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Stated Preference Analysis of Public Goods: Are we asking the right question?

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Abstract

In this paper we develop a simple question response model to dichotomous choice/referendum style stated preference questions. In our model, participants gather project information from the survey description, form a prior distribution of project costs, receive additional information through the survey's stated cost, and then respond to the dichotomous choice/referendum question with the belief that a yes increases the probability the project will be provided while a no decreases the probability the project will be provided. Based on our analysis we conclude that participants will generally not respond truthfully in the sense that they may say no to a stated cost that is less than their willingness to pay for a project or yes to a stated cost that is more than their willingness to pay. Given our findings, the resulting mean estimates will not in general be upwardly or downwardly biased. Rather the design of the stated costs used in the survey will influence the mean estimates from various studies in an unpredictable fashion. Our model predicts responses that are consistent with "yea-saying," answering yes to any stated cost amount, and "neah-saying," answering no to any stated cost amount. Further, we offer a potential solution to this problem involving the use of a cost share financing mechanism. Unfortunately this solution is not always applicable.

1. Overview of the Problem

Stated preference studies of public goods and projects that use methods such as contingent valuation or stated choice conjoint typically emphasize estimating the mean of the distribution of the population's value for the good or project. In order for the researcher to estimate the mean value, the stated cost that a study participant faces must be varied across participants for statistical identification.[1] Studies that consider the experimental design of choosing these stated costs emphasize statistical estimation efficiency.[2] The resulting designs based on the principle of statistical efficiency have nothing to do with the anticipated costs of the project - stated costs are essentially fictitious. Given the fact that stated costs are varied across participants and these stated costs are not linked to costs, it is likely that for *any given* participant, if the project is implemented it will not be at the cost stated in the survey.

Given the context in which stated costs are developed, it is only reasonable to consider the possibility that survey participants may find the stated costs presented to them lacking credibility. In a recently published study, Champ *et al.* (2002) investigate stated cost credibility in a contingent valuation study under three different dichotomous choice contingent valuation provision formats: individual contribution, provision point, and referendum.[3] Forty-two percent of the 626 participants to the referendum question indicated that if a referendum were held, they

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[1]We use the phrase "stated cost" to refer to the cost expressed in the survey while "cost" refers to the cost that will actually be realized if the project is implemented.

[2]For example see Alberini (1995).

[3]The good considered in Champ *et al.* (2002) is the public purchase and open space designation of a property near Boulder, Colorado.

believed that the actual tax request would be different than the amount stated in the contingent valuation survey. As shown in the table below, the other provision formats produced similar results. Though these results are from a single study, the overall results suggest that credibility of the stated costs in contingent valuation questions may indeed be problematic.

Table 5 From Champ et al.,(2002):
Distributions of Responses to Credibility Questions by Treatment

If a trust fund were actually set up (referendum held), do you think the amount you would be asked to donate (one-time tax assessment) would be $(offer amount)?	Individual Contribution	Provision Point	Referendum
No, more	50%	40%	38%
No, less	13%	8%	4%
Yes	37%	52%	58%

Much of the discussion surrounding credibility in survey design has been on the plausibility of the scenarios presented to the participants. The emphasis has been on the other attributes of the potential project or program and not specifically on the stated costs. In their report on contingent valuation measurement of passive use values in natural resource damage assessment, Arrow *et al.* (1993) recommend posing contingent valuation questions as a dichotomous choice (yes/no/no vote) framed as a referendum on account of the potential for study participants to strategically misrepresent their preferences. Following up on this recommendation, Carson *et al.* (1999) draw on results from the mechanism design literature and conclude that the dichotomous choice/referendum format is superior to other available question formats with regard to strategic potential. The crux of the Carson *et al.* (1999) analysis is the consequential nature of participants' responses. A participant faces a stated referendum question such as “if a referendum on this project at a cost of $X to your household were held today, how would you vote: yes, no, not sure?” Carson *et al.* reason that if a yes vote increases the probability that the project is provided at the stated cost while a no vote decreases the probability that the project is provided at the stated cost, then utility-maximizing study participants should not misrepresent their preferences as long as the value of the project is positive under zero costs. While Carson *et al.* note that participants must find stated costs credible, their analysis does not address instances when this credibility is lacking or incomplete. Similarly Green *et al.* (1998) and Schläpfer (2002) warn that stated costs that lack credibility to participants will prove problematic for stated preference analysis.

In this paper we move the analysis forward to consider situations in which stated costs are not perceived to be perfectly credible by survey participants. To address the implications of this issue, we develop a simple question response model in which participants gather project information from the survey description, formulate information regarding uncertainty over project costs, receive additional information through the survey’s stated cost, and then respond to a dichotomous choice/referendum question with the belief that a yes response increases the probability the project will be provided while a no response decreases the probability the project will be provided. Further, we offer a potential solution to the problem of credible variation by means of using cost shares as a valuation mechanism. This approach will only be successful in limited circumstances.

2. A Simple Model of Stated Preference Responses

A well-designed stated preference survey typically consists of several sections. The first section consists of “warm-up” questions. The second section provides a careful description of the good or project being valued. The third section contains one or more valuation questions. Finally, the fourth section provides demographic questions. We focus our analysis on sections two and three of the survey, the project description and valuation question. Our analysis proceeds as follows. First we consider a specific form of indirect utility that exhibits risk neutrality with regard to individual cost uncertainty. Similar to Arrow and Fisher (1974), we consider a risk neutral form of indirect utility in order to avoid the situation where results are driven by the risk profile of preferences. The issues identified in our analysis will only be further exacerbated when preferences exhibit risk aversion or risk loving. Then given this specification of utility, we develop a formal procedure for organizing cost information that uses a Bayes decision rule in an expected utility framework. Participants form a prior distribution on the mean of uncertain costs, receive additional information on costs through stated costs, form a posterior distribution on the mean of costs and apply a Bayes decision rule to arrive at a decision. We use a Bayesian updating framework because it provides a complete analytical approach to receiving new information and making decisions under uncertainty. Though there may exist incomplete, "rule of thumb," strategies that will produce results similar to what we present below, we focus on the more formal, Bayesian, approach. Within our Bayesian framework, we consider three cases that represent the range of possibilities.

Herriges and Shogren (1996) use a Bayesian updating framework to examine responses to double-bounded dichotomous choice contingent valuation questions. The Herriges and Shogren model differs considerably from ours in that costs are certain while a participant's value of the public good is random. Fundamentally, their model of preference uncertainty is a variant of models found in the psychophysics literature, particularly Thurstone (1927). The stated cost amounts in the double-bounded question sequence reveal information to the participant about their own value in a Bayesian framework. Though there may well be individual uncertainty regarding own valuation, we feel that a standard expected utility approach also deserves consideration, particularly given the evidence of stated cost/actual cost uncertainty revealed in the Champ *et al.* (2002) study.

2.1. Risk Neutral Utility Specification

Our first simplifying assumption is that for survey participant *i*, indirect utility is linear in the project and income. The project takes on a value of 1 if provided and zero otherwise. The ex-post difference in indirect utility takes on a very simple form.

$$\begin{aligned} \textit{Indirect Utility}: \quad & v(q, y) \equiv \beta q + y \quad \Rightarrow \\ & v(1, y - c_i) - v(0, y) = \beta_i - c_i \end{aligned} \tag{1}$$

For this utility specification, compensating variation for individual *i* is simply β_i. As noted above, the specification also exhibits risk neutrality which serves as a boundary case for other utility specifications that do not exhibit risk neutrality. Results presented below will be exacerbated under other non-risk neutral forms of indirect utility. Furthermore, this specification is found throughout the contingent valuation literature where choices are often statistically modeled in a random utility framework.[4]

2.2. Bayesian Normal Prior

As a Bayesian, participant *i* views the parameters of the mean of the cost distribution, μ, as random. Here we assume that after hearing the project description, *i* formulates a normal

[4]See Cameron (1988) and Hanemann (1984).

prior distribution of the mean of the cost distribution. We use 0 subscripts to signify prior information. This prior is completely known to *i* since it summarizes his uncertainty about the mean of the cost distribution which as an expected utility maximizer is his primary concern.

$$\textit{Prior Distribution of } \mu: \quad \mu \sim N(\mu_0, \tau_0^2) \qquad \textbf{(2)}$$

We interpret the parameter τ_0^2 to be the confidence that the individual has in their own knowledge about the expected costs of the project. More knowledge does not necessarily correlate to a smaller variance but may in fact result in a more diffuse prior. The density function of the prior is denoted $g_0(\mu)$. It is worth noting that a Bayes decision rule uses information on parameter uncertainty in combination with expected utility. Without any additional information, *i* considers whether $E_{g(\mu)}[E_{f(c|\mu)}(\beta_i - c)]$ is positive or negative which reduces to a comparison of willingness to pay and μ_0. The expectation inside is simply expected utility for a specific value of μ. The outside expectation uses information regarding parameter uncertainty as reflected through the prior.

2.3. Posterior Distribution

In cases where new information regarding uncertainty is obtained, Bayesian decision theory is complete in the sense that the theory provides a formal approach to incorporating the new information into the uncertainty framework. Recall Bayes rule which provides an identity relating the conditional probability of *A* given *B*, to the conditional probability of *B* given *A*, the unconditional probability of *A* and the unconditional probability of *B*.

$$\textit{Bayes Rule}: \quad P(A|B) = \frac{P(B|A)P(A)}{P(B)} \qquad \textbf{(3)}$$

Putting things in terms of density functions, we can use Bayes rule to compute a new density function for the random mean parameter given the new information, which in this case is the stated cost which we denote as b_i. This new distribution of the random mean parameter is referred to as the posterior distribution. The posterior density takes the place of $P(A \mid B)$; the prior density takes the place of $P(A)$; and the density of b_i given μ takes the place of $P(B \mid A)$. The unconditional or marginal density of b_i takes the place of $P(B)$ in the denominator. In terms of density, the marginal density of b_i does not depend on μ and is therefore viewed as a proportional factor which we denote with the symbol $\propto$. This proportional factor is a constant that basically scales the other factors so that integrating the posterior over μ equals 1.

$$\textit{Posterior Density of } \mu: \quad h(\mu \mid b_i) \propto f(b_i \mid \mu) g(\mu) \tag{4}$$

The posterior distribution summarizes *i*'s beliefs about uncertainty regarding the mean of the cost distribution after getting the stated cost information. In our application, *i* receives a signal through the stated cost b_i which is *i* considers normally distributed with an unknown mean μ (the same as the mean of the cost distribution) but with a variance σ^2 which is subjectively known to *i* and depends on the credibility of signal. Less (more) credible signals imply a larger (smaller) variance. The distribution of b_i can be thought of as the distribution of b_i conditional on the unknown cost distribution mean μ.

$$\textit{Distribution of } b_i \textit{ given } \mu: \quad b_i \sim N(\mu, \sigma^2) \tag{5}$$

Given the assumptions made so far, the posterior distribution of the unknown mean of costs given the stated cost signal is also normally distributed.

$$\textit{Posterior Distribution of } \mu \textit{ given } b_i\text{:} \quad \mu | b_i \sim N\left(\frac{\tau_0^2 \, b_i}{\tau_0^2 + \sigma^2} + \frac{\sigma^2 \, \mu_0}{\tau_0^2 + \sigma^2}, \frac{\sigma^2 \, \tau_0^2}{\tau_0^2 + \sigma^2} \right) \quad \textbf{(6)}$$

In responding to the contingent valuation question, *i* compares his ex-post willingness to pay with the mean of the posterior distribution. The mean of the posterior can be viewed as a convex combination of the stated cost received in the survey and the mean of the prior distribution. The weights in this convex combination depend on the variance from the prior and the variance from the conditional distribution of b_i. The important feature of the convex combination is that the respective weights depend on the credibility of the information in b_i as well as the individuals confidence in their own knowledge. If the information is not credible, the variance of b_i given μ is large relative to the prior variance and more weight is placed on the mean from the prior distribution. If the information is viewed as credible, the conditional variance is small relative to the prior variance and more weight is placed on the stated costs. Limiting cases will be discussed in the next section.

The Bayes decision still utilizes an iterative expectation as described above before the arrival of new information. The difference is that expectation for the parameters is taken over the posterior distribution instead of the prior. The Bayes decision rule in this case breaks down to whether the expectation of the expected utility difference under the posterior, $E_{h(\mu | b_i)}[E_{f(c | \mu)}(\beta_i - c)]$, is positive or negative. Given the form of indirect utility, the Bayes decision is equivalent to a comparison between willingness to pay, β_i, and the posterior mean.

$$\textit{Bayes Decision}: \quad \textit{Favor Project} \Leftrightarrow E_{h(\mu \mid b_i)}[E_{f(c \mid \mu)}(\beta_i - c)] > 0.$$

$$\Leftrightarrow \quad \beta_i > \frac{\tau_0^2 \, b_i}{\tau_0^2 + \sigma^2} + \frac{\sigma^2 \, \mu_0}{\tau_0^2 + \sigma^2} \tag{7}$$

Thus, there is a subjective benefit-cost at the individual level. Individuals are comparing their posterior expected costs with their personal benefits from the project.

As with Carson *et al.* (1999), we assume that the probability of the project being provided increases with the mean estimate from the inferred distribution of population willingness to pay. We further assume that the decision to implement is a "one-shot" decision. Denying this project does not affect the probability of providing alternative projects. The choice we model is binary and one shot. Therefore conditioned on the information in the posterior, participants should responded truthfully in the sense they vote yes for projects that have higher expected utility and no for those with lower expected utility. With this in mind, we now turn to three cases of outcomes.

3. Three Cases

There are three important cases of resulting posteriors. The first case is when the posterior distribution is degenerate and all support is on the stated cost from the survey. That is, the participant completely ignores the prior in favor of the information provided in the survey. The second case is when the posterior distribution is independent of the stated cost information, *i.e.* the participant completely discounts the stated cost information provided in the survey, resulting in a posterior cost distribution is identical to the prior cost distribution. The third case is when the posterior distribution is influenced by the stated cost amount, but there is posterior support for costs other than the stated cost amount.

3.1. Case 1: Degenerate Support

This first case, when the posterior distribution is degenerate and all support is on the stated cost, requires that participants completely abandon their prior distribution in favor of the cost stated in the survey. Participant *i* receives the stated cost information and believes that the project will cost b_i. Our model produces this case when credibility of the stated cost information is absolute which occurs when $\sigma = 0$. Letting σ go to zero results in a posterior with mean b_i and variance zero. In turn, this implies that a yes vote will occur if and only if a participant's realized willingness to pay/compensating variation is greater than b_i. Note that this would be true even if the indirect utility function did not exhibit risk neutrality.

This is the case emphasized by Carson *et al.* (1999). When willingness to pay exceeds b_i, the participant prefers implementation of the project and votes yes, thus increasing the probability of provision. In terms of misrepresentation of preferences, the one-shot assumption is important. As Carson *et. al* point out, if the decision can be revisited, then the participant may want to reject the project at the stated cost, even though the project will provide a utility gain, in hopes that a different, more favorable project will be presented. It is worth noting that if only rejected projects result in the presentation of an alternative, then misrepresentation is only in a downward direction. The only possibility for strategic misrepresentation is to say no even though their willingness to pay exceeds b_i. Saying yes to a project for which willingness to pay is less than b_i will only result in the higher probability of implementing a project that results in an ex-post utility loss. Given this line of reasoning, it is apparent why Carson *et al.* (1999) conclude that the referendum format is superior. This is the standard case dealt with in the literature, where credibility of the stated costs is taken for granted.

3.2. Case 2: Posterior Bid Independence

The second case is the opposite extreme. Participants put no weight whatsoever on the bid information and so the posterior exactly equals the prior. Our model produces this case when credibility of the stated cost information is zero which is represented by a σ tending to infinity. Letting σ go to infinity results in a normal posterior with mean μ_0 and variance τ_0^2. Participants effectively ignore the bid information and base their consequential responses according to whether they prefer the project is implemented given their prior distribution. They are essentially answering the question whether or not they want the project implemented given what they perceive as the cost potential.

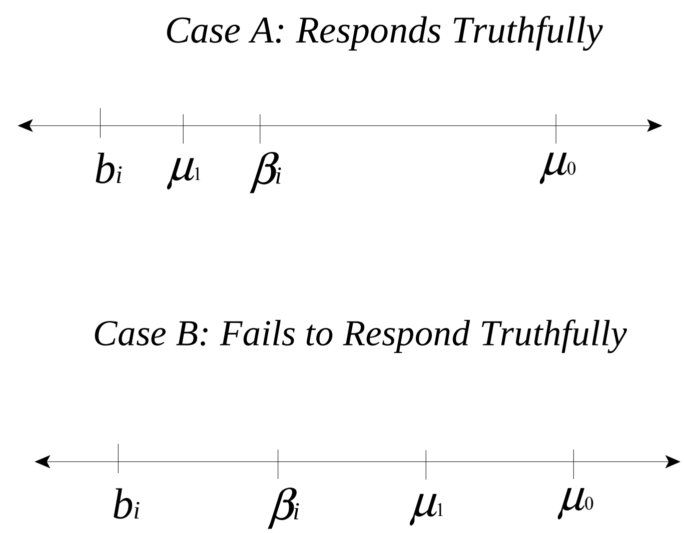
The fact that participants are basically answering a different question takes away any pretense of truthful response in the sense that we obtain information on an individual's realized gross value for the project based on their prior distribution. Participants can provide what appear to be truthful responses in the sense that they may coincidentally answer yes to a stated cost amount for which their willingness to pay is larger or similarly they may say no to a bid amount for which their willingness to pay is smaller. However, there will be cases for which they answer yes when their willingness to pay is smaller than the bid and no when their willingness to pay is larger. At issue is whether a given participant wants the project implemented given their perceived cost potential. Those wanting to increase the probability of project provision will say yes regardless of the stated cost amount they face and those wanting to decrease the probability of project provisions will say no regardless of the stated cost amount. In this extreme case, the stated cost presented in the valuation question has absolutely no influence on their response.

3.3. Case 3: Stated Cost Influence of the Posterior

Intermediate to the two cases discussed above is the situation when the stated cost influences the posterior distribution, but not completely as in the first case discussed above. This case encompasses instances when given a bid design, the best response will effectively take the form of either case one or case two. In our model with risk neutrality, it is the resulting mean of the prior that matters which is easy to graphically depict as in Figure 1. Let us consider the case where the prior mean, μ_0, exceeds *i*'s willingness to pay β_i.[5] Absent stated cost information, the Bayes decision is to say no. Now suppose *i* receives a stated cost amount that is less than β_i. As before we define a truthful response as saying yes to stated costs that fall below β_i and no to stated costs that fall above. Under this intermediate case of the posterior, a truthful response will only follow if the credibility placed on the stated cost is sufficiently high (low variance) to get the posterior mean, denoted μ_1, to fall below β_i. In Figure 1 case A, credibility of the stated cost is sufficiently high to induce a truthful response. For case B, the opposite is true. Obviously if ~~the~~ both the mean of the prior and the stated cost fall on the same side of willingness to pay, the Bayes decision is a truthful response. It is important to recognize that even with reasonably high credibility, participants may still fail to respond truthfully.

[5]For this example failing to answer truthfully is a no vote. The mirror image is when the prior mean falls below willingness to pay and the stated cost is above. Failing to respond truthfully in this mirror case is a yes vote. By providing our particular example we do not intend to downplay the mirror case.

Figure 1
Case 3 Bayes Decisions



Overall the intermediate case suggests that participants may or may not be responding truthfully in the sense that they are only saying yes when their willingness to pay is greater than the stated cost amount and they are only saying no when their willingness to pay is less than the stated cost amount. Taken together, our analysis suggests that truthful response in the context of referendum style valuation questions with designed and varying stated costs is not by any means guaranteed, but at the same time is not altogether ruled out.

4. Estimation Errors

Given the potential problems identified by our analysis, we now turn to a discussion of the implications for estimating the distribution of willingness to pay. Suppose that a participant feels their realized cost under project implementation will be higher than the stated amount but answers yes to the referendum question. In our simple model this corresponds to the situation in which the stated cost falls below the posterior mean which falls below willingness to pay, $b_i < \mu_1 < \beta_i$. A researcher using standard techniques correctly infers that the participant's willingness to pay is greater than or equal to the stated costs, b_i. Suppose the participant answers no to the referendum question. The researcher using conventional logic will infer that willingness to pay falls below b_i. This inference could be erroneous in cases where $b_i < \beta_i < \mu_1$. In this erroneous case, we learn nothing about the participant's willingness to pay. Willingness to pay could be less than the stated cost or much greater since there is no bound on the posterior mean. All we learn is that their perceived costs are greater than their value. The implication for estimating the mean is a downward bias.

At the other end, suppose a participant believes the realized cost will fall below the stated costs. If the participant answers no to the valuation question, the researcher will correctly infer that willingness to pay is less than or equal to b_i, the case in which $\beta_i < \mu_1 < b_i$. Now, consider when the participant answers yes to the valuation question. The participant infers that willingness to pay is greater than the stated cost. This inference could be erroneous in the case where $\mu_1 < \beta_i < b_i$. Again we learn nothing in this case. The posterior mean could be zero which means that the value is not bounded below. In this case the implication for estimating the mean is an upward bias. The two types of erroneous inference outlined in this section work in opposite directions where one type results in a potential downward bias for the estimated mean while the other results in a potential upward bias. For this reason we conclude that estimates may be biased in *either* direction.

5. Cost Sharing

If anywhere near 42% of the participants are answering a different question than the question given to them in a contingent valuation survey, then there may exist a fundamental problem in the design of contingent valuation questions that needs to be considered. One obvious way to address this problem is by giving participants realistic information on costs rather than fictitious prices motivated by concerns over statistical efficiency. If costs are known with some reliability, the use of this information may enhance stated cost credibility. Even with known costs, there exists a problem of identifying the mean of the population distribution of values which requires cost variation. As a first attempt, we propose exploiting a financing mechanism that will give us the properties of being able to give the same, credible costs to all participants, while still providing variation to identify the mean of the distribution of values.

Consider a project for which there are estimates of the project cost. Asking all participants the same question will only allow us to estimate the proportion of the population that is willing to pay the cost. Without cost variation across some of the participants, we cannot estimate the mean. One possibility for inducing variation in costs across participants, or even within participants, is through cost shares across different funding institutions. For example cost sharing is common for many federally funded water projects and for some state funded projects. The approach we suggest is only applicable in cases where cost sharing is credible and thus will not apply in many applications.

For simplicity, assume that the cost of the project is known with certainty, call this cost Δ. From the above discussion, in order for the survey to be credible and incentive compatible, we must reveal the cost of the project. Thus, if we ask a valuation question consistent with

$$\Delta = (1 - \alpha)\Delta + \alpha\Delta \qquad \textbf{(8)}$$

credible presentation of costs, there will be no variation in the stated costs of the project and the estimation will not be identified. A cost sharing mechanism assigns a portion of the cost paid for by a one-time tax at the local level and a one-time tax at the federal level. Let α denote the proportion of the amount paid for at the local level. Denote the populations of taxpayers in the federal and local jurisdictions respectively as N_{fed} and N_{loc}. For an α cost share, the cost for a local individual is given as follows.

$$C_{loc} = (1 - \alpha)\frac{\Delta}{N_{fed}} + \alpha\frac{\Delta}{N_{loc}} \tag{9}$$

We consider three cases for $\alpha = 0$, $\alpha = 1$, and $0 < \alpha < 1$. As is standard in the literature, we will assume that the cost of the project is small relative to the economy. Thus, Δ/N_{fed} is small for any Δ that is small relative to the size of the economy. That is, we may assume that any increase in federal taxes for a specific project will be negligible. To put this into perspective, suppose that a project has a cost of $10 million, then $\Delta/N_{fed} \approx 0.04$. Given small individual federal costs, the cost to a local resident is almost entirely made up of the local portion of cost. Under these conditions we can use α to vary credible costs between 0 and Δ/N_{loc}. Varying α will provide the necessary variation to identify the mean of the population distribution of willingness to pay. Through the cost share we can justify the use of variations in stated cost as long as the cost sharing financing structure is the credible

6. Conclusion

Referendum style valuation questions in the context of varying stated costs that have no relation to project costs can create a situation in which participants are essentially answering a completely different question than the one posed by the researcher.[6] Intuition suggests to us that stated costs amounts that are seriously at odds with prior beliefs, *i.e.* incredibly large stated cost amounts or incredibly low stated cost amounts, will likely be ignored by participants in their responses to valuation questions. $100 per household stated cost amounts that aggregate up to tens of billions of dollars for national programs that should cost in the range of several million dollars should raise eyebrows. Similarly $1 per household stated costs in the same context make no sense. In the debate over contingent valuation some researchers disparagingly use the phrase "ask a silly question and get a silly answer" to describe contingent valuation. Our analysis suggests a different phrase, "ask a silly question and get an answer to a completely different question."

It is fair to question the plausibility of our model since it is purely conceptual. To the credit of our model, it can easily produce response phenomena that are sometimes discussed in the literature. For example "nay-saying," the appearance of some participants saying no to any stated cost amount no matter how small, is predicted by case 2. Similarly case 2 predicts "yea-saying," the appearance of some participants saying yes to any stated cost amount. It is also conceivable that the intermediate case 3 can result in responses that give the appearance of anchoring bias. We are not claiming that our model is *the* answer, merely that these phenomena are consistent with the model and for this reason the issues that it raises deserve further attention.

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[6]Stated cost design conjoint analysis applied to public goods will face the same problems as those identified in section 2.

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