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# CHOICE MODELLING RESEARCH REPORTS

## SOME FUNDAMENTALS OF ENVIRONMENTAL CHOICE MODELLING

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# Abstract

Environmental Choice Modelling is an emerging technique used to estimate non-marketed benefits and costs that result from environmental impacts. In this report, the technique is described and the fundamentals of its application – principally to the task of estimating non-use environmental values – are outlined. The aim of the report is to provide a resource for those seeking a better understanding of the technique. It is not designed as a comprehensive guide but rather an introductory primer. Throughout the report, examples are drawn from previous Research Reports in this series.

# 1. Background

The demand for dollar estimates of non-market values, especially those associated with environmental impacts has grown steadily over the past two decades. In the public sector, decision-makers assessing capital works proposals and alternative natural resource management policies have sought quantitative assessments of environmental costs and benefits. In the private sector, an increasing number of firms find it useful to incorporate environmental value estimates in their project appraisals and environmental reporting processes.

To meet this demand, economists have developed an array of techniques that go beyond traditional market-based means of estimating benefits and costs. The techniques can be classified as either "revealed preference" or "stated preference" methods (see Box 1).

## Box 1: Non-market valuation techniques

*Revealed preference techniques for estimating non-market values involve the use of information from markets that are specifically related to the non-marketed value under consideration to infer value estimates. One such method is the travel cost method for estimating use values of recreation areas. Bennett (1996) used this method to estimate the benefits enjoyed by people visiting Dorrigo and Gibraltar Ranges National Parks. Another revealed preference technique is the hedonic pricing technique. It has been used extensively to estimate pollution costs but Fraser and Spencer (1998) used hedonic pricing to value the aesthetic benefits enjoyed by residents in Ocean Reef, Western Australia. The stated preference pathway uses peoples' responses to questions regarding their willingness to pay for hypothetical situations. Best known of these techniques is the Contingent Valuation Method which has been extensively used to estimate the total economic value (made up of use and non-use values – see footnote 1) of environments. For example, Bennett, Blamey and Morrison (1998) used the method to estimate the values of wetlands in South Australia. Choice Modelling is another example of a stated preference technique. Morrison, Blamey, Bennett and Louviere (1996) provide a comparison of a range of stated preference techniques.*

Interest in stated preference methods has been kindled by their capacity to yield estimates of the full array of use and non-use environmental benefits and costs[1] and the *ex post* focus of revealed preference techniques. However, the most commonly applied method in this type, the Contingent Valuation Method (CVM) has been widely criticised because of a range of potential estimation biases that it may generate. Most notably, CVM studies have been criticised because of the potential for "strategic bias" whereby respondents deliberately misrepresent their preferences in order to influence the decision making process in their favour[2]. In the face of such criticism, the CVM has been steadily evolving[3]. In addition, other stated preference methods have been developing. One such method is Choice Modelling (CM).

Because CM has only recently emerged as a non-market environmental valuation technique, there are few resources available to those seeking a greater understanding of its operation. It is the goal of this paper to provide some insights into the fundamentals of conducting a CM application. It is intended to give those contemplating using CM some foundations upon which to base their work. It is also intended to give those who are using the results of CM applications in decision-making, an understanding of how those results are obtained.

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[1] Use values generated by environmental assets involve direct contact with the resource. They include direct contact uses such as recreation and indirect uses such as the provision of good quality water from a protected catchment. Non-use values are generated without direct contact. For instance, people may value the biodiversity supplied by an environment without wanting to experience it directly. See Wills (1997) for details of this categorisation of benefits and costs.

[2] See Mitchell and Carson (1989).

[3] For an example of a contingent valuation method application that was designed specifically in an attempt to avoid specific biases, see Bennett, Blamey and Morrison (1997).

It is not intended that the reader of this paper should be immediately able to undertake a CM application. That would trivialise the many difficulties involved in applying the technique. Rather potential practitioners should see it as a first base from which they can go on to a deeper consideration of the theoretical issues and practicalities that are embedded throughout a CM application.

It should also be noted that the focus of this paper is on the application of CM to the estimation of values enjoyed by people who are not direct users of the environment under consideration. Readers who are interested in the application of the technique to the estimation of use values such as recreation benefits are referred to studies reviewed by Louviere and Timmermans (1990).

In the next section of the paper, a brief outline of the principles underpinning CM is provided. This includes a description of the structure of a typical CM questionnaire used to estimate non-marketed environmental values. Following sections of the paper present the stages of a CM application. In each section, a CM stage is described including an outline of the practicalities involved with potential pitfalls identified. The paper finishes with some conclusions regarding the strengths and weaknesses of CM. In this way, some future directions for research endeavours are identified.

## 2. What is Environmental Choice Modelling?

The basic idea behind any stated preference technique for estimating non-market environmental values is to quantify a person's willingness to bear a financial impost in order to achieve some potential (non-financial) environmental improvement or to avoid some potential environmental harm. Different stated preference techniques approach this task in different ways.

For instance, the most widely used stated preference technique, the Contingent Valuation Method (CVM), involves survey respondents being asked if they are willing to pay some amount of money to achieve a hypothetical environmental goal. This amounts to people being asked to choose between two options:

- the "status quo" situation (that involves them paying nothing extra to secure the environmental conditions that prevail under current policy); and,
- the "proposed" situation (that involves them paying an extra amount of money to achieve an environmental outcome that is superior to that which the current policy would provide).

An example of a typical CVM question is provided in Box 2. The method requires different sub-samples of the population being asked the same question except that the amount of the financial payment required is varied across the sub-samples (say from the $20 in the example in Box 2 to $10, $50, $100 and $200). The different proportions of respondents agreeing to pay the different amounts of money are used to infer the amount overall people are willing to pay for the environmental improvement.

A CM application involves asking survey respondents a very similar type of question. However, instead of being asked only one question regarding one "proposed" situation as occurs in a CVM questionnaire, CM respondents are asked to make a sequence of six to eight choices. Each choice is between a constant "status quo" situation (often referred to as the ***constant base)*** and a number of different "proposed" situations. The groupings of "status quo" and "proposed" alternatives are known as ***choice sets.***

The "proposed" alternatives in each choice are all different in terms of the condition of the environment described to respondents and the financial burden they impose. The descriptors of the environment and the financial impost involved are known as the ***attributes*** of the alternatives. They may be characteristics such as "the number of endangered species present", "the area of healthy vegetation remaining" or "the number of visitors per annum".

**Box 2: A typical Contingent Valuation Method question**

*Question X: Do you support the proposal to protect the environment that will ensure:*

- *an increase in the number of endangered species present from 5 to 10*
- *an increase in the area of healthy native vegetation from 1500ha to 1800 ha*
- *an increase in the number of visitors from 2000 pa to 3000 pa*

*to be funded by a one-off levy of $20 on your income tax, or do you oppose it?*

*Please circle the option that most closely represents your view:*

*I support the proposal with a $20 levy …… …… 1*
*I oppose the proposal and the $20 levy …….. 2*

The variations across the "proposed" alternatives in the choice sets are achieved by assigning different ***levels*** to the attributes. Hence, the attribute "number of endangered species" could be allowed to vary across the "levels" of 5, 10 and 15. The financial burden attribute could vary between the levels $10, $20 and $50. Different levels are assigned to attributes to create the proposed alternatives for inclusion in the choice sets according to a systematic process known as ***experimental design.***

A sample choice set is displayed in Box 3. In a CM questionnaire, six or eight of these choice sets would be presented to respondents as separate questions.

By observing and modelling how people change their preferred option in response to the changes in the levels of the attributes, it is possible to determine how they trade-off between the attributes. In other words, it is possible to infer peoples' willingness to give up some amount of an attribute in order to achieve more of another[4].

Hence, from a CM exercise it would be possible to estimate (in the context of the example in Box 3) the amount of visitor access people would be willing to forego in order to have more endangered species present at the site.

Given that one of the attributes involved is a dollar cost, it is also possible to estimate the amount that people are willing to pay to achieve more of an environmental attribute. This is called a ***part worth*** or ***implicit price*** estimate and can be estimated for each of the non-monetary attributes used in the choice sets.

Furthermore, it is possible to use CM results to infer the amounts people are willing to pay to move from the "status quo" bundle of attribute levels to specifically defined bundles of attribute levels that correspond with policy outcomes that are of interest. In other words, the willingness to pay to change from the status quo to a specific alternative can be derived. These estimates of ***compensating surpluses*** are consistent with the principles of welfare economics and are therefore suited for inclusion as value estimates in benefit cost analyses of policy alternatives.

[4] In the jargon of economists, these are estimates of marginal rates of substitution between the attributes.

**Box 3: A Choice Modelling Choice Set**

*Question Y: Consider carefully each of the following three options. Suppose these options were the only ones available, which one would you choose?*

| ***Alternative*** <br> ***Attribute*** | ***"Status Quo" alternative*** | ***Proposed alternative 1*** | ***Proposed alternative 2*** |
|---|---|---|---|
| ***Number of endangered species*** | *5* | *15* | *15* |
| ***Hectares of healthy native vegetation*** | *1500* | *1800* | *2100* |
| ***Visitor days per annum*** | *2000* | *3000* | *2000* |
| ***Cost to you ($)*** | *0* | *$20* | *$10* |

*Please circle your preferred option.*

*I would choose the Status Quo at no cost to me…….* *1*
*I would choose Alternative 1 at a $20 cost to me …….* *2*
*I would choose Alternative 2 at a $10 cost to me …….* *3*

Monetary estimates of the values ascribed to particular resource use alternatives (described by specific bundles of attribute levels) may not be considered applicable in some circumstances. Choice Modelling results can provide another type of information to policy makers. The relative support that various alternatives could be expected to receive from the public can be estimated from CM data. Where there are a number of competing alternatives (status quo included), between which policy makers must choose, the percentage of the public that would choose each can be estimated[5].

A CM application requires the careful implementation of a number of stages. In the following sections of this paper, these stages are outlined.

## 3. Establishing the issue

For CM results to be useful as inputs into a benefit cost analysis, the framework of the CM application must be consistent with the principles of benefit cost analysis. It is of particular importance therefore that the issue to be examined using CM is established in accordance with the concept of change at the margin.

Because policy-making regarding the environment is inevitably concerned with assessing the relative merits of making a change (or of avoiding a change), the tools of analysis which are aimed at assisting decision-makers are focused on values "at the margin". This is certainly true of benefit cost analysis whereby, the extent of the net benefit resulting from a change in resource allocation is estimated. Therefore, the values of interest are the additional benefits and costs (that is, marginal benefits and costs) resulting from the implementation of alternative policy options relative to some pre-defined status quo alternative.

If CM results are to be consistent with this marginal value framework, the issue under consideration must be defined in terms of change from a "status quo" reference point (see Box 4). The constant base alternative used in each choice set must reflect this status quo. Respondents to a CM questionnaire are therefore usually asked to compare alternatives against the status quo. The choice set questions are thus focused on an assessment of proposed change.

[5] This is often referred to as the "market share" of each alternative.

**Box 4: Defining the status quo**

*The status quo alternative that is presented to CM respondents may not describe the current situation. The choice facing respondents may relate to outcomes that will emerge after some period of time. Hence, the "status quo" will refer to the situation that emerges over time if there is no change made to the policy settings that can produce the alternative outcomes. For instance, in Blamey, Bennett, Morrison, Louviere and Rolfe's (1998) CM application, the choice sets presented to respondents provided information relating to the remnant vegetation that would remain in the Desert Uplands region of Central Queensland under various tree clearing regulations. The status quo option was to maintain the current regulations which would see the area of remnant vegetation significantly reduced from what is currently available.*

Inherent in the process of focussing on a proposed change is the definition of the environmental impacts under consideration. That is, what is the marginal benefit or marginal cost that is being estimated? A "boundary" must be established around the value to be considered. The CM analyst must be able to define the value - be it a use value, a non-use value or the total economic value[6] - in order to approach the task of describing the status quo and the proposed alternatives.

In defining the alternatives, the value under consideration must be defined. As an example, consider a situation where policy makers are contemplating the introduction of a regulation to restrict the use of a pesticide. The CM analyst must clarify whether, for instance, it is the non-use values associated with environmental damage caused by pesticides that are to be estimated or if use values are also to be estimated (see Box 5). The status quo - used as the constant base in the choice sets - would involve a listing of attribute levels describing the outcome of a continuation of the current pesticide use regime. Note that this may be defined at some point in the future when the effects of the pesticide use had reached their most environmentally damaging extent. The alternatives in each choice set would then involve levels of the descriptor attributes - at the same point of time in the future - which demonstrated the environmental improvements and financial cost penalties associated with changes from the status quo.

**Box 5: Value definition**

*In the remnant vegetation valuation exercise of Blamey et al (1998) and Morrison, Bennett and Blamey's (1997) estimation of wetland values, the primary focus was on non-use values. Respondents to the CM questionnaires were in the main selected from populations living distant from the environments at issue. However, neither studies sought to exclude the possibility of respondents expressing use values in their CM responses. To account for the impact of use values, respondents were asked if they had ever visited, or intended to visit the areas being described in the questionnaires. Answers to these questions can be used to determine if use has an impact on value.*

# 4. Defining the research design

Once the basic valuation issue has been defined consistent with the principles of benefit cost analysis, any other features of the resource allocation choice should be considered. This must be done at an early stage in the application process so that the structure of the research process can be designed.

It must be determined if there are any methodological sensitivities that require specific investigation. If there are, it may be necessary to set up parallel CM surveys that differ only in terms of the factor causing the hypothesised sensitivity. For instance, the inclusion/exclusion of an attribute may be hypothesised to have an impact on the value estimates obtained from a CM application. The two parallel surveys would thus differ only in that one survey's choice sets would include the attribute whilst the other would not. Parallel surveys can also be used to test how robust the value estimates derived are.

There may also be concerns regarding the geographic extent of the values under consideration. That is, the question of whether people living proximate to the environmental impacts of concern are greater

[6] Total economic value incorporates both use and non-use values of the environment

than those who live further away. To test this hypothesis, two CM applications may be required - one carried out using a survey of local residents and the other using a sample of people living further from the site - but with both surveys using exactly the same questionnaire. An alternative to this approach would be for a single questionnaire to be distributed across a wide geographic area, given that the questionnaire included a question regarding the respondent's place of residence. This would afford an analysis of how estimates of value are influenced by respondents' distance from the site of the environmental effects (see Box 6).

**Box 6: Research questions**

*To determine differences in the values held by different populations for the protection of the Gwydir Wetlands in the north west of NSW, Morrison, Bennett, Blamey and Louviere (1998) applied the same CM questionnaire to samples of households in Sydney and in Moree (the largest town in proximity of the wetlands). To determine differences held by the same population for different wetlands, Morrison et al (1998) applied two CM questionnaires that differed only in the details of the two wetlands involved (the Gwydir Wetlands and the Macquarie Marshes) to separate random samples of the Sydney population. In the remnant vegetation study conducted by Blamey et al (1998), the specific research issues addressed focused on the structure of the choice sets used. Slightly different versions of the same questionnaire were applied to different samples of the Brisbane population. The questionnaire differences involved the use of policy relevant "labels" on the alternatives presented in the choice sets and the number of attributes used to describe the alternatives.*

With the research issues defined, the structure of questionnaire versions, the "splitting" of the overall sample of respondents into sub-samples and the extent of sampling required can in turn be defined. Next, attention can be turned to issues involved in questionnaire design. The first of these issues is the definition of attributes to be used to define the environmental impacts.

# 5. Defining the attributes

Once the value to be estimated has been defined, the attributes to be used to describe the outcomes yielding that value can be defined. The attributes are used to describe the outcome of a continuation of the status quo and what would happen if an alternative were to be introduced. Two perspectives of these outcomes need to be taken into account when determining which attributes should be used.

First, it is important for the CM analyst to be cognisant of the requirements of policy makers. The attributes used to describe the alternatives in each choice set should be relevant to the policy making process. They should therefore be consistent with the policy instruments that are being used to form the outcomes depicted in the alternatives.

Second, the attributes used must have meaning to the people who will answer the questionnaire. If the attributes used are irrelevant to respondents, the likelihood of valid responses being received is reduced and response rates could be diminished.

To take into account these perspectives, the attributes must first be defined. Discussions with policy makers can be used to determine their perspectives. A more formal approach could involve the surveying of policy makers - and their advisers - using a structured questionnaire. In such a questionnaire, respondents could be asked to nominate the attributes that are believed to be most relevant to the decision making process. A Delphi process[7] could be used to allow respondents to refine their selection of attributes, given knowledge regarding other respondents' views.

The perspective of those who will be faced with answering the final CM questionnaire can be determined through a number of vehicles. A simple telephone survey of prospective respondents can be used to ask people what matters to them in the process of selecting between alternatives (eg. "What do

[7] The Delphi process involves an iterative sequence of interactions with respondents. Once the responses to a first round questionnaire are collected and analysed, the results obtained are provided to the respondents. An opportunity to revisit their response to the initial questionnaire is then provided. The process can then be repeated until some convergence of results is achieved.

you need to know before making a choice?" or "What are some good things and some bad things about possible alternatives?"). Further refinement of the list of attributes so obtained could take place in focus groups[8]. These groups of around eight people - selected from the population of potential CM questionnaire respondents - involve the structured discussion of points relevant to the design of the CM questionnaire. One of the points of discussion should be the determination of attributes (see Box 7). It is preferable for the policy relevant attributes to have already been established at this stage so that their relevance to potential respondents can be determined. What is required is a reconciliation of the two perspectives, if they do not already coincide. This may involve some give and take from both perspectives.

**Box 7: Focus groups**

*Morrison, Bennett and Blamey (1997) presents the results of focus groups carried out as a component of the wetland valuation CM application. These groups were undertaken in Sydney, Dubbo and Moree. The technique used in those focus groups to define attributes was to ask participants to explain what information they would need in order to assess alternative wetland management regimes. Through a process of refinement and prioritisation, a short list of attributes was distilled. A similar process was undertaken by Blamey, Rolfe, Bennett and Morrison (1997) for the remnant vegetation CM application. Those groups were held in Emerald and in Brisbane. Facilitation for both studies' focus groups was provided by the respective authors. A variety of facilities were used, ranging from purpose built focus group suites through to the function rooms of hotels. All groups were audio and/or video recorded to allow for more detailed examination of the dialogue. Participants were recruited primarily by market research companies but in the country towns where such services were not available, contacts were used to generate lists of "friends of friends" in order to diversify the socio-economic "coverage" of the participants.*

A specific problem that is common in the definition of attributes is the existence of some attributes that are "causally prior" to other attributes. For instance, the amount of pollution in a waterway may be regarded as a relevant attribute, as may the number of fish present in that waterway. However, before more fish can live in the waterway, the level of pollution would need to be reduced. The issue is whether the pollution is an attribute in itself, or whether it is merely a stepping stone to achieving what is valued by people and that is the number of fish. Such issues need to be determined in focus group discussions but by and large, the omission of causally prior attributes is the preferred strategy (see Box 8).

***Box 8: Causally prior attributes***

*Morrison, Bennett and Blamey (1997) detail problems experienced in defining the attributes of wetland protection from focus group sessions. Of particular importance was the finding that many focus group participants suggested water quality as the primary attribute of interest. It was apparent that good water quality was taken by respondents as an "indicator" that the environment as a whole was in good condition. Hence, people presumed that other environmental "outcomes" like the number of endangered species present in a wetland and the frequency of bird breeding events would be satisfactory so long as there was good water quality. A similar phenomena is reported by Blamey, Rolfe, Bennett and Morrison (1997) in their remnant vegetation focus groups. There, the attribute that was used by participants as an indicator was the "loss of area of unique ecosystems". If this loss was moderated, it was presumed that other environmental attributes – like the number of endangered species lost – would also be moderated. The strength of this finding led to the testing of the impact of including such "causally prior" attributes in choice sets (Blamey, Bennett, Morrison, Louviere and Rolfe 1998)*

## 6. Defining the levels

[8] See Krueger (1988) for details on focus groups.

With the attributes defined, the range over which they vary must be set. This involves establishing the levels that the attributes will take in the alternatives presented to respondents in the choice sets.

First, the way in which the levels are to be presented needs to be determined. Levels can be expressed either qualitatively or quantitatively. For instance, a water quality attribute may be expressed quantitatively in terms of the level of dissolved oxygen. Alternatively, the water's suitability for different purposes may be used to establish qualitative levels such as "suitable for boating" "suitable for fishing" and "suitable for drinking". The quantitative expression of levels has distinct advantages in terms of the modelling and valuation potential afforded and should be a goal in most circumstances.

Quantitative levels may be presented in absolute terms. For instance, the number of endangered species attribute may take on the level 10, thus informing the respondent that the alternative will result in 10 endangered species being protected. Alternatively, the levels may be presented as changes from what is currently present. This form of presentation may be particularly suited to cases where all alternatives, including the "status quo", involve levels which are different from the current situation. Hence, if there are currently 10 endangered species present and the status quo policy (ie no change in policy) would mean that only 4 species would remain in 10 years time, the status quo level for the endangered species attribute could be -6, with other alternatives providing smaller or zero declines. Percentage changes can also be used where it is important to demonstrate some relativities. The most appropriate presentation will need to be established through focus group testing (see Box 9).

The attributes must be allowed to vary across levels that are realistic. The range must however be sufficiently large to reflect the possible future values the attributes could take under all the policy options being considered. The selection of the range of levels to be taken by the financial attribute is of particular importance. It is necessary, most appropriately in focus groups, to put before participants, combinations of attributes at levels that make the overall package as desirable as possible. Discussions can then be initiated to determine the most money people would be prepared to pay for that alternative. This process is designed to establish the upper bound for the financial attribute's level. The lower bound for the financial attribute is set at zero (for the status quo option) largely because of the difficulties of establishing an attribute that can take on negative as well as positive values (ie that can accommodate both willingness to pay and willingness to accept compensation).

With the range set for the levels of each attribute, the increments between each level must be set. This implicitly determines the number of levels each attribute can take[9]. For example, if it is determined that the number of endangered species could vary between 10 and 30 depending on the policy adopted, a choice of interval of 10 endangered species would imply a three level attribute (10, 20 and 30).

Introducing risk into the specification of levels has received little attention. However, it is possible to define levels in terms of expected values and some associated variance or as a range of values. Alternatively, some overarching measure of risk could be introduced as a separate attribute

[9] This will be in part determined by the experimental design used to define the choice sets. See section 8 below.

***Box 9: The presentation of attribute levels***

*Complications regarding the presentation of the attribute levels can arise because of differences between the current situation and the outcome associated with the "status quo". For instance, the "status quo" alternative in the remnant vegetation study detailed in Blamey et al (1998) involved a considerable deterioration of the environment relative to the current situation. Two types of changes had to be understood by the CM respondents. First there was the change from the current situation to the future possible situations. Secondly there were the changes between the alternatives being presented in the choice sets. What was required was a careful depiction of the current situation and the range of future alternatives. Those future alternatives were presented to respondents as changes from the current situation. Hence, the status quo was depicted as involving the loss of 18 endangered species from the region whereas the stricter tree clearing regulation options involved between 4 and 16 endangered species lost. Other environmental attributes were presented as percentages of the current situation. For example, the status quo "loss in area of unique ecosystems" attribute was specified at 40% whilst the options involving tighter clearing restrictions gave lower percentage declines (15 to 35%).*

# 7. Designing the questionnaire

With attributes and levels determined, the issue and research design must be embedded into the structure of a questionnaire or sequence of questionnaire versions.

The questionnaire structure will in part be determined by the method that will be used to survey the population identified as being affected by the environmental impact under investigation. For instance, visual aids cannot be used in a telephone survey. Not withstanding such differences, a CM questionnaire follows a fairly standard pattern. This pattern is explained under the following sub headings.

## 7.1 An introduction

Respondents must first be introduced to the issue under investigation and the people who are undertaking the investigation. Hence, in the first part of a questionnaire, be it in the form of an introductory letter or as a preface, the purpose of the exercise must be explained. In particular, the importance of the information being gathered needs to be stressed so as to encourage participation. The credentials of the study team must also be displayed to induce respondent confidence and to allay any fears of unscrupulous behaviour. Respondents also have a right to know how they were selected to participate, given an opportunity to raise queries, be assured of the confidentiality of their responses and told of the time commitment they are being asked to provide in answering the questionnaire. Some guidance as to how the questionnaire should be completed and returned may also be desirable.

## 7.2 Framing

Respondents to any stated preference questionnaire must be made aware that the environmental good under consideration is embedded in an array of substitute and complementary goods. It is important that the questionnaire does not lead to respondents giving untoward weight to the issue in question because they have put the context or ***frame*** of the issue to the backs of their minds. The questionnaire must strive to establish the frame in respondents' minds which is appropriate to the circumstances of the policy decision being made.

For instance, estimating the values of a single river's environmental attributes would not yield appropriate results if the policy being informed by those estimates involved the restoration of numerous

rivers[10]. The over-estimation of the "stand-alone" estimates would be more exaggerated if as well as considering river environments, policy makers were also contemplating forestry policy. The appropriate frame must make respondents aware of these competing demands for public funds but it must also remind them of their own budget constraint and other ways in which they may wish to use their money.

Hence, the decision as to just what makes an "appropriate" frame will need to take account of the policy environment of the decision to be made and the frame of reference that exists in respondents' minds prior to being informed of the specific issue at hand. The latter can be identified during focus group sessions through questioning participants regarding their priorities for spending their personal funds and how taxation revenue ought to be allocated amongst competing public good.

On the basis of these findings, the CM questioning can begin by asking respondents to rank competing spending claims, with one of those claims relating to the issue at hand. This places the specific in the context of the wider picture and so establishes a frame of reference for the respondents (see Box 10). Such a question also provides a good "warm-up" exercise for respondents, so that they get into the process of answering the questionnaire. Notice that a ranking exercise is recommended as it requires respondents to make comparisons between competing interests. This begins to generate the concept of the trade-off that features so strongly in the choice set questions that form the heart of the questionnaire.

***Box 10: Framing strategies***

*Both the wetlands (Morrison et al 1998) and the remnant vegetation (Blamey et al 1998) case studies used two initial framing questions. The first asked respondents to rank areas of government responsibility that they would most like to see protected from spending cuts. One of those areas was the environment. Hence, responses to this question could be used to assess how respondents perceived the relative importance of government spending on the environment, as well as establishing the broad frame of the questionnaire. The second question took the frame to the next level by asking respondents to rank different areas of environmental concern. Amongst the areas listed for ranking was the issue of concern (wetland or remnant vegetation protection). Using this process, respondents were drawn from the general to the specific. A further element of the framing strategy employed by both studies involved respondents being reminded of other spending commitments they may have and of their overall budget constraint.*

## 7.3 Statement of the issue

With the frame established, the issue under consideration can be introduced. This is achieved through a statement of the dilemma that is being addressed. The issue may be one of an environmental decline or an environmental improvement. Some details of the situation will usually be appropriate: What are the current conditions and what will happen if the status quo prevails? The description can be based around the attributes to be used in the choice sets. A separate information pamphlet complete with some photographic evidence can be a useful means of presenting this information. The avoidance of perceptions of bias is particularly important at this stage (see Box 11).

## 7.4 Statement of a potential solution

After some questions are asked regarding respondents experience and knowledge of the issue under consideration and their general sentiment regarding the severity of the problem at hand, a potential solution to the problem can be provided in the questionnaire. The solution offered has to be believable for respondents, despite its inherently hypothetical nature.

Visual aids may again prove useful in demonstrating differences in attributes between the status quo and the alternatives. The emphasis in presenting material must be on changes across options. Careful focus grouping of such materials is important to ensure that the message carried is appropriate to the context of the questioning.

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[10] The observation that values estimated for goods as separate entities will be larger than when estimated as a component of a more inclusive whole is referred to as the "regular embedding effect" and is entirely consistent with the principles of economics. See Bennett, Morrison and Blamey (1997).

### *Box 11: Bias*

*It is unlikely that CM analysts will be able to detect elements of the questionnaire that are biased. This is simply because bias like beauty "is in the eye of the beholder". It is therefore important to use focus group testing to detect bias. Focus group participants should be drawn from a wide range of backgrounds so that a wide range of perceptions can be investigated. A further bias detection strategy is to ask representatives of vested interest groups (conservation groups, farmers, etc) to review a draft of the questionnaire. A design that can reconcile the polar interests of opposing vested interest groups is an ideal but obviously difficult to achieve. Perceptions of bias may not be limited to the information relating to the issue at hand that is provided to respondents. In the wetlands case study (Morrison et al 1998), focus group respondents indicated that the choice sets needed to include alternatives relating not just to the status quo and wetland improvements but also to "pro-irrigation" outcomes that would see wetland health decline further. Respondents denied wanting to choose such an outcome, but felt that its inclusion would ensure an unbiased questionnaire. To accommodate this request, the choice sets eventually used in the survey included an additional option that was simply specified to involve allocating more water for irrigation.*

An important component of the proposed solution must be a ***payment vehicle***. The solution must be available only if funds can be generated to pay for it and those funds must come from respondents indicating a willingness to pay. Hence a key component of the plausibility of the proposed solution must be a plausible payment vehicle. Focus group testing of alternatives is a key part of ensuring plausibility. Focus group participants can be asked what they would deem to be an appropriate payment vehicle or to suggest the vehicle they believe would be most likely used to generate the revenue required (see Box 12).

### *Box 12: Rates and taxes*

*Different CM applications will call for different payment vehicles. The selection of a payment vehicle must be guided by focus group testing. One strategy (used in Bennett, Blamey and Morrison 1997) involves asking focus group participants how they think funding would be raised to pay for the issue under consideration. They can also be asked what payment vehicle they think how funds should be raised. This process helps to define the plausibility of alternative payment vehicles. Because respondents must be convinced that they will be called to pay the amount they agree to contribute when they choose options from the choice sets, the payment vehicle must be compulsory (ie not a voluntary payment) and have the broadest possible coverage. Coverage of payment vehicles can be problematic. For instance, water and land rates apply (directly) only to property owners. Broader vehicles such as income taxes may not be relevant to low income groups. It is important in a CM questionnaire for issues such as plausibility and coverage of payment vehicles to be explored by specific questions. For instance, respondents can be asked if they own a house to test the coverage of land and water rates.*

To help ensure that respondents answer the choice sets truthfully (ie that they don't engage in strategic behaviour) it must be stressed that the payment made to effect the solution would be compulsory. The potential effect, financially, of the solution on the individual must be made very clear.

Following the explanation of the potential solution, some questions regarding the plausibility of the setting, the solution and the payment vehicle especially can be asked.

## 7.5 Introducing the choice sets

Respondents will need some help to comprehend the choice set questions that follow. Hence a section needs to be devoted to an explanation of the task they will be asked to perform and some ground rules for their answers. Usually this will involve stating that there are many variants to the solution just outlined and that peoples' opinions as to which variant is best for them is a useful input to policy determination. In other words, respondents are being asked to have a say in what future policy should look like. An example of what a choice set looks like can be provided and a sample answer given.

A final reminder for respondents to keep in mind the frame of the exercise - all the other goods that they may wish to buy and the constraint their income imposes - should immediately precede the choice sets.

## 7.6 The choice sets

The presentation of choice sets is a matter both of clarity for respondents and technicality for the analyst. Presentational clarity is vital for respondents to be able to understand the nature of the question that is embedded in the choice sets. Again, focus group testing is vital as there is no predetermined "appropriate" format.

Some technicalities do interpose. First, the alternatives that are presented to respondents can be either labelled or unlabelled. A "labelled" or "alternative specific" choice set includes descriptors of each alternative that go beyond the attributes. The labels may relate say to the policy that gives rise to the alternative. For instance, the status quo may be labelled "current policy" whilst the alternatives may be labelled " 10% more water" and "20% more water" to indicate the broad policies that underpin those alternatives. Where no labels are used - apart say from the headings Options 1, 2 and 3 - the choice sets are said to be "generic".

The choice between the labelled and generic choice set formats is important (see Box 13). Where the means of achieving environmental change is considered important (ie where the policy mechanism is a factor in determining choice) the labelled format is more appropriate. It is also better suited to situations where differing policy options give rise to widely differing levels of the attributes. With the labelled format, different level ranges can be specified for the attributes in the different alternatives. However, labels can prompt respondents to select their preferred alternative on the basis of the label alone and the impact of the varying levels of the attributes on respondent choice could be trivialised. Whilst this may be a true reflection of peoples' choices in some cases, in others it may simply be a reflection of the difficulties respondents are having in dealing with the choices presented in the format of a questionnaire. A case by case assessment of these matters during focus group testing is required to determine which format is more appropriate.

### *Box 13: Labelled vs generic choice sets*

*Blamey, Bennett, Louviere, Morrison and Rolfe (1999) detail the results of a test of the impact of using labelled rather than generic choice set formats in the context of the estimation of the value of protecting remnant vegetation in the Desert Uplands of Central Queensland. They show that labelling the alternatives presented in choice sets makes a difference to the way in which respondents approach their task. This has an impact on the values respondents ascribe to the attributes used to describe the alternatives, but appears to have little effect on the values estimated for potential scenarios of overall change.*

Further technicalities are involved in determining the number of alternatives to present to each respondent in each choice set and the number of choice sets to present in each questionnaire. This issue revolves around a trade-off. The more choice sets and alternatives within a questionnaire, the more cognitive ability (ie ability to comprehend) and tenacity/patience is required of respondents. However, fewer variations in the attribute levels are required to support an empirical model of the impact of attributes on choices made.

The choice sets presented to respondents carry a wealth of information that must be assimilated by respondents and acted upon. If the amount of information exceeds a respondent's ability to deal with it,

the questionnaire as a whole may be rejected or the answers given may not reflect true preferences either because random answers are given or decision-making short cuts or “heuristics” are used.

On the other hand, sufficient variations to the alternatives presented to respondents must be provided in order to establish statistically the impact of attribute levels on choices made.

To assess this trade-off, the capacity of respondents to answer bigger choice sets and longer strings of choice set questions must be established. Focus groups again provide a vehicle for this process. The selection of appropriate experimental designs to ensure an appropriate variation in attribute levels is presented to respondents is also critical. This issue is discussed in the next section.

### 7.7 Follow up questions

Immediately after the choice set questions a series of questions designed to explore the motivations behind respondents’ choices. In particular, these “follow-up” questions should be targeted at picking up any response aberations such as:

- payment vehicle protests (a respondent always chooses the status quo option because of an objection to the way in which their cost is to be imposed);
- lexicographic preferences (the environmental improvement options are always chosen irrespective of the costs associated with them); and,
- perfect embedding (respondents agree to pay in order to experience the “warm glow” of supporting a good cause rather than as a reflection of their value for the specific environmental benefits available).

In addition, follow-up questions can check to see if there were any specific problems faced by respondents in answering the choice set questions. Specifically these problems may relate to:
- ability to understand the questions;
- the amount of information provided ;
- the presence of bias in the questionnaire;
- perceived plausibility of the setting; and,
- confusion created.

### 7.8 Socio-economic and attitudinal data collection

The final section of the questionnaire must be devoted to questions seeking socio-economic data (age, sex, educational status, occupation, income etc) and information regarding attitudes (especially general sentiments regarding the environment). Beyond the general data of interest, specific cases may call for the collection of specific respondent information. For instance, if distance of the respondent’s place of residence from the site at issue is hypothesised as a factor that impacts on values then distance data would need to be collected.

These data are required as inputs into the modelling phase of the application, for verifying data and for checking on how well the sample represents the population of interest.

A final expression of thanks to the respondent and an opportunity to provide any additional comments on the questionnaire and survey process is appropriate.

## 8. Compiling the experimental design

Choice Modelling relies on the estimation of a response between the probability of a choice being made and the relative levels of the attributes in the alternative chosen. The model is driven by differing attribute levels in the alternatives available to respondents in the choice sets giving rise to differing probabilities of alternatives being chosen. With multiple attributes and each attribute varying across multiple levels, it is apparent that for a model to be able to separate out the effects on choice of individual attributes, a large number of choices between alternatives which incorporate a large number of different combinations of attribute levels will need to be observed. To identify completely the relationship, all the possible combinations of attribute levels should be presented to respondents.

The array of all possible combinations is called the "full factorial". For example, if there were two attributes, each allowed to vary over three levels, a total of nine possible combinations would make up the full factorial. If the three levels for attribute 1 were A, B and C and the attribute 2 levels were X, Y and Z, the full factorial would be : AX, AY, AZ, BX, BY, BZ, CX, CY, and CZ. In other words, all the cells in the matrix displayed in Table 1 would form the full factorial.

## Table 1: A full factorial

| | | **Attribute 1** | | |
|---|---|---|---|---|
| | | **A** | **B** | **C** |
| | **X** | AX | BX | CX |
| **Attribute 2** | **Y** | AY | BY | CY |
| | **Z** | AZ | BZ | CZ |

Hence the first alternative put to respondents for comparison against a status quo, constant base option would be described by attribute 1 at level A and attribute 2 at level X. Other alternatives making up the choice set would then be selected in a systematic fashion from the pool created from the full factorial. The way the alternatives' levels are set and structured into the choice sets is known as the "experimental design".

As the number of attributes and number of levels increases, the size of the full factorial grows rapidly to the extent that the total number of choice sets required to present them all to respondents soon exceeds the ability of respondents to cope. Two strategies are used to overcome this problem: the use of a "fractional factorial" and the "blocking" of the experimental design.

A "fractional factorial" is a selection of the available attribute level combinations that go to make up the full factorial. The process of selecting a fractional factorial requires the maintenance of the orthogonality property of the full factorial (ie there is no correlation between the attributes). However, the smaller the part of the full factorial that makes up the fractional factorial, the less able is the experimental design to drive a model that can identify all the possible interactions that may occur between the attributes.

So whilst a smaller fractional factorial may be preferred because it gives fewer choice sets for respondents to evaluate, it may not be capable of driving a model that accurately represents the relationships existing between choice probabilities and attribute levels. Alternative fractional factorial designs are available in design catalogues such as Hahn and Shapiro (1966) and an increasing number of computer packages that are used for statistical analysis.

The second strategy used to cope with the large number of choice sets created even with the use of a fractional factorial is to segment the fractional factorial into blocks. Each respondent, therefore, is only exposed to the alternatives that comprise one block of the fractional factorial. If the fractional factorial is divided into three block, it takes three respondents to provide choice responses that cover all the alternatives that are created under the fractional factorial.

The creation of the alternatives to be used in the choice sets is only the first phase of the creation of an experimental design. The second phase involves the combining of alternatives together to form the complete choice set. Commonly, choice sets comprise a constant base or status quo option that stays the same across all choice sets and two or more alternatives that involve varying attribute levels. The experimental design must be used to provide the combinations of alternatives.

Two approaches are available. The first, known as the sequential approach, involves taking the alternatives created in the fractional factorial and assigning them to choice sets using a specific strategy. For instance, a separate experimental design can be used as the assignment instrument.

The second approach , the simultaneous method, uses an expanded version of a fractional factorial that determines the levels of the attributes for all the alternatives in the choice sets. $L^{MN}$ designs (where L is

the number of levels, M is the number of alternatives in each choice set and N is the number of attributes) perform this function.

Once the choice sets have been created using the experimental design, it is important to review each choice set for the presence of implausible or dominated alternatives. Implausible alternatives are those in which the experimental design has dictated that the levels of the attributes move in directions that would be counter intuitive to most respondents. Dominated alternatives are those that are combined with other alternatives that are universally superior in their experimental design driven attribute levels. Dropping choice sets with implausible or dominated alternatives is one strategy to remove the problem but this can cause departures from the orthogonal character of the fractional factorial used. This is potentially an even more serious problem because without an orthogonal design, the models derived from the choice data will be unreliable.

The problem of implausibility can be avoided by adequately explaining why alternatives can appear counter intuitive at the beginning of the choice set questions. Furthermore, the issue of what is a dominated alternative is usually far from clear cut. What appears to be dominated to one person can be be a logical choice for another. It is likely that leaving "dominated" alternatives in choice sets will do little harm.

# 9. Surveying the respondents

The sampling frame to be used to generate potential respondents will be dependent on the nature of the particular application. The sample drawn will need to be split into a number of sub-samples. First, sub-samples will need to be drawn to reflect the number of blocks used in the experimental design process. Hence if the blocking strategy used has created four lots of choice sets then there will be four versions of the same questionnaire and four sub-samples will be needed to answer each of these versions. The size of the sub-samples drawn will depend on the size of the population and the statistical power that is required of the model derived. However, the minimum size of the sub-sample should be in the order of 50 respondents.

If the research design calls for the testing of a specific hypothesis which involves changing some element of the questionnaire, then the block sub-samples will need to be replicated for the two versions of the questionnaire. Hence, for a four block experimental design and one hypothesis test, a set of eight sub-samples will need to be drawn.

The delivery of the questionnaires to respondents can be via:

- mail-out/mail-back
- personal drop-off with a later personal pick-up
- personal interview[11].

Each delivery mode involves both benefits and costs. For instance, personal interviews are relatively expensive but do generate higher response rates. They are, however, subject to possible "interviewer bias". Postal delivery is relatively low cost but can be prone to low response rates and consequential sampling bias. Using the post does however allow respondents the time to contemplate their answers more completely and removes the prospect of interviewer bias. The drop-off/pick-up option is almost a hybrid of the mail out and personal interview approaches. It is a compromise on cost, interviewer bias, giving respondent adequate time for consideration and response rates. The decision regarding the most appropriate form of delivery will depend on the case at hand and the budget availability[12].

# 10. Preparing and analysing the data

[11] It is unlikely that a CM questionnaire could be delivered using a telephone survey. The complexity of the choice sets that are integral to the technique is such that it is difficult to imagine how the survey could conducted without some form of visual input. One possible use of the telephone, is for potential respondents to be contacted initially by phone, a questionnaire mailed to those who are willing to participate and a subsequent phone call used for recording the answers.

[12] See Dillman (1978) for details of survey processes.

With the survey work complete, the data must be coded. It is important to recognise that the data generated from the survey are only the tip of the iceberg of the data used to determine the models of choice. For each choice set, the respondent indicates their preferred alternative. That is, they provide one piece of data. For the modelling work, that data element must be combined with information about the levels of the attributes of the alternative chosen and the levels of the attributes not chosen and the socio-economic/attitudinal data relating to the person who made the choice. Hence for a choice set that involves three alternatives, including the constant base, three lines of data emerge. Each data line depicts one of the alternatives … its attribute levels[13], the characteristics of the respondent and whether or not (0 or 1) the alternative was chosen.

As well as the levels of the attributes, modelling constants must be included in the rows of data. These constants are known as the "alternative specific constants" (ASCs). If there are three alternatives in a choice set, two of the alternatives must be associated with an ASC. Hence, new "attributes" must be created for two of the three alternatives which take on the value of 1 in the lines of data relating to their alternative and zero otherwise. It is the role of the ASCs to take up any variation in choices that cannot be explained by either the attributes or the socio-economic variables.

The choice models of the data are generated by statistical routines in software packages such as LIMDEP. The most straight forward of the model estimation procedures is known as Multi-Nomial Logit (MNL)[14]. Under the MNL procedure, the probability of choosing an alternative is modelled as a function of the attributes and the socio-economic characteristics of the respondents. That is, the probability of a respondent choosing an alternative increases as the levels of desirable attributes in that alternative rise and the levels of undesirable attributes falls - relative to the levels of the attributes in the other alternatives that are available. The probability is therefore an indication of the relative ***utility*** (defined by economists as well-being or satisfaction) provided by the alternatives, given that an individual will choose the alternative that provides the greatest utility[15].

What the modelling of respondents' choices is able to provide is a sequence of equations that each describes the log of the odds that alternatives will be chosen. These equations can thus be interpreted as the indirect conditional utility (V) derived from the alternatives.

For a three alternative choice set with three quantitatively[16] described attributes ($A_1$,$A_2$ and $A_3$) the estimated (linear in parameters without any attribute interactions) model (without socio-economic factors) would be:

Status Quo: $V_1 = \beta_1 A_1 + \beta_2 A_2 + \beta_3 A_3$
Alternative 2: $V_2 = ASC + \beta_1 A_1 + \beta_2 A_2 + \beta_3 A_3$
Alternative 3: $V_3 = ASC + \beta_1 A_1 + \beta_2 A_2 + \beta_3 A_3$

The $\beta$ values are the coefficients associated with each of the attributes[17].

Note that the ASC used for Alternatives two and three are equivalent. This indicates that the model formulated is generic. If the choice sets used were labelled, then an alternative specific form of the

[13] Note that if qualitative attribute levels are used, the individual levels of the attributes are introduced as ***effects codes***. Hence for a three level attribute, the levels are coded as -1, 0 and 1.
[14] Others included nested logit and the heteroscedastic value model.
[15] This is the essence of the Random Utility Model that underpins Choice Modelling. For more details, see Carson et al (1994) and/or Ben-Akiva and Lerman (1985).
[16] For qualitative attributes, the equations will produce coefficients relating to all but one of the levels of the attribute. So for a three level attribute, two coefficients will be estimated. The coefficient relating to the third level would be equal to one minus the sum of the other two levels' coefficients.
[17] The $\beta$ coefficients cannot be interpreted as the contribution made to utility by each attribute in any absolute sense as they are each confounded by a scale parameter ($\lambda$). Each CM data set will be characterised by a different value of $\lambda$ because it is determined by the variance of the statistical error inherent in the modelling. Furthermore, it is not possible to estimate the value of $\lambda$ in any one model. It is, however, possible to estimate $\lambda$ by merging a related revealed preference data set with the CM data set (Swait and Louviere 1993).

model would be required. This would involve the use of differing ASCs for each equation, and potentially differing coefficients for each of the attributes.

To introduce respondent heterogeneity (ie differences between the individual respondents) into the model, socio-economic variables can be used as independent variables in each of the equations estimated. This can be an important part of the model estimation process as the socio-economic variables may help to overcome problems associated with violations of important assumptions that underpin the MNL model[18]. However, they cannot be introduced alone into the modelling. Because every respondent provides multiple lines of choice data, "Hessian singularities" arise in the model estimation process unless the socio-economic characteristics are introduced as interactions with either the attributes or the ASCs.

More complex models involving non-linear forms and interactions between attributes can be estimated but care must be exercised in ensuring that the experimental design used as the foundation for the data collected is sufficient to the exercise.

The validity of the model estimated can be assessed using a number of tools. First, the logic of the relationships estimated must be considered: do the equations estimated accord with any priors established in theory? Secondly, the model's statistical properties can be assessed. The significance of the individual $\beta$ coefficients can be assessed with reference to their t-statistics (a t statistic greater than 1,96 indicates that the attribute coefficient is statistically significantly different from zero at the 5% level). The overall explanatory power of the model can be assessed using the log-likelihood statistics and the McFadden's (or pseudo) $R^2$ statistic (values between .2 and .4 are considered adequate).

# 11. Analysing the results

## 11.1 Part worths

The $\beta$ coefficients estimated under the MNL model can be used to estimate the rate at which respondents are willing to trade-off one attribute for another. For instance, the amount of recreational days a person is willing to give up in order to ensure the survival of an additional endangered species can be estimated by dividing the $\beta$ coefficients of the endangered species attribute by the $\beta$ coefficient of the recreation days attribute and multiplying through by minus one. Where the attribute being sacrificed is a monetary attribute, the trade-off estimated is known as a "part-worth" or an "implicit price". They demonstrate the amount of money that respondents are willing to pay in order to receive more of the non-marketed environmental attribute.

$$\text{Part worth} = -\left(\beta_{\text{non-marketed attribute}} / \beta_{\text{monetary attribute}}\right)$$

Hence, if the $\beta$ coefficient estimated for the monetary attribute was -0.012 and the $\beta$ coefficient for an attribute describing the number of endangered species present was 0.05, then the implicit price for an additional endangered species would be \$4.16[19] (see Box 14).

Estimates of implicit prices are made on a "ceteris paribus" basis - that is, they are estimates of the willingness to pay of respondents for an increase in the attribute of concern, given that everything else is held constant.

Note that the principles applying to the determination of part worths can also be applied to derive the willingness to trade-off between any pairs of attributes. Hence by the division of $\beta$ coefficients, the marginal rates of substitution across all the attributes, monetary and non-monetary can be estimated. Such estimates may be useful when policy calls for environmental remediation efforts to be put into place that restore community well-being, not necessarily by the payment of financial compensation for environmental losses. Thus, a CM application that uses different ecosystems as the attributes may be

[18] Most importantly, the MNL model uses an assumption that the error terms are "independently and identically distributed". This assumption gives rise to the independence of irrelevant alternatives (IIA) characteristic.

[19] That is, - ( 0.05 / -0.012).

capable of determining how much additional rain forest protection would compensate people for the loss of a wetland.

***Box 14: Implicit price estimates***

*Morrison et al (1998) report implicit prices (per Sydney household) for:*
** protecting an additional square kilometre of Macquarie Marshes wetland of around 40 cents;*
** an increase in the frequency of bird breeding by one year in the order of $20; and,*
** an additional endangered species in those wetlands of a little over $4.*
*Blamey et al's (1998) implicit price estimates demonstrate that they are sensitive to design features of the choice sets. For instance, the implicit price of an additional protected endangered species in the Desert Uplands is around $11 when the causally prior attribute "area of unique ecosystems" is included in the choice sets but rises to over $17 when that attribute is dropped. Clearly, the context is important to value estimates.*

For qualitatively described attributes, the calculation of part worths involves a different procedure and has a different interpretation. For such attributes, coefficients in the utility equations are estimated for each level. By dividing the difference between the coefficients of two of the levels for one attribute by the monetary attribute coefficient, the willingness to pay to move between those two levels is estimated. For instance, if a water quality attribute has two levels - "good for boating" and "good for drinking", then the willingness to pay to improve water quality from boating-standard to drinking-standard could be estimated by this process.

Implicit prices are useful in that they demonstrate the value of individual attributes. They allow an analysis of the composition of potential alternative allocations of resources. A comparison of the implicit prices of attributes affords some understanding of the relative importance that respondents hold for them. On the basis of such comparisons, policy makers are better placed to design resource use alternatives so as to favour those attributes that have higher (relative) implicit prices. For instance, if it is found that the recreational use of a natural area delivers relatively little value when compared to the protection of biodiversity, then management regimes that limit recreation and foster species protection can be recommended.

The comparison of relative values afforded by the calculation of implicit prices is not possible simply through the comparison of the coefficients associated with each of the attributes. It can be tempting for analysts to observe the indirect utility functions estimated using CM and conclude that the coefficients represent the contributions to that utility of each of the attributes. This is an incorrect approach because the coefficients by themselves are confounded by what is known as a "scaling parameter" that is dependent on the variance of the error involved in the estimation process. In other words, the extent of the variance of the statistical error involved in the estimation process has an impact on the absolute magnitude of the $\beta$ coefficients. It is only through the division of the $\beta$ coefficients that is integral to the process of part worth calculation that the scaling parameter is cancelled out and the confounding effect of the error variance is eliminated (see footnote 16).

In addition, it is important to note that the comparison of implicit prices across attributes should be undertaken in full recognition of the differing units used to define the attributes. Hence, care should be taken when comparing the implicit prices of "days of recreation" and "numbers of endangered species present". Similarly, the costs of achieving the mix of attributes that is indicated by the relativities of attribute implicit prices are not a component of this analysis. The relative merits of alternative management packages of attributes would need to be further assessed in a cost-benefit framework. This type of assessment requires the estimation of economic benefits created by different alternatives under consideration.

## 11.2 Economic surplus

A particular strength of CM is its ability to generate estimates of the values of many different alternatives from the one application. Hence, from one set of choice data, the values of an array of alternative ways of re-allocating resources can be estimated. This feature of CM arises because it specifically investigates trade-offs between attributes. Thus, different combination of the attributes that are used to describe alternatives can be evaluated.

The process by which this is achieved involves an investigation of the difference between the well being (or utility) achieved by the individual under the status quo (or constant base) alternative and some other alternative. It is therefore a matter of considering the marginal value of a change away from the status quo.

First the values of the attributes that are associated with the status quo are substituted into the equation that estimates the indirect utility associated with that option. If socio-economic variables are included in that equation, the values to be substituted are the sample means. Note that the monetary attribute is assigned a value of zero for this stage.

Next, the values of the attributes that are associated with an alternative allocation of resources are substituted into the equation that relates to the relevant change alternative. The value of the relevant ASC should be included in this calculation. Socio-economic variables are treated the same as for the status quo option and again the monetary attribute is set at zero.

The value associated with the change alternative is then subtracted from the value associated with the status quo option. This difference between the "conditional indirect utilities" is then divided by the negative of the coefficient associated with the monetary attribute:

$$\text{Economic surplus} = -(1/\beta_{monetary})\ (V_1 - V_2)$$

where $V_1$ is the value of the indirect utility associated with the status quo and $V_2$ is the indirect utility associated with the specific levels of the attributes describing the changed resource allocation.

A negative value for this surplus estimate would indicate that respondents are willing to pay the amount of the surplus in order to experience an improvement in their well being caused by a re-allocation of resources from the status quo to the change alternative.

Again, the complexities caused by the existence of the scale parameter within each $\beta$ coefficient are avoided through the division throughout by the $\beta$ coefficient associated with the monetary attribute.

By setting up multiple scenarios of alternative resource allocations (by varying the values the attributes can take on) and repeating this arithmetic exercise, an array of values associated with the array of scenarios can be estimated (see Box 15).

Having access to this potential to estimate any combination of attribute levels (within the ranges initially established in the choice set design process) provides the decision maker with the flexibility to consider numerous options without the need to commission separate valuation exercises.

***Box 15: Surplus estimates***

*Both Morrison et al (1998) and Blamey et al (1999) provide estimates of the surpluses arising from a number of potential environmental management options. These value estimates are for changes relative to the pre-defined "status quo" options. Hence, the studies enable the construction of a comprehensive picture of the values associated with changing the management of the wetlands and of instigating alternative tree clearing regulations in the Desert Uplands. For instance, Brisbane households are willing to pay around $100 to see the tree retention rate in the Desert Uplands increased from 20% to 30% which would see:*
** reductions in the numbers of endangered species lost in the area from 18 to 16; and, * the losses in population sizes of non-threatened species cut from 80 % to 50%.*
*This value estimate increases to $150 when the restrictions are tightened to a 50% retention rate whereby:*
** endangered species losses drop from 18 to 10; and,*

| |
|---|
| ** non-threatened species numbers fall by only 35% instead of 80%.* |

### 11.3 Market shares

The relative values of each of the utilities (V) when different levels of the attributes are included gives an estimate of the "support" that each alternative would generate. If, for instance, each alternative related to a different forest protection strategy, and the status quo, then the percentage of the total of the Vs that was contributed by each of the individual Vs would represent the percentage support that alternative would generate. In a political context, policy makers could therefore use these market share results to predict the voter support that would be generated by alternatives.

## 12. Conclusions

Choice Modelling is a stated preference technique for the estimation of non-market values. It has some distinct advantages over other techniques - such as contingent valuation - that have been more widely applied. Its ability to provide a disaggregated view of values is a key feature. With respondents' preferences broken down into components associated with the attributes that go to make up a good, it is possible to use CM results to investigate the relative importance of attributes and estimate the values associated with various combinations of attribute levels.

However, CM should not be regarded as the "holy grail" of non-market valuation techniques. Many of the problems facing other stated preference techniques also serve as challenges to CM users. And CM provides additional challenges, especially in the design of the questionnaire which is inherently more difficult, from the perspective of respondent cognition, than a contingent valuation questionnaire.

The process of applying CM is complex. Those intending to use CM will need to be skilled in questionnaire design as well as experimental design and statistical modelling. What has been set out in this paper should be regarded as an introductory guide only. Many of the complexities associated with the technique have been treated only briefly. Others have not been considered at all in the interests of brevity and simplicity. It is hoped that those who may be interested in taking the next step toward an application will make use of the more technical references provided.

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