Valuing Remnant Vegetation Using Choice Modelling: An Application to the Desert Uplands of Central Queensland.

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ABSTRACT

The Desert Uplands is a biogeographic region in central-western Queensland that lies within the rangelands area of Australia. In the region, many pastoralists are clearing the scrub and woodland vegetation in order to improve production for cattle grazing. Only limited production gains are possible because of the low rainfall and infertile soils relative to many other areas of Queensland. To assess whether such developments are economic and desirable, a first step is to value the environmental implications of alternate management regimes. A stated preference choice modelling study was undertaken to provide estimates of these values. Attributes included in the choice model pertain to reductions in the population size of non-threatened species, the number of endangered species lost to the region, and changes in regional income and employment. A nested logit model was used to model the data. Results indicate, inter alia, that the loss of one endangered species to the Desert Uplands region is valued similarly to three jobs lost. The welfare implications of several different policy options regarding levels of tree retention are estimated.

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1.0 Introduction.

Rangelands in Australia are facing a number of pressures (Tothill and Gilles 1992, Wilcox and Cunningham 1994, Holmes 1996). Heavy grazing pressures relative to the long term carrying capacity have resulted in the widespread deterioration of most native pasture types. These problems have been amplified by the spread of weeds and pest animals. There are concerns about pressures on biodiversity, including the loss of critical habitat (Gill, Landsberg and Morton 1995), and concerns about declining economic viability of the pastoral industries, with consequent implications for the financial and social health of rural communities (Dale and Bellamy 1998). There is increasing dependence on public funding to address issues in the maintenance of biodiversity, as well as to provide support and services to isolated communities and encourage sustainable use of natural resources (Dale and Bellamy 1998).

Rangeland managers (both land owners and policy makers) face difficult trade-off decisions involving multiple rangeland outputs. Understanding the nature of these relationships and the relative values involved can lead to improved decision-making. Unfortunately, such information is often not readily available. Whilst the financial returns from increased production are usually transparent and relatively easy to assess, impacts on biodiversity are rarely priced in markets, and are often complex and uncertain.

Nonetheless, changes in biodiversity often impact on the non-use values held by humans, and such values should be incorporated into decision-making[1]. Failure to do so may result in inefficient allocation of resources. For example, graziers in rangelands areas respond to the demands from the wider population for meat and wool, but receive no corresponding demand signals from the wider population for biodiversity protection. The absence of a market for biodiversity may result in market values for rangelands areas dominating the decisions of individual graziers. To correct for these "missing markets", governments are usually expected to take the values of the wider community into account when making resource allocation or protection decisions.

The difficulty for decision makers wishing to assess the public good aspects of resource allocation choices (such as these non-use values) is that they cannot be inferred from direct observation of behaviour in markets. Non-market valuation techniques have been developed to estimate non-use and non-excludable use values.

One of these techniques, termed Choice Modelling (CM), appears to be particularly appropriate for application to complex and multifaceted trade-off choices. In this paper, some description of the CM technique is given, and results of an application of the technique to remnant vegetation and potential changes to broad scale tree clearing regulations in the Desert Uplands, a biogeographic region in the rangelands area of Australia, are reported.

An overview of CM is given in the next section, followed by an outline of the case study in section three. In section four an overview of the design stages, and conduct of the survey, is given. Analysis and discussions follow in section five, and final conclusions are presented in section six.

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[1] Non-use values arise when people have preferences for the existence of biodiversity (existence value), for preserving the opportunities afforded by continued existence (option value), and for guarding against the loss of options in the face of uncertainty and incomplete knowledge (quasi-option value).

2.0 The Choice Modelling Technique.

There have been limited applications of CM to environmental issues, and only recent studies (eg Rolfe and Bennett 1996, Adamowicz et al 1998, Morrison et al 1998, Blamey et al 1998a,b, 1999) have begun to explore the use of the technique for estimating non-use values. Such applications involve the use of questionnaires to elicit information regarding the community preferences and values associated with particular changes in environmental quality.

Respondents are typically presented with between six and ten hypothetical sets of policy or market alternatives and asked to indicate which alternative they prefer in each set. A ‘none of these’ alternative is commonly included in each set. The data obtained from this hypothetical choice exercise are used to estimate a model that relates people’s choices to the set of environmental and other attributes used to define the alternatives in the questionnaire. Any policy-relevant set of environmental or other outcomes can then be substituted into the model and the extent of community support for the alternatives guaged.

Operationally, the CM technique involves several stages. The first stage involves the identification of key attributes relevant to the choices of interest. This needs to be done from both the perspective of the end-user (the population of interest) and the decision makers/resource managers to ensure that the attributes are not only easily identifiable, but produce policy relevant information (Blamey et al 1997). As well, the levels across which each attribute is allowed to vary should also be identified. Generally the levels should be set to cover the full extent of the possible range for each attribute. Some monetary payment attribute (such as a tax increase) is also included within the scenario descriptions.

The second stage is the selection of scenarios (alternatives) that will be used in a choice experiment. These do <u>not</u> correspond to the alternatives actually under policy consideration. Rather, the levels of the attributes characterising the different options are varied according to an experimental design, permitting estimates of the relative importance of the attributes describing the options to be obtained. Instead of “being questioned about a single event in detail...subjects are questioned about a sample of events drawn from the universe of possible events of that type” (Boxall et al, 1996, p244).

The third stage is the performance of the actual survey. Respondents are generally chosen at random from the population of interest, and invited to complete a questionnaire. As well as a series of ‘choice sets’, questionaries often include questions on background information, related issues, and the attitudes and socio-economic characteristics of the respondents. A glossary describing each of the attributes listed in the questionnaire may also be included.

The fourth stage involves the modelling and analysis. This includes selecting a statistical model with which to estimate a relationship between respondent choices and the attributes of the alternatives presented. Typically, the probability that a given alternative will be chosen is assumed to be a function of the satisfaction (utility) derived from the alternative in question and each of the other alternatives in the choice set. The alternative offering the highest expected utility has the highest choice probability. The most common statistical models employed in CM studies are the multinomial logit model (MNL) and the nested logit model (NL). These are described briefly in the Appendix[2].

[2] Refer to Morrison et al (1997) and Blamey et al (1998a, 1998b) for further details.

Three broad types of results are available from a CM experiment. At the simplest level, the statistical model estimated can be used to indicate the probability that a given alternative will be chosen from a specified set of alternatives. This information can be obtained for any set of alternatives that can be built from the attributes and levels used in the experiment, and is not restricted to the options that were presented in the choice sets. Choice probabilities can be aggregated across the sample to obtain estimates of market or voter share, which can be used to derive a community ranking of the set of policy options under consideration. See Blamey et al (1999) for an example.

The second type of result is marginal values (implicit prices) for specific attributes. This can be thought of as the amount by which the monetary payment has to vary to have the same impact on utility (and hence the probability of choice) as the change in environmental and other attributes. For example, the loss of two endangered species may produce the same average loss in utility as an increase in land rates of $20. This implies that the loss of two endangered species is valued by the community at approximately $20. These are marginal values in the sense that they represent the value of a small change in just one of the attributes listed in the questionnaire. They are estimated on a “ceteris paribus” basis whereby everything else except the two attributes involved is kept constant.

The third type of result involves estimating the value for changes in the packages of attributes associated with specific policy options. Of particular interest are the values associated with changes from the status-quo as specified by the policy proposals of interest. For example, in the context of tree clearing guidelines, the community’s willingness to pay to obtain tighter (or weaker) tree clearing restrictions, described in terms of the associated environmental and economic implications, can be estimated.

Each of these types of results can be useful to decision makers and resource managers. The choice probability models help to predict the proportions of a population that would choose between different options, as well as being able to disaggregate these choices across different groups of respondents. In a political environment where broad community support is often a prerequisite to successful policy implementation, this type of information may be particularly useful. In this way, a CM application can act as a mechanism for public participation in decision making.

The marginal values that can be estimated for particular attributes provide some indication about how people view the importance of each attribute in making choices relative to the other opportunities and constraints that they face. These values provide a convenient overview of the relative value of each attribute.

The estimates of value for differences in packages of attributes can be used to evaluate more complex choices between resource use options. Most resource use options involve trade-offs between different factors. In some cases, as in the application reported below, values for differences between alternatives may already include internal trade-offs between environmental and/or social attributes. The information revealed in a CM application can be added to information revealed in markets under the framework of cost benefit analysis so that more fully informed decisions can be made.

3.0 The Case Study.

The Desert Uplands is one of thirteen terrestrial biogeographic regions of Queensland. Covering some 6,881,790 hectares (4% of Queensland), it straddles the low tablelands of the Great Dividing Range in central-western Queensland.

The region is essentially a band of scattered woodland country between the open grasslands of the arid western plains and the semi-arid to sub-humid brigalow (*Acacia harpophilla*) country to the east. The region is relatively unproductive for pastoral and agricultural purposes compared to other regions in the south and east of Queensland. This is because of its relatively low rainfall and poor soils, and its vegetation which is reasonably unpalatable to domestic stock (Rolfe, Blamey and Bennett 1997). One reason why the term 'desert' is attached to the area is because spinifex (*Triodia spp*.), a grass common to the drier areas of Australia, is a major grass species in the region.

The region is used almost exclusively for pastoral purposes. Cattle are bred and fattened for beef production over much of the region, and sheep are also run in some areas. Pastoralists have been attempting to increase the carrying capacity of their land by a variety of methods, including the clearing of trees and the introduction of non-native grass species. Initially these developments were limited to patches of more fertile soils. The region now has one of the highest clearing rates in Australia, with between 4 and 8% of many broad country types being cleared between 1992 and 1995 (McCosker and Cox 1996).

While the region is still relatively undeveloped compared to the brigalow regions to the east, and the integrity of most ecosystems in the region remains high, trends in management and development appear to be impacting on biodiversity (Landsberg, Ash, Shepherd and McKeon 1998, McCosker and Cox 1996). Tree clearing is the most visible form of change, but overgrazing, land degradation and weed invasion are also problems.

Approximately 80% of the region is held as leasehold tenure, where the State Government is the legal owner of the natural resources. Leaseholders must gain permission to clear trees through the Department of Natural Resources. In issuing permits for broadscale tree clearing, the State Government policy calls for a balance between the benefits of increased productivity (most of which accrued directly to the landholders) against the environmental costs of diminished vegetation cover (which are more broadly spread across the regional and national communities). It is these environmental costs that the CM application described below is directed at estimating.

The Queensland Government has recently been revising its tree clearing policies, with the result that vegetation communities that are endangered or vulnerable (whether through past clearing activities or limited initial occurrence) are now protected. Other vegetation communities can be cleared to 20% of their original extent on individual properties, with 30% of each vegetation type to be retained across the region.

In some cases, choices about environmental protection in the Desert Uplands may be very site specific. Many of the smaller, unique ecosystems and endangered species are associated with the brackish lakes in the region and several moundsprings on the western side of the Desert Uplands. The estimation of values for both unique ecosystems and endangered species will help to determine preservation values and appropriate trade-offs for individual sites within the region, providing valuable input into policy decisions.

At the same time, preservation options are rarely neutral in relation to non-environmental factors such the health of regional communities. Some preservation options might be expected to reduce opportunities for production, and therefore impact on regional income and job opportunities. In common with many rangelands areas of Australia, the small townships and rural communities of the Desert Uplands are facing population loss and diminishing prospects. In this context, policy actions that reduce the viability of individual enterprises and regional communities are very visible. However, some initiatives, such as changed management practices, may have very little impact on social factors.

These complexities mean that the CM experiment has to be able to address a wide range of situations. The essence of the important trade-offs has to be captured within the selection of attributes and the design of the experiment. Values may have to be estimated for a wide range of options built on different combinations of the attributes and model characteristics. These goals can be met in part by focusing on tree clearing as a mechanism for explaining environmental losses, even though a variety of other different reasons contribute to environmental losses in the real life situation.

4. Questionnaire design and survey logistics.

A CM questionnaire was developed for the purpose of establishing the preservation values that Queenslanders might hold for environmental and social attributes in the Desert Uplands region. Design of the questionnaire followed a two-stage approach.

The first stage was a detailed overview of information available about the region relating to environmental attributes and the possible consequences of tree clearing activities. The level of knowledge in the community about environmental systems and relationships is not high, and there is very limited knowledge about the possible long term effects of broadscale tree clearing and the extent to which it might occur (Rolfe et al 1997). This uncertainty resulted in the selection of a very broad spectrum of possible outcomes, which is reflected in the broad range across which each of the attributes was allowed to vary.

The second stage of the questionnaire design phase involved focus groups being held in both Brisbane and Emerald, the latter being a town adjacent to the Desert Uplands. The purposes of the focus groups were to identify the broad attributes of importance to people in making choices about the impact of tree clearing in the Desert Uplands, and to identify levels of knowledge and familiarity with the case study of interest.

A number of possible attributes were identified. These were subsequently condensed (for logistical and modelling purposes) to six possible attributes, being:

- Levy on income tax
- Income lost to the region ($ million)
- Jobs lost to the region
- Number of endangered species lost to the region
- Reduction in population size of the non-threatened species (%)
- Loss in area of unique ecosystems (%).

The levels chosen for each attribute reflected the broad possible range of resource use options in the biogeographic region, rather than just the outcomes relating immediately to tree clearing. For example, the number of endangered species reflected the total number that may be affected by development and grazing pressure options. Selection of attribute ranges in this way had the advantage of making the results broadly applicable to resource use options in the region, and avoided the difficulty of disaggregating changes between tree clearing and other development and management impacts. As well, it helped to ensure choices were framed against the array of possible development and preservation outcomes.

To generate a representative sample of the distribution of possible scenarios and ensure scenarios were orthogonal, an experimental design process was used. A range of specific modelling issues were tested by offering slightly different versions of the surveys to different samples of the respondents involved. The results of these methodological issues have been reported in Blamey et al (1998a, 1998b).

An example of a choice set presented to respondents is shown in Figure 1. This shows that respondents were presented with a status quo option (Option A) and two options for increased preservation (Options B and C). While the same status quo option was included in all choice sets for all respondents, the attributes of options B and C varied according to the experimental design.

Figure 1: A Typical Choice Set

Implications	Option A Current Guidelines	Option B	Option C
Levy on your income tax	none	$60	$20
Income lost to the region ($ million)	none	5	10
Jobs lost in region	none	15	40
Number of endangered species lost to region	18	8	4
Reduction in population size of non-threatened species	80%	75%	45%
Loss in area of unique ecosystems	40%	15%	28%

The description for Option A, together with the background material presented, made it clear that some standards of preservation were already being met under the current tree clearing guidelines.

The final version of the survey was administered in the form of a B5 booklet with a colour insert containing photos and an attribute glossary, and included a number of background, attitude and respondent characteristic questions as well as the series of eight choices. The surveys were administered in a door knock drop-off/pick-up format to 480 Brisbane households in November 1997.

5.0 Results and Discussion.

The most accurate models of choice were generated from the experimental data with a nested model, where respondents were initially seen to choose between ‘doing something’ and ‘doing nothing’. This choice was found to be heavily influenced by three key attitudes of respondents. Once the ‘doing something’ branch of the ‘nest’ was chosen, respondents chose between the two improvement options (B and C), mainly on the basis of the attributes of these alternatives. The status quo option (Option A) was the ‘do nothing’ alternative.

The variables describing respondents' attitudes are defined in Table 1, and the results of the nested logit analysis are presented in Table 2. The "branch choice equations" indicate the relative utility of 'doing something' versus 'doing nothing'. Respondents with a pro-environment orientation (envatt=1) were more likely to choose one of the environmental improvement options than respondents with a pro-development perspective (envatt=0). Those who report being confused by the choices presented in the questionnaire (confuse=1) were more likely to choose the status quo, as were those who have problems with the notion of a tree levy (object=1). The results suggest that despite the best efforts to minimise confusion and protest through questionnaire design, a significant degree of confusion and protest remained. This appears to have generated a degree of bias toward the status-quo, potentially similar to that reported by Adamowicz et al (1988)[3]. Respondent income was not found to have a significant influence on choice.

The choice between Options B and C is modelled as shown under the heading 'Utility functions' in Table 2. The attributes in the utility function are all signed as expected and are highly significant. The negative coefficient on *Levy* indicates that respondents are less likely to choose options with increasing payment amounts. The negative signs on the other coefficients means that increasing amounts of the other attributes (eg more job losses, more endangered species losses) are negatively correlated with choice[4].

The marginal values of the different attributes are reported in Table 3. The implicit prices for all the attributes are positive, implying that Brisbane residents have positive values for reductions in all environmental and economic losses listed in the choice sets. For example, mean respondent willingness to pay (WTP) for job preservation is $3.04 per job, while the WTP to maintain each million dollars of regional income is $5.60. For the environmental attributes, the WTP to maintain endangered species in the region is $11.39 per species, the WTP to avoid each percent loss in non-threatened species is $1.69, and the WTP to avoid each percent loss in the area of unique ecosystems is $3.68. These results imply that one endangered species lost is valued similarly by the community to four jobs lost, and a 10% reduction in the population of non-threatened species is valued similarly to six jobs lost.

These results illustrate the information that can be generated for resource managers and policy makers. The marginal values show that there is significant support for protecting both social and environmental factors. In relation to the social factors, there appears to be substantially more support for preserving jobs rather than regional income when policy options are considered. An option that preserved $1 million in regional income but few jobs would have substantially less value than an option that preserved $500,000 in regional income but 10 extra jobs.

Similarly, it appears that support for endangered species and unique ecosystems is higher than support for non-threatened species. Depending on the situation, it is clear that large areas of low-impact clearing may occur without high welfare losses, but also that small amounts of clearing impacting on endangered species and/or unique ecosystems would generate substantial environmental costs.

The results also suggest that the environmental values are related more closely to some uniqueness factor than to the quantity of the environmental assets. This indirectly confirms that the broad thrust of the current tree clearing guidelines is valid. Vegetation types that are unique or restricted in extent are of high value and thus deserving of protection, while

[3] Status-quo bias is typically associated with respondent protest or confusion.
[4] These results are explained in some detail in Blamey et al (1998a).

clearing of non-threatened species that generate other production and social benefits may be allowed. As further clearing restricts those vegetation types though, protection measures should be considered.

A further way of using the CM results is through the comparison of welfare estimates for different scenarios. Welfare estimates can be generated as the difference in community value between some base condition (Option A in the choice sets) and some other alternative (Options D1 to D5 in Table 4), generated from the attributes and levels involved in the choice experiment. Table 4 lists the mean WTP of Brisbane residents for five different tree clearing options for the Desert Uplands.

For example, the adoption of new guidelines as described by Option D1 rather than staying with the current guidelines generates welfare improvements of $87. Brisbane households are thus prepared to pay an average of $87 in a one-off tree levy to obtain the outcomes associated with Option D1. A cost-benefit-analysis of the various options would need to consider these value estimates along with other market and non-market values not addressed in the CM application, including the non-market values accruing to individuals living both within the local region, and other more distant regions.

It is notable that the value of Option D1 is only partly explained by the change in the attributes used in the CM experiment. The value for Option D1 shown in Table 4 is higher than the simple sum of marginal values for the specified attribute changes (Table 3). This is due to the influence of the constant and its interaction with the attitudinal variables in the branch-choice equation in Table 2, and suggests that preservation values for rangeland ecosystems may relate to a wide variety of sources and influences. As noted above, a degree of bias toward the status quo option is apparent.

Now consider the influence that social costs in the form of losses in jobs and income in the Desert Uplands region have on welfare estimates. The above estimate for the difference between Options A and D1 focused only on changes in environmental attributes. In Option D2 in Table 4, some human impact consequences are added to the environmental consequences listed in Option D1.

The estimate for the difference in value between the two alternatives (Option A and Option D2) is $76. This value is lower than that estimated for Option D1. Thus the addition of negative social consequences to outcomes of increased protection measures reduces the values of those outcomes. Brisbane households thus appear to hold 'non-use' values regarding levels of employment and income in the Desert Uplands region.

Option D3 is similar to D1 in that it specifies environmental improvements without losses in jobs and regional income. However, in this case, the environmental improvements are much larger than in D1. Consequently, Brisbane households are willing to pay 35% more for this option than D1. When the environmental improvements specified in D3 can only be obtained at the expense of 30 jobs and $10 million in regional income, mean WTP falls to $88.

The final option included in Table 4 specifies the minimum environmental improvements included in any of the choice sets in the questionnaire and the maximum economic costs in the form of income and jobs. In this case, WTP falls to $36. It appears that although increasing losses of jobs and income in the Desert Uplands region reduce the WTP of Brisbane residents, WTP for tighter tree clearing guidelines remains positive for all combinations of environmental and economic outcomes considered in the questionnaire.

Table 1: Non-Attribute Variable Definitions

Variable	Definition
const	Alternative-specific constant taking on a value of 1 for options 2 and 3 in the choice sets, and 0 for the base option.
const1	Alternative-specific constant taking on a value of 1 for option 2 in the choice sets, and 0 for the base option.
envatt	Dummy variable taking on a value of 1 for respondents indicating that, over the years, when have heard about proposed conflicts between development and the environment, they have tended to "More frequently favour preservation of the environment"; 0 otherwise.
confuse	Five point likert scale response indicating extent of disagreement with the statement "I found questions 3 to 10 [the choice set questions] confusing".
object	Five point likert scale response indicating extent of disagreement with the statement "A tree levy is a good idea".

Table 2: Nested Logit Results

Variables	coeff.	s. error
Utility Functions		
const1	0.1644#	0.0663
levy on income tax	-0.0107*	0.0011
jobs	-0.0324*	0.0053
regional income	-0.0597*	0.0138
number of endangered species	-0.1214*	0.0111
population of non-threatened species	-0.0180*	0.0029
area of unique ecosystems	-0.0392*	0.0065
Branch Choice Equations		
const	-1.9738*	0.5913
const*envatt	1.1344*	0.1105
const*object	-0.5750*	0.0501
const*confuse	-0.1550*	0.0477
Inclusive Value Parameters		
do something	0.1904#	0.0795
do nothing	1.0000	0.0000
Model Statistics		
n (choice sets)	5769	5784
Log L	-1685.564	-1547.388
adj rho-square (%)	20.1	26.7

NB: + denotes significance at the 10 per cent significance level, # denotes significance at the 5 per cent level,
* denotes significance at the 1 per cent level.

Table 3. Marginal values for the different attributes.

Variable	Value of a one unit improvement $
Jobs lost in local region	3.04
Loss in regional income ($m)	5.60
Number of endangered species lost	11.39
Percentage reduction in population of non-threatened species	1.69
Percentage loss in area of unique ecosystems	3.68

Table 4. Welfare estimates associated with more stringent tree clearing guidelines.

Attribute	Option A (current guidelines)	Option D1 (new guidelines)	Option D2 (new guidelines)	Option D3 (new guidelines)	Option D4 (new guidelines)	Option D5 (new guidelines)
Jobs lost in the region	0	0	10	0	30	40
Regional income lost	0	0	5	0	10	15
# of endangered species lost to region	18	16	16	8	8	16
Reduction in non-threatened species	80%	50%	50%	35%	35%	75%
Loss in area of unique ecosystems	40%	30%	30%	20%	20%	35%
WTP (A $\rightarrow$ D)	n/a	$87	$76	$117	$88	$36

The welfare estimates presented in Table 4 are calculated at the mean values of envatt, object and confuse over the sample (see Table 1). The values can be recomputed for different values of these variables to see how WTP varies between segments. For example, WTP for option D2 falls to $21 for respondents having a pro-development orientation, and rises substantially to $128 among those with a pro-environment orientation, holding object and confuse at their mean values. Interestingly, respondents with a pro-development orientation are still willing to pay a positive amount of money to obtain the outcomes associated with option D2 rather than option A. However, WTP among this segment falls to zero when the number of jobs lost increases to 30 and $14 million in regional income is lost. By contrast, WTP among the pro-environment segment only falls to zero when 150 jobs and $50 million in regional income are lost![5]

6.0 Conclusion.

There is widespread recognition in Australia that rangelands systems are under increasing pressure from a range of different influences. The integrity and resilience of many ecosystems are being degraded, production and financial returns to some sectors of the pastoral industries appear to be spiralling downwards, and many rural communities are contracting. The interrelationships between these factors vary according to specific situations. In some cases there are clear tradeoffs between environmental, financial and social goals, and in other cases there are complementary relationships. The simultaneous quantification of these influences is desirable from both the perspective of the policy analyst and for methodological reasons.

The CM application reported in this paper has focused on valuing changes in resource use options that incorporate both environmental and social aspects. The results indicate that Australians, and in particular, Brisbane residents, do hold values for the protection of both aspects, and that these may be offsetting or complementary according to the setting. Estimates of implicit prices and welfare estimates demonstrate how the technique is useful in generating explicit information for policy analysts.

However, successful use of the technique in this application is tempered by its complexity and associated methodology issues. For example, the apparent occurrence of status quo and related biases in the present study suggests a need to better understand how respondents go about completing CM questionnaires, and how this varies with changes in questionnaire design. These and other issues relating to this experiment are reported in more detail in Blamey et al (1998a, 1998b).

Research effort that has gone into the development of the CM technique is helping to streamline and simplify applications. Further work is needed in what is promising to be a successful direction in non-market valuation.

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[5] This estimate involves extrapolation beyond the range of the jobs and regional income attributes in the experiment and hence should be treated with caution.

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Appendix: Statistical Form of the Choice Model

Whilst a number of different statistical models can be applied to the choice data obtained from a CM questionnaire, only the multinomial logit model (MNL) and nested logit model (NL) are considered here.

MNL

Let Vih represent the satisfaction (utility) that respondent i receives from consuming the hth alternative in a set C of alternatives. The probability that the respondent will choose alternative h is estimated as:

$$P_{ih} = \frac{\exp[\lambda V_{ih}]}{\sum_{j \in C} \exp[\lambda V_{ij}]} \qquad \text{(i)}$$

where λ is a scale parameter, commonly normalised to 1 for any one data set (Ben-Akiva and Lerman, 1985). An estimated linear-in-parameters utility function for the jth alternative often takes the following form:

$$Vj = ASC_j + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots \beta_k X_k + \ldots \beta_n X_n + \gamma_1 (S_1 * ASC_j) + .. + \gamma_m (S_m * ASC_j) \qquad \text{(ii)}$$

where there are n attributes with generic coefficients across alternatives, and m individual-specific variables multiplied by an alternative-specific-constant (ASC). The S_g can also be interacted with the attributes.

An important assumption of the MNL is the assumption of independent irrelevant alternatives. This requires that the ratio of the choice probabilities for any two alternatives be unaffected by the addition or removal of alternatives. Violations of the IIA assumption render the MNL model inappropriate.

NL

One way of circumventing IIA violations is to allow for correlations among the error terms within different groups or classes of alternatives by estimating a nested logit model (McFadden, 1978, Dagunzo and Kusnic, 1993). In a two level nested logit model, the probability of an individual choosing the hth alternative in class r (P_{hr}) is represented as:

$$P_{hr} = P(h/r)P(r) \qquad \text{(iii)}$$

where P(h|r) is the probability of the individual choosing the hth alternative conditional on choosing the rth class of outcome, and P(r) is the probability that the individual chooses the rth class. Following Kling and Thomson (1996):

$$P_i(h/r) = \frac{\exp[V_{ihr}/\alpha_r]}{\exp[I_r]} \qquad \text{(iv)}$$

$$P_i(r) = \frac{\exp[\alpha_r I_r]}{\sum_{k=1}^{R} \exp[\alpha_k I_k]} \qquad \text{(v)}$$

where

$$I_r = \log\left[\sum_{i=1}^{Jr} \exp(V_{ir}/\alpha_r)\right] \qquad \text{(vi)}$$

is referred to as the inclusive value, a measure of the expected maximum utility from the alternatives associated with the rth class of alternatives. The coefficient of inclusive value α_r measures substitutability across alternatives. When substitutability is greater within rather than between alternatives, $0<\alpha_r<1$. In this case, respondents will shift to other alternatives in the branch more readily than they will shift to other branches (Train, McFadden and Ben-Akiva, 1987).