the model is aimed at identifying an optimal level of indirect monitoring by the traveller, which will maximise user utility to guide agent's performance. Whether TfNSW performs effectively on the interest of travellers it can understand how it should achieve sustainable transport management. Thus, the finding of this study contributes to the AT debate, in essence that the TfNSW will improve the performance to avoid possible conflict of traveller interests and eventually to minimise the agency uncertainty.

AT, also known as the principal-agent or principal agency theory/model describes the relationship between two or more parties, in which one party is designated as *principal* that assigns another party, called *agent* to perform some tasks on behalf of the principal (Jensen and Meckling, 1976; Moe, 1984; Ross, 1973). AT assumes that agents have more information than principal (Grammenos and Papapostolou, 2012) which is known as *informational asymmetries* that adversely affects the principal's ability to monitor agent's activities. Moreover, an assumption of AT is that principals and agents should act rationally and try to maximise their interests. Since principals do not have access to a decision that is made by an agent, they are unable to control or motivate whether the agent's actions are in the best interest of the principal called *adverse selection*.

Several researchers (such as Thompson and McKee, 2011; Zu and Kaynak, 2012; Rasmussen and Gulbrandsen, 2012; Sarens and Abdolmohammadi, 2011; Zsidisin and Ellram, 2003; and Whipple and Roh (2010) have applied the knowledge of AT in their respective fields, but the application of this theory in transport service sector is still left aside. The application of AT in transport service research is not well understood by the previous researchers and therefore, this theory has not been used before. The current study, then, takes an attempt to fill in this gap. Rarely in transportation arena, AT investigates the relationship between government and service operator (Hensher et al., 2007) but they ignored the travellers' preferences, which influence government's decision making process significantly, in their study.

The role of TfNSW (agent) is to maximise the utility (i.e. traveller preferences) of the traveller (principal) within available resources. To understand the utility function of travellers in mode choice, TfNSW should have information about the nature of traveller's desires and expectations. Thus, a metaphoric relationship is understood in between *traveller* and *TfNSW* as a principal and an agent as indicated in AT. In view of this relationship, the need to maximisation of travellers' utility within the limited budget is, therefore, important to examine travellers' preferences for various attributes of the modal choice. Travellers may not trust the quality of services performed by the TfNSW, because of its tendency to focus on its internal goals as opposed to more direct measures of the principals' goals.

Focusing internal goals may be realised due to lack of better understanding of travel decision making attributes such as latent and socioeconomic variables. Limited budget could also be another issue to characterise mistrust agent. Thus, this research contributes to this unaddressed understanding of travel choice behaviour in exploring the relationship between traveller and TfNSW.

This paper is organised as follows. Section 1 introduces the subject matter of this paper with understanding a relationship between traveller and TMA. Section 2 gives a conceptual description of the relationship and hypotheses involved. Section 3 provides the data sources and methods employed in this paper. In section 4, the empirical results have been stated and discussions on inferred relationship are accommodated in section 5. Finally section 6 offers guidelines on the improvement of agency problem and conclusions.

2. Agency and Traveller-TfNSW Relationship

Due to the agency problem[1], the concept of *perfect* and *imperfect* agent has become apparent. If the agent executes entrusted tasks *perfectly* to what the principal wants, it is called a *perfect agent* that is quite difficult to achieve in the real world and therefore, the concept of *imperfect agent* has emerged. However, Scott and Vick (1999) defines 'perfect' agent as follows:

> *…one who makes the same decisions that the principal would have made if the principal possessed the same information and expertise as the agent. (p.113)*

According to this definition, TfNSW may not be a perfect agent since travellers do not possess the same and necessary information and knowledge as TfNSW, and also services (tasks) expected by travellers are not performed perfectly by TfNSW. Rather, it is more useful to understand the possible sources of imperfect agency with the effects of attributes on the decision made by travellers. The **first** of these is to what extent TfNSW acts in travellers' best interests. Imperfect agency may arise if the TfNSW has an incorrect perception about the travellers' utility function.

There are **two aspects** to this misperception. The **first** is that travellers have more information than the TfNSW about the arguments in their utility function. The **second** is that only travellers possess information about the importance that they attach to these arguments. Imperfect agency arises where there is a difference between the perception of TfNSW about the travellers' utility function, and the importance attached to its arguments by travellers themselves.

The **second** main source of imperfect agency is informational asymmetries between the traveller and TfNSW. TfNSW has more information and experience about the process of designing and implementing a transport system and its effects on mobility.

Hence, *traveller choice is an* important issue here. *Choice* of traveller describes preference which is connected to goal conflicts in AT. *Choice* is clearly seen as important in assessing the effectiveness of the agency relationship between traveller and TfNSW.

Considering the above discussion, two hypotheses can be stated to understand the traveller- TfNSW relationship as below:

Hypothesis 1 (H_1): *Where there is a high use of public transport, the TfNSW is performing the entrusted tasks as per travellers' demand, which indicates an improvement in agency uncertainty;*

[1] The agency problem may arise when an agent pursues self-interested goals at the expense of the principal's goals (Kivisto, 2008).

Hypothesis 2 (H_2): *Where there is a high use of private transport, it is likely that the TfNSW is acting largely in its own self-interest, and the agency problem remains unresolved.*

3. Data and Methods

3.1 Data source

The key data source of this research was cross-sectional 2010/11 household travel survey (HTS) data. This was the largest and most comprehensive household travel survey of Sydney conducted by the Bureau of Transport Statistics (BTS) of TfNSW. BTS conducted a household questionnaire survey. This survey includes Sydney, Newcastle and Illawarra areas and collected four types of data: household data, person data, trip data and linked trip data. For this particular study, only 'Sydney' and 'person data' have been taken into consideration for data 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 that was released in 2012. This collection method ensured high data quality and maximised response rates too. Each respondent was requested to maintain a simple travel diary to record the details of all trips undertaken for their nominated 24-hour period. An interviewer then interviewed each respondent to collect the details of each trip. Detailed socio-demographic information was also collected through this survey.

Descriptions of data used in this study

Six latent variables (LV) and 13 traditional objective attributes (TOA) are evaluated to determine the impact on travellers' mode choice to understand traveller-TfNSW relationship.

LVs are:

(i) Comfort,
(ii) Convenience,
(iii) Safety,
(iv) Flexibility,
(v) Reliability, and
(vi) Satisfaction

Thirteen TOAs are:

(i) income (in Australian dollar),
(ii) age (in years),
(iii) gender (1 if male, 0 otherwise),
(iv) having children (0-14 years),
(v) car ownership,
(vi) family size,
(vii) full time workers of household,
(viii) travel time (in minutes),
(ix) travel cost (in Australian dollar),
(x) waiting time (in minutes),
(xi) trip rate (trip per person per day),
(xii) trip purpose (1 if work, 0 otherwise), and
(xiii) distance travelled (in kilometre).

To explain the LVs, twenty indicators (Table 1) were identified.

Table 1. Description of LVs

Latent factors	Explained by (indicators)	Definitions
Comfort	- Enjoy time to read/relax on vehicle	Importance with 1, otherwise 0
	- Stressfulness on vehicle	Importance with 1, otherwise 0
	- Service slower	Importance with 1, otherwise 0
Convenience	- Mode availability	Importance with 1, otherwise 0
	- Accessibility (does not go where required)	Importance with 1, otherwise 0
	- Timetable availability	Importance with 1, otherwise 0
Safety	- Safety response for mode used in 1st trip	Importance with 1, otherwise 0
	- Safety response for mode used in 2nd trip	Importance with 1, otherwise 0
	- Safety response for mode used in 3rd trip	Importance with 1, otherwise 0
Flexibility	- Fixed start and finish times – each day can vary	Importance with 1, otherwise 0
	- Rotating shift	Importance with 1, otherwise 0
	- Roster shift	Importance with 1, otherwise 0
	- Variable hours	Importance with 1, otherwise 0
Reliability	- Frequency	Importance with 1, otherwise 0
	- Punctuality	Importance with 1, otherwise 0
	- Faster	Importance with 1, otherwise 0
Satisfaction	- Cleanliness	Importance with 1, otherwise 0
	- Travel time	Travel time in minutes
	- Travel cost	Travel cost in Australian dollar
	- Waiting time	Waiting time in minutes

Reliability of all the indicators listed in Table 1 was tested using factor analytic models (exploratory and confirmatory factor model) with the model fit criteria according to GFI, AGFI, NFI, CFI and RMSEA with lower and upper bound. The factor analytic model focuses solely on how, and the extent to which, the observed variables are linked to their underlying latent factors (Byrne, 2010). However, due to the space reason findings of factor analytic models are not presented in this paper. For further details about the findings of factor analytic models, please see Anwar, 2014.

3.2 Methods[2]

To achieve the objectives of this paper, it focuses on both LVs and TOAs during the mode choice process within the agency relationship. A traditional random parameter logit (TRPL) model is also compared with a hybrid RPL (HRPL) model in this paper. For the later model, a two-step approach (also known as sequential approach) is implemented to incorporate LVs in choice models. 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.

Modelling with latent variables

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

[2] Authors have also used similar methods in other papers (Anwar et.al, 2014)

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

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

where, *i* to an individual, *j* refers to an alternative, , *l* to a LVs, *r* to an explanatory variables belong to TOAs and *p* to an indicator; α_{jlr} and γ_{jlp} are parameters to be estimated, while ν_{ijl} and ζ_{ijp} are error terms with mean zero and standard deviation to be estimated.

Specification of latent variable model

Six LVs and 13 TOAs are considered in this study. The structural relationship in MIMIC model guides the specification for computation of LVs (Figure 1 illustrates the results of this process), which results in the following set of equations:

$$\textbf{Comfort}_{ij} = \alpha_{inc\text{-}com,j}*Income_i + \alpha_{tco\text{-}com,j}*Travel\ cost_i + \alpha_{wti\text{-}com,j}*waiting\ time_i + \alpha_{car\text{-}com,j}*Car\ ownership_i + \alpha_{dt\text{-}com,j}*Distance\ travelled_i + \alpha_{chi\text{-}com,j}*Having\ children_i + \nu_{com,ij}$$

$$\textbf{Convenience}_{ij} = \alpha_{age\text{-}conv,j}*Age_i + \alpha_{gen\text{-}conv,j}*Gender_i + \alpha_{car\text{-}conv,j}*Car\ ownership_i + \alpha_{wti\text{-}conv,j}*Waiting\ time_i + \alpha_{tti\text{-}conv,j}*Travel\ time_i + \alpha_{chi\text{-}conv,j}*Having\ children_i + \alpha_{inc\text{-}conv,j}*Income_i + \alpha_{tp\text{-}conv,j}*Trip\ purpopse_i + \alpha_{tr\text{-}conv,j}*Trip\ rate_i + \alpha_{dt\text{-}conv,j}*Distance\ travelled_i + \alpha_{tco\text{-}conv,j}*Travel\ cost_i + \nu_{conv,ij}$$

$$\textbf{Safety}_{ij} = \alpha_{age\text{-}saf,j}*Age_i + \alpha_{tr\text{-}saf,j}*Trip\ rate_i + \alpha_{car\text{-}saf,j}*Car\ ownership_i + \alpha_{dt\text{-}saf,j}*Distance\ travelled_i + \alpha_{chi\text{-}saf,j}*Having\ children_i + \alpha_{wti\text{-}saf,j}*waiting\ time_i + \nu_{saf,ij}$$

$$\textbf{Flexibility}_{ij} = \alpha_{gen\text{-}fle,j}*Gender_i + \alpha_{chi\text{-}fle,j}*Having\ children_i + \alpha_{car\text{-}fle,j}*Car\ ownership_i + \alpha_{tp\text{-}fle,j}*Trip\ purpopse_i + \alpha_{tp\text{-}fle,j}*Trip\ purpopse_i + \nu_{fle,ij}$$

$$\textbf{Reliability}_{ij} = \alpha_{tti\text{-}rel,j}*Travel\ time_i + \alpha_{wti\text{-}rel,j}*Waiting\ time_i + \alpha_{ft\text{-}rel,j}*Full\ time\ workers_i + \alpha_{car\text{-}rel,j}*Car\ ownership_i + \alpha_{dt\text{-}rel,j}*Distance\ travelled_i + \nu_{rel,ij}$$

$$\textbf{Satisfaction}_{ij} = \alpha_{tti\text{-}sat,j}*Travel\ time_i + \alpha_{tco\text{-}sat,j}*Travel\ cost_i + \alpha_{wti\text{-}sat,j}*Waiting\ time_i + \alpha_{car\text{-}sat,j}*Car\ ownership_i + \alpha_{age\text{-}sat,j}*Age_i + \nu_{sat,ij}$$

$y_{y1,ij} = \gamma_{y1,j} * Comfort_{ij} + \zeta_{y1,ij}$
$y_{y2,ij} = \gamma_{y2,j} * Comfort_{ij} + \zeta_{y2,ij}$
$y_{y3,ij} = \gamma_{y3,j} * Comfort_{ij} + \zeta_{y3,iq}$
$y_{y4,ij} = \gamma_{y4,j} * Convenience_{ij} + \zeta_{y4,ij}$
$y_{y5,ij} = \gamma_{y5,j} * Convenience_{ij} + \zeta_{y5,ij}$
$y_{y6,ij} = \gamma_{y6,j} * Convenience_{ij} + \zeta_{y6,ij}$
$y_{y7ij} = \gamma_{y7,j} * Safety_{ij} + \zeta_{y7,ij}$
$y_{y8,iq} = \gamma_{y8,j} * Safety_{ij} + \zeta_{y8,ij}$
$y_{y9,ij} = \gamma_{y9,j} * Safety_{ij} + \zeta_{y9,ij}$
$y_{y10,ij} = \gamma_{y10,j} * Flexibility_{ij} + \zeta_{y10,ij}$
$y_{y11,ij} = \gamma_{y11,j} * Flexibility_{ij} + \zeta_{y11,ij}$
$y_{y12,ij} = \gamma_{y12,j} * Flexibility_{ij} + \zeta_{y12,ij}$
$y_{y13,ij} = \gamma_{y13,j} * Flexibility_{ij} + \zeta_{y13,ij}$
$y_{y14,ij} = \gamma_{y14,j} * Reliability_{ij} + \zeta_{y14,ij}$
$y_{y15,ij} = \gamma_{y15,j} * Reliability_{ij} + \zeta_{y15,ij}$
$y_{y16,ij} = \gamma_{y16,j} * Reliability_{ij} + \zeta_{y16,ij}$
$y_{y17,ij} = \gamma_{y17,j} * Satisfaction_{ij} + \zeta_{y17,ij}$
$y_{y18,ij} = \gamma_{y18,j} * Satisfaction_{ij} + \zeta_{y18,ij}$
$y_{y19,ij} = \gamma_{y19,j} * Satisfaction_{ij} + \zeta_{y19,ij}$
$y_{y20,ij} = \gamma_{y20,j} * Satisfaction_{ij} + \zeta_{y20,ij}$

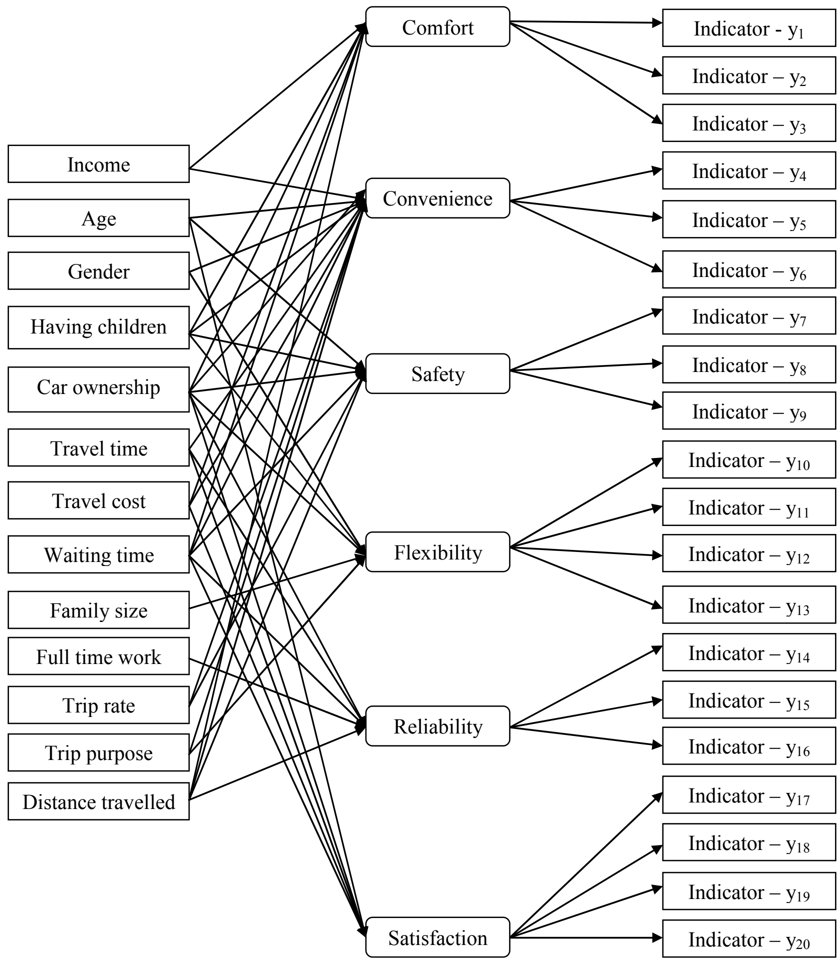

Figure 1 Process of structural and measurement relationship
(Adapted from Anwar *et al.* 2014)

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 utility (V_{ij}) function, therefore, an error term (ε_{ij}) to each alternative (Ortúzar and Willumsen, 2001) is required to be included in the function as stochastic component. Mathematically the utility function becomes as below:

$$U_{ij} = V_{ij} + \varepsilon_{ij}, \qquad (3)$$

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

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

$$V_{ij} = \Sigma_k \theta_{jk} * X_{ijk} + \Sigma_l \beta_{jl} * \eta_{ijl} \qquad (4)$$

Only the alternative j is chosen, if the utility of alternative, 'j', is greater than or equal to the utility of all other alternatives[3],'t', in the choice set, C. This can be expressed mathematically with binary variables d_{ij}:

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

As sequential approach is used in this study, discrete choice model is estimated with MIMIC model's structure (Eq.1) and measurement (Eq.2) equations (Ben-Akiva et al., 2002).

Specification of random parameter logit (RPL) model

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

The systematic component of utility V_{ij} can be rewritten as $x_{ij}\beta_j$, where x_{ij} is a vector of explanatory variables that are observed by the analyst from any source related to individuals and alternatives. β_j is a vector of parameters to be estimated. The stochastic component of utility ε_{ij} can also be rewritten as $z_{ij}\eta_i + e_{ij}$, where z_{ij} is a vector of characteristics that can vary over individuals, alternatives, or both (there may have some or all common elements in both z_{ij} and x_{ij}), and e_{ij} is a random term with zero mean that is IID (independent and identically distributed) over individuals and alternatives and is normalised to set the scale of utility. The random variable η_i is a vector of random terms with zero mean that varies over individuals according to the distribution $f(\eta \mid \Omega)$, where Ω are the fixed parameters of the distribution f. Accordingly, the utility U_{ij} that individual i gets from alternative j can be written as $[x_{ij}\beta_j + (z_{ij}\eta_i + e_{ij})]$. In matrix form, it can be written as:

$$U = X\beta + (Z\eta + e) \quad (6)$$

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

To derive a RPL model from Eq. (6), e is assumed as IID extreme value, while η follows a general distribution, $f(\eta \mid \Omega)$. If $\eta = 0$, 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 η and the probability to select alternative j for individual i with conditional on η is similar as MNL below:

$$P(j|\eta) = Lj(\eta) = \frac{e^{X_j\beta_j + Z_j\eta}}{\sum_{k\in J} e^{X_k\beta_k + Z_k\eta}} \quad (7)$$

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

[3] All t includes alternative j

$$P(j)=\int_{\eta}\left[\frac{e^{X_j\beta_j+Z_j\eta}}{\sum_{k\in J}e^{X_k\beta_k+Z_k\eta}}\right]f(\eta|\Omega)\partial\eta \qquad (8)$$

$$i.e \quad P(j)=\int_{\eta}Lj(\eta)f(\eta|\Omega)\partial\eta \qquad (9)$$

Models of this form are called *random parameter logit (RPL)*. The probabilities do not exhibit the IIA property, and the specification of *f* describes different substitution patterns. The RPL model handles it in two ways. *One* way is known as random parameter specification that specifies each β_i with both a mean and a standard deviation. The error component is another way to deal with the unobserved taste variation as a separate error component in the random parameter that is by estimated with standard deviation as an additional error component which is an identical outcome.

4. Empirical Results

Due to space reason in this paper, only the results of α vector matrix in structural equation of MIMIC model are presented here (Table 2). The estimated coefficients were valid according to model fit criteria such as GFI, AGI, NFI, CFA and RMSEA with lower and upper bound that were calculated by AMOS v.19. The results obtained from MIMIC model have been used to quantify latent variables that are incorporated in discrete models (Table 3) as explanatory variables. The models were estimated with Nlogit v.4 econometric software, using maximum likelihood estimation procedures.

Table 3 presents the results obtained from RPL models. The models discuss effects of choice attributes both traditional and latent on transport mode. The TRPL model includes only the traditional attributes and HRPL model incorporates both latent and traditional attributes.

Table 2. MIMIC model results using 2010/11 HTS data: α vector matrix of structural equations (t-values in the parenthesis)

LVs	Travel time	Travel cost	Waiting time	Age	Income	Family size	Gender	Car ownership	No. child	Full time	Trip rate	Distance travelled	Trip purpose
Comfort	-0.045 (-3.16)	-0.212 (-3.86)	-0.165 (-5.71)	-0.011 (-2.91)	0.121 (2.87)	-0.002 (-3.01)	0.061 (4.1)	0.301 (6.12)	0.202 (3.89)	0.006 (2.01)	0.038 (2.21)	0.123 (3.81)	0.021 (1.90)
Convenience	-0.211 (-7.27)	-0.102 (-1.71)	-0.216 (-5.13)	-0..125 (-2.21)	0.156 (2.53)	-0.002 (-2.76)	0.126 (2.63)	0.275 (5.48)	0.189 (4.51)	0.002 (1.67)	0.117 (2.51)	0.11 (2.63)	0.131 (2.01)
Flexibility	-0.092 (-3.47)	-0.003 (-1.99)	-0.066 (-1.89)	-0.088 (-3.41)	0.031 (1.90)	0.022 (3.01)	-0.102 (-2.13)	-0.117 (-5.15)	-0.131 (-5.31)	-0.007 (-2.85)	0.001 (2.13)	0.013 (4.11)	0.126 (4.20)
Safety	-0.091 (-4.22)	-0.012 (-3.04)	-0.132 (-3.91)	-0.21 (-4.67)	-0.088 (-2.89)	0.005 (3.64)	-0.098 (-4.12)	-0.219 (-7.72)	-0.166 (-6.61)	-0.008 (-2.44)	0.112 (3.01)	0.171 (3.69)	0.041 (2.58)
Reliability	-0.514 (-6.21)	-0.011 -2.01	-0.107 (-6.11)	-0.042 (-1.89)	0.031 (2.12)	-0.005 (-2.11)	0.012 (3.07)	0.414 (4.56)	0.003 (4.11)	0.007 (2.12)	0.016 (3.19)	0.112 (3.12)	0.009 (2.51)
Satisfaction	-0.192 (-3.91)	-0.166 (-6.21)	-0.121 (-3.71)	-0.142 (-5.11)	0.032 (3.90)	-0.008 (-2.12)	-0.087 (-3.21)	0.139 (5.11)	0.092 (6.15)	0.007 (5.16)	0.097 (6.91)	0.062 (5.33)	0.068 (3.01)
Model fit criteria													
GFI	0.963												
AGFI	0.945												
NFI	0.901												
CFI	0.950												
RMSEA	0.033												
Lower bound	0.013 (90% CI of RMSEA)												
upper bound	0.048 (90% CI of RMSEA)												

Source: Anwar et al., 2014

Table 3. Results of random parameter logit models**.**

Attributes	RPL(t-values)	HRPL(t-values)
Random parameter in utility functions		
Travel cost (mean)	-3.14 (-4.15)	-2.09 (-3.00)
Travel cost (st.dev.)	0.41 (3.11)	0.70 (2.22)
Waiting time (mean)	-1.76 (-3.19)	-1.70 (-4.00)
Waiting time (st.dev.)	0.03 (5.00)	0.09 (3.94)
Age (mean)	-0.111 (-0.05)	-0.091(-1.60)
Age (st.dev.)	0.25 (1.891)	0.49 (1.70)
Car ownership (mean)	1.86 (5.11)	1.94 (5.55)
Car ownership (st.dev.)	0.01 (4.51)	0.05 (3.55)
Having children (mean)	-1.77 (-4.11)	-1.81 (-5.01)
Having child (st.dev.)	0.06 (4.00)	0.09 (5.19)
Trip purpose (mean)	0.071 (3.01)	0.062 (3.00)
Trip purpose (st.dev.)	0.04 (3.12)	0.02 2.72)
Comfort (mean)		3.51 (8.79)
Comfort (st.dev.)		0.11 (6.66)
Convenience (mean)		3.25 (5.46)
Convenience (st.dev.)		0.02 (4.36)
Safety (mean)		5.51 (10.22)
Safety (st.dev.)		0.09 (7.01)
Flexibility (mean)		0.72 (0.80)
Flexibility (st.dev.)		0.03 (1.21)
Reliability (mean)		5.71 (9.01)
Reliability (st.dev.)		0.01 (5.15)
Satisfaction (mean)		1.25 (3.00)
Satisfaction (st.dev.)		0.10 (3.25)
Nonrandom parameter in utility functions		
Travel time	-1.20 (-4.10)	-1.13 (-4.64)
Gender	0.40 (1.89)	-0.214 (2.01)
Income	1.99 (2.11)	1.46 (1.99)
Family size	0.90 (1.12)	0.89 (1.00)
Full time workers of HH	0.94 (0.56)	0.93 (0.07)
Trip rate	0.89 (2.55)	0.85 (2.70)
Distance travelled	-0.81 (-2.22)	-0.26 (-1.90)
Mode constant		
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	-0.15 (-4.89)	-0.103 (-3.11)
Heterogeneity around the mean		
Travel cost :Income	-0.129 (-3.51)	-0.011 (-4.11)
Waiting time :Income	-0.48 (-5.01)	-0.033 (-4.15)
Age: Income	-0.07 (-0.98)	-0.11 (-1.96)
Car ownership: Income	0.011 (2.91)	0.61 (4.15)
Having child: income	-0.1 (-3.16)	-0.19 (-4.07)
Purpose: Income	0.001 (3.01)	0.052 (3.11)
Comfort: Income		0.101 (4.21)

Convenience: Income		0.112 (3.80)
Safety: Income		0.51 (10.51)
Flexibility: Income		0.052 (1.80)
Reliability: Income		0.35 (9.10)
Satisfaction: Income		0.089 (4.11)
Model statistics		
Log likelihood function	-696.80	-576.53
McFadden Pseudo R-squared	0.28	0.38
Akaike Information Criterion (AIC)	0.0165	0.0136
Modal choice probability		
Car as a driver	0.720	0.770
Car as a passenger	0.049	0.020
Train	0.204	0.211
Bus	0.053	0.033

HRPL model has the similar specification of model TRPL, but the effect of LV is allowed to vary among individuals; and also models introduce an interaction between the mean estimate of the random parameter and a covariate, which is equivalent to revealing the presence or absence of heterogeneity around the mean parameter estimate. In the TRPL models, all variables except age, family size, full time workers of household, and gender are significantly associated with the choice of travel mode. The HRPL model provides a better representation of the nature of preferences, as it accounts for variation in travellers' preference heterogeneity across socioeconomic and other characteristics.

In particular, the parameters of LVs are statistically significant in hybrid RPL model. Moreover, the high significance of the LVs standard deviation parameters in hybrid RPL model implies that the effects of the LVs over the choice process effectively and importantly vary across individuals. It is also noticed that the signs of the estimated parameters are coherent. With respect to mode-related and individual-specific attributes, the car ownership per adult in household exhibit strong effects on travel mode choice (Bresson et al., 2004). As expected, owning car per adult in a household increases the propensity to use a car as a driver or train (park and ride) for daily trips to work. In contrast, none of the socioeconomic and trip variables age, family size, full time workers of household, and gender significantly impacted mode choice.

The estimated coefficients suggest that the most important attribute is "travel cost", followed by "waiting time" "car ownership", "having child", and "travel time" according to TRPL models. The estimated coefficients on the waiting time, travel cost and travel time variables have the expected negative signs since the utility of a mode decrease as the mode becomes high waiting time and/or slower and/or more expensive and are considered as disutility. The expected negative signs of these three variables, in turn, imply that this reduces the choice probability of the corresponding mode. Having child variable has negative sign that indicates the sensitivity over the choice. The positive sign of coefficient of car ownership indicates that respondents were more likely to choose (and prefer) car to make trip. From this it can be inferred that the lesser importance given by TfNSW on modal services generates lower utility on the services and therefore, people still desire to use their car.

Having child also influences preferences for comfortable, safe and reliable mode of transport. While LVs are incorporated in the model, significance level of objective variables has been decreased and it implies that travellers are more motivated by their latent preferences during the mode choice process. Thus, TfNSW is obliged to promote the modal services as per as travellers' expectations.

By incorporating the LVs in the hybrid RPL model, the results have been turned into more rational. Effects ofLVs show that travellers prefer "safer" and more "reliable" mode of transport to less safer and less reliable modal service. The coefficients of these two variable are high that indicate its dominant influence over the mode choice process. Importance of a convenient and comfortable mode of transport is also adequately observed. These are all as expected, confirming the theoretical validity. However, the introduction of HRPL allows us not only to improve model fit, but also to achieve better estimates of the parameters.

As per model statistics, the values of McFadden Pseudo R-squared are inflated from TRPL to HRPL which indicates that HRPL model is better. The lowest AIC values also signify the best model and thus HRPL models are better than TRPL models in this case.

5. An Inferential Relationship: Perspective of Agency and Transport Mode Services

In general, travellers take either public transport (e.g. train, bus) or private transport (e.g. car) that maximises their level of satisfaction or 'utility'. TfNSW provides public transport and travellers own their private cars. Travellers expect *reliable*, *safe* and *comfortable* public transport, and entrust this task to TfNSW to perform. TfNSW applies its experiences and skills to execute this task as per travellers' expectations. A higher probability of public transport usage would indicate better performance by TfNSW. It would imply that the travellers are getting their desirable mode of transport, similar to what they get from their own car, which is an indication of low agency problem in transport mode services. In contrast, a high probability of car usage would indicate the presence of high level of agency problem.

In terms of the adverse selection in AT, travellers are not in a position to be aware, at a reasonable level, about the implementing phase of mode service project undertaken by TfNSW, and do not have the access to monitor it. Thus, TfNSW may be influenced by other related stakeholders such as political, civil servants, transport companies and traveller's access is limited to TfNSW's project finalising stage (Anwar, 2014). Therefore, *goal/choice conflicts/adverse selection* may occur.

Generally, choice processes of travellers are dominated by TOAs, such as travel time, travel cost, income. According to analysis in section 4, LVs contribute significantly to the determination of utility. The effects of choice attributes and the probability of using a particular mode are crucial aspects of understanding the principal-agent relationship in mode of transport service. LVs (e.g. comfort, convenience, safety, reliability) dominate the choice process considerably in addition to TOAs. TfNSW is not fully aware about the traveller utility function and tends to ignore the LVs, which cause goal/choice conflicts and adverse selection.

In terms of mode choice probability, the decreasing rate of probability for the mode "car as a passenger" (Table 3) indicates that the travellers are not comfortable with being a passenger on a car once the travellers consider the latent and other relevant attributes. The probability of car usage as a driver is notably high which means that travellers (principal) are not provided with the services they desire and have entrusted to TfNSW for execution. Basically, TfNSW struggles to reduce the transport problems of cities such as 'unreliable' 'no direct route' and 'congestion' that travellers expect. However, since TfNSW is not reasonably able to perform according to travellers' expectations, travellers continue to use the private car. It indicates an agency problem in transport mode services.

6. Conclusions: Solutions to Agency Problem

The efficient and customer–focused performance may occur if TfNSW offers a higher expected utility for public transportation service to car use. Travellers may stop using public transport if TfNSW is less responsive to customers' dissatisfaction. It is assumed that TfNSW does not worsen the conditions for private transport users, the switching of travellers to public transport can occur only by increasing the expected utility of using public transportation services without reducing expected utility for private car.

According to the findings of this paper, it was found that the probability of traveller transport mode choice is dominantly higher for private car use than public transport, which suggests that an agency problem exists in transport mode service. To reduce the agency problem, TfNSW should integrate traveller preferences, which are identified in this research as prominent critical aspects, in planning and implementing stages of transport mode related projects. The results are also very useful for policy makers in shaping effective policies.

As it was found that LVs are mostly dominant in traveller mode choice process, it should be adequately reflected in the current policy responses. Since the probability of using a private car is dominantly high, it indicates that public transport is not efficiently successful to attract travellers. In this case TfNSW should incorporate the traveller latent choice preferences in mode service and public transport use may be increased. Importantly, the strength of this paper is the clarification of the nature of traveller preference heterogeneity, both observed and unobserved, in the process of mode choice as a principal-agent relationship in transport mode services. It can assist the transport planners or departments such as TfNSW to formulate effective and worthwhile policies to improve the transport system and to rectify the agency problem in the services finally.

TfNSW's goal is to improve traveller's welfare and thus high frequency usage of public transportation should be targeted. By looking at the results describe in Table 3, priorities for managerial actions are highlighted below. Base of the estimated coefficients of relevant parameters, the followings quality areas are critical for the agent (TfNSW) to make improvements of the situation:

<u>Among LVs</u>

- Safety;
- Reliability;

<u>Among TOAs</u>

- Travel cost;
- Travel time;

- Comfort; and
- Convenience.
- Waiting time; and
- Car ownership.

The analysis described in section 4 indicates that these traveller choice attributes are found important and TfNSW has not satisfactorily succeeded in meeting these needs since the percentage of public transport use is remarkably low. TfNSW should attempt to increase its ability to meet these needs that helps to improve the agency problem in transport mode services.

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References

Anwar, A.H.M.M. (2014). Integrating traveller preference heterogeneity in transportation planning from the perspective of principal-agent theory. *PhD thesis*. University of Wollongong, Australia.

Anwar, A.H.M.M., Tieu, K., Gibson, P., Berryman, M., Win, K.T. (2014). Analysing the heterogeneity of traveller mode choice preference using a random parameter logit model from the perspective of principal-agent theory. *International Journal of Logistics Systems and management,* 17(4), 447-471.

Anwar, A.H.M.M., Tieu, K., Gibson, P., Berryman, M., Win, K.T. (2013). Analysing the merit of latent variables over traditional objective attributes for traveller mode choice using RPL model. In *Proceedings of the 3rd International Choice Modelling Conference*, online, July 3-5, Sydney.

Ben-Akiva, M.E., Walker, J.L., Bernardino, A.T., Gopinath, D.A., Morikawa, T., Polydoropoulou, A. (2002). Integration of choice and latent variable models. In H.S.Mahmassani (Ed.), *Perpetual Motion: Travel Behaviour Research Opportunities and Challenges*, Pergamon: Amsterdam.

Bresson G., Dargay J., Madre J.L., Pirotte A. (2004). Economic and structural determinants of the demand for public transport: an analysis on a panel of French urban areas using shrinkage estimators. *Transportation Research Part A: Policy and Practice*, 38(4), 269–285.

Byrne B.M. (eds) (2010). *Structural equation modeling with AMOS: Basic concepts, applications, and programming*. Routledge.

Grammenos, C.Th. & Papapostolou, N.C. (2012). US shipping initial public offerings: do prospectus and market information matter? *Transportation Research Part E: Logistics and Transportation Review*, 48(1), 276-295.

Hensher D.A., Yvrande-Billon A., Macário R., Preston J., White P., Tyson B., Van de Velde D.M., Wee B.V., de Aragão J.J.G., dos Santos E.M., Filho R.D.O., Hensher D. (2007). Delivering value for money to government through efficient and effective public transit service continuity: some thoughts. *Transport Reviews: A Transnational Transdisciplinary Journal*, 27(4), 411-448.

Jensen, M,, & Meckling, W, (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, 3(4), 305-360.

Kivisto, J. (2008). An Assessment of Agency Theory as a Framework for the Government–University Relationship. *Journal of Higher Education Policy and Management*, 30(4), 339-350.

Moe, T.M. (1984). The new economics of organization. *American Journal of Political Science*, 28(4), 739–777.

Ortuzar, J. de D. and Willumsen, L.G. (2001). *Modelling Transport*, 3rd edition, Chichester: John Wiley and Sons.

Rasmussen, E. & Gulbrandsen, M, (2012). Government support programmes to promote academic entrepreneurship: A principal-agent perspective. *European Planning Studies*, 20(4), 527-546.

Ross, S.A. (1973). The economic theory of agency: The principal's problem. *American Economic Review*, 63(2), 134–139.

Sarens, G. & Abdolmohammadi, M.J. (2011). Monitoring effects of the internal audit function: agency theory versus other explanatory variables. *International Journal of Auditing*, 15(1), 1-20.

Scott, A. & Vick, S. (1999). Patients, doctors and contracts: An application of principal-agent theory to the doctor-patient relationship. *Scottish Journal of Political Economy*, 46(2), 111-134.

Thompson, C.R. & McKee, M. (2011). An analysis of hospital capital planning and financing in three European countries: Using the principal–agent approach to identify the potential for economic problems. *Health Policy*, 99(2), 158-166.

Whipple, J.M. & Roh, J. (2010). Agency theory and quality fade in buyer-supplier relationships. *The International Journal of Logistics Management,* 21(3), 338-352.

Zsidisin, G.A. & Ellram, L.M. (2003). An agency theory investigation of supply risk management. *The Journal of Supply Chain Management*, 39(2), 15-27.

Zu, X. & Kaynak, H. (2012). An agency theory perspective on supply chain quality management. *International Journal of Operations & Production Management*, 32(4), 423 – 446..