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MODELLING ZERO BIDS IN CONTINGENT VALUATION SURVEYS

Summary

When modelling data generated from a discrete choice contingent valuation question, the treatment of zero bids affects the welfare estimates. Zero bids may come from respondents who are not interested in the provision of the public good; alternatively, some zero-bidders may be protesting about the valuation exercise, but hold positive values for the good. In this paper we investigate the effect of different levels of information on zero-bidders on welfare estimates for the population. We find that different strategies of identification may have non-trivial effects. We recommend use of full debriefing questions for zero-bidders, and use of sample selection models to correct for bias caused by protest behaviour.

Non Technical Summary

The contingent valuation method consists in eliciting the reservation price of sampled individuals for some change in the provision of a public good. If negative bids are ruled out, a combination of zero and positive values is elicited. Any members of the population with strictly increasing preferences for the good may be assumed to have positive reservation prices, while those that are indifferent to the good may be assumed to hold zero values.

Unfortunately, it may turn out that some zero bids may be motivated by protest behaviour, and do not convey correct information on the respondents' preferences. It is crucial that the questionnaire contains elements that helps to discriminate between individuals that are not interested in the public good, and protesters. Individuals belonging to the second group hold positive values, that may, or may not, be distributed as those of non zero-bidders. In fact, the presence of protest responses may introduce a selectivity bias in the estimation process, and produce biased estimates of welfare benefits. A sample selection model is therefore required to correct for selection bias generated by these responses.

This paper explores the effects of information on zero-bidders on the estimates of the WTP function, and the resulting welfare measures. Protest responses are modelled by means of a sample selection model, so that selectivity bias can be corrected. It is shown that different levels of information on the nature of the zero-bidders may have significant effects on the welfare estimates. It is therefore recommended that the questionnaire contains full debriefing questions for a correct identification of zero values and protest responses.

Keywords: Contingent Valuation, Zero Bids, Protest Votes, Selectivity Bias, Sample Selection Model, Survey Design.

JEL: C35, C51, C81, D60, H41, Q26.

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1. Introduction

Individual preferences for public goods may be assessed using contingent valuation (CV) methods. These techniques are commonly used to investigate public willingness to pay (WTP) for a proposed change in public good provision. If the additional provision of the public good has a non-negative impact on the welfare of any households, i.e. no part of the population is made worse off by the proposed change, it can be assumed that WTP for the proposed change is non-negative. In particular, any members of the population with strictly increasing preferences for the good may be assumed to have positive WTP, while those that are indifferent to the good may be assumed to have zero WTP for the increase in provision.

In fact, when negative WTP is ruled out, CV surveys typically elicit a combination of zero and non-zero bids across a sample population. Unfortunately, while some zero bids are a true reflection of preferences, others may be motivated by protest behaviour. Respondents may react to some component of the survey design on conceptual rather than economic grounds, and as a result signal a refusal to pay for the hypothetical change in provision. The presence of protest responses in the estimation process may produce biased estimates of welfare benefits.

In discrete choice (DC) CV studies respondents are asked whether or not they would be willing to pay a specified sum for a proposed change in the provision of the good. In such studies ad *hoc* debriefing questions may be used to distinguish between the different underlying motives for a "No" response. In a well-designed debriefing session the prevalence of one motive or another may be inferred by examining respondents' reasons for being unwilling to pay a given amount. For example, some respondents who refuse to pay any amount may be voicing an objection to increased taxation, to the current expenditure policy, or merely disbelief in the realism of the proposed change in provision. All of these reasons may give rise to protest responses.

This paper explores the effects of information on protest behaviour on the estimates of the WTP function, and the resulting welfare measures. In this case, the public good under investigation is the implementation of a traffic calming scheme that effectively reduces the speed of the vehicles in built up areas to 30 miles per hour. Effective speed reduction is deemed to be achieved when 85 percent of drivers comply with the speed limit (though by definition 15 percent of drivers still exceed it). The sample population for the study were the residents of three small towns in the North East of England, all of whom suffer from negative externalities associated with high volume through traffic.

In this context we find that the treatment of the information recorded on the motivation for zero bids has significant effects on the welfare estimates.

The remainder of the paper is organised as follows. The next section presents the theoretical background for this research and in section three the methodology adopted for the study is outlined. In section four the results of the analysis are discussed, while the final section summarises these findings and concludes the paper.

2. Theory

In the DC CV framework, individuals are questioned whether or not they would be willing to pay a specified sum for a proposed change in the provision of some public good. The method is used in two variants: the *single bound*, if only one price is proposed to each individual; and the *double bound*, where a second bid is offered, higher than the first if the answer was positive, and lower otherwise.

The scenario is similar to a standard market situation, where individuals face given prices, and decide to accept or refuse the transaction, depending on their own reservation price. In general, if the proposed hypothetical transaction underlying the DC CV question is accepted by the respondent, then it can be assumed that she is in the market for the good, i.e. is interested in the provision of the public good. Hence, a positive answer given to the valuation question can be treated as informative regarding the respondent's preference for the public good. If instead the answer is negative, or, when the double bound elicitation format is used, both answers to the bid questions are negative, the resulting information is more blurry, and can be interpreted in different ways.

A first possibility is that the respondent is interested in the public good, but holds a reservation price lower than the lower offered bid: if an appropriately low bid were offered, the transaction would have been accepted. Another possibility is that the respondent is not interested in the provision of the public good: in this case, the transaction would be rejected for all positive bids. However, the converse is not necessarily true: it is possible that the respondent rejects the transaction as a protest against some of the features of the hypothetical transaction depicted in the CV scenario.

In terms of individual WTP, the following three cases can be identified:

- some people may provide this response because their valuation of the programme is truly between zero and the lowest of the two proposed bid-amounts;
- others may have a zero valuation for the proposed policy because they are truly not in the market for the good, and therefore indifferent to the proposed change;
- finally, another group may be reacting to some elements of the CV exercise and not conveying a response motivated by economically rational preferences, but instead by a desire to protest against the proposed hypothetical transaction1. Such respondents may be in the market for the good, and their differential treatment in the estimation of the valuation function is investigated below.

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[1] While one may argue that in a well-constructed CV study these should be minimised, this problem may be of difficult resolution in the phase of survey design.

In the recent practice, contingent valuation surveys usually contain information that help to distinguish the first case from the latter two, but often no further investigation on the zero-bidders. It is the purpose of this study to show that analysis may be hampered if no other information is collected about the motivations behind the rejection of the proposed transaction.

Since additional questions make the interview more cumbersome, it is important to adopt a low-cost and effective identification procedure. In the present study -characterised by a double bound elicitation format- debriefing questions were administered to individuals who rejected both the proposed bid-amounts: i.e. "No-No" respondents.

The following possibilities are explored:

a) No further information is collected after receiving a No-No response to the WTP question;
b) A question is introduced after receiving a No-No response to the WTP question, aimed at discriminating between zero bids and positive WTP;
c) A further question is prompted to zero bidders, aimed at discriminating between zero values and protest responses.

These schemes give rise to different specifications of the decision model. This study investigates how sensitive welfare measures are to these alternative designs. The methodology is described in the next section.

3. Methodology

In the following it is assumed that the elicitation method does not produce any anchoring effect, or other possible bias: i.e., once an individual decides to signal his or her reservation price, the answers to the bid questions are expression of the true WTP. Also, the possibility of negative WTP is excluded: at worst, individuals are indifferent to the public good, holding zero values, but are not negatively affected by its provision.

This section is structured in two parts: the first part deals with the general specification of the decision models, that is dependent on the informative structure of the data defined by the three designs described above. The second part presents the particular specifications for the choice functions that have been adopted in our application.

3.1 Decision models

Design a) The setting in which no further information is collected to discriminate between zero-bidders and No-No responses can be analysed by means of a conventional double bound DC-CV, applied to the whole set of observations. This set up carries the implicit assumption that all individuals hold a positive WTP for the provision of the good. In this context, individual's choice can be seen as a one stage decision process. Assuming that each individual knows his or her reservation price for the public good, he or she compares this value to the proposed bids, and gives a positive or negative answer according to the following scheme:

$$
\begin{aligned}
&Y_1 = 1 \quad if \quad W^* > t_1 \\
&Y_1 = 0 \quad if \quad W^* \le t_1 \\
&Y_2 = 1 \quad if \quad W^* > t_2 \\
&Y_2 = 0 \quad if \quad W^* \le t_2
\end{aligned}
\qquad (1)
$$

where Y_i is the answer to the first or second question, t_i is the first or second bid, and W^* is the (latent) individual's WTP. An individual accepts the payment of the amount t if her WTP is greater than the proposed bid, and refuses to pay the amount t otherwise. This model is implemented through the following log-likelihood function:

$$\ell(q) = \sum_{i=1}^{N} (Y_{1i} Y_{2i}) \ln\left[1 - H(t^u, q)\right] + Y_{1i}(1 - Y_{2i}) \ln\left[H(t^u, q) - H(t, q)\right] + \\ + (1 - Y_{1i}) Y_{2i} \ln\left[H(t, q) - H(t^l, q)\right] + (1 - Y_{1i})(1 - Y_{2i}) \ln\left[H(t^l, q)\right] \quad (2)$$

where t indicates the first bid amount while tu and tl indicate the upper and lower follow-up bids respectively; H is a cumulative univariate distribution function, having as arguments the matrix θ of parameters and regressors, and the vector of the bids.

Design b) When the DC-CV design conveys information that identifies zero-bidders, but no further information is available to distinguish between protest responses and true zero values, zero bids will be treated as a homogeneous set. Two alternative strategies are available: either considering all zero bids as protest responses, or considering all of them as zero values.

In the first case, it is implicitly assumed that all individuals hold a positive WTP for the good. The decision process can be modelled as a two-stage sequence: first, the individual chooses whether or not to signal his true reservation price; if yes, he decides to accept or refuse the proposed bid. When the double-bound procedure is employed, the process may be represented as a sequence of three choices that can be represented by three dummy variables I, W1 and W2, and two latent variables, I_1^* and W^*:

$$\begin{aligned}
&I = 1 \quad if \quad I^* > 0 \quad Y_1 = 1 \quad if \quad W^* > t_1 \\
&I = 0 \quad if \quad I^* \le 0 \quad Y_1 = 0 \quad if \quad W^* \le t_1 \\
&\qquad Y_2 = 1 \quad if \quad W^* > t_2 \\
&\qquad Y_2 = 0 \quad if \quad W^* \le t_2
\end{aligned} \quad (3)$$

The first dummy variable I indicates whether or not an individual is in or out of the market, depending upon some latent variable I*, representing willingness to enter the market and depending upon some specified socio-economic covariates. The dummy variable W1 indicates whether or not the individual accepts or refuses the first proposed bid, and analogously W2 for the second bid. But W is observed only if I=1: the observed outcomes of W are conditioned on I=1, i.e. on the individual choosing to be in the market.

The generic likelihood for the sample observations is:

$$L = \prod_{I_1=0} P(I^* \leq 0) \prod_{I_1=1} [\prod_{Y_1=1,Y_2=1} P(I^* > 0, W^* > t^u) \prod_{Y_1=1,Y_2=0} P(I^* > 0, t \leq W^* \leq t^u) \\ \prod_{Y_1=0,Y_2=1} P(I^* > 0, t^l \leq W^* \leq t) \prod_{Y_1=0,Y_2=0} P(I^* > 0, W^* \leq t^l)] \qquad (4)$$

where the first term applies to the zero bidders (I=0), and the second term is decomposed into four intervals for individuals: accepting both bids; accepting the first bid but not the second; refusing the first bid and accepting the second; and finally refusing both of bids.

Now define by $H(x,\theta)$ the cumulative distribution function evaluated at the implicit valuation function; N is the number of respondents, either in or out of the market; ZB is the number of zero-bidders.

The log-likelihood sample-selection model is specified as follows (see Calia and Strazzera,1999):

$$\begin{aligned} \ell(q, r) = \sum_{i=1}^{N} & (1 - ZB_i) \ln[1 - H_z(q_z)] + (Y_{1i} Y_{2i})[\ln H_2(q_z, -q, t^u, r)] \\ & + Y_{1i}(1 - Y_{2i})[\ln H_2(q_z, q, -t^u, -r) - \ln H_2(q_z, q, -t, -r)] \\ & + (1 - Y_{1i}) Y_{2i} [\ln H_2(q_z, q, -t, -r) - \ln H_2(q_z, q, -t^l, -r)] \\ & + (1 - Y_{1i})(1 - Y_{2i})[\ln H_2(q_z, q, -t^l, -r)] \end{aligned} \qquad (5)$$

where t indicates the first bid amount while t^u and t^l indicate the upper and lower follow-up bids respectively; H_z is a cumulative univariate distribution function for the zero bidders, functionally dependent on a matrix of parameters and regressors q_z; H_2 is a cumulative bivariate distribution function for those individuals in the market, having as arguments q_z, another matrix q of possibly different parameters and regressors, the vector of the bids, and the correlation coefficient r.

The estimate obtained from the sample selection model is different from what would be obtained from the sub-sample of observed responses of Y2, because the latter is affected by a bias term, which has the same sign as ρ, and is null only if ρ is zero (further details are given in section 3.2). In fact, use of the truncated sample to estimate WTP is quite common among CV practitioners. It is worth stressing that this strategy is equivalent to assuming that the probability of obtaining a zero-bid response from individuals with specific socioeconomic characteristics is independent of the value they give to the good. In other terms, zero-bidders are assumed to be protesters, and the two choices (protest or not) are assumed to be independent among sample observations.

If zero bids are interpreted as zero values, it is assumed that zero bidders represent a part of the population that is not interested in the provision of the public good. When attempting to estimate the benefits arising from the provision of local public goods, it is necessary to establish the fraction of the population that is in the market for such a good, and to estimate the relevant parameters of the valuation function. Assuming that the entire population is in the market for the good may result in a significant bias in the estimated benefits. Recent developments in estimation methods for public good valuation by means of DC-CV try to address this problem by means of models with a positive mass at zero, the so-called "spike" models.

Kriström (1997), Ayala and An (1996), Scarpa *et al.* (1999), among others, approach this issue. In these studies the probability of being in the market is estimated without placing any conditions on covariates. Alternatively, McFadden (1994), and Reiser and Shechter (1998) introduce covariate effects on the probability of zero WTP. The present work does not address the problem of the treatment of zero values, which will be the object of a further stage of the research. Here, full information on zero values will serve only for the purpose to identify the two groups of protesters and non protesters: zero values in this case will be included in the sample of non protest responses, and the exact information on the amount (zero) will be ignored, by including them in the No-No set of responses.

Design c) Zero bidders may be requested to explain the reasons of their response, and this information helps to classify them either as protesters, or instead as being indifferent to the provision of the good (since negative WTP is ruled out). The statistical treatment of the data set produced by this setting is similar to that of case b), with a sample selection model that selects between protesters (that are now correctly identified) and non protesters (that include both individuals with positive and zero WTP). It is worth to recall that proper treatment of zero values would require a spike to be included in the sample selection model, but this path of research is not pursued at this stage.

3.2 Specification of the choice functions

The choice of specification of the underlying valuation function can now be considered in more detail. The dependent variable can be modelled either as a dichotomous variable, as in the random utility model (RUM) framework; or as a censored variable, which is the approach proposed by Cameron and James (1987) and Cameron (1988). For the computation of the relevant central tendency measures, the RUM approach requires the use of complex integration procedures, while the censored variable approach produces a direct conditional estimate of the reservation prices and of the relevant central tendency measures. Confidence intervals for these measures can be easily computed according to the analytical formula suggested by Cameron (1991). The latter approach was therefore chosen for this application.

It is hypothesised that the amount that each individual is willing to pay for the resource is functionally related to the individual's socio-economic characteristics, according to the following non-linear function:

$$W_i^* = \exp(x_i' b)\exp(u_i)\,, \qquad (6)$$

where x_i is the vector of regressors, and u_i is a random term, that is assumed to be log-normally distributed, such that its logarithm u_i is normally distributed with zero mean and variance s^2. This functional form can be linearised by taking the logarithm:

$$\ln W_i^* = x_i' b + u_i\,. \qquad (7)$$

The central tendency measures for the WTP|x;β latent variable can be computed at their mean values: if the error term has zero mean, then:

$$E(\ln W_i^*) = E(x_i' \hat{b}) = \bar{x}_i' \hat{b}\,, \qquad (8)$$

Therefore if the variables are continuous, the estimated coefficients are applied to the regressors taken at their mean values: if the regressors are dummy variables then they taken at each of the alternative values. Using the properties of the log-normal distribution and taking anti-logs, the median of the WTP latent variable is obtained; to calculate its mean, the estimate should be multiplied by $\exp(s^2/2)$ (see Greene, 1991, p.168).

Analytical computation of confidence intervals around the median is straightforward, since it is sufficient to apply the formula proposed by Cameron (1991):

$$CI_{1-a}\left[E(\ln W_i^{*})\right] = \bar{x}'\hat{b} \pm t_{a/2}\sqrt{\bar{x}'V\bar{x}}\ , \qquad (9)$$

where V is the variance-covariance matrix of the coefficients. Computation of confidence intervals around the mean would be less precise, and the median should be preferred to the mean as a measure of central tendency.

When the discrete choice elicitation method is employed, the variable W_i^* cannot be directly observed: it is only observed if the latent variable is above or under some level t_i, that is the amount proposed to each individual. The latent variable W_i^* can be interpreted as a censored variable, the level of censoring being the amount t_i.

The statistical model is the following:

$$\begin{aligned} \Pr(Y_i = 1) &= \Pr(W_i^* > t_i) = \Pr(\ln W_i^* > \ln t_i) = \Pr(x_i'b + u_i > \ln t_i) \\ \Pr(Y_i = 0) &= \Pr(W_i^* \le t_i) = \Pr(\ln W_i^* \le \ln t_i) = \Pr(x_i'b + u_i \le \ln t_i) \end{aligned} \quad .(10)$$

Given the above specification for the distribution of the error term, under the double-bound format the following log-likelihood function is obtained:

$$\begin{aligned} \ell(b,s) = \sum_{i=1}^{N} \Big\{ & I_i\, I_i^u \log\left[1-\Phi\left((t_i^u - x_i'b)/s\right)\right] + \\ & + I_i\left(1-I_i^u\right)\log\left[\Phi\left((t_i^u - x_i'b)/s\right) - \Phi\left((t_i - x_i'b)/s\right)\right] + \\ & + I_i^l\left(1-I_i\right)\log\left[\Phi\left((t_i - x_i'b)/s\right) - \Phi\left((t_i^l - x_i'b)/s\right)\right] + \\ & + \left(1-I_i\right)\left(1-I_i^l\right)\log\left[\Phi\left((t_i^l - x_i'b)/s\right)\right] \Big\} \end{aligned} \qquad (11)$$

This is the model that is adopted for the in-the-market component of the sample estimates. It can be observed that the variable censoring level allows separate estimation of the parameters s and b, so that the variance-covariance matrix of the estimated coefficients can be used to calculate the confidence intervals around the central tendency measure of interest.

If there is no *a priori* reason to assume that the two structural equations, the selection equation and the valuation equation, are independent, then the sample selection model should be used.

Let x_1 and x_2 be two vectors of socio-economic characteristics of individuals (not necessarily distinct), and assume the following specification for the two models:

$$I^* = x_1' b_1 + u_1 \tag{12}$$

$$W^* = \exp(x_2' b_2)\exp(u_2) \Rightarrow \ln W^* = x_2' b_2 + u_2 \tag{13}$$

where u_1 and u_2 are two error terms with joint c.d.f. $F(u_1, u_2)$. It is assumed that (u_1, u_2) have bivariate normal distributions with mean zero and covariance matrix:

$$\mathbf{\Sigma} = \begin{bmatrix} 1 & s_{12} \\ s_{21} & s_{2} \end{bmatrix}; \tag{14}$$

the variance of I* is set to 1 for normalisation while the variance of ln W^* can be estimated since the bids are varied among individuals.

The log-likelihood of the resulting sample selection model is then specified as follows:

$$
\begin{aligned}
&\ell(b_1, b_2, s_2, r) = \sum_{i=1}^{N} \ (1 - ZB_i)\ln[1-\Phi(x_1' b_1)] + \\
&(Y_{1i}Y_{2i})[\ln\Phi_2(x_1' b_1, (x_2' b_2 - \ln t^u)/s_2, r)] \\
&+ Y_{1i}(1-Y_{2i})[\ln\Phi_2(x_1' b_1, (\ln t^u - x_2' b_2)/s_2, -r) - \\
&\ln\Phi_2(x_1' b_1, (\ln t - x_2' b_2)/s_2, -r)] \qquad (15)\\
&+ (1-Y_{1i})Y_{2i}[\ln\Phi_2(x_1' b_1, (\ln t - x_2' b_2)/s_2, -r) - \\
&\ln\Phi_2(x_1' b_1, (\ln t^l - x_2' b_2)/s_2, -r)] \\
&+ (1-Y_{1i})(1-Y_{2i})[\ln\Phi_2(x_1' b_1, (\ln t^l - x_2' b_2)/s_2, -r))]
\end{aligned}
$$

Estimates of the parameters b_1, b_2, s_2, r can be obtained simultaneously, by maximising the log-likelihood function with respect to all arguments. However, in practice, it has often been noticed that the likelihood function in sample-selection models can behave in an irregular manner (see Copas, 1990; Nawata and Nagase, 1996). Because the likelihood function is well-behaved for fixed values of ρ, it is suggested that the likelihood profile $l(r \mid \hat{b}_1, \hat{b}_2, \hat{s}_2)$ should be evaluated for a grid of values of ρ in the interval (-1,+1) and an approximate confidence interval calculated for ρ as $[\, r : 2l(\hat{r}) - 2l(r) \le c^2_{1,1-a} \,]$ around the maximum $l(\hat{r})$. If the interval contains zero then the null hypothesis that there is no selection bias is accepted.

The estimate obtained from the truncated sample of observed responses of Y_2 is the following:

$$
\begin{aligned}
E(Y_2^* \mid Y_1 = 1) &= x_2' b_2 + E(u_2 \mid u_1 > -x_1' b_1) \\
&= x_2' b_2 + r s_2 \frac{f(x_1' b_1)}{\Phi(x_1' b_1)} \qquad (16)
\end{aligned}
$$

where the term $r s_2 \dfrac{f(x_1' b_1)}{\Phi(x_1' b_1)}$ is the bias due to selection of individuals, the sign depending on the sign of r: if $r < 0$ we would under-estimate the mean *wtp* while if $r > 0$ we would over-estimate the mean *wtp*. Only if $r = 0$, the two choices are independent among sample observations, and unbiased estimates of the parameters could be obtained by fitting two separate equations for *I* and *W*.

4. Survey and Data

The households sampled for the survey were drawn from the residential telephone listings of three villages in the North East of England. These were (1) Haydon Bridge on the A69 west of Hexham; (2) Rowlands Gill on the A694 near Gateshead; and (3) Seaton Sluice on the A193 between Whitley Bay and Blyth. Although each village is somewhat different in terms of layout and location, all three are crossed by busy trunk roads with sustained through traffic travelling at high speeds. Actual speeds were measured on site and detected to be below the 85 percent compliance threshold, which had been deemed to be the definition of effective speed limit enforcement. The measured 85^{th} percentiles were 42 mph in Seaton Sluice, 40 mph in Rowlands Gill and 35 mph in Haydon Bridge.

One focus group was conducted in each of the three villages to inform survey design and aid understanding of households' perceptions of traffic-related externalities. During these preliminary studies, focus group participants unequivocally identified speed as a major concern for them and for other residents. With respect to the other negative externalities from traffic, noise, air pollution, and community severance were also mentioned and some of these are studied more in depth elsewhere (see Garrod *et al.* 2000).

Interviews with respondents were conducted by telephone between March and May 1999. Since interviews were aimed at investigating WTP at the household level, calls were made at times when the head of the household was likely to be found at home, i.e. mainly after 5.30pm. The payment vehicle used in the hypothetical scenario was a yearly increase in council tax for the duration of a traffic-calming scheme ensuring effective speed reduction. As a consequence, whenever possible, the interviewers tried to administer the survey to the family member in charge of these payments. About a quarter of the sample declined to be interviewed. This non-response rate was of similar magnitude to that recorded in other telephone surveys.

The focus groups enabled the proposed wording of the questionnaire to be tested and helped to determine the attitudes of local people to traffic and speed reduction. The focus groups were also used in the identification of the initial bid vector. In the hope of obtaining a more efficient bid-design under the maintained hypothesis of log-normality of the WTP distribution, the bid vector was updated after the first 300 responses had been collected. Since both parametric and non-parametric[2] estimation was intended, and these imply different prescriptions for efficiency in bid-design, the bid up-date had to accommodate the needs of both.

Parametric estimation makes little use of bid amounts placed away from mean WTP, such as those in the tails, while non-parametric estimation requires a good investigation of the behaviour along the whole bid range. As a compromise, the survey proceeded by increasing the number of probes on the percentiles around the estimated mean and by reducing those at intermediate ones, while maintaining some probes at the extreme percentiles.

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2 See Scarpa et al. (1999) for a non-parametric analysis of the CV responses.

Table 1: Sample Means of Regressors

Variables	Full sample	In the Market	Out of the Market	*Protesters*	*Indifferent*
Driving	0.762	0.758	0.768	0.772	0.763
Children	0.221	0.275	0.132	0.146	0.113
Walk to School	0.115	0.128	0.095	0.122	0.062
Wages*	1.185	1.230	1.111	1.122	1.098
Disability	0.172	0.175	0.168	0.138	0.206
Participation	0.278	0.294	0.250	0.236	0.268
Haydon Bridge	0.326	0.297	0.373	0.333	0.423
Rowlands Gill	0.367	0.397	0.318	0.276	0.371
n. observations	580	360	220	123	97

* Wages is the only continuous variable, ranging in the interval [0,5].

The questionnaire is presented as an appendix to this paper. A selection of sample statistics relevant for this study is presented in Table 1.

5. Estimation Strategy and Results

As discussed in an earlier section, this study aims at assessing the effects on the estimation of welfare benefits of the following three levels of information on zero-bidders:

a) No further information is collected after receiving a No-No response to the WTP question;

b) A question is introduced after receiving a No-No response to the WTP question, aimed at discriminating between zero bids and positive WTP;

c) A further question is prompted to zero bidders, aimed at discriminating between zero values and protest responses.

Design a) The first strategy gives rise to the conventional double-bounded interval data model. Additional information on the nature of the zero-bid is not used, and all No-No responses are modelled as true non-negative WTP values below the lowest bid. The parameter estimates of Model 1 are obtained by applying eq. 12, and selecting between different nested specifications by means of a Likelihood Ratio test. The selected model is presented in Table 2. The relative median WTP estimates, on various sets of conditioning values, are reported in Table 3. From Table 3 it can be seen that the effect of having children under 13 years of age is twice as strong as being willing to participate in further surveys on this topic, or as being resident in Rowlands Gill, the most affluent of the three villages.

Table 2: Model 1. Parameter Estimates for Full Sample Model

Parameters	Full sample		
N=580	Estimates	St. Error	*p*-value
Constant	1.751	0.144	0.000
Children	1.046	0.220	0.000
Participation	0.395	0.203	0.026
Rowlands Gill	0.419	0.187	0.013
s	1.786	0.107	0.000
ℓ	-776.046		

Table 3: Model 1: Median WTP and Confidence Intervals

Model	Median WTP	95% C.I. for Median WTP
Reduced[(a)]	5.760	[4.342, 7.641]
Children[(b)]	16.400	[10.709, 25.115]
Participation[(c)]	8.549	[6.019, 12.156]
Rowlands Gill[(d)]	8.756	[6.478, 11.836]

(a) all dummy values are zero (reduced model): this is also the modal character;

(b) dummy for children =1, others zero;

(c) dummy for participation =1, others zero;

(d) dummy for RG =1, others zero.

Further combinations (i.e. children+RG, etc.) would be redundant, since their frequency in the sample is negligible.

Design b) The second strategy is implemented by means of a sample selection model: the relative specification is Model 2 in Table 4, for the value ρ = –0.93 that maximises the likelihood. Notice that the set of significant covariates for the valuation function are now different from those which were significant in Model 1. In particular, WTP increases with the number of wage earners in the household and is higher for drivers. The selection equation shows that people with children below the age of 13 are more likely to reveal that they are in the market for effective speed reduction.

Table 4: Model 2 - Parameter Estimates for Sample Selection Model

Parameters	Sample Selection		
	Estimates	St. Error	*p*-value
Selection eq: N=580.			
Constant	0.223	0.070	0.000
Children	0.717	0.164	0.000
Walk to School	-0.328	0.207	0.056
Participation	0.140	0.102	0.085
Haydon Bridge	-0.223	0.010	0.011
Wtp eq.: N=360			
Constant	3.457	0.137	0.000
Driving	0.237	0.146	0.052
Wages	0.212	0.073	0.002
s	1.322	0.082	0.000
r	-0.93		
ℓ	-885.776		

On the other hand, residents of Haydon Bridge and, surprisingly, those households with children who walk to school, both have a negative impact on the selection equation, i.e. are more likely to be protesters. The negative effect of the variable “walk to school” may be logical if this means that those children are not affected by traffic (e.g. they take other routes to school, away from the main road): this may reduce the incentive for these parents to signal their interest in effective speed reduction.

The assumption of no correlation between the two equations is nested in the sample selection model, for ρ = 0, and can be tested by means of a Likelihood Ratio test. For ρ in the range [-1,+1], the test is: $[\, r : 2l(\hat{r},\hat{q}) - 2l(r,q) \le c^{2}_{1,1-a} \,]$, where the hat denotes parameters evaluated at the maximum. The results of the test are omitted for brevity: it suffices to report that the L-ratio for ρ=0 is 24.66, so that the hypothesis of no correlation is strongly rejected ($p<0.0001$).

To show the effect of an incorrect assumption of zero correlation between the two equations, the following tables report the estimates obtained when incurring this type of misspecification.

Table 5. Model 3: Parameter Estimates for Truncated Sample Model

Parameters	Truncated sample		
n=360	Estimates	S. Error	p-value
Constant	2.697	0.141	0.000
Driving	0.286	0.165	0.041
Wages	0.219	0.080	0.003
s	1.095	0.064	0.000
ℓ	-520.380		

Model 3 is estimated using the double-bound approach only on those respondents who are in the market and neglecting any selection effect. In this case the log-valuation function shows a markedly smaller constant effect, with a stronger marginal effect for drivers and one of similar magnitude for the number of wages. Median WTP estimates are reported in Table 7 for both Models 2 and 3. As one can see the choice of specification matters. In particular the adoption of a sample-selection model produces a median estimate twice as big for each set of values of the covariates.

Table 6. Models 2 and 3: Median WTP and Confidence Intervals

Model	Median WTP	95% C.I. for Median WTP
Sample Selection		
No Driving	40.770	[31.167, 53.330]
Driving	51.681	[42.168, 63.340]
Truncated sample		
No Driving	19.222	[14.624, 25.265]
Driving	25.591	[21.582, 30.344]

It is quite clear that lack of information on the nature of the zero bids produces dramatically different estimates of the central tendency measure for the WTP, ranging from £ 5.7 of model 1 (using the modal characterisation) to £ 51.7 of model 2 (again, in the modal characterisation). To assess the bias due to the misspecification of the model, we compare the previous results with the estimates obtained when protesters are correctly identified.

Design c) The fourth model (see Table 8) is estimated using this information. Now having a disability shows a significant positive effect in the probability of being in the market, while the effects of the dummy for children under 13 and of participation are in the same direction, but of a much stronger magnitude. In the valuation function the set of structural parameters with significance also changes, as driving is no longer significant. Note that the constant effect also diminishes in this model, while the effect of wages increases.

Table 7. Model 4 - Parameter Estimates for the Sample Selection Model

Parameters	Sample Selection		
	Estimates	St. Error	p-value
Selection eq. N=580			
Constant	0.657	0.066	0.000
Children	0.785	0.201	0.000
Walk to School	-0.581	0.234	0.006
Disability	0.160	0.136	0.119
Wtp eq. N =457			
Constant	2.971	0.130	0.000
Wages	0.254	0.083	0.001
s	1.857	0.110	0.000
r	-0.98		
ℓ	-959.720		

Table 8. Model 5 - Parameter Estimates for Truncated Sample Model

Parameters	Truncated sample		
n=457			
Constant	2.444	0.136	0.000
Wages	0.242	0.09	0.004
s	1.566	0.094	0.000
ℓ	-678.590		

Model 5 (see Table 8) is nested within in Sample Selection Model 4: also in this case the hypothesis $\rho=0$ is rejected by the Likelihood Ratio test, with value 12.50 ($p<0.001$). The values for the median and the corresponding confidence interval for both models are reported in Table 9.

Table 9. Median WTP and Confidence Intervals

Model	Median WTP	95% C.I. for Median WTP
Sample Selection	26.373	[21.846, 31.839]
Truncated Sample	15.352	[12.975, 18.164]

It is apparent that a lack of information about the nature of the zero bidders can strongly affect the estimates of the benefits, as can be observed by comparing median WTP estimates obtained by Model 1 and Model 2, and the corresponding estimates obtained by Model 4 (see Tables 3, 6 and 9). Incidentally, it can be observed that the modal characterisation of Model 3 produces a WTP estimate close to that of Model 4, and that this specification was rejected when compared to Model 2.

6. Conclusions

Discrete choice CV surveys are often used to estimate social benefits from public goods for which no conventional market exists. Given the hypothetical nature of contingent markets, the identification of the section of the population outside the market is imperfect, and in the absence of adequate debriefing questions it is difficult to separate true zero values from protest responses.

This paper utilises data from a DC-CV study with a follow-up question aimed at estimating the benefits from a local public good. The good in question was a reduction in effective speed limits in three villages experiencing heavy through traffic. This reduction in speed would be achieved through traffic calming measures. In this study *ad-hoc* debriefing questions were used to probe the motivation behind "No-No" responses, so that each response could be classified either as positive WTP, or as a zero value, or as a protest response. This allows us to investigate the effects of three information structures on the estimates of welfare benefits. First, it is assumed that no information is collected after receiving a No-No response to the WTP question; then, information is added to discriminate between zero bids and positive WTP;

finally, further information is allowed to identify zero bids as zero values or protest responses.

In the latter two cases, the valuation function is estimated through a sample selection model. In both selectivity models the hypothesis of zero correlation between the selection and the valuation equation is rejected. This result should warn contingent valuation practitioners always to test the selectivity hypothesis: the double bound model on the truncated sample of people in-the-market is often applied without an appropriate testing of the hypothesis of zero correlation between the two equations.

The present study has shown that different strategies of identification for the sample fraction out-of-the-market may have non-trivial effects on welfare estimates. Use of full debriefing questions for zero-bidders is therefore recommended. Further research should be conducted to investigate the sensitivity of the WTP estimates to specific choices of model specification. This could be done by means of adequately framed Monte Carlo experiments.

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Appendix

Traffic regulations impose speed limits that are not always enforced successfully. In (NAME OF THE VILLAGE) our researchers have found out that 85% of the vehicles driving through the village on the main road (that's eight or nine vehicles in every ten) travel at a speed of (SPEED MEASURED AT THE VILLAGE) mph or slower, compared with the speed limit of 30 mph.

Now, suppose that the council were considering introducing a traffic calming scheme in your village. It is certain that this scheme will reduce the speed of traffic through the main road so that 85% of vehicles would be driving through the village at a speed of 30 mph or slower.

Unfortunately, the cost of this scheme is not covered by the local council budget. The only way to implement the speed reduction scheme in (NAME OF THE VILLAGE) is if each household resident in (NAME OF THE VILLAGE) pays an additional fee to the council for this new safety scheme. This fee would be on top of the normal council tax.

We are now going to mention some money amounts, these can sound ridiculously high or low to you, please do not take these proposed amounts as an indication of value, because there are not. We are just interested in your honest answer.

Suppose, that the council wants to know the residents' opinion about this public programme and in order to do so it asks residents to vote for or against the realisation of such a scheme in a local referendum.

This programme will cost your household additional yearly fees. Please, before answering, consider that there are other things you can buy with this money. Would you vote in favour of the scheme if it would cost you £(bid 1) every year in additional fees.? (if you are not paying local taxes because you are a pensioner, this fee would still apply to your household).

Yes **No**

If yes

Suppose now that the programme will cost your household £ (bid2) every year in additional local fees. Would you still vote in favour of the programme?

If No

Suppose now that the scheme will personally cost your household £(bid2) every year in additional local fees. Would you vote in favour of the programme at this lower amount?

If two Nos.

Would you be WTP any amount of money at all for such a speed reduction programme through additional local fees?

Yes No

If No again.

With which of the two following statements would you most agree with?

a) "The reduction of traffic speed is of no value to my household and I am therefore willing to pay nothing for the proposed traffic calming scheme".

b) "I actively oppose the realisation of traffic calming schemes and my household is willing to pay *not to have it implemented in my village.*"

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