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Using Choice Modelling to assess the willingness to pay of Queensland households to reduce greenhouse emissions

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Abstract:

This paper presents the results of a choice modeling survey of households in Queensland to assess values for reductions in national greenhouse emissions by 2020. The study is novel in two main ways. First, labeled alternatives were used to assess whether the types of broad management options for reducing net emissions (green power, alternative technologies or carbon capture) are significant in understanding preferences for reducing emissions. Second, the importance of the level and type of uncertainty involved in reductions is tested. They include (1) the uncertainty of achieving emissions reduction and (2) the uncertainty of international participation as the percentage of total global emissions covered by international agreements. The results of this survey identified how choice responses vary when the level of uncertainty associated with emissions reduction options are included within choice alternatives.

1. Introduction: Background and Objectives of the Study

The objective of this paper is to present the results from a pilot project testing the use of *a non-market valuation* techniques (choice modelling) to assess community preferences regarding greenhouse gas emission reduction options. In the project, a survey of households in Queensland was used as the method of data collection. The survey questionnaire included choice modelling methodology in order to estimate participants' preferences and tradeoffs regarding their preferred emission reduction options. Focus groups were used to test the survey instrument before it was distributed to participants.

The study is novel in two main ways. First, labeled alternatives were used to assess whether the types of broad management options for reducing net emissions (green power, alternative technologies or carbon capture) are significant in understanding preferences for reducing emissions. Second, the importance of the level and type of uncertainty involved in reductions is tested. They include (1) the uncertainty of achieving emissions reduction and (2) the uncertainty of international participation as the percentage of total global emissions covered by international agreements. The results of this survey identified how choice responses vary when the level of uncertainty associated with emissions reduction options are included within choice alternatives.

The rest of the paper is structured as follows. A relevant literature review and an overview of the methodology used for the survey conducted in Queensland are presented in Section Two. Results of the survey and the choice modeling experiments are presented in Sections Three and Four, with discussions and final conclusions following in Section Five.

2. Design and Performance of Surveys

Environmental issues are complex. Rolfe and Bennett (2001) emphasized that framing is one of key issues faced by researchers using non market valuation techniques. Uncertainty exists about issues regarding consumers' willingness to pay for improvements in environmental quality and in particularly for policies to reduce emissions.

Uncertainty can be grouped into two main types: choice uncertainty associated with the respondents' perceptions of the alternatives and outcome uncertainty associated with the achievement of environmental outcomes (e.g provision of the environmental good). The uncertainty of achieving outcomes can be due to several different reasons such as the uncertainty about the relationship between the chosen policy and the environmental improvement.

Prelec and Loewenstein (1991) suggested that certainty of outcome can affect estimated willingness to pay (WTP) for improvements. Kahneman and Tversky (1979) also showed that the outcomes that are certain to occur tend to be valued dis-proportionally compared with the outcomes that are uncertain. There is evidence that the framing effect associated with changing the way that options are presented has a significant impact on choice (Tversky and Kahneman 1981, Prelec and Loewenstein 1991).

Pat and Schrag (2003) further explored the issue of communication of the degree of uncertainty associated with numerous possible outcomes. They analysed the use of specific language to describe probability ranges adopted by the Intergovernmental Panel on Climate Change in their Third Assessment Report. Pat and Schrag (2003) argued that the use of words can lead to miscommunication and under-estimation of the probability of high magnitude possible outcomes.

Several approaches have been developed in order to deal with uncertainty in non market valuation experiments. Respondents' uncertainty about choices can be taken into account explicitly by asking them how certain they are (on the confidence scale or using the Likert type scale) in choosing a particular scenario. The resulting information can be used to adjust estimated WTP. The literature is not uniform on this issue. Li and Mattson (1995) showed that failure to take account of this uncertainty can lead to a serious bias of estimated WTP. They showed that mean WTP decreases after uncertainty is incorporated into the responses. Alberini et al (2003) on the contrary showed that the WTP estimates increased when the uncertain responses were included.

There were four subsamples of the survey: labelled/unlabelled and two types of uncertainty.

This study focused on two types of outcome uncertainty in relation to valuing emissions reductions: 1) the uncertainty of achieving emissions reduction with chosen emissions reduction options and 2) the uncertainty of international participation to challenge the global issue of climate change. While the primary focus of the choice experiment was to assess values for reducing emissions, it was realistic to present some associated information about the uncertainty of achieving outcomes. Certainty levels were provided as a percentage range, which were identified from focus groups as a preferred format. An element of "vagueness" to represent uncertainty was added by the word "around" next to the percentage range.

The emissions reduction target can be achieved using a variety of options. In two labeled subsamples respondents were presented with four options of emissions reduction: 1) the status quo option – "*Current policy"*, 2) "*Green power options"*, 3) "*Efficient technology options"*, and 4) "*Carbon capture options"*. In two unlabeled subsamples respondents were presented with four options: 1) the status quo option – "*Current policy"*, 2) "*Option A"*, 3) "*Option B"*, and 4) "*Option C"*. The unlabeled options were included to distinguish the influence of labels from the attributes.

Among the key challenges in a Choice Modelling experiment is to identify the suitable attributes and levels that are relevant to potential participants, frame them in a way that is appropriate, and keep the choice task interesting but relatively simple. Another challenge was to identify the relevant information to provide to participants. The survey had to be simple and concise so that it was easy for respondents to complete, but still be capable of providing useful information. That challenge was overcome in the focus groups where the discussion allowed narrowing down the choices.

The questionnaire length for this study was 15 minutes maximum. The questionnaire followed a modular approach:

Section 1: respondents were asked their opinions of the importance of various issues, impacts of climate change and actions they have been taken (Questions 1 to 12).

Section 2: respondents were randomly allocated to one of the four sample splits of Choice Modelling questions after completing Section 1 (Questions 13 to 21).

Section 3: respondents were asked follow up questions after the choice sets to explore reasons why different patterns of choice had been followed as well as a contingent valuation question and socio-demographic information (Questions 22 to 32).

2.1 Design of the Choice Modelling profiles

Choice Modelling involves asking respondents to a survey to make a series of choices about alternative scenarios or profiles. In this study each choice set involved four profiles describing the alternatives on offer. One of the profiles described the potential condition by 2020, and remained constant between the choice sets. The other profiles varied, so that respondents were being asked to make a series of similar, but different choices. An example of a choice set used in this experiment is given in Figure 1.

The profiles were made up of a number of attributes that described the issue in question. These attributes were defined in focus groups. The key attributes included in the choice sets (Table 1) were:

- Additional annual costs to the household (to 2020).
- Total emissions change in Australia by 2020 compared to 2000 (target).
- Certainty that option will make significant contribution to the target (subsamples 1 and 2) or.
- Percent of emissions covered by international participation (subsamples 3 and 4).

In this experiment, three attributes were used to describe each profile. To generate differences between profiles, these attributes were allowed to vary across different levels (e.g. $0, $250, $500 and $1,000 in Additional annual costs to the household). These profiles then represent different options for respondents to consider. The levels in the constant 'opt-out' option remained set across the choice sets. The attributes and levels used in the profiles are shown in Table 1. In the labelled options the levels for each attribute were tailored to be more reliable. For example, the cost of *Green power options* were more expensive but came with higher certainty in experiment 1 (subsample 1).

Figure 1: Sample Choice Set

Q13. Suppose the four options below were the only options available, which would you choose?

Options		Additional annual costs to your household (to 2020)	Total emissions change in Australia by 2020 compared to 2000 (target)	Certainty that option will make significant contribution to the target	I would choose
			Potential Condition by 2020		
1	**Current policy**	**$0**	Decrease in emissions by **5%**	**around 95%**	☐
2	**Green power options**	**$1,000 ($83/month)**	Decrease in emissions by **11%**	**around 70-80%**	☐
3	**Efficient Technology options**	**$500 ($42/month)**	Decrease in emissions by **8%**	**around 60-70%**	☐
4	**Carbon Capture options**	**$250 ($21/month)**	Decrease in emissions by **10%**	**around 50-60%**	☐

This is the 1st out of 9 questions

Please treat each set of choices independently of others

Table 1. Attributes and levels for the choice sets.

Subsample 1

Label	Cost	Emissions decrease	Certainty
Status quo	$0	5%	around 95%
Green power	$250, $500, $1000	7%, 9%,11%	around 70-80%, around 80-90%, around 90-95%
Efficient technologies	$100, $250, $500	8%,11%,14%	around 50-60%, around 60-70%, around 70-80%
Carbon reduction	$50, $100, $250	10%, 15%, 20%	around 30-40%, around 40-50%, around 50-60%

Subsample 2

Label	Cost	Emissions decrease	Certainty
Status quo	$0	5%	> 95%
Option A	$50, $100,$250, $500, $1000	7%,9%,15%,20%	around 30-40%, around 50-60%, around 70-80%, around 90-95%
Option B	$50, $100,$250, $500, $1000	7%,9%,15%,20%	around 30-40%, around 50-60%, around 70-80%, around 90-95%
Option C	$50, $100,$250, $500, $1000	7%,9%,15%,20%	around 30-40%, around 50-60%, around 70-80%, around 90-95%

Subsample 3

Label	Cost	Emissions decrease	% of emissions covered by international participation
Status quo	$0	5%	around 30%
Green power	$250, $500, $1000	7%, 9%,11%	around 40-50%, around 50-60%, around 70-80%
Efficient technologies	$100, $250, $500	8%,11%,14%	around 40-50%, around 50-60%, around 70-80%
Carbon reduction	$50, $100, $250	10%, 15%, 20%	around 40-50%, around 50-60%, around 70-80%

Subsample 4

Label	Cost	Emissions decrease	% of emissions covered by international participation
Status quo	$0	5%	around 30%
Option A	$50, $100,$250, $500, $1000	7%,9%,15%,20%	around 40-50%, around 50-60%, around 70-80%
Option B	$50, $100,$250, $500, $1000	7%,9%,15%,20%	around 40-50%, around 50-60%, around 70-80%
Option C	$50, $100,$250, $500, $1000	7%,9%,15%,20%	around 40-50%, around 50-60%, around 70-80%

There are a large number of potential profiles that could be drawn and presented to respondents. As it was only possible to present a selection of profiles, an experimental design process was used to select the profiles, and then partition them into blocks for presentation to respondents in different versions of the survey. D-efficient designs for these experiments were created using Ngene.

A key stage in the application of the Choice Modelling exercise is to explain to respondents what the purpose of the exercise is and how it will be presented. To achieve this, the following information was provided to respondents (sample 1) (Figure 2). The additional

information regarding climate change and emissions reduction was also available to respondents through the click on menu.

Figure 2. Information provided to respondents

The Australian Government is already committed to reducing greenhouse gas emissions by 2020 to 5% below 2000 levels (instead of an estimated 20% above 2000 levels). This target will cost about $365 per year (or $30 per month) to the average household in higher fuel and energy prices, with some compensating payments to lower income households.
Larger reductions in greenhouse gas emissions could be targeted, but at a higher cost to households. These additional reductions are the focus of this survey.

In the next few questions, we ask you about different targets for emissions reduction and the certainty of achieving the target. In each question, we are going to give you four options for how additional emissions reduction can be achieved in the future. The outcome of each option is different – please choose one that is the best for you. We have described each option in terms of three main factors.

Total emissions change in Australia by 2020 compared to 2000 *indicates the additional target reduction.*

Certainty that the option will make a significant contribution to the emissions target *depends on the type of technology, its market size and the likelihood to reduce total emissions. Some options come with higher risks that they will not reach planned reductions.*

Additional annual costs to your household (to 2020) *can increase because emissions reduction options can be costly and their cost will be ultimately bourn by households in Australia.*

There are three main ways presented of reducing emissions.

- ***Green energy options*** *refers to increased use of renewable energy sources such as wind and solar for electricity generation.*

- ***Efficient technology options*** *would reduce consumption of energy through more use of energy efficient appliances.*

- ***Carbon capture options*** *can include carbon capture from existing electricity generation technologies (storing carbon in forests and underground), and use of clean coal technologies.*

  *If you would prefer the current policy situation to continue, you can choose the option of expected future outcomes with "**current policy**" on each page. In some cases you may prefer that option because other options are expensive or unattractive. There are no right or wrong answers – we are just interested in your point of view. There are nine similar choice sets on the pages that follow.*

The same information for reducing emissions was given to sample 2 except that the choice alternatives were not labelled options. The information on international participation instead of certainty was given to samples 3 and 4.

2.2 Performance of the survey

The Choice Modelling survey was developed and tested in the focus groups. The survey was conducted in a web-based format through a market research company for Queensland households. The participants were chosen randomly from a research only panel that is managed by the private company providing Internet sampling services to universities. This company monitored the representativeness of the sample.

The survey of Queensland households used an internet collection technique. This research was conducted online by the marketing research company. The sample for this research was drawn from a national online panel. The sampling design consisted of four split samples, each with a sample size of 250 respondents. Quotas were introduced to ensure that each sample split reflected the overall sample target:

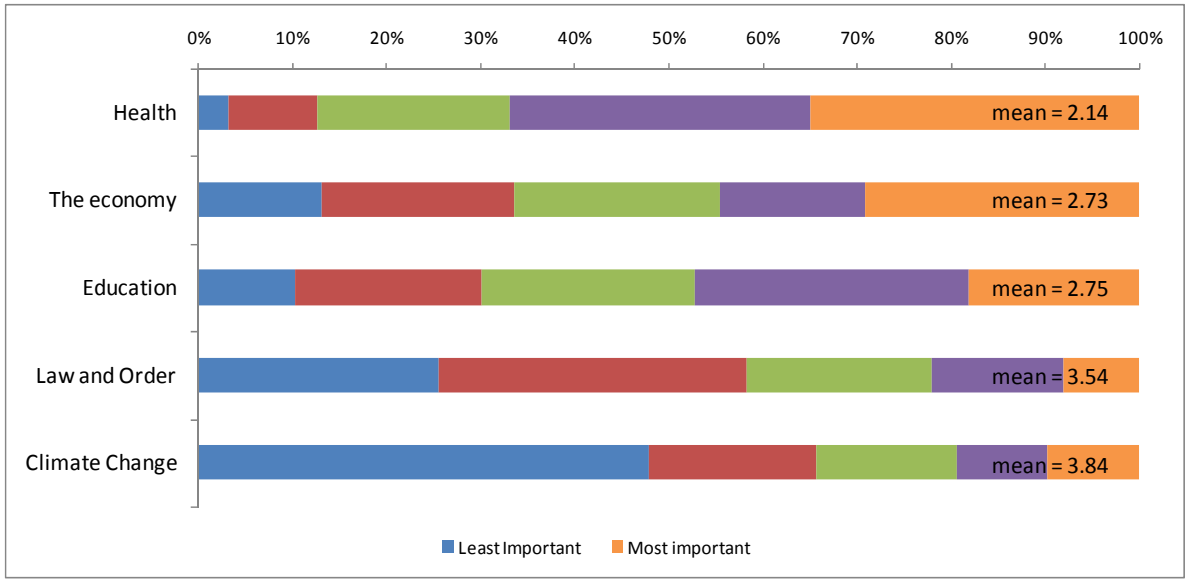
- Location (approx. 60% Brisbane / 40% other areas of Qld).
- Age (approximately 50% under 35 and 50% 35 +)
- Gender (approximately 50% female/50% male)

3. Demographic and Attitudinal Results

3.1 Australian Issues

The respondents were asked to rate a list of issues in order of most important to least important. Health and the economy were the two areas reported as most important with education also having a high importance (3). Of least importance to the respondents was climate change.

Figure 3 Importance of issues for Australia



3.2 Climate Change

Respondent opinions of nine aspects of climate change on Australian environmental condition and human effects (4) were addressed. The parameters people thought would be most affected by climate change were the water supply/incidence of drought, the Great Barrier Reef and biodiversity. The two things of least concern to the respondents were rising sea levels and health problems.

When respondents consider a trade off between greenhouse gas emissions and the economy/employment they overall had a fairly neutral response, with a slight lean toward the economy and employment. On the scale of 1 to 10, respondent responses averaged 6.13 (SD 2.168) with 7 being the most common response (Figure 5).

Apposed to this respondents generally preferred to favour the environment over development (40.3%) or favour them equally (48.4%). Only a small amount of respondents (the remaining 11.3%) favoured development over the environment.

Figure 4 Potential impacts on Australia from climate change

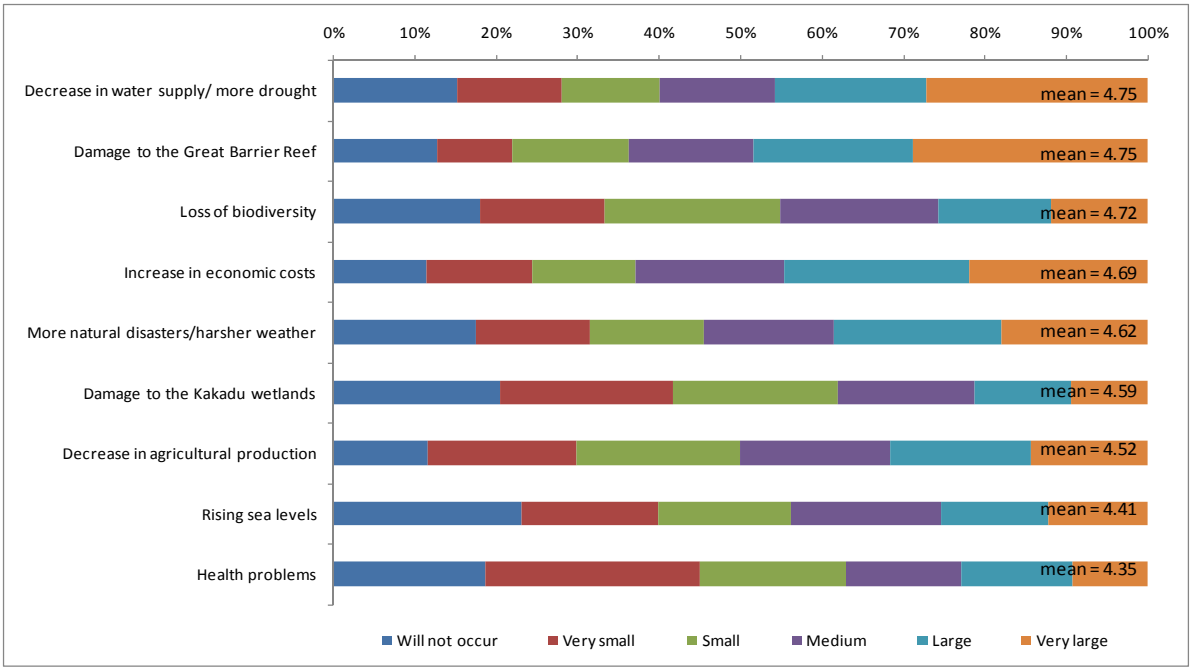
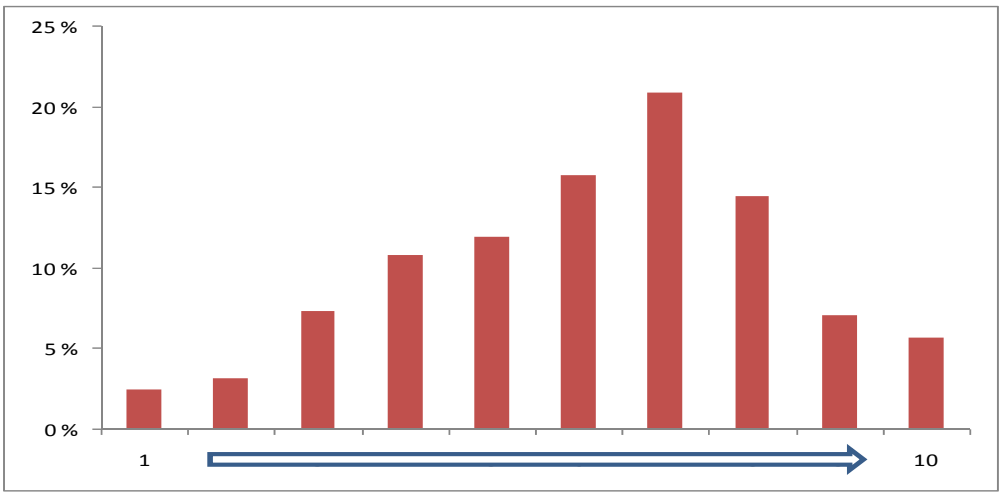


Figure 5 Respondent preferences for 1 'reducing emissions at any cost' and 10 'retaining the economy and employment at any cost'



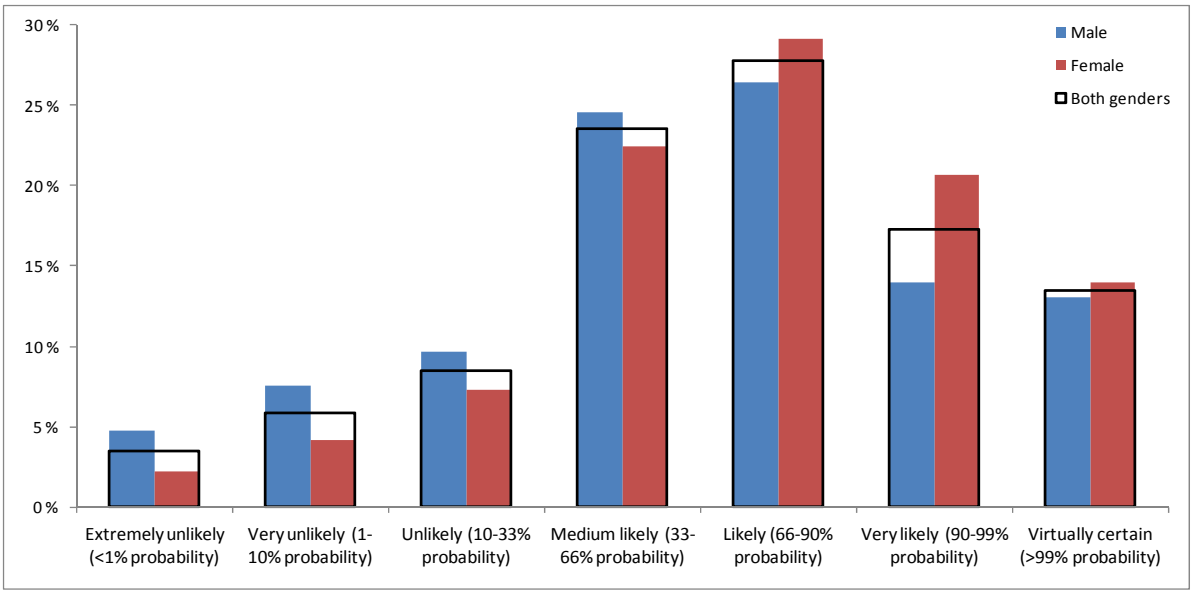
Approximately 70% of respondents agreed that climate change is currently occurring, with 65.2% of respondents considering it to be increased by human activity. Similarly 60% also considered the global effect of humans on climate change to be very large.

By reducing the emissions output globally there is not a great confidence with the respondents that climate change will stop, only 36.5% considered that it would, while 42.3% of respondents felt that climate change in Australia would not stop in our life time as a result of any reduction in emissions.

Respondents considered that climate change would impact the standard of living (51.2%), future generations (60.9%) and the environment (68.2%). Most neither agreed nor disagreed, about a reduction in their current standards of living as an effect of climate change, or the level of contribution Australia makes to the global greenhouse gas emission. However, over 60% of respondents felt that Australia should reduce its greenhouse emissions regardless of what other countries are doing. When asked about who should pay for a reduction in greenhouse gas emissions, there was a trend toward industry paying (61.2%) as opposed to the consumer paying (24.8%).

The occurrence of climate change as a result of greenhouse gas emissions was considered to be medium likely (21.9%) to likely (25.9%), with many (12.6%) considering it to be certain (Figure). Respondent opinions were not correlated with their age ($\chi^2_{24} = 25.881$, P = 0.359), education ($\chi^2_{36} = 36.578$, P = 0.442), income ($\chi^2_{30} = 35.385$, P = 0.229) or if they had children ($\chi^2_{6} = 1.832$, 0.934). The gender of the respondent, however, did show significant ($\chi^2_{6} = 19.800$, P = 0.003) influence on their opinion (Figure 6).

Figure 6 Proportion of respondent's opinion on the likelihood of climate change occurring as a result of greenhouse gas emission

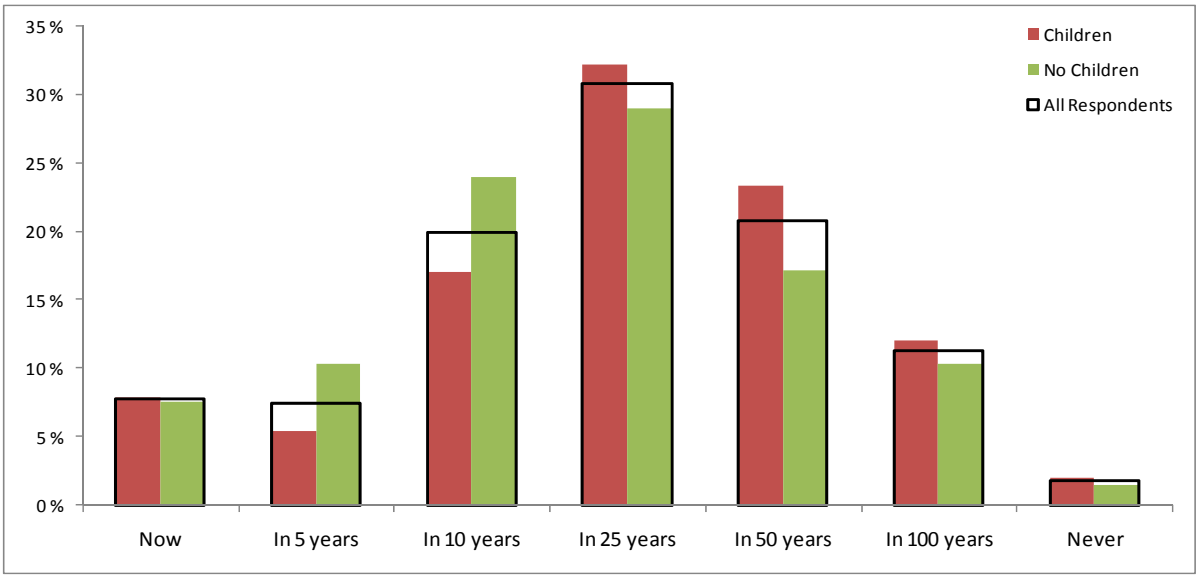


In the event that climate change does occur, most thought it would happen in about 25 years (26.4%) with 61.3% of respondents expecting a change in between 10 and 50 years (

Figure). A large proportion of the respondents (14.5%) were not sure of the timing of any impacts. Of those who did nominate an expected time interval, the presence of children in their household affected their opinions (χ^2_6 =19.077, P = 0.004) (

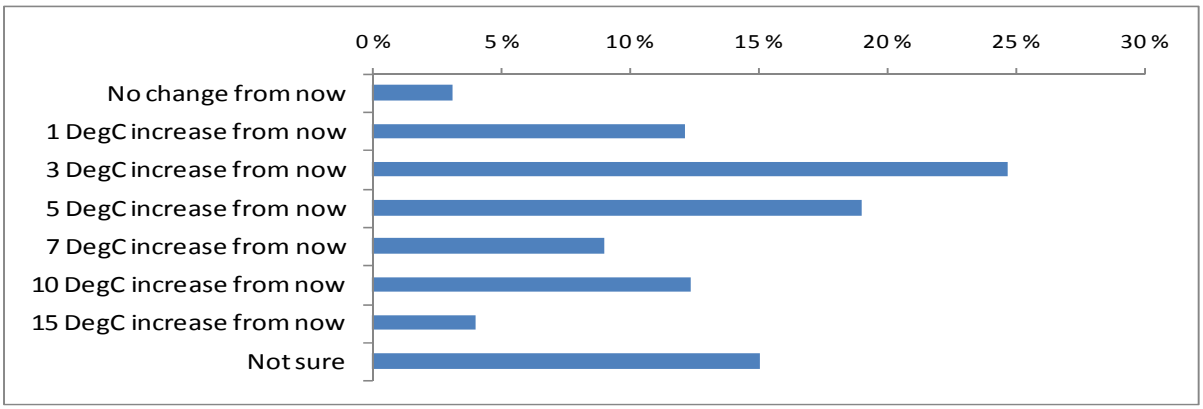
Figure). Other factors such as income ($\chi^2_{30} = 43.496$, P = 0.053), education ($\chi^2_{36} = 22.618$, P = 0.960), gender ($\chi^2_{6} = 10.576$, P = 0.102) and age ($\chi^2_{24} = 32.635$, P = 0.112) had no effect on respondent responses.

Figure 7 Respondent opinions on the timing of possible climatic change



Future predictions of temperature rises by the year 2050 were varied (Figure 8). Only 3.1% of respondents felt there would be no temperature increase over the next 40 years, while a high number of respondents (15.1%) were unsure of an exact temperature rise. Of the remaining respondents (940), most estimated an increase of 3°C or 5°C.

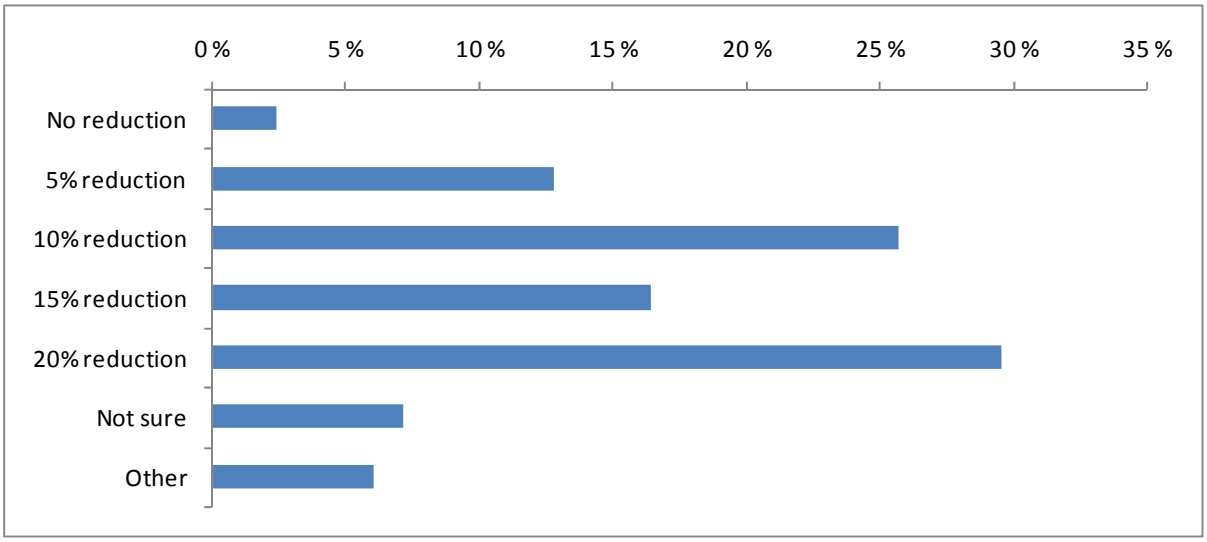
Figure 8 Temperature change predictions by 2050



The age of the respondent was a factor in their opinion of an exact temperature change ($\chi^2_{24} = 57.991$, P = 0.000). Of those who did respond to the question, older respondents (over 55 years old) tended to choose proportionally lower rises in temperature (no change to 3°C increase), while the younger age group (18-24 years old) choose proportionally higher predicted temperature changes (over 7°C). Similarly, gender also influenced respondent opinions ($\chi^2_6 = 34.633$, P = 0.000), as female respondents predicted a 10°C increase proportionately more than male respondents. The level of education also had some influence on the respondents' estimates of temperature increase ($\chi^2_{36} = 92.448$, P = 0.000). Other socio-economic factors did not influence respondent opinions; children in the household ($\chi^2_6 = 4.725$, P = 0.580) and income ($\chi^2_{30} = 31.533$, P = 0.390).

There are several recommended targets for an emission reduction before the year 2020, between industries supporting a 5% reduction to environmentalists proposing between 10 to 20%. The government plan at the time of the survey (2009) was to reduce greenhouse gas emission by 5 to 15%. Respondents' targets for emissions reduction were bi-modal, with 25.7% targeting a 10% reduction and 20% targeting a 20% reduction (**Error! Reference source not found.**). Additionally, most thought that Australia's participation in reducing greenhouse gas emission should not be dependent on the participation of other countries (34.1%). Very few (10.1%) felt that all the countries should be involved before Australia commits.

Figure 9 Respondent target greenhouse emissions reduction by the year 2020



Schemes to reduce emissions may sometimes result in job losses and increased unemployment. Participants were asked to indicate how they felt about the trade off between job losses and a reduction in emissions. Almost 40% preferred no job losses, with a further 20% agreeable with minimal (<0.1%) job losses. Very few (6%), were agreeable with job losses for 100 000 or people. Interestingly, almost 20% of participants were unsure or had no opinion about the prospect.

3.3 Participant Actions

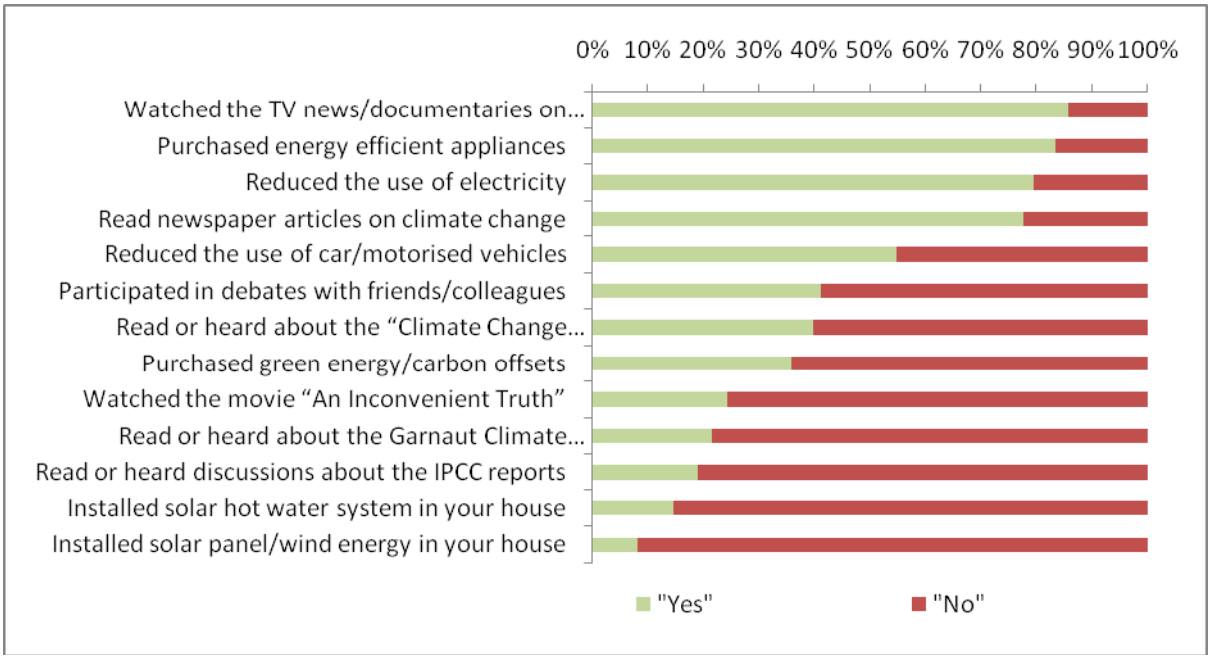
Respondents were generally aware of the issues relating to global warming, with over 85% having watched or read news of climate change and 77.6% having read articles about the topic (Figure 1). More formal reports such as the 'Climate Change Review Report', the 'Garnaut Climate Change Review' and the IPCC Reports, were not well read or known (39.8%, 21.5% and 19.0% respectively).

There are many actions respondents have undertaken to minimise the greenhouse gas production and reduce their contribution to global warming. Many (80% ore more), have purchased energy efficient appliances and reduced their use of electricity, other actions respondents have taken include a reduction in motor vehicle use (54.8%) and purchased green energy/carbon offsets (36.0%) (Figure 1). Very few, less than 15%, have installed solar hot water or solar/wind generated energy to their homes.

"Other" responses from respondents featured actions that were environmentally friendly, if not necessarily to reduce climate change, some of these included:

- Recycling/reduce waste
- Insulation of water tanks
- Energy efficient light bulbs
- Other solar powered devices (pool filters, lights, etc.)
- Insulation in homes

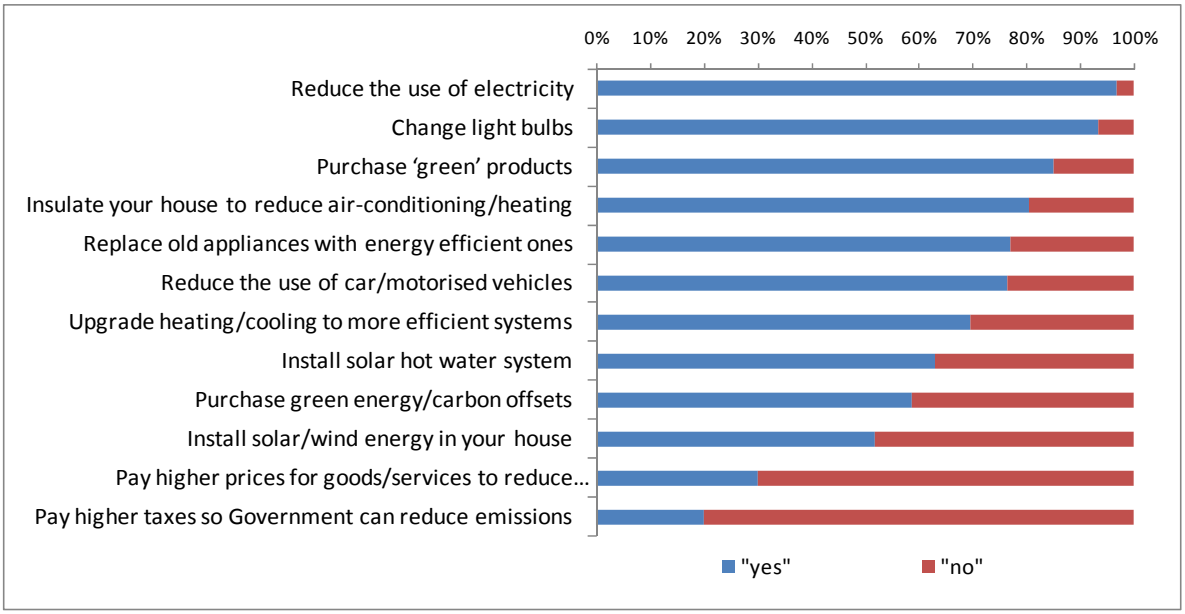
Figure 1 Respondents individual actions regarding climate change



The future involvement of participants to reduce emissions is fairly proactive (

Figure). Over 90% were willing to change household activities to reduce electricity use and change light bulbs to energy efficient ones. Purchasing green products, insulation and energy efficient appliances were also popular among participants. The most unpopular options involved consumer payments for goods and services and higher taxes.

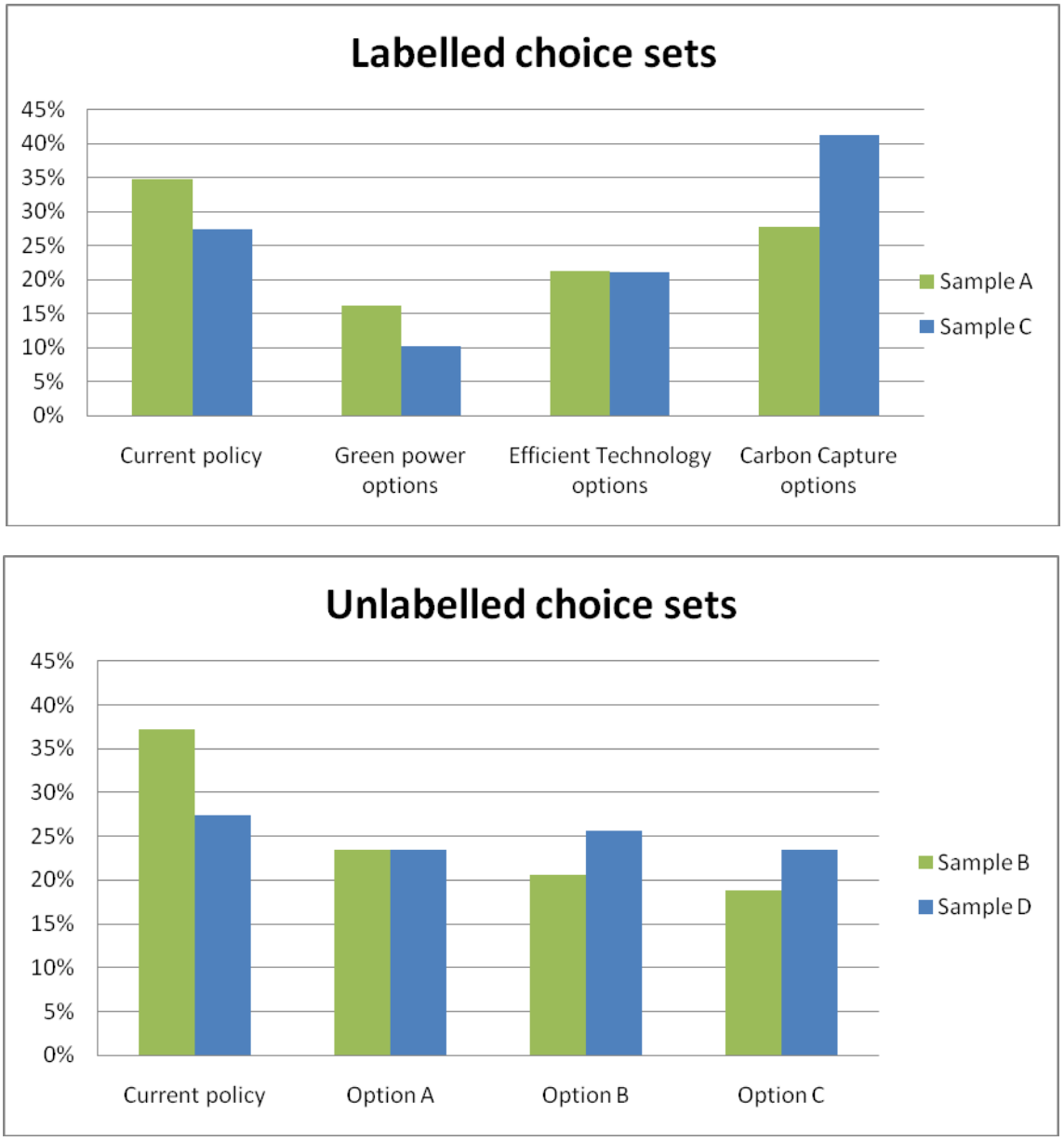
Figure 12 Participant future willingness to reduce emissions



4. Results of the Choice Modelling Experiment

In the Choice Modelling experiment, participants were given four similar tradeoffs relating to their potential choices in emissions reduction, and asked to indicate their preferred choice in each. The number of choices made by respondents are summarised in the following figure. In labelled choice experiment the dominant preference of respondents (31%) was for the current policy and for the carbon capture option (35%), implying they preferred to have some changes in emissions reduction policy (Figure 13). In unlabelled choice experiment the preferred option was for some changes in the current policy (even at a higher cost than the current emissions reduction policy) (68%).

Figure 13. Support for different emissions reduction options



The choice information was analysed using a logistic regression (e.g. multinomial logit) models. The probability that a respondent would choose a particular emissions reduction option can be related to

the levels of each attribute making up the profile (and the alternative profiles on offer), the socio-economic characteristics of the respondent, and other factors. A summary description of the variables used in the statistical analysis and the original questions used in the survey is provided in Table 2.

Table 2. Variables used in the Choice Modelling analysis

Variable	Description/Original Question
ASC	Alternative Specific Constant (capturing the influence of other factors on choice)
Cost	Additional annual costs to your household
Emissions	Emissions reduction
Certainty	Level of certainty of ooutcome (subsamples 1 and 2) Level of International participation (subsamples 3 and 4)
Certainty SQ	Square value of certainty (subsample 3*)*
Female	Gender
Children	Children in the household
Income	Which broad income range is relevant for your household? (before-tax income for all household members)
Age	What was your age on your last birthday?

A summary of the regression models for the data fro the first split-sample are presented in Table 3. The results show that Random Parameters Logit (RPL) model and Latent Class models had high rho-square statistics, indicating an appropriate model fit. For each subsample the RPL model was chosen to explore the relationships further.

Table 3. Models for subsample 1 Outcome uncertainty, Labelled

	MNL Model		RPL (N-distr)		Latent class (3 classes)	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
					Class 1	
ASC Green P	0.2992	0.2070	2.659***	0.634	-3.7587***	0.6887
ASC Eff.Tech	0.2048	0.2182	3.090***	0.638	-1.8113**	0.7649
ASC Carbon C	0.1551	0.2671	2.939***	0.662	0.2401	0.9946
Cost	-0.0017***	0.0002	-0.006***	0.001	0.0033***	0.0006
Emissions	-0.0636***	0.0093	-0.073***	0.017	0.2751***	0.0496
Certainty	0.0098***	0.0032	0.040***	0.006	0.0193	0.0165
Female	0.1140	0.0898	0.410	0.289	-0.3363	0.2512
Children	-0.1729	0.0927	-0.592**	0.301	0.0849	0.2581
Age	0.0143***	0.0038	0.035**	0.014	0.0268**	0.0113
Income	-0.0032***	0.0010	-0.007**	0.003	-0.0053**	0.0022
Ns ASC Green P			1.052***	0.232		
Ns ASC Eff.Tech			1.417***	0.136		
Ns ASC Carbon C			0.514**	0.242		
Ns Cost			0.007***	0.001		
Ns Emissions			0.175***	0.025		
Ns Certainty			0.056***	0.005		
					Class 2	
ASC Green P					1.3548***	0.2783
ASC Eff.Tech					1.3117***	0.2530
ASC Carbon C					1.5524***	0.3013
Cost					-0.0046***	0.0003
Emissions					-0.1010***	0.0119
Certainty					0.0015	0.0041
Female					0.4360***	0.1023
Children					-0.2300**	0.1084
Age					0.0166***	0.0042
Income					0.0009	0.0013
					Class 3	
ASC Green P					2.1928***	0.3144
ASC Eff.Tech					1.8428***	0.3370
ASC Carbon C					0.3069	0.4077
Cost					-0.0030***	0.0002
Emissions					-0.1111***	0.0131
Certainty					0.0297***	0.0043
Female					0.7297***	0.1293
Children					0.0818	0.1260
Age					-0.0184***	0.0065
Income					-0.0064***	0.0015
Number of observations	2511		2511		10044	
Log likelihood function	-3292.421		-2334.618		-2591.195	
R-sqrd	0.054		0.330		0.256	
Correctly predicted	28.7%		29.3%		54.9%	

(crosstab)			

*** = significant at the 1% level, ** = significant at the 5% level, * = significant at the 10% level.

Table 4. Random Parameters Logit model for subsample 1 Outcome uncertainty, Labelled

	Coefficient	Standard Error	Partworth, expected	Confidence intervals for Partworth (95%)	
				Lower CI	Higher CI
ASC Green P	2.659***	0.634	$441	$241	$640
ASC Eff.Tech	3.090***	0.638	$512	$299	$731
ASC Carbon C	2.939***	0.662	$487	$261	$718
Cost	-0.006***	0.001			
Emissions	-0.073***	0.017	$12	$6	$19
Certainty	0.040***	0.006	$7	$5	$9
Female	0.410	0.289			
Children	-0.592**	0.301			
Age	0.035**	0.014			
Income	-0.007**	0.003			
Ns ASC Green P	1.052***	0.232			
Ns ASC Eff.Tech	1.417***	0.136			
Ns ASC Carbon C	0.514**	0.242			
Ns Cost	0.007***	0.001			
Ns Emissions	0.175***	0.025			
Ns Certainty	0.056***	0.005			
Number of observations	2511				
Log likelihood function	-2334.618				
R-sqrd	0.330				

*** = significant at the 1% level, ** = significant at the 5% level, * = significant at the 10% level.

For respondents, each of the Choice Modelling attributes was significant in explaining the choices between the options. Respondents were more likely to prefer the future scenarios that had higher levels of the attributes. As expected, they were less likely to choose scenarios that came at a higher cost. Gender was not a significant factor in explaining choices. However, having children, higher income and the age of respondent were significant factors in explaining respondents' choices.

The logistic regression function can be used to generate probabilities of choice and estimates of economic value between different choice profiles. As well as these estimates of economic values, the models can also be used to generate estimates of marginal value changes for each attribute. Known as part-worths, implicit prices, or attribute values, these provide an indication of the annual value to respondents of each one unit change in the provision of an attribute (Rolfe, et al. 2000).

To compare results between models, part-worths were estimated for the attributes using the following equation:

Part-worth = -1 x Attribute coefficient/payment coefficient.

Summary results for the part-worths are also shown in Table 5. In each model, the part-worths show the value of a one-unit change in the attribute. For example, one percent change in the level of the *Emissions* attribute was valued at $12 per year by respondents.

The results provide some indication about the relative importance of the different attributes, with the *Emissions* attribute being relatively more significant than the *Certainty* attribute. Among the three options of emissions reduction, the *Efficient Energy Technologies* options were relatively more

important than *Carbon Capture Options* or *Green Energy Options* in determining choices. The value for respondents from the change from the current policy to involve more *Efficient Technologies Options* is $512 per year.

Table 5. Models for subsample 2 Outcome uncertainty, Unlabelled

	MNL Model		RPL (N-distr)		Latent class (3 classes)	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
					Class 1	
ASC1	-0.267	0.328	-3.773	1.486	2.134***	0.732
Cost	-0.002***	0.000	-0.007***	0.001	-0.001***	0.001
Emissions	-0.075***	0.006	-0.074***	0.010	-0.041**	0.018
Certainty	0.006**	0.003	0.037***	0.006	0.008	0.007
Female	0.061	0.086	0.049	0.438	-0.444***	0.169
Children	0.278***	0.092	0.281	0.609	-0.249	0.185
Age	0.014***	0.004	0.028	0.017	0.031***	0.008
Income	-0.004***	0.001	-0.001	0.004	-0.002	0.002
Ns Cost			0.007***	0.001		
Ns Emissions			0.086***	0.014		
Ns Certainty			0.056***	0.004		
					Class 2	
ASC1					-0.966***	0.323
Cost					-0.002***	0.000
Emissions					-0.083***	0.005
Certainty					0.010***	0.003
Female					0.088	0.087
Children					0.096	0.093
Age					0.000	0.004
Income					-0.003***	0.001
N of observations	2502		10008			10008
Log likelihood	-3144.022		-2174.742			-2667.424
R-sqrd	0.0935		0.373			0.231
Correctly predicted (crosstab)	31.4%		30.66%			49.28%

*** = significant at the 1% level, ** = significant at the 5% level, * = significant at the 10% level.

For respondents in sample 2, each of the Choice Modelling attributes in the RPL model was significant in explaining the choices between the options. Respondents were more likely to prefer the future scenarios that had higher levels of the attributes. As expected, they were less likely to choose scenarios that came at a higher cost. None of the socio-demographic variables were significant factors in explaining respondents' choices.

Summary results for the part-worths are also shown in Table 6. For example, a change in one percent of the *Emissions* attribute was valued at $10 per year by respondents.

In subsample 3, the certainty square was added to improve the model fit (Table 7). The results of the RPL model for subsample 3 show that respondents valued a 1% improvement in international certainty more than 1% reduction in emissions but the change from the current policy to any other options were not significant.

Table 6. Random Parameters Logit model subsample 2 Choice Outcome uncertainty, Unlabelled

	Coefficient	Standard Error	Partworth	Confidence intervals for Partworth (95%)	
				Lower CI	Higher CI
ASC1	-3.773	1.486			
Cost	-0.007***	0.001			
Emissions	-0.074***	0.010	$10	$7	$14
Certainty	0.037***	0.006	$5	$4	$7
Female	0.049	0.438			
Children	0.281	0.609			
Age	0.028	0.017			
Income	-0.001	0.004			
Ns Cost	0.007***	0.001			
Ns Emissions	0.086***	0.014			
Ns Certainty	0.056***	0.004			
N of observations	10008				
Log likelihood	-2174.742				
R-sqrd	0.373				

*** = significant at the 1% level, ** = significant at the 5% level, * = significant at the 10% level.

Table 7. Models for subsample 3 International participation, Labelled

	MNL Model		RPL (N-distr)		Latent class (3 classes)	
	Coefficient	St. Err.	Coefficient	St. Err.	Coefficient	St. Err.
					Class 1	
ASC Green P	-0.807**	0.344	-0.082	0.868	3.707***	0.974
ASC Eff.Tech	-0.810**	0.329	-0.456	0.877	3.696***	0.968
ASC Carbon C	-0.922***	0.331	-0.829	0.877	2.769***	0.983
Cost	-0.004***	0.000	-0.013***	0.001	-0.001***	0.000
Emissions	-0.064***	0.009	-0.088***	0.025	-0.050***	0.018
Certainty	0.155***	0.041	0.170***	0.066	0.031	0.073
Certainty SQ	-0.001***	0.000	-0.001**	0.001	0.000	0.001
Female	-0.324***	0.093	-0.424	0.278	-0.847***	0.331
Children	0.207**	0.100	-0.511	0.317	1.345***	0.373
Age	0.007*	0.004	-0.015	0.011	0.026***	0.010
Income	-0.010***	0.001	-0.013***	0.004	-0.006	0.004
Ns ASC Green P			0.521	0.498		
Ns ASC Eff.Tech			1.225***	0.164		
Ns ASC Carbon C			1.014***	0.206		
Ns Cost			0.010***	0.001		
Ns Emissions			0.342***	0.031		
Ns Certainty			0.058***	0.007		
Ns Certainty SQ			0.000	0.000	**Class 2**	
ASC Green P					-2.390***	0.523
ASC Eff.Tech					-2.083***	0.466
ASC Carbon C					-2.087***	0.466
Cost					-0.009***	0.000
Emissions					-0.102***	0.010
Certainty					0.401***	0.069
Certainty SQ					-0.003***	0.001
Female					-0.346***	0.127
Children					-0.709***	0.153
Age					-0.005	0.005
Income					-0.011***	0.002
					Class 3	
ASC Green P					0.402	0.847
ASC Eff.Tech					0.436	0.741
ASC Carbon C					0.125	0.791
Cost					-0.004***	0.001
Emissions					-0.060**	0.027
Certainty					-0.328**	0.130
Certainty SQ					0.003**	0.001
Female					-0.396***	0.139
Children					0.635***	0.158
Age					0.028***	0.007
Income					-0.011***	0.002
N of observations	2502		10008		10008	
Log likelihood	-2925.986		-1957.284		-2254.140	
R-sqrd	0.156		0.436		0.35	
Correctly predicted	35.7%		35.9%		60.3%	

*** = significant at the 1% level, ** = significant at the 5% level, * = significant at the 10% level.

Table 8. Random Parameters Logit model for subsample 3 International participation, Labelled

	Coefficient	Standard Error	Partworth, expected	Confidence intervals for Partworth (95%)	
				Lower CI	Higher CI
ASC Green P	-0.082	0.868			
ASC Eff.Tech	-0.456	0.877			
ASC Carbon C	-0.829	0.877			
Cost	-0.013***	0.001			
Emissions	-0.088***	0.025	$4	$0	$8
Certainty	0.170***	0.066	$12	$2	$22
Certainty SQ	-0.001**	0.001			
Female	-0.424	0.278			
Children	-0.511	0.317			
Age	-0.015	0.011			
Income	-0.013***	0.004			
Ns ASC Green P	0.521	0.498			
Ns ASC Eff.Tech	1.225***	0.164			
Ns ASC Carbon C	1.014***	0.206			
Ns Cost	0.010***	0.001			
Ns Emissions	0.342***	0.031			
Ns Certainty	0.058***	0.007			
Ns Certainty SQ	0.000	0.000			
Number of observations	10008				
Log likelihood function	-1957.284				
R-sqrd	0.436				

*** = significant at the 1% level, ** = significant at the 5% level, * = significant at the 10% level.

Table 9. Models for subsample 4 International participation, Unlabelled

	MNL Model		RPL (N-distr)		Latent class (3 classes)	
	Coefficient	St. Err.	Coefficient	St. Err.	Coefficient	St. Err.
					Class 1	
ASC1	-1.347	0.327	-1.838**	0.719	-1.811**	0.774
Cost	-0.001***	0.000	-0.007***	0.001	0.002***	0.000
Emissions	-0.042***	0.006	-0.055***	0.015	0.209***	0.030
Certainty	-0.379***	0.041	-0.038	0.051	-0.637***	0.128
Certainty SQ	0.003***	0.000	-0.001	0.000	0.005***	0.001
Female	-0.339***	0.093	-0.548**	0.229	0.302	0.203
Children	-0.121	0.100	0.209	0.246	-0.645***	0.200
Age	0.010**	0.004	0.007	0.010	0.026***	0.009
Income	-0.007***	0.001	-0.007***	0.003	-0.007***	0.002
Ns Cost			0.006***	0.000		
Ns Emissions			0.268***	0.025		
Ns Certainty			0.109***	0.011		
Ns Certainty SQ			0.001***	0.000		
					Class 2	
ASC1					3.853***	0.684
Cost					-0.001***	0.000
Emissions					-0.079***	0.006
Certainty					-0.064*	0.036
Certainty SQ					0.001**	0.000
Female					-1.591***	0.208
Children					-1.106***	0.211
Age					-0.069***	0.012
Income					-0.011***	0.003
					Class 3	
ASC1					-3.971***	0.487
Cost					-0.010***	0.001
Emissions					-0.106***	0.012
Certainty					-0.264***	0.073
Certainty SQ					0.002***	0.001
Female					0.473***	0.128
Children					0.396***	0.139
Age					0.021***	0.006
Income					-0.003*	0.002
N of observations	2502		10008		10008	
Log likelihood	-3077.348		-2260.971		-2453.467	
R-sqrd	0.113		0.348		0.293	
Correctly predicted (crosstab)	33.6%		34.1%		57.8%	

*** = significant at the 1% level, ** = significant at the 5% level, * = significant at the 10% level.

Table 10. Random Parameters Logit model for subsample 4 International participation, Unlabelled

	Coefficient	Standard Error	Partworth, expected	Confidence intervals for Partworth (95%)	
				Lower CI	Higher CI
ASC1	-1.838**	0.719	-$251	-$472	-$73
Cost	-0.007***	0.001			
Emissions	-0.055***	0.015	$7	$4	$11
Certainty	-0.038	0.051			
Certainty SQ	-0.001	0.000			
Female	-0.548**	0.229			
Children	0.209	0.246			
Age	0.007	0.010			
Income	-0.007***	0.003			
Ns Cost	0.006***	0.000			
Ns Emissions	0.268***	0.025			
Ns Certainty	0.109***	0.011			
Ns Certainty SQ	0.001***	0.000			
N of observations	10008				
Log likelihood	-2260.971				
R-sqrd	0.348				

*** = significant at the 1% level, ** = significant at the 5% level, * = significant at the 10% level.

The results of MNL model for subsample 4 showed that all choice attributes are significant predictors of respondents' choices. However, in the MNL model the *International Participation* attribute is negative, implying that increasing international participation creates a disutility for respondents. The RPL model tells a different and somewhat more believable story, the *International Participation* is not a significant predictor of the respondents' choices. Perhaps respondents were feeling that regardless of the international participation in emissions reduction programs Australia has to reduce its emissions. About 67% of respondents who answered the question agreed and strongly agreed with the statement: "Australia should reduce greenhouse gas emissions even if other countries do not agree to reduce their emissions".

The part-worths indicated that while increase in emissions reduction was seen as an increase in value ($7/each percent decrease in emissions).

4.1 Identifying Differences in Certainty between two subsamples

Subsamples 1 and 2 had the attribute Certainty relating to the certainty that the option will make a significant contribution to the emissions target depending on the type of technology, its market size and the likelihood to reduce total emissions. Some options were identified with higher risks that they will not reach planned reductions. In subsamples 3 and 4 *Certainty* was explained as international participation indicating the percent of total global emissions covered by international agreements such as the Kyoto protocol. Higher levels of participation will lead to more effective reductions at a global level. To determine if there are differences in the *Certainty* attribute, the analysis was extended by pooling the data for subsamples 1 and 3 and subsamples 2 and 4.

The Swait-Louviere (Swait and Louviere, 1993) test was performed to test the equality of coefficients and the scale parameter for the certainty attribute. Both hypotheses were rejected therefore both scale

parameter and coefficients are different between different samples. That means that the each survey measured a different cognitive process. Since only the certainty attribute was different between samples, it can be assumed that respondents have different associations with two different representatives of uncertainty of emissions reduction and climate change.

5. Summary

This paper provides two key insights about how respondents from Queensland view the emissions reduction options. Two types of outcome uncertainty were examined in the survey. For two subsamples the attribute *Certainty* was explained as a certainty that the emissions reduction options will make a significant contribution to the emissions target depending on the type of technology, its market size and the likelihood to reduce total emissions. Two other subsamples had *Certainty* explained as a percentage of total global emissions covered by international agreements such as the Kyoto protocol. The dominant preference of respondents across the subsamples was for some changes in the current policy. The statistical analysis of the survey results identifies a number of similarities in the responses, as well as some key differences.

First, the results showed that respondents place importance on the types of broad management options for reducing greenhouse gas emissions (i.e. green power options, efficient technology options and carbon capture options). In subsample 1, the value for a change from the current policy to any of a higher level emissions reduction policy option was more than $400 a year. Among the three options of emissions reduction, *the Efficient Energy Technologies* options were relatively more important than *Carbon Capture Options* or *Green Energy Options* in determining choices. Second, the result showed that the uncertainty of achieving emissions reduction and the uncertainty of international participation attract different cognitive process. It might mean that respondents have different associations with two different representatives of uncertainty of emissions reduction and climate change.

The implications of this study confirm the importance of uncertainty while designing the policy of emissions reduction. The results from subsamples 1 and 2 show that adding the labels increase the values respondents hold. Perhaps respondents could make more informed choices or the suggested options have additional values to respondents. For example, Ivanova (2005) reported the results from the contingent valuation survey of Queensland households where the total economic value of electricity generated from renewable energy and its' components (such as emissions reduction value, values other than emissions reduction, personal value and value for other people) were attempted to be elicited. The results showed that about 60% benefits represent benefits other than emission reduction, for example benefits from locally produced electricity, and from having diverse electricity sources. If consumers do hold additional values for the emissions reduction options that explains higher values in the choice modeling experiment when the labels (such as *Green Power Options* label) were added to the questionnaire. One labelled version of the survey showed that respondents place a value on a particular type of greenhouse gas management options. May be there are additional values to respondents associated with different management options.

It is also possible that respondents used the assumption based reasoning (Cohen 1989) while choosing the preferred scenario. Under this theory, people fill the gaps in firm knowledge by making assumptions. Since people prefer less uncertainty to more uncertainty while making decisions (Curley, Yates and Abrams 1986), the inclusion of labels might contributed to reduction of uncertainty and therefore can also explain higher values in labelled experiment.

Respondents want to see more emissions reduction and higher certainty that the particular management option will achieve that target. International participation subsamples provided several insights: 1) the options of emissions reduction are not significant, 2) the higher international participation creates the higher utility for respondents and 3) there is a non linear relationship

between the choice and certainty of international participation when the labelled options of emissions reduction are presented.

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