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A cognitive psychological approach of analyzing preference uncertainty in contingent valuation

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Abstract

The sources of preference uncertainty in contingent valuation (CV) studies have rarely been investigated from a theoretical standpoint. This paper proposes a holistic theoretical framework of preference uncertainty that combines microeconomic theory with the theories of cognitive psychology. Empirical testing of the proposed theoretical model was carried out in Australia in the context of a national 'Carbon Pollution Reduction Scheme (CPRS)' to be introduced in 2010. Two separate ordered probit models for a certainty score associated with CV 'Yes' and 'No' responses were estimated. The results of the estimated regression models provide evidence supporting the hypotheses drawn from the theoretical model.

Key words: Contingent valuation, preference uncertainty, cognitive uncertainty, climate change, Australia

1. Introduction

Empirical evidence in the contingent valuation (CV) literature over the past 15 years suggests that respondents are uncertain about their responses (Ready et al., 1995; Champ et al., 1997; Alberini et al., 2003). Hanemann et al. (1996) proposed a welfare model that incorporates an element of uncertainty in behavioral intentions and individual responses to hypothetical or experimental market situations. Hanemann et al. (1996) argued that individuals do not necessarily know their true willingness to pay (WTP*) for a good with certainty. Rather, they perceive that the true value of the good lies within an interval {WTP*- δ, WTP* + δ} where 'δ' refers to the unknown component of preference (δ>0). Building upon the framework proposed by Hanemann et al. (1996), Li and Mattsson (1995) extended the theory of preference uncertainty by defining preference uncertainty as a stochastic error term. Li and Mattsson (1995) argued that ignoring preference uncertainty in stated preference studies may result in measurement bias and they, therefore, proposed a numerical scale to measure uncertainty in preferences.

According to the utility difference model proposed by Hanemann (1984), a respondent agrees to pay if at a certain bid level (BID), the deterministic utility from obtaining an environmental good (V=1) by paying BID exceeds the base line utility from not obtaining the good (V=0) by more than the difference in the stochastic part of utility ($\varepsilon^1 - \varepsilon^0$), i.e.

$$\Delta V = V^1(V = 1,\ Y - BID) - V^0(V = 0,\ Y) > \varepsilon^1 - \varepsilon^0 \qquad (1)$$

where ΔV represents the change in utility between the baseline (V^0) and the provision of environmental good (V^1) and Y is income. Maximum WTP (MAX WTP) is an amount that makes the respondents indifferent between V=1 and V=0 by setting ΔV=0. Loomis and

Ekstrand (1998) argued that the level of individual preference uncertainty is determined by the magnitude of difference between the deterministic and the stochastic parts of the utility difference function. The greater the proximity of the stochastic part to the deterministic part, the higher is the experienced uncertainty in respondent preferences. When BID is substantially lower or substantially higher than the MAX WTP, the deterministic part $(V^1(V=1,\ Y-BID)-V^0(V=0,\ Y))$ would exceed the stochastic part $(\varepsilon^1-\varepsilon^0)$ of the utility difference function in Equation 1 by a sufficiently large amount to make the respondents feel certain about their answers. On the other hand, when BID is close to the MAX WTP, the difference in the deterministic part of utility would be close in magnitude to the difference in the stochastic part of utility, making the respondent uncertain as to whether they would answer 'Yes' or 'No'. This proposition closely corresponds to Wang's (1997) argument that respondents experience the highest level of uncertainty at the middle bid and relatively lower level of uncertainty at high bid and low bid. In essence, these propositions suggest that the relationship between BID and preference uncertainty is quadratic function, i.e. *ceteris paribus*, as bid level increases, preference uncertainty increases; preference uncertainty reaches at a maximum point at middle bid level and falls as bid level continues to increase.

There is limited empirical evidence (Champ and Bishop, 2001; Samneliev et al., 2006; Akter et al., forthcoming) to support the quadratic relationship hypothesis and theoretical development of the concept of preference uncertainty has not progressed beyond this point. The explanatory variables that have been included in the econometric models aimed at explain variations in preference uncertainty have been more intuitive than theoretically based. This study proposes a theoretical framework to underpin the sources of preference uncertainty in CV studies. Psychological theories explaining cognitive uncertainty are used as a basis to develop the

theoretical model. Empirical testing of the proposed theoretical model was carried out in Australia in the context of a national 'Carbon Pollution Reduction Scheme (CPRS)'. About 300 households were asked for their willingness to bear extra household expenditure to support the CPRS using a single bounded dichotomous choice (DC) elicitation format. A post-decisional confidence rating scale, first constructed by Li and Mattson (1995), was used to measure the level of uncertainty experienced by the respondents while answering the DC WTP question. Two separate ordered probit regression models on the 'Yes' and 'No' responses were estimated to test the theoretical model outlined in the paper.

The next section of the paper provides a review of the preference uncertainty literature followed by a discussion of theories in cognitive psychology in Section 3. A description of the case study and a discussion of the survey results are provided in Section 4 and Section 5 respectively. Section 6 discusses the empirical findings and Section 7 concludes.

2. Literature review

In this section the results of econometric models estimated to establish a causal relationship between the levels of preference uncertainty and one or a group of theoretically and intuitively expected explanatory variables are discussed. To date, four studies have estimated a preference uncertainty model by regressing the self reported certainty scores against explanatory variables. Loomis and Ekstrand (1998) estimated an ordinary least square regression model on pooled (both 'Yes' and 'No' responses) data. Champ and Bishop (2001) and Akter et al. (forthcoming) estimated ordered probit regression models whereas Samneliev et al. (2006) estimated two logistic regression models separately for 'Yes' and 'No' responses.

Loomis and Ekstrand (1998) conducted a mail survey of 1600 US households where respondents were asked to indicate their WTP for preserving the Mexican Spotted Owl and its critical habitat. A follow-up DC certainty scale was used to elicit respondents' levels of certainty regarding their responses to the WTP question. The authors found a quadratic relationship between the self reported certainty levels with the bid levels. This implies that, *ceteris paribus*, at low and high bids respondents were more certain about their responses and less certain at the intermediate bid levels. Furthermore, Loomis and Ekstrand (1998) found statistically significant, positive relationships between certainty scores and respondents' prior knowledge about the particular endangered species and their visiting the area proposed for protection.

The studies by Champ and Bishop (2001) and Samneliev et al. (2006) failed to provide similar empirical evidence. Instead they indicate that self reported certainty scores reflect respondents' attitudes towards the hypothetical market (a form of protest response). Champ and Bishop (2001) examined household preferences for a voluntary wind energy program provided by a local private electricity utility by surveying 2,500 of their customers. Like Loomis and Ekstrand (1998), a follow-up DC certainty scale was applied to measure the level of certainty. Respondent perception of and attitude towards the proposed program were found to be responsible for the observed variation in the self-reported certainty scores. Respondents in favour of the program and willing to pay the extra cost expressed higher certainty levels than other respondents. Samnaliev et al. (2005) asked 1,600 households in New Hampshire and Idaho for their preferences for paying a user fee to access public land. The same follow-up DC certainty scale was used to measure respondents' levels of certainty about their decision to pay. Similar results were found in this study to those of Champ and Bishop (2001). Respondents who objected against the imposed user fees in principle were more certain in rejecting the bid than others,

reflecting respondent general attitude towards the hypothetical market, usually referred to as protest response in CV.

Akter et al. (forthcoming) conducted a double bounded CV study where more than 400 air travel passengers from around the world were interviewed face-to-face at Amsterdam Schiphol airport about their preferences for a tree plantation program to offset their contribution to greenhouse gas emissions. A five category polychotomous choice question format (Extremely unlikely, Fairly unlikely, Not sure, Fairly likely, Extremely likely) was used to ask the respondents if they would actually pay the stated WTP value should the carbon travel tax be voluntary. The authors find a significant negative relationship between start bid and the stated likelihood of paying a voluntary tax. This finding partly supports Loomis and Ekstrand (1998)'s proposition regarding the bid level being a source of preference uncertainty. However, no significant quadratic effect was detected as suggested by Loomis and Ekstrand (1998). The study, furthermore, provides evidence which supports the relationship between respondent attitudes, perceptions and stated likelihood of paying which is consistent with the findings reported by Champ and Bishop (2001) and Samnaliev et al. (2005). A respondent's perceived individual responsibility for contributing to climate change, attitude towards paying to protect the environment and belief in the effectiveness of the proposed tree plantation program on climate change mitigation were found to be the main sources of stated uncertainty.

3. Development of a theoretical preference uncertainty model

3.1 Theories in cognitive psychology

A theoretical model of preference uncertainty is proposed in this section which builds upon the empirical results discussed in the previous section. The concept of 'preference uncertainty' is defined here as a form of cognitive uncertainty. Cognitive uncertainty refers to agents' lack of confidence about the validity of the results of their own information processing (Clausing, 2000). More specifically, it refers to uncertainty due to possible errors in the cognitive processes of the problem solver in the human neuro-cognitive system that produces information for decision making (Schunn et al., 2000). The cognitive information processing model proposed by Hogarth (1987) describes how decision makers encode, store, transform, and retrieve information before generating a response. After an agent receives information from an external source, the information is first extracted, encoded, stored and transformed into memory and then retrieved from memory to take the necessary course of action (Hogarth, 1987). The end outcome of this cognitive procedure is a 'decision'. Errors occur during these phases of translating information into decision action which in turn gives rise to uncertainty about the final decision (Schunn et al., 2000). These errors are due to inherent limits of human cognition.

Chaiken's (1980, 1987) Heuristic-Systematic Model (HSM) of information processing provides more insight of the sources of errors. According to HSM, information processing may follow two fundamental modes, namely heuristic and systematic. Heuristic information processing involves the use of simple decision rules for judging information while systematic information processing involves a comprehensive effort to scrutinize, analyze and understand information. The key aspect of heuristic information processing is the idea that relatively simple heuristics, e.g., previous knowledge or attitude, can be useful ingredients in reaching a quick, low-cost decision especially when the decision maker is dealing with complex, uncertain, or unfamiliar situations

(Chaiken et al., 1989). Essentially, systematic processing requires more cognitive capacity than heuristic processing and therefore, systematic processing is assumed to be generally more effective in reducing errors occurring at the information processing stages than heuristic processing (Zuckerman and Chaiken, 1998). Systematic information processing occurs when an individual possesses adequate levels of cognitive capacity and motivation (Chaiken et al., 1989) whereas reliance on heuristic process increases under time pressure and lack of prior experience with the decision context (Ratneshwar and Chaiken, 1991).

3.2 Preference uncertainty in CV

In the light of this cognitive psychology theory, a theoretical model of preference uncertainty can be constructed in the form presented in Figure 1. In a CV study, a respondent is presented with a hypothetical valuation framework where they are provided with information about the current condition of a non-market good, the potential deterioration of the state of the good if no future action is undertaken and a monetary cost of the potential action to be borne by the respondent in conjunction with the community or the society. In some instances, the information supplied to the respondent may be more complex if the valuation framework involves a provision rule, cheap talk script or more than one possible future scenario. Upon receipt of the potentially large volume of information, the respondents engage in the cognitive procedure of translating the information into a WTP choice.

INSERT FIGURE 1 HERE

As the psychological literature suggests, errors are inevitable during the translation process and therefore, respondents are not expected to be fully confident of their final choice. Preference uncertainty is a positive function of these errors. The more errors experienced by the respondents during the information processing stage, the lower is expected to be their stated certainty score. However, the magnitude of the errors, and therefore the level of preference uncertainty, depends on the information processing mode used by the respondents. Theory suggests that when an individual has little experience or knowledge about the topic at hand (Wood et al., 1985) or is under time pressure (Ratneshwar and Chaiken, 1991), the heuristic mode will dominate over the systematic mode. A CV context involves limited or no prior purchase experience with the good and very few if any market signals are available during the survey. In particular, a DC elicitation format does not offer the repetition, learning and experience possibilities of real markets which Bateman et al. (2004) consider as a contradiction of the Discovered Preference Hypothesis (DPH) (Plott, 1996). The central argument of the DPH is that decision makers gain experience through practice and repetition which in turn helps to formulate stable and theoretically consistent preferences. Furthermore, in some CV studies, the good in question is intangible (for example protection of a rare bird species in a distant location, mitigation of climate change). As a result, systematic information processing is less plausible in CV studies. Respondents who take part in CV surveys, therefore, predominantly tend to rely on heuristic information processing mode to reach a decision (Bateman et al., 2004).

Empirical studies suggest that respondents use bid level, attitudes and prior experience as heuristics to process information (Loomis and Ekstrand, 1998; Champ and Bishop, 2001; Samneliev et al., 2006; Akter et al., forthcoming). Bid level serves as an important information

processing heuristics within the decision making framework of a CV study. Microeconomic theory suggests that an individual decides to purchase a good when the marginal cost of the outcome is less than individual's expected marginal benefit (WTP*). A sufficiently high or low bid serves as guidance for respondents, i.e. for a 'Yes' response, Bid – WTP* $< \pm\delta$ and for a 'No' response, Bid – WTP* $> \pm\delta$ where 'δ' refers to the unknown component of preference ($\delta>0$). Therefore, the higher (lower) the offered bid level, the lower is the error (lower preference uncertainty) for a 'No' ('Yes') response.

Respondents' attitudes towards the valuation problem in question can guide the conceptual cognitive processes by determining the decision to be taken. This process is known as an 'attitude heuristic' in the psychology literature. It refers to a decision rule that uses an evaluative relationship as a cue in the problem solving strategy (Pratkanis, 1989). A positive attitude towards an issue invokes a decision in favour of the policy (a 'Yes' response) whereas a negative attitude influences rejection (a 'No' response). However, respondents can hold both positive and negative evaluation of a given attitude object at the same time (Kaplan, 1972), a state known as 'ambivalence' in the psychology literature. Ambivalence is resolved by focusing on one side of the evaluative conflict (Nordgren et al., 2006) or by making a choice between the opposing behavioral beliefs. However, dissonance[1] – a state of psychological discomfort – can occur after the ambivalent attitude holder makes a decision. Festinger (1964) argued that after making a decision, individuals tend to focus their attention on the unfavorable aspects of the chosen alternative and on the desirable aspects of the rejected alternatives. People experience dissonance especially when they feel responsible for the negative consequences of their behavior (Scher and

[1] The difference between ambivalence and dissonance is that the former is a pre-decisional phenomenon, while the later concerns post-decisional conflict between attitudes and behavior (Harreveld et al., 2009).

Cooper, 1989). Dissonance is expected to manifest itself in the information processing errors. More specifically, in the presence of ambivalence, net errors occurring from the information translation process are expected to be higher and vice versa.

In summary, we argue that preference uncertainty is a form of cognitive uncertainty where cognitive uncertainty refers to individuals' lack of confidence about their decisions. Such uncertainty (or lack of confidence) arises in CV responses due to errors occurring at various stages of the cognitive information process. In a conventional CV survey, respondents tend to employ some common heuristics, e.g. bid level (BID), attitude (ATT), experience (EXP)/knowledge (KNOWD), to minimize errors and attain higher levels of certainty (C) about their decisions. The presence of ambivalent attitudes (AMB) contributes to the errors and invokes dissonance, therefore, lowering stated certainty scores. The argument can be summarized in the form of the following equation:

$$C = \alpha + \beta_1 BID + \beta_2 ATT + \beta_3 EXP + \beta_4 KNOWD + \beta_5 AMB \qquad (2)$$

where α is constant, β_i s are regression coefficient.

In this model, the sign of β_1, the coefficient of BID, is expected to differ for 'Yes' and 'No' responses. For 'Yes' certainty scores, β_1 is expected to be negative (higher the bid level, lower is the certainty score of a 'Yes' response) whereases for 'No' certainty scores, the sign of β_1 is expected to be positive (higher the bid level, higher is the certainty score of a 'No' response). For estimation purpose, we define ATT (attitude) as a set of beliefs and perceptions held by the decision makers that is consistent with the DC CV decision (a 'Yes' or a 'No' response). Likewise, AMB (ambivalence) is defined as a set of beliefs and perceptions that is contradictory

to the decision made by an individual in a DC CV framework. Therefore, the null and alternative hypotheses to be tested in the paper in relation to ATT and AMB can be written in the following forms:

$H_0 : \beta_2 \leq 0$ and $H_A : \beta_2 > 0$

$HH_0 : \beta_5 \geq 0 \, and \, H_A : \beta_5 < 0_0 : \beta_5 \geq 0$ and $H_A : \beta_5 < 0$

Prior knowledge and experience of the good being valued are expected to be positively related to stated certainty scores. Thus:

$H_0 : \beta_3 \leq 0$ and $H_A : \beta_3 > 0$

$H_0 : \beta_4 \leq 0$ and $H_A : \beta_4 > 0$

4. Case study description

The case study selected involves an investigation of Australian households' preferences towards the occurrence and mitigation of anthropocentric climate change. As part of fulfillment of its Kyoto protocol obligations, the Australian Government has recently proposed a national emissions trading scheme known as the Carbon Pollution Reduction Scheme (CPRS). The aims of the CPRS are to reduce emissions by 60 per cent of the 2000 level by 2050 and to encourage the development and use of emission free technologies (Department of Climate Change, 2008). The implementation of the CPRS will affect Australian households as the prices of a wide range of emission-intensive goods and services are expected to rise. The case study aimed to explore Australian households' willingness to bear extra expenses to support the CPRS.

A web-based CV survey was conducted with 300 respondents in Sydney from the third week of November 2008 until the first week of December 2008. In total, the questionnaire consisted of 35

questions. The questionnaire was primarily developed based on a series of focus group discussions with up to 12 participants in each session. During the first focus group, participants were asked to provide feedback on the level of comprehensibility of the information provided in the questionnaire. Participants, were furthermore, asked if the questionnaire appeared to be biasing their responses. Based on the feedback received from the first focus group, the questionnaire was revised and tested in a second round of focus groups. Before pilot testing, the questionnaire was sent to two climate change policy experts[2] in Australia in order to ensure that the information included in the questionnaire was consistent with existing scientific knowledge and policy prescriptions.

In the valuation part of the questionnaire, respondents were asked if they would be willing to bear extra expenses per month on behalf of their household to support the CPRS. Increases in the prices of goods and services were used as a payment vehicle. Eight different bids ranging from AUS$20 to AUS$400 per month per household were randomly assigned across the respondents. These bid amounts were selected based on responses obtained from an open-ended WTP question during the first round focus group. The bid amounts were tested in a second round of focus groups and a pilot survey. A follow-up numerical certainty scale (1-not at all certain to 10-very certain) was used to elicit respondents' levels of certainty about their decisions to pay (not to pay).

5. General survey results

[2] Dr. Frank Jotzo and Dr Stephen Howes are gratefully acknowledged for their inputs.

54 percent of the respondents participated in the online survey were female. The average age of the respondents' was about 34 years. One third of the respondents had completed university education, while another third had a trade certificate. The rest had completed high school. Over two thirds of the sample respondents were employed when the survey was conducted. Half of the employed respondents were working full time. Median yearly household income was within the range of AUS$67,600 to AUS$83,199 with about a quarter of the sample households earning more than AUS$104,000 per year. The sample median household income was higher than the true population median household income of AUS$57,600 per year (ABS, 2006).

Although over eighty percent of the respondents had heard of 'Kyoto protocol' and one third of them knew the protocol's objectives, a majority (82 percent) of the respondents had not heard of Intergovernmental Panel of Climate Change (IPCC). Over eighty percent of the respondents were familiar with the concept of 'carbon offset' while over ten percent of them purchased a carbon offset certificate. On average, respondents spent $85 on carbon offset certificate over the period of twelve months prior to the survey. Most of these offset certificates were purchased to counterbalance carbon footprints from air travelling (54 percent), followed by electricity consumption (43 percent) and use of motorized vehicle (16 percent).

Whilst more than half of the respondents (57 percent) had heard about the CPRS prior to the survey, a majority (83 percent) did not know when the CPRS would be implemented. Around two thirds of those who claimed that they knew when the CPRS would be implemented (5 percent of the total sample) could correctly indicate the proposed implementation year of the CPRS. Respondents' knowledge of the Kyoto protocol and the CPRS were positively correlated

(r=0.221, p<0.001) implying that respondents who were informed about the Kyoto protocol were also aware of the CPRS. Likewise, a low but statistically significant positive correlation was observed between respondents' knowledge of the CPRS and carbon offset (r=0.118, p<0.001). This implies that respondents who were familiar with carbon offset were also familiar with the CPRS.

When asking the respondents how concerned they were about the impact of climate change in Australia, less than a quarter (20 percent) of the respondents indicated that they were "highly concerned". The majority (40 percent) were "concerned". About a third of the respondents said that they were "somewhat concerned" while around ten percent of the respondents were "not so concerned" or "not at all concerned" about climate change. While the respondents were asked to rank five policy issues (climate change, education, health care, law and order and the economy) in Australia according to their level of relative importance, they personally attach to them, 12 percent of the respondents ranked climate change as the most important policy issue in Australia. About a third of the respondents indicated the economy is the most important policy issue whereas less than a third felt that health care facilities ought to be the top priority. Respondents' levels of concern about climate change and the level of relative importance they attached to climate change as a policy issue, as expected, were positively correlated (r=0.301, p<0.001). This implies that the respondents who were highly concerned about the impact of climate change in Australia attached a higher level of importance to climate change relative to other competing policy issues. Respondents varied in terms of their level of agreement with the statement that climate change is caused by human activities. Over a quarter (27 percent) of the respondents expressed strong agreement while almost half of the sample respondents (49 percent)

demonstrated a moderate level of agreement. Sixteen percent of the respondents neither agreed nor disagreed and the rest opposed the idea.

6. Results concerning to preference uncertainty

6.1 Uncertainty in preferences

About a third of respondents indicated the highest level of certainty (certainty score of 10) for their decisions while almost three quarters of the self-reported certainty scores were above five (on a scale of one to 10). Other empirical studies in the CV literature present similar evidence (Loomis and Ekstrand, 1998; Li and Mattsson, 1995; Samneliev et al., 2006). Samneliev et al. (2006) explain this tendency as respondents' attempts to avoid or deny self-contradiction or cognitive dissonance. Figure 2 depicts the distribution of self reported certainty scores across 'Yes' and 'No' responses. Over 40 percent of the respondents who said 'No' to the WTP question were very certain about their decisions as opposed to less than 20 percent of the 'Yes' respondents who were very certain. Hence, the respondents who replied 'No' to the WTP question stated significantly (Chi square=28.64, $p<0.001$) higher certainty scores than the respondents who replied 'Yes'. This finding is consistent with the findings of Loomis and Ekstrand (1998) where the authors showed that, in general, 'No' responses tend to be held with greater certainty scores than 'Yes' responses.

INSERT FIGURE 2 HERE

The distribution of certainty scores across bid levels was tested for both 'Yes' and 'No' responses. The self reported certainty scores equal to or below five for 'Yes' responses were

found to be significantly (Chi square=39.11, $p<0.08$) differently distributed across the bid levels, i.e., the lower the bid level the higher was the certainty score. No significant difference was observed in the certainty scores above 5 for a 'Yes' response and the bid level. A statistically significant linear association (r =0.13, $p<0.08$) was observed between the certainty scores of 'No' responses and the bid levels. This implies that, on average, respondents who were offered relatively higher bid level were significantly more certain about their decisions of not paying than respondents who were offered relatively lower bid level. Unlike the 'Yes' responses, no significant difference in the distribution of certainty scores for a 'No' response and the bid level was observed for certainty scores below or above five.

Respondents who stated a certainty score less than 10, were asked to indicate reasons for being uncertain about their responses in a follow-up question. The majority (31 percent) gave uncertainty regarding their future financial state as the reason for being uncertain about their decision. About a fifth of the respondents said that they preferred to reduce their carbon footprint by consuming less carbon intensive products instead of incurring extra household expenditure to support the CPRS. Eighteen percent of respondents indicated that they were not fully convinced about the success of the CPRS in mitigating climate change, seventeen percent expressed uncertainty about their future employment status and 11 percent indicated that they disliked the idea of placing a monetary value on climate change. Figure 3 presents the distribution of the reasons for being uncertain across 'Yes' and 'No' responses. A significantly larger proportion of respondents who declined to pay for the CPRS mentioned 'I am uncertain about my future financial state' (Chi square=3.57, $p<0.10$) and 'I did not like the idea of placing a monetary value on climate change' (Chi square=4.21, $p<0.05$) as reasons for the experienced uncertainty in

preference than respondents who said 'Yes' to the WTP question. No other statistically significant difference was observed across the 'Yes' and 'No' responses and stated reasons for not being fully certain.

INSERT FIGURE 3 HERE

The original 'Yes' responses were recoded based on four different certainty scale cut-off points, a calibration technique first used by Champ et al. (1997). Univariate logit WTP estimates obtained from different certainty scale cut-off points are presented in Table 1. Referendum CVM programs written by Cooper (1999) in GAUSS were used to estimate the Krinsky and Robb confidence intervals for the point estimates of mean WTP. As expected, the calibrated mean WTP values are substantially lower than the mean WTP without certainty calibration. Stepwise inclusion of the different certainty scale cut-off points yields mean WTP values which are 41 percent to 81 percent lower than the original DC mean WTP. The magnitudes of change in calibrated mean WTP values relative to the uncalibrated DC mean WTP estimates are consistent with the empirical findings summarized by Akter et al. (2008). The authors showed that eight point and ten point certainty calibrated mean WTP estimates were 39 percent to 86 percent lower than the uncalibrated mean WTP estimates (Akter et al., 2008). However, the range of efficiency loss as a consequence of certainty calibration observed in the current study (100% to 276%) is relatively larger than the range observed in other empirical studies (22% to 149 %) (Akter et al., 2008).

INSERT TABLE 1 HERE

6.2 Determinants of preference uncertainty

These stated certainty scores are ordinal as they show that one respondent is more (or less) certain than another respondent. They do not provide any information about how high or how low the certainty level of one respondent is relative to another. The ordered probit model, first introduced by McKelvey and Zavoina (1975), serves as an appropriate framework for statistical analysis in situations where the response variable is ordinal. An ordered probit regression model was estimated first using certainty scores of both 'Yes' and 'No' responses following the approach applied by Loomis and Ekstrand (1998) and Champ and Bishop (2001). A variety of explanatory variables reflecting respondents' attitude and perception towards climate change and climate change policy was included in the model using statistical backward and forward elimination techniques and trial and error. In view of the quadratic relationship hypothesis proposed by Loomis and Ekstrand (1998), the bid level and a squared term of bid were included in the model. However, no statistically significant effect could be detected for these variables on the self reported certainty scores in the pooled (for both 'Yes' and 'No' responses) model.

Two separate models for 'Yes' and 'No' responses were then estimated. This approach was first applied by Samneliev et al. (2006) where the authors estimated two separate binary logistic regression models for 'Yes' and 'No' responses (the dependent variable takes the value 1 if the certainty score for the 'Yes' or 'No' response equals 10, 0 otherwise). However, we applied ordered probit regression model following Champ and Bishop (2001). Tables 2 and 3 summarise the regression results for 'Yes' (n=102) and 'No' (n=204) responses respectively. In the 'Yes-certainty model' presented in Table 2, income, attitude and concern for climate change were found to influence the level of self reported certainty scores. This implies that, *ceteris paribus*,

respondents with higher income levels were more certain about their decisions to pay for the CPRS than other respondents. Respondents who believed that climate change is caused by human action and were highly concerned about the impact of climate change on Australia, on average, expressed higher levels of certainty scores about their decisions to pay than other respondents. 'BID' was not a significant factor.

INSERT TABLE 2 HERE

INSERT TABLE 3 HERE

In the 'No-certainty model' presented in Table 3, the coefficient of the variable BID, as hypothesised, is positive and statistically significant at the ten percent level. This implies that, *ceteris paribus*, the higher the bid level, the higher was the stated certainty scores for a 'No' response. The coefficient of the variable 'HUMAN' reflecting respondents' attitude towards climate change has, as expected, a negative sign. This implies that respondents who believed climate change is caused by human action but did not support paying for the CPRS, expressed lower certainty scores about their decisions.

Respondents' perceptions regarding the scale of climate change (measured through subjective best guess of temperature rise in future) was found to have a significant influence on the certainty levels of a 'No' response. Respondents, who stated relatively higher best guesses about change in temperature in 2100 relative to the current year, were less certain about their decisions of not paying for the CPRS. The relationship between the stated certainty scores and the scale of climate change is nonlinear as the square term of the expected best guess temperature rise is also statistically significant. The sign of the coefficients of the variable TEM_SQ imply that the certainty level of a 'No' response decreases at an increasing rate with the rise in best guess

temperature rise. The stated certainty score of a 'No' response, furthermore, was found to vary across perceived climate change impacts. Respondents who believed that climate change would cause loss of biodiversity (an indirect impact) expressed higher certainty scores about their decision to not pay whereas respondents who believed that climate change will cause severe water shortage (a direct impact) expressed lower certainty scores.

Finally, respondents' perception about the effectiveness of proposed policy intervention was found to be highly statistically significant in determining the stated certainty levels of 'No' responses. Respondents, who believed that the proposed climate policy will not be effective in curbing climate change, were significantly more certain about their decision to not pay than other respondents. This result corresponds to the findings documented by Akter et al. (forthcoming) where the authors found passengers' perception about the effectiveness of the tree plantation program positively influencing their self reported likelihood of paying for the voluntary carbon travel tax.

Although respondents' prior knowledge about the good being valued was expected to have a positive effect on respondent certainty (Loomis and Ekstrand, 1998), the coefficients of the variable CPRS (respondents' knowledge about the CPRS) were not statistically significant in any of the models presented in Table 2 and Table 3. It is important to note that none of the other CV studies except Loomis and Ekstrand (1998) found prior knowledge or experience to have statistically significant impact on the self reported certainty scores. Such an empirical result appears to be plausible because CV studies generally include an information section in the questionnaire containing key descriptions of the good being valued and the policy measures

under consideration. As a result, respondents may be equally informed about the good and the policy when they answer the WTP question.

7. Conclusions

It has been a decade since Loomis and Ekstrand (1998) presented their theoretical model of preference uncertainty where they described preference uncertainty as a function of the proximity or disparity between the deterministic and stochastic parts of the utility difference function. Loomis and Ekstrand (1998) further argued that a respondent's prior knowledge and experience of the good being valued significantly enhances the certainty level of their decisions. Empirical studies over the past decade have provided little evidence to support the propositions put forward by Loomis and Ekstrand (1998). Empirical results indicate that the variation in self reported certainty scores can be largely explained by respondents' attitudes towards the environmental problem and the proposed policy in combating the problem. However, to date, no attempt has been made to build a theoretical framework around these empirical findings. This paper offers a model that combines microeconomic theory with the theories of cognitive psychology. Preference uncertainty is defined as a form of cognitive uncertainty that arises from the errors that occur at various stages of the information translation process.

Like other empirical studies in preference uncertainty literature, the results of our study do not provide evidence in favour of Loomis and Ekstrand (1998)'s quadratic relationship hypothesis. We failed to find statistically significant relationship between the self reported certainty score and any of the theoretically or intuitively expected explanatory variables when a pooled model (certainty scores of both 'Yes' and 'No' responses were included as dependent variable) was

estimated. However, theoretically expected and empirically consistent results were found when the certainty scores for 'Yes' and 'No' responses were analysed separately. This implies that the underlying sources of preference uncertainty across 'Yes' and 'No' responses are different and therefore, more can be learnt if a separate estimation technique is applied instead of a pooled estimation technique.

Due to the limited number of observations in our data for the 'Yes' certainty scores, the results explain little of the sources of variation in the self reported certainty scores. Nevertheless, the results provide some evidence in favour of the hypotheses. The results of the 'Yes-certainty' model suggest that income, attitude and level of concern influence the certainty level of a 'Yes' response. Although the sign of the coefficient of the variable BID was negative reflecting what was theoretically expected, the relationship was not statistically significant. However, we find statistically significant negative relationship between bid level and certainty scores of a 'Yes' response below the five point certainty score. This provides some evidence in favour of the hypothesis that bid level and 'Yes' certainty scores are negatively related.

We find a statistically significant, negative relationship between bid level and certainty scores of 'No' responses. This implies that, *ceteris paribus,* the higher the offered bid level the higher was the stated certainty scores of a 'No' response. A statistically significant, positive relationship was found between the certainty scores of 'No' responses and respondents' levels of confidence about the effectiveness of the CPRS (an attitudinal variable). Respondents who believed that the CPRS will not be effective in mitigating climate change stated higher certainty scores of a 'No' response. The results of the 'No certainty' model, furthermore, showed evidence supporting the

ambivalence hypothesis. First, respondents who believed that climate change is caused by human action but did not support paying for the CPRS, stated lower certainty scores about their decisions. Second, respondents who stated higher subjective expectation of the extent of climate change (through 'best guess' future temperature) expressed lower certainty scores about their decisions of not supporting the CPRS. These results imply that when decision and attitude are consistent with each other, respondents are more confident about their decisions. To the contrary, when attitude and decision contradict each other, stated certainty scores of the decisions decrease.

In summary, we have used this paper to set out a holistic theoretical framework for analysing preference uncertainty in CV studies. We propose, through testing our own analytical model, that such a line of theoretical development is more relevant in underpinning the sources of preference uncertainty than the existing theories which have provided little empirical support of theoretical expectations to date. However, further research is warranted, particularly to investigate the 'Yes certainty' model more rigorously. The limited number of observations hindered thorough testing of the 'Yes certainty' model in this study.

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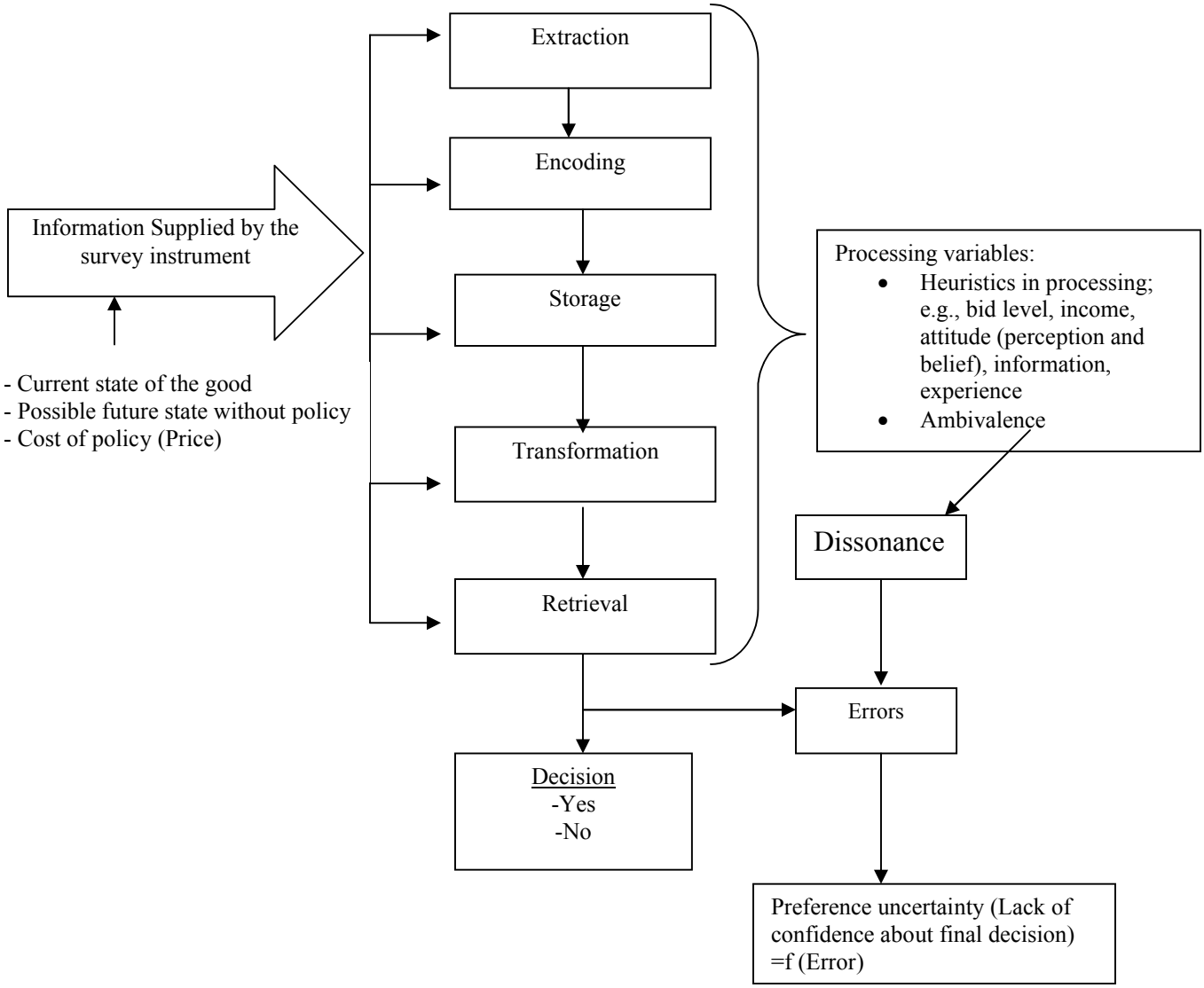
Figure 1 **Theoretical model of preference uncertainty.**



Source: Adapted from O' Reilly (1983) and Hogarth (1987).

Figure 2 **Distribution of the self reported certainty scores across 'Yes' and 'No' responses.**

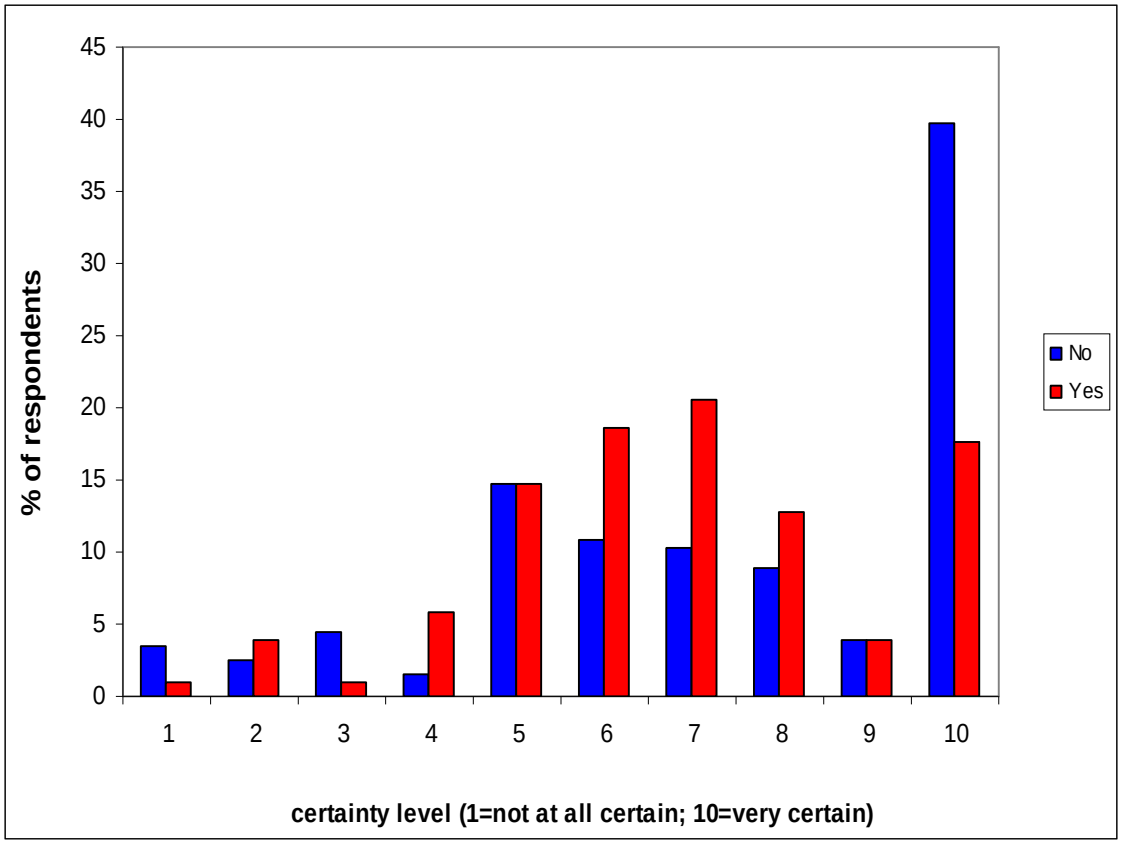


Figure 3 **Distribution of stated reasons of being uncertain across 'Yes' and 'No' responses.**

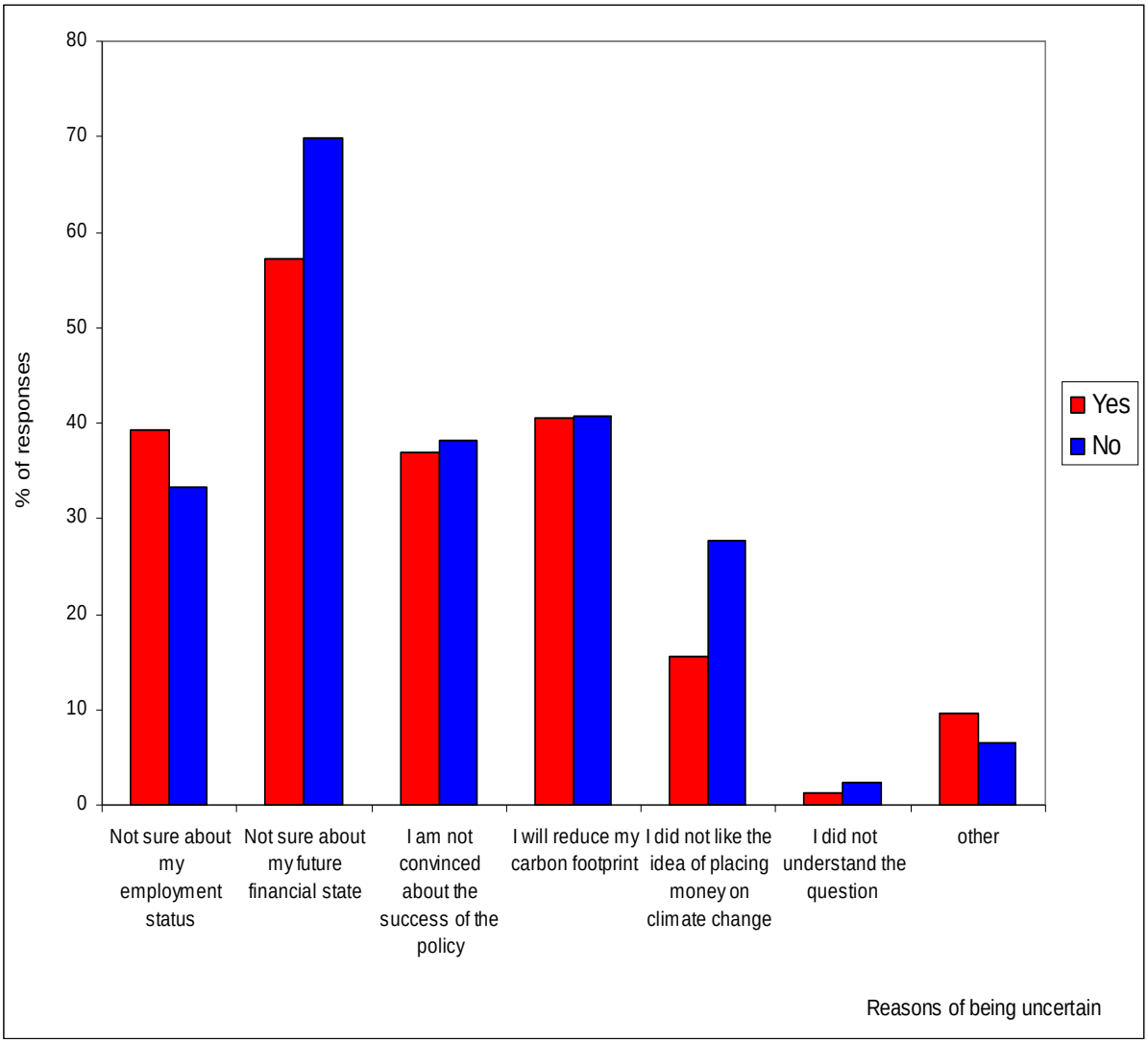


Table 1 **Mean WTP for the CPRS and 95% confidence interval (Krinsky and Robb 1000 repetitions).**

Calibration Technique	Mean WTP (AUS$) (95% confidence interval)	% change in WTP estimate relative to Baseline	% change in efficiency[3] score of the WTP estimate relative to baseline
Original Yes/No responses (Baseline)	133 (112 – 162)	-	-
YES7 (WTP Yes=Yes only for certainty ≥ 7)	78 (59 – 118)	-41	-0
YES8 (WTP Yes=Yes only for certainty ≥ 8)	52 (35 – 111)	-61	-284
YES9 (WTP Yes=Yes only for certainty ≥ 9)	29 (19 – 54)	-78	-216
YES10 (WTP Yes=Yes only for certainty ≥ 10)	23 (14 – 47)	-83	-276

[3] Efficiency score was calculated using the following formula: Efficiency =Difference between upper and lower CI over the Mean WTP.

Table 2 **Ordered probit regression results for stated certainty scores of 'Yes' responses.**

Variable	Description (Value range)	Parameter estimate (Standard error)	p<
BID	Bid level (20, 50, 100, 150, 200, 250, 300, 400AUS$/month)	-0.000 (0.000)	0.84
INCOME	Yearly household income ($0-7800 to $104,000-120,000)	0.000 (0.000)	0.032
HUMAN	Climate change caused by human actions (Strongly disagree=1, Strongly agree=5)	0.394 (0.143)	0.006
CPRS	Respondents have heard of the CPRS (Yes=1, No=0)	0.133 (0.214)	0.533
TEM	Best guess of temperature change in 100 years time (-5 degrees centigrade to +10 degrees centigrade)	-0.034 (0.151)	0.819
TEM_SQ	Square term of expected temperature rise	0.006 (0.012)	0.649
CONCERN	How concern are you about climate change (Not at all concerned=1, Highly concerned=5)	0.235 (0.136)	0.083
Model fit			
Log likelihood		-191.78	
LR chi square		24.51	0.001
N		102	

Table 3 **Ordered probit regression results for stated certainty scores of 'No' responses.**

Variable	Description (Value range)	Parameter estimate (Standard error)	p<
BID	Bid level (20, 50, 100, 150, 200, 250, 300, 400AUS$/month)	0.001 (0.000)	0.052
Ambivalence			
HUMAN	Climate change caused by human actions (Strongly disagree=1, Strongly agree=5)	-0.150 (0.084)	0.076
TEM	Best guess of temperature change in 100 years time (-5 degrees centigrade to +10 degrees centigrade)	-0.166 (0.087)	0.058
TEM_SQ	Square term of expected temperature rise	0.01 4 (0.008)	0.082
WATER	Climate change will cause water scarcity (Yes=1, No=0)	-0.042 (0.018)	0.019
Attitude			
BIOD	Climate change will cause loss of biodiversity (Yes=1, No=0)	0.068 (0.024)	0.004
POLICY	The policy will not be effective in slowing down climate change (Yes=1, No=0)	0.328 (0.087)	0.000
Familiarity			
CPRS	Respondents have heard of the CPRS (Yes=1, No=0)	-0.016 (0.155)	0.918
Model fit			
Log likelihood		-361.65	
LR chi square		39.84	0.001
N		204	