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Choice modelling in the development of natural resource management strategies in NSW

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Abstract

While the protection of environmental services generates social benefits, private landholders supplying these benefits may face some costs. Efficient provision of these services requires information about community values for the environment as well as landholders' costs.

The objective of this study is to explore the application of choice modelling (a non-market valuation technique) to estimate population wide values including use and non-use values for increased provision of environmental benefits in NSW. This paper provides a review of non-market valuation techniques for estimating environmental values followed by a discussion of methodological aspects of the choice modelling technique and its potential application as a regional planing tool for the Catchment Management Authorities.

Keywords: Nonmarket valuation, choice modelling, trade-offs, bio-physical modelling

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1. Introduction

Management approaches

Implementing new strategies for natural resources management (NRM) can provide many benefits including biodiversity conservation, water quality protection, reduced soil and water salinisation, and improved soil characteristics. However, private landholders implementing these strategies may face financial costs. Government intervention in NRM should be based on a consideration of the balance between these financial costs and the resultant benefits.

NRM thus requires an integrated, multidisciplinary analysis that considers environmental, economic and social factors. The interactions between these factors need to be considered when analysing different policy options. Information on these elements is particularly important when potential policy actions have irreversible environmental consequences. The research presented in this Report is aimed at the development of regional NRM strategies that will optimise the environmental and economic outcomes of land management.

In order to increase the efficiency and effectiveness of government intervention, investments in NRM should be prioritized to the activities and locations that have the potential to generate the highest net value to society over time. Investment prioritisation in NRM in NSW is currently coordinated by the Catchment Management Authorities (CMAs) through Catchment Action Plans.

Currently CMAs use a number of methods and tools to guide NRM. For example, the "Property Vegetation Plan Developer" (PVP Developer) is used by some CMAs in assessing proposals to clear native vegetation and to prioritise incentive payments to farmers who plan to improve the condition of native vegetation on their properties (NSW-Government, 2007). This program uses bio-physical information on projected salinity, water quality, land and soil capacity and invasive native species outcomes to provide guidelines for CMAs for the assessment of actions. Some CMAs use scoring and weighting methods to develop Environmental Benefit Indices (EBI) and Environmental Services Ratios (ESR) to compare potential environmental benefits against project costs and to develop cost shares that split public project costs between private landholders and the government. Other CMAs do not have any formal processes to prioritise natural resources investment (Farquharson et al., 2007). The diversity of approaches to investment prioritisation used by CMAs has caused inconsistency in the adoption of available tools with potentially inconsistent and inefficient application of public funds. Moreover, the scores and weights that have been used developed by experts with local knowledge, may not be representative for the whole state or country population. Socio-economic factors have received comparatively little prominence in most CMA decision making processes (Farquharson, 2007).

The approach to investment optimisation outlined in this Report takes into account the benefits and costs of alternative NRM strategies. Economic, social and environmental impacts are taken into account under the broad rubric of benefit cost analysis (BCA). BCA offers a process of knowledge integration that is superior to methods currently being used by CMAs as it takes into account the full spectrum of benefits and costs using a conceptually rigorous framework. This framework compares different investment alternatives and identifies the option that offers the greatest net social benefit. BCA however, requires all the benefits and costs to be expressed in monetary terms. Currently, none of the CMAs' NRM tools involve the estimation of the dollar values of non-market goods provided by different management actions. However, non-market benefits and costs can be estimated using non-market valuation techniques. The most advanced of these techniques is Choice Modelling (CM) (Bennett and Blamey, 2001). This valuation method determines people's willingness to trade-off the environmental, economic and social attributes of alternative NRM outcomes against each other (Bennett and Blamey, 2001) to estimate the relative values of each attribute. The CM framework is consistent with the principles of the benefit-cost framework. Therefore, the valuation derived from CM can be used in BCA, enabling decision makers to compare a more complete set of benefits and costs of different resource allocations (Bennett and Blamey, 2001).

The decision support tool being developed in this Research Report integrates spatial bio-physical modelling (MOSAIC)[1] with information on community values for environmental goods generated by CM. Sub-routines within MOSAIC are designed to predict the biophysical outcomes of changed NRM. With the values held by the community for these outcomes estimated through the use of CM, MOSAIC is capable of selecting the NRM strategies that will maximise environmental benefits net of any financial and social costs. This integration of bio-physical modelling and economic valuation within the rigorous conceptual framework of benefit cost analysis affords a more complete information base on which NRM decisions can be made.

1.2 Research objectives

The objective of this Research Report is to explore the application of CM to estimate the values (including both use and non-use values) held by residents of NSW for a range of environmental benefits provided by potential NRM strategies in specific NSW CMAs. These values will be estimated in a format that makes them suitable for integration into the bio-physical modelling constructs of MOSAIC and consistent with the welfare economic principles that underpin benefit cost analysis.

A further objective of this research is to provide readily-transferable monetary estimates of environmental values that can be applied to similar NRM decision contexts in different locations across NSW. Consequently, the value estimates could offer cost and time savings when dealing with similar NRM issues for other CMAs. In order to provide transferable estimates of environmental values, distance and scope effects on community preferences need to be investigated. Preferences for environmental outcomes can differ between areas depending on the distance of peoples' residences from the site of interest and the socio-economic characteristics of the populations. Peoples' monetary values for environmental benefits may also differ depending on the scale at which the issue is framed. For example, the values estimated for one km^2 of native vegetation protected may vary depending on whether one km^2 or 1000 km^2 are presented to respondents. This aspect is important especially if values framed in one context in a source study will be to be transferred to a different context in a targeted study (Bennett, 2006). These aspects of CM have not

[1] See Lawson, K., C. Hill, A. Hodges, & B. Jacobs (2007).

been fully explored in the literature and this study aims to investigate new ways of dealing with them.

Specifically, this study will test for variations in environmental benefit estimates across different communities including local residents and distant urban (Sydney) or rural residents. It will also examine the scale effect on the value estimates. Three NSW CMAs - Lachlan, Hawkesbury-Nepean and Namoi - have been chosen for this study. For each of the three case studies, three sub-samples of respondents will be drawn from the local community, the Sydney population and a geographically removed rural population. These sub-samples will be given comparable CM questionnaires. The values estimated across different locations will be tested for differences.

Using the same population (Sydney) a series of convergent validity tests will also be conducted to investigate any scale differences at a catchment and sub-catchment levels. This test will involve duplication of a Sydney sub-sample using a CM questionnaire that involves a different frame or context of analysis: For instance, NRM changes in catchment fragments rather than the full catchment scale. A comparison of the value estimates at different scales will be used to develop a scaling factor. This factor will allow the adjustment of the catchment value estimates for transfer to a smaller area context and vice versa.

2. Literature review

This section introduces the theoretical basis of the research and provides an overview of the CM technique. Emphasis is placed on the application of the CM technique to the valuation of environmental benefits and costs. First, the role of non-market valuation techniques in the assessment of the benefits and costs of different investments is discussed. The theoretical foundation of BCA for which CM provides input is also discussed. Secondly, the origin of CM and its conceptual base—random utility theory — is canvassed. Finally, the CM design process and its use in different environmental studies are reviewed.

2.1 Why non-market valuation is needed?

The relationship between agriculture production and the environment is complex and can be competitive or complementary. For example, agriculture modifies the landscape in rural areas, providing aesthetic value, recreation and amenity value, nutrient recycling and wildlife. On the other hand, the intensification of the agriculture can generate negative externalities such as soil erosion, water quality deterioration, salinity problems and bio-diversity reduction. Land-holders who are seeking to maximise profits from farming may not take into account the full costs that their practices impose on society. In many cases where public-goods are involved there is no incentive or feasible mechanism for landholders to account fully for the environmental impacts on society. The public good nature of environmental goods and services provides a rationale for government intervention but only if it generates a net improvement for society.

Different policy actions including information provision, suasive measures, economic and regulatory instruments may be required in different cases to address environmental issues. The policy and management options that offer the greatest net benefit to society should be chosen. Therefore, information on the private and social benefits and costs of government intervention can assist in the development of appropriate policy and management strategies. While the private costs of protecting the environment can be readily quantified in monetary terms, the social benefits of environmental improvement are not readily expressed in dollar terms because they are generally not brought and sold in markets. Due to the difficulty of estimating environmental values in monetary terms the most common methods for evaluating the effectiveness of policy interventions with environmental consequences have been the cost-effectiveness analysis (CEA) and multi criteria analysis (MCA). These methods, however, do not provide the full picture of changes in total welfare and suffer from methodological flaws.

Unlike CEA and MCA, BCA has a basis in welfare economics (Bateman et al., 2002). By taking into account all stakeholder preferences, BCA seeks increases in net social welfare. BCA allows the consistent comparison of the outcomes of a number of different policies. In order to make this comparison, non-market values need to be quantified. A number of approaches (e.g. CM, contingent valuation, hedonic pricing and travel cost method) can be used to estimate non-market environmental values. CM offers detailed, flexible and robust non-market valuations and has been widely applied in a range of non-market contexts including transportation and environmental studies. The advantages of this method and its application are discussed further in this section.

2.2 Benefit Cost Analysis

BCA is an evaluation technique that integrates the costs and benefits of a policy intervention or project. The net economic value of a project or policy is calculated by subtracting its social opportunity costs from its benefit (the increment of utility). Changes in welfare can be measured by quantifying and aggregating individuals' willingness-to-pay (WTP) for the benefits, and willingness to accept (WTA) compensation for the costs. If the net economic value is greater than zero a project or policy satisfies the requirement of increasing net social welfare. Projects or policies can be ranked for resource use optimisation purposes according to their relative net benefits.

Origins of Benefit Cost Analysis

BCA originated from welfare economics in the nineteenth century. In 1808, Albert Gallatin, U.S. Secretary of the Treasury, recommended the comparison of benefits and costs in water related projects (Hanley and Spash, 1993). However, much of the literature cites the beginning of BCA as the introduction of the Flood Control Act in 1936 (e.g. Dasgupta and Pearce, 1972, Eckstein, 1965, Hanley and Spash, 1993, Pearce, 1983).

In the 1960s, there was an increase in concern for environmental issues, especially in the evaluation of water projects. BCA was used by the U.S. government to support environmental regulations (Hanley and Spash, 1993) in the 1970s. In Australia, the first application of BCA was to assess a flood mitigation scheme for Launceston by the Tasmanian Government in 1956 (Sinden and Thampapillai, 1995). During the

1960s, the Bureau of Agricultural Economics undertook a number of BCAs of projects including the development of Brigalow woodland in Queensland, irrigation investments in Tasmania, road development in the Northern Territory, and water supply projects in Western Australia (Sinden and Thampapillai, 1995). In the late 1980s BCA was extensively used by government agencies to evaluate resource management issues such as Salinity Management Plans in Victoria, the Commonwealth MD2001 program, and the South Australian program “Accelerated Regional Implementation of On-ground Works” (Hajkowicz et al., 2000).

Most of these applications took into account the monetary values but non-market benefits and costs were largely ignored. However, in recent years it has been recognised that non-market values can have a significant impact on social welfare and have begun to be considered more often in BCA applications (Bennett and Adamowicz, 2001) .

The theoretical foundations of BCA

BCA is founded in welfare economic theory. The fundamental issue in welfare economics is the allocation of resources to maximise the net welfare of society (Schmid, 1989). In neoclassical economic theory, change in social welfare is measured by the aggregation of changes in individuals’ utilities. The aggregation process is guided by the Pareto concept (Dolan, 1998) . Pareto efficiency is defined to exist when resources are allocated such that it is not possible to make anyone better off without making someone else worse off. This principle has clear limitations. Moreover, in most cases the outcome of any policy change makes somebody better off and some others worse off. Therefore, a less restrictive concept has been developed, called Potential Pareto Improvement and also known as the Kaldor-Hicks criterion. It states that a project satisfies the criterion if it leads to an improvement in the welfare of some even if others lose (Sugden and Williams, 1978) so long as the gainers are able to compensate fully the losers without making themselves worse off. Note that the payment of compensation is not required for the criterion to be satisfied. In other words, even if as a result of undertaking a project, somebody is made worse off, the overall project generates net benefits (the sum of gains exceeds the sum of losses) then it should be undertaken (Pearce, 1983, Feldman, 1980).

Total economic value

Anything from which an individual gains contentment and for which he or she is willing to give up scarce resources has a value. Some of these values, such as environmental values, are not expressed through markets; however, they can be important components of the total economic value in project evaluation. They include use values, non-use values and option values (OECD, 1995).

Use values are the values from which utility is derived through actual use of these goods such as commercial, recreational use, aesthetic, etc. Non-use values are the values that individuals derive from knowing that theses resources are maintained (Perman et al., 1999). These values include:

- existence values are those from which utility is derived by simply knowing that they exist,
- bequest benefits are the value people place on passing resources to future generations,
- option value which is associated with the value that individuals place on the option to use this goods in the future.

Non-market values can be estimated using two approaches: revealed preference method (RP) and stated preference method (SP). The advantage of SP over RP is that SP can measure an individuals' willingness to pay (WTP) for not only use but also for non-use values.

2.3 Non-market valuation methods

The main difference between RP and SP methods is the method of data collection. RP techniques value non-market benefits and costs by observing consumers' behaviour whereas SP methods involve people being asked to state their preference for non-market impacts.

2.3.1 Revealed preference techniques

RP methods estimate people's WTP for environmental benefits through observing their behaviours in markets that are most closely related to the value of interest (Bennett and Blamey, 2001). In other words, values of the market goods are used to indicate the value of non-market goods. The most commonly used RP techniques are the travel cost method and the hedonic price technique. RP methods are extensively applied but they do have a number of limitations. They can only be applied in situations where quantifiable relationships between non-market and market goods can be observed (Bennett and Blamey, 2001). Hence they cannot be used to measure non-use values.

The hedonic pricing method

The hedonic pricing method takes into account the correlation between the level of environmental attributes such as noise, pollution, earthquake risk, amenity values and the price of market goods. This method has been used in environmental valuation in relation to individuals' WTP for a property with different sets of attributes (e.g. Hamilton, 2007, Mollard et al., 2007, Leggett and Bockstael, 2000, Miyata and Abe, 1994, Donnelly, 1991). For instance, comparing property prices with different levels of environmental attributes can be used to determine how much people are willing to pay to secure them.

The advantage of this method is that it uses individuals' actual choices. The disadvantage of this method is that it cannot be used for all environmental goods, as marketed complementary goods are not always available. Moreover, this method is prone to biases including those arising from the occurrence of omitted variables, multicollinearity, heteroscedasticity, choice of functional form and market segmentation (Kjær, 2005). The problem associated with market segmentation occurs due to restrictions on mobility between areas that cause the hedonic price to be unstable across different areas. This leads to biased parameter estimates (Rehdanz, 2006).

The travel cost method

The travel cost method has been applied to value environmental goods by observing consumer behaviour in relation to their demand for recreational goods. The price of non-market goods is measured by estimating the cost of travel to access these environmental goods and the visitation rate. In general, the longer the distance travelled the higher the cost of travel, and the lower is the rate of visitation. Through the observation of this “trip generation function” the surplus associated with visiting recreational sites can be estimated.

The advantage of this method is that it is relatively inexpensive to apply and the results are relatively easy to analyse. Common problems with the travel cost method include: choice of dependant variable, multi-purpose trips, calculation of distance costs, holiday-makers versus residents, the availability of substitutes sites that may affect values, and the value of time, and sampling biases (Kjær, 2005).

2.3.2 Stated preference technique

SP methods have the ability to generate estimates of non-use values as well as use values and are able to capture change in total economic value of a project or policy. The methods involve asking people to state their preferences for predefined alternatives of environmental outcomes (Boxall et al., 1996). This allows WTP for the improvement in some goods that are not expressed through market prices to be quantified in monetary terms (Bennett and Blamey, 2001). The most commonly used SP technique is the contingent valuation method (CVM). However, this method has been criticized for a number of biases it may generate. Partly in response to these criticisms, another SP technique, CM, has been developed.

The contingent valuation method

The most common method of evaluating the effect of a project on the environment used by many economists (Broberg and Brannlund, 2007, Zhongmin et al., 2003, Koss and Khawaja, 2001, Scarpa et al., 2000) is the CVM. People in a survey are asked either directly or indirectly how much they would be willing to pay for an increase in the quality or quantity of an environmental resource.

Originally this method used open-ended direct WTP questions. This format has been criticised because it is argued that people can find it difficult to express their maximum or minimum WTP for a good. They may prefer to chose one differently priced alternative over another in referendum style format (CIE, 2001). Therefore, closed-ended or "dichotomous choice" questions in the CVM are now used more widely. Nevertheless, this method has also some limitation due to the possibility of occurrence of "yea saying". This occurs when respondents agree to pay because they feel it makes them "look good" (Bennett and Blamey, 2001). An other criticism of this method focus on the prospect of strategic bias when respondents try to influence the policy outcome by not providing their true bid (Bennett and Blamey, 2001). There is also the potential for hypothetical biases that occur when hypothetical WTP does not reflect respondents' to pay (Venkatachalam, 2004, Aadland and Caplan, 2006). Other concerns over the validity of the CVM centre on scope problems that occur when respondents are not sensitive to changes in environmental attributes or when the value of good changes depending on whether it is assessed on its own or as part of a wider package (Bennett and Blamey, 2001, Lockwood, 1998, Hammitt and Graham, 1999, Bateman et al., 1997).

The use of the CVM in many environmental studies around the world has been widely criticised for its lack of validity and reliability (Sagoff, 1988). For example, in Australia, controversy surrounded this method when it was used in the valuation of the environmental damage that would result from a proposed mine at Coronation Hill near the Kakadu National Park (Bennett et al., 1998). In the Unites States criticism of the CVM was raised when the Federal Government and the State of Alaska filed suits against Exxon Corporation for the damage created by the oil spill. The CVM results were used as the basis for estimating the associated environmental losses (Carson et al., 2003). The National Oceanic and Atmospheric Administration (NOAA) created a panel of specialists to consider the criticism of the CVM. This panel confirmed the validity of this method and made recommendations regarding the application of the method to ensure the validity of its value estimates (Carson et al., 2003).

Despite the criticism, some authors support the CVM (e.g. Carson, 1998, Mitchell and Carson, 1989, Randall, 1990). Some of these studies argue that the CVM can overcome the problems mentioned above by more careful design of survey and the provision of better information to the respondents (Carson, 1998). Moreover, Spash (2006) for example, discusses some of the ways for improving the CVM by exploring a theoretical model of human behaviour in order to understand respondents' motives to action. The main advantage of the CVM is that it is relatively simple to apply. Further it is suitable for applications where only one alternative to the status quo is being evaluated.

Choice Modelling

CM is a non-market valuation technique that aims to estimate the values associated with the impacts of changes across different attributes that describe the outcomes of different policy options. In a CM questionnaire, respondents are presented with a number of alternative resource allocations and asked to indicate their most preferred options (Rolfe et al., 2004). Each resource allocation choice includes a baseline alternative representing the *status quo* situation (Rolfe et al., 2004). Therefore, choices made are between a *status quo* scenario and a series of different proposed alternatives (Rolfe et al., 2004). Each choice option is presented in terms of a common set of attributes (Bennett 2005), but the attributes' levels differ between the options (Blamey et al., 2000). Experimental design procedures are used to develop the particular options presented to respondents. Different levels of environmental attributes used in the choices to create the different resource use alternatives (Morrison et al., 1998).

Using this technique it is possible to determine individuals' willingness to trade-off the particular attributes against each other through their choice responses to different attribute combinations (Bennett and Blamey, 2001). Given that one of the attributes is presented as a cost term, respondents' WTP for changes in each attribute level can also be estimated (Bennett 2005). CM results can be used to determine the amount people are willing to pay to move from the *status quo* situation to other situations defined by different combinations of attribute levels as determined by the resource use options being evaluated (Bennett and Blamey, 2001).

In order to obtain reliable and accurate results it is important to design CM questionnaire with the greatest possible realism (Bennett and Blamey, 2001).

Adamowicz et al., (1998b: 7) identified the following advantages of CM in behavioural analysis:

- stimuli are controlled by the experimenter, *"*as opposed to the low level of control generally afforded by observing the real market place*";*
- control of the design matrix provides greater statistical efficiency and eliminates collinearity;
- more robust models can be developed through the application of wider attribute ranges than are found in real markets; and
- *"*the introduction and/or removal of products and services is straightforwardly accomplished , as is the introduction of new attributes*"*

The outcome of CM can be used in BCA enabling decision makers to compare total benefits and costs of different resources allocations (Bennett and Blamey, 2001). The information obtained from CM includes:

- the attributes that determine the values that people place on non-market goods;
- the ranking of these attributes within the relevant population;
- the value of changing a bundle of the attributes at once; and
- changes to the total economic value of a good; (Farquharson et al., 2007).

Choice modelling versus contingent valuation

CM is similar to the CVM as both methods are based on random utility models (RUM)[2] and use survey design models (Blamey et al 1999). Moreover, both methods can determine the cost of shifting from the *status quo* situation to an alternative scenario (Rolfe et al., 2004). The main difference between the two methods is that the CVM involves asking respondents to choose between the *status quo* scenario and a single alternative, whereas CM presents respondents with choices between several alternatives. Therefore, CM can value a number of attributes in one exercise (Blamey et al., 2000, Blamey et al., 1999a). Moreover, respondents in a CM survey are not directly asked to monetize non-market values as they are in an open-ended CVM questionnaire. Hence, the focus in CM is away from what some respondents find contentious context: money. Another advantage of CM over the CVM is that it can be used to identify and qualify simultaneously the social, economic, and environmental

[2] The RUM is described in details in section 2.4.2

factors that determine people’s choices. CM can avoid a number of survey biases that were discussed in the previous section. A disadvantage of CM is that is more complex and more expensive method.

There have been numerous studies that make comparison between CVM and CM in different contexts (e.g. Mogas et al., 2006, Boxall et al., 1996, Hanley et al., 1998, Adamowicz et al., 1998a, Lockwood and Carberry, 1998, Christie and Azevedo, 2002, Foster and Mourato, 2003, Poe, 1997). These studies have confirmed that welfare measures estimated by both techniques yield similar results. Although some studies confirmed robustness and accuracy of CM over CVM, some researchers still prefer the CVM over CM.

2.3.3 Benefit transfer

Some studies use the benefit transfer method to obtain value for non-market goods. This approach “borrows” the estimate of WTP from one study and applies it to another study with similar characteristics. To ensure the validity of this method there must exist close similarities in bio-physical conditions, the scale of change, the socio-economic characteristics and the frame or setting between both studies (Bennett, 2006).

There are numerous studies that examine the convergent validity (the degree to which estimated values from one study are similar to other studies) of benefit transfer of non-use values (e.g. Rolfe and Bennett, 2006, Kirchhoff et al., 1997, Morrison et al., 2002, Morrison and Bergland, 2006, Brouwer and Spaninks, 1999). These studies test the transferability of results across different sites, populations and over time using CVM and CM. In most cases the validity of benefit transfer for CM studies was confirmed (e.g. Morrison et al., 2002, Morrison and Bergland, 2006, Rolfe et al., 2002, Rolfe and Windle, 2006). CM is considered to be superior to the CVM in the benefit transfer application (Bennett, 2006, Morrison et al., 2002, Morrison and Bergland, 2006). CM provides a number of the valuation estimates that make it easier to find comparable conditions (Bennett, 2006).

The advantage of the benefit transfer method is that it offers time and money savings. The disadvantage is that there may not be studies available that are suitably comparable. Moreover, there are a number of issues with the application of benefit transfer such as generalisation error (when the value is generalized to unstudied resources or sites), measurement error (due to the many judgments and technical assumptions made in the studies) and publication biases (where benefit transfer is limited by the objectives for publishing research) (Rosenberger and Stanley, 2006). These problems and methods have been examined by many studies (e.g. Rolfe, 2006, Morrison and Bergland, 2006, Spash and Vatn, 2006, Wilson and Hoehn, 2006, Troy and Wilson, 2006).

2.4 Theoretical foundation of choice modelling

2.4.1 Fundamentals of Choice Modelling

CM is a form of conjoint analysis (CA) (Adamowicz et al., 1998a). CA involves people rating, ranking or choosing between different products. Conjoint studies use key product characteristics variables or attributes; experimental design that allows the formulation of alternative product scenarios; statistical methods to value the preferred attributes; and simulation methods to forecast preferences, choices or value options (Bennett and Blamey 2001). Several authors indicate the advantages of CM over other forms of CA such as contingent ranking and contingent rating (Louviere, 1988, Elrod et al., 1992, Bennett and Blamey, 2001).

The theoretical base of CM evolved from Thunstone's (1927) random utility model (RUM) (Bennett and Blamey 2001). The RUM has been widely applied in the 1980s, mostly in marketing studies (e.g. Tellis, 1988, Winer, 1986, Lattin, 1987). Its application was further developed in the 1990s by other scholars analysing more complex utility issues (e.g. Concu, 2007, Ben-Akiva et al., 2002, Louviere et al., 2005, Swait et al., 2002).

2.4.2 Random utility model and choice models

The RUM is based on the researcher being able to observe only part of respondent utilities. The unobserved component is taken to be randomly distributed. Under the RUM, U_{an}, utility that respondent *n* enjoys from choice alternative *a* can be described by:

$$U_{an}=V_{an}+\varepsilon_{an}$$

where V_{an} is the deterministic observable component of the utility that respondent *n* has for option *a*. ε_{an} is the stochastic unobserved component of the utility associated with option *a* and consumer *n*.

The observed component (V_{an}) is a function of the attributes Z_{an} and of individual characteristics S_n and a set of unknown parameters (Rolfe et al., 2000).

$$U_{an}=u\ (Z_{an,}\ S_n)+\varepsilon_{an}$$

Because of the random component, utilities can never be exactly determined. What can be concluded is that if consumer *n* chooses option *a* from choice set C_n, then it is probable that the deterministic and stochastic components of that option are greater than the deterministic and stochastic components of other option *j* in the same choice set. This is expressed in the following equation:

$$P(a/C_n)=P((V_{an}+\varepsilon_{an})>(V_{jn}+\varepsilon_{jn}))\ \text{for } j \text{ options in a choice set } C_n\ ,\ a\neq j$$

The greater the difference in observed utility the greater the probability of choosing alternative *a*. The researcher does not know the distribution of the random component, therefore in order to estimate the probabilities, assumptions about the distribution of the random component have to be made. The standard assumptions are that the ε terms are independently and identically distributed Gambel random variables, which leads to the familiar binary or multinomial logit (MNL) models (McFadden, 1974).

Under this assumption the probability that an individual *n* choose alternative *a* over *j* can be represented as:

$P_a / C_n = exp(\lambda x_{an}) / \sum exp(\lambda x_{aj})$ for all *j* in choice set C;

where λ is a scale parameter, which is usually normalized to one. The scale parameter is inversely proportional to the standard deviation of the error distribution (Rolfe et al., 2000). The MNL model generates a utility function of the form:

$$V_{an} = \beta_a + \sum_k \beta_k X_{kn} + \sum_p \theta_p Z_{pn} + \sum_{kp} \varphi_{kp} X_{kn} Z_{pn} + \sum_{pa} \psi_{pa} \beta_a Z_{pn}$$

where

β_a is vector of "intercept" terms (alternative specific constants) for $A-1$ of the $a= 1, \ldots\ldots, A$ choice options;

β_k is a matrix of $k = 1, \ldots., K$ attributes that relate to choice options, X_{kn};

φ_p is a matrix of $p=1,\ldots.,P$ characteristics that relate to individual respondents, Z_{pn};

φ_{kp} is a matrix of possible relationships of choice option attributes with the characteristics of the individuals, $X_{kn}Z_{pn}$; and

ψ_{pa} is a vector of possible interactions between individual characteristics and choice option intercepts (Louviere, 2001).

The utility function estimated for each alternative therefore contains the effects of attributes, an alternative specific constant (ASC) and the individual characteristics that can be interacted with the attributes or the ASC (Blamey et al., 2001). ASCs capture the influence of any variation in choices that can not be explained by the attributes or the socio-economic characteristics (Bennett and Adamowicz, 2001, Rolfe et al., 2000).

The use of the MNL model must satisfy the independence of irrelevant alternatives (IIA) condition (Rolfe et al., 2000). That is, the probability of the selection of a particular alternative is independent of the addition of the choice set of an irrelevant attribute. This means that in the case of the elimination to any alternative from the choice sets, the probability of choosing another option by individual *n* will be unaffected (Rolfe et al., 2000). Where the IIA condition is not met different assumption regarding the stochastic term need to be made, necessitating the use of alternative models including nested logit and random parameter logit.

Welfare estimates from MNL models are expressed in following formula:

$$CS=-1/\alpha(\ln\sum\exp V_{an}-\ln\sum\exp V_{jn})$$

CS is the compensating surplus welfare measure, α is the marginal utility income as reflected by the *β* coefficient of the cost attributes, and V_{an} and V_{jn} are indirect utility functions before and after a specified change in resource allocation.

The marginal value of a change in a single attribute can be calculated by dividing the β coefficient of the attribute by the *β* coefficient of the other monetary attribute and multiplying by *-1* (Rolfe et al., 2000).

$$W=-1(\beta_{attribute}/\beta_{money})$$

This formula provides estimates the trade-offs made between the non-market attributes and the cost attribute, and indicates how much the respondent is willing to pay for gaining or losing units of the attribute (Bergmann et al., 2004).

2.5 Choice modelling design

This section outlines the steps involved in conducting a CM application. Initial steps include the definition of the policy problem and the identification of the factors that impact social welfare. The following parts of this section describe these steps and the technical issues that are involved in conducting a CM survey, and descriptions of the modelling process and data analysis.

2.5.1 Characterisation of the decision problem

This stage of conducting a CM application focuses on identifying the key policy issues being addressed so that the structure of the CM application, including determination of the *status quo* situation and alternative options can be designed (Rolfe et al., 2004). Key activities include focus groups, interviews with experts and reviews of literature. The policy problem must be clearly defined and well understood by the respondents. The status quo situation must reflect reality and alternative options must relate to actual possibilities (Bennett and Adamowicz, 2001). To describe the status quo and alternative options, use and non-use values need to be taken into account.

Because the results obtained from CM are an input for BCA, the framework of CM application must be consistent with the marginal value framework. Therefore, estimates of values to be used in BCA must be at the margin (Bennett and Adamowicz, 2001).

2.5.2 Determination of attributes

In this part of the CM exercise, decisions about the number of options to be included in the choice sets, the type and number of attributes to be used to describe the options and the levels of these attributes need to be made. The attributes are used to describe what would happen if the status quo situation was continued or if some alternatives were to be introduced. It is important that the attributes are relevant to policy makers, are consistent with policy instruments that may be used to implement change and must also have meaning for respondents. The type and levels of attributes is usually selected with reference to the results of focus groups that are carried out in the study areas. Some studies survey the policy makers or use telephone-based surveys to ask potential respondents what they need to know to make informed choices before they select the attributes (Bennett and Adamowicz, 2001).

After potential attributes are selected, the next step requires their refinement to select the relevant attributes and exclude the irrelevant ones. Relevant attributes are those which have significant impacts on peoples' choices. Care needs to be taken not to eliminate important attributes.

The main problem in the process of determining attributes are that some of these attributes can be "casually prior" to other attributes. Therefore, focus group should be able to eliminate this type of attributes (Bennett and Adamowicz, 2001). A detailed study of the attribute causality problem was conducted by Blamey et al (2001).

Once the attributes are defined, the levels of these attributes must be determined. Levels can be expressed qualitatively or quantitatively, therefore decisions need to be made about how to present these attributes. Decisions are also needed regarding the presentation of the quantitative attributes in absolute or relative terms (Bennett and Adamowicz, 2001). It is important to use appropriate levels for the quantitative attribute to avoid over or underestimating WTP values that can lead to misleading results. The range of the levels of those attributes is established in consultations with experts. This requires specific knowledge of the subject to be able to quantify the future potential outcomes of different options (with implementation of the best management practices and the continuation of the status quo).

Usually, the selection of the most suitable presentation of attributes is assisted by focus group testing. The focus groups are also used to establish the upper bound for the monetary attribute's level. The next step is to establish the increments between each level of the attributes (Bennett and Adamowicz, 2001).

The attributes can be presented in words, numbers, percentage, via pictures, graphics, charts, etc. Usually the non-textual form of presentation is more costly and time consuming to produce but may have communication advantages (Adamowicz et al., 1998b).

2.5.3 Questionnaire design

This step requires selection of the type of questionnaire to be used and information required to frame the issue. CM questionnaires provide a description of the study area, visual aids, information about the issue and proposed changes in the attributes and a number of socio-economic questions. The structure of the questionnaire includes the following components:

- *An introduction*

The first part of the questionnaire introduces respondents to the issue by including information about the problem, and the importance of the research and questionnaire results. Respondents should also be informed about the way they were selected and are assured about the confidentiality of their responses. The questionnaire also displays the credentials of the study team. The approximate time for answering the questionnaire should also be provided.

- *Framing*

The questionnaire needs to make respondents aware that the considered non-market good is one of a group of substitute and complementary goods. The frame established by the questionnaire in respondents' minds must be adequate to the circumstances of the policy about which the decision need to be made. The appropriate frame must make respondents aware of the competing demands for funding and highlights the ways people spend their private budget (Bennett and Adamowicz, 2001).

- *Statement of the Issue*

This part of the questionnaire states the issue investigated, describes the current conditions and the consequences of the continuation of the *status quo* situation over time. This can be presented using photographic or graphical material.

- *Statement of a Potential Solution*

Potential solutions to the problem should be provided in the questionnaire. The proposed solutions must be believable and achievable. Funds for those solutions – albeit hypothetical - must be clearly sourced from respondent (Bennett and Blamey, 2001). The individual financial effect of their choice should be clearly understood by the respondents.

- *The Choice Sets*

The questionnaire should include instruction about the way that the choice sets should be completed and returned. The choice set should be presented in a way to ensure the clarity. Focus group testing should be conducted to ensure this. The alternatives presented to respondents can be labelled (named) or unlabelled. The amount of information presented in a questionnaire should be sufficient to allow choice making and possible to be assimilated by respondents to ensure the best quality of answers.

❖ *Choosing not to choose*

The questionnaire should also include an option of not choosing any of the proposed alternatives such as the *status quo* option.

❖ *Follow-up Questions*

The follow up-questions are included in a questionnaire to identify any anomaly in the responses. These anomalies may include:

- Payment vehicle protests – this situation exists when a respondents "always choose the status quo option or other option because of an objection to the way in which their costs is to be imposed";
- Lexicgraphic preferences – this situation exist when the alternative with the highest level of one attribute or the lower cost or some other single characteristics is chosen by respondents; and
- Perfect embedding – respondents agree to pay because it makes them feel good rather than as a reflection of their value for the environmental benefits available (Bennett and Adamowicz, 2001).

❖ *Socio-economic and Attitudinal Data Collection*

This part of the questionnaire collects socio-economic information on the respondents. These data are important inputs for the modelling phase, for the verification of data and for examining how well the sample represents the population. The final stage of the questionnaire is to ask respondents about their opinions of the questionnaire and the survey process (Bennett and Adamowicz, 2001).

2.5.4 Experimental design

This step involves constructing the choice options, alternatives or profiles for presentation to the respondents. Multiple attributes and multiple levels of these attributes create a number of combinations. The full set of the combination of these attributes is called the "full factorial" (Bennett and Adamowicz, 2001). Depending on a number of attributes and their levels, the “full factorial” can be very large. However, the number of alternatives in the experimental design needs to be sufficiently small to make the choice task manageable for respondents. This can be achieved by using a fraction of the “full factorial” and the “blocking” methods of experimental design.

In the process of selecting the fraction of the full factorial the properties of the full factorial should be maintained. However, some losses of information occur during this process (Louviere et al., 2000). If only a selective part of the full factorial is used to create the fractional factorial, the experimental design is less capable of deriving a model that correctly identifies all the possible relationships between attribute levels and choice probabilities (Bennett and Adamowicz, 2001). Therefore, each fraction involves factorial needs assumptions about the non-significance of higher-order effects (Louviere et al., 2000). Despite this, a smaller fraction is the preferred option as it gives smaller numbers of choice sets for respondents to evaluate (Bennett and Adamowicz, 2001).

A second strategy of dealing with a large number of combinations of alternatives remaining in fractional factorial designs is to segment them into blocks. Each respondent is presented with a number of alternatives that makes up one block of the factional factorial. Blocking requires the assumption that there are identically distributed preferences across the sub-samples of respondents answering each block (Bennett and Adamowicz, 2001).

There are two approaches to conducting experimental design. These include the sequential approach and the simultaneous approach. The sequential approach is usually used for large multi-level nested models (Louviere et al., 2000). This approach creates attribute combinations using one factorial design and the allocates each combination to choice set using a separate experimental design (Bennett and Adamowicz, 2001, Louviere, 2004). This approach has been criticised for potential significant losses of information, especially if there are path constraints on the state variables (Louviere et al., 2000). Moreover, it can be slow and expensive.

The simultaneous method uses one design that simultaneously creates attributes combinations and assigns them to the choice sets (Bennett and Adamowicz, 2001, Louviere, 2004). The advantage of this method is that it avoids computations of intermediate solutions and can overcome some data availability problems. The simultaneous method has been widely used (e.g. Blamey et al., 2000, Rolfe et al., 2004, Louviere and Woodworth, 1983).

2.5.5 Sample size and data collection

The sample size mostly depends on two factors: desired accuracy levels and data collection costs. The sample can be chosen by simple random sampling or by dividing the frame into groups that represents part of the population with different characteristics (Louviere et al., 2000).

The most common survey types include: telephone or personal interview, and mail out/mail back format survey. The web-based survey has been increasing in its popularity as it offers greater capacity to present complexity of the issue in a simple way such as using graphics. The disadvantage of this technique is that not everybody is familiar with computers or have access to the internet and may not be comfortable with this type of survey.

2.5.6 Model estimation

The probability of choosing a particular alternative is modelled using the survey information with a *status quo* and other alternative options (Bennett and Adamowicz, 2001). There are a number of models available. The method of estimation depends on the assumptions regarding the error term. The most common approach is the Multinomial Logit (MNL). Other choice models used include: Multinominal Probit (MNP) and Random Parameter Logit (RPL).

MNL is derived from RUM (McFadden, 1974). The main limitation of this model is its use of the Independence of Irrelevant Alternatives (IIA) assumption that in many situations is too restrictive (Haaijer and Wedel, 2007). If the IIA assumption cannot be made, other more complex models that avoid IIA must be used.

MNP models specify a continuous distribution of heterogeneity between individuals. MNP allows correlations among the repeated consumer's choices and correlation of random utilities of alternatives within choice sets (Haaijer and Wedel, 2007) thus avoiding the need for IIA conformity. However, some limitations of this model have been identified. They relate to the identification, prediction and estimation of the choice probabilities (Haaijer and Wedel, 2007). MNP has been widely applied in many choice studies (e.g.Christie et al., 2007, Lachaab et al., 2006), but its first application in a conjoint choice experiment was by Haaijer (1998).

RPL models assume that the estimated coefficient parameters are randomly distributed. Because RPL accounts for respondent heterogeneity across alternatives, it does not have to satisfy the IIA assumption (Johnson et al., 2000). The complexity of these models has been discussed by Hensher and Greene (2001). Examples of applications include Revelt and Train (1998), McFadden and Train (2000), Brownstone et al. (1997), Carson et al., (2003).

The most common statistical estimation method to estimate the parameters of choice models is the maximum likelihood estimation (MLE) method described by Hensher et al. (2005).

2.6 Review of choice modelling studies

The first application of choice modelling was undertaken by Louviere and Woodworth (1983). The technique has been extensively applied in many transportation studies (e.g. Louviere and Hensher, 1982, Ben-Akiva and Lerman, 1985), marketing (e.g. Swait and Louviere, 1993) and other areas such as electricity demand (e.g. Soderberg, 2007), renewable energy (e.g. Bergmann et al., 2004), and health (e.g. Ryan, 1999, Ryan and Hughes, 1997) .

The application of CM to environmental issues is relatively new. The first application of this technique in environmental studies was by Adamowicz et al., (1994). They used the technique to evaluate recreational preferences for different scenarios of the flow of Highwood and Little Bow Rivers in Alberta, Canada (Hanley et al., 1998).

With growing concern about the environment, CM has been more often applied to many environmental studies around the world. For example, CM was used in evaluation of international forest by Rolfe and Bennett (1996), of recreational moose hunting in the province of Alberta (Boxall et al., 1996), of landscape and wildlife protection in Scotland (Hanley et al., 1998), of old-growth forests in west central Alberta (Adamowicz et al., 1998a).

More recent studies that have applied CM to environmental problems include: Horne et al. (2005) who used CM to examine visitors' preferences for forest management in Finland, Xu et al., (2007) who used CM to value environmental benefits from changing natural resource strategies in the Ejina Region in China .Wang et al., (2007) who valued the environmental benefits derived from the conversion of cropland to forest and grassland in the Loess Plateau region of North West China and Christie et al (2007) who applied CM to value enhancements to forest recreation in Great Britain.

CM has also been applied in environmental studies in Australia (e.g. Bennett et al., 1997, Rolfe et al., 1997, Rolfe et al., 2004, Bennett et al., 2001, Blamey et al., 2000, Blamey et al., 1999b, Windle and Rolfe, 2005). These studies provide examples of how effectively the non-uses values and community preferences for different environmental quality can be determined.

For example, Bennett et al., (2001) applied CM to estimate the non-use values of the Macquarie Marshes wetland in New South. The questionnaire used for this study was developed using eight focus groups. Three options were presented in the choice sets including a *status quo*, and two alternative options involving increased water for the wetlands. Five attributes were specified in each choice set: water rates, irrigation related employment, wetlands area, frequency of waterbird breeding and endangered and protected species present. Respondents were presented with six choice sets. The survey results and socio-economic data were analysed using a MNL model. The study found that respondents' WTP for an extra irrigation related job preserved was 13 cents but they valued an additional endangered species present in the wetland at about $4.

A study by Blamey et al., (2000) estimated the benefits of retaining remnant vegetation in the Desert Uplands region of Central Queensland. In order to identify the relevant attributes, a detailed overview of the available information and consultations in focus groups were conducted. Six relevant attributes were identified: levy on income tax, income lost to the region, jobs lost to the region, number of endangered species lost to the region, reduction in population size of the non-threatened species and loss in area of unique ecosystems. Respondents were presented with a *status guo* option and two alternative options for increased vegetation preservation. The results showed that the WTP per household to maintain endangered species in this region was $11.39 per species, and $1.69 to avoid each one per cent loss in non-threatened species. They were also $3.68 to avoid one per cent loss in the area of unique ecosystems and $3.04 for an extra job saved. The WTP to maintain each million dollars of regional income was estimated at $5.60.

Blamey et al., (1999b) used CM to value multiple water supply options in the Australian Capital Territory taking into account use and non-use values. Five different policy options were investigated using six attributes: quality of water available for household, quality and perceived quality of the water used, annual household costs of water, the aquatic and riparian environment, endangered species losing habitat, appearance of urban environment. These attributes and the levels of these attributes were identified in a focus group. Three levels for each attribute were used. An increase in the cost of household water was used as a payment vehicle for this study. The results found that landholder annual WTP for prevention of habitat was $5 per species, for provision of recycled water for outdoor use was estimated at $47, for improvement in river flows from none to some rivers was $42 and for improvement from some to all rivers was estimated at $22. A 10 per cent reduction in household water use was estimated to be worth $10.

A study by Windle and Rolfe, (2005) used CM to explore how cane growers make trade-offs between different attributes associated with changing land use practices. This study was based on three cases studies in Central Queensland. The survey respondents were presented with the status quo and six other options in each choice set. Each option included five attributes: start-up costs, production costs, risk, management effort, net annual income. The experimental design for the survey generated 81 different choice sets. The information about socio-economic characteristics of the respondents was also collected in order to determine correlations with respondents' choices. The results of this study indicated that approximately two-thirds of growers in the Mackay and Proserpine regions and 41 per cent of Bundaberg growers did not choose options with diversified agricultural production.

The aforementioned studies show the extensive application of CM to different regions and policy issues. The information obtained from these studies provides inputs to the policy decision making process as they determine the strength of preferences for environmental benefits and costs. Based on this information, policy makers are better placed to ensure that the outcome of policy action leads to an increase in social welfare.

3. Conclusion

CM is increasingly being used in environmental valuation studies around the world. It has the capacity to avoid many of the biases faced by other SP techniques such as the CVM and the ability to assess a number of policy options in one exercise. In addition, it has advantages for benefit transfer application.

Knowledge of the scope and distance effects on value estimates to be investigated in this study would improve the transferability of these values to different areas in NSW. This would improve the effectiveness of many NRM policies through the easier integration of environmental values with bio-physical predictive tools into a BCA framework of decision making. More accurate estimates of changes in social welfare as a result of different policy actions would be available.

The integration of CM-derived value estimates into policy decision support tools used by NSW CMAs would provide more accurate information and improved resource allocation. NRM actions could be better targeted to generate greater net social well-being This would also help to reduce the uncertainty associated with different policy actions and increase the likelihood of the success of these policies. This study will provide useful inputs for the CMA's NRM investment prioritisation processes.

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