



Improving choice model parameter estimates by jointly modelling the SP choices with corresponding elicited certainty ratings



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ABSTRACT

The paper proposes a closed-form econometric model of joint SP choices and corresponding elicited certainty ratings. The connection between the SP choices and corresponding elicited certainty ratings is modelled through an entropy-based measure of SP choice task complexity. Empirical applications of the proposed model are presented by using two SP survey datasets collected in Vancouver and Toronto. Empirical models reveal that the SP choice task complexity, measured through SP choice entropy, directly influences SP certainty ratings. Such direct relationship proves to be important through establishing an endogenous relationship between them. It is clear that capturing such endogeneity improves the efficiency of parameter estimates of the SP choice model. However, the level and extent of such benefit gains vary by the nature and complexity of the SP survey. Empirical investigation presented in the paper proves that both efficiency gain and higher goodness-of-fit are probable with the choice contexts with higher number of choice alternatives. However, even for the smaller number of choice alternative case, efficiency in parameter estimates can be increased by proposed joint model formulation.

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1. Introduction

Stated Preference (SP) survey or SP experiment is now an unavoidable tool for investigating consumer behaviour in many circumstances (Carson and Louviere, 2011). Such investigations include uncovering apparently obscure marginal rate of substitutions of different product attributes and understanding demand of new product/choice alternatives. Application of the SP survey in transportation planning and travel demand modelling is now widespread and widely accepted. Our increasing reliance on SP to investigate consumer choice behaviour demands realistic depictions of choice scenarios in SP experiments. To some extent, the validity of any SP survey depends on how consistent the stated choices are compared to the actual choices of similar types in similar real contexts.

Since SP surveys deal with hypothetical scenarios, there is always a dilemma in using SP data because of the inherent uncertainty of hypothetical choices. From a respondent's point of view, such uncertainty stems from the apparent hypothetical nature of the experiment, where the respondent will not experience the immediate outcome of the choices. So, the choice modellers need to worry about the extent and nature of such uncertainty perceptions of the respondents that eventually affect the quality of data. A direct way of measuring such uncertainty is collecting respondent-elicited certainty ratings

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of their SP choices. Respondents can elicit their certainty through a Likert scale after each SP choice task. Efforts to improve the SP choice model parameter estimates through the exploitation of elicited certainty ratings are evident in the literature. However, concrete evidence of the nature and extent of such improvement on choice model parameter estimates is not yet fully clear yet.

To contribute to this topic, this paper proposes a joint econometric model for SP choice and corresponding elicited certainty ratings. Considering that the elicited certainty ratings are observed outcomes of a latent perception of SP choice task complexity, it uses SP choice entropy as a measure to establish the link between the SP choices and corresponding perception of certainty of the choice makers. Allowing unrestricted correlations between the SP choices and the corresponding elicited certainty rating, the proposed model allows investigating the ways to improve the SP choice model parameter estimates. Two empirical applications of the model are presented by using two datasets collected in Toronto and Vancouver.

The paper is organized as follows: Section 2 presents a brief literature review on the role and use of elicited certainty rating. Section 3 presents the econometric modelling frameworks. Section 4 presents a brief description of the datasets used for empirical investigations. Section 5 presents the discussions on empirical models. Finally, the paper concludes with a summary of key findings and recommendations for further research.

2. Literature review

A vast amount studies on various aspects of SP survey are documented in the literature. [Rose and Bliemer \(2009, 2013\)](#), [Louviere et al. \(2010\)](#), [Hensher and Ho \(forthcoming\)](#) are some recent examples that present comprehensive reviews of various aspects of SP surveys including scenario design methods, sample size determination, non-attendance, etc. However, the research on the potential use of users' perceived certainty (of SP choices) information is relatively new even though the preference uncertainty in SP surveys has been a recognized area of interest for a long time. Preference uncertainty in SP surveys has always been a concern in non-market valuations or welfare analysis in environmental economics ([Shaikh et al., 2007](#)). So, most of the approaches of uncertainty elicitation and usage of certainty rating information to reduce biases in SP survey are primarily for binary discrete choice experiments or contingent valuation studies. In many cases, these are difficult to generalize for multi-alternative SP contexts ([Dekker et al., 2016](#)). However, recent advances in multi-attribute and multi-alternative SP experiments reignited interests in elicitation of preference uncertainty in SP experiments and the use of such elicited information in improving SP choice models.

Elicitation process of SP choice (un)certainly has long been debated by the researchers. [Manski \(1995, 1999\)](#) suggested direct questions for the respondents to elicit (as a percentage or likelihood of) their probabilistic assessment of hypothetical preferences. [Bemmaor \(1995\)](#) argues that uncertainty elicitation should not be so strict in terms of continuous percentage or likelihood-based assessment, and suggested that it should be qualitative in nature, e.g., “very certain,” “probably not,” “certainly not,” etc. [Li and Mattsson \(1995\)](#) used the continuous certainty measure (as percentage 0–100%) for the elicitation of contingent valuation choices. They assumed that the respondents know their true preferences and hence can be very certain in eliciting certainty in percentages. They used a threshold for the elicited certainty to further strengthen/correct the yes/no responses to the hypothetical choice tasks and thereby adjusted their choice model parameter estimates. A criticism of continuous scale is that the assumption of accurate knowledge of preferences of respondents is a very strong assumption. Also, using elicited responses to further modify SP choices is very arbitrary. [Ready et al. \(1995\)](#), [Loomis and Ekstrand \(1998\)](#) and many others used qualitative measures for certainty-rating elicitation of their willingness-to-pay study. [Hanemann et al. \(1995\)](#) recommended the procedures of collecting respondent's perception of uncertainty in the form of interval scale than in the form of strict numbers.

In general, elicited certainty ratings of SP experiments are procedural invariants that capture choice task complexity of SP choice tasks ([Brouwere et al., 2010](#)). However, preference uncertainty contributes to a big portion of hypothetical biases in SP choice experiments ([Champ and Bishop, 2001](#)). In practice, both qualitative and quantitative ratings of SP choice certainty are used and often such information are used directly or indirectly in the investigation of SP choice data. One common way of incorporating such elicited certainty ratings into the SP choice models is applying a threshold of certainty to screen out similar response data to the model. Such practice of considering threshold to screen out similar response data is to eliminate SP choices that have very low certainty ([Champ et al., 1997](#); [Ethier et al., 2000](#); [Champ and Bishop, 2001](#); [Lundhede et al., 2009](#)).

However, [Noreheim \(2001\)](#) argues that scrapping of low- certainty SP choices in order to remove outliers from the SP data are counterproductive as low- certainty responses are not necessarily wrong choices. In fact, low- certainty choices reflect the respondent's ambivalence to the choice tasks because of the task complexity, and [Arentze et al. \(2003\)](#) found that choice task complexity may not always affect the quality of SP survey data. Obviously, the definition of ‘data quality’ is a subjective issue and difficult to generalize. However, [Caussade et al. \(2005\)](#) and [Olsen et al. \(2011\)](#) found that choice complexities, resulting from combinations of SP choice attributes and their levels, affect choice variance or consistency. [Shaikh et al. \(2007\)](#) report that accommodation of uncertainty in the choice model may result in better goodness-of-fit of the choice model, but also introduce additional variance. So intuitively, it would be better using the elicited certainty ratings into the SP choice model estimation process to reflect the choice uncertainty into the choice model parameter estimates. [Lundhede et al. \(2009\)](#) investigated various ways of accommodating respondents' elicited SP certainty ratings. They found that specifying choice model scale parameters as a function of elicited choice uncertainty (certainty rating) may not improve

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