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Choice modelling: assessing the environmental values of water supply options†

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Three criticisms of the contingent valuation method (CVM) are considered in this article. One technique that would appear to answer such criticisms is choice modelling (CM). CM permits value estimates for different goods sharing a common set of attributes to be pieced together using the results of a single multinomial (conditional) logit model. The CM approach to environmental value assessment is illustrated in the context of a consumer-based assessment of future water supply options in the Australian Capital Territory. CM is found to provide a flexible and cost-effective method for estimating use and passive use values, particularly when several alternative proposals need to be considered.

1. Introduction

Since the first Australian applications of the contingent valuation method (CVM) several decades ago, the CVM has seen a modest and somewhat controversial history of application. One concern with the CVM is that it is susceptible to yea-saying and the related notion of lexicographic responses. Yea-saying occurs when respondents 'agree with an interviewer's request regardless of their true views' (Mitchell and Carson 1989). This can lead to biased willingness-to-pay (WTP) estimates and reduced sensitivity to scope (Blamey, Bennett and Morrison 1998). Motivations pertaining to warm glow or moral satisfaction (Andreoni 1989; Kahneman and Knetsch 1992) and

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value-expression and symbolic responses (Blamey 1996, 1999) can have a similar influence on CVM results.

A second concern is that respondents sometimes ignore or discount substitution possibilities. Individuals may formulate their responses without adequate appreciation of the vast array of other environmental issues on government agendas that they might also consider making payments toward. This can have an upward influence on WTP estimates, and result in reduced sensitivity to scope.[1]

A related factor that has limited the application of CVM is that it may not be well suited to the evaluation of several policy options. A typical CVM questionnaire presents respondents with information regarding a status quo, or base option, and a single alternative involving an environmental improvement. The latter alternative can only be obtained by making a payment of A$$x$. Respondents are then required to choose between the two alternatives. Bennett (1991) observed the difficulties of conducting cost-benefit assessments of multiple (> 2) policy options when resources only permit the estimation of non-market values for one or two alternatives to the status quo.[2]

An alternative technique that may be less prone to such limitations is choice modelling (CM), the stated preference form often being referred to as the choice experiment. Choice experiments are similar in many ways to the discrete choice variant of CVM. They have a similar theoretical basis, and both involve presenting respondents with a description of alternative policy options and seeking an indication of the single preferred option. While the discrete choice CVM typically requires respondents to choose between a base option and a single alternative, choice experiments employ a repeated

[1] The inclusion of 'reminder statements' prior to CVM questions, in which respondents are reminded about other goods or services that may be substitutes for the object of valuation, has always seemed somewhat of a token effort to increase the salience of substitutes.

[2] There are several ways of assessing multiple policy options with CVM. In general, these take two main forms: those employing a between-subject variation in the good(s) being valued, and those employing a within-subjects variation. The former tends to involve splitting the sample and asking different respondents to value different options. This approach is expensive and may suffer from limitations regarding reduced salience of substitute possibilities and biases such as yea-saying. The second approach has been plagued by a lack of independence among responses to different CVM questions within the same questionnaire. Some individuals 'dump' significant proportions of their environmental (or good cause) budgets on the first one or two options, and either continue with similarly high bids in subsequent questions in order to appear consistent, or reduce their bids in accordance with diminishing marginal utility (despite the likelihood that the later alternatives may be valued more than those presented earlier). These problems can be reduced by framing the series of CVM questions in a similar way to that of CM studies.

measures approach. Respondents are typically presented with 6 to 10 choice sets, each containing a base option and 2 or 3 alternatives. They are then required to indicate which option they prefer in each choice set. The levels of the attributes characterising the different options are varied according to an experimental design, permitting estimates of the relative importance of the attributes describing the options to be obtained. Rather 'than being questioned about a single event in detail, as in CVM analysis, subjects are questioned about a sample of events drawn from the universe of possible events of that type' (Boxall *et al.* 1996, p. 244). Issues pertaining to scenario construction and selection of the vehicle (tax increase, higher prices, etc.) through which payment is to be made apply to choice experiments as they do with CVM.

The focus on differences in attribute levels may reduce the occurrence of yea-saying and related biases, particularly when options do not have emotionally infused labels around which respondents can anchor their responses (Blamey *et al.* 1997). Respondents may be less likely to 'dump' money on the first cause described to them, as they are explicitly required to consider the details of a number of alternative policy options. CM also permits values associated with a broader range of policy changes to be estimated (Boxall *et al.* 1996; Morrison *et al.* 1996). Dollar values can be estimated for any environmental or other change falling within the attribute-space selected for the experiment, given the inclusion of a cost attribute. This means that CM is better suited to the economic evaluation of multiple mutually exclusive policy options. In particular, it is ideal for estimating the community's ranking of different policy options.

In this article we illustrate how CM can be used to provide both welfare estimates corresponding to policy changes involving one or more attributes and community rankings of multiple policy options. While we highlight some areas where we feel CM has potential advantages over the CVM, a comprehensive comparison of the two techniques is beyond the scope of this article. The CM application involves the evaluation of multiple water supply options in the Australian Capital Territory (ACT), in terms of such attributes as increases in household water costs, restrictions on household water use, water quality and impact on habitat for rare and endangered species. While most applications of CM have to date focused on the estimation of use values, the present study focuses mainly on passive use values. It provides an important insight into the ability of CM to estimate passive use values and include the broad range of environmental costs in CM evaluations.

The article is structured as follows. In section 2 we outline the CM approach to non-market valuation (NMV) in more detail and contrast it briefly with that of CVM and some other consumer-based multi-attribute decision-making approaches. The application to water supply options facing

ACT Electricity and Water (ACTEW) is then presented in section 3, followed by some brief conclusions in section 4.

2. The choice modelling approach

Choice experiments have their origin in conjoint analysis, which has been widely used in market research. Conjoint analysis involves 'the decomposition into part-worth utilities or values of a set of individual evaluations of, or discrete choices from, a designed set of multiattribute alternatives' (Louviere 1988, p. 93). These approaches have much in common with Lancaster's (1966, 1991) modern consumer theory (see Blamey *et al.* 1997 for a discussion). Several different conjoint paradigms exist, differing in terms of the response modes employed, methods of statistical analysis and interpretation of results (Louviere 1988). Morrison *et al.* (1996) compare CM with other conjoint approaches such as contingent rating and contingent ranking.

Environmental applications of CM include Adamowicz *et al.* (1994, 1996), Boxall *et al.* (1996), Swallow *et al.* (1994) and Rolfe and Bennett (1996). Boxall *et al.* observe that choice experiments are attractive for environmental valuation because they rely on the same model structures as referendum CVM models and discrete choice travel cost models (Boxall *et al.* 1996, pp. 244–5). Indeed, both CM and CVM have a theoretical basis in random utility theory, RUT.[3]

According to RUT, the ith respondent is assumed to obtain utility U_{ij} from the jth alternative in a choice set, C, and U_{ij} is held to be a function of both the attributes of the alternatives presented to the individual, Z_{ij}, and characteristics of the individual, S_i. U_{ij} is assumed to comprise a systematic component V_{ij} and a random component e_{ij}. While V_{ij} relates to the measurable component of utility, e_{ij} captures the effect of omitted or unobserved variables. We thus have

$$U_{ij} = V(Z_{ij}, S_i) + e_{ij} \tag{1}$$

and respondent i will choose alternative h in preference to j if $U_{ih} > U_{ij}$. Hence:

$$\begin{aligned} P_{ih} &= \text{Prob}(U_{ih} > U_{ij} \text{ for all } j \text{ in } C, j \neq h) \\ &= \text{Prob}(V_{ih} - V_{ij} > e_{ij} - e_{ih}, \text{ for all } j \text{ in } C, j \neq h) \end{aligned} \tag{2}$$

[3] As such, they are both susceptible to any violations of RUT. These can arise, for example, when respondents employ non-compensatory decision heuristics such as those involved with the use of lexicographic strategies, and elimination by aspects (Blamey, Common and Quiggin 1995; Blamey *et al.* 1997).

The e_{ij} for all j in C are typically assumed to be distributed independently, identically and in accordance with the extreme value (Gumbell) distribution. This gives rise to the multinomial logit model (MNL), commonly employed in discrete choice modelling:

$$P_{ih} = \frac{\exp[V_{ih}]}{\sum_{j \in C} \exp[V_{ij}]} \tag{3}$$

The estimated linear-in-parameters utility function for the jth alternative is often specified as follows:

$$\begin{aligned} V_{ij} = {} & \mathrm{ASC}_j + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_k X_k + \gamma_1 (S_1 {}^* \mathrm{ASC}_j) \\ & + \ldots + \gamma_p (S_p {}^* \mathrm{ASC}_j) \end{aligned} \tag{4}$$

where there are j alternatives in the choice set, k attributes and p socio-economic variables in the utility function. The β are often not specified in a way that permits them to vary with the alternatives in the choice sets, implying that the effect of a choice-specific variable on the odds of a given option being chosen is the same regardless of which alternatives are being considered. It is common to estimate a set of $j - 1$ constants in conditional logit models, where j is the total number of alternatives. Because these constants take on a value of one for the jth alternative, and zero otherwise, they are generally referred to as alternative-specific constants (ASCs). These ASCs capture the mean effect of the unobserved factors in the error terms for each alternative. This provides a zero mean for unobserved utility and causes the average probability over the sample for each alternative to equal the proportion of respondents actually choosing the alternative. Socio-economic variables are included in utility functions by interacting them with either the ASCs, as shown in equation 4, or the attributes.

The inclusion of ASCs helps mitigate inaccuracies due to violations in the assumption of independence of irrelevant alternatives (IIA) (Train 1986). This assumption, which arises from the above-mentioned iid assumption, requires that the ratio of the choice probabilities for any two alternatives be unaffected by the addition or removal of alternatives. This is equivalent to assuming that the random error components of utility are uncorrelated between choices and have the same variance (Carson *et al.* 1994). IIA violations can be avoided by parametising the effects in the systematic utility component, or utilising the heteroscedastic error variance (HEV) or nested logit facilities in some statistical packages (Bhat 1995; Daganzo and Kusnic 1993). Heterogeneity in the sample with respect to mean effects and/or variances can result in iid violations. Segmentation methods are often used to address such problems, as are random coefficient models (Jain, Vilcassim and Chintagunta 1994).

Calculation of predicted probabilities given a set of values for the explanatory variables proceeds in much the same way as for binary logit. The estimated probability of the *i*th respondent choosing the *h*th option from a policy-relevant choice set is calculated by substituting the appropriate attribute levels and socioeconomics into the estimated utility functions in equations 3 and 4. Point estimates can be obtained for the average respondent, in terms of the socioeconomic variables. However, it is often preferable to allow for individual differences in utility functions and estimate the percentage market share ms(h) as:

$$\mathrm{ms(h)} = \frac{\sum_{i=1,N} P_{ih}}{\sum_{j \in C}\left[\sum_{i=1,N} P_{ij}\right]} * 100 \tag{5}$$

where N is the number of respondents. Welfare estimates are obtained using the following formula described by Hanemann (1984, cited in Adamowicz *et al.* 1994):

$$W = \frac{1}{\mu^1}\left[\ln \sum\nolimits_{j \in C_i} e^{v_{i0}} - \ln \sum\nolimits_{i \in C_i} e^{v_{i1}}\right] \tag{6}$$

where μ^1 is the marginal utility of income, v_{i0} and v_{i1} represent the utility before and after the change, and C_i is the policy-relevant choice set presented to the *i*th respondent. In choice experiments, the coefficient of the price attribute is taken as an estimate of μ^1. Changes in v_{i0} or v_{i1} can arise from changes in the attributes of alternatives or the removal (or addition) of alternatives altogether. For example, in the recreational fishing context, where alternative fishing sites are substitutes in consumption, the welfare implications of site closures can be estimated by removing the sites in question from anglers' choice sets. When alternatives are substitutes in 'production', or 'solution', for example when a single solution has to be chosen from a set of feasible mutually exclusive solutions, the removal of alternatives can be used to estimate selection probabilities and welfare implications based on different choice set configurations.

When the choice set includes a single before and after policy option, equation 6 reduces to:

$$\begin{aligned} W &= \frac{1}{\mu^1}[\ln(e^{v_{i0}}) - \ln(e^{v_{i1}})] \\ &= \frac{1}{\mu^1}[v_{i0} - v_{i1}] \end{aligned} \tag{7}$$

In the case of changes in a single attribute, k, this further reduces to

$\beta_k/\beta_{\text{price}}$ when a linear in parameters utility function is employed. This is equivalent to calculating the ratio of marginal utilities for the attribute in question and the price attribute (Hensher and Johnson 1981).

3. Application to water supply options in the ACT

CM was used to evaluate community values associated with different features of possible water supply options in the ACT. ACTEW commissioned the Centre for International Economics (CIE) to undertake the study as a follow-up to the *The ACT Future Water Supply Strategy*.

3.1 Problem definition and qualitative research

The objective was to assess community preferences and values relating to alternative water supply options for a future ACT population in the vicinity of 450 000, with particular attention to environmental costs.[4] It is not possible to meet the water needs of such a population without some form of policy intervention, be it increasing the supply of water, reducing demand, or some combination of the two. The following policy options were considered: (1) Tennent Dam on the Gudgenby River; (2) Coree Dam on the Cotter River (between the existing Bendora and Cotter Dams); (3) large-scale water recycling, involving construction of a 50 megalitre per day recycling plant with subsequent pumping to Cotter Dam; (4) a demand management recycling mix resulting in 20 per cent reduction in demand (small-scale recycling for public space, voluntary demand management with some incentive schemes and increasing use of grey water recycling, and regulations on new construction to be water-efficient); and (5) a demand management agenda with compulsory restrictions resulting in a 20 per cent reduction in demand (education, price increases and restrictions). The last option was viewed as a necessary undertaking if no action was taken to increase supply.

Having identified the alternative policy options, each option was then described in terms of major community concerns, ecological impact, financial cost, supply capacity and water quality. Stakeholder and focus group meetings were held with environmental groups, ACT and local government, and large and small water users. Several issues emerged in considering the options and their implications.

One such issue was the emotive nature of some of the options, particular those involving dams. It was felt that emotional reactions to the word 'dam'

[4] The options were developed for three time frames based on population growth and were matched in terms of population that could be supported by the option.

could potentially obscure the estimation of environmental values. For this reason it was decided to describe only the consequences of each option, in terms of environmental flows, habitat loss, etc., thereby avoiding the use of emotionally infused option labels. It is recognised that this approach can result in a loss in predictive validity, since real-life voting or market behaviour *is* influenced by emotions associated with policy labels (Blamey *et al.* 1997). The justification for our approach lies in an assumption that more informed and deliberative preferences are preferred from a decision-making perspective. Other studies have used a similar rationale. Opaluch *et al.* (1993), for example, used a generic attribute approach in diffusing the 'highly charged emotions' associated with alternative sites for noxious facilities. Mitchell and Carson (1989) advocate a 'super-referenda' interpretation of CVM, in which CVM responses are held to reflect a higher degree of information and deliberation than many real-life referenda.

Results of this first stage indicated that each of the five policy options could be characterised by levels of the following six attributes: (1) quantity of water available for household use; (2) quality and perceived quality of the water used; (3) annual household cost of water; (4) the aquatic and riparian environment — the health of the native fish and other aquatic animals and plants, and the health and appearance of the stream and river banks; (5) maintenance of habitat for native animals and preservation of native vegetation, and the access to areas in their natural state for passive recreational activities; and (6) the urban environment — the style of the urban environment in terms of the areas of grass, and the types of trees and gardens in both public and private areas. Table 1 summarises how the attributes finally selected for further analysis using CM map into each of the

Table 1 Mapping attributes into options

	Option				
Attribute	1. Coree	2. Tennent	3. Large-scale recycling	4. Demand manage: recycling	5. Base Option: no increase in supply
1. reduction in use (%)	0	0	0	10	20
2. use of recycled water	none	none	all purposes	outside use	none
3. increase in household cost A$	75	75	50	75	50
4. improvement in river flows	some	all	some	all	none
5. endangered species losing habitat	10	2	0	0	0
6. appearance of urban environment	green	green	green	some brown	brown

five options. The research underlying this table is presented in CIE (1997) and CSIRO (1997).

A key question that had to be addressed was how to embed the above set of policy options and attributes within a plausible CM scenario. In particular, two alternative ways of constructing the CM scenario were considered. The first would involve defining the constant base alternative in terms of current market conditions (water charges, demand management, supply) and estimating consumer surplus corresponding to various departures from these conditions, as defined by each of the five options listed in table 1. The second approach would involve defining the base scenario in terms of the demand management regime that would necessarily accompany a 'no increase in supply' decision and population of 450 000 (option 5 on p. 344), and defining the other options in terms of movements from that position.

The first approach would be expected to provide the most valid estimates of willingness to pay for changes from current environmental, pricing and other conditions. However, this was not the objective. Rather, the objective was to assess consumer preferences and willingness to pay in the context of a *policy-relevant* set of water supply options. Using the former approach to inform the latter objective would require an assumption of market correspondence which may not be appropriate.[5] The final decision was to define the base option in terms of the likely 'no increase in supply' scenario shown in table 1, involving a heavy demand management regime, with household use of water reduced by 20 per cent compared to current usage, and water charges to increase by A$50. A consequence of having a A$50 payment as part of the base option is that WTP estimates involving movements from the base option will be conditional on an A$50 payment having to be made. WTP results are interpreted accordingly.[6]

3.2 Questionnaire design

The focus groups were used to assess the importance of different attributes to members of the public, and to identify meaningful ways of defining them in the questionnaire. Three values (levels) were assigned to each attribute,

[5] Market correspondence is 'correspondence between the provision of the amenity described in the CV scenario and the amenity changes actually implied by the policy changes' (Mitchell and Carson 1989, pp. 297–8).

[6] A further issue that required careful consideration was the price implications of the different options. Some options have high fixed costs and relatively low variable costs, while others have high variable costs. Further complicating matters is that the price of water is not the only determinant of the cost of water to the household. Refer to CIE (1997) for further details.

Table 2 Attribute levels and corresponding variables in regressions

Attribute	Levels	Variable in regression
Reduction in household water use	None 10% 20%	reduce (quantitative) (0, 10, 20)
Use of recycled water	None Outdoor use Outdoor and inside use	recno = 1; recout = 0 recout = 1; recno = 0 recno = −1; recno = −1
Increase in water charges	A\$50 A\$75 A\$125	price (quantitative) (50, 75, 125)
Improvement in river flows	None Some rivers All rivers	rivsome = −1; rivall = −1 rivsome =1; rivall = 0 rivall =1; rivsome = 0
Number of species with habitat loss	None 2 species 10 species	spec (quantitative) (0, 2, 10)
Colour of grass in urban areas	Brown in most public areas Brown in some public areas Green in all public areas	sbrown = −1; green = −1 sbrown = 1; green = 0 green = 1; sbrown = 0

the upper and lower values being chosen so as to encompass the policy options of interest. Table 2 lists the final attributes and levels.

In order to ensure that the attributes vary independently of one another, such that their individual effect on respondents' preferences can be isolated, an orthogonal experimental design was used to assign attribute levels to options. A one-twenty-seventh fraction of the full 3^6 factorial design was used to reduce the number of alternatives to a manageable level. Combinations of the 27 resultant alternatives were assigned to three blocks such that any one respondent would be confronted with no more than nine different options (excluding the constant base option) in nine choice sets.

Some alternatives that come out of a design may not contain plausible or feasible combinations of attribute values. For example, the increase in the household cost of water may be small and yet there is no requirement for any restrictions on use. These combinations can be removed from the choice set without significantly disturbing the orthogonality if they are few in number. If many of the options do not appear feasible, the design of the experiment needs to be changed. No alternatives were removed in the present study, as a pre-survey exercise indicated that different individuals (and researchers) have different interpretations of what constitutes an implausible combination of attributes.

The work in the focus groups and the pilot survey demonstrated that answering CM surveys is not easy. The survey consequently went through a number of iterations to try and minimise the number of questions prior to the choice sets and yet prepare people to think about the choices. The number of attributes that could be digested was explored within the focus groups, with the number of attributes being reduced from nine to six as a consequence. The simplification of the questionnaire and the reduction in the number of choice sets to nine (three to a page) also facilitated respondent satisfaction with completing the questionnaire.

Section 1 of the final questionnaire described the ACT's water choices in general terms, asking respondents to read an information sheet describing the six main 'features' of the water supply options. The next section, labelled 'What do *you* think?', asked respondents to rank these six features from most important to least important. This question was included both as a framing exercise for respondents, and a means of cross-checking the results of the conditional logit model.

Section 2 then introduced the CM exercise, explaining the task requirements and defining the constant base 'no increase in supply' option. It was emphasised that the 'do nothing' option did not mean 'status quo', as without augmentation in supply (through new dams or recycling or voluntary reduction) restrictions would be necessary. The payment vehicle was defined as an increase in the cost of household water. Although highly plausible given the true policy context, water cost was expected to bite less with renters than owners. The nine choice sets followed an example choice set and explanation. Table 3 shows a typical choice set. A series of socio-economic questions formed the last section of the survey. Respondents were also asked to indicate whether they were currently renting. This permitted the relationship between rental status and bid value to be explored at the data analysis stage.

Table 3 Example choice set

Feature	I prefer option A ☐	I prefer option B ☐	I prefer the no change in supply option ☐
Reduce your household use by	none	10%	
You would use reclaimed treated water for	all uses	not at all	
Your household water cost will increase by	A$50	A$75	
Environmental flows improve in	all rivers	some rivers	
Some habitat loss for	no species	10 species	
The urban landscape would be	green	some brown	

3.3 Sample selection and interviewing

The questionnaire was administered using in-person, door-to-door, interviews. This approach adds an element of obligation to encourage people to fill out the questionnaire. It also allows for questions to be answered and the purpose to be explained. A small number of surveys were dropped off in accordance with respondents' wishes, and a time arranged for subsequent survey collection.

The sample size was limited by the decision to use face-to-face methods and the budget. Around 300 usable questionnaires were expected. Stratified random sampling was used to ensure a representative sample. Each choice set was expected to have about 30 observations under this approach.

3.4 Results

Sample representativeness

A degree of bias appears to have occurred in favour of individuals who are better educated, on higher incomes and male. This may be partly a result of the questionnaire being completed by the head of the household. Fifty-eight per cent of respondents were male, and half of all respondents were aged between 30 and 50 years of age. Forty-nine per cent of respondents indicate a household income (before tax) of between A$45 000 and A$100 000, with the average being A$54 000. This compares with the average household income for the ACT in 1993–94 of A$52 000, estimated by the Australian Bureau of Statistics (CIE 1997). Forty-three per cent of respondents have a tertiary qualification, with 12 per cent having a higher degree. Twenty-six per cent of the sample report they are renting, against the 33 per cent for the ACT as a whole. Results need to be interpreted with these potential biases in mind.

Issues arising from the survey process

A few respondents were frustrated by having to make difficult trade-offs, indicating that they would prefer to simply pick the attributes and values they like most. These responses were not included in the analysis.

In some cases respondents were annoyed by the inclusion of what they thought were infeasible options in a particular choice set, a response anticipated through piloting. This problem was to be avoided by having the interviewers explain that some of the options might be thought infeasible, but were included for good reasons. In retrospect, inclusion of a written explanation of why they were included in the choice sets would have been useful.

There is a concern that a small proportion of people may have filled out the questions randomly or by always picking the same choice number. Where respondents had picked choices that were obviously inconsistent, or had commented that the questions were *too* hard, their responses were excluded from the analysis.

Of the 321 surveys conducted, a total of fifteen were excluded as non-response, twelve were considered unusable, and 30 were only partly usable for the choice set analysis (e.g. partially completed). The 294 surveys provided 2 544 completed choice sets for analysis.

Conditional logit results

The results presented in this article were analysed using LIMDEP, a specialist discrete choice modelling package, as individual level data (as opposed to frequency data). Consistent with convention in studies of this type, the three qualitative attributes shown in table 2 were effect coded rather than dummy coded, the tactical difference with the former being that the control group is assigned a code of -1 instead of 0 (Bernstein 1988). When interpreting results, the base level takes the utility level of the negative of the sum of the other estimated coefficients, and the other levels take the utilities associated with their coefficients (Adamowicz *et al.* 1994). Adamowicz *et al.* (1994) discuss the advantages of effect coding in stated preference experiments. Table 2 lists the variables and their coding.

Table 4 presents conditional logit results for three different model specifications. For present purposes, we do not consider more complex specifications that permit the IIA assumption of the MNL to be relaxed.[7] A separate paper is intended on this issue. Model 1 in table 4 represents the most basic attribute specification. All the coefficients are significantly different from zero at the 5 per cent significance level, with the exception of 'green', which indicates whether grass can be expected to be green in all rather than some or no public areas. It appears that ACT residents are satisfied with knowing that only some public areas will be brown. Further reducing this to no brown areas is not a major concern. Most of the variables are significant at the 99 per cent significance level.

The signs of the attribute parameters are generally as expected. Higher compulsory reduction in water use reduced the probability that an option would be chosen, as did higher household cost. Greater flows in rivers increased the choice probability, greater adverse species effects reduced the probability, and a less brown urban environment increased the probability.

[7] The market share and WTP estimates reported in this article should be treated with a degree of caution as a result. It is recommended that the IIA assumption be appropriately addressed in studies providing an important input to decision-making.

Table 4 MNL results: determinants of option choice [a]

	Model 1	Model 2	Model 3
asc(option1)	0.3673 (0.1407)**	0.8731 (0.2570)**	0.8815 (0.2414)**
Reduce	−0.0134 (0.0039)**	−0.0155 (0.0044)**	0.0048 (0.0091)
Recout	0.4624 (0.0418)**	0.4753 (0.0473)**	0.5138 (0.0497)**
Recno	−0.1908 (0.0431)**	−0.1881 (0.0487)**	−0.2047 (0.0508)**
Price	−0.0126 (0.0010)**	−0.0115 (0.0011)**	−0.0067 (0.0028)*
Rivsome	0.0915 (0.0422)*	0.0639 (0.0474)	0.0852 (0.0429)*
Rivall	0.3831 (0.0423)**	0.3955 (0.0476)**	0.3839 (0.0430)**
Spec	−0.0642 (0.0072)**	−0.0692 (0.0081)**	−0.1008 (0.0179)**
Somebrown	0.0940 (0.0426)*	0.1209 (0.0479)*	0.0811 (0.0433)
Green	0.0671 (0.0426)	0.0619 (0.0477)	0.0779 (0.0433)
age*asc		−0.0770 (0.0261)**	−0.0830 (0.0352)*
income*asc		−0.0044 (0.0187)	
sex*asc		−0.0517 (0.1176)	
rent*asc		−0.4367 (0.1388)**	−0.1617 (0.1756)
age*reduce			−0.0035 (0.0016)*
age*price			−0.0011 (0.0005)*
age*spec			0.0069 (0.0032)*
rent*recout			−0.2196 (0.0951)*
rent*recno			0.0951 (0.0985)
rent*price			−0.0034 (0.0025)
logL(initial)	−2674.25	−2119.07	−2608.71
logl (final)	−2417.83 (n = 2544)	−1908.53 (n = 2010)	−2341.34 (n = 2481)

Notes: [a] Standard errors are shown in brackets. * indicates statistical significance at the 95 per cent significance level, and ** indicates significance at the 99 per cent level. Socioeconomic variables were coded as follows: age = age in tens of years; income = household income in units of A$10 000; sex = 1 if male, 0 female; and rent = 1 if renting, 0 if not. The alternative-specific constant (ASC) is coded 1 for options 1 and 2 in the choice set, and 0 for option 3.

It is interesting to observe that use of recycled water for outside use adds positively to the utility of an option, but the additional use of recycled water for inside use (the base coding level) has a negative effect: $-(0.4624 + -0.1908)$. From these results the support for grey water recycling for outdoor use is overwhelming, but people are still very wary about the potable use of such water.

Models 2 and 3 introduce socioeconomic variables to the indirect utility function. Model 2 includes these variables in an additive form while model 3 includes them in both an additive form and as interactions with selected attributes. Note that the additive specification requires the socioeconomic variables to be interacted with the alternative specific constant (see section 2). The reason for this is that variables taking the same value for all options within a choice set cannot be used to predict option choice. Results indicate that older residents are more likely to choose the base option than younger residents. Younger residents may be less averse to changes in their living environments. Similar considerations can be expected to apply to renters. Income and sex were not significant determinants of option choice.[8]

The results for model 3 provide further insight regarding how age and rental status, the two significant socioeconomic variables in model 2, influence option choice. Older respondents attach greater importance to reductions in household use of water than other respondents, and are more concerned about price increases. However, older respondents were less concerned about losses in species habitat. Renters attached less importance to using recycled water outside than other respondents. Note that the rent*price interaction is not significant, implying that renters are no more or less price responsive than non-renters. Renters thus do not appear to be discounting the payment vehicle on the belief that landlords would not pass increases in water charges on to them. Indeed, the coefficient is wrong-signed with respect to this hypothesis, which may in part be a reflection of lower renter incomes.

Ranking the options

A major purpose of the choice modelling exercise was to provide a method for ranking the set of feasible options listed in table 1. The highest ranked option provides the highest expected utility to consumers, conditional in this application, on some form of action having to be taken.

Table 5 compares the five policy options in terms of choice probabilities and market share. Two different probability estimates are given, the first indicating the probability of the average individual choosing an option when the only other alternative in the choice set is the base option. These binary choice probabilities provide an approximation of the results one might expect to obtain in dichotomous-choice CVM studies. The second set of probabilities correspond to an expanded choice set involving all five management options. Market share estimates corresponding to the latter choice set were calculated using equation 5. These provide an indication of the proportion of ACT residents favouring each option.

Results are generally consistent with each other. The demand management recycle option is the preferred option, with the use of recycling for outside water use and the best outcome for the rivers and streams weighing heavily in its favour.

[8] Note that income has the opposite sign to what might be expected on *a priori* theoretical grounds, given the base option is generally the cheapest option. Flores and Carson (1997) have shown that income elasticities of WTP are likely to be significantly less than income elasticities of demand, with which economists are more familiar. Additional analysis indicated that income did not attain significance when the other socioeconomic terms in the model were removed.

Table 5 Ranking the options and willingness to pay

	Management option				
Ranking Measure[1]	Coree (h = 1)	Tennent (h = 2)	Large-scale recycling (h = 3)	Demand-manage: reuse (h = 4)	Do-nothing: restrictions etc (h = 5)
P(h/Cn), Cn = {h, 5}, h $\neq$ 5	0.619	0.786	0.797	0.874	n/a
P(h/Cn), Cn = {1,2,3,4,5}	0.094	0.214	0.229	0.404	0.058
Ms(h/Cn) Cn = {1,2,3,4,5}	6.4%	19.4%	18.7%	51.1%	4.3%
WTP(h/Cn) Cn = {h, 5}, $h \neq 5$	$36.4	$98.0	$103.1	$145.8	n/a

Note: P(.) indicates the choice probability for hth option, Ms (.) indicates market share for the hth option, and WTP indicates willingness to pay for the hth option. Cn defines the policy options in the conditioning choice set. Hence P(h/Cn = {h, 5}) represents the choice probability for the hth alternative, when only the hth alternative and the do-nothing option are able to be chosen.

While the Tennent Dam option is the second ranked option according to the probability estimates, its estimated market share comes in slightly behind large-scale recycling. This illustrates how allowing for individual differences can lead to different rankings than those calculated for the average respondent. Although not providing utility through the provision of recycled water for outside use, the Tennent option provides the best outcome for rivers and streams, water restrictions and appearance of the urban environment, outweighing the cost to species.

To illustrate the use of CM in evaluating 'what if' scenarios, assume that under a worst case scenario the Tennent option would result in ten rather than two species affected, with the other attributes remaining unchanged. It is a straightforward exercise to re-estimate market share under this assumption. Results indicate that the Tennent share would fall to 10 per cent, with the share of all other options slightly increasing.

The large-scale recycling option is the third most preferred of the five, with the above exception. The lower cost relative to the other 'increase in supply' options accompanied by the medium outcome for flows in rivers and streams are the most important factors. However, it is possible that this option could end up costing, say, A$125 because of problems associated with the disposal of brine rather than the A$50 assumed in table 1 (CIE 1997). If this scenario is run through the model, the market share for this option drops from 19 per cent to 12 per cent, with most of the difference being taken up by the demand management recycle option, which increases its share to 55 per cent.

The Coree Dam is second last in the rankings, the loss of flow and additional species affected putting it well below the Tennent Dam option. The 'no change in supply' option is ranked last. The lower price of this option is not sufficient to offset the cost of greater restrictions, lower flows and a brown Canberra.

Willingness to pay estimates

The conclusions that can be drawn from any stated preference study are conditional on the scenario presented. In the CM case, this includes the attribute-space selected for the experiment and the definition of the constant base option. While the base option in the present study does not involve increasing the water supply, this necessarily implies demand management measures. Hence, WTP estimates are conditional on the fact that some form of action must be taken to address the water supply needs of an increased population. To the extent that our base option is policy relevant, which we believe to be the case given the research described in section 3.1, so are the corresponding WTP estimates. The present survey can thus validly be used to estimate the amount ACT residents are prepared to pay to obtain one policy-relevant water supply option for a population of 450 000, *in preference to another*.[9]

With this observation in mind, we now consider differences in welfare associated with alternative water supply options. As noted in section 2, the implicit value of marginal attribute changes can be estimated by observing the marginal rate of substitution between the price attribute and the attribute in question. Table 6 presents estimates of marginal attribute values, for the average respondent in terms of age and rental status.

Beginning with the environmental attributes, the results indicate that respondents are willing to trade off an A$42 annual increase in the household cost of water for an improvement in river flows from no to some rivers. The equivalent willingness to pay for an increase in improvement from some to all rivers is A$22. WTP to prevent losses in habitat for uncommon species is approximately A$5 per species, or A$24 for five species. On average, households would be willing to pay an extra A$18 in water costs to improve the appearance of Canberra from 'brown', the base case outcome, to 'some brown'. Consistent with the results in table 4, WTP for further improvement is insignificant.

The value of a 10 per cent reduction in household use of water is estimated at A$10, and WTP for the provision of recycled water for outdoor use is a

[9] In other words, we are not attempting to estimate consumer surplus for changes from current water supply conditions, but rather willingness to pay in a constrained market where consumers are aware that some action has to be taken to address future water supply needs.

Table 6 Attribute valuations

Attribute change	Implicit annual price (at mean age and rental status)
prevent 10% reduction in household use	\$10
recycled water for all uses, to outdoor use only	\$55
no use of recycled water to recycled water for outdoor use	\$47
environmental flows improve in no rivers, to some rivers	\$42
environmental flows improve in some rivers, to all rivers	\$22
reduce habitat loss for 5 species	\$24
brown urban landscape, to some brown	\$18
some brown landscape, to no brown (green)	−\$0.2

substantial A\$47. Interestingly, WTP for the provision of recycled water for all uses is equally substantial but negative (−A\$55), a reflection of the desire to avoid drinking recycled water.

Table 5 presents monetary estimates of the differences in utility of the five feasible water supply options listed in table 1 (calculated using equation 6). These figures represent the increase in water charges that, when applied to each of the four alternatives to the base case, would leave respondents indifferent between the alternative and the base case. Note that while all estimates are positive in sign, they need not have been. While the base option is dominated by the other four options in terms of appearance of urban landscape, improvement in ACT river flows, and reduction in household use, it involves less impact on endangered species than the Coree and Tennent Dam options, and less reuse of water than the large-scale recycling and demand-management/reuse options.

Results indicate that respondents are on average willing to pay almost A\$150 per year to obtain the fourth, demand management, option rather than the base case scenario involving water restrictions of 20 per cent. In terms of willingness to pay, the next most preferred options are large-scale recycling and the Tennent Dam. Respondents are willing to pay substantially less for the outcomes associated with the Coree Dam option than the Tennent option. These results are consistent with the community rankings presented above, with the above-noted exception regarding the second and third ranked options.

4. Conclusion

The use of choice modelling in the assessment of community preferences and values regarding alternative water supply options facing the ACT has been illustrated. The case study provided an excellent opportunity to apply

CM to a real policy issue, involving passive use values and a plausible payment vehicle.

On the basis of the results obtained, it would appear that choice modelling provides a viable and flexible alternative to CVM, that is particularly well suited to the evaluation of multiple alternative policy options, both in terms of monetary valuation and community ranking. The latter approach may be particularly attractive to those who are philosophically opposed to monetary valuation of the environment. In this case, the 'payment' attribute may need to be defined with reference to how the proposed environmental improvements would actually be funded, which will often not involve additional consumer payment.

While generating considerable cost savings through the ability to simultaneously value a number of options, CM also provides valuable information regarding the relative importance of different environmental, economic and other attributes. Scientific or other uncertainties can be addressed by running 'what if' scenarios through the model. By focusing respondents' attention on differences in outcomes for alternative management options, CM is also likely to provide more discerning responses than CVM, and may be less prone to yea-saying. Greater attention to substitute goods is also likely to reduce the tendency of some respondents to dump their WTP expressions on the first acceptable management option presented to them. Rather than simply reminding respondents about other possible substitute goods, as is common practice with CVM, CM offers the potential to explicitly include key substitute goods within the choice exercise, thereby providing a more salient and appropriate framing manipulation.

However, these potential advantages must be weighed up against the greater complexity of undertaking CM studies, in terms of experimental design, questionnaire design and focus grouping, and model estimation. Further research will continue to clarify the precise advantages and disadvantages of the different stated preference approaches for assessing environmental and other values.

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