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Option Price Estimates for Water Quality Improvements: A Contingent Valuation Study for the Monongahela River[1]

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William H. Desvousges
Center for Economics Research
Research Triangle Institute
Research Triangle Park, NC 27709

V. Kerry Smith
Department of Economics and Business Administration
Vanderbilt University
Nashville, TN 37235

Ann Fisher
Office of Policy Analysis
U.S. Environmental Protection Agency
Washington, DC 20460

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Direct correspondence to: William H. Desvousges
Center for Economics Research
Research Triangle Institute
P.O. Box 12194
Research Triangle Park, NC 27709

ABSTRACT

This paper presents the findings from a contingent valuation survey designed to estimate the option price bids for the improved recreation resulting from enhanced water quality in the Pennsylvania portion of the Monongahela River. The findings are based on a survey design that used professional interviewers to conduct personal interviews determined from a representative sample of 393 households. In addition, the research suggests that protest bids and outliers be viewed similarly. Accordingly, a new technique for identifying outlying responses is proposed. The findings suggest that the question format affects the option price estimates and that criteria for determining the final sample of responses have an important influence on contingent valuation results.

1. INTRODUCTION

Recent Federal and State policies that require benefit-cost analyses of major regulations have helped to focus attention on measuring nonuse benefits.[2] While the available empirical evidence suggests that these benefits can be a significant share of the total benefits provided by environmental resources, important conceptual and empirical issues remain to be resolved before nonuse can become a standard component of most benefit-cost studies.[3]

Perhaps the most important conceptual issues stem from our changing understanding of benefit concepts under uncertainty. For example, the environmental literature initially focused on option value--i.e., the difference between option price and the expected consumer surplus--as an "omitted component" of the benefits provided by changes in unique environmental resources. However, option value now is considered to indicate the importance of the selection of an ex ante versus an ex post perspective in the definition of benefits resulting from a change in some dimension of environmental quality under uncertainty.[4] If an individual's utility function is state dependent (i.e., it may differ depending on ~~the~~ which uncertain outcome~~s of uncertainty),~~ occurs), then the perspective for welfare measurement will affect the role of the marginal utilities of income for each state in defining benefits (see Smith [31]).

In this paper, we use option price as our ex ante measure of benefits under uncertainty. In our water quality application, option price is the maximum annual payment that an individual is willing to make now for access to the river with improved water quality, regardless of use. Although opicantly affected by question format. Finally, there was little evidence of interviewer bias.

The remainder of this paper is organized as follows. Section 2 highlights the definition of option price and how our survey and questionnaire design implemented it. Section 3 examines the implication of both protest and outlying bids as sample screening rules that can affect the analysis of contingent valuation responses. Equally important, it proposes a new procedure for determining outlying bids. Section 4 presents the option price results, along with examining the effect of outliers on the shape of the distribution of option prices. Section 5 describes the findings of our tests for framing effects, including the effects of both different question formats--bidding games, payment cards, and direct questions--and interviewers. Section 6 summarizes our main findings and discusses their implications.

2. SURVEY AND QUESTIONNAIRE DESIGN

The survey questionnaire elicited an individual's annual option price bid for water quality changes ~~in the Pennsylvania portion of the Monongahela River~~. Our definition of option price is based on the "timeless" framework.[6] ~~Since several detailed reviews of these conceptual developments are available, in this section we briefly define option price and describe the design of the questionnaire used to elicit it.[6] In addition, we describe the key methodological elements of the questionnaire design~~.

In defining an option price we are specifying a ~~specific~~ payment device that enables the individual to adjust his planned expenditures and reduce the uncertainty associated with any "future" uncertain events or consumption decisions. Option price (OP) can be defined as the maximum amount an individual is willing to pay for access to the good or service regardless of whether he will demand the service. More formally, in the timeless framework, the connection between current and "future" is left unspecified. We assume state-dependent utility functions can be used to characterize preferences, with $U_1(.)$ associated with demanding the service and $U_2(.)$ with not demanding it. The individual is assumed to know his probability of demanding the service in the future as π_1 (with $\pi_2 = 1-\pi_1$ being the no-demand case). Equation (1) then defines the option price:

$$\sum_{i=1}^{2} \pi_i U_i (Y_i - OP, a) = \sum_{i=1}^{2} \pi_i U_i (Y_i, \bar{a}) . \qquad (1)$$

where

Y = income

a = ~~implying~~ access to the service

$\bar{a}$ = no access.

These functions can be regarded as indirect utility functions, with the prices of all other goods and services held constant.[7] Our specification assumes that if the option price is paid, then consumption of the environmental service can be at any level desired. What is important for our purposes is the role of income in this relationship. The responsiveness of consumer surplus to income, as well as the nature of the demand uncertainty, help determine the bounds for option price.[8] This implies that our analysis of option price bids should consider their sensitivity to respondents' income levels.

In our survey design using option price, trained professional interviewers conducted a household survey based on a single-stage, stratified-cluster sample of 393 households from the five-county Pennsylvania portion of the Monongahela River basin, including the Pittsburgh SMSA. With the household defined as the unit of analysis, the interviewers randomly selected a respondent 18 years or older from a roster of individuals in the household.[9] The sample design ensured a representative sample of the target population. The interviews were conducted in November and December 1981; 301 were usable, resulting in an 80-percent response rate.

Before the option price concept was introduced to the respondent, the questionnaire established the general framing of the contingent market. This orientation started by eliciting recreation information about the use of the Monongahela and other water-based recreation areas. These questions also helped to establish rapport with the respondent. The framing process continued by introducing the market setting: improved water quality for the Monongahela River.

Following this introduction, the interviewer handed the respondent our vehicle for relating water quality to the feasible recreation activities--the Resources for the Future (RFF) Water Quality Ladder developed by Mitchell and Vaughan (in Mitchell and Carson [21]). The interviewer described the ladder and used it to link water quality levels to recreation activities.

A second important element in the hypothetical market involved identifying the reasons why an individual might value water quality changes. The interviewer used a second visual aid--the value card--to describe user, option, and existence values. ~~Also~~ The interviewer elicited the importance of actual use, potential use, and no use in each ~~person's~~ respondent's valuation of water quality. These attitudinal questions reinforced the concepts, provided a break in the discussion, and yielded an additional check for consistency in responses.

The payment vehicle was introduced to the respondent as follows:

> Now, we would like for you to think about the relationship between improving the quality of water in the Monongahela River and what we all have to pay each year as taxpayers *and* as consumers. We all pay *directly* through our tax dollars each year for cleaning up all rivers. We also pay *indirectly* each year through higher prices for the products we buy because it costs companies money to clean up water they use in making their products. Thus, each year, we are paying directly and indirectly for improvements in the water quality of the Monongahela River.
>
> I want to ask you a few questions about what amount of money you would be willing to pay each year for different levels of

water quality in the Monongahela River. Please keep in mind that the amounts you would pay each year would be paid in the form of taxes or in the form of higher prices for the products that companies sell.

This payment vehicle is not problem free because the economic activities involving water are simplified. For example, it ignores the possibility that some companies could experience lower production costs if the water were cleaner. In addition, it does not develop explicitly the share of costs companies pass on to consumers relative to the share borne by stockholders. The points could have been clearer with better wording and a visual aid. One wording problem stemmed from inadvertently mixing "and" and "or" in the description of the vehicle. This could have confused some respondents, although the interviewers did not mention it in a debriefing session.

Despite these qualifications, the payment vehicle does have its advantages. It avoids the problem of the implicit starting point that hampers increased water bills or sewage fees, a point made by Mitchell and Carson [21] in their critique of Greenley, Walsh, and Young [17]. This same problem seems to appear in Daubert and Young [12] when they used these two alternatives. Moreover, the payment vehicle is credible--it corresponds reasonably well to how people actually pay for improved water quality.

The final task in the framing of the contingent market was to elicit the option price bids for specific levels of water quality. The central methodological feature of the questionnaire is the comparison of alternative question formats. For this comparison, we divided the sample into fourths and gave a different survey instrument to each group. The four questioning modes were: the direct question method both with and without a payment card and the iterative bidding games with $25 and $125 starting points. Thus, the survey design provided the information necessary for explicit tests of starting point bias and for differences between the direct question and the iterative bidding formats.

The payment card used in the direct question method was simply an array of numbers representing annual amounts from $0 to $775 per year in $25 increments. This format contrasts with the Mitchell and Carson [21] payment card, where the amounts were adjusted based on the income level of the respondent.

Although the wording was the same both for the direct question and payment card formats, the payment card was shown to respondents in the latter case. The process was very simple, with the interviewer asking the respondent for an amount for each water quality level and stressing that additional amounts are being requested. The water quality ladder and the value card were available to the respondent during these questions. The principal difference between the two bidding games was their starting points. In each bidding game, the interviewer initiated the market process at the starting point and increased or decreased the requested amount until the respondent's maximum value was obtained. This was repeated for each of the water quality levels, emphasizing the additional nature of the amounts for higher levels of water quality.

In the hypothetical market, each respondent was asked to provide an option price for three water quality levels:

- Avoiding a decrease in water quality in the Monongahela River from (D) to (E), or from boatable to unsuitable for any water-based activities (including boating).
- Raising the water quality from (D) to (C), or from boatable to a level where gamefish would survive.
- Raising the water quality from (C) to (B), or from fishable to a level where individuals could use the river for swimming.

The option price amounts are based on the Hicksian surplus measures, using the equivalent surplus measure for the loss of the recreation services of the Monongahela River (Level D to Level E) and the compensating surplus measures for the improvements to the fishable and swimmable water quality levels. These measures correspond roughly to the existing property rights for the overall level of Monongahela recreation services. Although several sections of the Monongahela are capable of supporting sport fishing because of the influence of tributaries, the overall water quality of the river corresponds to the boatable level. Moreover, most of the survey respondents lived in or near Pittsburgh, which suggests that their experience with the river was most likely to be consistent with the boatable designation.

3. PROTEST AND OUTLYING BIDS

Estimates from contingent valuation surveys may also be affected by the procedures used to determine the final sample used in the analysis of responses (Randall, Hoehn, and Tolley [24]). Using largely informal procedures, analysts have screened contingent valuation data sets to eliminate protest bids and to identify/delete influential observations. In our view, these procedures should stem from a common objective to detect individuals who fall into one or more of four categories:

- Category 1: respondents who reject the framing of the contingent commodity (e.g., the whole notion of placing values on ~~the payment vehicle)~~ that commodity)
- Category 2: respondents who fail to take the valuation exercise seriously, thereby putting less effort into searching their preferences
- Category 3: respondents who are systematically affected by the framing of the commodity (e.g., the starting point in the bidding game)
- Category 4: respondents who misunderstand or are incapable of processing the information required to participate effectively in the contingent market.

In screening out these individuals, we are imposing, at least implicitly, a model of how individuals respond to contingent valuation questions. When protest bids are identified within the survey questionnaire, we are assuming that these responses are inconsistent with an implicit model of behavior. Outliers can be identified only by imposing some type of model, even the informal ones largely used in the past, on the responses.

The main objective of these selection rules is to remove observations that would most likely lead to biased estimates of a model's parameters.

Yet, characterizing the respondents giving protest zero bids or those classified as outliers may provide information that reflects the effectiveness of the questionnaire.

In this section, we examine the implications of both protest and outlying bids on the effectiveness of contingent valuation. In addition, we suggest a new procedure for identifying outliers.

A. Protest Bids

Table I presents summary characteristics for zero bidders, protest bidders, the full sample, and the characteristics of the survey area population. We constructed t-tests to examine the prospects for differences in means between zero and nonzero bidders. In addition, we used a logit analysis to examine the potential determinants of zero bids.[10] The analysis of means indicates that nonzero bidders were on average younger than zero bidders, earned higher annual family incomes, and were more likely to have rated the Monongahela at a particular site and to have participated in outdoor recreation during the last year. No significant differences existed between the groups in terms of sex, education, their water quality rating of the river, boat ownership, and length of residence in the area. Based on the logit analysis, respondents were more likely to bid zero if they were older, or if they considered themselves unwilling to pay the cost of improving water quality. Those respondents receiving the bidding game with the $25 starting point were <u>less</u> likely to bid zero when compared to those who received the direct question version of the questionnaire. Generally, these findings are consistent with those of Mitchell and Carson [21].

The questionnaire also elicited the respondent's reason for giving a zero bid which enabled us to separate protest zeros from valid zero bids.

Table I. Mean Characteristics by Zero and Protest Bids from Monongahela Survey Versus Census Information

	(1) Zero			(2) Nonzero			(3) Zero protest bids			(4) Total sample			(5) Population census[a]
	Mean	Standard devi- ation	N	Mean	Standard devi- ation	N	Mean	Standard devi- ation	N	Mean	Standard devi- ation	N	Mean
1 if yes, 0 if no for ownership or use of a boat	0.11	0.32	108	0.18	0.39	193	0.15	0.37	58	0.16	0.36	301	
1 if yes, 0 if no for participation in any outdoor recreation in the last year	0.38	0.49	108	0.66	0.48	193	0.50	0.50	58	0.56	0.50	301	
Numerical rating of the Monongahela River 0 lowest - 10 highest	3.51	1.76	61	3.92	2.07	160	3.63	1.68	38	3.81	1.99	221	
1 if yes, 0 if no if rating is for a particular site	0.07	0.26	108	0.21	0.41	193	0.10	0.31	58	0.16	0.37	301	
Length of residence	6.82	0.95	108	6.80	1.02	193	6.74	1.18	58	6.81	1.00	301	
Years of education	12.38	2.20	86	12.93	1.99	177	12.77	1.73	47	12.75	2.07	263	10.96
Race, 1 if white	0.94	0.23	107	0.88	0.33	193	0.93	0.26	57	0.90	0.30	300	.92
Income	17,577	11,500	07	20,534	13,879	173	19,895	11,484	48	19,538	13,184	260	19,907
Age	54.55	16.91	108	44.06	18.07	193	52.60	17.27	58	47.82	18.34	301	45.60
Sex, 1 if male	0.35	0.48	108	0.37	0.48	193	0.44	0.50	58	0.36	0.48	301	.47

[a] U.S. Bureau of the Census [36], 5-county area in Pennsylvania that includes the Monongahela River.

Valid zeros--respondents who indicated that the water quality change was not worth anything or that was all they could afford--are about half of the total number of zeros. The 10 respondents who bid zero because that is all they could afford tended to be elderly persons living on limited incomes. The protest bidders--58 out of 301 respondents--either rejected the idea of putting a dollar value on water quality or some aspect of the payment vehicle. There is little systematic relationship between protest bids and question format. ~~However~~ Since there are few ~~little~~ or no socioeconomic differences between the protest responders and the target population, ~~This suggests that~~ screening out these responses should not affect the representativeness of our sample. Generally, the plausible reasons for zero bids and the low ~~overall~~ rate of protest bids suggest that the questionnaire was reasonably effective.

B. Identifying Outliers

Nearly all analyses of contingent valuation surveys have used some judgmental procedure to eliminate some bids from the full sample of responses. For example, Brookshire, Ives, and Schulze [8] noted that very high and low bids relative to the mean may indicate false bids. Alternatively, this same phenomenon has been interpreted to imply a rejection of the contingent market. Generally, analysts have used one or the other reason to reject responses outside 10 standard deviations of the mean (see Rowe, d'Arge, and Brookshire [27] and Brookshire et al. [6] as examples).[11]

However, all of these approaches implicitly describe the process generating a number of large bids. (See Randall, Hoehn, and Tolley [24].) For example, one might assume that a diffuse distribution of bids may reflect that contingent valuation surveys are "imperfect estimators" of the representative individual's value of an environmental service. That is, a bid could be viewed as having a nonstochastic component based on a person's socioeconomic characteristics and a random error. This error may have a high variance, leading to a wide variation in bids. Thus, size of the bid alone is a poor basis for judging when an individual has rejected the market or has given a strategic response.

As noted earlier, under ideal conditions, we would specify a behavioral model that would explain how respondents answer valuation questions (see Hanemann [20], Smith [34], and Carson, Casterline, and Mitchell [9] for further discussion) and use it to interpret responses. As a first step, our approach is a sample selection rule that combines judgment with one of the Belsley, Kuh, and Welsch (BKW) [2] regression diagnostics, which is calculated for the estimated parameters of economic variables relevant to the option price responses. To describe it, we first review the BKW diagnostic index that we selected and then explain how we used it.

Regression diagnostics are procedures designed to identify influential observations. Using these methods in the context of an economic model implicitly acknowledges that some observations may be inconsistent with the model hypothesized to explain behavior. These observations may reflect one or more categories of inconsistent behavior noted earlier. Our selected diagnostic judges the effects of each observation on estimates of the parameter for income. This is the only economic variable that can be unambiguously specified a priori as important to the option price responses.[12]

Our approach begins with a linear-in-parameters model for option price in Equation (2):

$$Y = X\beta + \varepsilon \,, \qquad (2)$$

where

Y = T×1 vector of T observations for the option price

X = T×K matrix of T observations for each of K determinants of the option price (including a column of ones for an intercept)

β = K×1 parameter vector

ε = T×1 vector of stochastic errors.

The ordinary least-squares (OLS) estimate of β is given as b and defined in Equation (3):

$$b = (X^T X)^{-1} X^T Y \ . \tag{3}$$

The BKW diagnostic, DFBETA, is the change in each estimated coefficient as a result of deleting a single observation. It can be calculated without repeated regression estimates on all possible samples (size T-1) as defined in Equation (4) for the deletion of the i^{th} observation:

$$\text{DFBETA} = b - b(i) = \frac{(X^T X)^{-1} x_i e_i}{(1 - x_i (X^T X)^{-1} x_i^T)} \ , \tag{4}$$

where:

$b(i)$ = the OLS estimate of β with the i^{th} observation deleted

x_i = the i^{th} row of X

e_i = the OLS residual for the i^{th} observation (i.e.,

$e = Y[I - X(X^T X)^{-1} X^T]$).

DFBETA measures the influence of each observation. We normalize this index by the estimated parameter from the full sample and use the result (which is analogous to an elasticity) to identify outlying observations. Subsequently, we ranked the sample by the absolute magnitude of this percentage change and examined the characteristics of the observations (i.e., the respondents) having the largest effect to see if they had any common characteristics.

The specific model used in this analysis was linear with the option price specified to be a function of the respondent's income and a variety of other individual and survey format variables.[13] We based our initial screening of the sample on the option price combined for all levels of water quality (i.e., column 4 in Table V [discussed later in more detail]).[14] We used a 30 percent (±) change in the estimated parameter for income as the threshold for identifying the 32 influential observations shown in Table II. Most of the index values for the remaining observations were much less than the ±30 percent value used to classify a response as an outlier with only a few responses around ±20 percent. Thus, while our selection relied on an observed empirical threshold in our calculated index values, based on judgment, we evaluated the relative importance of each of the judgments underlying this selection and found that they had little effect on the group of responses considered outliers. That is, the 32 observations shown in Table II proved to have substantially large effects on the income coefficient across individual levels of option price and alternative model specifications.

Table II summarizes the characteristics of these respondents. These results show a striking consistency in the characterization of the outliers. Sixty-three percent earned annual incomes of $2,500 a year or less, and 78 percent of them earned less than $7,500 a year. Thirteen of the respondents [redacted] are 60 years of age or older. Female respondents comprised 80 percent of the outliers, while only four respondents had more than a high school

Table II. Profile of Outliers

BKW DFBETA elasticity	Version	Option price: avoid loss of site (D-E) ($/yr)	Option price: Improve water quality to swimmable ($/yr)	Income $/yr	Age (yr)	Sex	Education (yr)	User of Monongahela site	Boat ownership
-213.12	A	125	260	2,500	25	M	12	No	No
-155.99	A	125	200	2,500	20	F	12	Yes	No
-100.04	B	200	200	7,500	67	M	12	No	No
-79.83	A	500	500	22,500	39	M	14	No	Yes
-66.19	A	125	220	7,500	43	F	10	Yes	No
-63.25	C	25	5	2,500	70	F	10	No	No
-62.95	D	450	200	17,500	37	F	12	Yes	No
-56.70	C	60	85	2,500	23	F	12	No	No
-54.98	B	0	10	2,500	82	F	10	No	No
-49.68	D	50	250	7,500	40	F	14	Yes	No
-44.62	A	155	250	12,500	57	F	12	No	No
-43.80	C	5	5	2,500	69	F	10	No	No
-43.16	A	155	250	12,500	44	F	10	No	No
-37.34	C	5	5	2,500	62	F	10	No	No
-36.46	C	25	0	2,500	46	F	10	No	No
-36.03	C	0	0	2,500	76	F	16	No	No
-31.40	B	200	300	27,500	21	F	12	Yes	No
-30.43	A	200	285	22,500	66	F	12	Yes	No
31.24	B	5	3	7,500	34	M	12	No	No
33.98	A	0	0	12,500	38	F	12	No	No
35.39	A	0	0	2,500	78	F	0	No	No
37.77	D	75	10	2,500	59	F	12	Yes	No
41.78	D	25	10	2,500	72	F	12	No	No
47.15	A	5	130	2,500	61	F	12	Yes	No
52.23	A	0	30	7,500	50	F	12	Yes	No
52.86	D	0	0	2,500	43	F	10	No	No
58.18	A	0	0	2,500	79	F	10	No	No
65.70	A	0	10	2,500	66	F	12	No	No
69.15	B	10	20	2,500	33	F	12	Yes	No
79.58	A	55	0	2,500	71	F	10	No	No
82.52	D	0	0	2,500	53	F	12	No	No
112.04	D	0	25	2,500	26	F	12	Yes	Yes

NOTE: A = $125 bidding game; C = $25 bidding game
B = direct question; D = payment card.

education. ~~The last~~ It is interesting ~~element is~~ that 14 of the 32 outliers had received the $125 starting point bidding game--twice as many as the next most frequently occurring version (the payment card). Since these influential observations were eliminated from the subsequent analysis of the sample, the analysis of starting point bias discussed later cannot be distinguished from this decision.

While definitive implications from this simple characterization of the features of the outlying responses are impossible, one reason seems to explain a large fraction of the responses. Low income bidders are seen in these groups to be from two extremes in their responses--very low bids and fairly high bids, relative to their specified income. When we examine the ages of these corresponding individuals, several of these low income respondents (e.g., students) seem to have based their bid on anticipated permanent income levels rather than on reported current income. Of course, this does not explain all of the discrepancies. For example, the prevalence of the $125 starting point may suggest an unanticipated problem with bidding games. That is, the starting point may affect the likelihood of someone being judged an outlying response.

4. Option Price Results

In this section, we consider the features of the distribution of option price bids and discuss the estimated mean values for the option price responses. We evaluate the means grouped by questionnaire versions with users distinguished from nonusers.

A. Distribution of Responses

The option price responses are available for the loss of the recreation services of the site (avoiding a decrease from Level D to Level E on the water quality ladder) and for improvements in water quality first from boatable to fishable (D to C) and then from fishable to swimmable (C to B). The individual's aggregated option prices also are presented for both water quality improvements (D to B). (See Table IV, discussed in a later section.)

To characterize the distribution of option price estimates we report the kurtosis (K) and Uthoff's U-statistic.[15] Smith's [33] small sample experiments suggest that these two statistics, used together, provide a robust approach for detecting heavy tailed distributions. Table III presents these results for the full sample and the sample ultimately selected for analysis--that is, by eliminating protest zeros and the outlying observations.

Using the full sample, the null hypothesis of a symmetric distribution (a close approximation of the normal) would be rejected in nearly all cases--that is, across all water quality changes and question formats. Moreover, both test statistics support this conclusion. The iterative bidding with a $25 starting point for an improvement from boatable to fishable water quality conditions is the only exception. Eliminating the protest and outlying observations clearly affects the responses from questionnaires having the iterative bidding with the $125 starting point. This case is consistent with our above analysis of the features of the outlying observations, ~~in which question format occurred frequently among the outliers~~. Eliminating the outlying bids clearly affected judgments on the shape of the distribution. For 3 of 4 water quality changes, the results change from strong evidence of non-normal distributions to reasonably strong support for symmetric distributions. Moreover, deleting only the protest zero bids did not lead to reversals in the conclusions formed based on the full sample.

Table III. Results for Thick-Tailed Tests[a]

Version/water quality change	All responses (n=301)		Selected responses (n=211)	
	K	U	K	U
1. Iterative bidding - $25 starting point (Version C)				
D to E	19.05	1.58	18.35	1.80
D to C	3.54*	1.28*	2.71*	1.17*
C to B	5.07	1.70	3.96	1.45
Total (E to B)	8.41	1.40	8.86	1.45
2. Iterative bidding $125 starting point (Version D)				
D to E	12.50	1.41	2.09*	1.15*
D to C	4.11	1.42	2.89*	1.35
C to B	6.81	1.96	6.15	2.09
Total (E to B)	9.70	1.44	2.57*	1.24*
3. Direct question (Version B)				
D to E	11.62	2.17	13.36	1.86
D to C	8.91	2.05	8.72	1.85
C to B	16.42	2.62	9.38	2.19
Total (E to B)	9.44	1.97	5.05	1.61
4. Direct question payment card (Version A)				
D to E	13.39	1.78	6.40	1.56
D to C	16.30	1.90	17.92	1.68
C to B	23.66	2.72	23.20	2.56
Total (E to B)	9.57	1.61	6.41	1.41

[a]For 10 percent significance level and sample size of 50, Smith [33] estimated empirical critical values of K = 3.543 and U = 1.314.

*Not significantly different from normality at 10 percent level.

Thus, these findings offer some evidence of starting point effects on both the mean and the shape of the distribution of bids. This analysis may also suggest one reason why there has been such divergent evidence on this issue in the past literature. That is, indirect methods of detecting outlying observations may not be able to distinguish between responses that imply rejection or misunderstanding of the terms of the contingent market and those influenced by the starting points in iterative bidding. As Table III indicates, the deletion of protest and outlying responses had no effect on the results of hypothesis tests for the remaining question formats.

Figure 1 reports the actual frequency distribution of option price responses by version for an improvement in water quality from D to C. These results provide further support to the statistics used to detect thick-tailed distributions. However, neither the thick-tailed tests nor the frequency distribution take account of the potential role of the respondents' characteristics and income for their option price bids. Nevertheless, they do suggest that using test statistics for means based on normality should be done cautiously, with special attention given to sample size for the relevance of critical values.[16]

B. Mean Option Price Responses

Table IV reports the estimated means for the various water quality changes.[17] The means also are grouped by question format and by user/nonuser. Generally, the estimated means are sizable for the Monongahela River and are of the same order of magnitude, regardless of the method used to elicit the amount. Grouping users with nonusers, option price bids aggregated for all water quality levels range from a mean of $54 per household per year for the bidding game with a $25 starting point to $118 for the bid-

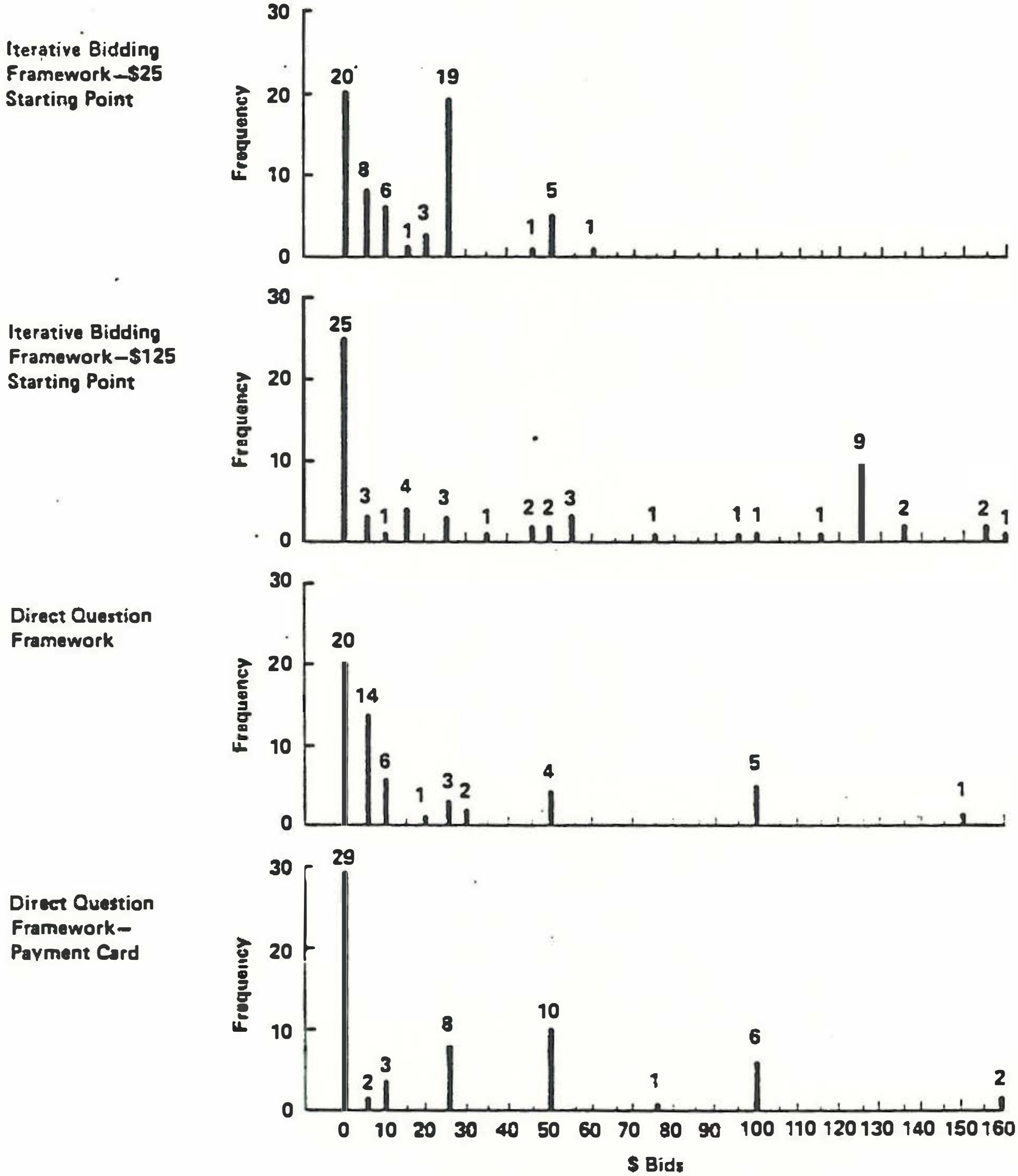
Iterative Bidding Framework—$25 Starting Point
Iterative Bidding Framework—$125 Starting Point
Direct Question Framework
Direct Question Framework—Payment Card
Frequency
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
$ Bids

Fig. 1

Table IV. Estimated Option Price for Changes in Water Quality: Effects of Instrument and Type of Respondent[a]

Change in water quality	User			Nonuser			Combined		
	$\bar{X}$	s	n	$\bar{X}$	s	n	$\bar{X}$	s	n
1. Iterative bidding--$25 starting point ~~(Version C)~~									
D to E (avoid)	27.4	16.7		29.7	35.7		29.0	30.6	
D to C	18.9	16.3		14.5	15.2		15.9	15.5	
C to B	11.8	14.5	19	7.2	11.6	39	8.7	12.7	58
D to B	32.1	27.1		21.7	24.0		25.1	25.3	
All levels	59.5	38.1		51.4	53.1		54.1	48.5	
2. Iterative bidding--$125 starting point ~~(Version D)~~									
D to E (avoid)	94.7	66.0		38.8	51.3		57.4	62.0	
D to C	58.1	51.9		26.3	45.4		36.9	49.5	
C to B	33.1	48.4	16	11.6	33.1	32	18.8	39.7	48
D to B	99.7	87.9		40.5	69.0		60.2	80.0	
All levels	194.4	136.5		79.2	102.5		117.6	126.0	
3. Direct question ~~(Version B)~~									
D to E (avoid)	45.3	65.2		14.2	27.1		24.5	45.4	
D to C	31.3	44.2		10.8	21.6		17.6	32.1	
C to B	20.2	35.5	17	8.5	21.9	34	12.4	27.4	51
D to B	52.9	72.5		20.3	41.4		31.2	55.2	
All levels	98.2	103.5		34.5	66.4		55.7	85.2	
4. Direct question: payment card ~~(Version A)~~									
D to E (avoid)	46.8	42.2		53.0	76.3		51.0	67.1	
D to C	45.3	71.4		21.9	33.8		29.3	49.3	
C to B	22.9	48.7	17	7.7	20.0	37	12.5	32.2	54
D to B	71.2	117.7		29.9	47.5		42.9	78.1	
All levels	117.9	117.0		82.8	104.7		93.9	108.9	

NOTE: $\bar{X}$ = sample mean.

s = sample standard deviation.

n = number of observations.

[a]Estimates are reported in 1981 dollars, the year of the survey.

ding game with a $125 starting point. Means for the aggregated bids for the payment card and direct question formats equaled $94 and $56, respectively. The range of mean option price amounts is even narrower when only the bids for improvements are considered, varying from $25 to $60 per year, with the two bidding games again indicating the widest differences.

These results can be compared with the estimates used in EPA's regulatory impact analysis (RIA) for valuing water quality improvements associated with the effluent guidelines for the iron and steel firms along this river. Since this analysis was conducted without access to the results from this study, such a comparison provides an informal plausibility check for our estimates. Based on existing literature from other sites, their aggregate benefit estimates implied a range of $7.50 to $17.00 in annual benefits per household for improving the water from boatable to fishable water quality level. This range was derived using all three benefit estimation methods reported in the RIA--participation, indirect, and survey.[18] For the improvement from D to C shown in Table IV, our survey estimates are uniformly larger for users. This outcome is consistent with our a priori expectations. Option price is an ex ante benefit measure, while those in the RIA are ex post measures. Option price will reflect both anticipated use and the individual's desire to adjust to water quality conditions in presence of uncertainty over the prospects for that future use.

5. Test Findings

The results of the tests for differences in means between question formats using pairwise comparisons for users, nonusers, and the combined groups are reported in Table V. Given our earlier findings, these conventional tests should be interpreted cautiously. Nonetheless, the results suggest

Table V. Student t-Test Results for Option Price

Means combined	Users	Nonusers	Combined
Payment card v. direct question			
D to E	--	2.806	2.353
E to B	--	2.300	1.991
Payment card v. $25 iterative bidding			
D to E	--	--	2.263
D to C	--	--	1.954
E to B	2.061	--	2.530
Payment card v. $125 iterative bidding			
D to E	-2.499	--	--
Direct question v. $25 iterative bidding			
D to E	--	-2.074	--
Direct question v. $125 iterative bidding			
D to E	-2.161	-2.453	-3.020
D to C	--	--	-2.308
D to B	--	--	-2.109
E to B	-2.289	-2.117	-2.8786
$25 iterative bidding v. $125 iterative bidding			
D to E	-4.294	--	-3.072
D to C	-3.119	--	-3.046
D to B	-3.183	--	-3.159
E to B	-4.131	--	-3.539

Note: Only the cases where statistically significant differences in the means were found at the 0.05 significance level are reported in this table.

that major differences do occur between the means in the bidding games, suggesting some influence from the difference in the starting points. The means would be judged under conventional criteria to be significantly different at least at the 5-percent level for users and for the combined groups. However, the estimates do not permit the null hypothesis of equal means to be rejected for nonusers. There is also some indication that the mean option price for users of the Monongahela is significantly higher when the bidding game with the $125 starting point is used to elicit option price compared to the direct question technique.

Our estimated option price equations shown in Table VI, which control for differences in individuals socioeconomic characteristics and a set of qualitative variables to account for the interviewer, provide additional insights into the effect of question format on option price. Based on a dummy variable that was defined to compare the payment card with the other three versions, option price would be judged to be significantly higher for some water quality changes for respondents with the payment card relative to the direct question and the $25 bidding game. ~~Finally,~~ as noted earlier in Section 4, the influence of the starting point cannot be separated from the effects of omitting influential observations.

Overall, our results on the effects of starting points would seem to fall between the results of Rowe, d'Arge, and Brookshire [27], who found evidence of a starting point bias, and Thayer [35], who found none. Some of the differences in the results may be due to the "commodity" sold in the hypothetical market. In Thayer's case, the respondents were all users who had a very clear conception of the commodity and of the costs of substitute recreation sites. Both our results and those of Rowe, d'Arge, and Brook-

Table VI. Regression Results for Option Price Estimates[a]

Independent variables	Water quality changes				Total improvements only
	D to E (avoid)	D to C	C to B	Total all levels	
Intercept	-34.512	-29.307	-5.430	-56.653	-22.141
	(-.973)	(-1.098)	(-.257)	(-.916)	(-.517)
Sex, 1 if male	8.451	-.672	-1.657	6.484	1.967
	(.916)	(-.097)	(-.302)	(.403)	(-.177)
Age	-.292	.290	-.265	(-.854)	-.562
	(-1.094)	(-1.440)	(1.668)	(-1.834)	(1.743)
Education	5.294	2.901	-5.27	8.066	2.773
	(2.071)	(1.508)	(.347)	(1.810)	(.899)
Income	.0006	.0003	.0003	.0012	.0006
	(1.652)	(1.151)	(1.260)	(1.832)	(1.278)
Direct question	-32.311	-14.372	-3.500	-50.734	-18.423
	(-2.771)	(-1.638)	(.505)	(-2.495)	(-1.309)
Iterative bidding geme ($25)	-20.623	-12.572	-5.657	-39.566	-18.943
	(-1.852)	(-1.500)	(-.854)	(-2.037)	(1.409)
Iterative bidding game ($125)	1.7522	6.639	.739	31.089	13.568
	(1.421)	(.716)	(.101)	(1.446)	(.912)
User, 1 if user	8.840	8.083	6.839	26.026	17.187
	(.919)	(1.117)	(1.96)	(1.552)	(1.481)
Willing to pay cost of water pollution, 1 if very much or somewhat	17.001	21.960	10.023	51.326	34.326
	(1.788)	(3.068)	(1.772)	(3.095)	(2.990)
Interviewer #1	14.211	7.090	11.334	26.509	12.298
	(.750)	(.497)	(1.006)	(.802)	(.538)
Interviewer #2	1.723	12.242	16.849	24.719	22.996
	(.099)	(.938)	(1.634)	(.817)	(1.099)
Interviewer #3	-22.833	21.141	17.578	9.292	32.125
	(-1.344)	(1.653)	(1.740)	(.314)	(1.567)
Interviewer #4	-28.125	3.050	20.605	-12.334	15.791
	(-.860)	(.124)	(1.059)	(-.216)	(.400)
Interviewer #5	6.932	4.996	2.191	11.435	4.503
	(.404)	(.387)	(.215)	(.382)	(.217)
Interviewer #6	47.012	95.513	66.288	198.450	151.439
	(.887)	(2.394)	(2.102)	(2.146)	(2.366)
Interviewer #7	27.670	2.470	4.130	39.645	11.975
	(1.425)	(.169)	(.357)	(1.170)	(.511)
Interviewer #8	14.022	29.961	19.871	58.063	44.041
	(.801)	(2.274)	(1.908)	(1.902)	(2.08)
Interviewer #9	17.874	39.586	-7.935	37.330	19.456
	(.454)	(1.336)	(-.339)	(.544)	(.409)
Payment card plus direct question, 1 if either					
R^2	.334	.284	.166	.366	.269
F	3.78	3.00	1.50	4.36	.278
Degrees of freedom	136.0	136.0	136.0	136.0	136.0

[a]The numbers in parentheses below the estimated coefficients are t-statistics for the null hypothesis of no association.

shire [27] used samples of households who may be more sensitive to the format used if they did not have a clear conception of the commodity.

The regression results in Table VI also provide some evidence on the effects attributable to differences in interviewers.[19] Using dummy variables, the results indicate that the interviewer effects are limited. Only two interviewer variables appear to have a significant effect on bids at the 5-percent level. Even in these cases, the effects are only present for some of the water quality changes. One of the cases involved an interviewer who conducted only two interviews before being removed from the interviewing team. This interviewer did not take part in the training session and also conducted interviews only in the Latrobe area, which is a considerable distance from the Monongahela River. The second interviewer also conducted interviews in the Latrobe area and in one area very close to the river. We cannot unambiguously attribute these differences to the interviewers involved, since the model cannot differentiate between an interviewer effect and omitted area specific variables.

6. SUMMARY AND CONCLUSIONS

Our findings indicate that contingent valuation approach can be used to elicit individuals' valuations of changes in water quality. Our estimates of option price with uncertain use were related to income as economic theory would imply. Overall, the prognosis from the Monongahela River case study for the continued use of the contingent valuation approach is positive. The empirical models performed reasonably well in explaining variations in option price, with little indication that individual interviewers influenced results. In addition, respondents apparently perceived enough realism in the survey that they did not have problems with its hypothetical nature.

Generally, the results confirm the recent state-of-the-art assessment by Cummings, Brookshire, and Schulze [11] and with the earlier summary judgments of Randall, Hoehn, and Tolley [24]: contingent valuation surveys seem capable of providing order-of-magnitude estimates of the benefits realized from enhancing one or more aspects of environmental quality. In addition, our findings further suggest that these benefit estimates are not confined to user-related values. Individuals can understand and incorporate values derived from uncertain future use into their bids for environmental improvement.

However, our results do suggest that the question format can be important to the estimates of option price. The bidding game with a $125 starting point and the payment card approach appear to have led to higher responses than the other two formats. There is some evidence of a starting point bias in the bidding game, but the results are not conclusive. Compared to the other formats, the higher starting point resulted in a higher percentage of outlying responses. However, the combined comparison of bidding games with nonbidding approaches showed no significant differences. Nonetheless, we caution against routinely using bidding games until more is known about their effect on how a respondent processes contingent valuation information.

Finally, we have argued that sample selection rules to identify protest and outlying observations should be viewed in an empirical framework that recognizes these rules as the result of each analyst's implicit model of how individuals respond to contingent valuation surveys. Interpreted in this way, regression diagnostics, which focus on the estimated parameters of economically relevant variables, provide signals of response patterns inconsistent with the sample norm for these variables. In effect, the individual is not responding in the same way as his peers in that income category (after using simple methods to hold other socioeconomic and questionnaire-related effects constant). Clearly, a model of the individual decision process leading to all responses would be preferrable. Nonetheless, this is a step toward developing such a model.

FOOTNOTES

[1]Two anonymous reviewers contributed constructive comments on an earlier draft of this paper. Matthew McGivney provided research assistance while Hall Ashmore lent editorial guidance. This research was supported by the U.S. Environmental Protection Agency under Contract No. 68-01-5838. The views expressed in the paper are those of the authors, not their respective institutions.

[2]Confusion abounds in the terms used to represent these benefits. In this paper, use benefits are those directly linked to use of a resource. Nonuse benefits do not require use of the resource. Existence values, which are a type of nonuse benefit, are not included in our empirical analysis.

[3]For a review of the empirical evidence on the relationship between nonuse and use values for water quality changes see Fisher and Raucher [14].

[4]This argument has been offered by a number of analysts in recent papers. See Bishop [3,4], Hanemann [19], and Smith [31,32] as examples.

[5]The reference operating conditions defined by Cummings, Brookshire, and Schulze [11] can be summarized as follows:

- Participants must understand and be familiar with the commodity to be valued.
- Participants must have had or be allowed to obtain prior valuation and choice experience with respect to consumption levels of the commodity.
- There must be little uncertainty.
- Willingness-to-pay and not willingness-to-accept valuation measures should be elicited.

These conditions are in contrast to the earlier optimism of Schulze, d'Arge, and Brookshire [30] and seem to be more in line with the view of Rowe and Chestnut [26].

[6]For a detailed discussion of the theory underlying the definition of option price in the timeless framework, see Bishop [3], Bohm [5], Graham [16], Schmalensee [28,29], and Smith [32]. For the time-sequenced analysis, see Arrow and Fisher [1] and Hanemann [19].

[7]Plummer and Hartman [23] have investigated the implications of relating uncertainty in various ways to the features of the indirect utility function. Freeman [15] has also used this line of argument to develop a set of empirical bounds on the size of the difference between option price and the expected consumer surplus ~~(ECS)~~.

[8]These general comments are consistent with Freeman's [15] conclusions.

[9]For more details, see Chapter 3 in Desvousges, Smith, and McGivney [13]. The interviewers participated in a 2-day training session devoted to measuring benefits, water pollution issues, and mock interviews using all four question formats.

[10]The details of the test results and logit analysis are presented in Desvousges, Smith, and McGivney [13].

[11]Randall, Hoehn, and Tolley [24] describe two general types of procedures for dealing with the outlying bids. The first, and most popular, uses some threshold for either the bid or the bid as a fraction of income and eliminates responses with values exceeding that threshold. The second censors the bids by altering these large bids to correspond to a set maximum threshold value. While these authors do not compare the approaches, there is no basis for recommending the second approach. Indeed, if one is con-

cerned with deleting observations, iteratively re-weighting observations with robust regression techniques would seem to provide a better alternative than a procedure that deliberately introduces a censoring problem in the sample of bids.

[12]A variety of other techniques could be used to detect influential observations, including using the fitted values for the option price based on the estimated models. See Belsley, Kuh, and Welsch [2] and Cook and Weisberg [10] for further discussion.

[13]These ~~sets of~~ variables refer to the measures used to describe the characteristics of each ~~individual~~ respondent, such as age, sex, income, and education, and the measures used to ~~take~~ account for ~~of~~ the specific survey questionnaire received by the individual, such as payment card, direct question, or ~~and~~ type of bidding format.

[14]The estimates reported in this table are based on the sample with the influential observations deleted. ~~These equations describe the functional specifications used. The specific estimates are~~ More detail is reported in Desvousges, Smith, and McGivney [13], Appendix C.

[15]The kurtosis statistic is defined as

$$K = (\sum_i (X_i - \bar{X})^4/n)/(\sum_i (X_i - \bar{X})^2/n)^2 \quad .$$

The Uthoff U is the ratio of the standard deviation to the mean deviation from the sample median.

$$U = (\sum_i (X_i - \bar{X})^2/n)^{1/2}/(\sum_i X_i - X_m /n)$$

where

n = sample size

X_i = value for ith observation

$\bar{X}$ = sample mean

X_m = sample median.

For more details on the performance of these and other tests for thick-tailed distributions see Smith [33].

[16]The central limit theorem assures that as long as response can be assumed to arise from distributions with finite first and second moments, the mean will have a normal distribution. What is relevant for practical purposes is the sample size at which the small sample distribution for test statistics approaches the hypothesized form used in defining the critical values for hypothesis tests. This is the reason for caution in interpreting test results using conventional criteria.

[17]Appendix C in Desvousges, Smith, and McGivney [13] presents the estimated means for both the full sample and the sample with only the protest bids excluded. Calculated t-statistics revealed no statistically significant differences between the means estimated from the full sample and those estimated with the protest bids excluded.

[18]These estimates are derived from Raucher and Fisher [25] by dividing the aggregate estimates reported in their Table 1 by the number of households in the region to derive an implied "average" willingness to pay. Therefore, they do not take account of the geographic dispersion of the households in the region.

[19]This test is limited because interviewers were assigned geographic segments, designed to minimize travel costs. The high cost of randomly assigning interviewers makes a complete test impractical for a household survey.

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Figure 1. Effects of instrument--distribution of option price for a change in water quality from boatable to fishable, protest bids excluded.