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DOES CONTINGENT VALUATION WORK?

RESULTS OF THE SANDHILL EXPERIMENT

by

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Value

* Invited paper, Joint Meetings of the Association of Environmental and Resource Economists, the American Agricultural Economics Association, and the Northeast Agricultural Economics Council, Cornell University, August 5-8, 1984. Research was supported by the College of Agricultural and Life Sciences, University of Wisconsin-Madison, the Electric Power Research Institute, and Resources for the Future, Inc. Research at Sandhill is possible only because of the help of the Bureau of Research and the staff of the Sandhill Wildlife Demonstration Area, Wisconsin Department of Natural Resources. All errors, however, are the sole responsibility of the authors, who are, respectively, Professor of Agricultural Economics, Professor of Rural Sociology, Research Assistant in Agricultural Economics, and Research Assistant in Rural Sociology at the University of Wisconsin-Madison.

While contingent valuation[1/] is being applied with increasing frequency, cynicism persists about the accuracy of the resulting values. Are people willing and able to accurately value environmental and recreational commodities? In this study, permits for a special Wisconsin deer hunt in 1983 were valued using contingent valuation and actual auctions to address this issue. The Sandhill Wildlife Demonstration Area, which served as the site for the special deer hunt, contains twelve square miles of land surrounded by a deer-proof fence. White-tailed deer research there has had the goal of developing a herd with a relatively large proportion of trophy bucks. Public deer hunting has been permitted at Sandhill to maintain the herd within habitat bounds. During the last three years, special one-day hunts for deer of either sex have been held on the Saturday preceding the opening of the regular deer season. In addition to their regular Wisconsin deer license, participants at Sandhill have needed a special permit. These permits, which are issued free to winners of a state lottery, were the commodity valued in our study. Both willingness-to-pay and willingness-to-accept-compensation were investigated.

Assessing the accuracy of contingent valuation requires a standard of comparison. Most economists would agree that contingent values are accurate to the extent that they approximate values that would be generated if a well-functioning, competitive market could be established. Past writers (for example Schulze, d'Arge, Brookshire, 1981) have identified several reasons why contingent valuation might be biased compared to real market values. Section I of this paper will define these categories of bias and briefly summarize past studies which have attempted to assess the extent of the distortions.

Our approach in the Sandhill study was to set up parallel contingent and real auctions for permits. Thus, in designing the experiment, we drew on the economic theory of auctions, as discussed in Section II. Section III will describe the design of the experiment in detail. Results are presented in Section IV. The Sandhill Experiment produced clear evidence of so-called "hypothetical bias." Evidence of "starting point bias" was also found. However, we argue in Section V that these biases were not large enough to justify ruling out the use of contingent values in policy analyses.

I. SOURCES OF BIAS

A complete discussion of the literature on bias is beyond the scope of the present paper. It is also unnecessary given the detailed treatment that this topic has received in the recent literature (Schulze, d'Arge, and Brookshire, 1981; Mitchell and Carson, 1981; Desvousges, Smith, and McGivney, 1983; and Cummings, Brookshire, and Schulze, 1984). Still, a brief overview of terminology and results will be helpful in viewing the Sandhill results.

The concept of hypothetical bias will play an important role in the present study. In our view, the artificiality of contingent markets may cause respondents to err in predicting how they would behave in a real market. Quoting from Bishop, Heberlein and Kealy (1983, pp. 627-628):

> Prior to being confronted by an interviewer or mail survey, subjects may never before have attempted to express how they feel about environmental assets in monetary terms. While constrained utility maximization is a useful construct, conversion of utility into monetary terms in the real world may involve repeated market transactions over time, consultation within peer groups, assessment of the markets for complements and substitutes, consultations within the household, and references to consumer information. It is questionable whether the interviewer or questionnaire designer can fully compensate for the lack of such experience and information in the limited time and space available. Hence, subjects are forced to deal with a situation which seems quite artificial from their point of view in comparison to situations where they normally arrive at monetary values. While the researcher hopes they will follow the same

> mental processes they would use in real markets, the social context within which contingent valuation occurs may be so artificial that people will be unwilling or unable to do so.

Thus, hypothetical bias may occur for two reasons. First, the "costs" of being wrong in a contingent market are quite low since all payments are hypothetical payments and changes in consumption are hypothetical as well. Respondents in a contingent market may not have the same incentives to thoroughly review their preferences and budgetary commitments that they would in a real market. Second, people may err in predicting their behavior even though they try hard to evaluate their preferences and circumstances. Such errors occur because they lack the experience and context to know how they would behave in a real market.

Several other potential sources of bias have been identified: Strategic bias would occur if respondents intentionally misled the researcher because they believed there was some economic advantage in doing so. For example, if people felt that study results might influence user fees, they might express lower values than they would in a real market. The opposite result is possible if respondents believed that large contingent values would result in increased flows of some free public service.

Vehicle bias would occur if respondents were sensitive to the method of payment used in the research. For example, if the contingent valuation mechanism used taxes as a payment vehicle, people might express relatively low values as a reaction to their current level of taxes rather than as an expression of their true values for the amenity in question.

Starting point bias is a potential phenomenon of the bidding game method of eliciting contingent values. This method involves asking respondents whether or not they would pay a given amount, the starting bid. A positive response would lead the interviewer to inquire about successively higher amounts while a negative response would lead to a successively lower amount, until an expression of maximum willingness-to-pay is elicited. Similar procedures would be used in a study of willingness-to-accept-compensation. Starting point bias would have occurred if people's final bids were significantly affected by the starting bid. Presumably, people's true willingness-to-pay ought not to depend on the value at which the researcher decides to start the valuation process. Starting point bias might occur because respondents do not know their true willingness-to-pay and use the starting bid as information about what would be a reasonable amount to pay. Alternatively, the problem might stem from starting bids which are so far away from true values that respondents become bored with the iterative bidding process and simply state a value to end the bidding process.

Information bias would occur if the information provided as a part of the contingent valuation exercise influences contingent values in ways that do not appear likely to influence true values. For example, theoretically, information on the value others place on the resource ought not to affect the true willingness-to-pay of any given individual. If it were found that participants in a contingent valuation study were influenced by information regarding the values of others, information bias would be suspected.

The normal sources of bias for survey research, such as interviewer bias and non-response bias, should also be mentioned for completeness, although they will not play an important role in the present study. Such biases are not peculiar to contingent valuation and can be minimized through careful attention to study design based on well-established principles. See, for example, Heberlein and Baumgartner (1978) for methodological insights about mail surveys.

This taxonomy of biases is not altogether satisfactory. The term "bias" is often used in a loose way in the literature. For example, vehicle bias and information bias are sometimes said to exist when what the authors mean to say is that they have shown that the payment vehicle or information provided influenced the mean values stated by their respondent. To establish a true bias, it would have to be shown that people would not change their true (i.e., real market) values in response to changes in vehicle or information. Furthermore, the definitions themselves are not always clear and mutually exclusive. For example, one wonders whether starting point bias ought to be considered a form of information bias. Where vehicle bias ends and hypothetical bias begins is not always clear. Hopefully, as contingent valuation evolves, this taxonomy can be refined. In the meantime, it will prove useful in looking at the Sandhill deer permit results.

Substantial empirical research has been done on the extent to which these potential biases actually affect contingent valuation results. Again, existing literature, including most recently Cummings, Brookshire and Schulze (1984), presents detailed summaries. It must suffice here to note that most observers have found the evidence at least modestly encouraging. Though not completely accurate, contingent values have appeared to be close enough to true values to be useful for policy. Three sources of empirical results have been cited in support of this conclusion. First, the experimental literature on public goods has, for the most part, failed to find large distortions due to strategic behavior. Second, several contingent valuation studies have employed so-called "methodological cross-checks." That is, along with contingent valuation mechanisms such studies have employed other methods of valuing non-market goods, such as the travel cost method and the hedonic price estimation. Such techniques have produced results that are supportive of contingent valuation, at least up to a point. Third, there have been a few laboratory and field experiments where behavior in contingent markets could be compared to the results of actual cash transaction. Since the Sandhill study is in this tradition, let us explore the role of experimental studies in validation of contingent valuation.

Experimental studies are needed because methodological cross-checks usually do not produce values that can be used as exact standards for comparison. For example, Brookshire, et. al. (1982) used property values in an hedonic price equation to derive values for improvements in air quality in the Los Angeles area. They compared these hedonic values to contingent values. However, they were not able to test the hypothesis that the hedonic prices equal the contingent values because their theoretical analysis indicated that contingent values should be less than or equal to hedonic prices. Likewise, market values for privately-provided recreation might be used as crude standards against which to evaluate contingent values for publicly-provided recreation. However, the characteristics of the two are likely to be so different that strict comparisons cannot be justified. It must also be explicitly recognized that alternative valuation techniques may have potential biases of their own. This raises questions about their validity as guides to the values that would exist in real markets. For example, the travel cost method is subject to continuing debate on very basic issues like valuation of time, choice of functional form, and treatment of multiple-purpose trips. Thus, using travel cost results to assess contingent valuation results may be like the blind leading the blind.

Experimental techniques overcome these difficulties by creating what we have termed "simulated markets" for the amenity in question where actual cash and actual consumption opportunities can change hands. Of course, simulated markets are not true markets in every respect. Disequilibrium may be a factor. Respondents to actual cash offers may get only one opportunity to engage in a transaction, while real markets, even for durables such as automobiles and houses, generally involve repeated transactions over long periods. The opportunities to gain experience, obtain information, and consider preferences and budgetary commitments must be much greater in real markets. To go a step further, simulated markets could well share some of the bias problems that are feared in contingent valuation. To take an extreme view, one might speculate, for example, about strategic bias. Suppose that individuals receive a cash offer for a recreational opportunity as part of a single experiment and that they see some advantage in influencing final results in an upward direction. They might well refuse offers which they would accept in a real market in order to further their long run goals. Thus, it is important to distinguish between simulated markets and real markets.

Still, simulated markets are enough like actual markets to provide valuable insights about the accuracy of comparable contingent markets. This is particularly true for hypothetical biases, since real money and real consumption opportunities are used in place of the hypothetical money and opportunities in contingent markets. The first such study was done by Bohm (1972) using a closed-circuit television program in a laboratory setting. Actually, Bohm's work explored several aspects of public goods valuation and allocation, but Bohm was also able to compare actual and hypothetical willingness-to-pay and did discover evidence of what would now be termed hypothetical bias, although Bohm himself (1972, p. 125) called his subjects "irresponsible" for behaving differently when payment was hypothetical.

A very recent laboratory experiment was conducted at the University of Wyoming by Hovis, Coursey, and Schulze. While their paper is as yet unpublished, the results are summarized in Cummings, Brookshire, and Schulze (1984). The commodity was a foul-tasting, but harmless, liquid and study subjects were involved in auctions either to pay not to drink the stuff or accept compensation to drink it. At first, valuation was hypothetical, but then repeated auctions were conducted to actually pay or receive compensation and drink or not drink. Contingent willingness-to-pay performed reasonably well.

Actual bids to receive compensation were very close to hypothetical bids. Furthermore, both hypothetical and initial real bids for willingness-to-accept were substantially higher than willingness-to-pay bids. However, after several iterations in the cash market, willingness-to-accept collapsed until the mean was not distinguishable statistically from willingness-to-pay. This result may indicate that hypothetical bias is a major problem only for willingness-to-accept-compensation.

Bishop and Heberlein (1979) conducted a field experiment where one sample of Wisconsin hunters was offered real money to give up their goose hunting permits. These permits allowed the taking of one goose from a specified area in Wisconsin during two weeks in October 1978. Offer amounts were randomly assigned to each hunter in advance and the respondent could either accept or reject the offer. Members of a separate sample was asked to imagine they had received such offers and each subject was asked to state whether he would accept or reject a specified amount. Contingent willingness-to-pay was also estimated. It turned out that people were more likely to sell for actual cash. This resulted in a contingent value of permits of $101 each on average, while responses to the actual cash offers indicated an average value of $63. This difference was attributed to hypothetical bias (Bishop, Heberlein and Kealy, 1983). Contingent willingness-to-pay in a question using similar take-it-or-leave-it offers was $21. Comparing this with simulated market willingness-to-accept of $63 and a travel cost value of $32 led us to suspect that hypothetical bias is in a downward direction for willingness-to-pay and in an upward direction for willingness-to-accept-compensation.

While the goose permit study supported the view that hypothetical bias is a problem in contingent valuation, the final conclusion was still positive:

"...let us emphasize that our contingent valuation mechanisms produced meaningful -- albeit inaccurate -- economic information. ...In a world where public policy would otherwise be made in total ignorance of the economic values of environmental assets, such contingent values may be useful." (Bishop, Heberlein, and Kealy, p. 632)

The Sandhill experiment would have been worthwhile if all we had done was to replicate the goose experiment in a new setting, but our goals were much more extensive. The goose study only measured the simulated market value for willingness-to-accept and our top priority was to extend the approach to willingness-to-pay. Also, the valuation mechanism in the goose study was rather unorthodox. Most past contingent valuation studies have used bidding games or open-ended valuation questions, rather than take-it-or-leave-it offers. Many researchers prefer bidding games because they feel the bidding process encourages more careful consideration of respondents' maximum values. With respect to the goose study, one has to wonder how bidding would have affected both the simulated market and the contingent valuation results. In a broader perspective, we also wanted to consider whether the large differences between willingness-to-pay and willingness-to-accept, documented consistently in contingent valuation studies, carry over into treatments involving actual cash transactions. The Sandhill study was designed to address these issues. To do so, it employed auctions and the theory of auctions was important to the experiment's design.

II. THE THEORY OF AUCTIONS

Auctions have been classified based on (1) the rules that apply in determining who wins and (2) the rules for determining how much the winner will pay or receive. Four basic types of auctions are:

1. English Auction: In this auction all of the bidders must be assembled in such a way that they are able to observe each others bids. The auctioneer states a low opening price and accepts bids that are higher. Each bidder is

allowed to bid as many times as he or she desires. The auction terminates when no one is willing to make a bid higher than the bid that the auctioneer has currently accepted. The participant with the highest bid wins the auction and is required to pay an amount equal to the amount of the top bid.

2. First Price Auction: In this type of auction, bidders are allowed to make one sealed bid. Participants are not required to make the amounts of their bids known to other participants in the auction. At a predetermined time, the auctioneer makes all of the bids known to all participants and accepts the highest bid. The winner of the auction is then required to pay an amount equal to the amount of his or her bid.

3. Dutch Auction: This auction is similar to the English auction in that the bidders must be assembled in such a way that they obtain information about the bidding process as it takes place. In the Dutch auction, the auctioneer makes the bids or offers. Each of the auction participants is allowed to accept any offer that the auctioneer makes. The auctioneer starts out at a very high offer, then lowers it until a bid is accepted. The winner of the auction is the first one to signal acceptance of the auctioneer's offer. The winner of the auction is required to pay the amount of the offer which he or she accepted.

4. Second-Price or Vickrey Auction: This type of auction follows the rules of the first price auction in all respects except for the determination of the winner's payment amount. In particular, the winner of the auction is not required to pay his or her bid. Rather the amount required equals the second highest bid. In auctions where more than one unit of the item is being auctioned, the price would be set equal to the amount of the highest unsuccessful bid.

For the Sandhill study, the English and Dutch auctions were infeasible due to the difficulty of assembling the bidders so that the auction could be carried out. Both the first price and the Vickrey auctions offered the advantage that they could be conducted through the mail. The choice between the first price and Vickrey auction involved two criteria: (1) ease of explanation to participants and (2) the ability to solicit bids that truly reflected the willingness-to-pay or willingness-to-accept of Sandhill hunters.

The first price auction was clearly the best choice when judged solely on the criterion of ease of explanation. Most people are familiar with first price auctions and many people have actually participated in them. However, when judged on the second criterion, the Vickrey auction is clearly the superior choice. This is because if people act according to expected utility theory, there is an incentive in a first-price auction for them to bid lower than maximum willingness- to-pay for the object or higher than their minimum willingness-to-accept. No such incentives exist in the Vickrey auction.

To see why, it is necessary to review the notion of an order statistic. Take N observations on a random variable, X, which has some probability density function f(.). We can define Y(N) as the maximum of the observations on X and Y(1) as the minimum. Y(1) and Y(N) are order statistics. Their probability density functions (pdf's) can be determined if we know the pdf of X (that is to say, if we know f(.)). The concept of order statistics is not confined to the maximum or the minimum of the observations on X. For example, the fourth highest of the observations is also an order statistic Y(N-3) with its own pdf.

Here, we will only consider the willingness-to-pay side. Arguments for willingness-to-accept are parallel. Assume that each individual knows the maximum value he or she places on the item being sold and that this value is not affected by the values that other bidders place upon it. (In the jargon of the auction literature, this is a "private and independent values model.") We will also assume that the individual's utility function is defined over income (y) and the item being sold. In particular, if he or she possesses the item, utility is U(y,1) and, if not, utility is U(y,0).

Assume also that compensating variation, CV, is the appropriate measure of the bidder's welfare. In any auction the individual bidder has three alternative strategies: he or she can bid more than CV, CV exactly, or some amount less than CV. These choices are illustrated below:

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0                   B'         CV         B"
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B' and B'' are amounts arbitrarily chosen to lie below and above CV, respectively. That is, by assumption, $0 < B' < CV < B'' < \infty$.

Now consider the first price auction. The individual does not know what the others will be bidding but has an idea (subjective probability density functions) about the distribution of the others' bids. From this knowledge, he or she can construct the probability density function of Y(N), the maximum order statistic. We will call this g(.). Assume throughout that B' and B" have been chosen such that g(B')>0 and g(B")<1. The individual wins the first price auction if his or her bid, B, is greater than Y(N). By definition, winning involves acquisition of the commodity, but it also entails paying an amount equal to B. When B is less than Y(N), nothing is obtained and nothing is paid. Thus, the individual bidder could view the problem of selecting a bid as a problem of maximizing:

$$(1) \qquad \int_0^B U(y-B,1)g(t)dt \; + \; \int_B^\infty U(y,0)g(t)dt.$$

Without finding an explicit solution to this problem, it is nevertheless possible to show that the individual would do better to select a bid less than CV.

First, write the expression for expected utility if the individual bids an amount equal to CV:

$$(2) \qquad E(U(CV)) = \int_0^{CV} U(y-CV,1)g(t)dt + \int_{CV}^{\infty} U(y,0)g(t)dt$$

Verbally stated, the expected utility of submitting a bid equal to CV is the product of the utility and the probability of each value of the order statistic, integrated over all possible outcomes for the order statistic. When Y(N) is less than CV, the bidder will buy the item, but must pay an amount equal to CV. When the order statistic, Y(N), falls above CV the individual does not win the auction and does not pay any amount.

For purposes of this discussion, it is convenient to write the two integrals in equation 2 in two different ways:

$$(2a) \quad E(U(CV)) = \int_{0*}^{B'} U(y-CV,1)g(t)dt + \int_{B'}^{CV} U(y-CV,1)g(t)dt + \int_{CV}^{\infty} U(y,0)g(t)dt$$

$$(2b) \quad E(U(CV)) = \int_0^{CV} U(y-CV,1)g(t)dt + \int_{CV}^{B''} U(y,0)g(t)dt + \int_{B''}^{\infty} U(y,0)g(t)dt,$$

where, recall, B' is an arbitrarily chosen positive amount less than CV and B'' is a finite, positive amount greater than CV. Each of the expressions 2, 2a, and 2b, represent the product of the utility function and the probability of that level of utility, integrated over all of the possible outcomes of the order statistic. In these equations, t plays the role of the dummy variable for the order statistic. Now, for the sake of comparison, write similar expressions for the expected utility from bidding the two reference amounts, B' and B'':

$$(3) \quad E(U(B')) = \int_0^{B'} U(Y-B',1)g(t)dt + \int_{B'}^{CV} U(y,0)g(t)dt + \int_{CV}^{\infty} U(y,0)g(t)dt$$

$$(4) \quad E(U(B'')) = \int_0^{CV} U(y-B'',1)g(t)dt + \int_{CV}^{B''} U(y-B'',1)g(t)dt + \int_{B''}^{\infty} U(y,0)g(t)dt.$$

Again, we have written the expected utilities as the product of the utility and the probability, integrated over the area of positive probability. When the bid is B', the individual will get the auctioned item and have to pay an amount equal to B' if the order statistic, Y(N), falls between 0 and B', and will not get the item if the order statistic exceeds B'. When the bid is B'', the individual will get the item (and pay an amount equal to B'') when the order statistic falls between 0 and B'', and will not get the item if the order statistic exceeds B''. If we could determine that E(U(B')) > E(U(CV)) > E(U(B'')), then we would be able to say that the optimal bid for an individual in the first price auction is something less than his true valuation of the object, CV. Expected utility would then be maximized by bidding some B'< CV. This can be shown from equations 2 through 4:

$$E(U(B')) - E(U(CV)) =$$

$$\int_0^{B'}[U(y-B',1) - U(y-CV,1)]g(t)dt + \int_{B'}^{CV}[U(y,0) - U(y-CV,1)]g(t)dt.$$

But, by the definition of the compensating variation, CV, we know that U(y,0) = U(y-CV,1). Also, the utility functions can be brought outside the integral sign because they have no random variables in them. Using these facts we can write:

$$E(U(B')) - E(U(CV)) = [(U(y-B',1) - U(y-CV,1)] \int_0^{B'} g(t)dt.$$

Since, by definition, B' < CV and, by assumption, indirect utility functions are increasing in income, we know that the utility difference in front of the integral is positive. The integral itself must also be positive since $g(\cdot)$ is a probability density function. Thus, we can conclude that the expected utility of bidding some amount less than CV will exceed the expected utility of bidding CV. Using a parallel argument it is possible to show that:

$$E(U(CV)) - E(U(B'')) = (U(y-CV,1)-U(y-B'',1)) \int_0^{B''} g(t)dt$$

Again, since CV < B'' we know that U(y-CV,1) > U(y-B'',1), which in turn implies that E(U(CV)) > E(U(B'')), since the integral of a probability function must be non-negative. Thus, we have proven that an expected utility maximizer will submit a bid that is somewhat less than his or her compensating variation.

Now consider why an expected utility maximizer will bid CV in the second price or Vickrey auction. This explanation follows the same strategy as was used in examining the first price auction. Remember that in a Vickrey auction the bidder wins if the bid is the highest, but pays an amount equal to the second highest bid. Thus, the bidder wins the auction if his bid exceeds the order statistic Y(N), and pays an amount equal to the order statistic. The bidder can be thought of as selecting a bid, B, which maximizes the following expression:

$$E(U(B)) = \int_0^B U(y-t,\ 1)g(t)dt + \int_B^\infty U(y,0)g(t)dt.$$

Note that, in the case where the bidder is successful, the order statistic enters directly into the bidders utility function. Again, the expected utility of submitting a bid equal to CV can be written as any of the three following expressions:

5. $$E(U(CV) = \int_0^{CV} U(y-t,1)g(t)dt + \int_{CV}^\infty U(Y,0)g(t)dt$$

5a. $$E(U(CV)) = \int_0^{B'} U(y-t,1)g(t)dt + \int_{B'}^{CV} U(y-t,1)g(t)dt + \int_{CV}^\infty U(y,0)g(t)dt$$

5b. $$E(U(CV)) = \int_0^{CV} U(y-t,1)g(t)dt + \int_{CV}^{B''} U(y,0)g(t)dt + \int_{B''}^\infty U(y,0)g(t)dt.$$

The expected utility of submitting a bid less than CV can be written as:

6. $$E(U(B')) = \int_0^{B'} U(y-t,1)g(t)dt + \int_{B'}^\infty U(y,0)g(t)dt$$

6a. $$E(U(B')) = \int_0^{B'} U(y-t,1)g(t)dt + \int_{B'}^{CV} U(y,0)g(t)dt + \int_{CV}^\infty U(y,0)g(t)dt.$$

The expected utility of submitting a bid which exceeds the true valuation may be written as:

$$7. \quad E(U)(B'')) = \int_{0}^{B''} U(y-t,1)g(t)dt + \int_{B''}^{\infty} U(y,0)g(t)dt$$

$$7a. \quad E((UB'')) = \int_{0}^{CV} U(y-t,1)g(t)dt + \int_{CV}^{B''} U(y-t,1)g(t)dt + \int_{B''}^{\infty} U(y,0)g(t)dt.$$

If it can be shown that E(U(CV)) > E(U(B')) and E(U(CV)) > E(U(B'')), then in a Vickrey auction the bidder's best strategy would be to bid CV. To check the first condition, 5a and 6a are used to write:

$$E(U(CV) - E(U(B') =$$

$$\int_{B'}^{CV} [U(y-t,1)-U(y,0)]g(t)dt.$$

This time, however, we cannot move the utility functions outside of the integral sign because the random variable appears in them. However, it is possible to apply the second mean value theorem of integrals (SMVT) to this integral (Loomis, p. 389). The SMVT says that, for any two functions, r(x) and s(x), there exists a value, d,

$$\int_{a}^{b} r(x)s(x)dx = r(d) \int_{a}^{b} s(x)dx$$

where $a \leqq d \leqq b$, if $s(x) \neq 0$ on [a,b]. The integral above will meet the requirements for application of the SMVT, where the utility difference will play the role of r(x) and the probability density function of the order statistic will play the role of s(x). Thus, by the SMVT, there exists a value, m, such that:

$$E(U(CV)) - E(U(B')) = [U(y-m,1) - U(y,0)] \int_{B'}^{CV} g(t)dt,$$

where $B' \leqq m \leqq CV$. Again, using the fact that U(y,0) = U(y-CV,1) and that indirect utility functions are increasing in income, we may conclude that $E(U(CV)) \geqq E(U(B'))$. A similar argument will demonstrate that $E(U(CV)) \geqq E(U(B'')$. By using equations 5b. and 7a. we may write:

$$E(U(CV)) - E(U(B'')) = [U(y,0) - U(y-m,1)] \int_{CV}^{B''} g(t)dt$$

where CV $\leq$ m $\leq$ B''. Thus, since both terms in the product are positive, E(U(CV)) - E(U(B'')) $\geq$ 0. Therefore, an expected utility maximizer has no incentive to overbid or underbid in a Vickrey auction.

Recall that this discussion arose out of a desire to select between two types of auction procedures for the Sandhill study: first price auctions and second price or Vickrey auctions. First price auctions have the advantage of ease and simplicity of explanation while the second price auction has the advantage that it offers incentives for the individual to reveal his or her full maximum value of a permit. Since both had potential advantages, both were included in designing the willingness-to-pay portion of the Sandhill experiment, as we shall now see.

III. DESIGN OF THE EXPERIMENT

The 1983 Sandhill hunt for deer of either sex was held on November 12. Applications to participate in the hunt had to be postmarked no later than Friday, October 7, 1983. A total of 5,349 applications were received. On Tuesday, October 11, the staff of the Wisconsin Department of Natural Resources held a random drawing to determine the 150 applicants that would be allowed to hunt. Hunting permits were mailed out the next day.

Regulations for the Sandhill hunt are revised annually and entered into the Wisconsin Administrative Code. The 1983 revisions not only authorized the issuance of 150 either-sex permits but also the issuance of four permits to the University of Wisconsin for research purposes. The simulated market involved purchase by the University of four permits from the lowest bidders among a sample of permitees drawn by the state and the sale of four permits to the highest bidders among a sample of hunters that had not been successful during the state lottery. The contingent valuation mechanisms in the study involved separate samples of hunters who participated in hypothetical auctions constructed to run parallel to the simulated market auctions. Five different auction formats were employed.

A. First-Price Auction, Willingness-to-Accept-Compensation

The 150 applicants randomly selected by the state to receive permits were divided into two groups of equal size. The first group participated in an actual first price auction and the four lowest bidders were paid their bids. The second group participated in a hypothetical first-price auction. The initial contacts were mailed on October 13, with a reminder postcard mailed out on October 18. Participants received a letter of explanation and those in the actual auction returned their bids on a contract form. Those in the contingent valuation auction submitted their bids on a contract-like form, which specifically emphasized the hypothetical nature of the auction, but was otherwise quite similar to the contracts used in the actual auction. Subjects in both groups were paid $5 for responding in a timely manner. The closing date was set as noon, Wednesday, November 2. A total of 73 respondents in the real auction and 73 respondents in the hypothetical auction returned completed contracts.

B. First-Price Auction, Willingness-to-Pay

A random sample of 150 applicants who were unsuccessful in the state drawing participated in sealed bid, first price auctions. Half were informed that they were part of an auction for a total of four Sandhill hunting permits and that their sealed bids would be entered into the auction at the amounts they stated. Contracts for this group expressed a commitment to pay the University of Wisconsin the amount of the bid if it was one of the four highest. The other half of this group submitted hypothetical sealed bids on contract-like forms. Materials were mailed on October 13 with a closing date of noon, Wednesday, November 2. A $5 incentive for timely participation was used. Responses from a total of 68 participants in the actual auction and 71 participants in the hypothetical auction were received.

C. Bidding Game 1, Willingness-to-Pay

A random sample of 150 additional unsuccessful applicants participated in a bidding game. The first step of the bidding game was to solicit sealed bids in exactly the fashion described in the preceding section except for two features. First, the contract specified that it would be possible to change the bid later. However, respondents were not informed that telephone bidding or any other mechanism for reconsidering their offer would be instituted. Second, the closing date for this group was earlier than for previously mentioned groups. The date set was noon, October 26. Those responding by that date were paid the $5 incentive. A total of 66 individuals in the actual auction and 70 individuals in the hypothetical auction returned the contract. Telephone interviews were then conducted, beginning on October 19. The interviews were conducted by six graduate students at the University of Wisconsin after training. Calls were begun at 6:00 p.m. each night and continued until approximately 9:00 p.m. Subjects who could not be reached during the evening were contacted during the day and on weekends. A total of 65 individuals in the real auction and 62 individuals in the hypothetical auction were contacted in this manner prior to the final closing date of November 2. The telephone interviewers were provided with scripts to follow when conducting the interviews and attempted to ascertain the subjects' maximum willingness-to-pay using an iterative bidding process. These final bids were entered into the willingness-to-pay auction.

D. Bidding Game 2, Willingness-to-Pay

Another random sample of 150 participants was divided into two equal sized groups to participate in real and hypothetical iterative bidding exercises where starting bids were specified in advance. People in this group were contacted through a mailing on October 12. Here, starting bids were set in advance at randomly selected amounts between $1 and $500. The offers specifically mentioned that participants would be recontacted to obtain their final bids. They responded on contract and contract-like forms by mail to the initial offer. A total of 72 participants in the actual auction and 72 participants in the hypothetical auction responded by the closing date of October 26 and received their $5 payments. The bidding games then proceeded as part of the bidding process described in the preceding section, except that the starting bids were used to begin the process. We succeeded in recontacting 68 members of the actual auction group and 69 members of the hypothetical auction group prior to the November 2 deadline.

E. Fifth-Price Auction, Willingness-to-Pay

The final random sample of 150 unsuccessful applicants was involved in a Vickrey auction. The respondents who were participating in the actual auction were informed that their bids would be entered into the final auction, but that if they were among the four highest bidders they would actually pay the fifth highest bid. The other half, who were participating in a hypothetical auction, were asked to set their bids based on the assumption of a fifth price auction. Since telephone bidding was not conducted with this group, the deadline was set at noon, November 2. Out of the subjects assigned to the actual auction, 69 chose to participate while 70 participated in the hypothetical auction. The usual $5 incentive was paid.

F. Auction Completion and Mail Survey

Final bids for both willingness-to-accept and willingness-to-pay were determined on the afternoon of November 2. Winners were contacted by telephone. While some participants expressed surprise at having won the auction, all the transactions were completed by mail without difficulty. Also, all members of the samples, whether they participated in a real or hypothetical part of the experiment or chose not to participate at all, were surveyed by mail after completion of the experiment. The purpose of the mail survey was to develop statistics on socioeconomic characteristics, attitudes and beliefs, and hunting history. The response rate to the mail survey was 81%.

IV. RESULTS

A. Basic Statistics and Comparison of Mean Bids

Actual cash bids to accept compensation ranged from $25 to $1,000,000. The $1,000,000 bid was interpreted as a response of "not for sale" and deleted from the analysis that follows. The next highest bid was $20,000. Accepted bids were $25, $62, and two bids of $72. Hypothetical bids to accept compensation ranged from $0 to $20,001. Cash bids expressing willingness-to-pay for a permit ranged from $0 to $200, with accepted bids being $200, $177, $152, and $150. Only the $152 bid came from the fifth price auction and this person actually paid $142.

Table 1 shows means and other statistics for the willingness-to-accept-compensation side of the experiment. The mean cash offer of $1,184 was not significantly different from the hypothetical bid of $833. The standard deviation of the bids was quite large.

For willingness-to-pay, our results are given in Table 2. Cash offers averaged between $19 and $25 in the different auction formats and the differences between these means were not significant at the .10 level. Mean

Table 1--Willingness-To-Accept Compensation for Sandhill Deer Hunting Permits

	Mean	Median	Mode	Standard Deviation	N
Cash Offers[a]	1184*	550	1000	2475	70
Hypothetical Offers	833*	102	100	2755	70

[a] $1,000,000 cash bid excluded as an outlier.

* Indicates that mean of cash offers and mean of hypothetical offers not statistically significant at the .05 level.

Table 2--Willingness-To-Pay for Sandhill Deer Hunting Permits

Auction Format	Mean	Median	Mode	Standard Deviation	No. of Observations
Sealed Bids					
Cash	$24	$15	$ 5	$35	68
Hypothetical	$32	$11	$10	$64	71
Bidding Game 1 [a]					
Cash	$19*	$10	$ 5	$23	65
Hypothetical	$43	$21	$ 0	$58	62
Bidding Game 2 [b]					
Cash	$24*	$15	$ 0	$30	68
Hypothetical	$43	$20	$ 0	$69	69
Fifth Price					
Cash	$25*	$20	$10	$30	69
Hypothetical	$42	$21	$10	$70	70

[a] Respondents set initial bids.

[b] Initial bids chosen at random.

* Indicates hypothesis that mean cash bid equaled mean hypothetical bid for these auction formats was rejected at the .10 level of significance.

hypothetical bids varied between $31 and $44 and there were also no significant differences among the auction formats. Comparisons of cash and hypothetical bids within auction formats showed that the hypothetical bids were significantly different at the .10 level in three out of the four cases. In all four cases the mean hypothetical bids were larger.

One anomoly relating to the comparison of means should be mentioned. As has already been said, for Bidding Game 1, respondents sent sealed bids by mail. This was done in a format identical to the First-Price Auction, except that the contracts for Bidding Game 1 mentioned the possibility of changing bids later and required bids to be in one week earlier than the first price bids. This close relationship between the First-Price Auction and initial bids in Bidding Game 1 led us to expect that the means would be equal except for variations due to sampling. However, this hypothesis was rejected for the means of the real auction. The initial bids in the real Bidding Game 1 averaged $14 and the hypothesis of equality with the corresponding mean bid for the First-Price Auction ($24) failed at the .10 level of significance in a one-tailed test. While the hypothesis that comparable means in the hypothetical auction were equal could not be rejected at the .10 level, the initial bid in the hypothetical Bidding Game 1 was only $25 compared to $31 in the hypothetical First-Price Auction. The $25 initial bid was significantly lower than all other final bids. Thus, it too seemed very low.

Three possible explanations exist. First, in the case of the real bidding game, we could have rejected a true hypothesis. There is, after all, a 10 percent chance of that happening. This seemed implausible, given that there is some evidence that the contingent mean is also low. Second, it is possible that people read the contract very carefully, realized that they were expressing starting bids only, and stated low bids as points at which to begin the bidding process. This explanation also appears unlikely. The opportunity to change bids was one line in the "fine print" of the contracts and no mention was made of any formal process of bidding. It seems more likely that most people, including those who read the contract carefully, assumed that their bids were final unless they themselves took action to modify them. The third alternative, and the one we consider most probable, is that the initial bids were affected by having to be in a week earlier than the First-Price Auction bids. On October 26, when the initial bids for Game 1 had to be in, the hunt was still 17 days away, while on November 2, the deadline for sealed-bids in the First-Price Auction, the hunt was only ten days away. We suspect that, as the November 12 hunting date came closer, the potential hunters became more certain of their schedules and were willing to pay more.

While on the topic of bidding, let us turn to what was learned about the effects of bidding games in real and hypothetical auctions.

B. The Effects of Bidding

Next consider the effects of bidding. The format designated as Bidding Game 2 most closely parallels the bidding game employed in traditional contingent valuation studies. Respondents here answered yes or no by mail to a starting bid. Then, bidding by telephone followed using the starting bid at the outset. Table 2 reports the mean final bids, which are amazingly close to those from the other treatments. The telephone bidding process did not produce significantly higher or lower results than the sealed bid auction, the fifth-price auction, or Bidding Game 1. This is true whether the comparison is among the cash offer bids or among the hypothetical auctions.

Random assignment of starting bids in Bidding Game 2 allowed a test for starting-point bias. A relationship of the following form was postulated:

$$B_f = a + bB_s + e$$

where

B_f = final bid

B_s = initial bid

e = regression error term

a,b = regression coefficients

Results from estimating this equation by OLS are given in Table 3. The regression coefficient on starting bid for the contingent auction had a sufficiently high t-statistic to be significantly different from zero at the .01 level. This was taken as positive evidence of starting point bias. In the cash auction, however, the coefficient on starting bid had the opposite sign and was not significant at the .10 level. Thus, starting point bias did not seem to carry over to the cash auction. More discussion of this and other evidence of starting point bias in contingent bidding games may be found in Boyle, Bishop, and Welsh (1984).

Table 3--Starting Point Bias Regression Results for Bidding Game 2 (Final Bid was Dependent Variable)*

	Cash Auction	Contingent Auction
Constant	29.689 (8.045)	8.661 (3.810)
Coefficient on Starting Bid	-0.026 (0.023)	0.152 (0.041)
SSE	8,786,300	1,423
n	68	69

*Standard Errors in Parentheses

To avoid starting point bias, one approach would be to let the respondent, rather than the interviewer, determine the starting bid. That is exactly what we did in Bidding Game 1, with very interesting results. As noted previously, the initial bids averaged $14 and $25 for the cash and hypothetical groups, respectively. Telephone bidding caused 42% of the cash bids to increase. The final bids averaged across the entire subsample increased by $5 to reach the $19 final mean bid reported in Table 2. For the hypothetical sample, the mean final bid was $43, an increase of $18. Of the 62 people we were able to recontact, 52% increased their bids. Comparing the mean increases showed that people tended to increase their bids more in the contingent auction than in the actual cash auction, with the difference being significant at the .01 level. Participants in the contingent Bidding Game 1 tended to be more willing to raise their bids and raised them by larger amounts than participants in the simulated market Bidding Game 1.

V. CONCLUSIONS AND PLANS FOR FUTURE RESEARCH

A. Summary of Sandhill Results

The results of the Sandhill study can be summarized in five major conclusions:

1) The large differences between willingness-to-pay and willingness-to-accept compensation so often observed in contingent valuation studies carry over to transactions involving real money and real recreational opportunities. In our contingent auctions, willingness-to-pay averaged $40 across all auction formats combined, while willingness-to-accept averaged $833. When real money and real permits were involved the difference was slightly larger at $23 versus

$1,184. Large differences between the two welfare measures are not simply a phenomenon of contingent valuation. Thus, our results support conclusions in Knetsch and Sinden (1984) and Knetsch (1984).

2) Willingness-to-pay was significantly higher in the contingent auctions than in the cash markets. We attribute this difference to hypothetical bias. We suspected a tendency to bid higher in the cash auction measure of willingness-to-accept, but the difference was not statistically significant in this data set.

3) Iterative bidding did not seem to make much difference. People in Bidding Game 1 did tend to raise their offer amounts and the tendency was stronger for the hypothetical bids. Those tendencies, however, did not produce changes that were large relative to variations in mean bids due to sampling. Bidding Game 2, which closely parallels traditional bidding games used in contingent valuation studies, produced results nearly identical to the other auction formats, although some starting point bias was observed.

4) The fifth-price auction did not produce the significantly larger bids that theory would lead one to expect. Vickrey auctions seem to be of questionable value in contingent valuation studies.

5) There was no evidence that strategic behavior had a significant effect on our results. If hunters wanted to engage in strategic behavior, they would most likely have understated their values in order to discourage use of their responses as justification for increasing hunting license fees. At least, fears of increased fees are often expressed when we have described our work to hunters. Yet, the Sandhill results showed contingent willingness-to-pay to be higher than cash auction willingness-to-pay. Thus, strategic bias of a significant magnitude appears unlikely.

B. Discussion

The relationships between contingent values and simulated market values in the Sandhill study were opposite to what we expected based on the goose permit study. In the goose study, contingent willingness-to-accept was significantly larger than the corresponding simulated market value. If anything, Sandhill contingent willingness-to-accept was smaller and the difference was statistically insignificant. While we did not have simulated market willingness-to-pay data for goose permits, there was some evidence that contingent willingness-to-pay was biased in a downward direction (See Bishop, Heberlein and Kealy, 1983, p. 630). As we have seen, the Sandhill results clearly pointed to the opposite conclusion. How is this contradiction to be explained?

As our analysis of the Sandhill data continues, and particularly as we estimate bid functions, additional possible explanations may become apparent. At this writing, our best guess is that a larger part of the differences between the goose study and deer study results are attributable to the added uncertainty imposed on participants in the deer study. The goose study respondents made their decisions under relative certainty. If they accepted our fixed, predetermined offer they received the amount of money offered. If they rejected the offer, they maintained their opportunity to hunt.

The problem for our deer hunters was more complicated. The results of bidding in terms of both cash position and hunting opportunities depended on the bid each decided to make <u>and the bids of all other auction participants</u>. The behavior of others, particularly given the absence of any information from past auctions, had to have been very uncertain for our participants. Laboratory experiments, as discussed, for example, in Cummings, Brookshire, and Schulze (1984), indicate that people do not react to uncertainty in ways that are consistent with what utility theory would lead us to expect. Theory would lead us to expect very similar values from simulated markets involving fixed take-it-or- leave-it offers (as in the goose study) and simulated markets involving various bidding frameworks, particularly the fifth price auction. However, people may react to the added uncertainty inherent in bidding against others in ways that lead to very different results. We suspect that people tended to adopt a "heuristic" which led them to behave very conservatively in response to the uncertainty of bidding.

Perhaps the approach to bidding we are hypothesizing for the Sandhill hunters can most easily be explained by asking you, the reader, to place yourself in the position of one of the winners of the state drawing. You have just won your permit in a lottery where your chances were only about 2.5 percent (150 winners out of 6000 applicants). Now you are asked by university researchers to state the minimum amount of money you would accept to give up your permit and the four lowest bidders will actually complete the transaction. If you win the auction you get the money but you also give up the chance to hunt at Sandhill, and whether you win or lose depends not only on your bid, but also the bids of everyone else. Are you going to submit a relatively high or a relatively low bid? Bidding low improves your chances of winning the auction but the amount of compensation you receive will be smaller. Bidding high reduced your chances of winning but if you do win you make more money and if you lose you can still hunt at Sandhill. We suspect that many people in this situation will tend to submit bids that are high relative to their true compensating surpluses.

Follow the same line of reasoning on the willingness-to-pay side. Suppose you were not drawn in the lottery, but received an opportunity to bid for a permit from the university. Bidding a low amount reduces your chances of getting a permit, but if you do win you will get a bargain. Bidding high improves your chances of winning, but increases the amount you will have to pay.

Here, we suspect that you will tend to bid an amount that is low relative to your compensating surplus. Indeed, the logic here only magnifies the logic in the expected utility model presented in Section II. While theory led us to hope that the Fifth-Price Auction would create incentives to counter balance the tendency to bid low, apparently uncertainty dominated.

Of course, this scenario is only speculative at this stage, but it does suggest a direction for future research.

C. Plans for 1984 Sandhill Experiment

In the 1983 Sandhill experiment, we were legally limited to selling only four permits and were thus constrained to auction formats. For 1984, we will be allowed to deal in any number of permits so long as the requisite number of hunters is present to meet biological objectives. Fortunately, the 1984 Sandhill hunt will have a format very similar to the 1983 hunt. To eliminate the uncertainty created by auctions, we are planning to utilize take-it-or-leave-it offers like those in the goose study. Unlike the goose study, however, willingness-to-pay will be measured along with willingness-to-accept. A sample of successful applicants will receive cash offers at predetermined prices that they can either accept or reject. Likewise, a sample of applicants not drawn in the state lottery will receive opportunities to purchase permits from us at predetermined prices. Thus, uncertainty about the behavior of others will no longer be relevant. In addition, separate samples will engage in parallel contingent valuation exercises. We also plan to conduct a standard bidding game with another sample of unsuccessful applicants to get a conventional set of contingent values without any influences from auctions and take it-or-leave-it formats.

Our expectation is that the take-it-or-leave-it formats will tend to produce slightly larger contingent willingness-to-pay values and slightly lower contingent willingness-to-accept values compared to the 1983 auction results. More importantly, we hypothesize that take-it-or-leave-it simulated markets will produce substantially larger willingness-to-pay values for Sandhill permits and substantially lower willingness-to-accept values compared with the auctions. We expect the standard bidding game to yield values much like the 1983 contingent auctions. However, as we found out in 1983, empirical work in this area is full of surprises. A second experiment at Sandhill may well produce additional unexpected results.

D. Closing Remarks

Goose and deer hunting permits are ideal commodities for the study of contingent valuation. The product is well-defined in the minds of consumers. Though hunting opportunities are provided by the public sector, hunting permits do not have public goods characteristics to complicate the analysis. Comparison of simulated and contingent market values is not complicated by possible vehicle or information biases since both use the same vehicle and hunters had the same information regardless of whether they are in the cash or hypothetical markets.

Even under such ideal circumstances, contingent valuation did not perform perfectly. Since strategic bias seems unlikely, hypothetical bias appears to be the culprit. Because payments and changes in consumption possibilities in contingent markets are hypothetical, people are not able to tell us how they would behave in a real market with complete accuracy. This appears to be an inherent flaw in contingent valuation techniques. By definition, contingent valuation involves hypothetical transaction. This problem is not likely to disappear when contingent valuation is applied in less ideal situations. In valuing changes in air and water quality, for example, the commodity itself may be poorly defined in respondents' minds. Such additional artificiality will be likely to exacerbate the problem.

Still, although contingent valuation is somewhat inaccurate, we have been surprised at how well it has performed. In the goose study, the dollar amount of take-it-or-leave-it offers was consistently the most powerful variable in predicting responses, always coming into regression models with the expected sign at high significance levels. Most contingent market respondents understood what was being asked of them and tended to respond as they would in a real market, albeit in an imperfect way. The Sandhill study seems to point to the same conclusion. Hypothetical and cash offer mean values were not statistically different for willingness-to-accept. While contingent willingness-to-pay was significantly higher, the difference is not overwhelming. Deer management decisions in Wisconsin would probably not be greatly different if based on a contingent value of $40 per permit rather than the cash auction mean value of $23.

Thus, while contingent valuation appears to be biased even under the best of circumstances, the degree of bias does not appear to be sufficient to rule out use of the results in public decision-making. In our judgment, contingent valuation is a promising approach to the valuation of nonmarket commodities.

To fully capitalize on this promise will require additional research. Carefully designed and executed field and laboratory experiments involving multidisciplinary teams of social scientists could greatly improve our understanding of which contingent valuation techniques are most accurate, how biases can be minimized, and where contingent valuation works well and where it does not. Such experiments may ultimately permit us to compensate for hypothetical bias by calibrating contingent valuation mechanisms over broad classes of commodities. Given the power of economic considerations in public decision-making and the fact that many of the most valuable environmental and other natural resources are outside the market system, we would argue that a large program of basic research on contingent valuation is long overdue.

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