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Estimating the Benefits of Agri-environmental Policy: Econometric Issues in Open-ended Contingent Valuation Studies

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ABSTRACT *This paper reports on an open-ended Contingent Valuation Method study of the conservation benefits of Environmentally Sensitive Areas (ESAs) in Scotland. The ESA scheme is a central component of agri-environmental policy in the UK, and an interesting policy question concerns the extent of non-market benefits generated by such ESAs. The econometric issues we raise in this paper revolve around bid curves. Bid curves are estimated in open-ended Contingent Valuation Method (CVM) studies for three reasons. These are: (1) as a test of theoretical validity; (2) as a test of discriminant validity; and (3) as a means of benefits transfer. Within the first and last of these aims, the partial relationship between willingness to pay (WTP) and independent variables such as income is of interest. There are several econometric issues involved in estimating such relationships, First, the selection process implicit in obtaining positive WTP bids should be explicitly modelled. Second, many CVM surveys suffer from item non-response with respect to 'sensitive' questions such as the respondent's income; these non-responses may be non-random in nature. Finally, it is possible to dis-aggregate the effect of marginal changes in, say, income on WTP into two elements, namely: an effect on the probability that the individual will be willing to pay something; and secondly, an effect on how much they are willing to pay.*

Introduction

Since the structural reforms of 1985, the Common Agricultural Policy has placed increasing emphasis on targeting payments to farmers away from food production related payments, and towards area payments and direct income support. Payments for environmental goods produced by the farm sector from European Union (EU) agricultural ministry budgets first became possible in

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1985, and the UK adopted its Environmentally Sensitive Areas (ESA) scheme two years later. Agri-environmental policies such as the ESA scheme can now be found in many EU countries (for a survey, see OECD, 1996), and may be justified on a number of grounds: that they pay farmers to produce environmental public goods which would otherwise be under-supplied from the point of view of economic efficiency (Hanley *et al.*, 1998a); and/or that they offer a means of supporting farm incomes without increasing food production, and thus adding to the costs of disposing of excess supplies at the EU level. Given that these schemes are costly, though, both in terms of foregone output and exchequer costs, attention has recently been directed at measuring the economic value of the environmental benefits of such policies (Willis *et al.*, 1993).

The Contingent Valuation Method (CVM) is now one of the most common valuation methods in use in both Europe and the USA. Willingness to pay (WTP) amounts can be estimated using a number of different designs in CVM, the most common of which are open-ended (OE) and dichotomous choice (DC). DC designs are known, on the whole, to result in higher mean WTP values than OE designs. Brown *et al.* (1996) summarize results from 11 CVM surveys which compared formats and found that, in all cases, DC mean WTP exceeded OE mean WTP, with the ratio of DC/OE varying from 1.12 to 4.78. This difference is partly due to the phenomenon of 'yea-saying', and partly due to preference uncertainty (Ready *et al.*, 1996; Brown *et al.*, 1996). Evidence from Loomis (1990) suggests that OE designs outperform DC on temporal stability grounds, whilst Brown *et al.* (1996) found that DC designs resulted in a greater hypothetical market error (in other words, resulted in a greater difference between stated and actual WTP) than an OE equivalent. There are thus grounds for preferring OE to DC designs, as offering a more conservative design of survey. In contrast, familiar claims are that DC designs are more realistic, are easier for respondents to answer, and are incentive-compatible (Hoehn & Randall, 1987). The 'trump card' usually played by proponents of DC designs is that the NOAA[1] panel recommended a DC design, although this conflicts with another of their recommendations, that of conservative survey design choices. Accordingly, the empirical study on which this paper is based used both DC and OE designs for CVM. This paper reports on the outcome of the OE study, and comments on some econometric issues raised by this design. We report elsewhere on the DC study, and on a choice experiment application to the same case studies (Hanley *et al.*, 1998b).

An important part of the OE CVM exercise is the estimation of bid curves. Bid curves (that is, a statistical relationship between WTP and variables thought to influence its magnitude) are usually estimated for three reasons. The first is as a test of theoretical validity, which involves checking whether signs on explanatory variables (such as income) are in accord with *a priori* expectations. The second is as a test of discriminant validity, by checking whether bids are simply random numbers, or can be explained statistically to a satisfactory level using variations in other variables collected as part of the survey (such as age, income and education). 'Satisfactory' is usually defined either with respect to R^2 values found in other published CV studies, or Mitchell & Carson's benchmark of 15%. The third is as a means of facilitating benefits transfer (Bergland *et al.*, 1995; Willis & Garrod, 1995; Foundation for Water Research, 1996). If WTP estimates can be predicted, then this makes it possible to adjust values gained at one 'study' site to represent values at a second 'policy' site. Transferring unadjusted WTP values is also possible.

With respect to the first and last of these reasons, a main feature of interest is the estimated impact of certain independent variables on an individual's WTP for a given environmental good or service. For example, WTP for environmental benefits is typically an increasing function of household income. The income elasticity of WTP has been estimated at values typically falling in the $+0.5$ to $+0.75$ range (Brisson, 1996). Finding intuitively and/or theoretically correct signs on variables such as income in the bid curve is one test for the validity of CVM results. Estimating the correct magnitude of partial effects of independent variables on WTP is important for benefits transfer and for other policy questions.

The purpose of this paper is to report on estimates of WTP for the environmental benefits of one element of UK agri-environmental policy, namely ESAs, and in the process to consider some econometric modelling issues in the estimation of bid curves. We concentrate on a sample-selection approach to do this, whereby we seek to distinguish different decisions which a potential CVM survey respondent must take in formulating a WTP bid. These decisions are whether to protest, whether to give a positive bid and how much to bid. This modelling approach allows us to 'decompose' the marginal effects of one independent variable on WTP into separable effects on these different stages, using a procedure first outlined by McDonald & Moffitt (1980).

The remainder of this paper is organized as follows. In the next section we outline the nature of WTP bids, and show briefly how 'self-selection' can create econometric problems in bid curve estimation. We also note some problems regarding incomplete responses, primarily with respect to income. In the third section, the main relevant features of the ESA scheme, and the two case study sites, are outlined. In the fourth section, we give details on the design and descriptive results from the CVM survey. The fifth section comments on the results obtained from a number of bid curve models, whilst a final section offers some conclusions.

Econometric Issues

The basic idea behind the estimation of bid curves is to relate a measure of willingness to pay, p, for an environmental change to a set of explanatory factors. That is:

$$p = f(\boldsymbol{X}) \tag{1}$$

where: $\boldsymbol{X} = X_1, X_2, \ldots, X_k$ is a vector of variables thought to influence the amount an individual is willing to pay to benefit from a certain environmental improvement or to avoid a certain environmental degradation. It is common to estimate this relationship as a linear regression equation of the form using an (assumed) random sample of individuals:

$$p = \beta' \boldsymbol{X} + \varepsilon \tag{2}$$

where: β is a vector of unknown parameters and ε is a random error term assumed to be normally distributed with a zero mean and constant variance. The estimated parameters of this relationship are important; their signs indicate the directions of the association between, say, income and WTP, and their sizes indicate the strength or magnitude of these associations. That is, for variables that are continuous in measurement:

$$\beta_k = \partial p / \partial X_k \tag{3}$$

where: $\partial p / \partial X_k$ is the partial derivative of p with respect X_k, which represents an estimate of the effect of a change in a given explanatory variable on willingness to pay holding constant the effect of the other variables included in the equation.

Despite the empirical simplicity of equation (2), there are two problems that emerge in practise when estimating bid curves in such a manner. The first is that in most CVM studies a significant proportion of respondents usually report 'zero bids'. The second is that there is often a substantial amount of missing information on some of the explanatory variables. As is argued below, the way these two issues are treated empirically may be problematic and casts some doubt on the validity of the parameter estimates of WTP equations of the type described in equation (2).

Zero bid responses to open-ended willingness to pay questions may be categorized into one of three types. The first are 'genuine zero bids' where the respondent indicates that she is not willing to pay anything for the good or service in question, because she does not value it. The second are 'protest bids', where the respondent tenders a zero bid for reasons other than placing a zero value (i.e. not being willing to pay anything) on the good in question. This may be, for example, because she disapproves of the principle of paying for environmental protection since she believes it should be required by law. The third are 'don't know' responses, where the individual is simply uncertain as to the amount she is willing to pay (this amount of course may also be zero).

The fact that these 'zero bids' do not necessarily mean that an individual is unwilling to pay anything has led to *ad hoc* estimation practises. In many WTP studies, individuals who report zero bids are excluded and equation (2) is estimated only for individuals who tender positive bids. Or, equation (2) is estimated for individuals who report positive bids and genuine zero bids, with individuals who tender protest bids or who give 'don't know' responses being excluded. Both these strategies are problematic since the willingness to pay equation is estimated on what may termed a 'self-selected sample'—a form of sample selection bias.

The second problem mentioned above relates to the treatment of individuals for whom some information is missing in the data set for a sub-set of explanatory variables. It is generally believed (for obvious economic reasons) that income is one of the key variables in explaining differences across individuals in their willingness to pay for goods and services. Income is also one of the questions that individuals tend to be reluctant to answer, and in practise this reluctance leads to a significant item non-response rates for income questions in CVM surveys. For example, in the two surveys that we carried out (discussed below), 11.3% and 19.6% of individuals surveyed did not give responses to the income question. In the estimation of bid curves it is common to exclude those individuals who do not respond to the questions used to construct the variables that are included in $\boldsymbol{X}$ in equation (2). This strategy would not be problematic if those individuals who do not report such information are a random sub-sample of all individuals surveyed. However, this is unlikely to be the case for 'sensitive' variables such as income. For example, it is well known that individuals who have high incomes have a lower propensity to report their income on surveys (i.e. have a higher non-response rate). If individuals who have higher income have a higher (or for that matter lower) willingness to pay, excluding individuals with missing income information from the estimation of equation (2) will lead to a biased estimate of the effect of income on willingness to pay (and biased estimates of the parameters of the other variables). In other words, missing information on the explanatory variables of interest may result in the estimation of willingness to pay equations with samples whose values on explanatory variables do not reflect those of the population of interest, a further source of sample selection bias. Several methods have developed for addressing such biases.

In order to demonstrate the problem that results from sample selection bias more formally, let $j = 1, 2, \dots, J$ denote individuals who report a 'valid' willingness to pay (i.e. $p \geq 0$); let $k = 1, 2, \dots, K$ denote individuals who do not report a valid willingness to pay (i.e. protest bids and 'don't know' responses); and let $i = 1, 2, 3, \dots, N$ where $N = J + K$. The population regression equation of the willingness to pay equation is the expectation of equation (2):

$$E(p_i/\boldsymbol{X}_i) = \beta' \boldsymbol{X}_i \tag{4}$$

(Note the subscript i). However, because of protest bids and 'don't know' responses, observations on p are only available for a sub-sample of N That is, only for $p \geq 0$ or sample J. In other words, the regression equation for the 'selected' sample is the expectation:

$$E(p_j/\boldsymbol{X}_j, \text{selected sample}) = \beta' \boldsymbol{X}_j + E(\varepsilon_j, \text{selected sample}) \tag{5}$$

(Note the subscript j). If the conditional expectation of ε_j is zero, then the regression equation for the selected sample (i.e. equation (5)) will be the same as the population regression equation (i.e. equation (4)). In this case, ordinary least squares (OLS) may be used to generate an unbiased estimate of the parameter vector β using only observations from the selected (J) sample. If, however, the sample selection process is non-random, equation (4) will not be the same as equation (5). The reason is, simply, that the mean of the error term will not be zero (i.e. $E(\varepsilon_j) \neq 0$) and the estimates of β will be consequently biased.

Heckman (1976, 1979) has recast the problem of sample selection bias as an omitted variable problem and has proposed what is an extremely popular econometric correction. Heckman's econometric procedure essentially involves modelling the sample selection mechanism and then using these estimates to 'purge' the equation of interest of degrading selection effects (i.e. the equation estimated on the selected sample).

In order to demonstrate Heckman's method in the context of estimating a bid curve, let z_i^* be a latent variable that determines whether or not an individual gives a valid willingness to pay response (i.e. $p \geq 0$). This latent variable may be related to a set of explanatory factors as a linear equation of the form:

$$z_i^* = \alpha' \boldsymbol{Z}_i + \mu_i \tag{6}$$

where: $\boldsymbol{Z}_i = Z_1, Z_2, \dots, Z_r$ is a vector of variables thought to influence whether or not an individual bids $p \geq 0$; α is a set of unknown parameters to be estimated; and μ_i is assumed to be normally distributed with a zero mean and constant variance. In this model z_i^* is not observed. What is observed is an indicator variable, z_i, that takes on a value of 1 if $p_i \geq 0$ and value of 0 if not. Based on equation (6) we may construct a 'selection equation' which determines inclusion in the sample that is used to estimate the willingness to pay equation. If $z_i^* > 0$ then $z_i = 1$ and p is observed (i.e. $p \geq 0$). If on the other hand, $z_i^* \leq 0$ then $z_i = 0$ and p is not observed (e.g. protest bid). Estimates of equation (6) are used to construct the inverse of the Mill's ratio, often referred to as 'Heckman's λ':

$$\lambda_j = \phi(-\alpha'\mathbf{Z}_j)/[1 - \Phi(\alpha'\mathbf{Z}_j)] \tag{7}$$

where $\phi(.)$ is the standard normal density function (pdf) and $\Phi(.)$ is the standard normal cumulative density function (cdf). This 'new' variable is then included in the willingness to pay equation—the 'structural equation'—as an additional regressor:

$$p_j = \beta'\mathbf{X}_j + \gamma\lambda_j + \varepsilon_j^* \tag{8}$$

where γ is the covariance between the error terms in the selection equation and willingness to pay equation. Equation (8) should provide an unbiased estimate of β if the selection process is adequately modelled (i.e. the selection equation is properly specified).

Although Heckman's two-step procedure can be used as a possible control for selection bias, it ignores the fact that the willingness to pay variable p is a 'censored' dependent variable. The censoring problem with respect to estimation of willingness to pay equations has two dimensions. The first is that there is a real lower bound—it is typically not possible to bid less than zero. The second is that there is often 'heaping' on the lower bound—often a significant proportion of individuals make zero bids. For example, in the two surveys that we carried out (discussed below), 36.8% and 46.6% of individuals made zero bids. Failure to account for the concentration of observations at the limit value can result in misleading estimates of the parameters of the explanatory variables of interest (e.g. parameters estimated using OLS).

Ignoring the sample selection issue for the moment, Tobin (1958) argued that it is useful to think of explanatory variables influencing both the probability of the limit response and the size of the non-limit response. More specifically in terms of the willingness-to-pay decision, the first is the impact of explanatory variables on the probability of making a positive bid and the second is the impact on the amount bid. More formally:

$$p_i^* = \beta'\mathbf{X} + \varepsilon \tag{9}$$

where: p_i^* is an unobserved latent variable underlying p; and ε is an error term with the usual properties. Let L_i be the lower limit (e.g. in the case of willingness to pay the lower limit is zero). If $p_i^* \leq L_i$ then $p_i = L_i$, and the observation is censored at the lower limit (i.e. $p_i = 0$). If on the other hand, $p_i^* \geq L_i$ then $p_i = p_i^*$ $(= \beta'\mathbf{X} + \varepsilon)$, and p_i is observed. Therefore, the expected value of p is:

$$E(p) = \mathrm{Prob}(p > 0) \times E(p/p > 0) \tag{10}$$

where the first term on the right-hand side is the probability that p is positive and the second term is the expected value of p given that p is some positive value.

In terms of the regression notation used above this expectation may be expressed as:

$$E(p) = \Phi(\beta'\mathbf{X}/\sigma_\varepsilon) \times (\beta'X/\sigma_\varepsilon + \sigma_\varepsilon\lambda_\varepsilon) \tag{11}$$

with:

$$\lambda_\varepsilon = \phi(\beta'\mathbf{X}/\sigma_\varepsilon)/\Phi(\beta'\mathbf{X}/\sigma_\varepsilon)$$

where: σ_ε is a scale parameter. The parameters of equation (11) can be easily estimated using maximum likelihood techniques (see Greene, 1993, for details).

Unfortunately the parameters of the Tobit model are more difficult to interpret than in the case of a simple linear regression. They *do not* (as some have unfortunately assumed) represent the effect of a change in a given explanatory variable on the dependent variable of interest (i.e. $\partial p/\partial X_k$). McDonald & Moffitt (1980) demonstrate that an informative way to present the results of a Tobit regression is to decompose the effect of an explanatory variable (or a series of explanatory variables) into two components. The first is the impact on the probability of being above the limit and the second is the impact on the dependent variable if it is already above the limit. More formally:

$$\partial E(p)/\partial X_k = [\Phi(\beta'\mathbf{X}/\sigma_\varepsilon)] \times [\partial E(p^*)/\partial X_k] + E(p^*) \times \partial[\Phi(\beta'\mathbf{X}/\sigma_\varepsilon)]/\partial X_k \quad (12)$$

where $E(p^*)$ is the expected value of p conditional on being above the limit and all other terms have been defined above. In terms of the willingness to pay problem, the first term on the right-hand side of equation (12) is the impact of the explanatory variable on the probability of a positive bid and the second term is the impact on the amount bid (conditional on a positive bid in the first place). Therefore, the relative magnitudes of these two components is of substantive importance.

The extension of the Tobit model to include sample selection is straightforward. The expected value of the Tobit model with selection is:

$$E(p|z=1) = \mathrm{Prob}(p>0,z=1) \times E(p|p>0,z,=1) \quad (13)$$

where as above z is an indicator variable that equals 1 if p is observed and 0 if not. The probability that $p>0$ *and* $z=1$ is:

$$\mathrm{Prob}(p>0,z=1) = \Phi_2(\beta'\mathbf{X}/\sigma_\varepsilon,\alpha'\mathbf{Z},\rho) \quad (14)$$

where: Φ_2 is the bivariate normal probability distribution and ρ is the covariance between the error terms in the selection equation (i.e. equation (6)) and the error term in the structural Tobit equation (i.e. equation (9)). The expected value of p given that $p>0$ and $z=1$ is:

$$E(p|p>0,\ z=1) = \beta'\mathbf{X} + E(\varepsilon|\varepsilon > -\beta'\mathbf{X},\ \mu > -\alpha'\mathbf{Z}) \quad (15)$$

The corresponding Tobit-like expression for the selected sample (analogous to equation (9)) is the product of equation (14) and equation (15). After some manipulation this expression may be written:

$$E(p|z=1) = \Phi_2(\beta'\mathbf{X} + \sigma_\varepsilon\{\phi(h)\Phi[\delta(k-\rho h)] + \rho\phi(k)\Phi[\delta(h-\rho k)]\}] \quad (16)$$

where $h = -\beta'\mathbf{X}/\sigma_\varepsilon$; $k = -\alpha'\mathbf{Z}$; and $\delta = -1/(1-\rho^2)^{-2}$. Unlike Heckman's two-step procedure, the selection equation and structural equation are estimated jointly by the method of maximum likelihood (see Greene, 1993, for estimation details).

It is straightforward to adapt the Tobit model with selection to include information on explanatory variables of central theoretical importance that have missing information, such as income, in the estimation of bid curves. In order to do this, one has to specify the selection mechanism in a slightly different way. More specifically, the selection mechanism when income reporting is ignored is a model of the probability that a valid bid (i.e. genuine zero or positive) is tendered, compared to a protest bid when all individuals with missing income information are excluded from the estimation. However, the selection mechanism when income non-reported is included in the estimation is a model of the joint probability that a valid bid is tendered and income is reported.

The use of the Tobit estimator to obtain bid curves is, of course, not uncommon in open-ended CVM studies, since this approach recognizes the censored nature of WTP values (see, for example, Hanley & Craig, 1991; Kaoru, 1993). However, the modelling of sample selection is far less common. The only example the authors are aware of is Kaoru (1993) who includes a Heckman-type selection equation in his estimation of WTP for water quality benefits in the Martha's Vineyard area of New England. Of 559 mailed out questionnaires, 200 were returned with complete socio-economic information. Of these 200 responses, 25 gave a zero WTP value and 30 responses were protest bids. Kaoru estimates a selection equation comparing positive WTP bids with (zero plus protest) bids. However, only income was significant in the selection equation, whilst the coefficient on the inverse Mills was insignificant. Kaoru does not model income non-responses, nor does he employ the McDonald/Moffitt decomposition. His approach is therefore very different to ours.

Agri-environmental Policy and the Case Study Areas

The data used in this paper relate to a contingent valuation study of two Environmentally Sensitive Areas in Scotland, carried out on behalf of the Scottish Office during 1994–96 (for full details, see Hanley *et al.*, 1996). ESAs were established under Article 19 of EC Structures Regulation 797/85 in 1985, as part of the early reform of the Common Agricultural Policy. They are designated areas of the country which are of special landscape and/or conservation interest where traditional farming methods are considered to be essential to maintaining wildlife and landscape quality.

In Scotland, 10 ESAs have been designated since 1987, covering some 1.4 million ha of farmland. Farmers may 'join' an ESA scheme by signing a 10-year agreement based on a plan which meets the conservation aims and objectives of the particular ESA. In return for agreeing to these restrictions on activities, farmers qualify for annual per hectare payments on two different levels: tier one (aimed at the preservation of conservation features at existing levels); and tier two (aimed at enhancement and extension of conservation features beyond existing levels). ESAs thus involve the state paying farmers to produce environmental public goods, in terms of wildlife and landscape quality, a notion which finds many echoes throughout the OECD (Hanley *et al.*, 1998a).

This study was concerned with two ESAs, Breadalbane, in Highland Perthshire, and The Machair of the Uists, Benbecula, Barra and Vatersay ('The Machair', from now on) in the Western Isles. Breadalbane ESA comprises 179 284 ha of mountains and valley lands. Land cover features comprise grasslands, heather moorland, wetlands, and birch and ash woodlands, with increasing amounts of conifer plantation in upland areas. Farming is a mixture of upland sheep and suckler cows plus intensive grassland cultivation on in-bye land. ESA payments are conditional on the management of broadleaved and native woodlands, wetlands, herb rich pasture, heather moorland, dykes, hedges and archaeological features. The main objectives of the ESA programme are to conserve and extend these features. The Machair ESA is spread over 15 166 ha of coastal plain on five islands. Land cover includes grasslands, cultivated machair, dune systems and rough pasture. Crofting activities are centred around small scale crop and livestock production, and have resulted in high floristic diversity on the machair lands. Rare breeding birds, such as the corncrake, are found in The Machair, and the conservation requirements of the ESA programme here may be thought of as an attempt to preserve and extend farming practices which result in favourable conditions for these birds[2] and flowers.

The ESA prescriptions will produce quite complex changes in flora, fauna and landscape, and will also have implications for archaeological features not protected under existing legislation. Two stages were thus involved in developing Information Packs to be used as part of the CVM survey: prediction of changes to these features; and representation of these changes, in the form of with/without scenarios.

With regard to prediction, the land area within each ESA was divided up into km^2 land class types, using the Institute of Terrestrial Ecology's land classification system (Institute for Terrestrial Ecology, 1991). This helped the organization of environmental and land management data for each ESA, and allowed the extrapolation of predicted conservation values across each ESA. Classifying land in this way gave six major types for Breadalbane, and two for The Machair. For each class, we predicted changes in land cover resulting from changes in management (for example, from changes in stocking rates or fertilizer use), using the National Vegetation Classification system for vegetative cover. Changes were predicted using succession models (see Simpson *et al.*, 1997, for further details). The impact of these likely biological successions on the conservation status of each land class (in terms of plant communities) was then assessed, using three criteria: biodiversity (number of species m^2); presence/absence of key indicator species; and relative rarity of the NVZ community. These predictions were also discussed with local agricultural advisors and farmers. Changes in bird numbers/species type were predicted in consultation with the Royal Society for the Protection of Birds, the Scottish Office Agriculture, Environment and Fisheries Department, and Scottish Natural Heritage. Changes in archaeological features were predicted in consultation with Historic Scotland. These changes were all then set in the context of *with* and *without* the ESA prescriptions, by predicting likely changes in the absence of the scheme. Representation of these predicted changes was accomplished by producing Information Packs for each ESA. These accompanied the CVM questionnaires, which gave background details on the ESA scheme in general. Changes were shown as *with* and *without* the ESA scheme in place, using colour photograph pairs which were manipulated using Adobe Photoshop. For Breadalbane, changes to the appearance of farmland and moorland, to archaeological features and to the number and types of flowers were included. For The Machair, changes to the machair lands, birds, flower diversity, dunes and archaeological features were portrayed.

In summary, the ESA scheme, if continued, will generate environmental improvements in both areas relative to the 'no ESA' case. These improvements are in terms of more attractive landscapes, the protection of rare and well-loved birds and flora, and the protection of archaeological sites. Respondents learn about what they are 'buying' in the information packs, which use words and pictures to compare the situation with and without the ESA scheme in place.

Respondents might therefore be reasonably expected to be very clear about the change in the quantity of the environmental good which the survey addresses.

Design and Descriptive Results of the CVM Survey

An initial 'attitudes' survey of 150 respondents showed that income tax increases were the second most preferred bid vehicle after entrance fees.[3] However, entrance fees were rejected for the main survey bid vehicle as: (1) impractical, due to the physical impossibility of excluding users from the areas; and (2) as excluding non-use values. The attitudes survey also revealed that a majority of the sample (70%) were in favour of farmers being paid by government to produce both food and environmental outputs. Some 32% of the sample had heard of the ESA programme, whilst 69% were in favour of paying for environmental improvements in these areas. In subsequent focus groups, no objections were made to the use of income tax as the preferred bid vehicle.

The target populations for the main survey were three-fold: the UK general public; residents in the two ESAs, and visitors to each ESA. Focus groups[4] were used to develop the wording and layout of the survey instruments (including the Information Packs) and a pilot study was carried out prior to the main survey. In general, the survey design follows NOAA guidelines, except that we obtained both open-ended and dichotomous choice bid responses, as the latter are well-known to result in higher WTP values than the former, due to 'yea-saying' and preference uncertainty; and in that both mail-shot and in-person interview responses were obtained. Response rates for the mail shot were good by CVM standards, being greater than 50% in almost all sub-samples. Respondents were repeatedly reminded that they were being asked their WTP for the environmental improvements at one ESA only, and that extra spending would be necessary for all other ESAs and for all other environmental policies. No formal test of part-whole bias was incorporated in the open-ended CVM design, although a test was included in the DC design.

Mean WTP in the open-ended sample for Breadalbane was £25.21 per household/year (95% ci = £19.06–£31.36), and £13.44 (95% ci = £10.10–£16.78) for The Machair. The median WTP values were £10 and £1 respectively. Mean WTP was thus higher for Breadalbane than for The Machair ESA, which may reflect the more specialist landscape and wildlife of The Machair areas. In both ESAs, WTP declined with decreasing familiarity with the site: bids were highest for those who had either lived in or visited the site; and lowest for those who had not even heard of it before the survey.[5] Significant non-use values were found, in that those neither living in nor visiting the sites had positive WTP amounts which were significantly different from zero at the 95% confidence level.[6] In both ESAs, residents had a higher WTP than non-residents, although the difference is never statistically significant. Mail shot returns gave a higher mean WTP than in-person interviews (for Breadalbane, £23.50 and £19.80 respectively), but this difference is not statistically significant in either ESA. For The Machair, in-person interviews actually gave a slightly higher WTP value.

Several tests for reliability and validity were incorporated into the open-ended CVM survey. First, a test–retest experiment was carried out. This procedure has been adopted by several authors previously (see, for example, Kealy *et al.*, 1990; Loomis, 1990; Laughland *et al.*, 1991; Bergland *et al.*, 1996). It involves surveying a different sample taken from the same population after some time period has elapsed, to check on what Bergland *et al.*, refer to as the "temporal stability" of CVM estimates. Some debate exists on whether it is preferable to re-survey the same individuals as in the main survey, or a different group drawn randomly from the same population. The latter approach was used here, with 200 questionnaires being sent to a different random sample drawn from the general public population three months after the main survey was completed. This sample yielded a 45% response rate, with a mean WTP of £23.39 for Breadalbane. This is insignificantly different from the main survey result; median WTP was identical in both samples. The test–retest procedure thus fails to reject the null hypothesis of temporal stability in the open-ended CVM survey.

Second, a test of 'scope' was used, as recommended in the NOAA report. This involves examining whether WTP is sensitive to the quantity of the environmental good being bid for. The null hypothesis is that mean WTP is increasing in the quantity of the environmental good. Accordingly, a sub-sample of respondents ($n = 220$) were sent information packs on both ESAs, and asked their maximum WTP for a programme to maintain the ESAs in both areas at once. This 'double information pack' sub-sample is therefore expected to yield a higher mean WTP than bids for either ESA in isolation. This was the result obtained. Mean WTP for both ESAs valued together was higher at £36.00 than for either ESA when valued alone (the relevant figures being £25.21 for Breadalbane and £13.44 for The Machair). The null hypothesis cannot thus be rejected. However, WTP for both ESAs combined is less than the sum of WTP for both ESAs valued independently; this may be evidence of a nesting effect, brought about through substitution possibilities.

Bid Curve Results

In this section, we illustrate the application of the econometric ideas discussed earlier to the open-ended data sets from our CVM surveys. Table 1 shows the distribution of the dependent variable for the two samples stratified by whether or not the respondent reported their income. The Breadalbane sample consists of 302 respondents and The Machair sample consists of 358 respondents. In both areas a substantial number of respondents did not report their income. More specifically, in Breadalbane 274 respondents or 90.7% of the sample reported their income. In The Machair the proportion of respondents reporting their income was lower—only 288 respondents or 80.4% of the sample.

With respect to the type of bid made (i.e. protest, zero or positive), Table 1 shows that 32.8% of responses in the Breadalbane sample and 25.1% of the responses in The Machair sample were positive bids (see the last column in Table 1). Likewise, genuine zero bids made up 21.5% and 25.1% of the responses in the Breadalbane and Machair samples respectively. Finally, protest bids were the most popular response, making up 45.7% and 49.7% of responses in the Breadalbane and Machair samples, respectively. Protest bids were distinguished from genuine zero bids by asking respondents why they were unwilling to pay for the ESA programme. Those replying either that it was of no worth to them, or that they could not afford it, were classified as genuine zeros. Other responses, including non-responses, were classified as protests. Those people who answered that they "did not know" whether they would be willing to pay were also classified as protests. This is somewhat unusual in CVM, since such persons are usually excluded from the analysis. However, we chose to model them as

Table 1. Distribution of willingness to pay responses

Willingness to pay	Income reported? No	Yes	Total
Breadalbane			
Protest	19 (67.9)[a]	119 (43.4)	138 (45.7)
Zero	8 (28.6)	57 (20.8)	65 (21.5)
Positive	1 (3.6)	98 (35.8)	99 (32.8)
Total	28	274	302
Machair			
Protest	36 (51.4)	142 (49.3)	178 (49.7)
Zero	22 (31.4)	68 (23.6)	90 (25.1)
Positive	12 (17.1)	78 (27.1)	90 (25.1)
Total	70	288	358

[a]Percentages in parentheses.

protests. This leads to quite a high level of protesting in this study (compared, for example, with figures of 6%–14% (Hanley & Milne, 1996); 6.5% (MacMillan *et al.*, 1996) and 22% (Hanley & Craig, 1991) in other UK open-ended CVM studies). Removing these people and those giving no reason for their zero bid gives lower protest rates—33% for Breadalbane and 31% for The Machair. The most popular reasons given for protesting were: “People should not have to pay for the programme” (41 responses) and; “Government should pay from lottery funds” (27 persons). We note that the proportion of positive bidders in the DC design was much lower, at 6–25% depending on sub-sample.

Table 1 also shows how the type of bid made varies with income non-response. A comparison of the distributions between groups with respect to the type of bid made provides some information that suggests there is a relationship between income non-response and type of bid made. More specifically, comparing the column percentages in Table 1 indicates that respondents who refuse to answer the income question appear to have a higher tendency to report genuine zero and protest bids compared to respondents who report their income (i.e. 96.4% compared to 64.2% in Breadalbane and 82.9% compared to 72.9% in The Machair). Given the differences in these distributions, it is unlikely that income non-reporters are a random sub-sample of all respondents. This makes the explicit modelling of a selection process all the more relevant here.

Table 2 presents the definitions and abbreviations of the variables used in the bid curve analysis. These include socio-economic variables such as income and age, survey-specific variables such as whether the response was obtained by mail-shot or in-person interview, and preference/awareness information such as whether the individual had visited the site in question. Of particular interest *a priori* are: income; variables reflecting the environmental preferences of the individual (such as *EnvGroup*, *LandPref* and *Envpref*); and variables reflecting the degree of knowledge the individual has about the good in question (*Heard* and *Resident*). It is common to see such variables used in bid curves, since they pick up what researchers believe ought to influence the value people place on

Table 2. Variable descriptions

Variable	Description
Heard	A dummy variable coded 1 if the individual has ever heard about the site but never visited and coded 0 if otherwise.
Income	Gross annual household income in pounds sterling.
Resident	A dummy variable coded 1 if the individual is a resident of the area of the site and coded 0 otherwise.
England	A dummy variable coded 1 if the individual resides in England and coded 0 otherwise (i.e. Scotland).
Age	The age of the individual in years.
Mail	A dummy variable coded 1 if the individual was interviewed via a mail-shot and coded 0 otherwise (i.e. in personal interview).
Visit	A dummy variable coded 1 if the individual has visited the site before and coded zero if otherwise.
LandPref	Rank order score of preference measure relating to the "importance of protecting landscape" (see text).
EnvPref	Rank order score of preference measure relating to the "importance of protecting environment and countryside" (see text).
AnimPref	Rank order score of preference measure relating to the "importance of protecting rare animals and plants" (see text).
HistPref	Rank order score of preference measure relating to the "importance of protecting historical sites" (see text).
AccessPref	Rank order score of preference measure relating to the "importance of ensuring public access to the countryside" (see text).
EnvGroup	Number of environmental groups of which the individual is a member.

environmental improvements. By including such variables in the bid curve, it is possible to test whether, on statistical significance grounds, this is indeed so. Finally, survey design dummy variables are often also included to test for design effects; here, the only design effect tested for is the effect of collecting data from mail shots as opposed to in-person surveys (*Mail*).

Table 3 shows means and standard deviations for the variables listed in Table 2. For each ESA there are three columns. The third column (i.e. (3) and (6)) reports the descriptive statistics for all respondents, regardless of whether or not they reported their income (note therefore that no mean or standard deviation is reported for the income variable). The second column (i.e. (2) and (5)) shows the descriptive statistics for only those respondents who reported their income (i.e. income non-respondents are excluded in the calculation of the summary statistics). Finally, the first column (i.e. (1) and (4)) shows the descriptive statistics for those respondents who reported their income *and* made genuine zero or positive bids (i.e. income non-respondents and protest bidders are excluded). The key point to note about this table is that comparing across the columns reveals that, for many of the variables, these summary statistics are quite different, which suggests further that income non-reporting and protest bidding is likely not a random process.

Table 4 reports estimates of the bid curves using different methods. Note that these equations exclude the environmental preference variables included in the selection equation, since we have chosen to specify these as influencing the choice of whether to protest or not, rather than influencing the magnitude of

Table 3. Descriptive statistics for regression variables means and standard deviations[a]

	Breadalbane			Machair		
Variable sample	(1)	(2)	(3)	(4)	(5)	(6)
Heard (%)	13.6	13.1	13.9	43.1	42.7	41.1
Income (£)	13 629	13 941	—	18 048	18 056	—
	(10 774)	(10 802)		(15 568)	(15 043)	
Resident (%)	35.5	28.1	26.5	19.2	28.1	27.1
England (%)	5.8	6.6	6.3	22.6	20.8	17.6
Age (years)	48.1	47.0	47.0	48.5	45.6	45.8
	(16.9)	(17.2)	(17.3)	(16.5)	(16.5)	(16.7)
Mail (%)	39.4	44.3	42.1	45.9	43.8	40.5
Visit (%)	61.3	59.9	58	27.4	31.6	30.2
LandPref	2.8	2.8	2.8	2.7	2.7	2.7
	(1.1)	(1.1)	(1.1)	(1.1)	(1.1)	(1.1)
EnvPref	3.7	3.5	3.5	3.6	3.6	3.6
	(3.3)	(2.6)	(2.5)	(0.9)	(1.0)	(1.0)
AnimPref	2.7	2.6	2.6	2.5	2.5	2.5
	(1.1)	(1.1)	(1.1)	(1.1)	(1.1)	(1.1)
HistPref	4.2	4.2	4.2	4.1	4.0	4.1
	(1.0)	(1.1)	(1.0)	(1.1)	(1.1)	(1.1)
AccessPref	3.8	3.8	3.8	3.8	3.9	3.9
	(1.2)	(1.2)	(1.2)	(1.3)	(1.2)	(1.2)
EnvGroup	0.3	0.3	0.3	0.4	0.3	0.2
	(0.74)	(0.64)	(0.68)	(0.75)	(0.62)	(0.58)
N	155	274	302	146	288	358

[a]Standard deviations in parentheses.

positive WTP bids. The table shows the estimated parameters, along with the ratio of the parameters to their standard errors: σ is the scale parameter of the Tobit model; ρ is the correlation between the errors in the selection equation (not reported here) and the bid curve. Note that the selection equation and the Tobit models are in practice estimated jointly; to avoid confusion we report only the latter. For the Tobit models, the R^2 values are likelihood ratio based pseudo-R^2 values.

For each region, there are four columns of estimates. The first column (i.e. (1) and (5)) is an OLS equation estimated using information on only those respondents who tender a genuine zero or positive bid and report their income. That is, no information relating to protest bidding and income non-reporting is included in the estimation of the bid curve. In this sense, the first column illustrates the most common way that bid curves are estimated. The second column (i.e. (2) and (6)) is a Tobit equation estimated using the same sample. The only difference therefore between the first and second column is that information relating to the censoring at zero is used in the estimation of the bid curve. The third column (i.e. (3) and (7)) is a Tobit model with sample selection which includes those respondents who tender protest bids in the estimation but *excludes* those respondents who do not report their income. In this model, information on income non-reporting is not included in the estimation of the bid curve. Finally, the fourth column (i.e. (4) and (8)) is a Tobit model with sample selection which includes both those respondents who tender protest bids and those respondents who do not report their income in the estimation. Therefore, this model uses information relating to both income non-reporting and protest bidding to assist in the estimation of the bid curve, and is the 'full information' version of our competing models.[7]

Although the parameters of the OLS and Tobit equations are not directly comparable, there are distinct differences with respect to the significance of some of the included explanatory variables. For example, for Breadalbane, residence in the ESA (*Resident*), age (*Age*) and awareness of the ESA before the survey (*Heard*) are statistically significant at conventional levels in the Tobit equation but are not significant in the OLS equation (see columns (1) and (2)). Likewise, for The Machair, being a resident of England (*England*), as opposed to Scotland, is statistically significant in the OLS equation but not in any of the Tobit equations. The distinction between whether responses were collected by mail shot or by face-to-face interview (*Mail*) is shown to be statistically insignificant: given the reasonable response rates also achieved for the mail shot, this perhaps suggests that the NOAA panel recommendation against using mail shots should be reconsidered, given a well-designed and produced survey instrument.

Comparing across the columns of Tobit estimates in Table 4 suggests that income is the most important determinant of willingness to pay. In all the Tobit equations, the income variable (*Income*) is highly statistically significant (1% level or below). This is especially the case for The Machair, where few of the other included explanatory variables achieve statistical significance, even at the generous 10% level. It is also important to note that, for both The Machair and Breadalbane, the parameter on income increases when the simple OLS model is compared with the full-information Tobit model with selection: this effect is much larger for the Machair than for Breadalbane, doubling the parameter in the former case (a significant change).

Table 4. Estimated bid curves

	Breadalbane				*The Machair*			
Equation no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Method	OLS	Tobit	Tobit[c]	Tobit[d]	OLS	Tobit	Tobit[c]	Tobit[d]
Selection?	No	No	Yes	Yes	No	No	Yes	Yes
Heard	9.615	22.850*	22.110*	21.916*	3.769	10.518	16.922	11.517
	(1.0)	(1.6)	(1.6)	(1.6)	(0.7)	(1.1)	(1.3)	(1.0)
*Income**100	0.101***	0.152***	0.146***	0.143***	0.0363***	0.0656***	0.0585***	0.0642***
	(3.0)	(3.1)	(2.4)	(2.3)	(2.7)	(2.9)	(2.8)	(3.2)
Resident	12.929	29.398**	24.153	20.451	−5.155	−18.534*	−5.097	12.628
	(1.5)	(2.2)	(1.3)	(0.9)	(−0.8)	(−1.6)	(0.3)	(1.0)
England	6.600	1.206	−0.217	−0.989	−12.607***	−9.868	−7.437	−13.788
	(0.5)	(0.0)	(−0.0)	(−0.0)	(−2.5)	(−1.2)	(0.5)	(0.9)
Age	−0.269	−0.569**	−0.631*	−0.659*	−0.045	−0.235	−0.528	−0.354
	(−1.3)	(−1.9)	(−1.7)	(−1.7)	(−0.3)	(−0.9)	(1.3)	(1.0)
Mail	−3.184	12.232	12.365	10.056	−1.509	1.4213	6.874	1.00
	(−0.4)	(0.9)	(0.9)	(0.6)	(−0.3)	(0.2)	(0.6)	(0.1)
Visit	−2.141	2.822	3.755	2.905	4.457	16.643*	19.907	15.338
	(−0.3)	(0.3)	(0.3)	(0.2)	(0.7)	(1.6)	(1.5)	(1.2)
Constant	21.998*	−3.065	12.797	22.975	11.650	−4.796	19.300	19.796
	(1.7)	(−0.2)	(0.3)	(0.5)	(1.4)	(0.3)	(0.8)	(0.7)
σ	—	53.4***	54.9***	56.2***	—	35.9***	41.4***	39.6***
		(13.2)	(6.6)	(11.1)		(11.5)	(4.4)	(4.7)
ρ	—	—	−0.30	−0.40	—	—	−0.62*	−0.53
			(0.4)	(0.6)			(1.7)	(1.3)
−2lnL	—	1135.1	1489.0	1530.0	—	865.2	1226.6	1322.2
R^2(%)	10.4	7.9[e]	9.7[e]	10.1[e]	11.1	7.7[e]	11.8[e]	11.4[e]
N	155	155	274	302	146	146	288	358

[a]Absolute value of the ratio of parameter to its standard error given in parentheses.
[b]*statistically significant at the 10% level; **statistically significant at the 5% level; and ***statistically significant at the 1% level.
[c]Individuals with 'not reported income' excluded from estimation (see text).
[d]Individuals with 'not reported income' included in estimation (see text).
[e]Pseudo-R^2.

Table 5. Macdonald–Moffitt Tobit decomposition

Decomposition based on equation no.	(1) Percentage of sample above limit	(2) Mean total response	(3) Percentage of mean total response due to response below limit	(4) Percentage of mean total response due to response above limit
A. *All variables*				
Breadalbane				
(2)	63.2	57.7	40.8	59.2
(3)	63.2	65.0	45.6	54.4
(4)	63.2	66.8	46.9	53.1
The Machair				
(6)	53.4	49.6	36.1	63.9
(7)	53.4	66.5	46.6	53.4
(8)	53.4	67.8	47.6	52.4
B. *Income*				
Breadalbane				
(2)	63.2	65.1	45.6	54.4
(3)	63.2	64.4	45.2	54.8
(4)	63.2	62.6	43.9	56.1
The Machair				
(6)	53.4	62.9	44.1	55.9
(7)	53.4	60.1	42.3	57.7
(8)	53.4	61.5	43.2	56.8

Note: See text for further discussion of these calculations.

Finally, Table 5 shows the McDonald & Moffitt decomposition of the Tobit results. As discussed above, this procedure decomposes the impact of a marginal change in, say, income into two components. The first component is the impact of a variable or a combination of variables on the probability of tendering a positive bid (column (3)). The second component is the impact on the magnitude of WTP, given the decision to bid positive (column (4)). The upper panel of Table 5 shows the decomposition for an equi-marginal change in all dependent variables, when they are initially set at their mean values. The lower panel shows the effect of changing income alone, holding all other right-hand side variables constant.

Considering panel A first, it may be noted that the breakdown of the overall response of WTP is roughly consistent across all six models, in that approximately 45% of the effect takes place on the probability of being a positive bidder, whilst about 55% of the effect is on the amount people are willing to pay once they have decided to pay something. Panel B shows that this pattern holds for the case when income alone is changed. This shows that simply interpreting the income coefficient in the Tobit model of WTP would lead to over-estimating elasticities (defined as the percentage increase in positive WTP for any individual due to a 1% increase in income) by around 45%. By way of example, for The Machair, the estimated elasticity of WTP with respect to income is +0.87 based on the Tobit model (Table 4, column (8)). Allowing for the decomposition, this value changes to +0.49.[8] For Breadalbane, the income elasticity using the Tobit model (column (4)) is lower at +0.43 once the decomposition has been allowed for, since not decomposing the parameter would increase the elasticity to +0.773.

Conclusions

In this paper we have considered two econometric issues in the estimation of bid curves from CVM surveys. One is concerned with selection: that the formulation of willingness to pay amounts is correctly modelled in a nested fashion, using selection models. Selection occurs when respondents decide whether to protest or else tender a genuine zero or positive bid. Selection can also be used to take account of the fact that income is a missing observation for a number of respondents, due to a non-random pattern of income non-reporting on estimation. That WTP is also a censored variable needs to be incorporated into the model too. Second, we showed how the parameter estimates that emerge from Tobit modelling can be decomposed into effects on the probability of being a positive bidder, and the size of WTP for such positive bidders. Neglecting this decomposition could lead analysts to over-estimate income elasticities (and does in our empirical example). Whilst the impact of specifying a selection model rather than a simple OLS model is not very great for the data set used in this paper, this does not of course mean that this will be so for other data sets.

This paper has also been about the application of CVM to one aspect of agri-environmental policy in the UK, namely the ESA scheme. Previous CVM analyses of other UK ESAs (for example, Willis *et al.*, 1993; Gourlay, 1996; Bullock & Kay, 1996) have also found that users and non-users were WTP significant amounts for similar environmental benefits. For example, Willis *et al.*, found that residents had a mean WTP of £27.52/household/year for the South Downs ESA and £17.53 for the Somerset Levels ESA; whilst Gourlay found a residents' mean WTP of £20.60/household/year for Loch Lomond ESA, and £13.00 for Stewartry ESA. These figures, all obtained using OE designs, are very comparable to the estimates obtained here for Breadalbane and The Machair. Referring to Breadalbane and The Machair specifically, then aggregating over just residents and estimated visitors, reveals a total benefit figure in each case well in excess of programme costs.[9] For Breadalbane, this (residents plus visitors) total benefit is £1.046 million/year; for The Machair, it is £329 790/year. Thus, on cost–benefit analysis grounds, there is a good case for maintaining the ESA programme in both these areas, even if the very large non-use values associated with them are ignored. Including non-use values greatly increases total WTP, since the sample was drawn from the entire population of the UK. This paper might be seen, then, as providing further evidence of the economic desirability, on efficiency grounds, of aspects of EU agri-environmental policy.

Finally, one might ask what implications the paper has for the design of future CVM studies. We suggest that data collection and subsequent modelling needs to be extended so that the analyst can explain: (1) what determines whether an individual is able to answer the WTP question at all; (2) what determines whether they protest, or else tender a genuine zero or positive bid; (3) assuming they do not protest, what determines whether they tender a positive bid or a genuine zero; and (4) assuming they tender a positive bid, what determines how high this bid is. This implies deciding at an early stage to collect data which can address each part of this value formulation/statement process, for example data on ethical beliefs with regard to protesting. Much bid curve analysis in CVM is aimed solely at question (4), with positive bids only being used in the regression (this is especially likely if the popular semi-log (dependent) functional form is specified). Allowing genuine zeros along with positive bids in an OLS framework will not, however, answer any of the other three questions. Selection models seem a promising way forwards in this regard. and might be compared with the nested multi-nomial logit models now becoming popular in recreational demand studies using random utility approaches. In addition, the decomposition we have suggested allows for more accurate measures of the income elasticity of demand for environmental goods.

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Notes

1. NOAA is the US National Oceanographic and Atmospheric Administration, the body responsible for implementing the Oil Pollution Act of 1990. This duty led NOAA to commission a well-known report on whether CVM was suitable for estimating environmental damage which could become part of a law suit; the report resulted in a set of guidelines for the design and implementation of CVM in the US (Arrow *et al.*, 1993).
2. Other rare birds predicted to benefit from the ESA in The Machair include corn bunting, red necked phalarope and arctic terns.
3. Other bid vehicles considered in the attitudes survey were payments to a trust fund, and higher food prices.
4. Focus groups were conducted in Aberdeen, Stirling, Dunblane, Dundee, Aberfeldy and Killin, giving 10 groups in all. Each group comprised no more than 10 people. Participants were paid £15 each for completing a one-hour session, which involved taped discussions of all materials being produced for the surveys.
5. It may seem odd to refer to a WTP for those who had not heard of the site before receiving the questionnaire. However, as Bishop & Welsh (1994) have noted, such unawareness does not in itself mean that non-use values do not exist, since a good which respondents were previously unaware of still has the potential to satisfy preferences.
6. All references to 'statistical significance' in this paper refer to a 95% confidence level unless otherwise stated.
7. One problem with the Tobit model is that it tends not to be robust to violations of the underlying distributional assumptions. In light of this, tests for heteroscedasticity and normality were carried out. First, conditional moment based tests for normality suggested by Pagan & Vella (1989) were carried out, and these tests reject normality. Second, multiplicative tests for heteroscedasticity were carried, and these tests reject homoscedasticity. Therefore, the estimated parameters summarized in Table 4 are inefficient since the variances of the parameters will be biased.
8. Assuming a mean bid of £13.30 and a mean income level of £18 048.
9. Programme costs will, in any case, over-estimate resource costs, since they include transfer payments in terms of support payments foregone.

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