CHOICE MODELLING APPROACHES: A SUPERIOR ALTERNATIVE FOR ENVIRONMENTAL VALUATION?

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Abstract. In this paper, we examine some popular 'choice modelling' approaches to environmental valuation, which can be considered as alternatives to more familiar valuation techniques based on stated preferences such as the contingent valuation method. A number of choice modelling methods are consistent with consumer theory, their focus on an attribute-based theory of value permits a superior representation of many environmental management contexts. However, choice modelling surveys can place a severe cognitive burden upon respondents and induce satisficing rather than maximising behavioural patterns. In this framework, we seek to identify the best available choice modelling alternative and investigate its potential to 'solve' some of the major biases associated with standard contingent valuation. We then discuss its use in the light of policy appraisal needs within the EU. An application to the demand for rock climbing in Scotland is provided as an illustration.

1. Introduction

Although still controversial, the contingent valuation method has managed to gain increased acceptance amongst both academics and policy makers as a versatile and powerful methodology for estimating the monetary value of environmental changes. Contingent valuation (Mitchell and Carson, 1989) is a direct survey approach to estimating consumer preferences. By means of an appropriately designed questionnaire, a hypothetical market is described where the good or service in question can be traded. This contingent market defines the good itself, the institutional context in which it would be provided, and the way it would be financed. Respondents are then asked to express their maximum willingness to pay (WTP) or minimum willingness to accept for a hypothetical change in the level of provision of the good. Theoretically, contingent valuation is well rooted in welfare economics, namely in the neo-classical concept of economic value based on individual utility maximisation. This assumes that stated WTP amounts are related to respondents' underlying preferences in a consistent manner.

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The choice of elicitation formats for willingness to pay questions in contingent valuation surveys has already passed through a number of distinct stages. In the early years, open-ended elicitation formats were predominant amongst practitioners. The answers were informative and statistically straightforward to analyse. Nonetheless, dissatisfaction with this approach gradually grew as evidence mounted of the incidence of protest bids possibly resulting from the associated cognitive burden, and of the potential for strategic bidding. During the 1980s, following the seminal work of Bishop and Heberlein (1979), there was a shift towards the use of dichotomous choice elicitation, which not only provided incentives for the truthful revelation of preferences but also simplified the cognitive task faced by respondents. After receiving the endorsement of the NOAA panel in 1993 (Arrow *et al.*, 1993) the use of dichotomous choice questions substantially increased particularly in US-based applications. However, an increasing number of empirical studies started to reveal that dichotomous choice results seemed to be significantly larger than open-ended values, possibly due to yeah saying. Moreover, neither approach is ideally suited to deal with cases where changes are multidimensional.

Partly as a response to these problems, valuation practitioners are increasingly developing an interest in alternative stated preference formats such as Choice Modelling (CM).[1] CM is a family of survey-based methodologies for modelling preferences for goods, where goods are described in terms of their attributes and of the levels that these take. Respondents are presented with various alternative descriptions of a good, differentiated by their attributes and levels, and are asked to rank the various alternatives, to rate them or to choose their most preferred. By including price/cost as one of the attributes of the good, willingness to pay can be indirectly recovered from people's rankings, ratings or choices. As with contingent valuation, CM can also measure all forms of value including non-use values. The conceptual microeconomic framework for CM lies in Lancaster's (1966) characteristics theory of value which assumes that consumers' utilities for goods can be decomposed into utilities for composing characteristics. Empirically, CM has been widely used in the market research and transport literatures (e.g. Green and Srinivasan, 1978; Henscher, 1994), but has only relatively recently been applied to other areas such as the environment.

This paper is organised as follows. Section two contains a descriptive analysis of the main CM techniques. An example of a recent CM experiment is presented in Section three. Section four summarises the advantages and disadvantages of CM and compares its performance with contingent valuation. The last section discusses the potential to use CM techniques to aid policy decisions in the environmental arena.

2. Choice Modelling Techniques

A typical CM exercise is characterised by a number of key stages. These are described in Table 1.

As mentioned in Table 1, individual preferences can be uncovered in CM surveys by asking respondents to rank the options presented to them, to score

Table 1. Stages of a Choice Modelling Exercise

Stage	Description
Selection of attributes	Identification of relevant attributes of the good to be valued. Literature reviews and focus groups are used to select attributes that are relevant to people while expert consultations help to identify the attributes that will be impacted by the policy. A monetary cost is typically one of the attributes to allow the estimation of WTP.
Assignment of levels	The attribute levels should be feasible, realistic, non-linearly spaced, and span the range of respondents' preference maps. Focus groups, pilot surveys, literature reviews and consultations with experts are instrumental in selecting appropriate attribute levels. A baseline 'status quo' level is usually included.
Choice of experimental design	Statistical design theory is used to combine the levels of the attributes into a number of alternative scenarios or profiles to be presented to respondents. *Complete factorial designs* allow the estimation of the full effects of the attributes upon choices: that includes the effects of each of the *individual* attributes presented (main effects) and the extent to which behaviour is connected with variations in the *combination* of different attributes offered (interactions). These designs often originate an impractically large number of combinations to be evaluated: for example, 27 options would be generated by a full factorial design of 3 attributes with 3 levels each. *Fractional factorial designs* are able to reduce the number of scenario combinations presented with a concomitant loss in estimating power (i.e. some or all of the interactions will not be detected). For example, the 27 options can be reduced to 9 using a fractional factorial. These designs are available through specialised software.
Construction of choice sets	The profiles identified by the experimental design are then grouped into choice sets to be presented to respondents. Profiles can be presented individually, in pairs or in groups. For example, the 9 options identified by the fractional factorial design can be grouped into 3 sets of four-way comparisons.
Measurement of preferences	Choice of a survey procedure to measure individual preferences: ratings, rankings or choices.
Estimation procedure	OLS regression or maximum likelihood estimation procedures (logit, probit, ordered logit, conditional logit, nested logit, panel data models, etc.). Variables that do not vary across alternatives have to be interacted with choice-specific attributes.

them or to choose their most preferred. These different ways of measuring preferences correspond to different variants of the CM approach. There are four main variants: choice experiments, contingent ranking, contingent rating and paired comparisons. As will be shown in this section, these techniques differ in the quality of information they generate, in their degree of complexity and also in their ability to produce WTP estimates that can be shown to be consistent with the usual measures of welfare change. Table 2 summarises the various approaches.

The next section provides a detailed analysis of each of the main CM variants depicted in Table 2.[2]

Table 2. Main Choice Modelling Alternatives

Approach	Tasks	Welfare consistent estimates?
Choice Experiments	Choose between two or more alternatives (where one is the status quo)	Yes
Contingent Ranking	Rank a series of alternatives	Depends
Contingent Rating	Score alternative scenarios on a scale of 1–10	Doubtful
Paired Comparisons	Score pairs of scenarios on similar scale	Doubtful

2.1. *Choice Experiments*

In a choice experiment (CE) respondents are presented with a series of alternatives, differing in terms of attributes and levels, and asked to choose their most preferred. A baseline alternative, corresponding to the status quo or 'do nothing' situation, is usually included in each choice set. This is because one of the options must always be in the respondent's currently feasible choice set in order to be able to interpret the results in standard welfare economic terms. Table 3

Table 3. Illustrative Choice Experiment Question

WHICH ROUTE WOULD YOU PREFER TO VISIT IN THE SUMMER, GIVEN THE TWO ROUTES DESCRIBED BELOW?

Characteristics of route	Route A	Route B
Length of climb	100 metres	200 metres
Approach time	3 hours	2 hours
Quality of climb	2 stars	0 stars
Crowding at route	Crowded	Not crowded
Scenic quality of route	Not at all scenic	Not at all scenic
Distance of route from home	160 miles	110 miles

PREFER ROUTE A?: ☐
PREFER ROUTE B?: ☐
STAY AT HOME? (CHOOSE NEITHER)?: ☐

presents an example used in a recent study of rock climbing in Scotland. In this study, described in detail in the next section, the good is a climb, defined in terms of its attributes such as length and congestion. Each respondent is asked a sequence of these questions.

The choice experiment approach was initially developed by Louviere and Hensher (1982) and Louviere and Woodworth (1983). Choice experiments share a common theoretical framework with dichotomous-choice contingent valuation in the Random Utility Model (Luce, 1959; McFadden, 1973), as well as a common basis of empirical analysis in limited dependent variable econometrics (Greene, 1997). According to this framework, the indirect utility function for each respondent $i(U)$ can be decomposed into two parts: a deterministic element (V), which is typically specified as a linear index of the attributes (X) of the j different alternatives in the choice set, and a stochastic element (e), which represents unobservable influences on individual choice. This is shown in equation (1).

$$Uij = Vij(Xij) + eij = bXij + eij \tag{1}$$

Thus, the probability that any particular respondent prefers option g in the choice set to any alternative option h, can be expressed as the probability that the utility associated with option g exceeds that associated with all other options, as stated in equation (2).

$$P[(Uig > Uih)\forall h \neq g] = P[(Vig - Vih) > (eih - eig)] \tag{2}$$

In order to derive an explicit expression for this probability, it is necessary to know the distribution of the error terms (e_{ij}). A typical assumption is that they are independently and identically distributed with an extreme-value (Weibull) distribution:

$$P(e_{ij} \leqslant t) = F(t) = \exp(-\exp(-t)) \tag{3}$$

The above distribution of the error term implies that the probability of any particular alternative g being chosen as the most preferred can be expressed in terms of the logistic distribution (McFadden, 1973) stated in equation (4). This specification is known as the conditional logit model:

$$P(Uig > Uih, \forall h \neq g) = \frac{\exp(\mu Vig)}{\sum_j \exp(\mu Vij)} \tag{4}$$

where μ is a scale parameter, inversely proportional to the standard deviation of the error distribution. This parameter often cannot be separately identified and is therefore typically assumed to be one. An important implication of this specification is that selections from the choice set must obey the Independence from Irrelevant Alternatives (IIA) property (or Luce's Choice Axiom; Luce, 1959), which states that the relative probabilities of two options being selected are unaffected by the introduction or removal of other alternatives. This property follows from the independence of the Weibull error terms across the different options contained in the choice set.

This model can be estimated by conventional maximum likelihood procedures, with the respective log-likelihood function stated in equation (5) below, where y_{ij} is an indicator variable which takes a value of one if respondent i chose option j and zero otherwise.

$$\log L = \sum_{i=1}^{N} \sum_{j=1}^{J} yij \log \left[\frac{\exp(Vij)}{\sum_{j=1}^{J} \exp(Vij)} \right] \tag{5}$$

Socio-economic variables can be included along with choice set attributes in the X terms in equation (1), but since they are constant across choice occasions for any given individual (e.g. income is the same when the first choice is made as the second), they can only be entered as interaction terms, i.e. interacted with choice specific attributes.

Once the parameter estimates have been obtained, a WTP compensating variation welfare measure that conforms to demand theory can be derived for each attribute using the formula given by (6) (Hanemann, 1984; Parsons and Kealy, 1992) where V^0 represents the utility of the initial state and V^1 represents the utility of the alternative state. The coefficient b_y gives the marginal utility of income and is the coefficient of the cost attribute.

$$WTP = b_y^{-1} \ln \left\{ \frac{\sum_i \exp(V_i^1)}{\sum_i \exp(V_i^0)} \right\} \tag{6}$$

It is straightforward to show that, for the linear utility index specified in (1), the above formulae can be simplified to the ratio of coefficients given in equation (7) where b_C is the coefficient on any of the attributes. These ratios are often known as implicit prices.

$$WTP = \frac{-b_C}{b_y} \tag{7}$$

Choice experiments are therefore consistent with utility maximisation and demand theory, at least when a status quo option is included in the choice set.[3]

Notice however that specifying standard errors for the implicit price ratios is more complex. Although the asymptotic distribution of the maximum likelihood estimator for the parameters b is known, the asymptotic distribution of the maximum likelihood estimator of the welfare measure is not, since it is a non-linear function of the parameter vector. One way of obtaining confidence intervals for this measure is by means of the procedure developed by Krinsky and Robb (1986). This technique simulates the asymptotic distribution of the coefficients by taking repeated random draws from the multivariate normal distribution defined by the coefficient estimates and their associated covariance matrix. These are used to generate an empirical distribution for the welfare measure and the associated confidence intervals can then be computed.

If a violation of the IIA hypothesis is observed, then more complex statistical models are necessary that relax some of the assumptions used. These include the multinomial probit (Hausman and Wise, 1978), the nested logit (McFadden, 1981) and the random parameters logit model (Train, 1998). IIA can be tested using a procedure suggested by Hausman and McFadden (1984). This basically involves constructing a likelihood ratio test around different versions of the model where choice alternatives are excluded. If IIA holds, then the model estimated on all choices should be the same as that estimated for a sub-set of alternatives (see Foster and Mourato, 2000, for an example).

Appendix 1 summarises some choice experiment applications in environmental economics.

2.2. *Contingent Ranking*

In a contingent ranking experiment respondents are required to rank a set of alternative options, characterised by a number of attributes, which are offered at different levels across options. As with CE, a status quo option is normally included in the choice set to ensure welfare consistent results. An example is provided in Table 4.

As before, the random utility model provides the economic theory framework for analysing the data from a ranking exercise. Under the assumption of an independently and identically distributed random error with a Weibull distribution, Beggs, Cardell and Hausman (1981) developed a rank-order logit model capable of using all the information contained in a survey where alternatives are fully ranked by respondents. Their specification is based on the repeated application of the probability expression given in equation (4) until a full ranking of all the alternatives has been obtained. The probability of any particular ranking of alternatives being made by individual i can be expressed as:

$$Pi(U_{i1} > U_{i2} > \cdots > U_{ij}) = \prod_{j=1}^{J} \left[\frac{\exp(Vij)}{\sum_{k=j}^{J} \exp(Vik)} \right] \tag{8}$$

Clearly, this rank ordered model is more restrictive than the standard conditional logit model in as much as the extreme value (Weibull) distribution governs not only the first choice but all successive choices as well. As before, the model relies critically on the IIA assumption, which in this case is what permits the multiplication of successive conditional logit probabilities to obtain the probability expression for the full ranking.

Table 4. Illustrative Contingent Ranking Question

RANK THE ALTERNATIVES FOR A SUMMER VISIT BELOW ACCORDING TO YOUR PREFERENCES, ASSIGNING 1 TO THE MOST PREFERRED, 2 TO THE SECOND MOST PREFERRED, 3 TO THE THIRD MOST PREFERRED AND 4 TO THE LEAST PREFERRED.

Characteristics of route	Route A	Route B	Route C	Stay at home
Length of climb	200 metres	250 metres	250 metres	
Approach time	3 hours	2 hours	2 hours	
Quality of climb	2 stars	1 stars	0 stars	
Crowding at route	Crowded	Not crowded	Crowded	
Scenic quality of route	Scenic	Not at all scenic	Not scenic	
Distance of route from home	160 miles	70 miles	30 miles	
RANKING:	□	□	□	□

The parameters of the utility function can be estimated by maximising the log-likelihood function given in equation (9).

$$\log L = \sum_{i=1}^{N} \sum_{j=1}^{J} \log \left[\frac{\exp(Vij)}{\sum_{k=j}^{J} (\exp\ Vik)} \right] \tag{9}$$

Contingent ranking can be seen as a series of choices in which respondents face a sequential choice process, whereby they first identify their most preferred choice, then, after removal of that option from the choice set, identify their most preferred choice out of the remaining set and so on. In other words, one can decompose a contingent ranking exercise into a set of choice experiments (Chapman and Staelin (1982); Foster and Mourato, 2000). Welfare values can therefore be estimated as in the choice experiment example. Ranking data provides more statistical information than choice experiments, which leads to tighter confidence intervals around the parameter estimates.

One of the limitations of this approach lies in the added cognitive difficulty associated with ranking choices with many attributes and levels. Previous research in the marketing literature by Ben-Akiva *et al.* (1991), Chapman and Staelin (1982), and Hausman and Ruud (1987) found significant differences in the preference structure implicit across ranks. In other words, choices seem to be unreliable and inconsistent across ranks. A possible explanation is that responses may be governed by different decision protocols according to the level of the rank (Ben-Akiva *et al.*,1991). Alternatively, the results could indicate increasing noise (random effects) with the depth of the ranking task as, in general, lower ranks seem to be less reliable than higher ranks (Hausman and Ruud, 1987). Foster and Mourato (1997) developed a number of tests of logicality, rank consistency and transitivity by including in the ranking sets dominated alternatives and repeated pairs of options.

More importantly, the fact that a baseline alternative is necessarily not present in all the trade-offs presented to respondents may result in welfare estimates that do not conform with standard consumer theory. In other words, once the baseline alternative is chosen, subsequent choices do not convey information about a respondent's real demand curve but reflect instead a conditional demand, conditional on the choices remaining in the choice set (Louviere, Hensher and Swait, 2000). To ensure welfare consistent results, once the status quo is chosen, any subsequent rankings should be discarded from the estimation procedure.

Used initially by Beggs, Cardell and Hausman (1981) and Lareau and Rae (1987), contingent ranking approaches have also been applied to environmental valuation. A summary of recent studies is included in Appendix 2.

2.3. Contingent Rating

In a contingent rating exercise respondents are presented with a number of scenarios and are asked to rate them individually on a semantic or numeric scale. This approach does not involve a direct comparison of alternative choices and consequently there is no formal theoretical link between the expressed ratings and economic choices. An example is provided in Table 5.

Rating data have been analysed within the framework of the random utility model with ratings being first transformed into a utility scale. In this context, the indirect utility function is assumed to be related to individual's ratings via a transformation function:

$$Rij(Xij) = \phi[Vij(Xij)] \tag{10}$$

where R represents the rating of individual i for choice j and ϕ is the transformation function. In marketing applications these data are typically analysed using OLS regression techniques which imply a strong assumption about the cardinality of the ratings scale. An alternative approach, which allows the data to be analysed in a random utility framework, is to use ordered probit and logit

Table 5. Illustrative Contingent Rating Question

ON THE SCALE BELOW, PLEASE RATE YOUR PREFERENCES FOR A SUMMER VISIT TO THE FOLLOWING ROUTE?

Characteristics of route	Route A
Length of climb	300 metres
Approach time	30 min
Quality of climb	2 stars
Crowding at route	Crowded
Scenic quality of route	Not at all scenic
Distance of route from home	200 miles

1	2	3	4	5	6	7	8	9	10
Very low preference									Very high preference

models that only imply an ordinal significance of the ratings. However, there remains the implicit assumption that ratings are comparable across individuals.

Roe *et al.* (1996) have shown how to estimate compensating variation measures from ratings data based on ratings differences. The approach consists in subtracting a monetary cost from income until the ratings difference is made equal to zero:

$$R^1ij(X^1ij, M - WTP) - R^0ij(X^0ij, M) = 0 \tag{11}$$

where R^0 is the rating of the baseline choice, R^1 the rating attributed to the alternative choice, and M is income.

Despite its popularity amongst marketing practitioners, rating exercises are much less used in environmental economics (see Appendix 3 for a summary of existing studies). The main reason for this lack of popularity lies in the strong assumptions that need to be made in order to transform ratings into utilities. These assumptions relate either to the cardinality of rating scales or to the implicit assumption of comparability of ratings across individuals: both are inconsistent with consumer theory. Hence, contingent rating exercises do not produce welfare consistent value estimates.

2.4. *Paired Comparisons*

In a paired comparison exercise respondents are asked to choose their preferred alternative out of a set of two choices and to indicate the strength of their preference in a numeric or semantic scale. This format is also known as graded or rated pairs. Table 6 provides an example.

The graded pairs approach is an attempt to get more information than simply identifying the most preferred alternative and, as such, combines elements of choice experiments (choosing the most preferred alternative) and rating exercises (rating the strength of preference). If the ratings are re-interpreted as providing an indication about choices only, then this approach collapses into a choice experiment and the comments and procedures described previously in Section 2.1 also apply in this case. Note that a status quo option must always be present in the pairs for the resulting estimates to be welfare consistent. But if only choice information is used from the ratings then why specify a graded pair rather than a CE in the first place? If instead it is assumed that a change in rating is related to a change in utilities, then the resulting data can be analysed using ordered probit or logit techniques, similarly to the contingent rating procedure, and the caveats described in Section 2.3 become relevant.

Pairwise comparisons are extremely popular amongst marketing practitioners, especially after the introduction of computerised interviewing techniques and the development of specialised computer software such as Adaptive Conjoint Analysis (Green *et al.*, 1991; Sawtooth Software, 1993) which determines attributes, levels and pairwise comparisons, tailor-made for each respondent. It should however be noted that these computer generated designs do not necessarily conform with standard optimality criteria. Some applications of paired comparisons exist in the environmental field and are summarised in Appendix 4.

Table 6. Illustrative Paired Comparisons Question

WHICH ROUTE WOULD YOU PREFER TO VISIT IN THE SUMMER, GIVEN THE TWO ROUTES DESCRIBED BELOW?

Characteristics of route	Route A	Route B
Length of climb	150 metres	50 metres
Approach time	3 hours	2 hours
Quality of climb	3 stars	1 stars
Crowding at route	Not crowded	Not crowded
Scenic quality of route	Not at all scenic	Very scenic
Distance of route from home	200 miles	110 miles

1	2	3	4	5	6	7	8	9	10
Strongly prefer Route A									Strongly prefer Route B

3. An Illustration: Modelling the Demand for Rock Climbing Sites in Scotland

Mountaineering is an increasingly popular sport in Scotland. Figures from Highlands and Islands Enterprise[4] suggest that 767 000 mountaineers from the UK visited the Highlands and Islands for hillwalking, technical climbing, ski mountaineering or high level cross-country ski-ing in 1996 (HIE, 1996). Spending by mountaineers is an important source of income for many areas of the Highlands. For rock-climbing (defined here to include both summer and winter climbing), participation is harder to estimate. In the HIE survey, mountaineers classified the main purpose of their trips to the area as hillwalking (77.2%); rock-climbing (10.8%); ski-mountaineering (5.5%) and ski-touring (6.5%). Using a mean of 14 trips per annum implies a total participation of between 82 836–153 400 total climbers, and 1 159 704–2 147 600 climbing days in Scotland per year.

Rock climbs are classified according to two grading systems in Britain, which between them describe both the overall difficulty and exposure of a route, and the degree of difficulty in making the hardest move on the climb (the crux). Climbers' appreciation of routes though extends beyond this technical grading, to include aspects such as length of climb, quality, and degree of crowding on a route. One may thus think of individual climbs as different bundles of a given set of attributes, although it may be hard for the researcher to completely describe a particular climb using this set. Climbers make choices from the set of all climbs in Scotland in deciding on where to go on a particular trip: a natural way to model this choice problem is thus to make use of random utility theory. In this section, a choice experiment applied to climbers' choices of rock climbing sites is described.[5] Results from this approach are then compared with results from a standard multinomial site choice model based on revealed preference data from the same sample of users.

3.1. *Study Design*

The initial steps in this study were to identify the choice sets and their relevant attributes. To accomplish this, focus groups were conducted with climbers from university mountaineering clubs in Edinburgh and Stirling. Eight principal climbing areas were identified. These were: Northern Highlands, Creag Meagaidh, Ben Nevis (including Glen Nevis), Glen Coe (including Glen Etive), Isle of Arran, Arrochar, the Cullins of Skye and the Cairngorms. The attributes and levels selected to describe these sites were:

Length of climbs: 50, 100, 200 and 300 metres
Approach time from the road to the base of the climb: 1/2, 1, 2 and 3 hours
Crowding on the climbing route: 'crowded' versus 'not crowded'
Quality of climbs, as measured by the star rating system popularised in SMC area guidebooks: 0, 1, 2 and 3 stars
Scenic quality of area: 'very scenic', 'scenic', 'not scenic' and 'not at all scenic'
Travel distance from home: 30, 70, 110, 160, 200 and 250 miles

The chosen attributes and levels produced a full factorial design with $2^1 4^4 6^1 = 3072$ possible climbing routes. A fractional factorial design reduced the number of route alternatives to 36. These alternatives were then grouped into 4 or 8 choice pairs to be presented to respondents. A baseline alternative ('staying at home') was added to each choice pair.

The sampling frame was provided through a list of climbing club members in Scotland. A random sample of addresses was selected, and a mail questionnaire was implemented. As a response incentive, a donation of £2 was promised to the John Muir Trust (a charity which exists to conserve wilderness areas in Scotland) for every questionnaire returned. To widen the sample in terms of representativeness, questionnaires were also administered at climbing walls in Edinburgh, Glasgow and Falkirk. A sample of 267 useable responses from climbers was acquired.

Climbers were asked questions relating to their total trips in the last twelve months (summer and winter) to each of the 8 areas; to score each area in terms of the 6 attributes used; to complete a number of choice experiments, ranging from 4 to 8 choice pairs; to provide a ranking of attributes in summer and in winter; to provide information on spending related to rock-climbing; to provide information on their climbing abilities and experience; and finally, to provide us with standard socio-economic information. An example choice set was given in Table 3.

3.2. *Results*

The majority of respondents ranked the star rating of the climb as the most important attribute in the summer and 50% ranked it as most important also in winter. In summer the largest group (27%) identified travel time as least important attribute with 26% of respondents stating that the scenic quality of the site was least important in winter.

Table 7. Choice Experiment Estimates

Attribute	Coefficient	Correct sign?	T statistic
Length of climb	0.00395	Yes	7.25
Approach time	−0.00671	Yes	−7.36
Quality of climb	0.637	Yes	13.72
Crowding at route	−0.618	Yes	−11.85
Scenic quality of route	0.591	Yes	11.83
Travel cost	−0.0321	Yes	−9.50
ASC1	1.723	?	6.83
ASC2	0.3458	?	4.501

L max: −1026.245; L (constants only): −1385.096; Pseudo-R square: 0.259.
N = 3996 choice occasions.

The conditional logit model, set out in equations (4) and (5) in Section 2.1, was used to analyse the survey data. The distance term was converted into a travel cost before estimation by multiplying by $(2 * 10p)$, to allow comparison with the revealed preference data and to allow estimation of welfare measures. Alternative specific constants (ASCs) were included in the estimation to reflect the differences in utilities for each alternative relative to the base. Results are given in Table 7. As may be seen, all signs are in accord with a priori expectations, and all attributes emerge as significant determinants of choice.

As explained above, assuming a linear utility function, the implicit price of any attribute can be calculated by dividing the parameter estimate for that attribute by the parameter estimate on the price term. In the above model, this implies that climbers would be willing to pay an additional £19.23 to climb at a 'not crowded' as distinct from a 'crowded' site and an extra £0.12 per additional metre length of climb. Based on the estimate for the travel cost parameter, the average consumers surplus per trip across all trips in the choice set was calculated as £31.15.

4. Advantages and Problems

4.1. *Advantages*

As several authors have pointed out, choice modelling approaches possess some advantages relative to the standard contingent valuation (CV) technique. Here, and for the rest of the paper, the focus will be mostly on choice experiments as an example of choice modelling. Principal among the attractions of CE are claimed to be the following:

(i) CE is particularly suited to deal with situations where changes are multi-dimensional and trade-offs between them are of particular interest because of its natural ability to separately identify the value of individual attributes of a good or programme, typically supplied in combination with one another. Whilst in principle CV can also be applied to estimate the value of the attributes of a programme, for example by including a series of CV scenarios in a questionnaire or by conducting a series of CV studies, it is a more costly and cumbersome alternative. Hence CE does a better job than CV in measuring the marginal value of changes in various characteristics of environmental programmes. This is often a more useful focus from a management/policy perspective than focussing on either the gain or loss of the good, or on a discrete change in its attributes. Useful here might mean more generalisable, and therefore more appropriate from a benefits transfer viewpoint (for encouraging evidence on the use of CE in benefits transfer, see Morrison *et al.*, 1998).

(ii) CE are more informative than discrete choice CV studies as respondents get multiple chances to express their preference for a valued good over a range of payment amounts: for example, if respondents are given 8 choice pairs and a 'do nothing' option, they may respond to as many as 17 bid prices, including zero. In fact, CE can be seen as a generalisation of discrete choice contingent valuation concerning a sequence of discrete choice valuation questions where there are two or more goods involved.

(iii) Choice modelling generally avoids an explicit elicitation of respondents' willingness to pay by relying instead on ratings, rankings or choices amongst a series of alternative packages of characteristics from where willingness to pay can be indirectly inferred. As such, CE may minimise some of the response difficulties found in CVM that were mentioned in Section 1 (protest bids, strategic behaviour, yeah saying). But this point has yet to be demonstrated.

4.2. *Problems*

Experience with choice experiments in environmental contexts is still fairly limited, despite the fact that choice modelling in general has been very widely applied in the fields of transport and marketing. Several problem areas seem to be important:

(i) Arguably, the main disadvantage of CM approaches lies with the cognitive difficulty associated with multiple complex choices or rankings between bundles with many attributes and levels. Both experimental economists and psychologists have found ample evidence that there is a limit to how much information respondents can meaningfully handle while making a decision. Swait and Adamowicz (1996) estimated an inverted U-shaped relationship between choice complexity and variance of underlying utility amounts; Mazotta and Opaluch (1995) found that increased complexity leads to increased random errors; Chapman and Staelin (1982) and Hausman and Ruud (1987) found evidence of increasing random effects with the depth of a ranking task; and Ben-Akiva *et al.* (1991) and Foster and Mourato (1997) detected significant numbers of inconsistent responses in even simple ranking tasks.

In addition, since respondents are typically presented with large number of choice sets both learning and fatigue effects can occur that may lead to apparently irrational choices (Tversky and Shaffir, 1992). Handling repeated answers per respondent also poses statistical problems and the correlation between responses needs to be taken into account and properly modelled (Adamowicz, Louviere and Swait, 1998).

This implies that, whilst the researcher might want to include many attributes, and also interactions between these attributes, then unless very large samples are collected, respondents will be faced with daunting choice tasks. The consequence is that, in presence of complex choices, respondents use heuristics or rules of thumb to simplify the decision task. These filtering rules lead to options being chosen that are good enough although not necessarily the best, avoiding the need to solve the underlying utility-maximisation problem (i.e. a satisficing approach rather than a maximising one). Heuristics often associated with difficult choice tasks include maximin and maximax strategies and lexicographic orderings (Tversky, 1972; Foster and Mourato, 1997). Hence, it is important to incorporate consistency tests into CM studies in order to detect the range of problems discussed above (Foster and Mourato, 1997; Hanley, Wright and Koop, 2000).

(ii) In order to estimate the total value of an environmental programme or good from a CE, as distinct from a change in one of its attributes, it is necessary to assume that the value of the whole is equal to the sum of the parts. For example, with a linear utility function, Hanley *et al.* (1998) calculate the value of the Environmentally Sensitive Areas programme as the sum of the values of its component parts. This clearly raises two potential problems. First, that there may be additional attributes of the good not included in the design which generate utility (in practice, these are captured in the constant terms in the estimated model). Second, that the value of the 'whole' is indeed additive in this way. Elsewhere in economics, objections have been raised about the assumption that the value of the whole is indeed equal to the sum of its parts. In order to test whether this is a valid objection in the case of CE, values of a full programme or good obtained from CE should be compared with values obtained for the same resource using some other method such as CV, under similar circumstances. In the transport field, research for London Underground and London Buses among others has shown clear evidence that values of whole bundles of improvements are valued less than the sum of the component values, all measured using CE (SDG, 2000, 1999). Furthermore, Foster and Mourato (1999) found that the estimates from a choice experiment of the total value of charitable services in the UK were significantly larger than results obtained from a parallel contingent valuation survey.

(iii) It is more difficult for CE and other CM approaches to derive values for a sequence of elements implemented by policy or project, when compared to a contingent valuation alternative. Hence, valuing the sequential provision of goods in multi-attribute programmes is probably better undertaken by CV (EFTEC, 2001).

(iv) As is the case with all stated preference techniques, welfare estimates obtained with CE are sensitive to study design. For example, the choice of attributes, the levels chosen to represent them, and the way in which choices are relayed to respondents (e.g. use of photographs vs text descriptions, choices vs ranks) are not neutral and may impact on the values of estimates of consumers' surplus and marginal utilities. Hanley, Wright and Koop (2000) found that changing the number of choice tasks respondents performed produced significant impacts on the model of preferences derived from their responses.

4.3. *Do Choice Experiments Solve Any of the Main Problems of CVM?*

Contingent valuation has been criticised as a means of eliciting environmental preferences by many authors, most famously perhaps by Kahneman and Knetsch (1992) and by Hausman (1993). Moreover, practitioners have been very open about areas of sensitivity in applying the method. Some of the main areas in which difficulties have been encountered include the following:

(i) 'Hypothetical' bias: from early on in the history of the CV, there has been a concern that the hypothetical nature of CV responses might lead respondents to overestimate their true valuations (e.g. Cummings *et al.*, 1986). Many studies that compare actual payments with behavioural intentions as expressed in CV surveys find the latter amounts to be significantly smaller than the former (see Foster, Bateman and Harley, 1997 and Christie, 1999 for reviews of these studies). Conversely, in a large comparative study (616 comparisons) of contingent valuation results and estimates derived from actual markets via revealed preference methods, Carson *et al.* (1996) found that CV estimates were on average lower than revealed preference estimates. Further inspection of the available evidence reveals that the only consistent case where CV estimates are higher than estimates from revealed preference and real payment experiments is when the values result from voluntary contributions. This is because voluntary contributions give respondents the incentive to overbid in the hypothetical market while free-riding in terms of actual payments (Carson, Groves and Machina, 1999). There are very few similar tests at present for CE in the environmental context (Carlsson, 1999). However, given that CE is in effect a generalisation of discrete choice CV, there is little reason to suppose, a priori, that it performs any better than contingent valuation in this regard.

(ii) Sensitivity to scope: one of the recommendations of the NOAA panel (Arrow *et al.*, 1993) was that CV surveys should include tests of scope to assess whether WTP values are sensitive to the size of environmental change being offered. This issue is very relevant from a policy appraisal perspective: in the UK, for example, a debate has been on-going of the extent to which it is acceptable to aggregate up from WTP findings for individual Environmentally Sensitive Areas to all ESAs, in calculating programme benefits.

Sensitivity to scope is typically assessed by one of two methods: either presenting each individual with a number of valuation scenarios which differ according to scope (a within group or internal test) or by presenting different sub-samples of the population with valuation scenarios which differ according to scope (a between groups or external test). One advantage of CE is that it provides a natural internal scope test due to the elicitation of multiple responses per individual. The internal test is however weaker than the external test in as much as the answers given by any particular individual are not independent from each other and thus sensitivity to scope is to some extent forced.

A meta analysis by Carson (1998) has shown that, on the whole, CV studies pass the scope test, although the evidence is mixed: for unfamiliar goods and with external tests scope effects can be less discernible. In one of the few formal tests of sensitivity to scope in both CV and CE, Foster and Mourato (1999) undertook separate CV studies of two nested public goods both of which were explicitly incorporated in a parallel CE survey. The authors found that, while there was evidence that both CV and CE produced results which exhibited sensitivity to scope, the evidence for the CE method was much stronger than that for CV. This result conforms with prior expectations as the scope test used for the CV method was an external test and consequently more demanding than the internal test provided by the CE method.

(iii) Sensitivity of estimates to study design: a common finding in CV studies is that bids can be affected by design choices, for example in terms of the choice of payment mechanism, the amount and type of information provided, and the rules of the market.[6] But, as noted above, design issues are as important in CE as in CVM.

(iv) Ethical protesting: a small percentage of respondents in contingent valuation studies typically refuse to 'play the game' due to ethical objections to the underlying utilitarian model (Spash and Hanley, 1995; Hanley and Milne, 1996). This implies, for example, an un-willingness to pay in principle to prevent environmental degradation.[7] Such responses are usually treated as protests, and are excluded from the analysis. The preponderance of ethical protests may be sensitive to the type and amount of monetary payment requested. Therefore, CE might reduce the incidence of ethical protesting as the choice context can be less 'stark' than direct elicitation of willingness to pay. However, as noted above, this point has yet to be proven.

(v) Expense: CV studies can be hugely expensive, especially when large probabilistic samples and personal interviews are used. If split-samples are required, for example to evaluate various components of a given programme, then the costs can quickly become prohibitive. When valuing multi-attribute programmes, CE studies can reduce the expense of valuation studies, because of their natural ability to value programme attributes in one single questionnaire and because they are more informative than discrete choice CV surveys.

5. Valuation in a Policy Context

Economics should ideally be useful, and one way it can be useful is through the provision of advice to policy makers. In the UK, much of the funding for environmental valuation studies has come from government departments and agencies with responsibilities for environmental policy design and implementation or with responsibility for policies which impact on the environment. This source of funding and interest was also important in the early development of valuation techniques in the US, especially prior to the use of contingent valuation in damage assessments.

Within the UK, a formal commitment to engage in environmental cost-benefit analysis (CBA) exists with respect to the national environment agencies (although varying degrees of importance are then attached to the results of these exercises). Government departments, since the publication of 'Policy Appraisal and the Environment' by the DETR in 1991, have all been encouraged to apply environmental CBA principles to policy design: this encouragement has been moved in the direction of a requirement by recent Cabinet Office guidelines. For policy-making within the European Union, Pearce (1998b) has argued that up until relatively recently, there was no or only little consideration given to comparing the environmental costs and benefits of draft directives, which has probably led to some expensive errors. However, the situation appears to be changing.

In this context, it seems likely that environmental valuation will increasingly be called upon by policy makers to aid improvement in policy design, although it also appears that this is unlikely to be solely or mainly as part of a formal CBA (Hanley, 2001). In many instances, choice modelling may be more useful in policy design than contingent valuation, since the latter does not typically involve the estimation of attribute values as constituents of the value of the whole. For example, in the Environmental Sensitive Areas scheme, farmers are paid subsidies to conserve or improve different environmental features within defined geographic areas of the country. Knowing the relative marginal values of, for example, wetlands compared to farm woodlands, may be very useful in this regard. Also, if a public forestry service is charged with managing forests in a manner which maximises net social benefits, then decisions over species mix, age diversity and the provision of recreation facilities would be helped if managers have estimates of the marginal values of these attributes. By focusing directly on attributes, choice modelling techniques seem to be ideally suited to inform the choice and design of multidimensional policies.

Furthermore, environmental valuation has been increasingly used in the UK for setting eco-taxes, for example with regard to the landfill tax and the potential future tax on quarrying. CV has been used in both justifying a tax, and in determining its level. However, applying an estimate of average external cost at the current level of activity does not constitute the Pigouvian tax which it is made out to be, that would measure the marginal external cost at the optimal level of externality. Here, the crucial issue is to find out how marginal damages vary with level of the externality-causing activity. This is essentially the question of scale in valuation. Whilst, as noted above, most contingent valuation studies are sensitive to scale, it is uncommon for more than a couple of quantities to be valued. Valuation functions can of course be estimated with scale as one independent variable, but choice experiments allow scale itself to be an attribute. Thus, CE may be more useful for eco-tax setting, but again this is unproven at present.

Environmental cost-benefit analysis seems to be under increasing pressure as a technique, in the sense that government appears worried that its focus is too narrow. There is an increasing interest among policy makers to be able to somehow combine environmental CBA with multi-criteria analysis and with participatory approaches, such as citizen juries (Kenyon and Hanley, 2000). Whether and how this can be done is an important area for future research. However, as Pearce (1998a) notes, ignoring CBA altogether is undesirable, since it means governments can end up with very inefficient policy designs. As Alan Randall notes, there is also a very powerful case to be made for continuing to use CBA in environmental decision making, since this is one way of representing peoples' preferences for the environment relative to alternatives (Randall, 1998). In this framework, a crucial question is whether choice modelling techniques are the way forward for environmental valuation, given this debate over the future role of environmental valuation within Europe. The current state of the literature is unable to answer this question adequately: to paraphrase Socrates:

'The only thing we know is that we don't know enough'.

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Notes

1. This approach is also sometimes known as 'conjoint analysis'.
2. See EFTEC (2001), Louviere, Hensher and Swait (2000) and Morrison *et al.* (1999) for further information on these techniques.
3. It is necessary to include a status quo option in the choice set in order to achieve welfare measures that are consist with demand theory. This is because, if a status quo alternative is not included in the choice set, respondents are effectively being 'forced' to choose one of the alternatives presented, which they may not desire at all. If, for some respondents, the most preferred option is the current baseline situation, then any model based on a design in which the baseline is not present will yield inaccurate estimates of consumer welfare.
4. Based on UK general population sample of 3539 adults; and a sample of 550 readers of High magazine.
5. Other studies which apply recreational demand models to rock climbing are Shaw and Jakus (1996), Hanley *et al.* (2001), Hanley *et al.* (2000), Cavlovic and Berrens (1999) and Cavlovic *et al.* (2000).
6. This sensitivity is desirable in some cases, as it mirrors the picture for market goods: for example, we expect WTP to change when respondents' information sets change (Munro and Hanley, 1999).
7. As many have pointed out, such prioritising of the environment on moral/ethical grounds has opportunity costs (for example, less schools and hospitals get built) which often get forgotten by such ethical protesters.

Appendix 1: Some environmental choice experiment studies in the literature

Year	Authors	Title	Journal	Subject of study
1994	Adamowicz, W., Louviere, J. and Williams, M.	Combining revealed and stated preference methods for valuing environmental amenities	Journal of Environmental Economics and Management 26: 271–292	First environmental application of choice experiments? Freshwater recreation in Alberta.
1996	Boxall, P. C., Adamowicz, W. L., Swait, J., Williams, M., Louviere, J.	A comparison of stated preference methods for environmental valuation.	Ecological Economics, 18(3): 243–253	Recreational moose hunting in Alberta, Canada.
1997	Adamowicz, W., J. Swait, P. Boxall, J. Louviere, M. Williams	Perceptions versus Objective Measures of Environmental Quality in Combined Revealed and Stated Preference Models of Environmental Valuation	Journal of Environmental Economics and Management. (32): 65–84.	Compares objective with perceived measures of attributes in choice modelling for moose hunting
1998	Adamowicz, W., Boxall, P., Williams, M., Louviere, J.	Stated preference approaches for measuring passive use values: choice experiments and contingent valuation.	American Journal of Agricultural Economics, 80(1): 64–75	Woodland caribou habitat enhancement in Alberta, Canada.
1998	Bullock, C. H., Elston, D. A., Chalmers, N. A.	An application of economic choice experiments to a traditional land use — deer hunting and landscape change in the Scottish Highlands.	Journal of Environmental Management, 52(4): 335–351	Preferences for deer stalking trips in Scotland.

1998	Hanley, N., MacMillan, D., Wright, R. E., Bullock, C., Simpson, I., Parsisson, D., Crabtree, B.	Contingent valuation versus choice experiments: estimating the benefits of environmentally sensitive areas in Scotland.	Journal of Agricultural Economics, 49(1): 1–15	Valuation of the Breadalbane ESA, Scotland.
1998	Morrison M, Bennett J, Blamey R and Louviere J	Choice modelling and tests of benefits transfer	Choice Modelling Research Report 8, University of NSW, Camberra	Benefits transfer test of weltlands
1998	Hanley, N., Wright, R. E., Adamowicz, V.	Using choice experiments to value the environment — design issues, current experience and future prospects.	Environmental and Resource Economics, 11(3–4): 413–428	Preferences for different forest landscapes in the UK.
1999	Garrod, G. and Willis, K.	*Economic Valuation of the Environment*	Cheltenham: Edward Elgar	Polluted beaches, polluted rivers and low flow rivers in SW England
1999	Blamey, R., Bennett, J., Louviere, J., Morrison, M. and Rolfe, J.	The use of policy labels in environmental choice modelling studies	Research report 9, Choice Modelling reports, University of NSW, Camberra	Value of remnant vegetation in desert uplands of Central Queensland

Appendix 2: Some environmental contingent ranking studies in the literature

Year	Authors	Title	Journal	Subject of study
1981	Beggs, S., Cardell, S. and Hausman, J.	Assessing the potential demand for electric cars	Journal of Econometrics 16: 1–19	Potential demand for electric cars
1983	Rae, D.	The Value to Visitors of Improving Visibility at Mesa Verde and Great Smoky National Parks	In Rowe, R. and Chestnut, L. (eds) *Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas*, Westview Press	Valuing visibility improvements
1985	Lareau, T. and Rae, D.	Valuing willingness to pay for diesel odor reduction: an application of the contingent ranking technique	Southern Economic Journal 55(3): 728–742	Valuing the benefits of diesel odor reductions
1986	Smith, V. and Desvousges, W.	*Measuring Water Quality Benefits*	Kluwer-Nijhoff, Boston	Valuing river water quality improvements
1997	Garrod, G. and Willis, K.	The Non-use Benefits of Enhancing Forest Biodiversity: A Contingent Ranking Study	Ecological Economics 21: 45–61	Valuing forest landscape attributes
1999	Foster, V. and Mourato, S.	Elicitation Format and Part-Whole Bias: Do Contingent Valuation and Contingent Ranking Give the Same Result?	CSERGE Working Paper GEC 99–17	Measuring the value of the charitable sector in the UK and respective sub-sectors

1998	Garrod, G. and Willis, K.	Using contingent ranking to estimate the loss of amenity value for inland waterways from public utility service structures	Environmental and Resource Economics 12: 241–247	Loss of amenity value for inland waterways from public utility service structures
1998	Bergland, O.	Valuation of landscape elements using a contingent choice method	University of Oslo, Working paper	Valuation of several rural landscape elements
1998	Israngkura, A.	Environmental Valuation: An Entrance Fee System for National Parks in Thailand	EEPSEA Research Report Series, August 1998	Environmental benefits of recreational areas in Thailand
1999	Machado, F. and Mourato, S.	Evaluating the Multiple Benefits of Marine Water Quality Improvements: How Important are Health Risk Reductions?	CSERGE Working Paper GEC 09–99, University College London	Evaluating the choice between alternative beaches, differing in access facility and water quality, in the Lisbon Coast
1999	Maddison, D. and Mourato, S.	Valuing different road options for Stonehenge	CSERGE Working Paper GEC 08–99, University College London	Valuing different road options for the A303 road in the Stonehenge bowl
2000	Atkinson, G., Machado, F. and Mourato, S.	Balancing Competing Principles of Environmental Equity	Environmental and Planning A 32: 1791–1806	Preferences for the different burden sharing rules: polluter pays, beneficiary pays or ability to pay
2000	Foster, V. and Mourato, S	Measuring the Impacts of Pesticide Use in the UK: A Contingent Ranking Approach	Journal of Agricultural Economics 51: 1–21	Value of health and biodiversity impacts of pesticide applications in the UK

Appendix 3: Some environmental contingent rating studies in the literature

Year	Authors	Title	Journal	Subject of study
1993	Mackenzie, J.	A comparison of contingent preference models	American Journal of Agricultural Economics: 593–603	Preferences for recreational hunting
1993	Gan, C. and Luzar, E.	A Conjoint Analysis of Waterfowl Hunting in Louisiana	Journal of Agricultural and Applied Economics 76: 760–771	Analysis of waterfowl hunting
1995	Jacobsson, K., Kennedy, J. and Elliot, M.	Survey Method of Valuing the Conservation of Endangered Species	Agricultural Economics Discussion Paper 26/95, La Trobe University	Preservation of endangered species (bandicoots)
1996	Roe, B., Boyle, K. and Teisl, M.	Using conjoint analysis to derive estimates of compensating variation	Journal of Environmental Economics and Management 31: 145–159	Preferences for recreational fishing
1998	Layton, D. and Lee, S.	From Ratings to Rankings: The Econometric Analysis of Stated Preference Ratings Data	Paper presented at the World Congress of Environmental and Resource Economists, Venice, July 1998	Recreational fishing
2001	Alvarez-Farizo, B. and Hamley, N.	Using conjoint analysis to quantify public preferences over the environmental inputs of wind farms	Energy Policy, forthcoming	Compares CE and CR values for wind farms in Spain

Appendix 4: Some environmental paired comparisons in the literature

Year	Authors	Title	Journal	Subject of study
1974	Sinden, J. A.	A Utility Approach to the Valuation of Recreational and Aesthetic Experiences	American Journal of Agricultural Economics 56(1): 61–72	Valuing recreation and aesthetic experiences
1988	Magat, W., Viscusi, W. and Huber, J.	Paired Comparisons and Contingent Valuation Approaches to Morbidity Risk Valuation	Journal of Environmental Economics and Management 15: 395–411	Valuing morbidity risk reductions
1991	Viscusi, W., Magat, W. and Huber, J.	Pricing Environmental Health Risks: Survey Assessments of Risk-Risk and Risk-Dollar Trade-offs for Chronic Bronchitis	Journal of Environmental Economics and Management 21: 32–51	Valuing morbidity risk reductions
1992	Krupnick, A. and Cropper, M.	The Effect of Information on Health Risk Valuations	Journal of Risk and Uncertainty 5: 29–48	Valuing morbidity risk reductions
1996	Desvousges, W., Johnson, F. R., Hudson, S., Gable, A. and Ruby, M.	Using Conjoint Analysis and Health-State Classifications to Estimate the Value of Health Effects of Air Pollution	Report for Environment Canada, Triangle Research Institute	Valuing morbidity risk reductions
1997	Johnson, F. R. and Desvousges, W. H.	Estimating Stated Preferences with Rated Pair-Data; Environmental, Health and Employment Effects of Energy Programs	Journal of Environmental Economics and Management 32: 79–99	Evaluating different characteristics of electricity programs
1998	Lockwood, M.	Integrated Value Assessment Using Paired Comparisons	Ecological Economics 25: 73–87	Preserving endangered species
1998	Newcombe, J.	The Risks and Environmental Benefits of Investing in Climate Change Projects Under the Kyoto Protocol: An Investor Perspective	Report to CIFOR	Evaluating the characteristics of potential CDM projects

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