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**Modelling Winners and Losers in Contingent Valuation of Public Goods:
Appropriate Welfare Measures and Econometric Analysis**

Peter Clinch* and Anthony Murphy**

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Abstract

Contingent Valuation is now the most widely used method for valuing non-marketed goods in cost benefit analysis. Yet, despite the fact that many externalities manifest themselves as costs to some and benefits to others, most studies restrict willingness to pay (WTP) to being non-negative. This paper explores appropriate welfare measures for assessing losses and gains and demonstrates how these can be elicited explicitly. Statistical / econometric methods are presented for modelling such responses. Median WTP is estimated non-parametrically. Grouped regression / Tobit and grouped regression / hurdle models are used to identify the determinants of WTP and to estimate mean WTP.

Keywords: contingent valuation, public good, public bad, externality, welfare measures, cost benefit analysis, non-parametric distribution, Tobit, hurdle model.

JEL Classification: C24, H41, Q26

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I. INTRODUCTION

Since the judgement of an expert panel chaired by Kenneth Arrow and Robert Solow (Arrow *et al.*, 1993) that Contingent Valuation "can produce estimates reliable enough to be the starting point of a judicial process of damage assessment, including passive-use values", this technique has become the most widely used method for placing values on non-marketed goods in cost benefit analysis. The results of such studies are often used as a basis for policymaking particularly in relation to environmental policy. In a contingent valuation study, representative members of a population are asked in a survey to place a value on such a good. In line with the recommendations of the Panel, most contingent valuation studies now use a dichotomous (binary) choice format for eliciting willingness to pay. This presents the respondent with a "price" for a change in the level of provision of a public good which they must agree or not to pay. This approach is considered to be more incentive compatible than an open-ended question and avoids the bias introduced by a payment card. In these studies, willingness to pay is often assumed to be strictly positive. However, in many cases this assumption is inappropriate and may lead to substantial errors when policy decisions are made using the results of such studies.

A feature of many private goods is that only a subset of all consumers buy them even at a zero price and there is no reason why this should not also be the case for public goods (Kriström, 1997). If one is indifferent between consuming a good and not consuming it, whether it is marketed or otherwise, one's willingness to pay for the good will be zero. Moreover, depending on one's tastes etc. the consumption of a good may increase or decrease one's utility e.g. some individuals enjoy a trip on a rollercoaster while others would find such a trip thoroughly unpleasant. The same can be said for public goods e.g. the re-introduction of wolves in an area would increase the utility of those who like wolves but decrease the utility of farmers whose sheep fall prey to the wolves (all else being equal). However, while an individual can choose not to consume a private good they cannot choose to avoid consuming a public bad.

Despite the fact that the implementation of many proposed projects and policies would result in both winners and losers, contingent valuation surveys using the dichotomous choice format have generally restricted willingness to pay to being non-negative. This paper explores appropriate welfare measures for use in contingent valuation when the externalities of a project manifest themselves as costs to some and benefits to others (Section II). It also examines methods of elicitation of such values (Section III). These methods are then applied to an example (Section IV). Appropriate statistical / econometric methods are presented for modelling positive, negative and zero willingness to pay responses (Section V). Median willingness to pay may be estimated non-parametrically. In the parametric approach, grouped regression / Tobit and grouped repression / hurdle models are used to examine the determinants of willingness to pay and to estimate mean willingness to pay. The estimates are shown to be sensitive to the distribution function. Finally, some conclusions are presented (Section VI).

II. WELFARE MEASURES

Two consumer's surplus measures can be elicited via the Contingent Valuation Method. Hicksian Compensating Variation (CV) measures the maximum an individual is willing to pay (WTP) for a specified increase in the quality of a public good or their minimum willingness to accept (WTA) compensation for a deterioration in the quality of a public good. Hicksian Equivalent Variation (EV) measures the minimum compensation an individual requires to forgo an increase in the quality of a public good or an individual's maximum WTP to avoid a decrease in the quality of a public good.

When valuing an increase in the quality of a public good, the appropriate measure is CV, i.e. we elicit in a contingent valuation survey the respondent's WTP for the improvement. However, if the public good also exhibits features of a public bad, an appropriate consumer's surplus measure must be chosen which can measure the loss of utility as a result of an increase in its provision. Willig (1976) suggested that the difference between WTP and WTA should be relatively small and thus either measure would be appropriate. Randall and Stoll (1980) extended Willig's analysis of price changes to cover quantity changes where expenditures on the good were a small proportion of income. They

suggested that, in contingent valuation experiments, the difference between WTP and WTA should not be more than 5%. However, contingent valuation surveys have shown there to be substantial differences e.g. Hammack and Brown (1974) showed that WTA amounts were over four times greater than WTP amounts for the same amenity. Some commentators saw this as demonstrating the lack of reliability of contingent valuation studies.

Practical reasons for such divergences between WTP and WTA in contingent valuation surveys have been put forward¹. These include rejection of the WTA property right such that respondents do not accept the property right implied by the question e.g. they may refuse to 'sell' the environmental asset at any price, regarding this as unethical. More frequently, individuals do not see the property right as plausible e.g. they may be asked how much compensation they would accept for the deterioration of air quality in their area, however, if they have never been compensated for environmental damage in the past, they may see this as implausible. This tends to result in 'protest' and / or enormous bids. Under conditions of uncertainty, risk-averse individuals will offer smaller WTP amounts and larger WTA amounts than they would under certainty (the Cautious Consumer Hypothesis). According to Prospect Theory, the value function is steeper for losses than for gains from a neutral position, i.e. people value a loss more highly than a gain since the former is considered the loss of a 'right' and the latter may be considered only as a 'bonus'.

If divergences between WTA and WTP were merely the result of practical difficulties in contingent valuation procedures, WTP to avoid the provision of a public bad could be used as a proxy for WTA when measuring welfare losses resulting from a public good which also exhibits features of a public bad. Indeed, the NOAA Panel (1993) recommends that the WTP format be used instead of WTA. However, Hanemann (1991) shows that the analyses of Willig (1976) and Randall and Stoll (1980) are not appropriate to all public goods and that there is a theoretical explanation for differences between WTA and WTP. He demonstrates that for unique and irreplaceable environmental goods which have low substitution elasticities, WTA should be greater than WTP. In addition, where there is

a significant income effect, even with an elasticity of substitution close to one, the divergence between WTP and WTA is to be expected. Moreover, he shows there to be a theoretical explanation for WTA to be more than five times greater than WTP. However, Hanemann's analysis shows that where the environmental good in question is substitutable (the elasticity of substitution is not very low), and the individual's WTP is not a large proportion of their income (the income effect is not substantial), WTP and WTA should not differ very significantly.

Given the practical difficulties of eliciting WTA compensation for a public bad in a contingent valuation survey, the question arises as to whether WTP to avoid a public bad is an appropriate proxy. From the above analysis, we can say that WTP will be a valid proxy for WTA when the public good / bad is not unique and irreplaceable and when WTP is unlikely to be a large proportion of income. Moreover, Mitchell and Carson (1989) suggest that where the public already pays for the provision of public goods, WTA would be an inappropriate measurement for a reduction in the quality or quantity of such goods. Rather, the appropriate measure is the amount of income the consumer is willing to pay to forgo the reduction in the quality or quantity of the good.

III. ELICITATION METHODS

The most commonly used approach for allowing welfare losses in contingent valuation has been to ask respondents for their willingness to pay for an increase in the provision of the public good / bad and then to allow for negative bids by the choice of valuation functional form for parametric estimators, i.e. to make assumptions regarding the negative tail of the distribution of willingness to pay. However, this approach does not allow respondents themselves to bid negative amounts and therefore the results may be inaccurate.

A second possible approach is to split the sample and ask one sub-sample their willingness to pay for an increase in the public good / bad and the other sub-sample their willingness to pay to avoid an increase in the public good / bad. This approach has three disadvantages. Firstly, splitting the sample

¹ See Mitchell and Carson (1989) and Bateman and Turner (1993).

is likely to require a larger total sample to achieve robust results. Secondly, the analysis still requires assumptions regarding zero bids, i.e. it is necessary to decide which of the zero bids would actually be negative bids (if the respondents had been in the other sub-sample), which are protest bids, and which are actual zero bids. Lastly, there is a problem regarding the information given to each of the samples. To ensure that the results are not biased, each sample must be given the same information, e.g. in the case of a change in the landscape, they could be told that such a change could be considered as good or bad depending on one's own personal opinion. Having received such information, it may then seem peculiar to a respondent who believes the change to be bad, if he or she were then asked to pay for the change and vice versa. Given uncertainty regarding the way a population may divide on the question of the effects of an environmental change and the difficulty of interpreting zero bids, this approach is somewhat deficient.

Kriström (1997) has already pointed out the importance of allowing for winners and losers and has gone some way to providing a useful technique for distinguishing between zero and positive bids. However, while the new question format suggested by him allows for winners and losers to be identified, his "Bromma-study" does not enable the magnitude of negative willingness to pay to be assessed explicitly. The author suggests that his approach is "incomplete". The application that follows shows how positive, zero and negative bids can be assessed using a binary choice format. In addition, it suggests appropriate methods for modelling the data econometrically.

IV. APPLICATION

In 1996, the Irish Government published a strategy to increase Ireland's forest estate from just 8% of the total land area of the State to 18% by the year 2030 at a total cost of nearly US\$4.4 billion. It is proposed that the funding, 75% of which would be provided by the European Union (EU) under the Community Support Framework, be used to extend existing schemes which provide grants to those planting trees. In most countries, forests are viewed as public goods and they provide a range of external benefits such as carbon sequestration, recreational opportunities, aesthetic benefits and wildlife habitats. However, in Ireland there has been no forestry tradition amongst the general public.

Most of the indigenous forests had been cleared by the end of the 17th century and while modest estate forestry emerged in the 18th and 19th centuries, this was often viewed as an avocation of the "occupying" landlord class. Since the 1980s, the introduction of EU subsidies has resulted in a rapid increase in afforestation of coniferous, non-indigenous plantation forestry. There has been considerable controversy regarding the external effects of this type of forestry particularly with regard to its landscape impact. Some believe plantation forests improve the environment while others disagree strongly. Thus, in order to value net external benefits of afforestation as part of an overall cost benefit analysis of the Government's strategy for the forestry sector, it was necessary to develop a valuation procedure which could measure both increases and decreases in utility.

Questionnaire Design

To allow for explicit negative bids, the respondents were given some background information regarding forestry in Ireland, i.e. information on the extent of the forest estate in Ireland, the rate of increase of planting, the species type and location of planting. They were then presented with the conflicting opinions regarding the effects of forestry on the environment. The first opinion presented was that more forestry of the type being planted at present is good for the environment. The alternative view presented was that more forestry of the sort being planted will spoil the natural environment. The respondents then were asked for their opinions regarding the effects of afforestation on landscape, wildlife and recreation. Finally, they were asked whether they believed that, on balance, more forestry would be good for the environment.

Those who responded in the affirmative were considered to be likely to experience either no change or an increase in utility if more forests were to be planted and thus would be likely to be willing to pay a zero or positive amount for an increase in the forest estate. Those who responded negatively were considered to be likely to experience no change in utility or experience a disutility if more forests were to be planted and thus would be likely to pay a zero or positive amount to *avoid* an increase in the area of forests. The respondents were thereby 'filtered' such that each group was placed in a

different contingent market. Figure 1 gives a simple outline of the filtering process and the structure of the questionnaire. The requirement for such a process clearly rules out the use of a mail survey.

- Figure 1 About Here -

Respondents with a positive view of forestry were asked whether they would approve of a Government programme to double the forest estate over the next 35 years. The scenario presented was specified such that it mirrored actual plans as put forward in the Irish Government's Strategic Plan for the forest sector. This provided the rationale for payment by the respondents as it was stated that subsidies would be used to compensate those who plant forests for the environmental benefits they provide. The willingness pay on the part of those who approved of the scheme was then assessed.

Meanwhile, those with a negative view of forestry were asked whether they would approve of a government scheme which would give subsidies to landowners to keep land in its present use which would effectively limit any substantial increase in the land area covered by forests over the next 35 years. The scheme suggested would be an expansion of the existing Rural Environmental Protection Scheme. The willingness to pay of those answering in the affirmative was then assessed. In this way, negative willingness to pay was measured. Thus, Compensating Surplus² (willingness to pay for a benefit) was used to assess the benefits of an expansion in the forest estate while Equivalent Surplus (willingness to pay to avoid a cost) was used to assess the costs.

Based on the earlier analysis of appropriate welfare measures, it seems reasonable to assume that WTP to avoid more forestry will be a valid proxy for WTA. The agricultural land which would be replaced is not unique and the damage is not irreversible such that the elasticity of substitution is not likely to be very low. WTP is not likely to be a large proportion of income. In addition, since the principal competing land use is subsidised and, therefore, the public already pays for its provision,

the appropriate measure is the amount of income the consumer is willing to pay to forgo the reduction in the quantity of the good.

Subsidies for forestry will be funded from the exchequer and thus a rise in income tax was considered to be the payment method that respondents would find most realistic. However, it was necessary to adjust for households which did not pay income tax. Such households might have been very willing to support an increase in income taxes since they would not have had to pay such an increase. To correct for this, the payment vehicle was specified as income tax for income tax payers and specified as a reduction in social welfare receipts for social welfare recipients.

The (single-bounded) dichotomous choice elicitation format was used. The respondents were informed that the programme was estimated to cost £X per household each year for ten years and they were asked whether their household would be willing to pay this amount. After carrying out a pilot survey the bid vector chosen was (£5, £15, £30, £50, £100³). It was decided not to ask for a lump sum as it would seem unrealistic that the Government would suddenly raise taxes for one year only. In addition, households have usually made their financial planning decisions early in the year so a yearly amount would avoid answers such as "I could pay it next year but not this year". Ten years was chosen as the length of payment since it was thought that respondents might find it difficult to think of financial consequences any further into the future.

A follow up question to a positive response to a willingness to pay question was included to check that the respondent was willing to pay the specified amount purely for the programme in question and no other environmental programme. Questions regarding sex, age group, education, household composition (numbers of adults and children), attitude to protecting the environment, and (log) household income, were combined with data on whether the respondents were from urban or rural areas, their geographical area, and whether the counties in which they live are relatively forested or

³ "£" denotes Irish Pound which equals St£0.86 and US\$1.41 at time of writing. A larger number of bid levels would have allowed for greater accuracy in the estimation of the bid curve but each subsample would have been smaller leading to greater sampling error.

² We use the term surplus since the consumer is constrained to consume discrete quantities of the goods.

unafforested, and included as potential covariates with willingness to pay. In order to check for consistency, questions which elicited the attitudes of respondents to the environmental effects of forestry were included prior to the elicitation of their willingness to pay for the good.

Survey Implementation

The questionnaire was attached to the EU Consumer Survey⁴ and a random sample of the population was surveyed. The Consumer Survey is a "mixed mode" survey (telephone and personal interview) which gauges public opinion regarding economic issues and elicits consumers' short and medium term purchasing intentions. This includes collecting data on the public's perception of past and future trends with regard to the general economic situation, consumer prices and the financial situation of the respondent household. Thus, by the time the respondents were asked questions regarding their willingness to pay for forestry they had been more than adequately reminded of alternative expenditure possibilities and of their household budget constraint.

The survey was carried out in two parts, in October 1996 and March 1997, to allow for consistency checks to be carried out. A 78% response rate was achieved resulting in a total effective sample of 2,895 households. Out of the total sample, 1.7% registered protest bids, 0.09% failed the embedding check and 2.8% failed to answer the required questions and 29% disagreed with the subsidy scheme with which they were presented. The remainder presented legitimate answers to the willingness to pay questions. Of these, 81.7% was in contingent market 1 (WTP for more forests) while the remainder was in the second contingent market (WTP to avoid more forests).

V. ECONOMETRIC MODELS AND RESULTS

For the remainder of the paper, "WTP" denotes willingness to pay for more forests while "NWTP" represents the absolute value of negative WTP, i.e. willingness to pay to avoid more forests.

⁴ The survey was carried out by a professional survey unit.

(a) Non-Parametric Estimates of WTP / NWTP Distributions

It is useful to start by looking at non-parametric estimates of the survival functions of WTP and NWTP. Using the methods in Ayer *et. al.* (1955) and Turnbull (1976) which have previously been used in contingent valuation by Kriström (1990) we obtained the results shown in Table 1. There are a lot of bids at both ends of the distributions - zero bids and bids above the maximum amount of £100 p.a. There is some tendency in the data for individuals randomly assigned higher bid amounts to report a zero bid rather than some intermediate amount.

- Table 1 About Here -

Note the large number of bids above the maximum amount of £100 p.a. This means that, using these data, it will be somewhat difficult to estimate with precision any parametric model with a long upper tail. It also means that estimates of mean WTP or NWTP will be sensitive to the choice of parametric model, since these measures depend on the areas in the upper tails of the distributions. This is why median WTP is often used instead of mean WTP.

- Table 2 About Here -

An estimate of the non-parametric survival function for WTP and NWTP combined is shown in Table 2. It is clear that median net willingness to pay is in the region of £30 per annum. Protest bids were omitted in the preparation of Tables 1 and 2 since it is not obvious what, if any, WTP or NWTP values could be imputed to individuals who reject the schemes designed to elicit their bids. If the incidence of protest bids is assumed to be randomly distributed across individuals and if one assumes that the distributions of WTP / NWTP are the same for protestors as for others (see section b), the estimated median value of WTP and NWTP combined is £10. The reason for this lower median figure is the much higher incidence of protest bids amongst those who thought that more forests constituted a public bad.

These results may be sufficient for some purposes but if one is interested in the determinants of WTP / NWTP, the data need be to be modelled parametrically as noted by Cameron and James (1987) and Cameron (1988)⁵.

(b) Model Structure

It is difficult to imagine any set of continuous preferences which could generate the large number of zero bids in Table 2. Therefore, we do not specify some underlying utility function with a stochastic term and then derive WTP and NWTP functions from it. Instead we adopt a more econometric or statistical approach to modelling the data. At the first stage, we model whether the individuals in the sample believed more forests were a good outcome or a bad outcome. Then at the second stage, we model WTP and NWTP separately, paying particular attention to the zero bids⁶. The structure of our model is set out in Figure 2 and is similar to the structure of the extended spike model in Kriström (1997).

- Figure 2 About Here -

(c) Spike and Hurdle Type Models

We estimate a probit equation for the first stage of the model set out in Figure 2. The second stage is modelled using a grouped regression / Tobit like estimator or a grouped regression / hurdle like estimator. The hurdle model, devised by Cragg (1971), generalises the Tobit model by allowing the process or latent regression generating the zero (bid) outcomes to differ from the process or latent regression generating the positive (bid) outcomes.

⁵ Considerably more data and a much larger number of bid amounts would be required to estimate some sort of non-parametric regression.

⁶ Note that a large number of individuals objected to the proposed tax and subsidy schemes designed to elicit their WTP / NWTP - 18.8% of those who believed more forests were a good option and 54.5% of those who believed more forests were a bad option. Probit equations were used to model the incidence of protests. In the more forests are good case, younger people were significantly more likely to object and people living in highly forested counties were significantly less likely to object to the proposed scheme. In the more forests are bad case, people living in urban areas were significantly more likely to object and people who thought it was very important to protect the environment were significantly less likely to object. The pseudo R²s in the two probit equations were 0.04 and 0.12. In the case of WTP, this suggests that the incidence of protests appears to be fairly random.

Another advantage of hurdle or double hurdle type models is that they are widely used and well understood in the micro-econometrics literature. In fact, the spike model advocated by Kriström (1997), *inter alia*, is just a special case of a hurdle model and so is not, as is sometimes suggested, a new statistical method for handling zero bids. In estimated spike models, the probability of a zero bid is treated as an unknown constant whereas in hurdle models this probability is parameterised

(d) The Basic Model

We will outline the simpler grouped regression / Tobit-like estimator first. Consider some individual i who believes that more forests is a good option (and who also accepts the proposed scheme for paying for more forests). Let y_i denote individual i 's latent WTP or, more generally, some transformation of it. Latent WTP may be positive or negative. In the latter case, one believes that more forests are a good option but, for whatever reason, is not prepared to pay anything for it. We assume that latent WTP y_i is a linear function of the product of some vector of observable explanatory variables x_i and associated coefficients β and a random error term u_i :

$$y_i = x_i' \beta + u_i$$

Now let $F(\cdot)$ denote the cumulative distribution function of the random error term u_i / δ , where δ is some scale term which may be equal to the standard deviation of u_i .

When modelling the data, we only consider three possible outcomes types - zero bids, bids in some range $[a, b)$ or bids above some amount b . The amounts a and b are equal to £5, £15, £30, £50, £100 (or transformations of known amounts when WTP is transformed). The probabilities of these three outcomes are then equal to $F((-x_i' \beta) / \delta)$, $F((b - x_i' \beta) / \delta) - F((a - x_i' \beta) / \delta)$ and $1 - F((b - x_i' \beta) / \delta)$ respectively. Since our sample is random, the log-likelihood is simply obtained by summing the logs of the probabilities of the outcomes observed for each individual. Once the form of $F(\cdot)$ is specified, the unknown parameters β and δ may be estimated by the maximum likelihood method or some other consistent method.

In the grouped regression / Tobit like case, we assume $F(\cdot)$ is either the standard normal or the extreme value distribution function⁷. Since the extreme value distribution is an asymmetric distribution with a somewhat fatter right-hand side tail than the standard normal, we use it to examine the sensitivity of our results when we allow some departure from the standard normal distribution. In the case of the standard normal distribution, mean WTP for individual i equals

$x_i' \beta + \sigma \phi(-x_i' \beta / \sigma)$ where $\phi(\cdot)$ is the standard normal probability density function. In the case of

the extreme value distribution, individual i 's mean WTP equals $\int_0^\infty \bar{F}((s - x_i' \beta) / \delta) ds$ where

$\bar{F}(\cdot) = 1 - F(\cdot)$. This expression is easily evaluated numerically once β and δ have been estimated.

(e) Extending the Basic Model with a Hurdle

Now consider the grouped regression / hurdle type estimator. The model may be set up using a pair of latent regression equations as in Cragg (1971) but we skip over this here. The hurdle refers to the zero bid / positive bid distinction. The probability of a zero bid is assumed to be $G(-z_i' \gamma)$ and the probability of a positive bid is $1 - G(-z_i' \gamma)$ where $G(\cdot)$ is some probability distribution function, z_i is some vector of observed explanatory variables and γ is the associated vector of coefficients⁸. In practise, we assume $G(\cdot)$ is the standard normal distribution function so we use a probit to model the incidence of zero and positive WTP / NWTP bids.

The positive bids may be modelled in a number of ways. In one approach, the conditional probability of observing a bid in the range $[a, b]$ is

$[F((b - x_i' \beta) / \delta) - F((a - x_i' \beta) / \delta)] / [1 - F(-x_i' \beta / \delta)]$ when a and b are known amounts.

⁷ When the random variable w has an extreme value distribution with location and scale parameters λ and δ , $F(k) = \text{prob}(w \leq k) = \exp(-\exp(-(k - \lambda) / \delta))$. The mean and variance of z are approximately equal to $\lambda + 0.577226$ and 1.644936^2 . In practise, we use $x_i' \beta$ in place of λ for individual i .

⁸ When $G(\cdot) = F(\cdot)$, $z_i = x_i$ and $\gamma = \beta / \sigma$, the grouped regression / hurdle type model collapses down to the simpler grouped regression / Tobit type model already discussed.

Likewise, conditional on the bid being positive, the probability of observing a bid of more than b is $[1 - F((b - x_i' \beta) / \delta)] / [1 - F(-x_i' \beta / \delta)]$. The non-negativity of the bids is guaranteed by truncating the distributions at zero. However, as noted by Cragg (1971), this is a little artificial. In practise, we had difficulty getting the constant and δ coefficient estimates to converge when this sort of model was estimated. Therefore we used an alternative approach which does not involve any truncation.

We assume that the distribution function $F(\cdot)$, which is not equal to $G(\cdot)$, is one which only assigns positive probabilities to positive bids. In particular we assume that $F(\cdot)$ is either the Weibull or the log-normal distribution function. When we work with the logs of the bid amounts, we are of course using the extreme value and normal distribution functions⁹. The log-normal distribution has a much longer right-hand side tail than the Weibull distribution, which has implications for estimating individual i 's mean WTP / NWTP.

The conditional probability of observing a bid in the range $[a, b]$ and a bid of more than b are now $F((\ln b - x_i' \beta) / \delta) - F((\ln a - x_i' \beta) / \delta)$ and $1 - F((\ln b - x_i' \beta) / \delta)$, when a and b are known amounts. Note that the bids amounts are logged and, as a result of this transformation, $F(\cdot)$ is now either the extreme value or the normal distribution (corresponding to the Weibull and log-normal distributions in levels). Individual i 's mean WTP / NWTP is readily calculated. It equals $(1 - G(-z_i' \gamma)) \exp(x_i' \beta) \Gamma(1 + \delta)$ in the Weibull case and $(1 - G(-z_i' \gamma)) \exp(x_i' \beta + \sigma^2 / 2)$ in the log-normal case when $\delta = \sigma$.

The Weibull and log-normal distribution function based grouped regression / hurdle type models are easily estimated by the maximum likelihood method. The unknown parameter γ can be estimated by looking only at whether the observed bids are zero or positive whereas the parameters β and δ or

⁹ Suppose the non-negative random variable w has a Weibull distribution with scale and shape parameters $\exp(\lambda)$ and $1/\delta$. Then w has an extreme value distribution with location and scale parameters λ and δ . The mean and variance of w is $\exp(\lambda) \Gamma(1 + \delta)$ where $\Gamma(\cdot)$ is the gamma function. In practise, we use $x_i' \beta$ in place of λ for individual i .

σ can be estimated using only positive bids. Unfortunately the two hurdle models which we used do not nest the grouped regression / Tobit models as special cases. As a result, model selection has to be based on one's priors, non-nested tests or the use of an information criterion such as the Akaike Information Criterion (AIC).

(f) Explanatory Variables

The standard set of explanatory variables used in all the models consists of the following: sex; age group (four categories); number of adults and children in the household; urban / rural area; location (three areas - Dublin, rest of the Eastern region and the rest of the country); level of afforestation (high / medium / low); education level (five categories); importance attached to protecting the environment (very important, important and not important). Economic activity, occupation and household income variables are not included in most of the models presented here. This means that education, for example, may be proxying income. We do, however, examine the effects of income on WTP and NWTP.

(g) Implications of Grouped Income Data

Our income data are grouped. When examining the effect of income on WTP / NWTP, the simplest approach is to include dummy variables for the various income bands in the data. However, it is a little difficult to interpret the coefficients on the income dummy variables. Another approach is to use a two-step estimation procedure. Firstly, estimate a standard grouped regression equation for (the log of) household income. Secondly, use the resulting fitted values in place of unobserved actual (log) household income, estimate versions of the models set out by the maximum likelihood method and adjust the standard errors to account for the sampling variation introduced by the use of fitted values.

However, a minimum distance estimation procedure is more efficient. We estimated reduced form equations for WTP / NWTP along with a grouped regression equation for (log) household income and then estimated the structural parameters using the (optimal) minimum chi-squared method outlined in Ferguson (1958). The over-identifying assumptions used are that all the economic activity and

occupation dummy variables, bar one, do not appear in the structural WTP / NWTP equations and that the level of afforestation in the respondent's county and the importance they attach to protecting the environment do not appear in the household income equation. A bonus of this approach is that the minimised chi-squared criterion function may be used to test the validity of these over-identifying assumptions.

(h) Econometric Results

Some probit models results for the first stage of our model - whether or not more forests are a good option - are set out in Table 3. These results suggest that, *inter alia*, being younger, living in an urban location or a highly forested county, having a high level of education and attaching a great deal of importance to protecting the environment are significant determinants of whether or not one believes that more forests are a good option. These results are fairly plausible.

Some second stage model results for WTP are set out in Tables 4 and 5. To save space, we only present the results for the grouped regression / Tobit model using the extreme value distribution (Table 4) and the grouped regression / hurdle model using the Weibull distribution (Table 5). These are our preferred models. In any case, the same explanatory variables were significant in the results for the models which we have not reported.

- Tables 4 and 5 About Here -

In the grouped regression / Tobit model, the probability of a positive bid and the amount bid are significantly related to being male, the number of adults in the household, living in an urban area, higher levels of education and attaching a great deal of importance to protecting the environment. In the more general grouped regression / hurdle model, the same explanatory variables as well as being in the younger age group significantly affect the probability of making a positive bid. However, conditional on making a positive bid, only a subset of these factors significantly affects the amount

bid. The amount bid is significantly related to being male, the number of adults in the household and higher levels of education, possibly proxying higher income levels.

Somewhat different results are found for NWTP, albeit with a much smaller sample. In the grouped regression / Tobit model, the probability of a positive bid and the amount bid are significantly related to being male, being younger, living in an urban area or a county with a high level of afforestation and having higher levels of education. In the more general grouped regression / hurdle model, the same explanatory variables significantly affect the probability of making a positive bid. However, conditional on making a positive bid, the amount bid is only significantly related to being male, the number of adults in the household and the importance attached to protecting the environment. These NWTP results and the unreported WTP results are available on request from the authors.

- Tables 6 and 7 About Here -

We summarise our model results and estimates of mean WTP and NWTP in Tables 6 and 7. It is clear that the estimates of mean WTP and NWTP are sensitive to the choice of model and of distribution. As noted in (a) above, we expected that the results would be sensitive to the choice of distribution but we did not anticipate the extent of this sensitivity. On the basis of the AIC, models with a hurdle for WTP are preferred to models without a hurdle. Using the AIC, the hurdle model using the log-normal distribution is the "best" model. However, the estimate of mean WTP obtained using this model seems implausibly high given the £80 or so median WTP figure obtained from the non-parametric survival function in Table 1. By way of contrast, the best fitting NWTP model, in terms of the AIC, is the grouped regression / Tobit like model using the normal distribution.

It is interesting to note that mean WTP to avoid more forests was significantly higher than mean willingness to pay for more forests. This suggests that, as a result of an increase in the forest area, those who dislike forestry would, on average, endure a greater loss of utility than the average

increase in utility to those who like forestry, although the overall result would be an increase in social welfare.

An important feature of our model is the inclusion of negative as well as zero and positive bids. Now suppose that, because of the survey design and / or the econometric model used, no negative bids were allowed and, instead, that all negative bids were coded as zero bids (as opposed to protest bids which are essentially ignored). In this situation, we can examine what happens to the estimated mean WTP figures in Table 6. As expected, all four figures fall - they become £78.9 (normal), £91.5 (extreme value), £464.9 (log normal) and £165.3 (Weibull). However, these figures are not comparable with the WTP figures in Table 6. Instead they should be compared with net WTP figures obtained by taking a weighted average of the WTP figures in Table 6 and (the negatives of) the NWTP figures in Table 7. The comparable net WTP figures are £53.1 (normal), £69.5 (extreme value), £317.9 (log normal) and £106.6 (Weibull). In all cases, ignoring negative bids, results in a significant overestimate of net WTP.

- Table 8 About Here -

Using the approach set out in (g) above, we estimated the effects of income on WTP and NWTP. These are reported in Table 8. The over-identifying restrictions in the more general model with a hurdle were decisively rejected. The test statistic for the over-identifying restrictions in the basic Tobit type model was borderline. A significant income effect was found for NWTP but not WTP. The results for the Tobit type model suggest that WTP is income inelastic, albeit not significantly so, and that NWTP is income elastic. Not too much should be read into these results, given the small NWTP sample size etc., but they correspond with the results obtained using income dummy variables. Evidence supporting the view that that the income elasticity of environmental improvement may be less than one has been put forward by Kriström and Riera (1996).

VI. CONCLUSIONS

This paper has demonstrated the rationale for allowing for winners and losers in contingent valuation. In addition, it has shown how appropriate measures of welfare gains as well as losses can be elicited in dichotomous choice contingent valuation. The results of the application show that, if explicit positive and negative valuations had not been facilitated, the value of the project in question would have been significantly overestimated. This shows that substantial errors can be made when losers from a project or policy are ignored. Since contingent valuation is now being used as a basis for policymaking, particularly in the relation to the environment, such errors may lead to welfare losses to society as a whole when a project is deemed to pass a cost benefit test as a result of welfare losses being ignored. We believe this result suggests that, in addition to the best practise guidelines set out by Arrow *et al.* (1993), another guideline is merited, i.e. where it is considered that a project or policy may result in winners and losers, the elicitation format used should enable respondents to make explicit positive and negative bids.

Having successfully elicited both positive and negative bids from a dichotomous choice contingent valuation survey their distribution may be modelled non-parametrically or parametrically. Both approaches are straight forward. If one is only interested in median WTP, the non-parametric approach is sufficient. If one is interested in the determinants of WTP, a parametric approach is generally required. A grouped regression / Tobit or grouped regression / hurdle model may be used. The hurdle version of the model allows the process or latent regression generating the zero bids to differ from the process or latent regression generating the non-zero bids. Spike models are just a special case of a hurdle model. In the parametric approach, estimates of mean WTP are sensitive to the choice of distribution function for WTP when many bids obtained are larger in absolute value than the maximum bid amount used in the survey.

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Figure 1

Outline of Main Body of Contingent Valuation Questionnaire.

Figure 2
Model Structure.

Table 1

Non-Parametric Estimates of the WTP and NWTP Survival Functions

Bid Amount	Zero	£5	£15	£30	£50	£100	Sample
WTP	0.745	0.732	0.682	0.623	0.537	0.480	1543
NWTP	0.622	0.611		0.521		0.442	344

Table 2

Non-Parametric Estimate of the Survival Function of WTP and NWTP Combined

-£100	-£50	-£30	Zero	£5	£15	£30	£50	£100
0.911	0.895	0.877	0.594	0.584	0.544	0.497	0.429	0.383

Table 3

More Forestry is a Good Option - Probit Results

Explanatory Variables		Including "Protest" Bids			Excluding "Protest" Bids		
		Coeff	t Stat	Marginal Effect	Coeff	t Stat	Marginal Effect
Constant		-0.546	-3.4	-	0.413	1.4	-
Male		-0.010	-0.2	-0.3%	-0.044	-0.6	-1.1%
Age Group	16-29	0.496	4.7	16.3%	0.664	4.3	16.3%
	30-49	0.069	0.8	2.3%	0.093	0.7	2.3%
	50-64	-0.055	-0.6	-1.8%	-0.001	-0.1	0.0%
Household Composition	Number of Adults	0.070	2.3	2.3%	-0.029	-0.6	-0.7%
	Number of Children	0.009	0.4	0.3%	-0.001	-0.0	-0.0%
Area	Urban	0.188	3.0	6.2%	0.514	6.0	12.6%
	Dublin	0.396	1.9	13.0%	0.231	0.9	5.7%
	Rest of Eastern Region	0.402	4.2	13.3%	0.268	2.1	6.6%
Level of Afforestation in respondent's county	High	-0.327	-4.7	-10.8%	-0.292	-3.0	-7.1%
	Medium	0.109	1.3	3.6%	0.019	0.2	0.4%
Education Level*	Intermediate Certificate	-0.026	-0.3	-0.9%	-0.121	-1.0	-3.0%
	Leaving Certificate	-0.138	-1.7	-4.5%	-0.314	-2.7	-7.7%
	Other Second Level	-0.092	-0.9	-3.0%	-0.176	-1.2	-4.3%
	University Level	-0.274	-3.2	-9.0%	-0.328	-2.7	-8.1%
Protecting the Environment	Very Important	0.961	6.6	31.6%	0.497	1.9	12.2%
	Important	0.630	4.2	20.7%	0.444	1.7	10.9%
Number of Observations		2838			1874		
Log Likelihood		-1645.5			-813.8		
Mean of Dependent Variable		0.69			0.82		
Percentage Correct Predictions		71.2%			81.7%		
Pseudo R ²		0.074			0.072		

*Secondary school is equivalent to US high school. Intermediate and Leaving Certificates are taken at ages 14/15 and 17/18 respectively.

Table 4

WTP - Grouped Regression / Tobit Like Model Results - Extreme Value Distribution

Explanatory Variables		Coefficient	t Statistic
Constant		-177.1	-4.2
Male		11.18	1.7
Age Group	16-29	18.72	1.4
	30-44	3.85	0.4
	45-59	10.16	0.8
Household Composition	Number of Adults	12.90	3.3
	Number of Children	1.43	0.5
Area	Urban	38.45	4.5
	Dublin	7.53	0.3
	Rest of Eastern Region	-19.84	-1.5
Level of Afforestation	High	8.40	0.9
	Medium	-10.09	-1.0
Education Level	Intermediate Certificate	26.06	2.4
	Leaving Certificate	26.90	2.5
	Other Second Level	39.05	2.9
	University Level	46.88	4.0
Protecting the Environment	Very Important	127.21	3.4
	Important	88.11	2.3
Extreme Value Scale Parameter *		100.42	15.5

Number of observations = 1510, log likelihood = -1459.5.

Table 5

WTP Grouped Regression / Double Hurdle Like Model Results - Weibull Distribution with Probit Hurdle

Explanatory Variables		Hurdle Zero/Positive Bids		Positive Bids	
		Coeff	t Stat	Coeff	t Stat
Constant		-1.45	-4.4	3.41	3.8
Male		0.08	1.2	0.45	2.6
Age Group	16-29	0.28	1.9	-0.29	-0.8
	30-44	0.10	0.8	-0.52	-1.5
	45-59	0.15	1.1	-0.30	-0.9
Household Composition	Number of Adults	0.13	2.9	0.17	1.8
	Number of Children	0.02	0.8	-0.02	-0.3
Area	Urban	0.42	4.5	0.17	0.8
	Dublin	0.17	0.6	-0.82	-1.7
	Rest of Eastern Region	-0.17	-1.2	-0.38	-1.1
Level of Afforestation	High	0.07	0.7	0.38	1.4
	Medium	-0.04	-0.3	-0.37	-1.4
Education Level	Intermediate Certificate	0.29	2.6	-0.02	-0.1
	Leaving Certificate	0.24	2.1	0.49	1.8
	Other Secondary	0.39	2.6	0.51	1.4
	University Level	0.50	4.0	0.38	1.3
Protecting the Environment	Very Important	1.24	4.3	1.61	2.0
	Important	0.85	2.9	0.99	1.2
Weibull Shape Parameter δ		-	-	1.07	10.3

Probit hurdle: number of observations = 1510, log likelihood = -796.6, mean of dependent variable = 0.75, percentage correct predictions = 75.6%, pseudo R^2 = 0.08.

Positive bids: number of observations = 1127, log likelihood = -633.4.

Table 6

Estimates of Mean WTP

Model		N	K	LL	AIC	WTP
Grouped Regression / Tobit	Normal	1510	19	-1465.2	1.966	90.2
	Extreme Value	1510	19	-1459.5	1.958	104.4
Grouped Regression / Double Hurdle	Log Normal	1510 / 1127	18 + 19	-1413.8	1.921	602.9
	Weibull	1510 / 1127	18 + 19	-1430.0	1.943	214.6

Notes: N = number of observations, K = number of parameters, LL = log likelihood, AIC = Akaike information criterion = $-2 (LL - K) / N$.

Table 7

Estimates of Mean NWTP

Model		N	K	LL	AIC	NWTP
Grouped Regression / Tobit	Normal	337	19	-276.5	1.966	113.1
	Extreme Value	337	19	-282.0	1.958	86.9
Grouped Regression / Double Hurdle	Log Normal	337 / 210	18 + 17	-268.2	1.921	958.6
	Weibull	337 / 210	18 + 17	-268.8	1.943	377.3

See notes to Table 6.

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Table 8
Estimated Income Effects

Model and Distribution	WTP / NWTP	Effect	Coeff	t Stat
Tobit - Extreme Value	WTP	$\partial \text{WTP} / \partial \ln y$	22.95	1.3
	NWTP	$\partial \text{NWTP} / \partial \ln y$	206.21	3.1
Hurdle - Weibull	WTP	$\partial \text{Prob}(\text{WTP} > 0) / \partial \ln y$	0.55	2.8
		$\partial \text{WTP} / \partial \ln y \mid \text{WTP} > 0$	-0.65	1.4
	NWTP	$\partial \text{Prob}(\text{NWTP} > 0) / \partial \ln y$	1.80	4.1
		$\partial \text{NWTP} / \partial \ln y \mid \text{NWTP} > 0$	4.14	2.1

Notes: The minimised chi-squared criterion functions were 24.61 (14 d.f.) and 56.96 (30 d.f.) in the two models. The associated P values are 3.9% and 0.2% respectively.

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