# A Test of Contingent Market Bid Elicitation Procedures for Piecewise Valuation

**John C. Bergstrom and John R. Stoll**

Economists are frequently faced with the task of valuing commodity package components. The valuation of specific impacts of public policies is a case in point. Two contingent market bid elictation procedures were tested for valuing changes in single components of a multicomponent government program. Results of the test suggested that respondents provided more accurate component or piecewise valuations when a two-step bidding approach, rather than a one-step approach was used. Thus, there is evidence that a two-step approach which helps respondents to isolate valuations for package components is perhaps a preferable bid elicitation procedure for piecewise valuation.

*Key words:* bid elicitation procedures, contingent markets, multicomponent commodities, piecewise valuation.

Many types of commodities which are of interest to economists are not traded in competitive markets (e.g., public goods). To measure the economic value of such commodities, nonmarket valuation techniques must be used. A nonmarket valuation technique receiving extensive application in recent years is the contingent valuation method (CVM). CVM techniques include any valuation approach which relies upon individual responses to contingent circumstances posited in artificially structured markets (Sellar, Stoll, and Chavas). CVM involves eliciting values directly from consumers, values from which consumer's surplus associated with nonmarket commodity service flows can be derived. CVM has a strong theoretical base, and its overall validity has been discussed in numerous empirical applications (Brookshire et al.; Cummings, Brookshire, and Schulze; Randall, Hoehn, and Brookshire).

## Valuation Process Limitations

Although CVM has gained widespread acceptance as an alternative nonmarket valuation technique, unresolved concerns over its application remain. The focus of some of these concerns is upon the effects of contingent market structure on final revealed valuations. These concerns are motivated, in part, by the results of recent psychological studies which suggest that the outcomes of human cognitive decision-making processes are sensitive to the context in which the problem is presented (Beach and Mitchell; Tversky and Kahneman; Payne).

A context issue of recent concern is the effect of contingent market structure on the valuation of commodity package components or piecewise valuation. For example, it has been shown that values placed on components of a complex environmental commodity vary with the sequence of valuation. Thus, the reliability of component valuations is dependent upon choosing an appropriate valuation path (Randall, Hoehn, and Tolley). The reliability of

The authors are an assistant professor in the Department of Agricultural Economics, University of Georgia, and an associate professor in the Department of Agricultural Economics, Texas A&M University, respectively.

Station Article No. TA-21927.

The authors would like to thank Buddy L. Dillman, Clemson University, for advice on the design and conduct of the empirical test and three anonymous reviewers for additional helpful comments.

piecewise valuation, it is argued here, is also sensitive to the manner by which component values are elicited. Specifically, because of limitations on the human cognitive decision-making process (e.g., limited information-processing abilities or limited analytical abilities), the context of the bidding question itself may affect stated values for commodity package components.

Economists are often interested in measuring economic values in a piecewise manner. This interest is motivated by the desire to measure the contribution of various components to the overall value of a commodity package. In the case of CVM, the objective of piecewise valuation is usually the valuation of nondivisible, multidimensional nonmarket commodity components. Examples include environmental quality components, recreational experience components, habitat characteristics, and management program components.

## Conceptual Framework

Let a nondivisible, multidimensional nonmarket commodity be denoted as

$$Q = Q(a_1, a_2, \ldots, a_n), \tag{1}$$

where $a_i$ is the $i^{\text{th}}$ package component, $i = 1, 2, \ldots, n$. The components of $Q$ are assumed to be provided in exogenously determined quantities. Thus, $Q$ enters into a consumer's utility function as a predetermined or rationed commodity (Bergland). That is, the consumer's utility function is defined as

$$U = U[X, Q(a_1, a_2 \ldots, a_n)], \tag{2}$$

where $X$ is the vector of nonrationed commodities. It is further assumed that each component of $Q$ has a positive marginal utility, that is,

$$\frac{\partial U}{\partial Q}\frac{\partial Q}{\partial a_n} > 0, i = 1, \ldots, n.$$

Suppose that a public policy will result in an increment in all components of $Q$ from some pre-policy level given by $a_1^0, a_2^0, \ldots, a_n^0$, to some post-policy level given by $a_1^1, a_2^1, \ldots, a_n^1$. Thus, $Q$ changes from some pre-policy level defined by $Q^0 = Q(a_1^0, a_2^0, \ldots, a_n^0)$ to some post-policy level defined by $Q^1 = Q(a_1^1, a_2^1, \ldots, a_n^1)$. Conceptually, willingness to pay ($WTP$) for increments and decrements in $Q$ is expressed by first specifying a conditional indirect utility function of the form

$$V = V[P, Q(a_1, a_2, \ldots, a_n), M], \tag{3}$$

where $P$ is a nonrationed commodity price vector, $Q(.)$ is a rationed nonmarket commodity quantity, and $M$ is money income. The inverse of equation (3) is a conditional expenditure function of the form

$$M = E[P, Q(a_1, a_2, \ldots, a_n), U^*], \tag{4}$$

where $U^*$ is given level of utility.

The derivative of equation (4) with respect to $Q$ generates an inverse Hicksian demand function for changes in the entire nonmarket commodity package. This demand function is given by

$$g = \partial E/\partial Q = E_Q[P, Q, U^*], \tag{5}$$

where $g$ is marginal $WTP$ for a change in $Q$. Total $WTP$ for a nonmarginal change in $Q$ from the pre-policy level ($Q^0$) to the post-policy level ($Q^1$) is calculated by the integral (Bergland; Freeman; Randall, Hoehn, and Tolley).

$$WTP^Q = \int_{Q^0}^{Q^1} [E_Q(P, Q, U^*)]\, dQ. \tag{6}$$

Suppose, however, that one is interested in measuring the contribution of an increment in a specific component of $Q$ to the overall value of the increment in $Q$ defined by equation (6). For example, suppose the objective is to measure the value of the increment in $a_1$ from $a_1^0$ to $a_1^1$, which occurs as part of the change in $Q$ from $Q^0$ to $Q^1$. Because all other components of $Q$ have also changed, willingness to pay for the change in $a_1$ is calculated by first differentiating the conditional expenditure function given in equation (4) with respect to $a_1$, where the quantities of all other components are held constant at the post-policy levels. This differentiation yields a conditional, inverse Hicksian demand function for that component.

$$z = \partial E/\partial a_1 = \partial E[P, Q(a_1, a_2^1, \ldots, a_n^1), U^*]/\partial Q \times \partial Q/\partial a_1, \tag{7}$$

where $z$ is marginal $WTP$ for $a_1$ conditioned upon the overall change in total commodity package. Total $WTP$ for a nonmarginal change in $a_1$ from $a_1^0$ to $a_1^1$ conditioned upon an overall change in $Q$ from $Q^0$ to $Q^1$ is therefore calculated by (Freeman; Hoehn; Randall, Hoehn, and Tolley):

$$WTP^{a_1} = \int_{a_1^0}^{a_1^1} \partial E[P, Q(a_1, a_2^1, \ldots, a_n^1), U^*]/\partial Q \times \partial Q/\partial a_1\, da_1. \tag{8}$$

## Value Elicitation Considerations

In the previous section, piecewise valuation for a change in a specific component of a commodity package was described. The research objective was assumed to be measurement of the contribution of change in $a_1$ which occurs as part of an overall change in a nondivisible, multidimensional nonmarket commodity from

$$Q^0 = Q(a_1^0, a_2^0, \ldots, a_n^0) \quad \text{to}$$
$$Q^1 = Q(a_1^1, a_2^1, \ldots, a_n^1).$$

Conceptually, the value of such a change in $a_1$ is defined by equation (8).

The empirical problem is one of measuring the willingness to pay given by equation (8) in an accurate and reliable manner. This measurement perhaps could be accomplished using an indirect exact welfare measurement procedure such as discussed by Bergland, and Morey. Alternatively, total *WTP* for the change in $a_1$ given by equation (8) could be estimated directly via the contingent valuation method (CVM).

There are at least two approaches for eliciting total *WTP* for a change in $a_1$ by CVM. Both approaches involve constructing a contingent market where respondents state their *WTP* for changes in $a_1$. The first approach is a two-step bidding process. In the first step of the process respondents would be asked to reveal their overall *WTP* for the change in $Q$, as depicted in equation (6). In the second step, respondents would be asked to partition out their *WTP* for the associated change in $a^1$, as depicted in equation (8).

The second approach is a one-step process. In the first and only step, respondents would be asked to state their *WTP* for a change in $a_1$ as part of an overall change in $Q$ directly. That is, with this approach respondents would not be asked to first calculate an overall *WTP* for the change in $Q$ before calculating their *WTP* for the associated change in $a_1$. They would simply be asked to value a change in $a_1$ without reference to a calculated valuation of the overall change.

The two-step and one-step value elicitation approaches place different demands upon CVM respondents' cognitive valuation processes. It is conjectured that the mental task of valuing package components is made more difficult by the one-step approach relative to the two-step approach. With the one-step approach, respondents may have a difficult time isolating *WTP* for the one package component because of the lack of reference to *WTP* for the overall change in the commodity package. The two-step process, on the other hand, requires respondents to first calculate *WTP* for the overall change in $Q$ and then forces respondents to partition out their *WTP* for the change in $a_1$. Thus, the two-step approach is expected to generate more accurate valuations of commodity package components by helping respondents to isolate *WTP* for changes in one package component from *WTP* for changes in all other package components.

## An Empirical Test

Two refutable hypotheses concerning the valuation of package components were tested in a contingent valuation exercise. The "package" valued in the exercise was a farmland protection program. In the contingent market, the program was described as having four major benefits, i.e., components. These described benefits were protection of local and national food supplies, protection of local agricultural jobs, more orderly urban development, and protection of environmental amenities. The overall objective of the exercise was to measure respondents' *WTP* for the environmental amenity component of the program (Bergstrom, Dillman, and Stoll).

The site of the study was Greenville County, South Carolina. Greenville County is typical of regions faced with a trade-off between agriculture and urban-industrial development. The loss of prime land to development and what to do about it was an issue of growing concern in the county. Many residents were aware of the issue; thus, it was believed that they would be quite responsive to questioning about the subject.

Data for estimating *WTP* for farmland protection were collected using a CVM mail survey instrument. Questionnaires were sent to 600 randomly selected Greenville County households. A total of 130 questionnaires of the original 600 mailed were undeliverable primarily because of incomplete addresses. Of the 470 questionnaires received by sample households, 250 were returned, yielding a final response rate of 53%. A more detailed discussion of the survey methodology is presented in Bergstrom, Dillman, and Stoll.

The survey instrument elicited *WTP* for the

**Table 1. OLS Estimates for Joint Bid Function**

| Parameter Estimates and $t$-Values | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *INTERCEPT* | *AGE* | *INCOME* | *EDUCATION* | *ACRES* | *BID*1 | *BID*2 | $R^2$ | $F$ | N |
| −4.315 (−1.84) | .078*[a] (2.78) | .015* (5.18) | 2.022* (4.21) | .084* (4.24) | −5.24* (−5.33) | −1.967 (−1.99) | .15 | 22.35 | 768 |

[a] Asterisk indicates significant at .01 level.

environmental amenity component of farmland protection by two approaches: a one-step approach and a two-step approach. One sample subgroup (subgroup one) used the one-step approach, and a second sample subgroup (subgroup two) used the two-step approach. In the first step of the two-step approach, subgroup two respondents were asked to state their *WTP* for the entire package of benefits. Let this *WTP* be denoted as $WTP^Q_{2S}$. Conceptually, $WTP^Q_{2S}$ corresponds to willingness to pay for an overall change in a commodity package as denoted by equation (6). In the second step, respondents were asked to state their *WTP* for the environmental amenity component only. Let this *WTP* be denoted as $WTP^A_{2S}$. In the one-step approach, subgroup one respondents were simply asked to state their *WTP* for the environmental amenity benefits directly. Thus, in the one-step approach, respondents did not calculate an overall *WTP* for the package to use as a reference point. Let the one-step measure of *WTP* be denoted as $WTP^A_{1S}$. Conceptually, $WTP^A_{2S}$ and $WTP^A_{1S}$ correspond to willingness to pay for a change in one component which occurs as part of an overall change in a commodity package as denoted by equation (8).

It was hypothesized that those respondents who did not calculate $WTP^Q_{2S}$ to use as a reference point would have difficulty separating out their *WTP* for the environmental amenity benefits from their *WTP* for the other three benefits of farmland protection. In other words, it was hypothesized that $WTP^Q_{2S}$ would be close, if not equal to, $WTP^A_{1S}$. In addition, it was hypothesized that the two-step approach would help respondents to better recognize and isolate their *WTP* for the environmental amenity component. That is, it was expected that $WTP^A_{2S}$ would be significantly lower than $WTP^A_{1S}$. These working hypotheses were tested jointly by specifying the following bid function:

$$(9)\ WTP = F(AGE, INCOME, EDUCATION, ACRES, BID1, BID2),$$

where *AGE* is age of respondent; *INCOME*, household income; *EDUCATION*, years of respondent education; *ACRES*, acres of farmland included in the protection program; *BID*1, *BID*2 are indicator variables with $(0, 0) = WTP^A_{1S}$, $(1, 0) = WTP^A_{2S}$, $(0, 1) = WTP^Q_{2S}$. The specification of the indicator variables *BID*1 and *BID*2 in equation (2) allowed the testing of the following hypotheses:

$H_1$: $WTP^A_{2S} = WTP^A_{1S}$
$H_a$: not $H_1$
$H_2$: $WTP^A_{1S} = WTP^Q_{2S}$
$H_a$: not $H_2$.

The parameters for equation (9) were estimated by ordinary least squares (OLS) procedures. Estimation results are presented in table 1. The results indicate that the coefficient on *BID*2 was not significant at the .01 level. Thus, $H_2$ cannot be rejected at the .01 level of significance. That is, $WTP^Q_{2S}$ was not statistically different from $WTP^A_{1S}$. This result supports the a priori expectation that respondents would have difficulty partitioning their *WTP* for the environmental amenity component of the package when the one-step approach was used. The coefficient on *BID*1 was negative and statistically significant at the .01 level, leading to rejection of $H_1$. This result indicated that the two-step approach resulted in a lower bid for the environmental amenity component, as compared to the one-step approach. That is, $WTP^A_{2S}$ was significantly lower than $WTP^A_{1S}$. Thus, this result supported the a priori expectation that the two-step process would help respondents to better recognize and isolate their *WTP* for the environmental amenity component of the farmland protecton program. Conceptually, $WTP^A$ must be less than $WTP^Q$ unless the value associated with all other farmland protection components taken together is zero or negative. Thus, the results of the experiment are defensible both conceptually and empirically.

**Implications and Conclusions**

Economists are frequently faced with the task of valuing commodity package components. The valuation of specific impacts of public policies is a case in point. Many public policies have multiple impacts or components. For example, a policy which results in improved wildlife habitat may result in population increases for several major wildlife species. Similarly, a pollution control program may change several environmental quality parameters.

One general methodology for component or piecewise valuation is to directly ask respondents in a contingent market to reveal their *WTP* for package components. The results of the test described in this paper, however, suggest that such measurements should proceed with caution. In particular, the results suggest that respondents may be limited in their ability to separate their *WTP* for the package components when asked to do so. This limited ability may be related to constraints on the cognitive decision-making process (e.g., limited analytical and information processing abilities).

A respondent's ability to value components may also be sensitive to the exact manner by which component values are elicited. For example, the test described in this paper indicated that CVM respondents provide component valuations more consistent with theoretical expectations when a two-step bidding approach, rather than a one-step approach, is used. Thus, when valuing components of a package using CVM (e.g., multiattribute commodities, public policies), bidding approaches which provide respondents with carefully selected information which helps them to recognize and isolate valuations for package components may be preferable.

The results reported in this paper support previous work by Randall, Hoehn, and Tolley which shows that piecewise or component valuation is sensitive to contingent market structure. The fundamental question is "Under what conditions can CVM respondents be expected to provide accurate and reliable piecewise or component valuations?" In order to address this issue adequately, much more research is needed. Future research should directly analyze the relationships between market structure and bidding behavior using tightly designed and controlled experiments with strict adherence to sound scientific methodology.

[*Received August 1986; final revision received April 1987.*]

**References**

Beach, L. R., and T. R. Mitchell. "A Contingency for the Selection of Decision Strategies." *Academy of Mgmt. Rev.* 3(1978):439–49.

Bergland, O. "Exact Welfare Analysis with Quantity Rationing." Paper presented at ASSA meetings, New York, Dec. 1985.

Bergstrom, J. C., B. L. Dillman, and J. R. Stoll. "Public Environmental Amenity Benefits of Private Land: The Case of Prime Agricultural Land." *S. J. Agr. Econ.* 17(1985):139–49.

Brookshire, D. S., M. A. Thayer, W. D. Schulze, and R. C. d'Arge. "Valuing Public Goods: A Comparison of Survey and Hedonic Approaches." *Amer. Econ. Rev.* 72(1982):165–77.

Cummings, R. G., D. S. Brookshire, and W. D. Schulze, eds. *Valuing Environmental Goods: An Assessment of the Contingent Valuation Method.* Totowa NJ: Rowan and Allanheld, 1986.

Freeman, A. M. "Approaches to Measuring Public Goods Demands." *Amer. J. Agr. Econ.* 61(1979):915–20.

Hoehn, J. P. "The Benefit Cost Evaluation of Multi-Part Public Policy: A Theoretical Framework and Critique of Estimation Methods." Unpublished Ph.D. dissertation, University of Kentucky, Lexington, 1983.

Morey, E. R. "Characteristics, Consumer Surplus, and New Activities." *J. Public Econ.* 26:(1985):221–36.

Payne, J. W. "Contingent Decision Behavior." *Psych. Bull.* 92(1982):382–401.

Randall, A., J. P. Hoehn, and D. S. Brookshire. "Contingent Valuation Surveys for Evaluating Environmental Assets." *Nat. Resour. J.* 23(1983):635–48.

Randall, A., J. P. Hoehn, and G. S. Tolley. "The Structure of Contingent Markets: Some Results of a Recent Experiment." Paper presented at joint AEA–AERE meetings, Washington DC, 1981.

Sellar, C., J. R. Stoll, and J. P. Chavas. "Valuation of Empirical Measures of Welfare Change: A Comparison of Nonmarket Techniques." *Land Econ.* 61(1985): 156–75.

Tversky, A., and D. Kahneman. "The Framing of Decision and the Psychology of Choice." *Science* 211 (1981):453–58.