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Estimating Benefits for Effective Enforcement of Speed Reduction from Dichotomous-Choice CV

The Case of Rural Trunk Roads

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Abstract. We present an empirical estimation of the distribution of WTP for effective speed restriction via implementation of local traffic calming schemes. Random samples are drawn from the populations of households (henceforth HHs) of three centres intersected by main trunk roads with varying through traffic conditions. We estimate the underlying WTP distributions from discrete-choice responses to site-specific referendum contingent valuation studies accounting for zero-bidders. We then test the hypothesis of different distributions across villages. The statistical analysis consists first of a parametric specification and then of a totally non-parametric one. Stated welfare changes for effective speed reduction are found to be sizeable and the parameters of the random utility models are plausibly related to differences in objective speed measures across centres. The results appear to encourage the use of the referencum-CV method in the estimation of local public goods. In this case study the proposed public project would seem to pass the Kaldor-Hicks potential compensation test.

JEL classification: D12, D62, C42, C35, C14

1. Introduction

High speed is probably perceived as the most undesirable externality of traffic along roads crossing residential areas. This is particularly true in rural villages crossed by long distance through routes, such as trunk roads. Here, the local authorities often do not take action to enforce speed restrictions effectively, because this is costly and its benefits are not well known. Given that the fraction of traffic which is most inclined to exceed speed limits is that destined to further destinations along the through road, the construction of a by-pass may suffice in reaching satisfactory speed behaviour within these developed areas. However, this solution is a particularly expensive one, and it is often impractical.

In the UK, traffic engineering standards assess that "effective speed restriction" (henceforth ESR) is achieved when 85 percent of the vehicles cruise at a speed up to or below the speed limit. This degree of compliance is neither easy nor cheap to achieve. Traffic calming schemes are amongst the various measures that local authorities can apply to effectively enforce speed limits in residential areas in a relatively inexpensive fashion. Amongst the "losers" of such a local policy are people who use the through road for commercial road transport and for commuting to and from other destinations. They lose out because their jouney lengthens by their being held-up when driving through these centres. The potential beneficiaries are the local residents, who will enjoy increased safety and possibly decreased disturbance. But not all of the residents may find this policy beneficial. Some may oppose it, while other may feel indifferent towards it. Those who do benefit, may value the benefits differently. Hence the economic analyst ought to account for these variations. Our survey probes respondents households for all three types of behaviour.

The costs of implementing traffic calming schemes for effective speed restriction are easy enough to define. On the other hand, the estimation of the economic benefits enjoyed by the resident population as a consequence of a decreased average speed is a more challenging task. One major difficulty is related to the public nature of this good and the inherent absence of a private market for increased road safety. As is well known, the individual propensity to reveal reservation prices for public goods is quite low because of lack of proper incentives for truth-telling.

One avenue to estimate the benefits of avoiding speed-related traffic accidents could be that of employing an actuarial approach. Another approach could involve hedonic techniques on residential property values. However, both these approaches have some well known shortcomings. For example, collecting site-specific statistics of the type required for actuarial analysis is time consuming. Meanwhile injuries and even deaths may occur. Moreover, safety from speed-related accidents may well be worth more to people than the equivalent loss of earnings. When the statistics on the risk of injury are transferred from other sites, the transfer estimate often relies on assumptions that many may find implausible. Hedonic approaches suffer from the lack of reliable data on both market transactions and of property exposure to speed-related risks.

As an alternative, in this paper we present results from a referendum contingent valuation study. At the moment, this is the most commonly employed method for public good valuation, and it is particularly well investigated in the environmental economics literature (Bateman and Willis 1999). The objective is to assess the properties of the distribution of willingness-to-pay in the relevant population from statements collected in a referendum contingent valuation study. As a means of validation of the estimation method, we assess the consistency of the resulting estimates with *a-priori* objective information on recorded speed at each site.

In the statistical analysis of the results we try to take on board the recent modeling advances for discrete choice CV as they appear in the relevant literature. In particular, following Kriström (1995, 1997), Ayala and An (1996a) and Reiser and Shechter (1999), we model the distribution of willingness-to-pay (henceforth WTP) amounts with a random utility model with positive probability mass at zero to account for those who are indifferent to the proposed public good. This fraction of the population is clearly not in the market for the public good. To validate the results that we obtained with this method with some *a-priori* expectations, we then proceed by formally testing various null hypotheses about the differences between the estimated WTP distributions at different sites and provide point and interval estimates of expected WTP.

Welfare estimates are obtained in three ways. First by accounting for respondents who declared themselves indifferent to the proposed policy package (zero-bidders) in a "full information" model; then by ignoring such information with a "partial information" one; finally by means of the more robust KTM non-parametric estimation. The differences in the resulting estimates are contrasted and discussed.

The parametric estimates of expected WTP are computed by truncating the integral of the expectation at the upper bid amount (Duffield and Patterson 1991). This limits the effect of "fat-tails" which characterize the log-logistic distribution, hence producing a conservative estimate on the support of the data. We find that the estimates of E(WTP) obtained in this fashion can be placed with a 95 percent confidence interval between £12.53/year and £22.10/year across the three sites, while the estimated fraction of population outside the relevant market for ESR varies between 13 percent – recorded in the site with highest recorded actual average speed – and 28 percent, in the site with the lowest.

The remainder of the paper is organized as follows. In section 2 we outline the theory of benefit estimation with discrete choice contingent valuation data with a follow-up in the case of speed reduction. In section 3 we describe the methods employed for the data collection and the survey administration along with those for the econometric analyses. The results obtained are discussed in section 4, their role in the benefit-cost analysis in section 5, while our conclusions are drawn in section 6.

2. Theory

2.1. THE NATURE OF THE PROBLEM

Speed reduction of through traffic in residential areas can be seen as a non-excludable and non-rival positive externality for local residents: a "local" public good. Microeconomic theory suggests that public goods are expected to be sub-optimally supplied and allocated by competitive markets. Optimal supply can be achieved by local government intervention only with knowledge of the costs and benefits associated with the provision schedule. In the case of a traffic calming scheme, once the engineering solution is agreed upon, the costs are relatively easy to determine. However, benefit estimation poses a challenge to the economic analyst for the lack of observable transactions related to this phenomenon.

In as much as speed reduction is effectively achieved by provisions enforced by local authorities and funded via taxes paid by local residents, the benefits associated with it are to be interpreted as provided by a local political market. Since no alternative market exists, these benefits remain unpriced and their marginal value unknown, unless transactions in simulated political markets are observed. Voting on referenda is one mechanism through which private preference can be revealed for collective goods (Deacon and Shapiro 1975; Mitchell and Carson 1989). Yes and no responses to referendum questions can be used to retrieve the salient features of utility changes (Hanemann 1984, 1989; Hanemann and Kanninen 1999).

The introduction of ESR via locally funded traffic calming schemes, is correctly measured in welfare terms by the compensating variation C. That is, the amount that implicitly equalises the following utility levels:

$$U(\mathbf{x}, 0, m) = U(\mathbf{x}, 1, m - C), \tag{1}$$

where $U(\cdot)$ is the household's indirect utility function, x is the current consumption level of all other private and public goods, m is income, 0 and 1 indicate respectively the absence and presence of ESR. It is the money amount which makes a given household indifferent between enjoying ESR at the cost of C and not enjoying it and saving the amount C, other consumption levels being equal.

One problem with locally provided collective goods is that some members of the relevant population may well not be in the market for that good at all. In the case of ESR, for example, those households resident in sites sufficiently away from the main road, or who do not cross or use the main road frequently, may well receive no benefits. For those households not in the market $C = 0$. Further, it is plausible to assume C to be non-negative for ESR across the population (ESR is not a "bad"), this translates in the need for an econometric specification allowing for $C \in \Re^+$.

Under the above conditions it is necessary to employ a distribution which allows for a positive probability mass at WTP = zero. This class of models, in the context of discrete-choice CV, are called "spike" models (Kriström 1995, 1997; Hanemann and Kanninen 1999; Reiser and Shechter 1999), where the word "spike" refers to the parametric probability estimate of observing a WTP = zero in the population.

So the objective of the investigation is to estimate the distribution of WTP as a proxy for C, starting from sample responses to a simulated political market, that is, from discrete Yes-No responses to survey questions. This estimate should identify the fraction of population indifferent to the proposed change (implementation of ESR) as well as the distribution of values of C across those for whom $C > 0$.

In multi-site analyses, a further interesting question to ask is whether or not the distributions estimated from samples drawn from different sites are significantly different, and whether these differences can be explained by observed differences in traffic features across sites. If the differences in estimated benefits are consistent with the *a-priori* expectations derived from the differing traffic conditions, the sample of observations fails to confute the hypothesis that CV provides meaninful value estimates.

2.2. LINKING REFERENDUM RESPONSES TO UTILITY CHANGES AND THE ROLE OF FOLLOW-UPS

In the typical referendum CV question the respondent is asked whether or not she would vote in favour of a government programme that would bring about a change in the provision of a given public good which involved a personal cost of t, in terms of increased taxes or expenditures.

The respondent will reply with a "Yes" only if her utility level in the presence of the proposed change and cost exceeds the utility level in its absence. In other words:

$$\text{Yes} \rightarrow U(\mathbf{x}, 1, m - t) > U(\mathbf{x}, 0, m) \tag{2}$$

However, although discrete choice responses require low cognitive effort and may be consistent with real referendum formats (Carson et al. 1999), they are also very sample inefficient. In fact, an observed positive response only reveals that $C > t$. To increase the sample efficiency of this method Hanemann et al. (1991) have proposed to follow-up the first question with a reiteration. If the first amount encounters a positive response, then the follow-up question is reiterated at a higher amount th, with $th > t$. If, instead, the first amount t is rejected, the follow-up employs a lower bid amount $tl < t$. This approach relies on the assumption that both first and second response are driven by the same distribution of C. In this case the following implications hold:

$$\text{Yes-Yes} \rightarrow C > th, \tag{3}$$

$$\text{Yes-No} \rightarrow th > C > t, \tag{4}$$

$$\text{No-Yes} \rightarrow t > C > tl, \tag{5}$$

$$\text{No-No} \rightarrow tl > C, \tag{6}$$

with strict equalities that are undefined. Thus, in the presence of zero-bidders (those who are not in the market for the proposed change) amongst the "No-No" respondents there will be those for which $C = 0$, that need to be identified by a de-briefing question. As is evident from the conditions laid out above, the use of a follow-up restricts the interval within which the real measure is contained, hence making estimation of the underlying distribution more efficient at any given sample size. Further bounding (a second follow-up) has been shown to bring about only minor efficiency gains under conventional specifications (Scarpa and Bateman 2000) while they encounter a higher risk of respondent tiredness and reiteration bias.

In a very influential paper Cameron and Quiggin (1994) show that the first and the follow-up responses may well be better modeled employing bivariate specifications, further Monte Carlo studies have also shown that when the focus is on welfare estimates, rather than on marginal effects of covariates, the expected bias implied by the assumptions implicit in a double-bounded specification may be quite small when the real data generating process is bivariate (Alberini 1995). The interval-data analysis seems therefore adequate to inform our benefit-cost exercise where the objective is to derive an estimate of mean economic benefits linked to the speed-calming scheme.

3. Data and Methods

3.1. THE SURVEY

The CV survey was conducted in three separate villages in the North East of England: Haydon Bridge, Seaton Sluice and Rowlands Gill. These are all bisected by fairly busy trunk roads with a sustained through traffic. Actual speed conditions were measured on site and detected to be below the 85 percent compliance threshold, which is deemed to be the definition of effective speed limit enforcement. In particular, the measured 85th percentiles were 42 mph in Seaton Sluice, 40 mph in Rowlands Gill and 35 mph in Haydon Bridge.

The HHs in the sample were randomly drawn from the residential telephone listings of each village. Interviews were conducted by phone in the period between March and May 1999 and at times in which the head of the HH was likely to be found at home. Whenever possible, interviewers aimed at surveying the member of the HH in charge of council tax payments. The vehicle of hypothetical payment was an increase in the yearly HH council tax for the duration of the traffic-calming scheme ensuring ESR. About a quarter of the selected sample declined to conduct the interview.

Three focus groups were conducted and the outcomes enabled the testing of the wording of the questionnaire and the identification of the general sensitivity of how the public regards traffic and speed reduction. They also allowed us to identify the elements of the initial bid vector, which were then up-dated after the first 300 responses had been collected (Table I). Since both parametric and non-parametric distribution estimation were intended, and these imply different prescriptions for efficiency in bid-design, the bid up-date had to accommodate two needs. Parametric estimation of measures of central tendency for WTP makes little use of bid amounts placed away from the mean WTP, such as those in the tails, (Kanninen 1993) while non-parametric estimation requires a good investigation of the behaviour along the whole investigated bid range (McFadden 1994). As a compromise we proceeded by increasing the probes on the estimated percentiles around the estimated mean and reduced those in intermediate ones, while maintaining some probes on the extreme percentiles.

Table I. Value of bid amounts.

t^l	t	t^h
1	2	5
2	5	10
5	10	15
10	15	20
15	20	30
20	30	40
30	40	50

The relevant content of the questionnaire is presented in the appendix to this paper. The observed pattern of responses is presented in Table II.[1]

3.2. PARAMETRIC ESTIMATION

Unconditional probability estimates of positive responses to referendum questions are sufficient to identify the relevant parameter of the WTP distribution in the population (McFadden, 1994). We hence concentrate on unconditional estimation.

Parametric estimation of a (spike) WTP distribution has been proposed by Kriström (1997) and requires the decomposition of the probability of positive response into a mixture of a cumulative distribution function over the plausible WTP range and a parameter called "spike", denoted here by ρ. This represents the probability of a HH producing a "No-No" response as a consequence of not being in the market for the public good of interest.

Following An and Ayala 1996a, we define the probability as follows:

$$M(\text{WTP} \leq x; \theta, 0) = \begin{cases} 0, & \textit{if } x < 0 \\ \rho, & \textit{if } x = 0 \\ \rho + (1-\rho)H(x, \theta), & \textit{if } x > 0 \end{cases} \tag{7}$$

Where $H(x, \theta)$ is a cumulative distribution function of the probability of positive response equivalent to that of WTP, with $H(0,\theta) = 0$, while the probability of WTP = 0 is independently estimated by ρ.[2]

The identification of a HH as belonging to the market is equivalent to the HH having a positive value for the perspective good, in our case ESR. These "zero bidders" were identified in our study by asking whether or not the HH is willing to pay any amount for ESR to those respondents who answer "No" to both the first and the follow-up bid-amount.

No HH in the sample showed negative values for ESR. Negative values are also implausible for residents, who are unlikely to lose out in a scenario with reduced

Table II. Summary of CV responses.

First bid	Total obs.	YY	YN	NY	NN	Zero bidders
Haydon Bridge						
2	48	25	6	1	16	9
5	11	6	1	1	3	2
10	60	12	11	7	30	18
15	7	3	0	0	4	2
20	59	12	6	6	35	18
30	8	1	0	1	6	4
40	44	8	4	4	28	13
Seaton Sluice						
2	47	21	14	0	12	4
5	4	0	0	0	4	1
10	50	13	10	4	23	8
15	2	0	0	0	2	2
20	46	8	11	2	25	7
30	4	1	0	0	3	1
40	51	7	8	4	32	6
Rowlands Gill						
2	37	21	7	1	8	6
5	16	7	6	2	1	0
10	46	14	16	1	15	13
15	10	4	1	0	5	2
20	45	10	13	2	20	11
30	11	2	1	1	7	3
40	36	10	6	2	18	10

speed of through traffic. Hence a cumulative distribution function spanning the non-negative orthant is adequate to model probability at various bid amounts. In our econometric analysis we adopted the log-normal distribution.

Following An and Ayala 1996a, the spike parameter, that is the probability of having a zero-bidding HH, can be computed using the information of self-revealed zero-bidders in the sample in a "full information" model, or ignoring this information, the "partial information" model.

3.2.1. *Full information model (FIM)*

This model gives rise to the following log-likelihood function:

$$\begin{aligned}\ln L(\rho,\theta) \;=\; & \sum_{i=1}^{N}\{(I_i^1 I_i^2)\ln[(1-\rho)(1-H_i(t^h;\theta))]\\ & +I_i^1(1-I_i^2)\ln[(1-\rho)(H_i(t^h;\theta)-H_i(t;\theta))]\\ & +(1-I_i^1)I_i^2\ln[(1-\rho)(H_i(t;\theta)-H_i(t^l;\theta))]\\ & +[(1-I_i^1)(1-I_i^2)-ZB_i]\ln[(1-\rho)H_i(t^l;\theta)]\\ & +ZB_i\ln(\rho)\},\end{aligned} \tag{8}$$

for $i = 1, 2, \ldots, N$, where $H(x, \theta) = \Phi(\alpha + \beta\ \ln(t))$, $\Phi(\cdot)$ is the standard normal cdf, $\theta = \{\alpha, \beta\}$, I^1 and I^2 are the indicator functions for a first and second "Yes" response respectively, ZB is the "zero-bidding" indicator function, and t indicates the first bid amount while t^h and t^l indicate the high and low follow-up bids respectively.

3.2.2. *Partial information model (PIM)*

This model gives rise to the following log-likelihood function:

$$\begin{aligned}\ln L(\rho,\theta) \;=\; & \sum_{i=1}^{N}(I_i^1 I_i^2)\ln[(1-\rho)(1-H_i(t^h;\theta))]\\ & +I_i^1(1-I_i^2)\ln[(1-\rho)(H_i(t^h;\theta)-H_i(t;\theta))]\\ & +(1-I_i^1)I_i^2\ln[(1-\rho)(H_i(t;\theta)-H_i(t^l;\theta))]\\ & +(1-I_i^1)(1-I_i^2)\ln[\rho+(1-\rho)H_i(t^l;\theta)]\end{aligned} \tag{9}$$

Note that in this model the spike parameter draws from the entire pool of "No-No" responses, while in the previous model only self-declared zero bidders are assigned to the computation of the spike. As a result the "full information" model is more constrained than the "partial information" one, and it achieves a maximum at lower values.

3.2.3. *Parametric expected WTP estimates*

The parameter estimates from both of the above models allow the estimation of expected WTP as an integral truncated at a given upper amount t^{max}, using the following formula:

$$E[\mathrm{WTP}(t^{max})] = (0)\rho + (1-\rho)\int_0^{t^{max}} \Phi[\alpha+\beta\ln(t)]dt \tag{10}$$

These estimates will clearly be sensitive to the choice of t^{max}, so that higher t^{max} will produce higher values. As a matter of general practice t^{max} = maximum bid amount, which in our case is £50. The sensitivity of the expectation to higher upper limits of integration may also be investigated.[3]

In our case there is also a practical reason as to why we adopt a truncated expectation, and it is due to the fact that although the log-logistic specification fits the data well, the estimated slope parameter for the log-bid amount β has an absolute value smaller than 1 in 2 of the three sites. In this circumstance the proper expectation is undefined. On the other hand the median WTP value is not satisfactory in the context of benefit-cost analysis (Johansson et al. 1989).

3.3. PARAMETRIC HYPOTHESIS TESTING

A number of restrictions can be tested from the pooled sample of responses collected in the three villages to test the existence of significant differences across sites. Given the simplest linear-in-parameter specification of the indirect utility difference (Hanemann 1984) $v = \alpha + \beta \ln(t)$, site-specific dummies can be tested for both the effect on the constant α and the slope β given a baseline site. The slope parameter β can be interpreted in this context as the negative of the marginal utility of money and the relative site-specific dummies can therefore be interpreted as site effects on the marginal utility of money. The constant parameter can instead be interpreted as the mean effect in utility change, therefore the constant site specific dummies represent site effects on this mean. Sites with higher observed speed are expected to show higher site-specific utility effects.

We choose to obtain parameter estimates via maximization of the sample likelihood. An adequate specification test to assess the significance of these site-specific dummies in this context is the likelihood ratio test. The statistic of relevance is known to be asymptotically distributed χ^2_k, where k are the degrees of freedom, represented by the number of parameter restrictions.

To assess site-specific effects we proceed by testing parameter restrictions for constant dummies, slope dummies individually and then for the joint addition of both types of dummies.

Let us identify the constant (α) and slope (β) site specific dummies with the subscripts HB and SS for Haydon Bridge and Seaton Sluice respectively. α_{HB} and $\beta_{\mathrm{HB}} = 1$ if the response was recorded at a HH resident in Haydon Bridge, 0 otherwise. Similarly for α_{SS} and β_{SS} that correspond to the Seaton Sluice dummy. Hence dummies pick up differences with respect to the baseline case of Rowlands Gill.

The following null hypotheses are of interest:

1) H_0^1: $\{\alpha_{\mathrm{HB}}, \alpha_{\mathrm{SS}}\} = \mathbf{0}$, H_A^1: at least one element of $\{\alpha_{\mathrm{HB}}, \alpha_{\mathrm{SS}}\} \neq \mathbf{0}$. This test is implemented by using Model II as the unresticted model, where $v = \alpha + \beta \ln(t) + \alpha_{\mathrm{HB}} + \alpha_{\mathrm{SS}}$.

Rejection of the null implies that mean effects in utilty changes exist in at least one of the two sites from the Rowlands Gill estimated baseline.

2) H_0^2: $\{\beta_{HB}, \beta_{SS}\} = \mathbf{0}$, H_A^2: at least one element of $\{\beta_{HB}, \beta_{SS}\} \neq \mathbf{0}$. This test is implemented by using Model IV as the unresticted model, where $v = \alpha + \beta\ln(t) + \beta_{HB} + \beta_{SS}$.

Rejection of the null implies that marginal utility of log-money is different at least in one of the two sites from that estimated for Rowlands Gill. This can be due to differences in disposable income across residents in the various villages.

3) H_0^3: $\{\alpha_{HB}, \alpha_{SS}, \beta_{HB}, \beta_{SS}\} = \mathbf{0}$, H_A^3: at least one element of $\{\alpha_{HB}, \alpha_{SS}, \beta_{HB}, \beta_{SS}\} \neq \mathbf{0}$. This test is implemented by using Model III as the unresticted model, where $v = \alpha + \beta\ln(t) + \alpha_{HB} + \alpha_{SS} + \beta_{HB}\ln(t_{HB}) + \beta_{SS}\ln(t_{SS})$.

Rejection of the null implies that at least one of these effects is significantly different from that estimated for Rowlands Gill. Throughout tests 1)–3) the restricted model is represented by the simple constant-slope specification.

Individual restrictions on constant and slope site-specific dummies can also be informative and are here tested using the unrestricted Model III, down to Models II and IV, respectively for constant or slope dummies. These give rise to the following tests.

4) H_0^4: $\{\alpha_{HB}, \alpha_{SS}\} = \mathbf{0}$, H_A^4: at least one element of $\{\alpha_{HB}, \alpha_{SS}\}$ is significantly different from zero along with $\{\alpha, \beta, \beta_{HB}, \beta_{SS}\}$ in explaining the probability of positive response. This test is implemented by using Model IV as the restricted model.

Rejection of the null implies that at least one of the site-specific constant effects is significantly different from that estimated for Rowlands Gill when slope differences are accounted for.

5) H_0^5: $\{\beta_{HB}, \beta_{SS}\} = \mathbf{0}$, H_A^5: at least one element of $\{\beta_{HB}, \beta_{SS}\} \neq$ is significantly different from zero along with $\{\alpha, \beta, \alpha_{HB}, \alpha_{SS}$ in explaining the probability of positive response. This test is implemented by using Model II as the restricted model.

Rejection of the null implies that at least one of the site-specific slope effects is significantly different from that estimated for Rowlands Gill when constant differences are accounted for.

In tests 4) and 5) the unrestricted model is Model III.

The above five tests are conducted for both the FIM as well as the PIM specifications so as to assess the sensitivity of the conclusions with regard to these alternative specifications.

3.4. NONPARAMETRIC ESTIMATION WITH KAPLAN-MEIER-TURNBULL (KMT)

Parametric estimation provides a powerful means to relate economic theory to observed data. Often the estimated parameters have a clear economic interpretation in terms of marginal effects or elasticities, hence facilitating econometric analysis. Unfortunately the statistical identification of theoretically meaningful parameters often comes at a high cost. The assumptions required for parametric estimation are often theoretically unsubstantiated and inherently unverifiable. In the context of commonly used parametric maximum likelihood estimators, model misspecification leads to biased estimates. For this reason more robust non-parametric estimators have been developed and applied to CV discrete responses with follow-ups. Robust estimation allows the identification of robust estimates of probability of positive response in the population over the investigated bid range, and hence it delivers robust welfare estimates.

In the context of CV nonparametric interval and censored data, probability estimation can be achieved by using the so called Kaplan-Meier-Turnbull (KMT) estimator. Seminal papers proposing this estimator are Kaplan and Meier (1958) and Turnbull (1974, 1976). Haab and McConnell (1997) investigate the properties of this estimator in the specific context of CV studies. An and Ayala (1996b) provide a generalised algorithm to compute these estimates in the context of CV follow-up data. More recently, Boman et al. (1999) have shown how this estimator can be interpreted to produce analogue estimates to the Laspayres and Paasche price indices. The estimator is often employed to support with robust estimates results obtained from less robust parametric estimates (Hutchinson et al. 2001).

The KMT probability estimator produces a monotonically non-decreasing step function over the investigated bid values. In our case, the point probability of positive response is estimated at the vector $\{1,2,5,10,15,20,30,40,50\}$. Point estimates of expected WTP can be obtained by discrete integration under the step function probability estimates. These are often referred to as lower-bound estimates for two reasons. Firstly because the imposed monotonicity creates a downward bias in the probability estimates, secondly because integration can be conducted only within the support of the bid range, up to the maximum bid, as extrapolation is unfeasible due to the non-parametric nature of the estimates. Close-form expressions for the variance of the expected WTP are available for single bound discrete choice responses (Haab and McConnell 1997). Confidence intervals for expected WTP derived from interval-data from follow-ups, can instead be approximated by means of naïve bootstrap techniques (Efron 1981).

4. Results and Discussion

4.1. POOLED SAMPLE PARAMETRIC ESTIMATES

The pooled sample gave rise to the full (FIM) and partial information model (PIM) estimates presented in Tables III and IV. With the exception of the slope dummy for Seaton Sluice, all the parameter estimates are individually quite significant on the basis of the estimated asymptotic standard errors. In the FIM the negative signs on α_{HB} and α_{SS} in Model II would seem to indicate that on average the utility change for achieving ESR is superior in Rowlands Gill compared with the other two sites. However, when the slope dummies are included (Model III), accounting for differences in income as reflected in changes in the marginal utility of money, the net effect on Seaton Sluice (α_{SS}) becomes positive and significant while that in Haydon Bridge is much more negative. This is in accordance with the gradient

Table III. Full information probit models for pooled sample N = 682.

	Model I	Model II	Model III	Model IV
Model *LL*	−1070.47	−1061.64	−1052.63	−1093.39
ρ	0.2053 (0.0155)	0.2053 (0.0155)	0.2053 (0.0155)	0.2053 (0.0155)
α	1.5452 (0.099)	1.8274 (0.1258)	2.0075 (0.1491)	1.4885 (0.0993)
β	−0.6023 (0.0343)	−0.6106 (0.0346)	−0.6793 (0.0461)	−0.6066 (0.0401)
α_{HB}		−0.2575 (0.1262)	−1.5391 (0.159)	
α_{SS}		−0.5075 (0.1208)	0.0768 (0.0057)	
β_{HB}			−0.5133 (0.141)	0.0198 (0.0016)
β_{SS}			−0.0005 (0.0038)	−0.0061 (0.0034)

Table IV. Partial information probit models for pooled sample N = 682.

	Model I	Model II	Model III	Model IV
Model *LL*	−831.931	−829.019	−812.739	−830.11
ρ	0.2315 (0.0285)	0.2212 (0.0297)	0.1649 (0.0308)	0.2238 (0.0305)
α	2.1826 (0.1867)	2.3133 (0.2001)	2.3934 (0.2312)	2.0322 (0.2106)
β	−0.7998 (0.0564)	−0.7871 (0.0578)	−0.8332 (0.0696)	−0.7212 (0.0712)
α_{HB}		−0.2640 (0.1366)	−1.9667 (0.1892)	
α_{SS}		−0.3057 (0.1375)	0.0923 (0.0076)	
β_{HB}			−0.3448 (0.1595)	−0.0053 (0.0043)
β_{SS}			0.0009 (0.0043)	−0.0071 (0.0039)

of observed speeds of through traffic: in sites where ESR reduces speed most the effect in estimated utility difference is higher. Constant site-specific dummies reflect changes with respect to Rowlands Gill, which is the site with intermediate observed speed (85th percentile = 40 mph). An observed positive change for α_{SS} is consistent with the fact that in Seaton Sluice ESR at 30 mph will reduce it from the observed 42 mph, hence producing a higher utility than in Rowlands Gill where the reduction is only from 40 mph. Similarly, a negative effect in the Haydon Bridge constant dummy is consistent with a lower improvement with respect to Rowlands Gill, since the observed 85th percentile in this site was 35 mph. Similar results are born out by the PIM estimates.

The slope site-specific dummies in Model III are concordant in both FIM and PIM specification in indicating that in Haydon Bridge money is more valued than in Rowlands Gill, while the coefficient for Seaton Sluice is negative in FIM and positive in PIM, but statistically significant in neither.

Table V. Results of tests of hypotheses

	H_0^1 Deg.Fr. 2		H_0^2 Deg.Fr. 2		H_0^3 Deg.Fr. 4		H_0^4 Deg.Fr. 2		H_0^5 Deg.Fr. 2	
	FIM	PIM	FIM	PIM	FIM	PIM	FIM	PIM	FIM	PIM
Restricted	−831.93	−1070.47	−831.93	−1070.47	−831.93	−1070.47	−830.11	−1062.94	−829.02	−1061.64
Unrestricted	−829.02	−1061.64	−830.11	−1062.94	−812.74	−1052.63	−812.74	−1052.63	−812.74	−1052.63
L-ratio stat.	5.82	17.67	3.64	15.07	38.38	35.68	34.75	20.61	32.56	18.01
P-value	0.95	1.00	0.84	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Conclusion	*Not Rej.*	Str. Rej.	*Not Rej.*	Str. Rej.	Str. Rej.	Str. Rej.	Str. Rej.	Str. Rej.	Str. Rej.	Str. Rej.

4.2. PARAMETRIC SPECIFICATION TESTS

The hypotheses tests outlined in paragraph 3.3 were conducted at the 5 percent significance level and results are shown in Table V. All hypotheses of restrictions were rejected in the PIM, indicating that for this specification relevant site specific dummies significantly help improve the fit to the observed pattern of responses. With the exception of H_0^1 and H_0^2 all the hypotheses were also rejected in the FIM specification.

These results seem to indicate that site-specific model estimations may be warranted, so as to disentangle the various effects at the village level and to obtain more reliable welfare estimates associated with the proposed public good.

4.3. SITE-SPECIFIC PARAMETRIC ESTIMATES

A test of whether site-specific parametric spike models fit significantly better than a unique model estimated from the pooled sample can be conducted by means of a likelihood ratio test. The unrestricted log-likelihood is represented by the sum of those estimated for each site-specific model, $\ln L_{\mathrm{HB}} + \ln L_{\mathrm{SS}} + \ln L_{\mathrm{RG}}$, while the restricted one is represented by the relevant pooled sample Model I. The number of parameter restrictions are 6 and hence so are the number of degrees of freedom.

The estimates necessary for conducting such a test are reported in Tables III and IV. In the case of the FIM specification we obtain a test statistic of 38.342 with a p-value of nearly one, strongly rejecting the restrictions implicit in the pooled model in favour of the site-specific ones. The analogue test for the PIM gives a p-value of 0.964, rejecting the restrictions at minimum confidence level of 3.6 percent.

Given these rejections of the pooled model we obtain point estimates of expected WTP at four different truncation points. These are presented in the bottom rows of Tables III and IV. The superscript 1 refers to a truncation point of £50, the maximum amount in the bid range; the superscripts 2, 3 and 4 refer respectively to extrapolations at £80, £100 and £120. It can be seen that the resulting estimated expectations are quite sensitive to choice of truncaton point due to the typical "fat tails" of the log-normal distribution. For each of the estimates the corresponding 95 percent confidence interval are reported, obtained by parametric boostrapping

Table VI. Site-specific probit models and expected WTP estimates.

	Full information			Partial information		
	Haydon B.	Seaton S.	Rowlands G.	Haydon B.	Seaton S.	Rowlands G.
N	237	224	221	237	224	221
Mean ln$L$	−1.52362	−1.53015	−1.57216	−1.13442	−1.22259	−1.27815
Model ln$L$	−361.098	−342.754	−347.447	−268.858	−273.86	−282.471
ρ	0.2785 (0.0291)	0.1295 (0.0224)	0.2036 (0.0271)	0.2785 (0.0291)	0.251 (0.0569)	0.1441 (0.0396)
α	1.513 (0.1774)	1.1593 (0.1533)	2.1222 (0.1958)	1.513 (0.1774)	1.9441 (0.3346)	2.381 (0.294)
β	−0.5875 (0.0623)	−0.5438 (0.0534)	−0.723 (0.0667)	−0.5875 (0.0623)	−0.7531 (0.0975)	−0.8362 (0.0919)
$E(\text{WTP})^1$	14.99 (12.53–17.73)	14.81 (12.33–17.49)	19.22 (16.58–22.10)	14.90 (12.50–17.44)	14.76 (12.36-17.33)	19.38 (16.88-22.02)
$E(\text{WTP})^2$	18.79 (15.06–23.12)	18.34 (14.69–22.47)	23.71 (19.76–28.27)	17.47 (14.17–21.39)	17.40 (14.12-21.35)	22.88 (19.25-27.04)
$E(\text{WTP})^3$	20.66 (16.21–26.06)	20.06 (15.74–25.12)	25.77 (21.12–31.42)	18.52 (14.69–23.26)	18.52 (14.77-23.34)	24.32 (20.08-29.49)
$E(\text{WTP})^4$	22.19 (17.10–28.57)	21.48 (16.60–27.45)	27.38 (22.06–34.08)	19.28 (15.09–24.76)	19.35 (15.20-24.97)	25.36 (20.62-31.40)

Table VII. KMT non-parametric estimates for pooled sample.

t	Point estimate	2.5º perc.	Median	97.5º perc.
0	1	1	1	1
1	0.7730	0.7195	0.7731	0.8245
2	0.7604	0.7075	0.7609	0.8117
5	0.6041	0.5579	0.6042	0.6494
10	0.5289	0.4818	0.5288	0.5754
15	0.3818	0.3385	0.3815	0.4241
20	0.3424	0.3001	0.3418	0.3854
30	0.2292	0.1910	0.2291	0.2683
40	0.1857	0.1466	0.1856	0.2258
50	0.1080	0.0727	0.1077	0.1446
E(WTP)	14.84	13.39	14.83	16.30

the asymptotic distribution of the ML estimates ten thousand times (Krinsky and Robb 1986; Cooper 1994). Expected WTP estimates from FIM and PIM models are very similar. However, while for Haydon Bridge and Seaton Sluice these amount to approximately £15/year (± ≈£2.70), in Rowlands Gill they amount to approximately £19/year (± ≈£2.76).

4.4. NONPARAMETRIC ESTIMATES

It is of some interest to compare the parametric estimates of E(WTP) values with those obtained using the KMT estimator. Point and interval estimates of the probability of positive response along with the respective expected values are presented in Table VII for the pooled model and in Tables VIII to IX for the individual sites. The 95 percent interval estimates approximations are obtained via naïve bootstrap (Efron 1981), by resampling with restitution the empirical distribution 10,000 times. We also report the median of the simulated WTP distributions.

All the non-parametric estimates are inferior to the parametric ones as they are conservative lower-bound measures. However, the estimated distributions of WTP in Haydon Bridge and Seaton Sluice still produce very similar expected WTP values (£13.50/year and £13.80/year), while that for Rowlands Gill produces the highest expected WTP at £17.46/year.

5. Cost-benefit analysis

The benefits to the community of traffic calming schemes at each of the three sites (Haydon Bridge, Rowlands Gill, and Seaton Sluice) depend upon households' value for speed reduction from current levels (35 mph, 40 mph, and 42 mph respec-

Table VIII. KMT non-parametric estimates for Haydon Bridge.

t	Point estimate	2.5º perc.	Median	97.5º perc.
0	1	1	1	1
1	0.6988	0.6059	0.6990	0.7913
2	0.6799	0.5891	0.6797	0.7690
5	0.5679	0.4915	0.5688	0.6455
10	0.4769	0.4012	0.4772	0.5548
15	0.3443	0.2758	0.3438	0.4148
20	0.2852	0.2161	0.2848	0.3557
30	0.2148	0.1537	0.2145	0.2781
40	0.1642	0.1026	0.1632	0.2275
50	0.1095	0.0502	0.1077	0.1696
E(WTP)	13.50	11.11	13.48	16.00

Table IX. KMT non-parametric estimates for Seaton Sluice.

A	Point estimate	2.5º perc.	Median	97.5º perc.
0	1	1	1	1
1	0.755	0.6584	0.7558	0.8502
2	0.755	0.6582	0.7555	0.8500
5	0.5407	0.4575	0.5411	0.6236
10	0.4884	0.4047	0.4892	0.5758
15	0.3642	0.2917	0.3637	0.4395
20	0.3404	0.2672	0.3406	0.4179
30	0.2163	0.1521	0.2164	0.2856
40	0.1730	0.1076	0.1720	0.2423
50	0.0807	0.0305	0.0795	0.1374
E(WTP)	13.80	11.37	13.77	16.46

tively) to 30 mph at the 85th percentile; and the number of households in each area benefiting from the speed reduction. The size of the population of HHs benefiting from the scheme was identified as those HHs in close proximity to each road. These people would need to walk along or to cross the main road to use local community services (such as school, library, church, post-office, shops, pubs and restaurants, buses, rail transport, etc.). The number of HHs was determined from the current electoral roll information, in which each HH is legally obliged to be listed each year by the local authority. In Britain the electoral roll information linking each HH

Table X. KMT non-parametric estimates for Rowlands Gill.

t	Point estimate	2.5º perc.	Median	97.5º perc.
0	1	1	1	1
1	0.8624	0.7859	0.8621	0.9361
2	0.8452	0.7663	0.8450	0.9203
5	0.7059	0.6286	0.7061	0.7820
10	0.6243	0.5423	0.6243	0.7034
15	0.4424	0.3670	0.4425	0.5213
20	0.4098	0.3319	0.4095	0.4873
30	0.2613	0.1906	0.2610	0.3380
40	0.2240	0.1502	0.2221	0.2979
50	0.1400	0.0703	0.1387	0.2139
E(WTP)	17.46	14.79	17.39	20.30

to an address is the most complete (>99.5%) and accurate information available on numbers of HHs.

Total benefits (estimated household annual WTP times the number of households) were capitalised at 6%,[4] but only over a 10 year period. This period reflects the fact that traffic calming schemes eventually wear-out and need to be replaced and maintained; whilst the shorter period also provides a more conservative estimation of total benefits.

Costs depend upon the combination of traffic calming measures adopted.[5] Since no traffic calming scheme has been implemented at any of the three sites,[6] the precise costs are uncertain, and local authorities are not able to calculate these costs until the final design and precise location of the traffic calming measures along the road are agreed. Costs of schemes vary widely (see County Surveyors Society and Department of Transport 1994), depending upon the length of road to be calmed (0.4 miles at Haydon Bridge to 0.93 miles at Seaton Sluice, and 1.0 mile at Rowlands Gill), the type of calming to be achieved, the combination of traffic calming measures used and their appropriateness to the site, the quality of the design and materials, and the ease with which the measures can be installed at each site.

The appropriate measures to include at each site, and the likely costs were compiled through discussions with local authority officers responsible for traffic calming; and with documentary evidence on the costs of individual measures comprising other traffic calming schemes that have already been implemented (see for example, County Surveyors Society and Department of Transport 1994).

Table XI documents a cost-benefit analysis (CBA) of possible traffic calming measures at each site. Clearly each site would support some basic low cost traffic calming measures to reduce speed, assuming that the traffic calming measures are

Table XI. Cost-benefit summary of 3 traffic calming schemes.

Site	Households	Capitalised benefits	Cost 1	Cost 2	B/C ratio 1	B/C ratio 2
Haydon Bridge[7]	748	82,580	£25,000	£73,000	3.30	1.13
Rowlands Gill[8]	1178	164,733	£38,000	£140,000	4.33	1.18
Seaton Sluice[9]	1123	123,980	£48,000	£200,000	2.58	0.62

effective in reducing speed to 30mph at the 85th percentile. Indeed the benefit/cost (B/C) ratio for these measures is large: in excess of 2.5, which partly explains why basic traffic calming measures are proposed for two of the sites. However, the B/C ratio for more extensive traffic calming measures of higher visual quality is more difficult to justify. Whilst the B/C ratios exceed 1.0 for two of the sites, excess benefits over costs are small. Indeed, within the confidence limits of the benefit estimates, and the uncertainty about the precise costs of the enhanced measures, the B/C ratios for the enhanced traffic calming measures could actually be less than 1.0.

6. Conclusions

Effective speed reduction is a sensitive issue in many small urban centres crossed by through roads with heavy commercial or commuting traffic. By-pass constructions are expensive enterprises and traffic-calming may well achieve effective speed restriction. However, benefits from these policies are difficult to estimate, as they provide local public goods without a proper market.

In this study we apply the referendum contingent valuation method to estimate the benefits of effective speed restriction. Households were sampled from local residents of three centres crossed by through roads in North-East England. Respondents were faced with a referendum scenario where traffic calming could be voted in subject to their willingness to pay an increased level of annual local taxes for the duration of the scheme. The survey instrument employed addressed the issue of indifference and negative WTP for the proposed programme, and found that the latter was not represented in the sample, nor in the focus groups or the pilot study.

The nearly seven hundred observed responses collected in telephone surveys amongst residents were analysed using parametric and more robust non-parametric methods allowing for estimation of zero-bidding (spike). The parametric random utility difference analysis shows that site-effects on utility differences are consistent with objective speed measurements, while those in marginal utility of log-income are consistent with differences in property values across the three villages. Specification testing indicates that individual site models perform better than pooled sample ones. Estimates of welfare measures derived from site-specific parametric models are concordant with those derived from the more robust non-parametric Kaplan-Meier-Turnbull estimator. These benefit estimates can be used in cost-benefit analysis as lower bounds on real benefits.

The estimation of the parameters of the indirect utility function from the pooled model are consistent with expectations with respect to the absolute values of speed reductions needed to meet the 85 percent standard of effective speed restriction. However, probably due to the lower marginal utility of money associated with higher average wealth, the residents in Rowlands Gill have an estimated WTP per household for the programme which is £4 higher than in Seaton Sluice and Haydon Bridge.

Altogether we find that this first experimental application of referendum CV to a local public good provides estimates that appear to make economic sense, in terms of both absolute and relative magnitude, especially when gauged against physical measures of speed reduction observed at the three sites. The benefit estimates obtained for local residents, although derived from a conservative stand, provide evidence that the economic benefits provided by a basic public scheme designed to achieve ESR would quite likely be in excess of their estimated cost for the local authorities. A more comprehensive benefit-cost analysis should also try and capture and quantify the disbenefit that driving through a speed-regulated area would produce to drivers, but this however, was beyond the scope of the present study.

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Notes

1. The sample split across bid design was originally equally balanced, but after the first 250 observations had been collected across the 3 sites the bid-design was updated to increase efficiency of the mean estimate under the distributional assumptions underlying the analysis presented here. As a result the final bid allocation is unbalanced. More information on this can be obtained from the authors.
2. Because the de-briefing investigating zero WTP was carried out after recording the WTP responses, the spike parameter can also be assumed to be dependent on socio-economic characteristics or survey treatments. In our case, for example, a probit model from the pooled sample explaining the zero-bidding behaviour conditional on a constant and on the first bid amount produces a coefficient estimate for the bid treatment with an asymptotic p-value of 0.047. However, the predicted effect of bid values on probability of zero-bidding is small, ranging from a 0.176 at the minimum bid amount of t = £2 to 0.25 at the maximum bid amount t = £40.

Furthermore, when estimated on the site-specific data, the bid coefficient had higher p-values (0.42 in Seaton Sluice, 0.06 at Rowlands Gill and 0.1 at Haydon Bridge). We hence chose to present the results based on an unconditional specification for the spike parameter.

3. Some authors object to the practice of truncation of expectations in parametric models. We appreciate their viewpoint, however, we feel that this is consistent with the nonparametric estimator used here. Maximizing the likelihood of the sample using a truncated cdf at t^{max} has also been suggested, this ensures integration to 1 of the cdf over the investigated range. Unfortunately, we feel that there is not an easy answer to the problem of fat-tail behaviour, short of ad hoc data cleaning, which we had rather not engage in. Other estimations attempting to address this issue on our sample are available upon request from the authors.
4. The 6% discount rate is the rate used by all government departments in the UK to discount non-market benefits (see H.M. Treasury 1991).
5. A diverse range of traffic calming measures exist. The most common traffic calming measures by implementation are 75 mm flat top humps; 75 mm round top humps; speed cushions; single lane working chicanes, thermoplastic humps, and 2-way working chicanes (Boulter and Webster 1997). But numerous other devises exist: raised junctions; rumble devises; pinch points and narrowings; central islands and refuges; mini-roundabouts; surface treatment; entrance treatment; gateways; street furniture; visual effects; speed cameras and speed camera signs; speed limits; and weight and width restrictions. Each of these can be used in combination with others, and with themselves, at varying distance intervals along a stretch of road (see Collins 1997). Many of the measures can be also implemented with varying degrees of quality in design and construction.
6. At the Seaton Sluice site Blyth Valley District Council and Northumberland County Council are (at January 2001) conducting a public consultation exercise with local residents to agree types of traffic calming measures to be adopted; whilst Gateshead Metropolitan Borough Council is implementing a speed camera traffic calming measure at Rowlands Gill in 2001.
7. The main problem at Haydon Bridge is heavy traffic. Northumberland County Council's transport plan proposes a by-pass for the town; but the Highways Agency responsible for the A69 though Haydon Bridge have yet to adopt this proposal. The A69 is managed on behalf of the central government's Highways Agency by Roadlink, a private commercial firm who derive an annual revenue on the basis of traffic volume and (low) accident levels. This revenue is used to maintain and improve the road, and the difference between revenue and costs forms the firm's profits. The lack on any traffic calming measures suggests that accidents in the town are low, otherwise Roadlink could increase its profits by undertaking traffic calming to generate higher revenue payments for accident (speed) reductions. In the view of the authors, a low cost traffic calming solution would be gateways and road narrowing at the approach to the town to reduce speed. Because terraced houses and other properties front directly onto the road some traffic calming measures are infeasible in the town (e.g. because they would create more noise). An alternative higher cost solution would be the gateways plus improvement to visual attractiveness by adding some safety street furniture through the town with an additional pelican crossing.
8. Gateshead Metropolitan Borough Council are to undertake some traffic calming measures at this site in 2001. Since the A694 through Rowlands Gill is a primary route and a bus route, Gateshead MBC do not propose any vertical deflection measures. Instead a speed camera will be installed, with police control and enforcement. Only one camera is feasible given the winding nature of the road. A more extensive solution would be to have gateways and horizontal deflections measures to slow traffic at the entrance to the village; with road narrowing at appropriate points and a series of central refuges at principal pedestrian crossing points.
9. The main problem at this site is speed, rather than accidents. A low cost solution would be to narrow the road with cycle lanes, hatched white lines, and traffic islands. A high cost solution would be to have more permanent road narrowing, with chicanes, traffic island refuges, mini-roundabouts at side roads, and speed cameras.

References

Alberini, A. (1995), 'Efficiency vs Bias of WTP Estimates: Bivariate and Interval-Data Models', *Journal of Environmental Economics and Management* **29**, 169–180.

An, M. Y. and R. A. Ayala (1996a), *A Mixture Model of Willingness to Pay Distributions*, Mimeograph. Available by FTP at "pub/man/papers/npecross.ps".

An, M. Y. and R. A. Ayala (1996b), *Nonparametric Estimation of a Survivor Function with Across-Interval-Censored Data*, Mimeograph. Available by FTP at "pub/man/papers/npecross.ps" or at "http://econwpa.wustl.edu".

Bateman I. J. and K. G. Willis (1999), *Valuing Environmental Preferences: Theory and Practice of the Contingent Valuation Method in the US, EC and Developing Countries*. Oxford University Press.

Boman, M., G. Bostedt and B. Kriström (1999), 'Obtaining Welfare Bounds in Discrete Response Valuation Studies: A Non-Parametric Approach', *Land Economics* **75**, 284–294.

Boulter, P. G. and D. C. Webster (1997), 'Traffic Calming and Vehicle Emissions: A Literature Review', *TRL Report 307*. Transport Research Laboratory, Crowthorne, Berkshire.

Cameron, T. A. and J. Quiggin (1994), 'Estimation Using Contingent Valuation Data from a Dichotomous Choice with Follow-Up Questionnaire', *Journal of Environmental Economics and Management* **27**, 218–234.

Carson, R. I. and R. C. Mitchell (1989), *Using Surveys to Value Public Good: The Contingent Valuation Method*. Washington, DC: Resources for the Future.

Carson, R. T., T. Groves and M. J. Machina (1999), *Incentive and Informational Properties of Preference Questions*. Paper presented at the IX Conference of the European Association of Environmental and Resource Economists, Oslo 25–27 June.

Collins, G. (1997), *Traffic Calming on Through Routes*. Edinburgh: National Roads Directorate, Scottish Office.

Cooper, J. C. (1994), 'A Comparison of Approaches to Calculating Confidence Intervals for Benefit Measures from Dichotomous Choice Contingent Valuation Surveys', *Land Economics* **70**, 111–122.

County Surveyors Society and Department of Transport (1994), *Traffic Calming in Practice: An Authoritative Source Book with 85 Illustrated Case Studies*. London: Landor Publishing.

Deacon, R. and P. Shapiro (1975), 'Private Preference for Collective Goods Revealed Through Voting on Referenda', *American Economic Review* **65**, 943–955.

Efron, B. (1981), 'Nonparametric Standard Errors and Confidence Intervals', *Canadian Journal of Statistics* **9**, 139–172.

H.M. Treasury (1991), *Economic Appraisal in Central Government: A Technical Guide for Government Departments*. London: HMSO.

Haab, T. C. and K. E. McConnell (1997), 'Referendum Models and Negative WTP: Alternative Solutions', *Journal of Environmental Economics and Management* **32**, 251–270.

Hanemann, W. M. and B. Kanninen (1999), *The Statistical Analysis of Discrete Response CV Data*. Bateman and Willis, pp. 302–441.

Hanemann, W. M. (1984), 'Welfare Evaluations in Contingent Valuations Experiments with Discrete Responses', *American Journal of Agricultural Economics* **66**, 332–341.

Hanemann, W. M. (1989), 'Welfare Evaluations in Contingent Valuations Experiments with Discrete Response Data: A Reply', *American Journal of Agricultural Economics* **71**, 1057–1061.

Hanemann, W. M., J. Loomis and B. Kanninen (1991), 'Statistical Efficiency of Double Bounded Dichotomous Choice Contingent Valuation', *American Journal of Agricultural Economics* **73**, 1255–1263.

Hutchinson, G., R. Scarpa, S. Chilton and T. Mc Callion (2001), 'Parametric and Non-Parametric Estimates of Willingness to Pay for Forest Recreation in Northern Ireland: A Multi-Site

Analysis Using Discrete Choice Contingent Valuation with Follow-Ups', *Journal of Agricultural Economics* **52**(1), 104–122.

Johansson, P-O., B. Kriström and K. G. Mäler (1989), 'Welfare Evaluations in CV Experiments with Discrete Response Data: Comment', *American Journal of Agricultural Economics* **71**, 1054–1056.

Kanninen, B. J. (1993), 'Optimal Experimental Design for Double-Bounded Dichotomous Choice Contingent Valuation', *Land Economics* **69**, 138–146.

Kaplan, E. and P. Meier (1958), 'Nonparametric Estimation from Incomplete Observations', *Journal of the American Statistical Association* **53**, 457–481.

Krinsky, I. and A. Robb (1986), 'Approximating the Statistical Properties of Elasticities', *Review of Economics and Statistics* **68**, 715–719.

Kriström, B. (1995), *Spike Models in Contingent Valuation: Theory and Illustrations*. Invited paper to the First Toulouse Conference on Environmental and Resource Economics, Toulouse, France, 30–31.

Kriström, B. (1997), 'Spike Models in Contingent Valuation', *American Journal of Agricultural Economics* **79**, 1013–1023.

McFadden, D. (1994), 'Contingent Valuation and Social Choice', *American Journal of Agricultural Economics* **76**, 689–708.

Reiser, B. and M. Shechter (1999), 'Incorporating Zero Values in the Economic Valuation of Environmental Program Benefits', *Environmetrics* **10**, 87–101.

Scarpa, R. and I. Bateman (2000), 'Efficiency Gains Afforded by Improved Bid Design Versus Follow-Up Valuation Questions in Discrete Choice CV Studies', *Land Economics* **76**(2): 299–311.

Turnbull, B. W. (1974), 'Nonparametric Estimation of a Survivorship Function with Doubly Censored Data', *Journal of the American Statistical Association* **69**, 169–173.

Turnbull, B. W. (1976), 'The Empirical Distribution Function with Arbitrarily Grouped, Censored and Truncated Data', *Journal of the Royal Statistical Society*, Series B **38**, 290–295.

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 faster, 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 that each household resident in (NAME OF THE VILLAGE) be paying 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 ridicolously 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 realization 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?

No

Suppose now that the scheme it 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 realization of traffic calming schemes and my household is willing to pay not to have it implemented in my village."