11. Using choice experiments to value urban green space

Craig Bullock

INTRODUCTION

Estimates of the value of environmental goods help to ensure that these are properly taken into account once they are compared with costs in a cost–benefit analysis. This in turn improves the prospects of decision-makers paying more attention to environmental impacts when new policies or projects are implemented. Much has been written on the relative theoretical merits of alternative valuation techniques. Typically, researchers have provided examples of applications that demonstrate the relevant author's assertion of the appropriateness of the method or of a particular approach. However, sufficient consideration is not always given to the ultimate use to which such values are put.

Some methods of environmental valuation expose their limitations where decision-makers require information on a variety of project scenarios, rather than just a single strategy or outcome. For instance, it is cumbersome to include a variety of different scenarios within a contingent valuation study. Environmental valuation requires that survey respondents are given as much of the full context of information as possible before they are asked to express a willingness to pay. While frequently argued in theory, in practice this is difficult to achieve in a questionnaire-based survey. There is a risk that the information provided will be insufficient and will contribute to any other of the numerous potential biases that the diligent researcher is desperately attempting to avoid. Where respondents are asked to consider various scenarios, the risk of information overload is increased. As an alternative, the researcher could prepare different versions of a questionnaire each describing a different scenario, but as reliable contingent valuation requires an adequate (usually large) sample size, this is time-consuming and costly to achieve.

Consequently, valuation is often limited to information on a discrete 'policy on/policy off' scenario. This, of course, is valuable where decision-

makers need a monetary measure of the benefits (or costs) of a policy. Indeed, there have been numerous instances where policy-makers have commissioned a valuation study simply to justify an existing policy or set of plans. However, there will be other occasions where valuation methods can be used to help design policy.

CHOICE MODELLING

Origins

The use of discrete choice experiments in the context of environmental valuation is based on the premise, expounded by Lancaster (1966), that the utility of goods depends on their constituent characteristics. This assumption is applied within conjoint analysis whereby people are asked to indicate their preferences for various goods using a ranking or rating scale. Conjoint analysis has frequently been used in market research to demonstrate consumer preferences for alternative products that vary only in terms of key characteristics. One of these characteristics can, of course, be product price.

Unfortunately, the application of conjoint analysis within economics has been stalled by economists' natural scepticism of any technique that elicits information by means of an ordinal ranking scale, or by a rating scale where relative distances between successive rating levels are ill-defined. Admittedly, this has not prohibited economists from being tempted to use rankings or ratings to provide supplementary information where conventional valuation methods have been used.

Theoretical Foundations

A breakthrough came when Louviere and Woodworth (1983) demonstrated how orthogonal factorial designs can be used to underpin various scenarios defined in terms of different characteristics, or attributes. Orthogonal factorial designs can be used to represent attribute combinations while removing all collinearity between attributes. These attribute levels can then be presented as choice sets where people are asked to *choose* between two or more alternatives and the fixed status quo. This they do by mentally trading off the benefits of one set of attributes, or attribute levels, against another.

As with contingent valuation, the exercise is still one of stated preference based on hypothetical scenarios. Actual preferences will vary within the population. For instance, people's perception of the same attributes will differ, as will their awareness of the full set of alternatives. These differences

between hypothetical and actual behaviour, or between different individuals' preferences, represent a source of random error. From the researcher's perspective, choice therefore becomes a function of both a deterministic element and a random element (e). If the latter is assumed to have a linear distributional form, utility can be represented as

$$U_i = V_i + e_i \tag{11.1}$$

where V_i is the conditional utility for alternative i and is comprised of additively separable components with respective parameter values β.

A framework for linking choice to behaviour is provided by the 'random utility model' (McFadden 1974). As e_i is unknown, a random utility model can be referenced to predict choice depending on the probability that $V_i > V_j$. If it is assumed that all attributes influence choice in the same way,[1] then the probability of choice can be estimated from the difference in the parameter values for alternative i and the composite alternative j:

$$P(i_i) = \frac{\exp(V_i)}{\sum_{j \in C} \exp(V_j)} \tag{11.2}$$

Assuming an additive linear model, a multinomial logit analysis provides information on the odds, or the probability, of choosing one set of alternatives over another. The output also provides for an estimation of the marginal relative value of any one attribute in terms of another. This is in contrast to the discrete changes in environmental goods typically measured by contingent valuation.

Survey Approach

By means of a questionnaire, each recipient is presented with a number of choice sets in which each alternative is defined by a different set of attribute levels. To prevent respondent fatigue, it is typical to present no more than ten choice sets depending on the complexity of the exercise. Presenting a series of choice sets also allows the researcher to check the consistency of responses.[2]

As well as presenting varying choice sets to each individual, the combination of attribute levels in each choice set varies from one survey recipient to the next. With anything more than a handful of attributes, the number of prospective combinations increases dramatically. Indeed, in a full factorial design, where every attribute level is combined with every other attribute level, hundreds of people can each receive a unique set of attribute pairs.

Consequently, more data is available than can be achieved through the use of contingent valuation. The huge amount of information collected on each respondent's choices means that a well-designed survey can often arrive at significant values for most or all attribute level parameters.

Unlike rankings or ratings, economists are comfortable with the notion of choice. It is through the process of choice that goods are purchased or most policies decided upon. Economists can therefore respect a technique in which marginal attribute values can be derived from a large amount of choice data. If one of the attributes is a pricing attribute, such as an entry fee or package tour cost, then it is possible to measure the relative value of each of the other attribute levels in the same monetary terms. These attribute values become meaningful where one alternative is a reference level, for instance, the status quo. In principle, it is also possible to add these values together to arrive at a compensating variation measure of the benefit of one alternative over another.

There is still the same dependence on a payment vehicle (i.e. an entry fee) as occurs with contingent valuation, but choice experiments avoid the need to request an overt expression of willingness to pay. Not only is it easier for a respondent to choose an alternative than to express a willingness to pay, but the payment attribute is one or several attributes. This can 'mask the true purpose of the exercise' and make it more difficult for respondents to give a strategic response to influence the outcome of a study (Alpizar et al. 2002; Bristow and Wardman, 2004). It also reduces non-response by recipients who may object to such a willingness to pay question.

Estimated attribute values alone provide information to policy-makers. If, furthermore, these attribute values can be reliably combined into a package, then the policy-maker can be given information that demonstrates the relative value of taking one particular action over another. Taking the example of agri-environmental policy (e.g. Hanley et al., 1998), the policy-maker could be given information on whether to design a strategy where farmers are paid relatively more for actions that help to protect water quality than for landscape features (or vice versa). Furthermore, the results can be extended to demonstrate the level of water quality that people are prepared to pay for. It would appear, therefore, that the method provides policy-makers with more useful information with which to design a strategy than the relatively blunt valuation estimates supplied by other valuation methods.

Relationship with Revealed Preference Methods

Choice experiments have another major advantage. The process of asking people to choose between alternative packages of attributes is only fundamentally different from revealed preference techniques (e.g. the travel

cost method) in terms of the means of elicitation, namely the reliance on surveys (stated preference). Increasingly, researchers have been applying the same random utility approach to hedonic pricing or to travel cost (e.g. Earnhart, 2001) to arrive at estimates of the probability of choosing a property, or of travelling to a recreation site, based on that property or location's attributes. The approach allows for more flexible application than before. For example, with travel cost, more information is provided on the factors that make the destination attractive in the first place.

As an extension, the attribute-based data from hedonic pricing or travel cost can potentially be merged with data from a stated preference choice experiment. The error variance within each data set will vary, but this can be overcome by normalizing one data set's scale to unity. Where data is merged in this way, it has been argued that the revealed preference information reduces the hypothetical effect of the stated preference data by grounding the experiment in reality, for instance via a common baseline scenario. In turn, the stated preference data is not dependent on an existing scenario and can be used for forecasting the benefits of alternative scenarios, whereas revealed preference data may depend on a small number of actual destinations or property sales. Being based on an orthogonal design, the stated preference data also reduces the influence of the multi-collinearity that inevitably occurs with revealed preference data where attributes may be physically related to one another. Furthermore, in environmental economics, it is not uncommon to find that the influence of environmental variables on, for example, property prices can be weak and difficult to identify. In the choice experiment, there are less restrictions. By being listed as an explicit attribute, the environmental attribute's value can more easily dissected from the estimates of other attribute values.

APPLICATION: URBAN GREEN SPACE

Experimental Design

Dublin has a good number of open spaces, but much of this could be described as being either of two extremes, that is, formal parkland or rather featureless open space. Large green areas were set aside during the development of new housing estates up to the 1990s, but unimaginative design, combined with the low funding priority given to parks, has meant that many of these spaces have become little more than open landscapes of grass with few facilities. More recently, government guidelines have encouraged local authorities to reverse the former policy of low-density suburbanization by providing for the infill development of some of these

open spaces. Simultaneously, private apartment development is removing the few remaining pockets of semi-natural green areas, so further reducing the diversity of space.

The Greenspace study first applied a factor analysis to 40 attributes to help identify the motivations for park use. This was then followed by the core choice experiment to determine what attributes of green space provide people with the most utility. Eight key green space attributes were selected, namely park size, maintenance, vegetation, water features, play facilities, other facilities (seating, paths and trails), number of users and journey time. Each of these was described in detail before being presented at two or three levels in the choice sets. For example, for vegetation, these levels were 'mostly mown grass few trees', 'parkland with scattered trees' and 'mostly woods and meadows'.

In all, 500 householders were interviewed. Each was presented with eight choice sets (see Figure 11.1) in which the attribute combinations were almost unique for each respondent. They were then asked to choose which of two hypothetical green spaces they would be most inclined to visit. This was followed by a ranking question in which respondents were asked to rank the two parks in relation to their usual park destination (or their nearest park). In this context, the ranks could also be analysed one level at a time using logit according to the so-called exploding rank method (Chapman and Staelin, 1982). Supplementary questions were asked about nature of park visits, the attributes of the respondent's usual park, mode of transport and personal characteristics.

The choices that respondents made between combinations of attributes were modelled to provide a quantitative estimate of the marginal value of any one attribute level. In addition, because 'Journey time' can be given an opportunity cost in terms of the alternative use of leisure time, it was possible to quantify the value of each attribute level in monetary terms for the purposes of a cost–benefit analysis.

Results

The analysis provided coefficients for each of the attributes in relation to the base level. Most parameters were significant. Table 11.1 also shows that positive coefficient values are associated with a moderate level of facilities, as well as with a 'mix of quiet and busy areas', 'advance play facilities', 'scattered trees', and 'riverside walks'. 'Adventure play facilities' have a consistently high positive coefficient. 'Scattered trees' too have a positive influence on choice, although this does not extend to 'woods and meadows'. The negative coefficient on woods and meadows appears to arise

A LARGE PARK

Moderate maintenance
Plenty of scattered trees and grass
Riverside walk
No playground
Plenty of seating, paths, trails and cycle paths
Mix of busy and quiet areas
45 minutes by foot/20 minutes by car

B SMALL LOCAL PARK

High maintenance
Woods and meadows
Natural-looking lake
Small playground
Only a few benches and paths
Tends to be quite busy
45 minutes walk/20 minutes by car

Comparing just parks A and B which would you prefer to visit?   Tick one

A = ☐   B = ☐   Not go/Do something else ☐

Compared with your usual park which do you consider best (1st), second best (2nd) and third best (3rd)?

A = ☐   B = ☐   Your usual park ☐   Rank

Figure 11.1   Choice set example

246

from respondent fears over personal security, although this same attribute level becomes slightly positive when the data is restricted to large parks only. 'Journey time' is also significant with a negative coefficient as is to be expected where utility decreases with distance.

Table 11.1 Attribute coefficients and marginal economic values (multinomial logit)

Parameter	Coefficients	Attribute Value Per Visit
Size (large)	–0.205	–€3.07
Maintainance (high)	0.013	€0.06
Woods and meadows	–0.197	–€0.95
Scattered trees	0.140	€0.67
Mostly mown grass, few trees	–0.057	€0.27
Riverside walks	0.071	€0.34
Natural-looking ponds/lakes	–0.028	–€0.13
Small man-made pond	–0.043	€0.21
Adventure play facilities	0.135	€0.65
Small playground	0.146	€0.70
No playground	–0.281	–€1.33
Plenty of surfaced paths, seating, trails and cycle paths	0.288	€1.38
Surfaced paths, some seating	0.186	€0.89
Few paths and seating	0.474	–€2.27
Can be quite busy	–0.307	€1.47
Mix of busy and quiet areas	0.197	€0.95
Few people around	–0.110	€0.53
Journey Time (four levels)	–0.033	
Log-likelihood (parameters)	–1941.61	
Log-likelihood (no parameters)	–2196.13	
Adjusted p^2 (significance)	0.113	

The results in Table 11.1 represent average parameter values. However, it can be expected that the utility that people associate with visits to green space varies depending on the purpose of their visit or their personal characteristics. A random parameters, or mixed logit, approach was therefore used to identify the sources of variation in the data. In many cases, this variation was indeed related to the respondents' socio-demographic characteristics such as age or gender. Using this approach raised model significance to up to 0.433.

For example, more frequent visitors appear to appreciate the presence of a playground, a result that is consistent with the observation that people with children are amongst the most frequent visitors to parks. Indeed, for the subset of respondents with dependent children it was no surprise to find that the coefficients on play facilities were higher. Although, the coefficient for 'natural-looking ponds/lakes' was negative, possibly due to parents' concern with safety despite the familiar image of children feeding ducks. Other significant differences and interactions were found between size and journey time, socio-economic class and journey time, age and woodlands, and gender and woodlands.

ISSUES IN RELATION TO THE APPLICATION

The analysis of the choice experiment data resulted in a good level of significance for most attribute parameters, and model fit improved once the data was split into particular subsets based on use or socio-demographics. The following provides some discussion of issues that should be borne in mind by researchers who wish to use choice experiments for environmental valuation.

Journey Time and Model Fit

The habitual assumption of a linear model is rather restrictive, but linearity does permit a straightforward monetary estimation of the value of each attribute by dividing the coefficient values for the physical parameters by that for 'Journey Time'. Table 11.1 gives these values per park visit. However, 'Journey Time' proved to be both an interesting and awkward parameter to include in the experiment. An earlier question had estimated the value that respondents place on their leisure time by means of a contingent rating exercise. However, the true value of leisure time remains more difficult to pin down than might be the case for work time, which has a clearer opportunity cost in that the alternative of earning an income provides a more reliable yardstick (at least for those respondents who do work).

Further investigation of the data revealed a relationship between the disutility of journey time and journey inconvenience, such that lower socio-economic classes placed a high value on short journey times, particularly in cases where they had children. Interestingly, journey time ceased to have a high coefficient for some socio-economic classes at weekends. At these times, it appears that people have made a commitment to a family outing to a more distant park.

Model Significance

The significance of the 'Journey Time' parameter was such that, for some socio-economic or user groups, model significance was greatly improved where people held a similar disutility for journey time. Likewise, model significance was also higher within groups who could be expected to hold similar preferences, such as frequent users or those with dependent children. However, for the most part, variation in preferences could not easily be identified by the usual socio-demographic variables, but appeared to be more inherent to the respondent's own personality and motivations. Model significance could probably have been improved had an analysis (i.e. latent class) been used to link the choice experiment to the results of the earlier factor analysis. Similarly, model significance was improved where more information was available on the context in which respondents visit parks, for example, dedicated trips, exercise, passing through, etc.

Numbers of Attributes

A critical consideration for the application of choice experiments is that respondents must be able to perceive a good in terms of its attributes rather than just in its entirety. A related limitation is that rather few attributes can be included to describe the good before the underlying statistical design becomes unmanageably large. In this study, more attributes could have been included if two attribute levels had been described rather than three. However, offering a choice of just *no* park facilities or *many* park facilities, is arguably of little practical use to decision-makers. Including more attributes means that there is also less information on interactions between attributes. If the design does not allow for an analysis of these interactions, then the coefficients for these two attributes in isolation could be inaccurate. There is also the important risk of an exercise becoming too difficult for respondents if many attributes are included. This would lead to a risk of error and consequently poor parameter significance.

A promising approach is suggested by attempts to restrict the design (D-optimal designs) to those attribute levels between which people are more likely to make trade-offs. This requires pre-testing and some judgement. Potentially, though, these more efficient non-linear designs could allow more attribute combinations to be examined.

Merging Stated Preference with Revealed Preference

In an earlier question people had been asked which parks they visited most frequently and which they did not. In addition, the second question

in the choice set in Figure 11.1 calls for a similar comparison between the hypothetical alternatives and the respondent's usual park destination. These questions are therefore asking respondents about their revealed behaviour. Analysis of these two questions resulted in a far better model fit than the analysis of the stated preference data alone. However, this better fit is illusionary and arises largely from the actual collinearity that exists between attributes in the usual park choices. Typically, popular parks are well-managed, contain good facilities including playgrounds, and are busy. While it has been argued that the merger of revealed and stated preference data helps to ground an exercise in reality, the benefits of the latter's orthogonal design are much diluted. In practice, there are many instances of high collinearity and researchers must therefore consider whether the nature of the good merits merging the two databases.

In the Greenspace study, a high proportion of respondents preferred their usual park to the hypothetical alternatives. It is not unusual to find a bias towards the status quo. More reliable results were, though, achieved where those respondents who chose the usual park alternative in most of the eight choice sets were removed from the analysis. This left only those cases where respondents were prepared to trade off attributes.

CONCLUSION

Choice experiments have a number of advantages over other valuation methods. Not least, they are useful for providing decision-makers with information of the utility that people attach to various environmental attributes. This information can be used by decision-makers to adapt policy in a way that provides the greatest public welfare.

A fundamental consideration is whether survey respondents are able to perceive goods in terms of their attributes. While this may be true of some applications, for instance climbing (Grivalja et al. 2002), fishing (Hauber and Parsons, 2000) or hunting (Bullock et al., 1998), for park use much depends on information on context and user type. Contingent valuation has been argued to be a preferable approach where discrete scenario changes are being considered (Kriström and Laitila, 2002).

There are also issues as to whether the number of attributes that can be included in a choice experiment can sufficiently describe the good in question and whether the omission of certain interactions or consideration of varying preferences can provide an unrepresentative result. If such factors are taken into account, then choice experiments can, indeed, provide a reliable alternative method of environmental valuation.

NOTES

1. The assumption that all random elements are independently and identically distributed (IID) is a key feature, and weakness, of multinomial logit approach to estimation.
2. There is a risk of serial correlation between factors leading to each respondent's choices.

REFERENCES

Alpizar, F., F. Carlsson and P. Martinsson (2002), *Using Choice Experiments for Non-market Valuation*, Gothenburg: Environmental Economics Unit; Dept of Economics, Gothenburg University.

Bristow, A. and M. Wardman (2004), 'Traffic related noise and air quality valuation: evidence from stated preference residential choice models', *Transportation Research Part D: Transport and Environment*, **9** (1), 1–27.

Bullock, C.H., D. Elston and N. Chalmers (1998), 'An application of economic choice experiments to a traditional land use – red deer hunting and landscape change in the Scottish Highlands', *Journal of Environmental Management*, **52** (4), 335–51.

Chapman, R. and R. Staelin (1982), 'Exploiting rank ordered choice set data within the stochastic utility model', *Journal of Marketing Research*, **19**, 288–301.

Earnhart, D. (2001), 'Combining revealed and stated preference methods to value environmental amenities at residential locations', *Land Economics*, **77**, (1), 12–29.

Grijalva, T.C., R. Berrens, A. Bohara, P. Jakus and W. Shaw (2002), 'Valuing the loss of rock climbing access in wilderness areas: a national level random utility model', *Land Economics*, **78** (1), 103–20.

Hanley, H., D. Macmillan, R. Wright, C. Bullock, I. Simpson, D. Parsisson and R.Crabtree (1998), 'Contingent valuation versus choice experiments: estimating the benefits of environmentally sensitive areas in Scotland', *Journal of Agricultural Economics*, **49** (1), 1–15.

Hauber, A.B. and G.R. Parsons (2000), 'The effect of nesting structure specification on welfare estimation in a random utility model of recreation demand – an application to the demand for recreational fishing', *American Journal of Agricultural Economics*, **82** (3), 501–14.

Kriström, B. and T. Laitila (2003), 'Stated preference methods for environmental valuation: a critical look', in H. Folmer and T. Tietenberg (eds), *International Yearbook of Environmental and Resource Economics 2003–4*, Cheltenham, UK and Northampton, USA: Edward Elgar, pp. 305–30.

Lancaster, K. (1966), 'A new approach to consumer theory', *Journal of Political Economy*, **74**, 132–57.

Louviere, J. and G. Woodworth (1983), 'Design and analysis of simulated choice or allocation experiments: an approach based on aggregate data', *Journal of Marketing Research*, **20**, 350–67.

McFadden, D. (1974), 'Conditional logit analysis of qualitative choice behaviour', in P. Zarembka (ed.), *Frontiers in Econometrics*, New York: Academic Press.