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JOINT ESTIMATION OF CONTINGENT VALUATION SURVEY RESPONSES

Timothy A. Park
Department of Agricultural Economics
University of Nebraska
Lincoln, Nebraska 68583-0922

and

John Loomis
Division of Environmental Studies
and
Department of Agricultural Economics
University of California, Davis
Davis, California 95616

ABSTRACT

The utility difference model proposed by Hanemann for the dichotomous choice contingent valuation method is modified to account for interrelationships between responses to a set of contingent valuation questions. Mean WTP estimates for three alternative scenarios for valuing changes in the quality of California deer hunting were uniformly lower for the joint logit model compared to a set of independent logit models.

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I. INTRODUCTION

Mitchell and Carson's (1989) comprehensive survey of the contingent valuation method (CVM) emphasized the versatility of this tool for valuing non-market resources. This research reinforces the usefulness of the CVM method by developing and empirically testing a method which more efficiently uses the information obtained from a dichotomous choice contingent valuation survey. When confronted with a series of contingent valuation questions, individual responses reflect a series of trade-offs in willingness to pay (WTP) for amenities and cross relationships that may occur when valuing alternative quality levels of a resource. The proposed model accounts for these interrelationships in estimating WTP from a DC contingent valuation survey.

This approach is motivated by Hoehn's (1990) evaluation of the benefits associated with multi-dimensional changes in environmental amenities using open-ended contingent valuation techniques. In evaluating a set of alternative policy scenarios, bid functions for respondents were developed which reflect the substitution effects associated with proposed environmental changes.

The empirical application presented here examines the WTP for deer hunting in California and the value of improvements in the quality of deer hunting conditions. Hunters were asked a series of dichotomous choice contingent valuation questions. In the first question hunters were asked specifically about WTP for hunting under current conditions. Two questions focussed on improvements in hunting quality which could be influenced by deer hunting regulations and deer habit management. In the first scenario a DC CVM question elicited how the value of the trip would change if the hunter saw half as many other hunting parties as on the most recent trip. A second scenario inquired about trip values if the hunter saw twice as many legal deer.

II. FORMULATION OF THE JOINT RESPONSE MODEL

Following Hanemann the individual's preferences for hunting are represented by a utility function which depends on income and other observed individual attributes. The indirect utility function is $V(z^i, y; s)$ where z^0 represents access to the current resource or initial quality level and z^1 represents access to the improvements in the resource given the respondent pays the bid amount denoted by A, y is income and s is a vector of observable respondent attributes or quality measures of the environmental amenity.

If the utility difference, d**V**, from paying the bid amount and having access to the hunt site is positive, the respondent maximizes utility by answering "yes" to the DC CVM question, or

$$Prob[\,Yes\,] - Prob[dV] - Prob\left[V(z^1, y-A; s) + \epsilon_1 \geq V(z^0, y; s) + \epsilon_0\right] \qquad (1)$$

where ϵ_0 and ϵ_1 are independently, identically distributed random variables with zero means.

When valuing a set of environmental amenities in a contingent valuation survey, a respondent is faced with a series of J dichotomous choice questions. Estimation of the utility difference model is modified recognizing that responses to a set of contingent valuation questions by the same individual may be interrelated. The utility difference model for the set of J choices is specified as

$$dV_{jt} = X_{jt}\beta_j + \epsilon_{jt} \tag{2}$$

where dV_{jt} denotes the indicator of the utility difference for the j^{th} choice by the t^{th} respondent. The choices of each individual are linked to a vector of observable individual attributes and measures of environmental quality, X_{jt}, with a set of coefficients to be estimated, β_j. The stochastic error term ϵ_{jt} represents the unobservable and random effects which influence the respondent's choices.

The observed responses to the set of contingent valuation questions confronting each participant are defined by the set of binary variables $Y_1 = [Y_{1t}, Y_{2t}, Y_{3t}]$ where

$$\begin{aligned} Y_{jt} &= 1 \ (positive\ response)\ if\ dV_{jt} > 0 \\ Y_{jt} &= 0 \ (negative\ response)\ if\ dV_{jt} \leq 0 \ . \end{aligned} \tag{3}$$

The independent contingent valuation model estimates a single logit or probit model for each scenario. Estimates derived from a set of independent logit or probit models are consistent and efficient when the vector of random errors $[\epsilon_{1t}, \epsilon_{2t}, \epsilon_{3t}]$ are independently and identically distributed.

By contrast, the joint estimation procedure proposed here for the set of DC questions accounts for the interdependencies in responses across alternative valuation scenarios. Kiefer (1982) has noted that neglecting cross-equation correlation among the error terms may lead to biased estimates of choice probabilities. Estimated standard errors are also inconsistent. In addition, the mean WTP will also be affected. Mean WTP estimates based on the single equation approach are compared with mean WTP derived from the joint or multivariate model.

Following Fu et al. (1988) the probability of a yes response by the t^{th} individual toward the j^{th} DC CVM question is denoted by

$$P_{jt} = Prob(Y_{jt} = 1) = f(X_{jt}\beta_j) \tag{4}$$

where $f(\cdot)$ is the cumulative distribution function of a standard logistic variate. Let Y_{jt} be an indicator of the probability that an individual with characteristics X_{jt} will respond yes to the j^{th} DC CVM question. That is,

$$\begin{aligned} Y_{jt} &= P_{jt} + \epsilon_{jt} \\ &= f(X_{jt}\beta_j) + \epsilon_{jt} \end{aligned} \tag{5}$$

where $E(\epsilon_{jt}) = 0$ and $V(\epsilon_{jt}) = P_{jt}(1 - P_{jt})$.

Applying a first-order Taylor series expansion to equation (5) around an initial estimate of β_j, say $\hat{\beta}_j$, the estimating equation for the j^{th} response is

$$Y_{jt*} = X_{jt*}\beta_j + \epsilon_{jt} \tag{6}$$

where Y_{jt*} and X_{jt*}, the transformed dependent and independent variables respectively, are

$$\begin{aligned} Y_{jt*} &= Y_{jt} - f(X_{jt}\hat{\beta}_j) + f'(X_{jt}\hat{\beta}_j)\hat{\beta}_j \\ X_{jt*} &= f'(X_{jt}\hat{\beta}_j) \end{aligned} \tag{7}$$

and $f'(\cdot)$ is the 1xK gradient of $f(\cdot)$ with respect to β_j.

Interrelationships between responses to the DC contingent valuation questions are incorporated in the covariance elements of the equations. The joint model for contingent valuation responses is estimated as a seemingly unrelated nonlinear regression. A weighted nonlinear least squares estimation technique is used to account for the heteroscedastic error term, yielding estimates that are consistent and asymptotically efficient.

III. ECONOMETRIC SPECIFICATION OF THE JOINT LOGIT MODEL

A valuation study of deer hunting in California was undertaken based on data collected by sampling California residents and non-residents who had purchased a deer hunting license for the 1987 deer hunting season. The dichotomous choice approach to CVM was the survey method with an increase in trip cost used as the payment vehicle. Data was obtained for the value of deer hunting in the specific hunt zone the hunter visited on the most recent trip. The study was based on the series of three DC CVM questions about the most recent deer hunting trip described above.

A linear specification was used for the utility difference model. For current hunting conditions the bid amount was denoted by CRBID. Explanatory variables were included based on attributes of both the respondent and the environmental amenity. The quality of the hunting experience was measured by the number of other hunting parties seen by the hunter on the most recent trip (PARTIS) and the number of deer seen (DEER). The number of hunting parties reflects the preferences of hunters for isolation in the wilderness experience. A measure of the price to participate in hunting was incorporated based on total expenses incurred by the hunter for the most recent hunt (EXP).

The household income of the hunter (INC) and an interaction term between INC and ORGMEM, a dummy variable equal to one when the hunter is a member of a hunting or sportsman's organization (INCORG) are also included. Smith and Kaoru (1986) suggested the incorporation of income in a binary choice model. McConnell (1990) emphasized the role of the income variable in allowing the marginal utility of income to vary across alternative states of the resource and across individual respondents.

The utility difference model for the j^{th} alternative was estimated based on a logit model using the specification

$$dV_1 = \beta_{10} + \beta_{11}Crbid + \beta_{12}Exp + \beta_{13}Partis + \beta_{14}Deer + \beta_{15}Inc + \beta_{16}Yorg + \eta_{11} \quad (8)$$

where η_l represents the difference in error terms for the indirect utility functions and is defined as $\epsilon_1 - \epsilon_0$.

Empirical Results and WTP Estimates

Maximum likelihood estimates of the three independent logit models along with the joint model of the contingent valuation responses are obtained for alternative quality levels of deer hunting in California. The estimated logit equations for current conditions are presented in Table 1. The results for reduced congestion due to other hunters and increased chances of viewing legal deer are omitted here for brevity.

The signs of coefficient estimates from both the independent model and the joint model are in agreement and consistent with prior expectations. The coefficient on the bid amount is negative and highly significant across all three quality levels. Higher bid amounts are negatively related to the probability of a yes response. Increases in the number of parties seen decreased the probability of a yes response, reflecting a decline in the perceived quality of the hunting experience. The number of deer seen is a measure of probable success and was positively related to the probability of a yes response. The coefficient on the income variable is positive and significant for the valuation of the alternative deer hunting conditions, confirming the important role that income plays in valuation models.

The independent logit models yields a larger number of statistically significant explanatory variables than did results from the joint logit model. Only the variables for bid amount, trip expenses, income are significant in both models. In general, the joint logit model produces coefficient estimates with higher standard errors.

An important policy application is to compare mean WTP estimates from the independent logit model and the joint logit model. The estimates presented in Table 2 indicate that for each of the three deer hunting scenarios the joint logit model results in lower mean WTP estimates than the independent models. For current hunting conditions the mean WTP from the independent logit model was $165, an estimate 27 percent higher than that derived from the joint model. In the scenarios for increased deer viewing opportunities and reduced crowding larger, even larger differences were observed in mean WTP between the independent logit and joint models.

IV. CONCLUSIONS

When valuing a set of environmental amenities in a contingent valuation survey, the factors which influence the respondent's WTP may be closely linked across the alternative scenarios. The utility difference model can be modified using a joint estimation procedure for a set of logit models. This method accounts for the interrelationships between responses to a set of contingent valuation questions and may be used to test theoretically derived restrictions which link WTP. The empirical application examines the WTP for deer hunting in California and the value of improvements in the quality of deer hunting conditions. Mean WTP estimates for each of the three scenarios were uniformly lower for the joint logit model as compared to the independent logit models.

TABLE 1. Coefficient Estimates for Independent and Joint Logit Model

	Independent Model	Joint Model
Current Conditions[a,b]		
Intercept	0.6193 (1.7956)*	0.1153 (3.4278)*
Bid Amount	-0.0141 (-6.6058)*	-0.0133 (-3.7798)*
Exp	0.0026 (2.6784)*	0.0034 (2.6685)*
Partis	-0.0130 (-1.6822)*	-0.0084 (-1.0665)
Deer Seen	0.0032 (2.1095)*	0.0030 (1.3945)
Income	0.0284 (2.9264)*	0.0218 (1.8913)*
Bidorg	0.0008 (0.4367)	-0.0009 (-0.2776)
IncOrg	-0.0221 (-2.2232)*	-0.0125 (-0.8955)

[a] Asymptotic t-values in parentheses.
[b] Asterisk indicates significance at .01 confidence level.

TABLE 2. Comparison of Mean Willingness to Pay for Deer Hunting

	Current Conditions	Bigger Deer	Reduced Crowding
Independent Logit Models			
Mean WTP	$165	$138	$170
Joint Logit Model			
Mean	$129	$102	$98

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