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Measuring the Value of a Public Good: An Empirical Comparison of Elicitation Procedures

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The practical problems associated with accurately measuring the value of a public good in an applied setting are considered. We compare and contrast the values obtained from hypothetical elicitation procedures with those obtained in a marketplace. When hypothetical measurements are elicited in the field, buying-selling discrepancies similar to those predicted by psychological models of behavior are observed. These discrepancies decrease greatly when a market with appropriate incentives for accurate relevation is used to elicit the value for the public good.

A large body of recent research has been concerned with the psychological phenomenon variously labeled the endowment effect (Richard Thaler, 1980), reluctance to trade (Daniel Kahneman and Amos Tversky, 1984), and the buying-selling price discrepancy (Jack Knetsch and John Sinden, 1984; and Ronald Cummings, Brookshire, and William Schulze, 1986). According to the results of this research, people require far more compensation to give up a public good than they are willing to pay to acquire it. The empirical differences in these two measures are much larger than can be accounted for by any income effects which are derived from a utility-based model. Following received economic theory (Robert Willig, 1976; Alan Randall and John Stoll, 1980; and Akira Takayama, 1982), there should be symmetry in value measurements when the quantity of the public good is increased or is decreased away from a baseline level, especially when the quantities in question are relatively small.

The existence and stability of this psychological phenomenon has been challenged by another body of literature. In a series of studies, researchers have concluded that the initial discrepancy between compensation demanded and willingness to pay is an anomaly, which can properly be eliminated by the forces of learning and incentives which are present in a market (Peter Knez et al., 1985; Coursey et al., 1987). We extend these results by considering in this paper the practical problems associated with accurately measuring the value of a public good in an applied setting. Specifically, we compare and contrast the values obtained from hypothetical elicitation procedures with those obtained in a marketplace. We find that when hypothetical measurements are elicited in the field, buying-selling discrepancies similar to those predicted by psychological models of behavior are observed. These discrepancies decrease greatly when a market with appropriate incentives for accurate revelation is used to elicit the value for the public good.

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I. A Framework for Comparing Public Good Valuation Measurements

Assume that there are $N+1$ goods over which an individual consumer has a preference ordering. The first N of these are represented by a vector $x = (x_i : i \in N)$ while the $N+1$st commodity, the public good, is denoted by a scalar z. We assume that the goods which make up x are traded in markets at strictly positive prices $p = (p_i : i \in N)$ over which the consumer has no influence. The public good z is not traded in a market, but is determined by the level of H attributes, $a = (a_h : h \in H)$. Each of these attributes has a price q_h. These prices depend upon the level of attributes associated with the commodities, and so will implicitly reveal a function $q(a)$ relating prices and attributes in Sherwin Rosen's (1974) sense of hedonic prices.

The consumer's preferences are described by the strictly increasing, quasi-concave, ordinal utility function $U(x, a)$. The budget constraint which the individual faces is $p \cdot x + q(a)z \leq y$, where $y > 0$ is the consumer's exogenous income. In this case, we may write the consumer's indirect utility function as[1]

$$(1)\quad V(p, q(a), y) = \max_{x,a} \{U(x, a) : p \cdot x + q(a)z \leq y\}.$$

Consider the Hicksian income compensation function for two situations where only the level of the public good's attribute is changed from a^0 to a'. The compensation demanded for a decrease ($a' < a^0$) in the public good's attributes is defined by a willingness-to-accept (WTA) function:

$$(2)\quad \mathrm{WTA}(p^0, q(a'); p^0, q(a^0), y^0) = \min_y \{y > 0 : V(p^0, q(a'), y) \geq V(p^0, q(a^0), y^0)\}.$$

Similarly, the willingness to pay for an increase ($a' > a^0$) in the public good's attributes is defined by a willingness-to-pay (WTP) function:[2]

$$(3)\quad \mathrm{WTP}(p^0, q(a'); p^0, q(a^0), y^0) = \max_y \{y > 0 : V(p^0, q(a'), y) \geq V(p^0, q(a^0), y^0)\}.$$

When, however, small decreases in the public good's attributes described in (2) are compared to similar increases in the public good's attributes described in (3) then, as discussed in the introduction, empirical value measurements are found to depend upon the *direction* of the attributes' change.[3]

[1] In this analysis, as well as in the conduct of the empirical work to follow, we are assuming that the attributes are use-related variables as opposed to existence values. The attributes enter the utility function only by making the public good more desirable for consumption. As will become apparent shortly, we will treat these attributes as if they themselves were public goods, following the approach of the other field studies associated with visibility, water quality, and other so-called public goods. Olvar Bergland and Randall (1984) provide an outline of the theoretical restrictions which this assumption about attributes imposes upon preferences.

[2] Bergland and Randall provide a derivation for obtaining the correct calculation of these Hicksian variations from observable data.

[3] In an unpublished paper, Michael Hanemann (undated) has shown that holding income effects constant, greater disparity between WTP and WTA is implied by the availability of fewer substitutes for the public good. Thus if there are private goods which can be readily substituted for z, then there ought to be little difference between an individual's WTP and WTA for a change in z. The assumption of a large degree of substitutability is implicit in our empirical research. As will be seen, the attribute under examination in this study is trees, which have both intra- and interpark substitutes readily available. An individual is assumed to possess a utility function which allows trees to be traded off against other park attributes and against other completely different parks. In the actual collection of individual bids which is described in the next section, it is assumed that the medium which allows these tradeoffs to take place is money or a Hicksian composite commodity. Even if one were to reject the conjecture that money or a Hicksian composite commodity allows these tradeoffs to take place, it is doubtful Hanemann's argument could justify the extremely large differences between willingness to pay and willingness to accept that we observe in our field studies.

Economic speculation about the nature of this asymmetry has centered upon the strategic biases associated with different elicitation procedures. The conventional wisdom emphasizes that the provision of a public good is nonoptimal when individual values are solicited outside of a market or "market-like" context. If respondents treat a public good evaluation procedure as a nonmarket process, a logical strategy is to exaggerate their actual values. In a willingness-to-pay environment, they will tend to respond with value measures which understate their actual demand for the public good. Likewise, in a willingness-to-accept environment, they will tend to overstate the compensation required to reduce the level of a public good's provision. Without the addition of a market-like elicitation procedure that induces truthful revelation of value, the gap and associated asymmetry between willingness-to-pay and willingness-to-accept measures is not expected to disappear.

Psychologists attribute the asymmetry in value measurements to another problem. Their central argument hinges upon the conjecture that an individual may not exhibit a coherent set of preferences. Specifically, the prospect theory of behavior includes an analysis of value that compares different levels of a good's provision to a neutral frame of reference point. This reference point is usually taken to be the current level of provision of the good. The most important implication of this model is that decreases in the quantity of the good away from this reference point are valued at a marginally higher rate than corresponding increases in the quantity of the good above the reference point. This phenomenon of losses looming larger than gains is usually referred to as "loss aversion." The main implication of loss aversion is that when equal increases and decreases in quantity are valued, one should not expect to observe symmetry between willingness-to-pay and willingness-to-accept measures.

Although the explanations of asymmetry differ across the two professions, two common features prevail. First, both argue that it is impossible to separate the measured value of the public good from the elicitation procedure by which that value is obtained. More specifically, the economist may argue that any biases in measured value over different elicitation techniques are a direct reflection of the strategic incentives associated with these techniques. The psychologist may place more argumentative emphasis upon the notation that biases arise from variations in the framework through which values are elicited.

The second common feature relates to the joint professional belief that the value asymmetry will disappear in a market-like environment. A market-like environment will accomplish the role of providing both incentives to accurately state demand and learning opportunities to the individual. The first important attribute of the market-like environment is the incentive property; specifically, the design of a public good allocation process which provides the greatest possible incentive for truthful revelation of value. Once truthful values are obtained, any sources of bias which lead to the asymmetry should then disappear. Additionally, the market-like environment is important because recurrent and reversible transactions can take place in a market. The importance of these transactions lies in the fact that attitudes toward losses may change as the individual becomes familiar with the experience of obtaining a public good and then giving it up. After a period of time, what is given up will be perceived as an opportunity cost, rather than a loss. The loss-aversion phenomenon can then be expected to become a less predominant factor in the valuation measurement process.[4]

Whichever explanation is invoked to explain asymmetry, it is apparent there will be differences when attribute levels are either decreased or increased. The important em-

[4]See Kahneman's comments in Cummings et al. for background on the dynamics of how individuals exhibit less loss aversion through the trading process. Psychologists also argue that other factors such as bidding low or requesting large compensation in situations where preferences are unknown may help explain the loss-aversion phenomenon. These sources of the disparity are also predicted to disappear as individuals "learn" their values in the marketplace.

pirical issue is whether this asymmetry will disappear based upon arguments that provide for correct incentives and repeated learning experiences.

Hypothesis 1: *Will a hypothetical, nonmarket elicitation process for valuing a public good in an applied field setting yield symmetric baseline valuation measurements*?

This hypothesis is tested through the use of a survey which directly elicits values in the field. Survey or contingent valuation methods are distinguished from other forms of public good valuation methods by their use of a questionnaire to acquire information. Central to this approach is the construction of a hypothetical allocation and valuation procedure for the good. The procedure is conducted as follows. First, the public good under study is described to the individual. Second, the hypothetical situation involving either a decrease or increase in the quantity of the public good is posited to the individual. Finally, each individual responds with a compensation-demanded or willingness-to-pay value.

Hypothesis 2: *Does the addition of the primary demand-revealing properties of an incentive-compatible public good allocation mechanism in the field result in elimination of the asymmetry between valuation measurements*?

In a series of papers Vernon Smith (1977; 1979a, b; 1980), John Ferejohn, Robert Forsythe, and Roger Noll (1979a, b), Ferejohn, et al. (1982), and Martin Loeb (1977) have considered the problem of designing a market-like auction process to elicit the value of a public good. This process involves designing a process based upon a Theodore Groves-John Ledyard (1977) mechanism for providing a public good.

In experimental examinations of such a public good auction mechanism (for example, Smith, 1979a, b; 1980, and Coursey-Smith, 1984) using induced values (see Smith, 1976, 1982), Lindahl optimal quantities of a public good were provided by groups with up to nine members. These studies, and other studies conducted in the field by Peter Bohm (1972), Ferejohn and Noll (1976), and Bruce Scherr and Emerson Babb (1975), suggest that it is possible to elicit truthful, or at least more accurate, values for a public good using the auction mechanism.

Hypothesis 3: *Are the additions of repetition and actual monetary consequences in a controlled interactive laboratory setting required to eliminate the asymmetry in valuation measurements*?

An important additional conclusion to be drawn from the public good allocation studies mentioned above is that individuals require a period of time and interaction to "learn" that their optimal strategy is demand revelation. A public good auction process is necessary for demand revelation, but not always sufficient unless combined with a period of time over which experience and learning can occur. In testing Hypothesis 3, we allow for iterated interactions to take place in a controlled laboratory environment using a market-like mechanism. This is accomplished through the use of an equilibration process in which individuals can acquire a quantity of the public good z using an allocation process which determines a market-like value of $q(a)$. Additionally, as will be explained in the next section, individuals were made to realize actual (as opposed to hypothetical) monetary consequences of their actions.

II. Data Collection Methodology

A. *The Public Good*

To operationalize the hedonic compensation-demanded and willingness-to-pay measures described by (2) and (3), we concentrated our value elicitation techniques upon one attribute of a neighborhood park in Fort Collins, Colorado. To capture the public good nature associated with one attribute, we focused our attention upon alternative densities of trees in Troutman Park, a new, undeveloped recreation area in the city.

In the development of 25 parks in the past, Fort Collins has planted an average of

10 trees per acre. Applying this average to the 20-acre Troutman Park, 200 trees were assigned as a frame of reference point from which to establish alternative attribute increments for the compensation demanded and willingness-to-pay value measurements. The City Parks and Recreation Department was consulted to establish what would be discernible yet small levels of alternative tree densities upon which to base our value comparisons. Through a process of pretesting, it was established that increases and decreases over two increments, ± 25 and ± 50 trees, were visually and aesthetically distinguishable when an artistic representation of the park was utilized. This range of tree densities represents the historical range of densities found within the other 25 parks in the Fort Collins area.

A portfolio developed by a professional artist provided visual representations of different tree densities in the park from three vantage points.[5] These vantage points illustrated how the trees would look in the park from three alternative views. The complete portfolio consisted of a 3×3 matrix of illustrations. Each column of the portfolio presented a different perspective of the park. Column A presented a perspective of the park from the northeast corner looking toward the mountains. Column B provided a bird's-eye view of the park indicating the overall density of trees. Finally, column C illustrated a perspective of the park from the southwest corner looking toward town. The rows of the portfolio presented the alternative density levels of the trees with each tree depicted at approximately 75 percent maturity. Separate portfolios were utilized for the willingness-to-pay and willingness-to-accept questions where, for each case, the frame of reference level of trees was 200. For the willingness-to-pay questions, the density levels by row were 200 trees (row 1), 225 trees (row 2), and 250 trees (row 3). For the willingness-to-accept questions, the increments represented by the rows were 200 trees (row 3), 175 trees (row 2), and 150 trees (row 1).

[5]A representation of the portfolio, the survey instruments, and the experimental instructions are available upon request from the authors.

B. *Sample Plan*

Three independently conducted elicitation procedures were used to collect valuation measurements. A hypothetical contingent valuation methodology (CVM) was administered door-to-door. A Smith auction process, which is based upon Smith's (1980) decentralized mechanism for allocating public goods, provided the framework for the second hypothetical elicitation technique used in the field (SAF). Last, laboratory versions of the Smith auction (SAL) process were conducted in a local high school. For all three elicitation techniques, the presentation of the alternative tree levels used the portfolios and was identical in verbal and graphical content. In all three cases, additional information pertaining to uses of parks, preferences over park attributes, and socioeconomic data were also collected.

A one-square-mile area around Troutman Park, bordered by four major streets, defined the sample area for the CVM, SAF, and SAL valuation exercises. This square-mile area contains 667 houses. To insure that each elicitation technique would have observations in all regions of the sample area, the one-square-mile area was further divided into three sectors of equal distance from Troutman Park. Linear distance to the park, street distance to the park, and view of the park were used as guidelines so that each sector had approximately the same numbers of houses. The houses in each sector were numbered and then assigned randomly to one of three elicitation procedures. Two interview teams were used to complete the surveys. Within each sector and over each elicitation procedure, these teams were assigned in a random fashion separate from the initial household randomization.

C. *The Data Collection Methods*

1. *Contingent Valuation Methodology* (CVM). The procedures for obtaining CVM valuation measures followed traditional techniques as outlined by Cummings et al. and

Icek Ajzen and Martin Fishbein (1977). After the alternative tree density levels were explained using the visual portfolios, it was proposed that the city would pay (collect) a one-time payment to (from) households to change the base plan of 200 trees. A list of possible dollar value payments was used by the household to determine their willingness-to-accept (willingness-to-pay) response. The specific question asked was: "*What minimum dollar amount would your household be willing to accept to decrease the base plan to 175 trees under this one-time payment*?" The question was then repeated for a decrease from 200 to 150 trees. The willingness-to-pay question was: "*What maximum dollar amount would your household be willing to contribute to a fund to increase the base plan from 200 to 225 trees under this one-time payment*?" The question was then repeated for an increase from 200 to 250 trees. If in any case the response was zero, the individual was asked why.

2. *The Field Smith Auction Process* (SAF). The second field study combined elements of Smith's public good auction process with traditional CVM techniques. Although an auction was not conducted, the context of the questions asked reflected the important elements of this process. The CVM procedure outlined previously does not ask the individual to consider the valuation question in the context of what other individuals are bidding. Additionally, the CVM procedure does not present information to the household pertaining to the cost of the alternative tree density levels. Both of these elements are included by necessity in a Smith auction procedure.

The structure of the willingness-to-pay Smith auction procedure used in the field was as follows. The household was asked to assume that they were participating in the valuation process with the other households in the community. It was stated that offers from each of the 667 households in the immediate Troutman Park neighborhood were being collected to pay for the two alternative expansions to 225 and 250 trees.

The interview team explained that there were three possible outcomes depending on the sum of the payments from the households. First, if the sum of the payments was less than the cost of the additional trees, the base plan would not be expanded and the household would pay nothing. Second, if the sum of the payments equaled the cost of the additional trees, the base plan would be expanded and the household would pay exactly the amount it had offered. Third, if the sum of the payments was greater than the cost of the additional trees, the base plan would also be expanded. However, the household would not have to pay the full amount it offered. The offers in this case would be proportionally scaled back so that their sum exactly equaled the cost of the trees. Numerical examples of all three cases were provided to the respondent.

After stating the total cost of expanding the base plan from 200 to 225 trees, the household was asked: "*What maximum dollar amount would your household be willing to contribute to a fund to implement this expansion*?" The total cost for an expansion from 200 to 250 trees was then provided to the respondent and the willingness-to-pay question was asked again over the new increment. If the household was unwilling to contribute on either situation, they were asked why.

The willingness-to-accept question asked in the SAF surveys was a mirror image of the above. Each household was told that it could receive reimbursement from the group fund of fixed size in order to compensate for a reduction from the base level of 200 trees to 175 and 150 trees. Again, three outcomes were possible. First, if the sum of the requests was greater than the amount of the fund, the base plan would be followed and no reimbursement would be paid. Second, if the sum of the requests equaled the fund, the base plan would be reduced and the household would be reimbursed by exactly the amount requested. Third, if the sum of the requests was less than the fund, the base plan would be reduced but the household would receive more compensation than requested. The requests would be proportionally increased so that their sum exactly equaled the fund. Examples of the three possible outcomes were provided to the

households, and care again was taken to insure a complete understanding of the process.

After stating the total fund that would be available if the base plan was reduced from 200 to 175 trees, the household was asked: "*What minimum dollar amount would your household be willing to request from the group fund to implement this reduction*?" Then the total fund for a reduction of the base plan to 150 trees was provided to the respondent and the minimum compensation question was repeated.

3. *Laboratory Smith Auctions* (SAL). While the SAF procedure is designed to capture the incentive elements of a Smith auction process, it falls short in its ability to allow for the more complete revelation of responses that can occur in a repetitive market-like environment. Additionally, the SAF procedure is still rooted in hypothetical transactions, for which respondents never realize actual monetary consequences.

Fundamentally, the process of collecting payments for the group fund or requesting compensation from the group fund used in the SAF procedures was the same as that used in the laboratory. The groups consisted of individuals who participated in experimental sessions at the local high school. The fund consisted of money that was actually collected or distributed from or to the group. The amount of money in the fund was determined by using actual per household costs of either increasing or decreasing the tree density levels. As with the SAF procedures, these fund levels were known to the participants.

However, instead of eliciting payments or compensation only once from the participants, five possible trials (iterations) of the Smith auction process were possible. During each of these trials, individuals privately submitted willingness-to-pay or willingness-to-accept bids. These bids were then summed by the experimental monitor and this sum was reported to the group. As in the SAF procedures, three cases were possible: the bids exceeded, were equal to, or were less than the group fund level in question. If the group covered the cost of an expansion of trees after the second trial in the willingness-to-pay experiments, then that experiment concluded. In this case, the individuals would actually have to pay their (possibly adjusted) stated bids. This money was then contributed to Fort Collins' Recreation Department. If the group requested an amount of money less than or equal to the funds freed by a reduction of trees in the willingness-to-accept experiments, then that experiment ended. In this case, the individuals would actually be compensated their (possibly adjusted) bids from a fund of cash that otherwise would have been contributed to Fort Collins' Parks and Recreation Department.[6] In the other cases when the group either did not cover the cost of an expansion or requested more compensation than available for a reduction, another trial was conducted. Individuals then had the opportunity to change their bids.

If the group did not contribute an appropriate amount to or request an appropriate amount from the fund by the fifth trial, then the experiment ended automatically. When the willingness-to-pay experiments ended this way, no contribution for trees was made; when the willingness-to-accept experiments ended this way, no compensation was provided to the participants. It is this repetitive feature, combined with the fact that individuals only pay their adjusted bids, not necessarily what they bid, which makes the Smith auction perform as well as it does.[7,8]

[6]A sum of $1,500 was ultimately contributed to Fort Collins' Parks and Recreation Department for use in purchasing trees for Troutman Park.

[7]As noted by Ferejohn et al., the Smith auction process may not be expected to eliminate all underbidding in the willingness-to-pay experiments or all over requesting in the willingness-to-accept experiments. However, empirical evidence from induced valuation experiments conducted by a variety of researchers has indicated that the Smith auction can be expected to yield at least 80 percent efficient outcomes in most cases. When the same individuals in these experiments use similar induced valuation designs which do not utilize the Smith auction, efficiency measures of performance are found to drop significantly.

TABLE 1—SUMMARY STATISTICS: WILLINGNESS-TO-PAY AND WILLINGNESS-TO-ACCEPT BIDS

	Field Surveys							
	CVM-WTP		CVM-WTA		SAF-WTP		SAF-WTA	
	25[a]	50[b]	25[c]	50[d]	25[a]	50[b]	25[c]	50[d]
$\bar{x}$[e]	14.00	19.40	855.50	1734.40	14.40	15.40	807.20	1735.00
Median	9.60	9.30	199.80	399.30	11.80	13.80	30.30	100.40
σ	18.40	28.20	1893.20	3775.80	12.40	15.30	2308.00	4391.10
Number of Observations	48	48	45	45	47	47	47	47

	Laboratory Experiments							
	Initial Bids SAL-WTP		Final Bids SAL-WTP		Initial Bids SAL-WTA		Final Bids SAL-WTA	
	25[a]	50[b]	25[a]	50[b]	25[c]	50[d]	25[c]	50[d]
$\bar{x}$[e]	7.31	8.33	7.31	12.92	28.63	67.27	17.68	95.52
Median	9.33	2.50	5.09	7.50	15.00	20.00	7.25	18.66
σ	6.39	10.08	6.52	14.38	26.48	132.02	23.85	272.08
Number of Observations	17	12	17	12	12	13	12	13

[a]WTP of respondent for an increase in the base plan from 200 to 225 trees.
[b]WTP of respondent for an increase in the base plan from 200 to 250 trees.
[c]WTA compensation of the respondent for a decrease in the base plan from 200 to 175 trees.
[d]WTA compensation of the respondent for a decrease in the base plan from 200 to 150 trees.
[e]All bids are denoted in dollars.

Fifteen dollars was provided to all experimental participants to insure their arrival at the high school. In the willingness-to-pay experiments, individuals were provided an additional endowment of funds. Fifteen dollars was provided in the 25-tree increment experiments and $30 was provided in the 50-tree increment experiments. No individuals declined to participate in the experiments, but they could have kept their total endowments if they had declined.[9]

III. Comparisons of Results

Table 1 presents summary data for the three elicitation techniques.[10] Our data suggest that compensation demanded for a tree reduction is significantly larger than willingness to pay for a similar-sized expan-

[8]A technical addition was added to the design which allowed the participants to learn about the auction process itself, as opposed to learning about incentives. The first two trials were nonbinding in the sense that even if the group contributed or requested a plausible amount of money from the fund, the experiment would not end. This has been shown by Coursey-Smith and Coursey et al. to accelerate the learning process. See additionally Jeffrey Banks, Charles Plott, and David Porter (1986) for a discussion of various operational versions of the Smith auction process.

[9]The endowments provided in the willingness-to-pay experiments may invoke a small income effect. However, if the endowments provided are similar to the compensation which individuals receive in the willingness-to-accept experiments, it can be shown that the income effects in both sets of experiments will be nearly equal in magnitude (see Coursey, 1987). Additionally, the endowments might be expected to provide "anchors" and cause participants to simply give back the money they were provided to the experimenter. As will be seen in the next section, there is little evidence to support this anchoring conjecture.

[10]In the field surveys, 26 percent of the individuals surveyed using the CVM instrument indicated a zero bid because they *favored* the baseline level of 200 trees, while 11 percent bid zero because they felt that taxes should cover any incremental change of trees. For the SAF surveys, 27 percent of the individuals bid zero because they favored the original plan, while 6 percent felt that taxes should support any change in tree increments. Overall, the CVM, SAF, and SAL initial field contacts for participation, yielded a 98 percent positive response rate. No individual in the laboratory declined to participate in the Smith auction. Included in Table 2 is a report of zero bids obtained in the laboratory experiments. All of the data collected over the three elicitation techniques were used in subsequent analysis.

TABLE 2—LABORATORY EXPERIMENTS: SUMMARY STATISTICS

	Experiment	n	Initial Endowment	Group Fund	Summary Statistics	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Willingness-to-Pay Experiments	1	12	30	111.96	Mean Bid	9.58	8.41	9.17	9.52[a]	–
					Median Bid	10.00	9.00	10.00	10.00	–
					Sum of Bids	115.00	100.90	110.00	114.25	–
					No. Zero Bids	2	2	2	1	–
25 Tree Increment	2	5	30	46.65	Mean Bid	1.87	1.87	3.00	3.40	4.00
					Median Bid	0.00	0.00	0.00	0.00	0.00
					Sum of Bids	9.33	9.33	15.00	17.00	20.00
					No. Zero Bids	4	4	4	3	3
50 Tree Increment	1	9	45	168.12	Mean Bid	6.11	11.67	10.22	11.67	12.78
					Median Bid	0.00	15.00	15.00	15.00	5.00
					Sum of Bids	55.00	105.00	92.00	105.00	115.00
					No. Zero Bids	5	4	4	4	4
	2	3	45	55.98	Mean Bid	15.00	15.00	13.33	13.33	13.33
					Median Bid	15.00	15.00	10.00	10.00	10.00
					Sum of Bids	45.00	45.00	40.00	40.00	40.00
					No. Zero Bids	1	1	1	1	1
Willingness-to-Accept Experiments	1	8	15	74.64	Mean Bid	25.45	25.33	20.12	13.87	13.14
					Median Bid	10.00	9.67	7.67	5.50	5.00
					Sum of Bids	203.61	202.61	160.97	110.97	105.14
					No. Zero Bids	0	1	0	1	1
25 Tree Increment	2	4	15	37.32	Mean Bid	35.00	20.00	23.75	25.00	26.75
					Median Bid	37.50	15.00	22.50	25.00	25.00
					Sum of Bids	140.00	80.00	95.00	100.00	107.00
					No. Zero Bids	0	1	0	0	0
50 Tree Decrement	1	5	15	93.50	Mean Bid	33.89	33.12	32.14	22.73	18.15[b]
					Median Bid	18.75	18.60	18.60	18.66	18.60
					Sum of Bids	169.45	165.60	160.70	113.66	90.76
					No. Zero Bids	0	0	0	0	0
	2	8	15	148.28	Mean Bid	88.13	145.75	179.38	148.38	143.88
					Median Bid	32.50	26.50	27.50	25.00	25.00
					Sum of Bids	705.00	1166.00	1435.00	1187.00	1151.00
					No. Zero Bids	0	0	0	0	0

[a]Sum of Bids exceeded group fund, experiment concluded in Trial 4.
[b]Sum of compensation requested was less than group fund, experiment concluded.

sion in the number of trees when values are estimated in a CVM environment. There is approximately a seventy-fivefold difference between compensation-demanded and willingness-to-pay values. This finding is consistent with the loss-aversion phenomenon described by Kahneman and Tversky. We therefore fail to accept our first hypothesis that a nonmarket-like elicitation environment will yield symmetric valuation measurements.

The addition of the market-like demand revealing properties to the hypothetical survey environment, as captured in the SAF design, also yields values consistent with loss-aversion phenomenon. Indeed, the SAF results obtained in the field are consistent with the more traditional survey responses obtained using the CVM technique. This conclusion is supported both by the summary statistics comparing CVM and SAF, and in a frequency comparison of CVM and SAF results. Apparently, using only a limited addition of the demand-revealing properties is insufficient to accept our second hypothesis that value measurements will be symmetric around the baseline level of trees.

Laboratory results are less favorable to the contention that loss aversion is prevalent in the valuation measures. Using the final trial values obtained in the experiments, the ratio between compensation demanded and

willingness-to-pay measures of value drops to approximately five to one. This ratio is significantly smaller than the seventy-five-to-one ratio obtained using the field instruments. The ratio of five-to-one in valuation measurements does not reflect perfect statistical symmetry between compensation demanded and willingness to pay, but does suggest that the value of trees is more consistent with smoothly declining marginal utility.

The dynamics of the bidding observed during the repetitive laboratory auctions strongly indicate a decrease in the amount of money requested for compensation. As indicated in Table 2, mean bids for compensation begin in trial 1 at the same level as observed in the SAF surveys. However, these requests for compensation decline as the number of trials in the experiment increases. The willingness-to-pay values increase during each trial of the experiments, but not to the same magnitude that we observe the willingness-to-accept values declining.

Typical individual behavior in the laboratory experiments may be described as follows. In a willingness-to-pay experiment, some individuals consistently contribute nothing to the expansion. Most individuals in such an experiment exhibit a tendency to increase the amount of their contribution for the tree expansion program. A few other participants contribute a constant amount to the expansion. Likewise, a typical willingness-to-accept experiment indicates that a majority of individuals dramatically reduce their requests for compensation over the course of the experiment. It is important to note also that none of the obvious anchor points in the willingness-to-pay experiments were consistently used as a bid by the individuals. Possible anchors in the valuation process such as the $15 the individuals received for participating in the experiment or the $30 including the endowment which they had during the experiment, were not a focal point in bidding behavior. Also, as was typical in these experiments, some individuals bid more than their total endowment.

To evaluate the effects of economic and social variables upon bidding behavior over the three elicitation procedures, ordinary least squares estimation was conducted. The results of this estimation are reported in Table 3.[11,12] Three independent variables in these regressions are relevant for considering the three hypotheses outlined in Section I. The coefficient on tree-increment quantity reported for the two regressions provides a measure of the value functions slope in the CVM elicitation environment. Both of these measures are positive as expected, but the slope in the willingness-to-accept domain, 34.5, dominates the slope in the willingness-to-pay domain, 0.27. The coefficient on tree-increment quantity multiplied by the dummy variable *SAF*, with *SAF* being one if the bid was obtained using the *SAF* elicitation technique and zero otherwise, indicates the marginal change in slope of the valuation function using the *SAF* survey instrument. Changes in slope in the willingness-to-pay and willingness-to-accept domains are both

[11] Our criterion for including variables in both of these regressions was that the *t*-value of the coefficient on an independent variable had to be at least 1.00 in absolute value in one of the WTP and WTA regressions. Variables not reported in Table 3 which did not satisfy this requirement were education of the primary household wage earner and distance from the park (either in terms of the respondent's estimate of how long it would take to travel to the park, straight-line distance measured on a map, or minimum street distance to the park measured on a map). We also tested whether interview team bias had any effect upon the data collected. Using a dummy variable to control for the interview teams we found no significant interviewer effects. Finally, the willingness-to-pay regression was also estimated with the subset of the data which eliminated bids which indicated that taxes should pay for the proposed plan. This elimination had no significant statistical effects upon the estimates.

[12] WTP bids were positive and were regressed against positive tree increments. WTA bids were expressed as negative quantities and were regressed against negative tree increments. This allows us to compare the coefficients of the tree-increment variables directly. It is important to remember that bids are expressed in negative amounts for the willingness-to-accept regression when comparing other variables. For example, the positive coefficient on income in the willingness-to-pay experiments indicates that trees are a normal good. The negative coefficient on income in the willingness-to-accept regression indicates that as income increases, more compensation will be required to remove trees. This also is consistent with an interpretation of trees as a normal good.

TABLE 3—MODELS FOR WILLINGNESS-TO-PAY AND WILLINGNESS-TO-ACCEPT BIDS

	Dependent Variable			
	WTP Bids		WTA Bids	
Independent Variable	Coefficient	Elasticity	Coefficient	Elasticity
View 0 = Total View, 1 = Partial View, 2 = No View	−0.59 (−0.35)	−0.0645	−333 (−1.15)	0.512
Household Population	1.20 (1.17)	0.263	263 (1.83)	−0.811
Race 0 = White, 1 = Nonwhite	4.99 (2.47)	0.0365	132 (0.29)	−0.00994
Monthly Household Income after Taxes	0.0029 (2.76)	0.407	−0.26 (−1.55)	0.549
Tree-Increment Quantity	0.27 (3.20)	0.695	34.5 (2.31)	1.27
Tree-Increment Quantity × SAF	−0.096 (−1.52)	−0.0951	−1.26 (−0.12)	−0.0186
Tree-Increment Quantity × SAL	−0.16 (−2.14)	−0.0922	−31.3 (−2.40)	−0.248
Any Members of Household Attending School near Troutman Park	−4.65 (−1.86)	−0.157	480 (1.19)	−0.225
Sample Size	248		234	
F-statistic	29.6		5.95	

Note: The *t*-statistics are reported in parentheses, elasticities computed at means of all variables.

insignificant. The coefficient on tree-increment quantity multiplied by the dummy variable *SAL*, with *SAL* being one if the bid was obtained using the *SAL* elicitation technique and zero otherwise, indicates the marginal change in slope of the valuation function using the repetitive laboratory procedure. In both domains, the shift in slope is significant. Most important, the willingness-to-accept slope, when measured in the *SAL* elicitation environment, falls significantly. Thus, the overwhelming support for value asymmetry obtained in testing our first two hypotheses is not substantiated in a test of our Hypothesis 3.[13,14]

IV. Conclusions

Our consideration of the frame of reference effects associated with measuring the value of a public good has focused upon a comparison of hypothetical nonmarket and actual market-like elicitation techniques. Our econometric comparisons indicate that values obtained from responses to survey questionnaires or from single iteration Smith

[13] When examining Table 1 and relative frequency plots of WTP and WTA bids, it appeared that outliers and the potential for skewed residual distributions might have been important in affecting the results reported in Table 3. Edward Leamer (1984) has proposed a method of testing for the influence of outlying observations which leads to a *t*-test to gauge whether the estimates derived from ordinary least squares would be affected by downweighting outlying observations. When this method was applied to our data, no evidence was found to support the conjecture that outliers were the primary driving force behind the results reported in Table 3. The actual regression results are available upon request of the authors.

[14] Contrary to our expectations, the slope of willingness-to-pay decreases, rather than increases, in the context of the SAL market-like setting. This is consistent with the results obtained when a public good was allocated using a Smith auction process in our paper with William Schulze (1987). At the present time we have no explanation for this phenomenon. Speculation concerning the nature of this result has centered upon the role of altruism in affecting the willingness-to-pay bids. The conjecture most commonly pronounced is that the market-like mechanism may induce a smaller degree of altruism than hypothetical measures of value.

auction processes do result in loss-aversion inconsistencies. These inconsistencies appear to be especially pronounced in the willingness-to-accept domain of public good preferences.

However, the most important conclusion to be drawn from our research is that the magnitude of the loss-aversion phenomenon is sensitive to the degree in which values are measured in a market or nonmarket environment. When the market-like elicitation process is repeated even a small number of times, values for the public good are more consistent with traditional economic notions of diminishing marginal utility. Although individuals may initially exaggerate their preferences for the public good, they modify their stated values as a function of the incentives, feedback, interactions, and other experiences associated with the repetitive auction environment. We cannot reject the hypothesis that these individuals exhibit loss-aversion behavior. However, the marketplace appears to be a strong disciplinarian in terms of limiting this type of behavior.

Prospect theory models of value provide guidance for measuring the way in which individuals' preferences become incoherent in hypothetical settings. Depending upon the form of the question asked, hypothetical survey data may provide accurate or inaccurate measures of value. Our study provides evidence which suggests that hypothetical willingness-to-pay values may be both more accurate and more stable than hypothetical willingness-to-accept values. We interpret this evidence as providing a constructive response to those who would reject all contingent valuation methods, data, and implications for policy analysis in an out-of-hand fashion.

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