

Incentive Compatibility in an Attribute-Based Referendum Model

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The authors would like to acknowledge the Michigan Department of Natural Resources, USDA National Research Initiative of the USDA Cooperative Research, Education and Extension Service Grant #MICL08292, and the Environmental Science and Policy Program at Michigan State University for research support. The authors are solely responsible for any errors.

Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Orlando, FL, July 27-29, 2008.

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Attribute-Based Methods (ABMs) are stated preference techniques that use survey questions to elicit an individual's willingness to pay (WTP) for the provision of an environmental good or service (Bennett and Adamowicz 2001) and have become an increasingly common alternative to the standard Contingent Valuation (CV) approach in the nonmarket valuation literature (Adamowicz and Boxall 2001, Holmes and Adamowicz 2003, Holmes and Boyle 2005). The manner in which WTP survey responses are elicited has received much attention in the CV literature because of the potential bias that may be introduced via alternate response formats. One issue of particular concern is that of incentive compatibility, which refers to the truthfulness and accuracy of a respondent's choice (Boyle 2003). While ABMs are subject to many of the same methodological concerns as the CV method, including issues of incentive compatibility and strategic behavior, little empirical evidence exists on the effects of alternate response formats on WTP estimates with respect to ABMs.

Stated preference approaches present respondents with a hypothetical market that provides information about the environmental good to be valued, how it will be provided and paid for, and asks the respondent to make a decision about its provision (Mitchell 2002). A widely cited criticism of estimates based on state preference questions is that these estimates diverge widely depending on the elicitation format used in data collection (Carson and Groves 2007, McFadden 1994). The understanding of incentive properties of alternate elicitation formats has therefore been the subject of much work in the non-market valuation literature. Particular attention has been paid to the issue of incentive compatibility of alternate response formats and the effects of these response formats on WTP estimates. Many studies have found significant divergence between WTP estimates based on elicitation format, leading to what Carson and Groves (2007) refer to as the "...face-value dilemma...either agents always

truthfully reveal their preferences to the survey question as stated or else they never do.” The authors argue that this may be a false dilemma, and that divergence between estimates using different elicitation approaches is not due to poorly formed preferences of respondents but rather to the fact that respondents have taken the proposed scenario into serious consideration (ibid).

An underlying assumption of survey research is that individuals will express their true preferences if they believe that their input will have an effect on policy outcomes (Carson and Groves 2007). True preferences may not be expressed, however, if respondents behave strategically. Strategic behavior can be the result of elements of the survey design, and this can lead to unreliable WTP estimates. When respondents are presented with unfamiliar goods, the issue of preference uncertainty arises and may lead to high variance in WTP estimates or systematically biased estimates (Taylor et al 2001). Some evidence suggests that the hypothetical nature of contingent markets is consistent with incentive compatibility (Taylor et al 2001, Haab et al 1999), while other studies have found it to be inconsistent (Cummings et al 1997, Burton et al 2007). There are also mixed results in the literature with respect to the incentive compatibility of single versus multiple response formats (Bateman et al 2008).

A variant of the ABM approach, the Attribute-Based Referenda model (ABR), is a hybrid of CV and ABM that uses an attribute-based description of a hypothetical program and elicits responses with a referendum-style choice. While it includes a referendum elicitation format, the format most conducive to incentive compatibility (Carson and Groves 2007), it also allows for multiple choices to be presented. The increased statistical efficiency that can result from inclusion of multiple questions may come at a cost to the reliability of WTP estimates. Many studies in the CV literature have identified incentive incompatibility in multiple-bound response elicitation formats (Carson and Groves 2007, Whitehead 2002, Alberini et al 1997, Boyle et al,

1985). There is evidence from other studies, however, that multiple response formats may be preferable because they allow repetition and learning to occur with respondents, which are keys to the formation of consistent and stable preferences (Bateman et al 2008). While sequencing effects have been investigated in the ABR literature (Holmes and Boyle 2005), controlled tests of the effects of single versus multiple questions in ABR has not been addressed. As ABR models are increasingly used in nonmarket valuation work, it is important to gain better understanding of the effects of alternate response formats. Using data from a split-sample survey design, this paper tests the hypothesis that single and multiple question response formats yield the same preferences and WTP estimates in an Attribute-Based Referenda Model.

Attribute-Based Referenda Model

This research presents a nonmarket valuation analysis of major forest ecosystem services in an area of Michigan that was chosen for the importance of its forests to deer habitat, forest migratory songbird habitat and to the sustainability of the local economy. Ecosystem services provide benefits to people, but production of some, such as food and fiber, may occur at a cost to others, such as wildlife habitat or water quality (MA 2003). Many ecosystem services, such as wildlife habitat or biodiversity, are public goods that do not have market values but that may be valued by the public. Although it is important to understand the benefits of ecosystem services to society in order to effectively evaluate tradeoffs that may occur in their provision (NRC 2005), the nonmarket benefits of ecosystem services have not been extensively quantified (MA 2005).

Research on non-market values of managed forest ecosystems naturally lends itself to a multi-attribute approach because of the numerous characteristics of forests managed for multiple uses. Like the CVM, ABMs are based in random utility theory, but they focus on sets of

environmental policy-relevant attributes, along with cost, as opposed to one total value, which is the focus of traditional CV studies (Hanley et al. 1998, Bennett and Blamey 2001, Holmes and Boyle 2005). Numerous studies have compared traditional CVM with ABMs and have concluded that there are several advantages of using ABMs to estimate values of environmental goods with multiple attributes (Boxall et al. 1996, Hanley et al. 1998). A commonly used ABM is the choice experiment (CE), which is a non-market valuation method that is well suited for the estimation of marginal values of environmental attributes (Boxall et al. 1996, Hanley et al. 1998, Lupi et al. 2002, Stevens et al. 2000). This study uses an ABR model, a hybrid of CV and CE methods, based on a contingent market that presents respondents with a decision to vote ‘yes’ or ‘no’ to a forest and wildlife protection program for the Study Forest.

ABR models, like contingent valuation and attribute-based methods, are based in random utility theory (Holmes and Boyle 2005, McFadden 1974). Within the random utility theoretical framework, utility is assumed to be composed of a deterministic component and a random component. Indirect utility, u , is the maximum amount of utility that a household can derive from income, y , given prices of goods, a vector of environmental quality variables, \mathbf{x} , other respondent characteristics, \mathbf{z} , and a component of individual preferences, $\boldsymbol{\varepsilon}$, known to the individual but not to the researcher,

$$u = u(y, \mathbf{x}, \mathbf{z}, \boldsymbol{\varepsilon}), \quad (1)$$

In an ABR model, respondents are asked if they are willing to pay a certain amount to achieve an environmental quality improvement. In this model, the quality improvement is described by changes in the levels of attributes of a forested ecosystem that will be provided by a program at a cost to the respondent. Utility to the individual when an amount p is paid is:

$$u_1 = u(\mathbf{x}_1, \mathbf{z}, y - p, \boldsymbol{\varepsilon}_1). \quad (2)$$

In this equation, u_1 represents the indirect utility function for an individual who pays the cost of the program; \mathbf{x}_1 is a vector of forest ecosystem attributes under the forest protection program. If the cost, p , of the program is not paid, the indirect utility function is written as follows:

$$u_0 = u(\mathbf{x}_0, \mathbf{z}, y, \varepsilon_0) . \quad (3)$$

In this equation, u_0 represents indirect utility under the status quo, and \mathbf{x}_0 is the vector of forest attribute levels without the program. An individual will be willing to pay for the proposed program if:

$$u_1(\mathbf{x}_1, \mathbf{z}, y - p, \varepsilon_1) \geq u_0(\mathbf{x}_0, \mathbf{z}, y, \varepsilon_0) . \quad (4)$$

The probability that a respondent is willing to pay for the forest protection program (probability of saying yes) is given by the probability that the utility received from the forest protection program is greater than the utility received under the status quo:

$$\begin{aligned} \Pr(yes) &= \Pr[u_1(\mathbf{x}_1, \mathbf{z}, y - p, \varepsilon_1) > u_0(\mathbf{x}_0, \mathbf{z}, y, \varepsilon_0)] \\ &= \Pr[\Delta u > 0] \end{aligned} . \quad (5)$$

The indirect utility function has an unobservable, random component. Indirect utility of individual i from alternative j , therefore, can be expressed as the sum of its explainable and unexplainable components:

$$u_{ij} = v_{ij} + \varepsilon_{ij} , \quad (6)$$

where v_{ij} is the explainable component of utility to individual i from alternative j , and ε_{ij} is the unexplainable, random component of utility for individual i from alternative j .

The deterministic component of utility is defined as:

$$v_{ij} = \alpha \mathbf{x}_j + \gamma_j \mathbf{z}_i + \beta(y_i - p_j) , \quad \gamma_j = \gamma_m \quad \forall j, m \neq 0 \quad , \quad (7)$$

where i indexes individuals, j indexes alternatives, v is indirect utility, \mathbf{x}_j is a set of program

attributes, z_i is a set of respondent characteristics, y is income, p is the cost of the program and α , γ and β are estimable parameters. An individual will vote ‘yes’ to the program if utility with the program exceeds utility without the program. Because utility is composed of a deterministic and a random component, the following expression represents the probability that an individual will vote for the program:

$$\Pr(\text{yes}) = \Pr[v_{ij} + \varepsilon_{ij} > v_{i0} + \varepsilon_{i0}] \quad , \quad (8)$$

which, when substituting (7) for indirect utility, yields

$$\Pr(\text{yes}) = \Pr[\alpha(\Delta x_j) + \gamma z_i - \beta p_j > \varepsilon_{i0} - \varepsilon_{ij}] \quad . \quad (9)$$

Assuming that the error terms follow a standard normal distribution, the probit model can be used to estimate equation 9.

An assumption of the standard probit model is that the error component is independent and identically distributed among individuals and across observations for each individual. However, when an individual responds to more than one stated preference question, it is likely that there are unobservable characteristics specific to that individual that induce correlation across her responses. If this is suspected to be the case, it is appropriate to estimate a random effects probit model (Wooldridge 2002). In a random effects model, the error term is treated as separable into two components: one that is unobservable and specific to each individual and another that is unobservable and due to random response shocks across all individuals and all responses (Boxall et al. 2003).

The utility difference function is specified using a random effects utility model and is written as follows:

$$\Delta u_{ij} = \alpha(\Delta x_j) + \gamma z_i - \beta p_j + \mu_i + \varepsilon_{ij} \quad , \quad (10)$$

where μ_i is the individual-specific error term, and ε_{ij} is the random disturbance term across all individuals and observations.

Data Collection

The analysis uses data collected from a stated preference mail survey of Michigan residents. The study forest, which forms the focus of the survey, was chosen for the importance of its forests to deer habitat, forest migratory songbird habitat as well as to the sustainability of the local economy. The survey collected stated preference data using a dichotomous choice referendum format and also collected data on attitudes towards forest management in the study area.

Survey design

Designing the survey instrument involved a qualitative research phase in which focus groups and individual interviews were both integral parts of the survey design process (Kaplowitz et al. 2004). Questionnaire development was guided by the results of six focus groups, 21 individual pre-test interviews, and interviews with ecologists, foresters and state agency employees. In the questionnaire, individuals were presented with descriptions of the study area and each of the study attributes. Each attribute was described along with questions about the attribute that stimulated respondent interaction with the information about the attribute. Respondents were also asked to respond to a series of statements that reflect attitudes about the goals of forest management in the study area.

The questionnaire used a forest easement program as the policy context for the contingent market. Forest easements are a form of conservation easement that provide a way of conserving ecological values of forests while at the same time ensuring the continued economic and social

benefits generated by forests (Ward and Ervin 2005, Lind 2001). The services provided by the forest easement program were described in the survey using a set of six attributes, each of which was allowed to take on three levels (See table 1). The choice sets presented to respondents were created using an orthogonal main-effects 3^6 experimental design of the six attributes, producing 18 total choice sets (Addelman and Kempthorne 1961).

Survey Implementation

Two versions of the survey were implemented in two separate mailings, each sent to a stratified random sample of Michigan households using a modified version of Dillman's tailored design method (Dillman 2000). Survey Version A presented four choice scenarios to respondents and was sent to 2,000 Michigan households with a response rate of 50%. Version B presented one choice scenario to respondents and was sent to 2,000 Michigan households with a response rate of 55%. The sample was designed to represent four geographic strata of Michigan households. Strata were divided to represent: 1) households within the study area, 2) households within the Upper Peninsula but outside the study, 3) households within the counties of the Northern Lower Peninsula and 4) households within the counties of the Southern Lower Peninsula.

The survey was sent using four contacts: a hand-signed, personalized prenotice letter, a first mailing of the questionnaire, a hand-signed personalized reminder post card, and a second mailing of the questionnaire. Each questionnaire mailing included a hand-signed, personalized cover letter, a survey booklet and a postage-paid business reply envelope. Three first class stamps were included in the first questionnaire mailing of each group as a respondent incentive.

Model Specification and Results

Equations 9 and 10 are estimated using a series of random effects probit models. Socioeconomic characteristics and attitudes are included in the model as respondent characteristics, z_i . The utility difference function is specified as follows:

$$\Delta u_{ij} = \mathbf{\alpha}(\Delta \mathbf{x}_j) + \gamma z_i - \beta p_j + \mu_i + \varepsilon_{ij} , \quad (11)$$

where $\mathbf{\alpha}$ is a vector of estimable parameters for each of the k program attributes, \mathbf{x} , of alternative j , γ is a vector of estimable parameters for the effect of respondent characteristics, z_i , and β is an estimable parameter for the program cost. Variables included in the estimated models are reported in Table 1.

To test the hypothesis that a single-question elicitation format provides the same WTP information as a multiple-question elicitation format, two models were estimated. The first model regressed choices against six program attributes for all data from surveys A and B. The second model, the unrestricted model, regressed choices against twelve program attributes, including six Version A and six Version B attribute variables. Results of both models are presented in Table 2.

A log likelihood test with six degrees of freedom comparing the two models yielded a likelihood statistic of 23.9 with $p < 0.005$. This result leads to a rejection of the hypothesis that the number of choices presented to respondents has no effect on results. We can therefore infer that the number of choices presented to the respondent does have an effect on WTP estimates, however, it is not clear from these results whether the single choice or multiple choice model is the preferred model.

Conclusions

While the single choice (single referendum questions) elicitation format reduces the amount of information collected, the theoretical literature suggests elicitation formats with multiple choice questions may yield strategically biased results by altering the incentives of the respondent. A better understanding of this trade-off can aid in the design of nonmarket valuation studies to help ensure provision of realistic and policy-relevant information. A unique feature of this study is the split sample survey design to test the effect of providing respondents with at single versus multiple valuation questions. Our results from this study suggest that while the multiple choice response format of an ABR model can indeed improve statistical efficiency, WTP estimates are not consistent with the theoretically preferred single question format (Carson and Groves 2007). Results have implications for the reliability of nonmarket valuation information from multiple response formats in ABR models. This work supports the concerns raised in CV literature that including additional ABR questions to improve statistical efficiency and study cost-effectiveness may come at the cost of yielding estimated preferences that differ from the single question elicitation formats.

Table 1. Variable Definitions

Variable	Definition
<i>indjobs</i>	Number of forest industry jobs in the study forest
<i>Rtjobs</i>	Number of forest-based recreation and tourism jobs in the study forest
<i>birddiv</i>	Percent of study forest with high migratory forest songbird species diversity
<i>birdcons</i>	Number of migratory forest songbird species of conservation concern that are at or above their target population level (out of 19 possible species)
<i>Deer</i>	Percent of area with deer browse high enough to affect tree regeneration
<i>Cost</i>	Cost to household in increased annual taxes

Table 2. Restricted and Unrestricted Model Estimation Results¹

Restricted Model		Unrestricted Model	
Variable	Model 1	Variable	Model 2
Intercept	-0.8389*** (0.1161)	<i>Intercept</i>	-0.1652 (0.3417)
<i>Indjobs</i>	0.0071*** (0.0008)	<i>Indjobs_a</i>	0.0079*** (0.0009)
<i>Rtjobs</i>	0.0058*** (0.0011)	<i>Rtjobs_a</i>	0.0066*** (0.0012)
<i>Birddiv</i>	0.0107*** (0.0024)	<i>Birddiv_a</i>	0.0119*** (.00265)
<i>Birdcons</i>	0.0287*** (0.0028)	<i>Birdcons_a</i>	0.0208** (0.0096)
<i>Deer</i>	-0.0158*** (0.0050)	<i>Deer_a</i>	-0.0164*** (0.0054)
<i>Cost</i>	-0.0067*** (0.0004)	<i>Cost_a</i>	-0.0072*** (0.0005)
		<i>Indjobs_b</i>	0.0020 (0.0019)
		<i>Rtjobs_b</i>	0.0019 (0.0026)
		<i>Birddiv_b</i>	0.0058 (0.0054)
		<i>Birdcons_b</i>	0.0597*** (0.0195)
		<i>Deer_b</i>	-0.0025 (0.0109)
		<i>Cost_b</i>	-0.0053*** (0.0006)
Rho	0.7711*** (0.0180)		0.7613*** (0.0190)
# of observations	4270		4270
# of groups	1846		1846
Log Likelihood	-1877.60		-1865.62
Pr > χ^2	<0.0000		<0.0000

¹ Note: Standard errors in parentheses; ***Significant at the: 99% level; ** Significant at the 95% level; *Significant at the 90% level

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