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The Use of Follow-Up Questions to No Responses in Dichotomous Choice Contingent Valuation Surveys

John A. Curtis

The dichotomous choice contingent valuation survey format collects inexact information on willingness to pay (WTP), that is, whether WTP is greater or less than the bid price. Sometimes researchers make the precise conjecture that certain respondents have zero WTP using information from follow-up motive questions. But follow-up questions are designed to provide information on respondents' motives, not refined information on the magnitude of WTP. Assuming that certain respondents have $WTP = \$0.00$ is beyond the design of follow-up questions. The paper's results show that unless information from follow-up questions is utilized within the limitations of survey design, welfare and model parameter estimates are likely to have high standard errors leading to inappropriate policy prescriptions.

The dichotomous choice contingent valuation (DC-CV) survey format is designed to collect imprecise information on willingness to pay (WTP),¹ but researchers sometimes assume certain respondents have $WTP = 0$, a very precise conjecture. The assumption that certain respondents have $WTP = 0$ relies on follow-up questions to the CV proposal, which ask respondents about the motives for their dichotomous choice response. Whether follow-up motive questions provide information of sufficient detail to make such a precise determination that $WTP = 0$ is questionable. Undeniably the follow-up questions provide valuable information that enables researchers to interpret DC responses, for example, decide whether a DC No response actually means WTP is less than the CV bid price or otherwise. But to say that certain respondents have $WTP = \$0.00$ is beyond the scope and design of commonly used follow-up motive questions.² Follow-up questions do not normally seek to fur-

ther narrow the range within which a respondent's WTP lies and therefore it is without verifiable support that we may say certain respondents' WTP equals zero.

The implications of assuming some specific respondents have $WTP = 0$ are twofold. With a sample for model estimation conditioned on positive WTP, or at least presumed so, the researcher may unwittingly introduce a selection bias if respondents with positive WTP are systematically excluded from the analysis. Such biases may lead to erroneous conclusions on respondents' preferences. Secondly, if respondents are assumed incorrectly to have $WTP = 0$, estimates of welfare change may be flawed. Both cases may lead to inappropriate changes in policy.

We can never know *ex post* if a follow-up response accurately implies that a certain respondent had $WTP = 0$. The only way to be sure is to go back and ask the respondent again, which is not practicable. Our argument is that the appropriate approach for dealing with follow-up responses should be decided *ex ante*, as it is determined by the design of the survey instrument. The treatment of follow-up responses should firstly, be within the limits of what the survey responses can reasonably say about WTP and, secondly, where there is reason to believe certain respondents have WTP close to zero, incorporate this information into the model.

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The author wishes to thank Richard Carson, Javier Cuervo, Ted McConnell and anonymous reviewers for comments on earlier drafts of this paper. Support for this study was provided by the Maryland Agricultural Experiment Station.

¹ Imprecise in the sense of whether WTP is greater or less than the CV bid price as opposed to an exact measure of WTP elicited from an open-ended WTP question.

² Unless there is an actual follow-up question that asks whether $WTP = 0$.

Mindful that we cannot be certain which, if any, respondents have $WTP = 0$ a model is devised that has a likelihood function coincidentally like Kriström's (1997) model in which the author assumes that some respondents have $WTP = 0$. What distinguishes this paper from Kriström's is the motivation underlying the paper. This paper argues that there are limits on what we can reasonably interpret from the data. While Kriström does not question the limitations of the data but tries to circumvent the problem of having positive probability at a point in a continuous distribution. However, the bottom line is that this paper provides further motivation for using Kriström's extended spike model. But there are models other than Kriström's extended spike model that assume some respondents have $WTP = 0$. An *ex post* comparison of models with different treatments of follow-up responses will show whether the implications of assuming $WTP = 0$ as mentioned above hold true. A comparison will show whether the different treatments of follow-up responses affect the estimated models and if so to what extent they are affected.

The next section deals with follow-up responses and the difficulties drawing concrete conclusions from the information proffered. Following this is a brief description of two models commonly used to analyze DC-CV data. A model is then developed to analyze data from DC-CV where allowance is made for the limited information inherent in follow-up responses. This model is estimated and welfare analysis conducted using data on a deer population management proposal and compared to other DC-CV models.

Follow-Up Responses

The report of the NOAA panel on contingent valuation in its suggestions for the implementation of CV surveys recommended that following the response to the CV proposal, respondents should be asked the open ended question: "why did you vote yes/no?" (Arrow *et al.* 1993). The purpose of such a follow-up question was to allow an understanding of the different types of responses to a CV proposal. Follow-up questions have helped improve researchers' understanding of respondents' intentions but usually fail to create a complete awareness of respondent motives. Typical survey questionnaires are relatively brief in their questioning of motives but even with the most detailed surveys it is near impossible to be completely certain of respondents' motives. Recorded verbatim responses such as "why doesn't the government

pay," "that change is not big enough to make a difference" or "I'd prefer a different method" are difficult to interpret. Alternatively, in what Kriström (1997) calls the extensive margin of choice, the respondent may be indecisive between the discrete switch from zero to non-zero willingness to pay, which is then reflected in his response to the follow-up motive questions. In some cases the difficulty in interpreting respondent's motives is arguably due to respondent ambivalence. There are numerous reasons why a person may vote No to a CV proposal but the focus of this paper is confined to No responses that are presumed to have associated WTP exactly equal to zero.

DC-CV Models

Two commonly used CV models are briefly outlined that will be subsequently used for comparison. The first model is one in which the Yes and No responses in DC-CV are taken at face value without any examination of follow-up responses and respondent motives and is estimated to illustrate the importance of utilizing the information contained in follow-up responses. The likelihood function for survey responses for this approach is similar to the following:

$$(1) \quad L = \prod_i [F(f_i, \theta_i)]^{N_i} [1 - F(f_i, \theta_i)]^{Y_i}$$

where F is the cumulative distribution function of WTP , Y_i is a dummy variable for respondent i answering Yes, N_i a dummy variable for respondent i answering No, f_i is the bid price or fee facing respondent i and θ is a vector of respondent characteristics. This is a widely estimated model and similar to that proposed by Hanemann (1984).

The second model for comparison has been termed a spike model (Kriström 1997; Hanemann and Kriström 1995) and it is assumed as known which respondents have zero WTP . This information is usually obtained from the follow-up responses. The likelihood function for the spike model is exactly equal to likelihood (1) but is estimated conditional on having positive WTP . In the remainder of the paper when referring to the spike model it will be denoted likelihood or model (1') meaning the likelihood specified in equation (1) but estimated conditional on respondents with positive WTP .

Modeling the Imprecise Nature of Information in Follow-Up Responses

In the CV question the respondent is confronted with a proposal regarding resource q . Respondent

i 's indirect utility is $v(q, y_i; \theta_i)$ where θ is a vector of household characteristics, and y is income. The project is represented as $q^0 \rightarrow q^1$ for fee f . The DC-CV survey draws Yes and No responses and after examination of the follow-up responses the researcher can further classify respondents.

Consider the situation where the researcher presumes that some respondents receive no benefit from $q^0 \rightarrow q^1$ and therefore $WTP = 0$. But most survey instruments are not of sufficient accuracy that we can say with complete confidence that all respondents presumed to have $WTP = 0$ have indirect utility:

$$(2) \quad v(q^1, y_i; \theta_i) = v(q^0, y_i; \theta_i) = v(y_i; \theta_i)$$

For respondents with indirect utility $v(y_i; \theta_i)$, the classification as a respondent who does not receive benefit from $q^0 \rightarrow q^1$ and having $WTP = 0$ is correct. But we cannot be certain that all respondents that we presume have $WTP = 0$ actually have $WTP = 0$, there is some uncertainty. Consider respondent i who believes the CV proposal will diminish his indirect utility but who the researcher incorrectly presumes has $WTP = 0$. His indirect utility is

$$(3) \quad v(q^0, y_i; \theta_i) > v(q^1, y_i; \theta_i)$$

Alternatively consider respondent i , presumed to have $WTP = 0$ but who in fact favors the CV proposal, maybe with only a low WTP . The indirect utility of such a respondent is

$$(4) \quad v(q^0, y_i; \theta_i) < v(q^1, y_i; \theta_i)$$

In equation (3) the fall in indirect utility from the proposal is the extent of the error in classifying the respondent as receiving no utility from the CV proposal. This classification error can be measured by μ_i

$$(5) \quad \mu_i = v(q^0, y_i; \theta_i) - v(q^1, y_i; \theta_i)$$

Let $\mu^A = \text{Max. } \mu_i, i = 1 \dots T$, where T is the number of respondents presumed to have $WTP = 0$ and for which (3) holds.³ If we cannot distinguish these T respondents from other respondents that truly have $WTP = 0$ then we can say that the indirect utility of any individual in this combined group (both respondents correctly and incorrectly presumed to have $WTP = 0$) is such that

$$(6) \quad v(q^0, y_i; \theta_i) - \mu^A < v(q^1, y_i; \theta_i)$$

By a similar argument for respondents presumed to have $WTP = 0$ but who see the CV proposal as an improvement, i.e., satisfy equation (4), we can say

$$(7) \quad v(q^1, y_i; \theta_i) < v(q^0, y_i; \theta_i) + \mu^B$$

Where μ^B is the maximum error in classifying respondents as having $WTP = 0$ and for which $v(q^0, y_i; \theta_i) < v(q^1, y_i; \theta_i)$. Combining (6) and (7) we get the following:

$$(8) \quad v(q^0, y_i; \theta_i) - \mu^A < v(q^1, y_i; \theta_i) < v(q^0, y_i; \theta_i) + \mu^B$$

Equation (8) will hold true for all respondents presumed to have $WTP = 0$, regardless of what errors in classification are made. If no error is made, i.e. $WTP = 0$, then $v(q^1, y_i; \theta_i) = v(q^0, y_i; \theta_i) = v(y_i; \theta_i)$ from equation (2) and therefore $v(q^0, y_i; \theta_i)$ will always be greater than $v(q^0, y_i; \theta_i) - \mu^A$ or less than $v(q^0, y_i; \theta_i) + \mu^B$. If respondent i is presumed incorrectly to have $WTP = 0$, μ_i will always be less than μ^A or μ^B depending on whether equation (3) or (4) applies. Given the limits of accuracy of survey instruments the best a researcher can say about any respondent for which equation (8) applies is that these respondents have WTP in the vicinity of zero.

Assume for convenience that $\mu^A = \mu^B = \mu$.⁴ The probability that a respondent has WTP equal or close to zero, i.e. equation (8) holds, is

$$(9) \quad \Pr(WTP \text{ in vicinity of zero}) = \Pr(v(q^0, y_i; \theta_i) - \mu < v(q^1, y_i; \theta_i) < v(q^0, y_i; \theta_i) + \mu)$$

A graphical representation of the probability in (9) is presented in figure 1 along with the remaining probabilities derived in equations (10) to (12) below.⁵ The probability that a respondent is opposed to the CV proposal, that is has $WTP < 0$, is

$$(10) \quad \Pr(\text{opposed to CV proposal}) = \Pr(v(q^1, y_i; \theta_i) < v(q^0, y_i; \theta_i) - \mu)$$

Respondents in favor of the CV proposal consist those willing and those unwilling to pay the CV bid price.

$$(11) \quad \Pr(0 < WTP < f) = \Pr(v(q^1, y_i - f; \theta_i) < v(q^0, y_i; \theta_i) + \mu < v(q^1, y_i; \theta_i))$$

$$(12) \quad \Pr(f < WTP) = \Pr(v(q^1, y_i - f; \theta_i) > v(q^0, y_i; \theta_i) + \mu)$$

Indicator variables to be used as exponents in the likelihood function are defined as follows: M_i

⁴ This assumption is subsequently required for full identification of parameters in estimation.

⁵ The idea of a threshold between positive and negative WTP is analogous to the threshold between willing and not willing to pay the CV bid price in Wang's (1997) random valuation model. Wang graphically presents this on (p223).

³ If all respondents were classified correctly μ^A would equal zero.

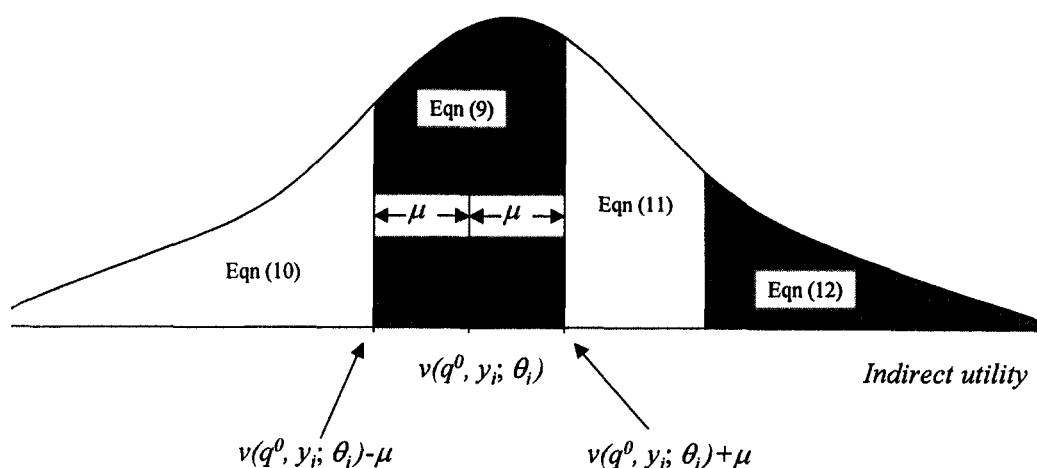


Figure 1. Probability Density Function for Utility

= 1 when a respondent opposes the CV proposal, zero otherwise. $Z_i = 1$, when the respondent is believed to have WTP in the vicinity of zero, zero otherwise. $N_i = 1$, when the respondent favors the CV proposal but $WTP < f$, zero otherwise. $Y_i = 1$, when the respondent votes in favor of the CV proposal, zero otherwise. Assuming a linear functional form for the indirect utility function ($v = \alpha_i + \beta y_i + \varepsilon_i$) and that G is the distribution function of indirect utility, the likelihood function is the product of the four probabilities:

$$(13) \quad L = \prod_i [G(-\alpha_i - \mu)]^{M_i} \cdot [G(-\alpha_i + \mu) - G(-\alpha_i - \mu)]^{Z_i} \cdot [G(\beta y_i - \alpha_i + \mu) - G(-\alpha_i + \mu)]^{N_i} \cdot [G(\beta y_i - \alpha_i + \mu)]^{Y_i}$$

The second term in the likelihood (13) is what most distinguishes this model. This term relates to the probability that WTP is in the vicinity of zero and has parallels to the spike model, such as those developed by Kriström (1997) and Hanemann and Kriström (1995). But in the spike model, such as (1'), it is assumed known with certainty which respondents have $WTP = 0$. Kriström's (1997) "Extended Spike Model" has a likelihood similar to (13) above, where he divides respondents into three categories: those who dislike the project (the "losers"), those who are indifferent and those who find that the project is welfare improving ("the winners").⁶ Respondents stating indifference to the CV proposal are assumed to have $WTP = 0$. A positive probability at a point, i.e., that $WTP = 0$,

cannot be estimated within a continuous distribution, and hence Kriström defines a parameter similar to μ that allows the spike to have density within the distribution of WTP. The parameter μ in Kriström's model appears to be a mathematical construct to facilitate estimation, whereas, in the model above the motivation for μ is to facilitate the element of uncertainty in classifying respondent types. Also μ has an interpretation within the utility framework of the model, it is a measure in utility metric of the maximum error that the researcher would make if respondents were instead assumed to have WTP exactly equal to zero.

Comparison of Models: Application to Deer Management

The analysis is based on a telephone survey of Maryland households completed by the Survey Research Center at the University of Maryland. The survey was designed to collect information on preferences for future deer management policies in Maryland, where large deer populations afford many benefits to Maryland residents but also cause considerable damage to property. A random sample totaling 1531 households across Maryland was drawn. A response rate of 65% was achieved with a further 14% of households having miscellaneous problems preventing answering the survey. Model estimation here will use the 838 records that deal with controlling the deer population.

The survey began by asking respondents whether they had seen deer, where they saw them, and how often. Following this were questions on whether seeing deer was enjoyable and whether respondents knew about or suffered deer damage.

⁶ Kriström fully specifies the Extended Spike Model's likelihood function in a working paper (Kriström 1996).

Table 1. Classification of CV Question Respondents

CV Question	Numbers of Respondents	In Favor of CV Proposal with Positive WTP	Voted No and Follow-Up Responses Suggested WTP Close to Zero*	Opposed to the CV Proposal with Negative WTP
Sharpshooting	432	245	75	112
Birth Control	406	267	70	69
Total	838	512	145	181

*It is subjective interpretation of the follow-up responses that allows these responses to be classified as having WTP close to zero. An alternative subjective interpretation is that these respondents have WTP exactly equal to zero.

Prior to the contingent valuation question there was a description of Maryland's deer population growth, the associated damages and also the potential benefits. Two CV questions were used to value deer population control programs, though respondents were asked only one of the valuation questions. One proposed using sharpshooters while the second proposed the use of deer birth control.⁷ To improve the informational content of the responses and understand why respondents answered No to the CV proposal, respondents were asked to explain the reason for doing so:

What's the main reason you'd vote against it? Is that because:

- (1) The program costs too much,
- (2) Deer are not a problem in your community,
- (3) Or for some other reason? SPECIFY
- (4) You are concerned about the humane treatment of deer
- (9) REFUSED

The interviewer read the question and options (1) through (3) and the respondent's answers were matched, if possible, to options 1, 2, or 4, otherwise a verbatim response was recorded. Option 4, being concerned about the humane treatment of deer was not read aloud to avoid prompting respondents into selecting this as a socially desirable answer.

The follow-up question just outlined is roughly

similar to usual CV survey instrument follow-up questions and elicits information that is more indicative than precise. Table 1 provides the classification of respondents into the three categories: opposed to CV proposal, WTP in vicinity of zero, in favor of CV proposal with positive WTP. The individual specific variables, which are all dichotomous variables, are described in table 2.⁸

Empirical Results

A linear functional form for the indirect utility function was assumed for estimation: $v(q, y; \theta_i) = \alpha(q, \theta_i) + \beta y_i + \varepsilon_{iq}$, where q represents the CV project, y is household income, and θ is a vector of household characteristics. The error term ε_{iq} represents what appears to be the random component of utility as observed by the researcher. The probability that an individual is a particular type of respondent can be estimated using the logit distribution if it is assumed that the error terms are independently and identically distributed with a Type I Extreme Value distribution. The α 's, β and μ are the parameters to be estimated.

Model Estimates

The estimated parameters from the three maximized likelihood functions are presented in table 3.

⁷ The two contingent valuation questions and the prior description of Maryland's deer population growth are contained in the appendix.

⁸ Further details about the survey are contained in Curtis (1998).

Table 2. Description of Variables

Variable	Description	Mean	Std. Dev.
SS	1 = sharpshooting CV question, zero otherwise	0.516	0.50
BC	1 = birth control question, zero otherwise (BC = 1-SS)	0.484	0.50
ETH	1 = believe it is unethical to kill deer, zero otherwise	0.636	0.48
AR	1 = animal rights advocate, zero otherwise	0.294	0.46
HUNTER	1 = deer hunter in household, zero otherwise	0.144	0.35
AGE \geq 35	1 = age \geq 35, zero otherwise	0.496	0.50

Table 3. Model Estimates

Likelihood Function:	(1)		(1')		(13)	
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
β	0.003	0.002	0.009	0.003 **	0.013	0.001 **
α_1 SS·ETH·AR	-0.367	0.267	0.701	0.354 **	0.878	0.245 **
α_2 SS·ETH·(1-AR)	0.016	0.203	1.149	0.276 **	1.112	0.167 **
α_3 SS·(1-ETH)·AR	-1.436	0.377 **	1.141	0.568 **	-0.598	0.248 **
α_4 BC·ETH·AR	0.528	0.350	1.882	0.555 **	1.733	0.284 **
α_5 SS·(1-ETH)·(1-AR)	-1.712	0.327 **	0.021	0.406	-0.325	0.204
α_6 BC·(1-ETH)·AR	0.622	0.315 **	1.992	0.444 **	1.774	0.252 **
α_7 BC·ETH·(1-AR)	-0.495	0.249 **	0.667	0.343 *	0.850	0.171 **
α_8 BC·(1-ETH)·(1-AR)	0.140	0.270	1.425	0.360 **	1.519	0.228 **
α_9 HUNTER·SS	-0.145	0.290	0.103	0.422	-0.183	0.249
α_{10} HUNTER·BC	-0.796	0.317 **	0.706	0.563	-1.335	0.246 **
α_{11} AGE \geq 35	0.385	0.153 **	0.538	0.208 **	0.308	0.134 **
μ	n.a.	n.a.	n.a.	n.a.	0.482	0.038 **
Log likelihood	-0.626		-0.587		-1.256	
No. of observations	838		512		838	

*Statistically significant at 90%. **Statistically significant at 95%

Only 512 observations are used to estimate the parameters of likelihood function (1'), as it is conditional on respondents with positive WTP.

The parameters from likelihood functions (1) and (13) are directly comparable while likelihood function (1') was estimated conditional on having positive WTP.

Likelihood (1) was estimated to illustrate the importance of utilizing follow-up responses. Most of the estimated parameters in likelihood (1) differ significantly from the other two likelihood functions. One difference is the improbable result that likelihood (1)'s estimate of the marginal utility of income, i.e. β , is insignificantly different from zero. Models (1') and (13), which utilize follow-up information, albeit in different ways, have more reasonable estimates of β , i.e. positive valued, and this result itself is some indication of the importance of utilizing follow-up responses in analyzing answers to CV questions.

In most cases the parameter estimates in models (1') and (13) are not significantly different. However, there are important deviations between the models, in particular, the significant estimate of μ from likelihood (13). The significance of μ means that some of the group of respondents with WTP in the vicinity of zero either gain or lose utility from the CV proposal.⁹ In model (1') these same respondents are assumed to receive no utility change from the CV proposal and accordingly have WTP = 0. The statistically significant estimate of μ shows the error of such an assumption. The greater number of statistically significant parameter estimates in likelihood (13) enables us to discern a wider diversity

in preferences for deer management across the different categories of respondents. This diversity in preferences is discussed in the policy implications section of the paper.

Welfare Change

With a linear utility function and mean zero error, mean WTP equals α/β .¹⁰ The welfare calculations are included in table 4.¹¹ In the case of model (1) the estimate of mean WTP for both the sharp-shooting (SS) and birth control (BC) management options are statistically insignificant. With widespread belief among the general population that the deer population should be reduced in size, as reflected both in the media and other survey question responses,¹² it is doubtful that WTP to achieve such an objective is zero. The estimated model parameters and unreasonable welfare estimates suggest that model (1) is unsuitable for learning about preferences in present circumstances.

For likelihood (1') the welfare calculations are conditional on the 512 respondents deemed to have positive WTP. The remaining 326 respondents were assumed to have zero WTP. The conditional estimate of mean WTP for SS is \$121.1 and \$171.7 for BC. Though both welfare estimates are signifi-

¹⁰ See Hanemann (1984).

¹¹ Confidence intervals were calculated over 100,000 drawings from the parameter vector according to the estimated variance-covariance matrix, similar to Krinsky and Robb (1986).

¹² Over 86% of survey respondents said they would not like the deer population to increase.

⁹ The sign of μ does not indicate whether the respondents with WTP in the vicinity of zero would on average be "winners" or "losers." By construction estimated μ is positive in sign.

Table 4. Estimates of Mean Willingness to Pay

	(1)		(1')		(13)	
	Estimate	95% C.I.	Estimate	95% C.I.	Estimate	95% C.I.
Mean WTP for SS	-172.4	-1145.9-867.6	121.1	89.2-210.9		
Mean WTP for BC	19.5	-229.7-260.0	171.7	130.8-296.8		
Mean (a)					146.9	131.8-165.8
WTP (b)					1.8	1.2-2.5
for SS (c)					-124.6	-141.9- -110.9
Mean (a)					165.4	149.1-185.7
WTP (b)					3.2	2.3-4.3
for BC (c)					-119.8	-136.5- -106.4

(a) Estimated mean WTP for respondents who find the CV proposal welfare improving.
(b) Estimated mean WTP for respondents presumed to have WTP in the vicinity of zero.
(c) Estimated mean WTP for respondents who dislike the project.

cantly different from zero the 95% confidence intervals are quite wide thus only allowing quite broad conclusions on welfare change.

Three conditional welfare calculations are made using the estimates from likelihood (13). Mean WTP for respondents who find that the project is welfare improving (“the winners”) is quite high, equaling \$146.9 for SS and \$165.4 for BC. These estimates are directly comparable and similar in magnitude to the welfare measures from model (1’). However, the confidence intervals for the welfare measures with likelihood (13) are much tighter and these tighter confidence intervals would be of considerable benefit in the policy arena when management options are being decided. For respondents believed to have WTP in the vicinity of zero the estimates of mean WTP are significantly different from zero, \$1.8 for the SS option and \$3.2 for the BC option. This follows from the significant estimate of μ and again highlights the error of assuming that these respondents have zero WTP. The third welfare measure from likelihood (13) is for respondents that dislike the CV proposal (the “losers”). These respondents have a large but negative WTP.

For transparency between models we calculate in table 5 a common unconditional welfare measure for the entire sample, which is the sum of conditional welfare measures in each model

weighted by the proportion of associated respondents. Again it is clear that the results from likelihood (1) are grossly at odds with the other models and once more highlights the importance of the information contained in the follow-up responses. For models (1’) and (13) the unconditional estimates of mean WTP are of similar magnitude. But the confidence intervals of the welfare measures differ substantially. For likelihood (13) the confidence intervals for mean WTP of SS and BC are both no greater than \$20. For likelihood (1’) the confidence intervals on mean WTP are as much as \$100. Likelihood (1’), unlike likelihood (13), interprets information from the follow-up motive questions in a manner that is difficult to reasonably justify. Imposing the strict assumption that certain specific respondents have $WTP = 0$ has led to welfare measures with wide confidence intervals. The much tighter confidence intervals for the welfare estimates from likelihood (13) will mean greater trust in policy recommendations based on welfare analysis from this model.

Policy Implications

In models (1’) and (13) the α parameters are used to differentiate variations in preferences for deer management based on personal characteristics. A series of hypothesis tests were undertaken to iden-

Table 5. Unconditional Estimates of Mean Willingness to Pay

Likelihood Function	(1)	(1')	(13)
Sharp Shooting	-172.4	68.7	51.3
(95% C.I.)	(-1145.9-867.6)	(50.5-119.3)	(45.8-58.1)
Birth Control	19.5	112.9	89.0
(95% C.I.)	(-229.7-260.0)	(80.7-183.5)	(80.2-99.9)
Sample size	838	838	838

Note: Mean WTP for SS from likelihood (13) is calculated as: $51.3 = 146.9*(245/432) + 1.8*(75/432) - 124.6*(112/432)$. The figures in parenthesis are the numbers of respondents as described in table 1. The other calculations for likelihood functions (1’) and (13) are calculated in a similar fashion.

tify differences in preferences across specific groups of people (e.g. animal rights advocates versus non-animal rights advocates) and in many instances the results from the two models concurred. But the models diverged in several areas, some of which are presented here to show how choice of a particular model might misdirect policy.

Crucial policy implications might revolve around hunters' preferences, an important stakeholder in deer population management. Policy makers presumably would like to know if hunters have any preference between the two management options, or whether hunters prefer sharp-shooting to birth control. Such a hypothesis involves testing whether $\alpha_9 = \alpha_{10}$ versus the alternative $\alpha_9 > \alpha_{10}$. The standard normal test statistic for this hypothesis is 3.296 for model (13) and -0.862 for model (1'), therefore, with model (13) we conclude that hunters prefer sharp-shooting to birth control while with model (1') we cannot distinguish any difference in hunters' preferences between the two management options.

It would also be useful to policy makers to know if hunters' preferences differ from preferences of the non-hunting population. This involves testing whether $\alpha_9 = 0$ and $\alpha_{10} = 0$. The chi-square test statistic for model (13) is 29.962 and for model (1') it is 1.627 compared to critical value of 5.991 at 95% significance. With model (13) we can conclude that hunters' preferences for deer management differ from non-hunters preferences, whereas with model (1') we find no difference between the preferences of hunters and non-hunters.

The differing conclusions from these hypotheses tests between the two models shows why it is important not to infer more than is reasonable from DC-CV survey data. Model (1') uses the data in ways that was not intended by the survey design when it assumes certain respondents have WTP exactly equal to zero. One of the effects of such an action in this instance is that the model is unable to distinguish important differences in preferences between diverse groups of respondents. Model (13) also uses the information from follow-up responses but does not impose strict assumptions that certain respondents have WTP = 0. Instead it utilizes the follow-up information that suggests certain respondents have low WTP possibly close to zero. The estimated model was subsequently better able to distinguish differences in preferences and welfare estimates had much narrower confidence intervals.

Conclusions

It is important how the information from follow-up motive questions is utilized in DC-CV because it

can affect policy decisions. This is evident when the estimated models and welfare calculations are compared. The poor results from model (1) illustrated why it is important to incorporate follow-up information in DC-CV. But the comparison of the second two models demonstrated that while the follow-up responses can contribute to our understanding of respondents' preferences, there are limits on what the follow-up questions can say about respondents' WTP. It is important that when the information from the follow-up questions is utilized it is utilized appropriately and in particular it is unreasonable to assume that certain respondent's WTP = 0.

In many cases follow-up responses will clarify respondents' motives. But in some cases it is often left to the researcher's subjective interpretation. When WTP is close to zero it will often be difficult for the researcher to say with complete accuracy whether WTP is zero or slightly different than zero. The usual design of follow-up questions is not to determine whether WTP = 0 but to understand respondents' motives for their DC responses. The model developed in the paper circumvents the researcher from making the decision that certain respondents' WTP = 0. Instead the researcher has only to determine which respondents have WTP in the vicinity of zero, a task normally possible within the constraints of the available data.

Model (13) appears to be the most preferable model to analyze respondents' preferences and welfare implications for several reasons. First, model (13) incorporates the uncertain and imprecise nature of the information contained in follow-up responses, unlike the spike model. Parameter estimates within the model have substantially lower standard errors, which in turn contribute to the much tighter confidence intervals on the welfare estimates. Unlike model (1'), model (13) is able to distinguish differences in preferences between diverse types of respondents. One important difference between the two models is the treatment of information from the follow-up responses. In the spike model, i.e. model (1'), certain respondents were assumed to have WTP = 0 and the remaining respondents assumed to have positive WTP. In model (13) no respondents were assumed to have WTP = 0 but where the available information suggested that certain respondents had very low WTP, possibly zero, this information was incorporated into the model.

The applicability of the proposed method for dealing with follow-up questions may be quite wide for at least two reasons. Even with optimal questionnaire design there are limits to what we can reasonably infer from DC-CV surveys (with

follow-up motive questions) and therefore the proposed method may prove useful. Since follow-up questions are now frequently used in CV surveys the method proposed will not be constrained by unavailability of data.

The results presented are conditional on the chosen functional form for the indirect utility function, on the selected probability density function, and on the data itself. If these results apply more generally this method for treating follow-up responses could substantially improve the accuracy of similar DC-CV welfare analysis. As a possibility for further research the robustness of the empirical results with respect to choices for functional form for indirect utility and the distribution of the random component of indirect utility should be tested.

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Appendix

Description of Maryland's Deer Population:

Ten years ago, there were about 150,000 deer in Maryland. Now, there are twice as many deer in Maryland—about 300,000.

This growth means that deer are now easier to see in areas where people can enjoy them. But, it also means deer now cause more crop losses, damage to private landscaping, as well as damage to cars from collisions. And, it has led to the spread of lyme disease among people.

Would you like to see the deer population continue to increase?

The Sharp-Shooting Proposal:

A proposal being considered to control the deer population is to hire professional hunters as sharpshooters. These sharpshooters will be instructed to reduce the deer population in specific areas where deer damage is highest. The sharpshooters will be safe to use in areas where people live nearby. The objective will be to reduce [your country's] deer population by 10% in total for the next five years. If this were to be used in [your county], it should reduce deer damage to cars, crops and landscaping. On the other hand, there will be fewer deer, and the likelihood of seeing deer will decrease.

This proposal to reduce [your county's] deer population by 10% using sharpshooters would cost your household [15, 30, 50, 75, or 100] dollars in higher state income taxes for one year. Keeping in mind that you would have [15, 30, 50, 75, or 100] dollars less to spend on other things, would you vote for it or vote against it?

The Birth Control Proposal:

A proposal being considered to control the deer population is to use deer birth control. This method of control can be used in areas where people live nearby. Qualified personnel will be hired to administer the contraceptive by methods that will avoid pain to the deer. This birth control will be used to control the population in specific areas where damage is highest. The objective will be to reduce [your county's] deer population by 10% in total for the next five years.

If this were to be used in [your county], it should reduce deer damage to cars, crops and landscaping. On the other hand, there will be fewer deer and the likelihood of seeing deer will decrease.

This proposal to reduce [your county's] deer population by ten percent using birth control would cost your household [15, 30, 50, 75, 100, or 125] dollars in higher state income taxes for one year. Keeping in mind that you would have [15, 30, 50, 75, 100 or 125] dollars less to spend on other things, would you vote for it or vote against it?