The role of perceived acceptability of alternatives in identifying and assessing choice set processing strategies in stated choice settings: the case of road pricing reform

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Version: 1 July 2015 (revised 24 August 2015) accepted 29 September 2015
To appear in Transportation Research Part E

Abstract

In designing choice experiments, it is common to present a number of alternatives to a respondent and have them choose the most preferred alternative. However, respondents may ignore one or more alternatives which they deem unacceptable for various reasons. This possibility aligns with the idea of the 'consideration set' which influences the choice of an alternative given the choice set of interest. This paper uses an endogenous choice set model to investigate the influence that contextual effects and socioeconomic characteristics play in explaining variations in the choice sets considered by respondents when they reveal their preferences.

Keywords choice of choice sets, processing strategies, acceptable alternatives, random parameters, stated choice, road pricing, elasticities.

Acknowledgment The research contribution is linked to an Australian Research Council grant DP140100909 (2014-2016) on 'Integrating Attribute Decision Heuristics into Travel Choice Models that accommodate Risk Attitude and Perceptual Conditioning'. The comments of Bill Greene are appreciated as are the very useful comments of four referees and the editor-in-chief Jiuh-Biing Sheu on various versions of this paper.

1. Introduction and Conceptual Context

Stated choice modelling focuses primarily on identifying the role of a set of attributes and attribute levels in establishing individual preference as an alternative/complementary approach to revealed preference modelling. In stated preference studies, a choice experiment is designed to ensure that the combinations of attribute levels that describe alternatives are optimal in a statistical sense; however, the number of alternatives is usually pre-defined in stated choice experiment and this carries forward to the modelling stage without sufficient consideration of the behavioural implications of the relevant choice set. Typically, the number of alternatives presented in a choice experiment (i.e., the size of the choice set) is fixed and individuals are asked to choose the best alternative amongst this set of alternatives or to rank the full set as if all alternatives are relevant. This includes experiments where the number of alternatives is varied across choice scenarios or across respondents but fixed within each choice scenario for each respondent.

In contrast to this common practice in stated choice modelling, respondents may not consider some alternatives imposed in a choice task, and thus assuming all designed alternatives are relevant to each respondent may not reflect the way in which respondents process the information and reveal their preference. This paper proposes the use of an additional response question related to the perceived acceptability of each alternative on offer in establishing individual preference. This approach is along similar lines of supplementary questions that reveal the extent to which specific attributes are attended to or not in attribute processing (see e.g., Hensher 2010, 2014). The inclusion of the acceptability of an alternative in choice models is effectively an additional endogenous choice response (Hess et al. (in progress) and Rose et al. (2015)). Most importantly, the acceptability of each alternative provides a response metric that can guide us in establishing the subset of alternatives that matter in narrowing down the preferred alternative. This is known as the 'choice of choice sets' problem (as mentioned by Louviere and Hensher in 1983) and is typically neglected in choice modelling. Regardless of what information is used to construct a choice set response, without such knowledge it is not possible to establish, from the full set of alternatives, which subset of alternatives are processed in making a preferred choice, and indeed in establishing a rank order for a behaviourally meaningful set of alternatives. The small but growing literature on the perceived acceptability of each alternative posits that when making decisions, people first identify an acceptable set of alternatives, known as a consideration set in the broader literature (especially in marketing research), and it is from this reduced set that the final choice is made1. This is also in line with the literature on choice set formation set out in the context of revealed preference data (see Manski 1977 and Swait and Ben Akiva 1987).

Despite frequent mention of these features of choice modelling, the great majority of applied choice modelling (using stated choice data in particular) ignores this stage of the choice making process. This might suggest that there is a view that modelling choices with endogenous choice set is either too difficult or that it has little significance in the determination of the choice outcomes of interest. Evidence from a recent study by Rose *et al.*

[1] In stated choice studies which impose a set of alternatives it is normal practice to ask which alternative is preferred. What we have done however is to proceed with that question but to add in the addition question to identify which alternatives in the set are acceptable. We could have asked these questions in the reverse order but did not do so, and although the reverse order might be interesting, we are of the view that the responses for only three alternatives are likely to be the same (at least for the majority of respondents). A sequence test is a good topic for future research.

(2015) rejects the latter explanation. Using an acceptability response to define choice sets of interest, Rose *et al.* find a large number of differences between parameters associated with the alternatives deemed to be acceptable and those deemed to be unacceptable by the respondent. They show that joint estimation allows the modeller to overcome potential endogeneity bias that may exist between the final choice made and the acceptability responses, where the latter conditions the relevance of an alternative. The authors also conclude that what might be thought of as preference heterogeneity may be linked to the overall acceptability of an alternative.

What concerns us in the contribution of *Rose et al.* (2015) is that the acceptability of each alternative is combined with its rank order to define the set of elemental alternatives for jointly estimating alternative acceptability and choice. This modelling technique does not account for the role that choice set formation plays in arriving at the selection of an alternative. This paper focuses on the higher level of choice set formation which conditions the lower level in a 'nested' structure of choosing a particular alternative. It differs from the choice set generation methods proposed by authors such as Ben Akiva and Boccara (1995) in that we treat the choice of choice sets as integral to the overall utility maximising framework and not a conditioning set of exogenous rules.[2]

The approach presented in this paper differs from previous contributions in that we use the responses on the acceptability of each alternative to identify a choice set considered by the respondent and formulate a model to predict both responses: the subset of alternatives considered and the final choice. From a choice task of J alternatives imposed on the respondent, we may construct up to 2^J subsets of alternatives with different combinations of acceptable alternatives. These subsets are referred to as outcomes of candidate choice set processing strategies (CCSPSs), and only one of these subsets is considered by the respondent when they make their final choice. This is in line with the idea of consideration sets.[3] Previous studies combined each alternative on offer with an acceptability response in defining a universal choice set and estimating parameters which can be generic or specific across an acceptability/certainty scale. These studies are interested in establishing different sets of parameters for different levels of acceptability/certainty, assuming *the relevance of all alternatives* offered in the experiment. In contrast, the current paper focuses on likely reasons for each imposed alternative being processed (up to a probability) where the sub-set of alternatives together with the alternative itself defines a choice response. The growing literature on process heuristics offers up many possible explanations for choice set selection, but one of particular interest in the context of choice experiments is the application of context-dependent heuristics such as extremeness aversion and compromise (proposed by Simonson and Tversky (1992) and Tversky and Simonson (1993)), that take into account the variations in attribute levels across a set of alternatives predefined in a choice experiment (Hensher 2014). Such context-dependent heuristics are an important feature of the empirical

[2] We are not able to conclude that our joint approach is empirically better than approaches in which exogenous rules are imposed to define eligible alternatives in choice set generation, but it has the appeal of being more general than approaches which select a few criteria to screen alternatives.

[3] Another way of including the acceptability of an alternative at the time of modelling is to assign a zero probability to alternatives that have been deemed to be out of the acceptable consideration set (Gilbride and Allenby 2004, Horowitz and Louviere 1995). However, asking whether an alternative is acceptable or not does not preclude the possibility that the alternative was actually considered when the final choice was made, and hence does not necessarily suggest that the alternative should be assigned a zero choice probability. Although, if at least one other alternative is deemed to be acceptable, then any unacceptable alternative would be expected to have a probability close to zero, and its treatment as outside of the final choice set has greater behavioural merit than maintaining its presence.

inquiry into some rules that might be adopted in 'screening' hypothetical alternatives, especially in the context of a reference or status quo alternative that reflects real market experience. We examine these possible processing rules through innovative ways of introducing attributes into the utility expression of each 'alternative' as defined by a choice set, such as the attribute range across the alternatives in a choice set.

Extremeness aversion or the compromise effect can be explained as follows. If an extreme alternative is defined as one with both the best value on a subset of attributes, and the worst value on other attributes, then a specific form of extremeness aversion known as the compromise effect is said to occur (see also Leong and Hensher 2015). That is, the inclusion of an extreme alternative in the choice set causes the pair-wise choice share of the compromise or the in-between alternative to increase, relative to the other extreme alternative.[4] It is also normally supposed that a "betweenness inequality" holds in choice making, in which the middle alternative (for example, in a three alternative choice set) loses relatively more than an existing extreme alternative when another extreme alternative is introduced (Tversky and Simonson 1993). Under this condition, the compromise effect can be seen as a violation of the betweenness inequality and its existence is generally attributed to a consequence of loss-aversive behaviour (Kivetz *et al.* 2004, 2008). There is a hint here of the nature of acceptability of an alternative in preference revelation and the refinement of choice set selection. The statistical design of choice experiments does not account for the possible set of underlying behavioural processing strategies that respondents adopt in choice revelation, something that has to be taken into account in modelling.

Given the interest in incorporating the endogenous acceptability response into choice models, we assess model options within the random utility maximisation (RUM) framework. A number of models have been developed at the alternative-level, allowing for the estimation of non-random parameters or random parameters. Candidate methods of interest are mixed logit and latent class models. The latent class model offers a framework within which to investigate many forms of *attribute processing* (Hensher 2010); however, the latent class approach is limiting when the focus is on understanding the role of *specific alternatives* in establishing acceptable choice sets. This is because it is not feasible to associate latent classes in a behaviourally meaningful way with combinations of alternatives that define potential choice sets considered by the respondent. In order to give some behavioural structure to each class (similar to imposing constraints of attributes in specific classes), this model form would have to be interpreted as a probabilistic decision process (see Hensher 2014). Given all possible candidate choice sets (or classes), we are interested in estimating the probability that each of the candidate choice sets is adopted (i.e., the class assignment probability) as opposed to treating the consideration set as known (i.e., probability =1) and the probability that each of the alternatives is ranked as most preferred given the class they belong to (conditional alternative probability). To do so, we would have to specify a latent class model with a number of restrictions based on the presence or absence of an alternative in each candidate choice set. This model will result in a singular variance matrix of parameters, as might be expected, since it involves an exact mapping of the restrictions imposed on the utility function of the same alternative that belongs to multiple candidate choice sets. A more appealing way to do this is a standard random (or fixed) parameter logit model with error components applied in this paper in which the error components are used to capture the correlation across overlapping choice sets (i.e., subsets with common alternatives).

[4] This notion of "extremeness" might be distinguished from "dominating/dominated" alternatives, in which all attributes of an alternative are better/worse than a competing alternative.

The CCSPS approach proposed in this paper enables efficient implementation of RUM for any choice set size since the emphasis at the upper level of the decision structure is on the choice of CCSPSs, and not of alternatives; however this is jointly estimated with the choice of best elemental alternative amongst those imposed in the experiment. The attribute descriptions of each elemental alternative are embedded in the CCSPS model together with explanatory variables designed to capture process heuristics such as extremeness aversion and to identify other possible ways in which the attribute levels are processed in establishing the acceptability of particular alternatives in defining a CCSPS. Examples are the range, maximum and minimum levels and deviation of levels from the best or worst level of an attribute across the full set of alternatives on offer, and the set deemed acceptable. Such an approach (aligned with context dependency) is a way of identifying the role of particular attribute processing strategies within and between alternatives in defining choices sets for subsequent model estimation.

The paper is organised as follows. We begin with the conceptual positioning of the proposed acceptability approach, followed by the context in which we empirically develop the CCSPS model. We then present the model findings, followed by an assessment of the main behavioural outputs. The paper concludes with the main findings and suggestions for ongoing research.

2. Conceptual Positioning of the Proposed Acceptability Approach

Hensher and Louviere (1983), in one of the very earliest choice experiments, show that an 'ideal' choice experiment is defined as one in which "… the basic elements of the choice process are abstracted and everything is controlled to permit unbiased estimates of choice strengths and choice probabilities." (p.228). Such an experiment would normally consist of a set of J alternatives (j=1,2,…,J) and different subsets of these J alternatives which simulate "availability" (although not strictly acceptability) or variance in choice sets. To ensure that the choice of alternatives is independent of the presence or absence of alternatives in choice sets (a condition satisfied when all alternatives appear equally often) and are also balanced with respect to the presence and absence of all other alternatives, we would need to design the choice experiment to satisfy this condition. A complete factorial design is likely to be too large, but a 2^J fractional factorial design can ensure a balanced occurrence of the presence/absence of alternatives in choice sets.

A choice set designed under these conditions will be one of all universal finite choice sets where each alternative appears equally often, $2^J/2$ or 2^{J-1} times, and each other alternative occurs $2^{J-1}/2$ or 2^{J-2} times when each other alternative occurs (or does not occur). Each individual is likely to have a different rank ordering of the alternatives which results in a distribution of choices over any sample of individuals. This distribution is assumed to be explained by the utility version of Luce's choice axiom (McFadden 1974). A discrete choice model that is estimated on such data will obtain a distribution of choice probabilities associated with each choice set that sum to 1.0 across all choice sets for an individual.

Although the theoretical and methodological merits of such a design that is capable of studying the 'choice of choice sets' are appealing, the design of the great majority of choice experiments typically results in a fixed choice set or partial structuring of alternatives which not only induces correlation across offered choice sets (the latter is not a concern when migrating from orthogonal to efficient or optimal designs – see Hensher *et al.* 2015). For such popular choice experiments, when we only know which alternative is chosen (or the full ranking of the alternatives), the choice of an alternative is by implication conditional on the full set of potential availability choice sets as defined by the statistical design.

What if a respondent actually considers a subset of the alternatives and effectively rejects other alternatives in constructing their preference response? One strategy that can be used to inform the choice process when each and every individual is shown all of the designed alternatives (in which attributes levels are the only variation across choice sets) is to seek out underlying behavioural processes that might define the 'relevant choice set' from which an individual makes a choice. The suggestion in a growing number of studies, cited above, that a respondent's perception of the acceptability of an alternative might be a way forward to narrow down the subset of alternatives that define the domain in which the probability of choosing an alternative is maximised, has merit and is worthy of further consideration. Although this will induce correlation between choice sets (given that the construction of choice sets is not based on statistical design criteria but on behavioural decision processes) correlation is not an issue, and can be accommodated in model estimation. Incorporating perceived acceptability of each alternative seems an appropriate mechanism if this can improve the ability of a choice model in terms of predicting the respondent's final choice.

We propose a two-stage model system in a random utility maximisation (RUM) setting in which the choice of a particular alternative is conditioned on a higher level choice from a set of choice sets constructed with knowledge of the perceived acceptability of each alternative in a choice scenario. The structural model system of interest is shown in Figure 1 for three elemental alternatives (*A,B,C*) defining a choice scenario designed in a choice experiment. The respondent may accept all three alternatives on offer or only a subset of these three alternatives. In total, seven candidate choice sets, each with a minimum of one acceptable alternative, can be defined and one of these candidate choice sets is considered by the respondent when they reveal their preference. By asking the respondent to indicate the acceptability of each alternative as well as the most preferred alternative in each choice task, we observes both the choice set considered by the respondent and their final choice. Thus, we can formulate a model with the upper level representing a set of alternatives considered by the respondent and the lower level representing the choice of most preferred alternative. The entire choice system can be jointly estimated as a conditional and a marginal probability.

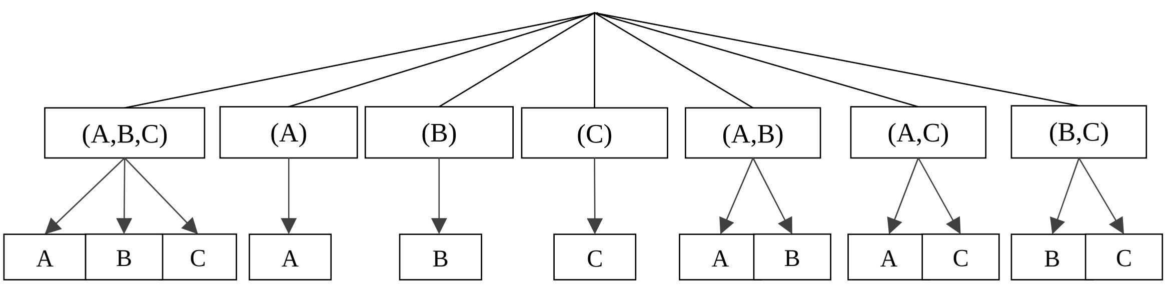


Figure 1: An example of a choice set formation structure

Formally, the probability of choosing an elemental alternative j (=A, B or C) as the best alternative amongst those presented in a choice task can be expressed as a probabilistic choice system with an endogenous choice set as given in equation (1):

$$P(A)=\sum_{\forall C_A} P(A \mid C_A)P(C_A)$$
$$P(B)=\sum_{\forall C_B} P(B \mid C_B)P(C_B) \quad (1)$$
$$P(C)=\sum_{\forall C_C} P(C \mid C_C)P(C_C)$$

where C_j is the choice set that contains the j^{th} alternative ($j = A, B, C$). These choice sets can contain one or more acceptable alternatives. For example, C_A represents one of four possible choice sets: (i) *A* is the only acceptable alternative, (ii) *A* and *B* are acceptable, (iii) *A* and *C* are acceptable, or (iv) *A*, *B* and *C* are acceptable. The same logic applies to C_B and C_C.

Clearly, there is a presence of common elemental alternatives across candidate choice sets and this induces the correlation of the error terms across 'nests' or choice sets. Thus, an adopted model should be able to accommodate cross-nest correlated errors. This is often handled through a generalized or cross nested logit model (see Hensher *et al.* 2015). In this paper, we use a random parameter with error components model to take account of preference heterogeneity (through random parameters) as well as the correlated errors due to the presence of common elemental alternative across the choice sets (through error components). As explained in Greene and Hensher (2007), this model form incorporates additional unobserved heterogeneity through effects that are associated with the individual's preferences within the choices. These appear as $M \leq J$ additional random effects,

$$U_{qjt} = \beta_q^{'} X_{qjt} + \varepsilon_{\text{qjt}} + c_{j1}W_{q1} + c_{j2}W_{q2} + \ldots + + c_{jM}W_{qM} \quad (2)$$

where $\boldsymbol{U_{q,j,t}}$ is the utility expression associated with alternative *j* and individual *q* in the t^{th} choice scenario, $\boldsymbol{\beta}_q$ are the parameters of observed attributes ($\mathbf{x}_{q,j,t}$) associated with the q^{th} individual, $\varepsilon_{q,j,t}$ is the random component associated with a particular alternative, individual and choice scenario, the $W_{q,m}$ are normally distributed error component effects with zero mean, $m = 1,\ldots,M \leq J$ and $c_{jm} = 1$ if *m* appears in utility function of alternative *j*. This specification can produce an error components model as used in this paper if one and only one error component appears in each utility function, as in (3).

$$U_{qjt} = \beta_q^{'} X_{qjt} + \varepsilon_{\text{qjt}} + W_{qj}, j = 1,\ldots,J \quad (3)$$

Across the elemental alternatives, the error components can be constrained so that the elemental alternatives can be classified into different groups (or nests), each contains a common error component. This specification give rise to the 'nested' system as in (4):

$$U_{q1t} = \beta_q^{'} X_{q1t} + \varepsilon_{\text{q1t}} + W_{q1}$$
$$U_{q2t} = \beta_q^{'} X_{q2t} + \varepsilon_{\text{q2t}} + W_{q1} \quad (4)$$
$$U_{q3t} = \beta_q^{'} X_{q3t} + \varepsilon_{\text{q3t}} + W_{q2}$$
$$U_{q4t} = \beta_q^{'} X_{q4t} + \varepsilon_{\text{q4t}} + W_{q2}$$

or a cross nested model if the error components overlap across nests as in (5):

$$
\begin{aligned}
U_{q1t} &= \beta_q^{'} X_{q1t} + \varepsilon_{q1t} + W_{q1} + W_{q2} \\
U_{q2t} &= \beta_q^{'} X_{q2t} + \varepsilon_{q2t} + W_{q1} + W_{q2} \\
U_{q3t} &= \beta_q^{'} X_{q3t} + \varepsilon_{q3t} + W_{q2} + W_{q3} + W_{q4} \\
U_{q4t} &= \beta_q^{'} X_{q4t} + \varepsilon_{q4t} + W_{q3} + W_{q4}
\end{aligned} \tag{5}
$$

This extension of the mixed logit model entails capturing additional unobserved variance that is alternative-specific through a mixture formulation which imposes a normal distribution on the error components across the sampled population. The standard deviation of these normal distributions can be parameterised for each alternative with special cases in which there are cross-alternative equality constraints on the estimated standard deviations. Through cross-alternative constraints we can permit an alternative to appear in more than one subset of alternatives, giving it the appearance of a nested structure.

This model, which is an elegant way to account for flexible substitution patterns across alternatives, goes beyond the patterns commonly achievable by means of generalised extreme value models, such as the nested and cross nested logit models. Alternatives whose utility have some form of covariance share error components, which are typically distributed as zero-mean random normal with a standard deviation to be estimated. In this way, the model may approximate a covariance structures in a more accurate way than the typical nested logit model by forming complex covariance structures between alternatives.

The interpretation of the error components relates to their associations with specific alternatives and not with attributes as with more traditional random taste models. Each estimated error component represents the residual random error variances linking those alternatives, and by estimating different error components for different subsets of alternatives, it is possible to estimate complex correlation structures amongst the error variances of the various alternatives being modelled. Indeed, the use of error component s in a model induces particular covariance structures amongst the modelled alternatives, and hence represents a relaxation of the IID assumption typically associated with most logit type models.

3. Testing Choice Set Formation - The Empirical Illustration

We use a data set collected in Sydney in 2012 that focussed on investigating commuters' preferences for a number of alternative road pricing reform packages. Respondents were shown three alternatives: the status quo and two currently unavailable road pricing schemes. The two road pricing schemes were labelled as a cordon-based charge and a distance-based charge and randomly assigned to road pricing schemes 1 and 2. Respondent were asked to choose the best and the worst schemes amongst the three alternatives presented in the experiment. After these choice responses, they were asked to indicate whether each of the three alternatives is acceptable or not acceptable. We then construct choice sets that are the various combinations of elemental alternatives that are acceptable, varying from one to three alternatives, of which the choice sets with one or two elemental alternatives have different alternatives and hence they vary across the available set of eligible alternatives. The sequence of questions are shown in Figure 2, and in the actual survey, the acceptability question only appears after the choices of the best and the worst schemes are made. The survey instrument was an online computer assisted personal interview accessed via laptops. Interviewers sat with the respondents to provide any advice that was required in working through the survey, while not offering answers to any of the questions. Each respondent was shown four choice scenarios. An illustrative choice screen, together with the boundaries of the proposed cordon-based charge area, is presented in Figure 2. Other information about the survey is available in Hensher *et al.* (2013) and Hensher and Ho (2015).

THE UNIVERSITY OF SYDNEY

ROAD PRICING REFORM SURVEY

Road Pricing Games

Consider again these two road pricing schemes, as well as the status quo (your travel over the last week).

Game 1 of 4

Characteristics	Status Quo	RPScheme 1	RPScheme 2
Implementation of the scheme			
Year scheme will be introduced	---	2015	2016
Description of the scheme	Current Experience	Cordon Based ($/day)	Distance Based ($/km)
Predicted impact on you personally			
Weekly toll charges	$ 2.40	$ 0.00	$ 0.00
Weekly fuel outlay	$ 40.00	$ 28.00	$ 24.00
Annual vehicle registration fee (per annum)	$ 320.00	$ 320.00	$ 240.00
Peak period (7-9am, 4-6pm) congestion charge (total based on travel by car last week)	---	$ 11.00	$ 0.12 / km ($ 14.40 for 120 kms)
Off-peak period congestion charge (total based on travel by car last week)	---	$ 3.00	$ 0.12 / km ($ 3.60 for 30 kms)
Revenue Raised will be allocated as:			
improving public transport	---	80 %	0 %
improving existing and construct new roads	30 %	0 %	0 %
reducing personal income tax	---	0 %	80 %
general government revenue	65 %	20 %	0 %
private toll road companies (to compensate for removal of tolls)	5 %	0 %	20 %

Thinking about your own situation and what is best for you

What is the best scheme? ○ Status Quo ○ RPS 1 ○ RPS 2

What is the worst scheme? ○ Status Quo ○ RPS 1 ○ RPS 2

Thinking about what is best for the community as a whole

What is the best scheme? ○ Status Quo ○ RPS 1 ○ RPS 2

What is the worst scheme? ○ Status Quo ○ RPS 1 ○ RPS 2

If you had to vote for one of the schemes shown in a referendum, which would you vote for?

I would vote for ○ Status Quo ○ RPS 1 ○ RPS 2

Looking at each scheme, from your perspective, which schemes do you think are acceptable or unacceptable?

The Status Quo ○ Acceptable ○ Unacceptable Road Pricing Scheme 1 ○ Acceptable ○ Unacceptable Road Pricing Scheme 2 ○ Acceptable ○ Unacceptable

If road pricing scheme 1 or 2 was to be actually introduced such that the status quo was no longer available, how many of the current 14 trips would:

not be undertaken? [ ] be by car or motorbike? (currently 12) [ ] be by public transport? (currently 2) [ ]

Would you support a 3 month trial of any road pricing scheme that you have indicated as acceptable in order to see if it actually provides the hoped for benefits to users and the community?

○ Yes ○ No

Next

Figure 2 An illustrative choice screen and the location of the cordon-charge area

In this paper, we make use of the responses to the acceptability of each alternative, together with the best choice response (studied in Hensher and Ho 2015) of the full set of alternatives, to estimate a model that allows for the choice set processed by each respondent. In response to this question, the respondent is assumed to consider the attributes and attribute levels that together describe an alternative. These are provided in Table 1. The survey was generated using a Bayesian D-efficient measure but this does not guarantee that all presented alternatives are acceptable to, and hence processed by, the respondent. For example, some segments of the car users may oppose any road pricing reform and thus consider the cordon-based charge and the distance-based charge as unacceptable alternatives, leaving the status quo as the only acceptable, and hence most preferred alternative. Other people, for example, may find one or both of the road pricing alternatives unacceptable in a choice scenario where all (100%) revenues collected from road pricing are allocated to public transport. Potential influences on the acceptability of an alternative are discussed below and tested with the model described in the next section.

Table 1 The choice experiment attribute levels and range

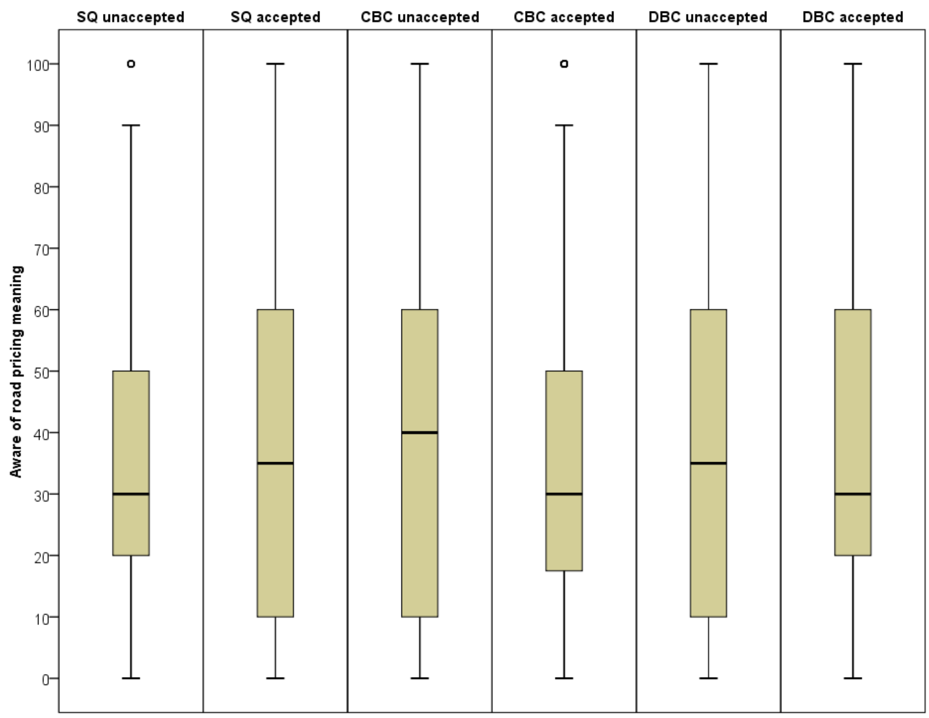
Attribute	Status quo	Cordon-based scheme	Distance-based scheme
Year scheme introduced	-	2013, 2014, 2015, 2016	2013, 2014, 2015, 2016
Average fuel per week	User reported level	0%, -10%, -20%, -30%, -40%, -50%	0%, -10%, -20%, -30%, -40%, -50%
Average toll per week	User reported level	$0.00	$0.00
Annual vehicle registration	User reported level	0%, -25%, -50%, -75%, -100%	0%, -25%, -50%, -75%, -100%
Peak cordon-based charge (per trip)	$0.00	$2.00, $6.50, $11.00, $15.50, $20.00	-
Off peak cordon-based charge (per trip)	$0.00	$0.00, $3.00, $6.00, $9.00, $12.00, $15.00	-
Peak distance-based charge (per km)	$0.00	-	$0.05, $0.12, $0.19, $0.26, $0.33, $0.40
Off peak distance-based charge (per km)	$0.00	-	$0.00, $0.06, $0.12, $0.18, $0.24, $0.30
% of funds allocated to public transport	0%	0%, 20%, 40%, 60%, 80%, 100%	0%, 20%, 40%, 60%, 80%, 100%
% of funds allocated to road infrastructure	30%	0%, 20%, 40%, 60%, 80%, 100%	0%, 20%, 40%, 60%, 80%, 100%
% of funds allocated to reducing tax	0%	0%, 20%, 40%, 60%, 80%, 100%	0%, 20%, 40%, 60%, 80%, 100%
% of funds allocated to general revenue	65%	0%, 20%, 40%, 60%, 80%, 100%	0%, 20%, 40%, 60%, 80%, 100%
% of funds allocated to private (toll) firms	5%	0%, 20%, 40%, 60%, 80%, 100%	0%, 20%, 40%, 60%, 80%, 100%

We know from earlier research on the design of designs (e.g., Hensher 2006) and more recently (e.g., Weller *et al.* 2014) that the composition of the attribute levels associated with subsets of alternatives has an important influence on the choice of an alternative (hence the growing literature on the impact of the dimensionality of choice experiments in both choice making and in the use of processing heuristics, broadly linked to the literature on context dependency). Within the context of an acceptable choice set, we have a rich array of candidate ways of representing, and hence testing, attribute dimensionality. For example, a possible explanation for the unacceptability (i.e., exclusion or irrelevance) of an alternative might relate to a specific attribute level. This may also be built into a respondent's attribute processing rule that impacts on the acceptability of an alternative through a *relative metric* of attributes such as the range across all alternatives or its presence as the maximum or minimum level, or level relative to the best or worst level (somewhat akin to the relative advantage or disadvantage model; see Leong and Hensher 2015). An attribute of particular interest is the amount outlaid on tolls compared to the pricing reform options.[5]

Given that the empirical topic is road pricing reform (involving cordon-based and distance-based charging), there is likely to be a wide range of awareness (or lack thereof) within a sampled population. To identify the extent of awareness, a context-dependent effect, we asked the following question: 'To what extent are you aware of what road pricing means?'

[5] Given the number of concession toll roads in Sydney, and the proposal under the reform package alternatives to remove the toll and replace it with either a CBD cordon-based charge regime or a distance-based charging regime.

where 0 means totally unaware and 100 means totally aware. Figure 3 provides a Box-plot distribution, highlighting a wide range of respondent awareness, with some being fully aware (4.5%) and some totally unaware (15.5%) of the meaning of road pricing. There exists no clear distinction in awareness between two groups of car commuters given another question identifying support for and against road pricing reform. This suggests the presence of heterogeneity in awareness, which we hypothesise may have an influence on the acceptability (and hence on choice set formation) of reform packages associated with a CBD cordon-based charge or a distance-based charge throughout the metropolitan area that varies between peak and off-peak periods, and hence the choice of CCSPS.[6]



Note: Extreme values are marked with circle (more than 1.5 Interquartile Range)
Figure 3 Awareness of the meaning of road pricing

Socioeconomics characteristics may have a role to play in the acceptability of alternatives. For the sample, the mean personal income is $74,225 (StdDev = $53,158); the mean age is 50.55 (StdDev = 14.19), and 35.5 percent of the sample are males. The data includes personal income, age and gender. One might hypothesise that individuals with higher incomes are more likely to support road pricing reform and to include one or both of the charging regimes in their acceptable choice set. The influence of gender is somewhat ambiguous, but for age we might expect a greater acceptability of the reform packages for older individuals, noting that the sample is commuters and so excludes retirees who may have a different perspective.

4. Model Results

For the choice experiment of three alternatives, each with a binary response of acceptable or not, we have $2^3 = 8$ possible choice sets with different combinations of acceptable and

6 In Balbontin *et al.* (2015) we are investigating the role that awareness plays in both conditioning the entire utility expressions for the road pricing reforms alternatives, and as another endogenous influence.

nonacceptable alternatives in these eight subsets. In the empirical data, at least one alterative (the best) was acceptable, and thus we do not have a choice set with all three alternatives deemed as unacceptable. This leaves us with 8 – 1 = 7 possible choice sets, of which one is considered by the respondents when they form their preference (ranking). Herein lies the use of acceptability responses in identifying which of the possible choice sets is actually processed by the respondent. Table 2 shows the frequency of consideration sets across the sample. A large proportion of choice sets that are observed to be processed by the respondent (i.e., consideration sets) contain one or both road pricing schemes. This is an encouraging piece of evidence in its own right because it suggests that the alternatives designed in the overall stated choice experiment cover a range of attributes and attribute levels that are aligned with support for road pricing reform.

Table 2 Observed frequency of CCSPS chosen by respondent

CCSPS (Acceptable alternatives)	**Observed frequency**
All alternatives are acceptable (CCSPS1)	128
Only status quo is acceptable (CCSPS2)	60
Only cordon based charge is acceptable (CCSPS3)	87
Only distance based charge is acceptable (CCSPS4)	39
Both status quo and cordon based charge are acceptable (CCSPS5)	179
Both status quo and distance based charge are acceptable (CCSPS6)	63
Both cordon and distance based charges are acceptable (CCSPS7)	176
Total	**732**

The dependent variable in the mixed logit model with error components is the selection of the best alternative from the choice set processed by a respondent, defined as the one that contains all acceptable alternatives. The processed choice set can vary across the four choice scenarios shown to them. Figure 4 shows that only 42 out of 200 respondents processed the same choice set for all four scenarios, while a majority of the respondents processed at least two different choice sets.[7] The panel nature of the data is accounted for in model estimation (see Train 2009).

To estimate the endogenous choice set model of three alternatives, we need to create multiple elemental alternatives (one for each candidate choice set processing strategy or CCSPS) from each alternative shown to the respondent. From the three initial alternatives, 12 elemental alternatives were constructed and assigned to different candidate choice set processing strategies (CCSPS). This is just a modelling technique and does not reflect what the respondent observes in the experiment, which contains only three alternatives. Consequently, the observed portion of the utility function for each elemental alternative is specified to have two components: one associated with the alternative the respondent sees in the experiment and one associated with the CCSPS the elemental alternative belongs to. Constraints are then imposed on the parameters so that the former component is the same for all elemental alternatives, reflecting that these elemental alternatives are created from a unique alternative shown to the respondent. In addition, the model was specified in such a way that different alternatives belong to the same CCSPS have the same CCSPS utility component. Thus, the observed utilities of elemental alternatives differ by either the CCSPS component (same initial alternative in different candidate choice sets) or the alternative component (different alternatives in the same nest).

[7] Table 2 and Figure 4 are not directly comparable because Table 2 is an overall summary whereas Figure 4 is broken down by the number of choice scenarios (out of a maximum of 4) that a respondent answered.

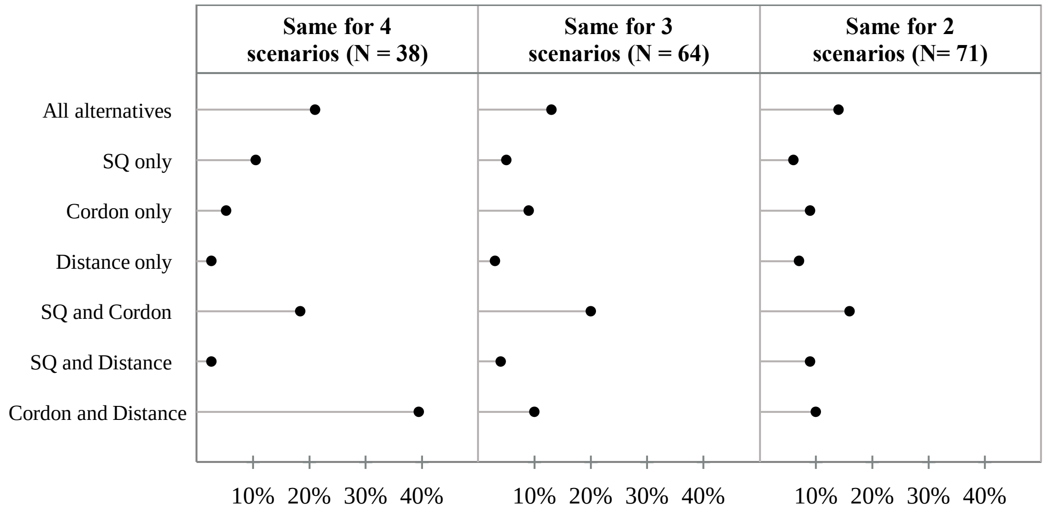


Figure 4 Distribution of adopted CCSPS by number of times it is used by the same respondent for four scenarios

The results of a mixed logit model for seven candidate processing strategies and 12 alternatives are summarised in Table 3. The model is estimated using Nlogit6 (Econometric Software 2015), and simulated likelihood maximisation with 500 intelligent (Halton) draws used for the random parameters. Full details are given in Greene and Hensher (2007). The model has a pseudo R^2 of 0.275 with a number of statistically significant influences on each CCSPS. The estimated probability of choosing each CCSPS for each sampled respondent's choice scenario is shown in Table 4.[8] Of particular interest is the probabilities of choosing the choice sets where the status quo alternative is not acceptable, suggesting that an experienced alternative is not necessarily acceptable, despite being chosen in a real market (i.e., the best of possibly a poor set). In the presence of a number of new pricing reform regimes, we see opportunities to switch to a more acceptable alternative, which is encouraging evidence that recognises there is community support for road pricing reform. The notion of acceptability appears to be interpreted as a relative construct.

[8] The predicted choices set shares align very closely with the actual sample shares in Table 2. Most differences are less than 1 percent and are in due essentially to rounding error.

Table 3 Summary of estimated mixed logit model (183 respondents, 732 observations); 500 Halton draws, and random parameters normally distributed.

Choice Sets: CCSPS1=all alternatives acceptable (SQ1,CB1,DB1), CCSPS2=Status quo (SQ2) or experienced alternative acceptable, CCSPS3=Cordon-based charge (CB3) reform acceptable, CCSPS4=distance-based charge (DB4) reform acceptable, CCSPS5= Status quo (SQ5) and CBC (CB5) reform alternative acceptable, CCSPS6= Status quo (SQ6) and DBC(DB6) reform alternative acceptable, CCSPS7= CBC (CB7) reform and DBC (DB7) reform alternative acceptable

Candidate influences	Alternatives	Coefficient (t-value)
Random parameter mean estimates		
Range of toll, CBC and DBC ($/week)	CCSPS1	0.00368 (0.26)
Range of toll, CBC and DBC ($/week)	CCSPS3	0.01968 (1.50)
Range of toll, CBC and DBC ($/week)	CCSPS4	-0.20661 (-2.25)
Range of toll, CBC and DBC ($/week)	CCSPS5	0.02208 (2.43)
Range of toll, CBC and DBC ($/week)	CCSPS6	-0.05046 (-2.13)
Range of toll, CBC and DBC ($/week)	CCSPS7	-0.02998 (-2.24)
Range of annual registration cost ($pa)	CCSPS1	-0.00182 (-1.38)
Range of annual registration cost ($pa)	CCSPS3	-0.00212 (-1.58)
Range of annual registration cost ($pa)	CCSPS4	0.00065 (0.58)
Range of annual registration cost ($pa)	CCSPS5	-0.00249 (-2.76)
Range of annual registration cost ($pa)	CCSPS6	-0.00196 (-1.08)
Range of annual registration cost ($pa)	CCSPS7	0.00168 (1.71)
Awareness	CCSPS1	0.1347(1.09)
Awareness	CCSPS7	-0.01890 (-1.47)
Non-random parameters		
CCSPS2 constant	CCSPS2	-2.3202 (-2.32)
CCSPS3 constant	CCSPS3	-3.6537 (-3.61)
CCSPS3 constant	CCSPS4	-3.2210 (-3.13)
CCSPS5 constant	CCSPS5	-2.9663 (-3.07)
CCSPS6 constant	CCSPS6	-3.7312 (-3.96)
CCSPS7 constant	CCSPS7	-5.4213 (-5.16)
Age (years)	CCSPS1	-0.0802 (-2.93)
Personal income ($ '000s)	CCSPS1	-0.0127 (-1.91)
Personal income ($ '000s)	CCSPS7	0.0200 (3.66)
Registration fee ($/annum)	CCSPS1-7	-0.0033 (-7.55)
Tolls ($/week)	SQ1,SQ2,SQ5,SQ6	-0.10089 (-2.33)
Fuel cost ($/week)	CCSPS1-7	-0.0459 (-3.64)
Cordon peak charge ($/day)	CB1,CB3,CB5,CB7	-0.0677 (-2.89)
Cordon off-peak charge ($/day)	CB1,CB3,CB5,CB7	-0.0731 (-3.73)
Distance peak charge ($/day)	DB1,DB4,DB6, DB7	-0.0393 (-2.58)
Distance off-peak charge ($/day)	DB1,DB4,DB6, DB7	-0.0539 (-3.65)
Revenue allocated to public transport (%)	All CB and DB alts	0.0167 (4.68)
Revenue allocated to roads (%)	All CB and DB alts	0.0089 (2.38)
Revenue allocated to reduced taxes (%)	All CB and DB alts	0.0139 (3.69)
Cordon-based charge constant	CB1,CB3,CB5,CB7	-2.0079 (-2.42)
Distance-based charge constant	DB1,DB4,DB6, DB7	-1.9215 (-2.24)
Support trial of road pricing reform (1.0)	All CB and DB alts	2.8750 (4.28)
Random parameters – standard deviation		
Range of toll, CBC and DBC ($/week)	CCSPS1	0.02151 (1.07))
Range of toll, CBC and DBC ($/week)	CCSPS3	0.02855 (1.75)
Range of toll, CBC and DBC ($/week)	CCSPS4	0.16591 (2.90)
Range of toll, CBC and DBC ($/week)	CCSPS5	0.01022 (0.91)
Range of toll, CBC and DBC ($/week)	CCSPS6	0.05306 (3.25)
Range of toll, CBC and DBC ($/week)	CCSPS7	0.02954 (2.02)
Range of annual registration cost ($pa)	CCSPS1	0.00530 (3.64)
Range of annual registration cost ($pa)	CCSPS3	0.00317 (3.62)
Range of annual registration cost ($pa)	CCSPS4	0.00050 (0.40)
Range of annual registration cost ($pa)	CCSPS5	0.00404 (4.67)
Range of annual registration cost ($pa)	CCSPS6	0.00582 (3.58)
Range of annual registration cost ($pa)	CCSPS7	0.00173 (1.31)
Awareness	CCSPS1	0.03087(6.13)
Awareness	CCSPS7	0.07913 (4.50)
Standard deviations of latent random effects (error components)		
Status quo	SQ1,SQ2,SQ5,SQ6	3.4138 (6.13)
Cordon-based charge	CB1,CB3,CB5,CB7	0.6672 (1.30)
Distance-based charge	DB1,DB4,DB6, DB7	1.2673 (3.28)
Model fit		
Log-likelihood (no parameters)		-1818.95
Log-likelihood at convergence		-1316.99
Pseudo R^2		0.275
Information criterion (AIC), sample adjusted		3.318

The random parameters relate to the range of the pricing charges across the elemental alternatives evaluated, as represented by the toll in the status quo alternative and the reform prices in the cordon-based and distance-based charging regimes, and separately, the annual registration fee. Some of the random parameters had statistically significant standard deviation parameters and non-significant mean parameter estimates, suggesting that preference heterogeneity cannot be approximated by a mean estimate. Fuel costs are excluded and treated as a separate attribute, and are limited to its role at the alternative level (given we were unable to find a statistically significant mean and/or standard deviation parameter estimate for the range across the elemental alternatives.

Awareness associated with CCSPS1 and CCSPS7, both consist of cordon-based and distance-based schemes, is also treated as a random parameter, with a statistically significant standard deviation parameters and non-significant mean parameter estimates, suggesting that preference heterogeneity cannot be approximated by a mean estimate.

Table 4 Summary of Choice Probability Moments for RUM MMNL by CCSPS

Choice Probability	CCSPS1 (All)	CCSPS2 (SQ)	CCSPS3 (CBC)	CCSPS4 (DBC)	CCSPS5 (SQ, CBC)	CCSPS6 (SQ, DBC)	CCSPS7 (CBC, DBC)
Mean	0.19	0.08	0.12	0.06	0.23	0.09	0.23
Standard Deviation	0.12	0.06	0.08	0.04	0.11	0.05	0.14
Range	0.56	0.36	0.36	0.26	0.52	0.24	0.75
Minimum	0.00	0.00	0.01	0.00	0.02	0.01	0.01
Maximum	0.56	0.36	0.36	0.26	0.54	0.25	0.76

The range attributes together with the CCSPS constants are the direct influences on the choice of choice sets. The six constants are relative to CCSPS1 which includes all elemental alternatives. These constants are all negative, suggesting that after accounting for the observed influences on choices and the correlated error structure, respondents are less likely to deem one or more alternatives as unacceptable.

At the elemental alternative level, we find that all of the pricing and cost attributes are statistically significant, as are three of the revenue allocation plans (namely allocation to public transport, roads, and reduced income tax relative to being contributed to general government revenue and to compensate toll road operators). We included a constant that accommodates the mean of the unobserved effects associated separately with the cordon-based and distance-based charging regimes, both being negative which indicates that, relative to the status quo, there are some unobserved influences that place downward press on utility and hence support for each of the pricing reforms. The dummy variable for whether there is support for a trial of the reform schemes is positive and suggests that support is strong.

Finally, the variance parameter estimates (essentially ‘variance of variance’ estimates) as error components are statistically significant for the status quo and distance-based charging regime, but not for the cordon-based charging regime, across the 12 elemental alternatives grouped by the initial alternative from which they were created for modelling. The significance of the error components suggests that the endogenous choice set model captures correlated and co-varying relationships due to the presence of a common alternative across candidate choice sets (which are only common in name but not in the influences in their utility expressions). In addition, the higher the mean parameter estimate, the greater the variance and hence smaller the scale associated with a particular set of alternatives. Thus, there appears to be greater variance heterogeneity associated with the status quo set.

A behaviourally more informative way of presenting the findings is through a set of direct elasticities which indicate the impact of a unit change in the level of an attribute on the probability of choosing a particular alternative conditional on a CCSPS and the probability of choosing a CCSPS (i.e., $\partial lnP_{in}/\partial lnx_{ikn}$). Selective elasticities of particular interest are summarised in Table 5. As point elasticities, they are only meaningful for relatively small changes in an attribute’s level.

Beginning with the range attributes, these attributes relate to context dependency and are relatively inelastic. For example, the range of the user charges (toll in SQ and cordon-based and distance based charges) has elasticities which vary from -0.20 (CB7) to 0.53 (CB3). This suggests, for example, that a 10 percent increase in the range of the offered costs, *ceteris paribus*, will produce a 2.0 percent decrease in the probability of a respondent choosing the cordon-based charging scheme in a choice set where the acceptable alternatives are the cordon-based charge and a distance-based charge. In the choice set in which all alternatives are acceptable, we see a 1.9 percent increase in the probability of a respondent choosing the cordon-based charging scheme; however this increases to 5.3 percent where the only acceptable alternative is the cordon-based charge (CCSPS3).

The other attributes that are associated with the choice of choice sets are personal income, and age. *Ceteris paribus*, a 1 percent increase in personal income, results in a reduction in the probability of choosing an alternative associated with full choice set, with this being 0.42, 0.39 and 0.36 respectively for the SQ, CB and DB alternatives. In the choice set in which CB and DB are acceptable this becomes a positive effect, with a 1 percent increase in personal income resulting in a 0.80 and 0.87 increase in the probability of choosing the CB and DB alternatives respectively.

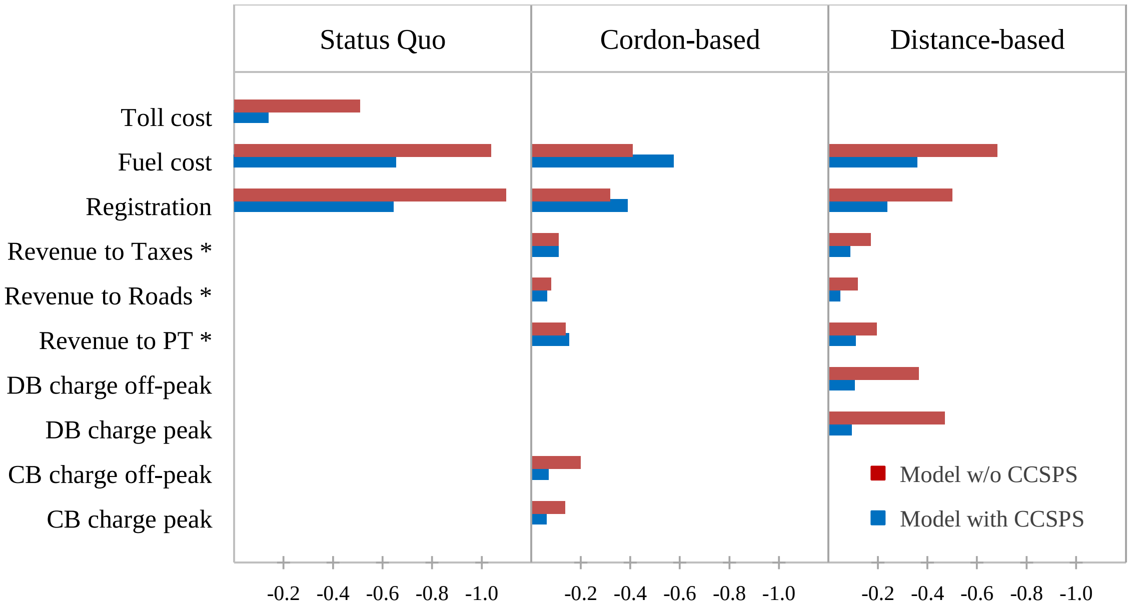
Table 5 Mixed Logit direct elasticities (choice probability weighted across the sample)

Attribute	**SQ1**	**SQ2**	**SQ5**	**SQ6**	**CB1**	**CB3**	**CB5**	**CB7**	**DB1**	**DB4**	**DB6**	**DB7**
Range of Toll+CBC+DBC	0.22	-	0.05	0.03	0.19	0.53	0.36	-0.20	0.10	0.04	-0.10	-0.19
Range of registration charge	0.46	-	0.04	1.04	0.53	-0.05	-0.05	0.43	0.48	0.15	0.69	0.50
Cordon-based charge – peak	-	-	-	-	-0.09	-0.08	-0.07	-0.08	-	-	-	-
Cordon-based charge – off peak	-	-	-	-	-0.10	-0.10	-0.09	-0.08	-	-	-	-
Distance-based charge – peak	-	-	-	-	-	-	-	-	-0.19	-0.12	-0.15	-0.16
Distance-based charge – off peak	-	-	-	-	-	-	-	-	-0.23	-0.14	-0.17	-0.18
Revenue allocated to Public transport	-	-	-	-	0.22	0.21	0.19	0.17	0.22	0.20	0.19	0.19
Revenue allocated to Roads	-	-	-	-	0.09	0.09	0.08	0.07	0.09	0.08	0.08	0.09
Revenue allocated to reduced taxes	-	-	-	-	0.16	0.15	0.13	0.14	0.16	0.17	0.16	0.15
Awareness	-	-	-	-	0.61		-	0.69	0.54	-	-	0.82
Personal income	-0.42	-	-	-	-0.39	-	-	0.80	-0.36	-	-	0.87
Age	-2.12	-	-	-	-1.96	-	-	-	-1.79	-	-	-
Registration	-1.15	-0.99	-1.05	-1.22	-0.60	-0.53	-0.49	-0.43	-0.47	-0.38	-0.41	-0.41
Fuel cost	-1.02	-1.01	-1.22	-1.09	-0.77	-0.82	-0.73	-0.68	-0.65	-0.56	-0.61	-0.68
Toll cost	-0.21	-0.21	-0.28	-0.21	-	-	-	-	-	-	-	-

A full set of direct elasticities are also provided at the choice of alternative level conditional on CCSPS (in contrast to choice of CCSPS). The cordon-based charging elasticity estimates are significantly more inelastic (i.e., -0.07 to -0.09) than the distance-based charges (i.e., -0.16 to -0.23). These results accord with the fact that the cordon-based charging is effective in the central business district whereas the distance-based charging is metropolitan wide. In order to get some idea about the behavioural implication of these findings, we contrast in Figure 5 the mean direct estimates derived from the model with (see Table 5) and without (see Table 6) CCSPS using the same data. The differences are quite marked, and with probability weighting for membership of each CCSPS, the mean estimates obtained when we allow for choice of choice sets are much lower than the model that assumes all alternatives are acceptable (i.e., model without CCSPS). This is a potentially important finding, suggesting that the mean elasticity estimates obtained from a model that does not account for candidate choice set processing strategies tends to produce higher behavioural sensitivity of the model to changes in levels of attributes of interest. However, by way of contrast, the relative direction is far less clear for earmarking of revenue allocation, with the evidence suggesting a slightly weaker response for a distance-based charge when allowing for CCSPS. The fuel cost and registration fee sensitivity is much lower for the status quo and DB under the model with CCSPS but the reverse is true for the CB charge, albeit to a much lesser extent. For the toll cost, when we account for choice of choice set we obtain a much lower (one-third) mean elasticity estimate.

Table 6 Mixed Logit direct elasticities (choice probability weighted across the sample) for the base model defined on the three elemental alternatives

Attribute	SQ	CB	DB
Cordon-based charge - peak	-	-0.136	-
Cordon-based charge – off peak	-	-0.198	-
Distance-based charge - peak	-	-	-0.470
Distance-based charge – off peak	-	-	-0.364
Revenue allocated to Public transport	-	0.138	0.195
Revenue allocated to Roads	-	0.080	0.118
Revenue allocated to reduced taxes	-	0.110	0.170
Registration	-1.099	-0.318	-0.498
Fuel cost	-1.037	-0.409	-0.680
Toll cost	-0.509	-	-



*Note: * Sign of elasticities is reversed for graphing*

Figure 5 Direct elasticity contrast: model with and without candidate choice set processing strategy

5. Conclusions

The objective of this paper is to show how additional information on the perceived acceptability of an alternative, aligned with the literature on consideration sets, can be used to inform the relevance of specific choice sets that respondents find acceptable (up to a probability), given an imposed or offered set in a stated choice experiment. We use a random utility maximisation mixed logit error components model to consider the role of context-dependency, amongst other possible effects, in influencing the acceptable alternatives processed by the respondent.

An endogenous choice set model is estimated with the response being the best alternative out of the set of all acceptable alternatives (i.e., the choice set processed by respondents). A suite of elasticities offer behaviourally rich evidence on the sensitivity of behavioural responses to changing attribute levels when account is taken of the probability of subsets of alternatives being chosen in eliciting preferences for specific alternatives, given the acceptability or otherwise on each alternative in the full set of fixed offered alternatives common in stated choice experiments.

The empirical study which analyses the level of support for road pricing reform from car commuters, illustrates how researchers can take the imposed set of alternatives offered in a stated choice experiment, and use an acceptability response as a candidate choice set processing strategy to identify which set of alternatives are processed as the considered choice set. We found that accounting for the consideration sets of alternatives (akin to choice set generation) results in varying sensitivities to changes in attribute levels which differ from the findings when the choice of choice sets is not taken into account. The value range of various attributes was also found to influence the acceptability of different alternatives. The evidence suggests that the attribute dimensionality across the choice sets and within choice sets (i.e., the context-dependent effects) has a statistically significant role in sanitising the full choice set offered.

While we cannot conclude that the mean elasticity estimates obtained when we account for an acceptability response (treated as endogenous) are preferred over other estimates that might be obtained using other rules or assumptions, if we believe that this is useful additional information that has some intuitive appeal in informing the analyst on how respondent's make choices (in real or hypothetical settings), then the evidence might have enriched behavioural relevance. What we can claim is that there is a growing body of literature that questions the imposition of full attribute and alternative relevance associated with choice scenarios designed as part of choice experiments and imposed on respondents as if all matters in choice making and preference revelation. If as a consequence of road pricing reform, for example, we find that the behavioural responses identified through direct elasticities for specific attributes vary across subsets of alternatives that define the choice making set, then this suggests that there are segmentation effects (or heterogeneous responses conditioned on relevant choice sets) that should be recognised, and the evidence herein hints that this does make a difference to the overall behavioural response (once the incidence of membership of each segment is known). What we have is a potentially important additional candidate criterion for segmenting markets just like we do with trip purpose, time of day, income, trip length and the like.

The evidence and approach set out in this study suggests that there is likely to be significant value in including an additional question in choice studies that is designed to establish the perceived acceptability of each alternative presented in stated choice studies[9] (along the lines of consideration sets that precede choice sets). The response to such a question might be expected to better inform model estimation as to the set of alternatives that are likely to matter to decision makers in a way that can enrich the behavioural responses obtained from each choice set segment and overall.

The extent to which the identification of a choice set actually processed by each respondent increases model performance, behavioural response validity and hence prediction, constitutes a fruitful area for ongoing research. Testing the ideas in this paper using other data sets will provide further evidence of the value of this approach to identify respondent-specific choice sets where the initial set is imposed by the analyst, typically through a stated choice experiment.

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[9] The support for such an additional question is also given in Hensher and Rose (2012), Rose *et al.* 2015 and Hess *et al.* (in progress).

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