Experimental Economics and the Environment: Eliciting Values for Controversial Goods

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We illustrate the experimental method by examining bidding behavior for controversial goods, i.e., goods in which bidders have positive and negative values. Our results suggest that bidding behavior differs across auction type. Bidders with positive induced values bid sincerely in a WTP auction. Bidders bid conservatively, however, in the WTA auction, foregoing profitable opportunities. Informing bidders of their optimal strategy serves to attenuate bidding discrepancies but does not eliminate them. Treating the WTP and WTA auctions as equivalent given positive and negative values could lead one to overstate the costs relative to the benefits of the controversial good.

Key Words: experiments, willingness to pay, willingness to accept, positive and negative induced values

In 1992, the Northeastern Agricultural and Resource Economics Association (NAREA) invited Jason Shogren to make a case for experimental methods and for why more researchers might consider using the approach to study questions in environmental and natural resource economics (see Shogren 1993). At the time, a few resource economists used experimental methods to examine the behavioral underpinnings of environmental policy. The few experiments that existed focused primarily on stated preference valuation work; they were designed to try to understand how people stated values given alternative preference elicitation devices (see Cummings, Brookshire, and Schulze 1986). Shogren's experience was likewise limited. But in graduate school in Wyoming in the mid-1980s Shogren witnessed Professors Bill Schulze, David Brookshire, Don Coursey, and Betsy Hoffman use experimental economics as a legitimate tool. Charlie Plott also visited Wyoming several times. He convinced Shogren completely why the method was valid and why it mattered—experiments could crack open ideas too tangled with institutional rules for theory alone. Finally, a year studying with Peter Bohm in Stockholm taught Shogren an appreciation of the nuances between control and context. These scholars did not seem to consider themselves "experimental economists" per se, but rather as economists interested in experiments. Energized by their commitment and spurred by their encouragement, Shogren came to prefer the experimental method and mindset as a method of analysis.

Seventeen years later, in 2009, NAREA again extended an invitation to Shogren, this time to revisit how the experimental method contributes to environmental and resource economics. What a difference a few decades makes. While doubts persist, today most environmental and resource economists have judged that experiments can be a valid and useful tool. They either run experiments

themselves, support graduate and undergraduate courses in experimental methods, encourage grant funding based on experimental treatments, or at a minimum do not discourage young researchers from entering into the lab and field. Many enticing themes have emerged over the last decade—behavioral economics challenging the dominion of rational choice theory, academic debates over laboratory versus field versus virtual versus neuroeconomic experiments, and a movement toward serious test-bedding of environmental and agricultural policy. For recent work using experiments to explore environmental and natural resource economics, see, for instance, the two dozen chapters and discussion in Cherry, Kroll, and Shogren (2008).

One key ingredient has remained constant over the past two decades—the experimental mindset. The experimental mindset is the passion to observe real people making economic choices within alternative institutions invented or replicated by the researcher. The mindset is what matters most, not where it is applied—i.e., the lab versus field ultimately is a red herring. Researchers design the allocation and cost rules of the exchange institution, the game theoretic structure, or the isolated decision. They strive to control the environment to the degree they can in order to test theory, recognize patterns, and design mechanisms. Since no "people vacuum" exists, balancing control versus context will always be a struggle and a constant inspiration for newcomers.

Herein we provide one example of our recent work on using experimental economics to explore the behavior underpinnings of environmental policy. We focus on experimental auctions to elicit values for controversial goods—i.e., goods in which a population can have both positive and negative values—e.g., wolf reintroduction or genetically modified foods. We consider within-sample comparisons of bidding behavior in Vickrey willingness to accept (WTA) and willingness to pay (WTP) auctions given that both positive and negative induced values exist. In both auction settings, a negative induced value represents a diminution in welfare (or a cost), and a positive induced value represents a welfare improvement (or a benefit). Within-sample comparisons between the WTA and WTP auctions suggest that demand-revealing bidding occurs in the WTP auction when people have positive values. But for negative values in the WTP auction and for all values in the WTA auction, bidding behavior is widely dispersed and inconsistent with demand revelation. These results hold whether subjects are uninformed or informed of the optimal bidding strategy, although bidding behavior does move closer to predicted bidding behavior for informed subjects relative to uninformed subjects.

Background

Experimental auctions have become a popular method to elicit individuals' private values for changes in private and public goods (see Lusk and Shogren 2007). Auctions typically elicit either willingness to pay (WTP) or willingness to accept (WTA) measures of value, depending on the property rights of the good. If people hold property rights, we use a WTA auction; otherwise, we use a WTA auction. The common approach for assigning property rights in experimental auctions is to endow people with an inferior good and ask them their WTP to trade up to a superior good, or to endow them with the superior good and then ask their WTA to trade down.[1] The assignment of the goods as superior or inferior is done *a priori* and ordered according to the social norm.[2]

But for controversial goods like irradiation, genetic modification, wolf reintroduction, and water quality improvements, values will differ—some positive, others negative.[3] Both positive and negative values could arise in either auction, WTP or WTA. The open question is: Does bidding behavior in a Vickrey-style WTA auction parallel bidding behavior in a Vickrey-style WTP auction when bidders have both positive and negative induced values?

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[1] Corrigan and Rousu (2006) have shown that endowing people with a good may create an obligation within the subjects that causes them to overbid their true values in an effort to repay the experimenter. In our experiment subjects are endowed with an induced value, which has no intrinsic value unless they win the auction and which avoids creating the reciprocity value posited by Corrigan and Rousu (2006).

[2] For example, because irradiated chicken reduces the risk of illness-causing food-borne pathogens, a sandwich made using irradiated chicken is thought to be an improvement over the identical sandwich made using non-irradiated chicken, and, as such, a WTP auction is employed (see Fox, Hayes, and Shogren 2002).

[3] Parkhurst, Shogren, and Dickinson (2004), for example, examined the influence of negative values on bidding behavior in WTP Vickrey auctions. They observe in a 2nd-price WTP auction that bids were biased upwards for both positive and negative values; in a random nth-price auction, bids were sincere on average, but strategic bidding was observed.

One might think that within a Vickrey incentive-compatible auction the answer is "yes." Separating what a person says from what he pays makes telling the truth the weakly dominant strategy (Vickrey 1961), regardless of the type of auction—WTA or WTP. Lab experiments provide evidence indicating that demand revelation for a WTA mechanism is similar to a WTP mechanism when subjects are given positive induced values in the WTP auction and positive induced costs in the WTA auction (Kahneman, Knetsch, and Thaler 1990, Irwin et al. 1998, Noussair, Robin, and Ruffieux 2004). We test whether these findings are robust in an incentive-compatible demand-revealing auction in which both positive and negative values exist.

Experimental Design

We use positive and negative induced values to examine bidding behavior in a Vickrey-style auction. We use a uniform 4th-price auction to engage more bidders.[4] Because we have both positive and negative induced values in each auction, we maintain consistency in the design such that the monitor buys back the good in both auctions—i.e., an induced value equal to $4.00 would pay a winning bidder $4.00 in either auction.[5] We use an AB (BA) design, in which subjects bid first in 10 WTP auction rounds and then 10 WTA auction rounds, or vice versa. The AB design allows for within-sample comparisons, while controlling for learning effects. Two AB sessions and two BA sessions are conducted for each of two treatments—(i) subjects uninformed of the optimal strategy, and (ii) subjects informed of the optimal strategy—for a total of 8 sessions. Each session had 10 subjects (80 subjects in total), with each subject participating in 20 rounds. Subjects

were recruited following standard procedures from undergraduate economics courses.

The experiment design for the WTA auction followed a nine-step process:[6]

Step 1. Each bidder received a value sheet that had his private resale value for the round. The bidder's resale value is the price the monitor would pay to the bidder if he or she won the auction. We replicate and combine two sets, A and B, of private values used in Parkhurst, Shogren, and Dickinson (2004), which gives us 8 different negative values and 10 different positive values. Two induced values, $1.30 and $2.90, were replicated, with each bidder having each of the two values—once in the WTP auction, and once in the WTA auction.[7]

In the WTA auction, a negative value is illustrative of the marginal cost of production, and a positive value indicates that the person could relinquish the good and still receive positive private benefit.[8] Induced values were randomly assigned in each round with no two bidders having the same induced value within a round. Each bidder had a personal and private record sheet to maintain, which created a history of past induced values, bids, profits, and the market-clearing compensation for previous rounds.

Step 2. The rules of the auction mechanism were introduced to the bidders. For the uniform 4th-price WTA auction, subjects were told that the three people with the lowest bids would each acquire one unit of the good and be paid the market compensation equal to the fourth-lowest bid. Subjects were told they could bid any value—positive or negative—they chose. Each bidder then submitted a private bid to acquire one unit of the good. In the informed treatment, sub-

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[4] Tradeoffs in engaging bidders exist across kth-price uniform auctions (see Knetsch, Tang, and Thaler 2001, and Shogren et al. 2001). Knetsch, Tang, and Thaler (2001) show that WTA increases and WTP decreases when 10 bidders are engaged in a 9th-price auction relative to a 2nd-price auction. A possible explanation for this divergence could be the ability of people to tacitly collude as the number of winners becomes large relative to the number of participants. The results from our 4th-price WTP auction parallel those observed in the literature for 2nd-price auctions (see Parkhurst, Shogren, and Dickinson 2004, Kagel 1995).

[5] For a cleaner comparison between auction mechanisms, subjects were presented with induced values in both auction mechanisms in which the induced value specifies the individual's resale value in both cases.

[6] Experimental instructions are available from the authors upon request.

[7] Set A: [-4.7, -3.9, -2.8, -1.5, -1.0, 0.2, 1.3, 2.6, 2.9, 3.9]. Set B: [-4.8, -4.4, -1.3, 0.8, 1.3, 1.4, 2.9, 3.1, 3.2, 4.4]. Using the same set of values across rounds creates a focal point on market compensation (price) that provides on-margin, off-margin information to subjects. Subjects on-margin then bid sincerely, while subjects off-margin bid insincerely. But we would expect strategic behavior to be consistent across auction types. This paper examines whether the two auction mechanisms are truly consistent.

[8] Examples of people relinquishing a good and receiving a positive private benefit are abundant. These include habitat preservation where the individual has a private conservation value that exceeds the developed value of the land, or restoration of wetlands where the value of hunting leases may exceed the foregone value of production.

jects were informed of their dominant strategy and were provided illustrative examples.

Step 3. The monitor ranked the bids from lowest to highest.

Step 4. The fourth-lowest bid set the market-clearing compensation.

Step 5. The monitor posted the market-clearing compensation as public information.

Step 6. The three lowest bidders each acquired one unit of the good at the market compensation.

Step 7. The three lowest bidders then sold the unit back to the monitor at his or her assigned resale value for that auction. The bidder's profits equaled the sum of his or her resale value and the market compensation for that round: *profits = resale value + market compensation*. Subjects were informed that they could have negative profits, and profit calculations were verified.

Step 8. All bidders at or above the market compensation did not acquire the good and recorded profits equal to zero.

Step 9. The round ended and the bidders returned to Step 1.

In the WTP auction, the steps were identical except the process was inverted. Now, bids were ranked from highest to lowest, with the fourth highest bid determining the market-clearing price and the three highest bidders each buying one unit of the good. The profit function also changed, and now profits were equal to the difference between the individual's private induced value and the market-clearing price.

Optimal Strategies

In the WTP auction, the optimal strategy is for a bidder to bid his induced value: $Bid^*_{WTP} = induced\ value$. A bidder who bids in excess of his induced value risks earning negative profits; negative profits are realized if the market price falls between his bid and his induced value. A bidder who underbids foregoes profitable opportunities.

In the WTA auction, the optimal strategy is for a subject to bid (-1) times his induced value:

$Bid^*_{WTA} = (-1) \times induced\ value$. Recall that a negative value is a welfare diminution (or a cost), so bidding the optimal strategy in the WTA auction implies that to incur the reduction in welfare associated with his negative induced value, the subject must be compensated a positive amount of equal absolute magnitude. The consequences of underbidding and overbidding in the WTA auction are opposite those of the WTP auction. In the WTA auction, overbidding risks foregoing profitable opportunities; whereas in underbidding his optimal WTA strategy, the subject risks earning negative profits.

For simplicity, define *bidding aggressively* as bidding that results in the subjects risking negative profits (overbidding in the WTP and underbidding in the WTA). Alternatively, define *bidding conservatively* as when bidders risk foregoing profitable opportunities (underbidding in the WTP and overbidding in the WTA).

Results and Discussion

We present the results in three phases: (i) benchmark WTP bidding, (ii) WTA bidding relative to auction theory, (iii) bidding across the WTA and WTP auctions, and (iv) bidding behavior when bidders know the optimal strategy relative to uninformed bidders in the WTA and WTP auctions.

Phase 1: Benchmark behavior in the WTP auction. First, consider bidding behavior in the WTP auction. Table 1 presents the descriptive statistics. The median and modes are almost always at the predicted values. We test three hypotheses:

HYPOTHESIS H1A. Bidding behavior is demand-revealing over positive induced values in the WTP auction.

HYPOTHESIS H1B. Bidding behavior is demand-revealing over negative induced values in the WTP auction.

HYPOTHESIS H1C. In the WTP auction, subjects' bidding behavior does not differ when the subjects' induced value is negative relative to positive.

We test these hypotheses by estimating equation (1):

$$(1) \quad Bid_{it} = \alpha_i + \phi IN_{it} + \beta_1 NEG_{it} + \beta_2(NEG_{it} \times IN_{it}) + u_i + \varphi_t + \varepsilon_{it},$$

Table 1. Summary Statistics on Bidding Behavior—WTP Auction

Induced Value	Mean	Med.	σ	Mode	Dev.[*]
4.4	4.68	4.39	2.30	4.39	0.28
	4.56	4.40	1.75	4.40	0.16
3.9	3.99	3.84	1.23	3.00	0.09
	3.92	3.90	0.64	3.90	0.02
3.2	3.92	3.19	1.90	3.19	0.72
	3.60	3.20	1.14	3.20	0.40
3.1	3.72	3.09	2.17	3.10	0.62
	3.08	3.10	0.70	3.10	-0.02
2.9[††]	3.05	2.89	1.89	2.90	0.15
	2.86	2.90	0.67	2.90	-0.05
2.6	3.47	2.57	2.38	2.00	0.87
	2.70	2.60	0.52	2.60	0.10
1.4	1.98	1.39	2.06	1.40	0.58
	1.52	1.40	0.55	1.40	0.12
1.3[††]	1.72	1.29	1.44	1.30	0.42
	1.49	1.30	1.16	1.30	0.19
0.8	0.97	0.79	1.06	0.80	0.17
	0.68	0.80	0.25	0.80	-0.12
0.2	0.50	0.15	1.58	0.15	0.30
	0.18	0.20	0.41	0.20	-0.02
-1.0	-0.96	-1.00	1.37	-1.00	0.04
	-0.38	-1.00	1.19	-1.00	0.62
-1.3	-0.37	-1.00	1.22	-1.30	0.93
	-1.63	-1.30	2.07	-1.30	-0.34
-1.5	-0.38	-1.50	2.28	-1.55	1.12
	-1.19	-1.50	0.87	-1.50	0.32
-2.8	-2.06	-2.81	1.87	-3.00	0.74
	-1.85	-2.80	2.32	-2.80	0.95
-3.9	-2.55	-3.91	2.54	-4.00	1.35
	-2.65	-3.90	2.78	-3.90	1.26
-4.4	-1.35	-4.38	5.24	-4.40	3.05
	-3.46	-4.40	2.94	-4.40	0.94
-4.7	-3.24	-4.70	3.03	-4.70	1.46
	-2.90	-4.70	3.25	-4.70	1.80
-4.8	-1.53	-2.00	3.69	-5.00	3.27
	-4.18	-4.80	2.01	-4.80	0.62

Note: Uninformed descriptive statistics are on the top, informed are on the bottom.
[*] Mean deviation from optimal bid equals bid minus induced value.
[††] Sample size was 40 for these induced values, 20 otherwise.

where Bid_{it} denotes subject i's bid in trial t; IN_{it} denotes subject i's induced value in trial t; u_i represents subject-specific characteristics; φ_t represents trial-specific effects, including learning or other trends in bidding behavior; and ε_{it} is the iid error. NEG_{it} is a dummy variable, which equals one when bidder i has a negative value in round t, and equals zero otherwise. NEG_{it} allows the intercept term to adjust for bids on negative values. $NEG_{it} \times IN_{it}$ is an interaction term that allows the slope of the regression line to vary between positive and negative values. We test bidder behavior as follows: In equation (1), H1A implies that if $\alpha = 0$, and $\phi = 1$, then the bidder's

behavior is demand-revealing over positive values. For H1B, if $\alpha + \beta_1 = 0$, and $\phi + \beta_2 = 1$, then bidding behavior is demand-revealing over negative induced values. For H1C, if $\beta_1 = \beta_2 = 0$, then aggregate bidding behavior does not differ across positive and negative induced values.

The estimated equation, assuming two-way random effects,[9] is

$$Bid_{it} = 0.38 + 0.99 IN_{it} - 0.32 NEG_{it}$$
$$\quad\quad (0.35)\quad (0.09)\quad\quad (0.42)$$

$$- 0.48 \, (NEG_{it} \times IN_{it}).$$
$$\quad (0.14)$$

Standard errors are in parentheses. For positive induced values, the intercept is 0.38, but not statistically different from zero, and the slope of the bid line is 0.99. Using a Wald test, we fail to reject the joint hypothesis of H1A; people bid sincerely in the aggregate for positive induced values (p-value = 0.42). Turning to negative induced values, we observe that the intercept is close to expectation, $\alpha + \beta_1 = 0.06$, but that the slope is flatter than unitary, $\phi + \beta_2 = 0.51$. Testing the joint hypothesis of H1B, we reject the null of sincere bidding for negative induced values at the 1 percent significance level (p-value = 0.002). Lastly, we reject H1C at the 1 percent significance level (p-value = 0.001)—bidding behavior differed between positive and negative values. In summary, people bid differently for negative values relative to positive values, with peoples' bids being demand-revealing for positive induced values; but people bid their negative induced values aggressively.[10]

Phase 2: Behavior in the WTA auction. Table 2 summarizes the central tendencies and standard deviations of observed bidding behavior in the WTA auction by induced value. For the WTA auction, we test three hypotheses:

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[9] A Hausman test supports the use of two-way random effects over two-way fixed effects (p-value = 0.50).

[10] As a benchmark, bidding behavior here in the uniform 4th-price auction resembles the bidding behavior of the 2nd-price auction in Parkhurst, Shogren, and Dickinson (2004):

$$Bid_{it} = -0.25 + 1.14 IN_{it} - 0.08 NEG_{it} - 0.31 \, (NEG_{it} \times IN_{it}),$$
$$\quad\quad (0.41)\quad (0.10)\quad\quad (0.41)\quad\quad\quad (0.14)$$

where subjects overbid both positive and negative induced values.

HYPOTHESIS H2A. Bidding behavior is demand-revealing over positive induced values in the WTA auction.

HYPOTHESIS H2B. Bidding behavior is demand-revealing over negative induced values in the WTA auction.

HYPOTHESIS H2C. Subjects' bidding behavior does not differ when their induced value is negative relative to positive in the WTA auction.

Recall that in the WTA auction, a bidder's optimal strategy is to bid -1 times his induced value. If a subject bids conservatively—overbids his optimal strategy (e.g., bids $-1.00 when his induced value is $2.00)—he foregoes opportunities to make positive profits if the market compensation falls between his bid and his optimal strategy. If he bids aggressively—underbids his optimal strategy (e.g., bids $-3.00 when his induced value is $2.00)—he runs the risk of negative profits if the market compensation falls between his bid and his optimal strategy. Failing to reject H2A (or H2B) implies that a person's bid was $[(-1) \times in$-*duced value*] for positive (negative) induced values. We test H2A, H2B, and H2C by estimating equation (1) for the bids of uninformed subjects in the WTA auction.

We test bidder behavior as follows: from the estimated regression equation, H2A implies that if $\alpha = 0$, and $\phi = -1$, then the bidder's behavior is demand-revealing over positive values. For H2B, if $\alpha + \beta_1 = 0$, and $\phi + \beta_2 = -1$, then the bidder's behavior is demand-revealing over negative induced values. Finally, for H2C, if $\beta_1 = \beta_2 = 0$, then a bidder's behavior in the WTA auction does not differ across positive and negative induced values.

Assuming two-way random effects,[11] the estimated equation is

$$Bid_{it} = -0.06 + 0.03 IN_{it} + 0.84 NEG_{it}$$
$$\quad\quad (0.41)\quad (0.13)\quad\quad (0.57),$$

$$- 0.37 (NEG_{it} \times IN_{it}),$$
$$\quad (0.18)$$

where standard errors are in parentheses. For positive induced values, we observe that the intercept term is not statistically different from zero

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[11] The random effects model is supported by the Hausman test, p-value = 0.27.

Table 2. Summary Statistics on Bidding Behavior—WTA Auction

Induced Value	Mean	Med.	σ	Mode	Dev.*
4.4	-0.68	0.01	3.75	-4.40	3.72
	-3.22	-4.40	2.85	-4.40	1.18
3.9	0.35	0.35	2.39	-3.90	4.25
	-2.88	-3.90	2.57	-3.90	1.03
3.2	-0.49	0.07	3.04	0.01	2.71
	-2.57	-3.20	1.24	-3.20	0.63
3.1	0.45	0.33	2.54	-3.10	3.55
	-2.19	-3.10	2.08	-3.10	0.91
2.9 [††]	0.04	0.02	2.15	-2.90	2.94
	-1.77	-2.90	2.55	-2.90	1.13
2.6	0.58	0.30	1.66	2.60	3.18
	-1.81	-2.60	1.94	-2.60	0.79
1.4	-0.58	-0.05	1.65	-1.40	0.82
	-1.14	-1.40	0.91	-1.40	0.26
1.3 [††]	0.21	0.02	2.09	-1.30	1.51
	-1.28	-1.30	1.73	-1.30	0.02
0.8	-0.23	0.00	0.98	0.20	0.57
	-0.77	-0.80	0.39	-0.80	0.03
0.2	0.05	0.09	1.04	1.00	0.25
	-0.42	-0.20	1.11	-0.20	-0.22
-1.0	1.20	1.00	2.28	1.00	0.20
	0.59	1.00	1.00	1.00	-0.42
-1.3	1.32	1.30	1.13	1.30	0.02
	0.99	1.30	0.95	1.30	-0.31
-1.5	1.23	1.00	2.56	1.50	-0.27
	0.91	1.50	1.56	1.50	-0.59
-2.8	1.70	1.75	2.60	2.80	-1.10
	2.27	2.80	2.23	2.80	-0.54
-3.9	2.34	1.50	4.05	1.00	-1.56
	3.42	3.90	3.27	3.90	-0.48
-4.4	1.40	3.70	4.37	4.40	-3.00
	3.96	4.40	1.89	4.40	-0.44
-4.7	2.07	3.00	3.91	4.70	-2.63
	3.21	4.70	3.86	4.70	-1.49
-4.8	3.66	4.81	3.18	5.00	-1.14
	2.68	4.80	3.72	4.80	-2.12

Note: Uninformed descriptive statistics are on the top, informed are on the bottom.
* Mean deviation from optimal bid equals bid plus induced value.
[††] Sample size was 40 for these induced values, 20 otherwise.

(p-value = 0.27), nor is the slope (0.03) statistically different from zero (p-value = 0.80). We reject the joint hypothesis (H2A) of zero intercept and slope equal to -1 for positive induced values at the 1 percent significance level (p-value < 0.001). Bidding behavior over positive induced

values deviates from the dominant strategy—subjects appear to be bidding conservatively by truncating their bids at zero.

Turning now to negative induced values, from the regression results we see an intercept of 0.78 ($= \alpha + \beta_1$) and slope of -0.34 ($= \phi + \beta_2$). The WTA bid line for negative induced values shows that individuals bid their negative induced values aggressively (underbid their optimal strategies). The tendency to bid negative induced values aggressively may be a result of off-margin bidders moving towards the market compensation in an attempt to become engaged in the auction. We reject H2B at the 1 percent significance level—bidding behavior over negative induced values in the WTA auction is not demand-revealing. Turning now to H2C, we compare bidding behavior across positive and negative values in the WTA auction. Using a Wald test statistic to test the joint hypothesis that $\beta_1 = \beta_2 = 0$, we reject the joint hypothesis at the 2 percent significance level. Bidding behavior is statistically different when subjects possess negative as opposed to positive induced values in the WTA auction.

Examining the regression results from the uninformed WTA sample, we see that bids were more consistent with the theoretical prediction for negative values relative to positive values. This is surprising given that bidders with negative values were theoretically projected to submit the highest bids[12]—off-margin. Bidders with positive values should have submitted the lowest bids, and should have been the winners and market-clearing compensation setters. Past research has shown that on-margin bidders match up with theoretical predictions in incentive-compatible Vickrey-style auctions, whereas off-margin bidders tend to bid aggressively (see Shogren et al. 2001). Here, however, we observe on-margin WTA bidders bidding conservatively (overbidding), while off-margin bidders bid aggressively as expected (underbidding).[13]

Phase 3: WTA vs. WTP auction. Now consider whether bidding behavior differed in the WTP and WTA auctions. Table 3 presents the mean bids and deviations from optimal bidding strategies by auction type grouped by positive and negative induced values. Recall that the optimal strategies indicate that mean bids should be the same magnitude but with opposite signs. We focus on the deviations from optimal strategies to help illustrate bidding behavior.

Table 3 shows that, in the aggregate, people overbid their induced values by $0.92 in the WTA auctions and by $0.84 in the WTP auctions. Assuming unequal variances and using a two-sample t-test, we fail to reject the null hypothesis that aggregate deviations from optimal bids were the same in the two auction mechanisms. Restricting observations to negative induced values (mean deviation $-1.19 in the WTA auction and $1.50 in the WTP auction), we reject the null hypothesis at the 1 percent significance level. Likewise, for deviations from optimal strategies for positive values (mean deviation $2.33 in the WTA auction and $0.40 in the WTP auction), we reject the null hypothesis at the 1 percent significance level.

These results suggest that "deviations" in bidding behavior (while on average the same) differ for positive and negative values. For positive values, people overbid in both the WTA and WTP auctions; overbidding was about 6 times greater in the WTA auction (see Table 4).[14] Recall that overbidding positive values has different implications depending on the auction type. In the WTP auction, overbidding positive values runs the risk of negative profits (people bid aggressively, perhaps in an attempt to increase their likelihood of winning the auction), whereas overbidding positive values in the WTA auction results in foregone profitable opportunities (people bid conservatively, reducing their likelihood of winning the auction). For negative values, a different bidding pattern emerges—people underbid in the WTA auction, while they overbid in the WTP auction (see Table 4). However, the ultimate risk to negative-value bidders is similar in both auction types. Underbidding in the WTA auction exposes the bidder to negative profits; likewise, overbidding in the WTP auction also exposes him to negative profits (in both auctions subjects bid aggressively

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[12] The optimal strategy was to bid $(-1) \times$ *induced value*. Those with negative values were expected to bid the positive value equal to the negative induced value. If they followed this strategy, they would have expressed the highest value bids and been off-margin.

[13] In the WTA auction, lowest bids win, implying that the lower an individual's bid, the more likely is the individual to be engaged in the auction. As such, underbidding off-margin bids in the WTA auction is consistent with off-margin bidders overbidding in the WTP auctions.

[14] Deviations from optimal strategies are significantly different at the 5 percent level for 16 of 18 induced values.

Table 3. Positive and Negative Induced Value Deviations (bid minus optimal strategy)

		WTA Auction	WTP Auction	Two Sample t-test Unequal Variance Dev (WTP) = Dev (WTA)
Positive induced values N = 240	Mean	-0.004 (2.24)	2.73 (2.19)	t = -12.34
	Mean – Bid*	2.33 (2.55)	0.40 (1.80)	p < 0.001
	|Mean – Bid*|	2.57 (2.32)	0.88 (1.62)	
Negative induced values N = 160	Mean	1.86 (3.19)	-1.55 (3.01)	t = 11.94
	Mean – Bid*	-1.19 (3.33)	1.50 (3.05)	p < 0.001
	|Mean – Bid*|	2.12 (2.78)	1.85 (2.84)	
Aggregate N = 400	Mean	0.74 (2.82)	1.02 (3.30)	t = -0.42
	Mean – Bid*	0.92 (3.35)	0.84 (2.44)	p = 0.68
	|Mean – Bid*|	2.39 (2.52)	1.27 (2.24)	

Notes: Bid* indicates the optimal bid. Each cell gives mean on the top line with S.D. in parentheses, mean deviations from optimal strategies on the middle line with S.D. in parentheses, and then the mean absolute deviations from optimal strategies on the bottom line with S.D. in parentheses. A t-test comparing positive WTP deviations from negative WTA deviations yields t = 8.42, p < 0.001. Negative WTP deviations from positive WTA deviations yields t = -4.18, p < 0.001.

over negative values—taking on the risk of negative profits in an effort to become engaged in the auction). Seemingly, our average bidder was willing to take that risk.

We confirm these observations with conditional analysis. To allow for comparisons across auction types, we transform the bid-induced value data by using the profit function from each of the auction mechanisms. Let δ represent the value function; using the profit functions from the two auctions, we make the following transformation:[15]

$$(2) \qquad \delta = \begin{cases} \text{Induced Value } - \text{ Bid, WTP} \\ \text{Induced Value } - \text{ Bid, WTA} \end{cases},$$

such that if a person bids optimally, then δ = 0.

We test the hypothesis that bidding behavior is identical across auction type and positive and negative induced values by estimating

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[15] To guarantee comparability across auctions, we transform the bid-induced value data by using the profit function from each of the auction mechanisms. The profit function transformation sets a floor on possible earnings of the winner. For the winner, the price (compensation) can be at most (least) one cent less (more) than his bid. As the divergence between price (compensation) and bid increases, potential earnings are also increasing. Our normalization of the data leads to a sharp interpretation. If the value function is negative, regardless of auction type the person has a range of market prices (or compensations) that yield him negative profits. If the value function is positive, regardless of auction type a range of market prices (or compensations) exists in which he foregoes the opportunity to earn positive profits.

$$(3) \qquad \delta_{it} = \alpha + \phi IN_{it} + \beta_1 D_{it} + \beta_2 D_{it} \times IN_{it}$$
$$+ \beta_3 \times Neg_{it} + \beta_4 \times D_{it} \times Neg_{it}$$
$$+ \beta_5 \times Neg_{it} \times IN_{it} + \beta_6 \times Neg_{it}$$
$$\times D_{it} \times IN_{it} + u_i + \varphi_t + \varepsilon_{it},$$

where Bid_{it}, IN_{it}, Neg_{it}, $Neg_{it} \times IN_{it}$, u_i, φ_t, and ε_{it} are the same as in equation (1). D_{it} is a dummy variable: if individual i participated in the WTA auction in round t, $D_{it} = 1$; otherwise, 0. The variables $D_{it} \times Neg_{it}$, $D_{it} \times IN_{it}$, and $Neg_{it} \times D_{it} \times IN_{it}$ are interaction terms and allow slope and intercept changes across auction and bidder type (positive and negative). Based on theory, we expect all slope and intercept coefficients to be statistically zero (see Figure 1). The GLS estimated equation with two-way random effects is

$$\delta_{it} = \underset{(0.36)}{-0.43} + \underset{(0.12)}{0.02} \times IN_{it} + \underset{(0.43)}{0.46} \times D_{it} + \underset{(0.16)}{0.97}$$
$$\times D_{it} \times IN_{it} + \underset{(0.51)}{0.59} \times Neg_{it} + \underset{(0.71)}{0.18} \times D_{it}$$
$$\times Neg_{it} + \underset{(0.16)}{0.53} \times Neg_{it} \times IN_{it} - \underset{(0.23)}{0.87}$$
$$\times Neg_{it} \times D_{it} \times IN_{it},$$

where standard errors are in parentheses.

Table 5 presents the Wald statistics for the hypotheses tests. From the test statistics, only bid-

Table 4. Summary Statistics on Bidding Behavior (uninformed)

Induced Value	WTA Mean	WTA Dev.*	WTP Mean	WTP Dev.*	Two Sample[††] t-test	Mann-Whitney Test[†]
4.4	-0.68 (3.75)	3.72	4.68 (2.30)	0.28	t = -3.50 p < 0.001	p < 0.001
3.9	0.35 (2.39)	4.25	3.99 (1.23)	0.09	t = -6.89 p < 0.001	p < 0.001
3.2	-0.49 (3.04)	2.71	3.92 (1.90)	0.72	t = -2.47 p = 0.02	p < 0.001
3.1	0.45 (2.54)	3.55	3.72 (2.17)	0.62	t = -3.92 p < 0.001	p < 0.001
2.9[††]	0.04 (2.15)	2.94	3.05 (1.89)	0.15	t = -6.17 p < 0.001	p < 0.001**
2.6	0.58 (1.66)	3.18	3.47 (2.38)	0.87	t = -3.58 p < 0.001	p < 0.001
1.4	-0.58 (1.65)	0.82	1.98 (2.06)	0.58	t = -0.40 p = 0.70	p = 0.05
1.3[††]	0.21 (2.09)	1.51	1.72 (1.44)	0.42	t = -2.73 p = 0.01	p < 0.001**
0.8	-0.23 (0.98)	0.57	0.97 (1.06)	0.17	t = -1.24 p = 0.22	p = 0.01
0.2	0.05 (1.04)	0.25	0.50 (1.58)	0.30	t = 0.13 p = 0.89	p = 0.01
-1.0	1.20 (2.28)	0.20	-0.96 (1.37)	0.04	t = -0.27 p = 0.80	p = 0.60
-1.3	1.32 (1.13)	0.02	-0.37 (1.22)	0.93	t = 2.45 p = 0.02	p = 0.06
-1.5	1.23 (2.49)	-0.27	-0.38 (2.28)	1.12	t = 1.84 p = 0.08	p = 0.33
-2.8	1.70 (2.56)	-1.10	-2.06 (1.87)	0.74	t = 2.57 p = 0.01	p = 0.05
-3.9	2.34 (4.05)	-1.56	-2.55 (2.54)	1.35	t = 2.72 p = 0.01	p = 0.01
-4.4	1.40 (4.37)	-3.00	-1.35 (5.24)	3.05	t = 3.96 p < 0.001	p = 0.01
-4.7	2.07 (3.91)	-2.63	-3.24 (3.03)	1.46	t = 3.71 p < 0.001	p = 0.01
-4.8	3.66 (3.18)	-1.14	-1.53 (3.69)	3.27	t = -4.05 p < 0.001	p = 0.05

* Deviations are measured as the mean difference of the bids from the optimal bidding strategy
** Each subject faced each induced value once in each auction. We pair the observations by subject and perform a Wilcoxen match paired signs rank test.
[†] We assume unequal variances and test deviations from optimal strategies.
[††] Sample size was 40 for these induced values, 20 otherwise.

ding behavior for the positive-value WTP auction statistically conforms to theory—we cannot reject the null hypothesis of zero intercept and zero slope. But for the negative-value WTP auction and both the positive- and negative-value WTA auction, we reject the null hypothesis at the 1 percent significance level. These conditional results confirm the unconditional observations. In the
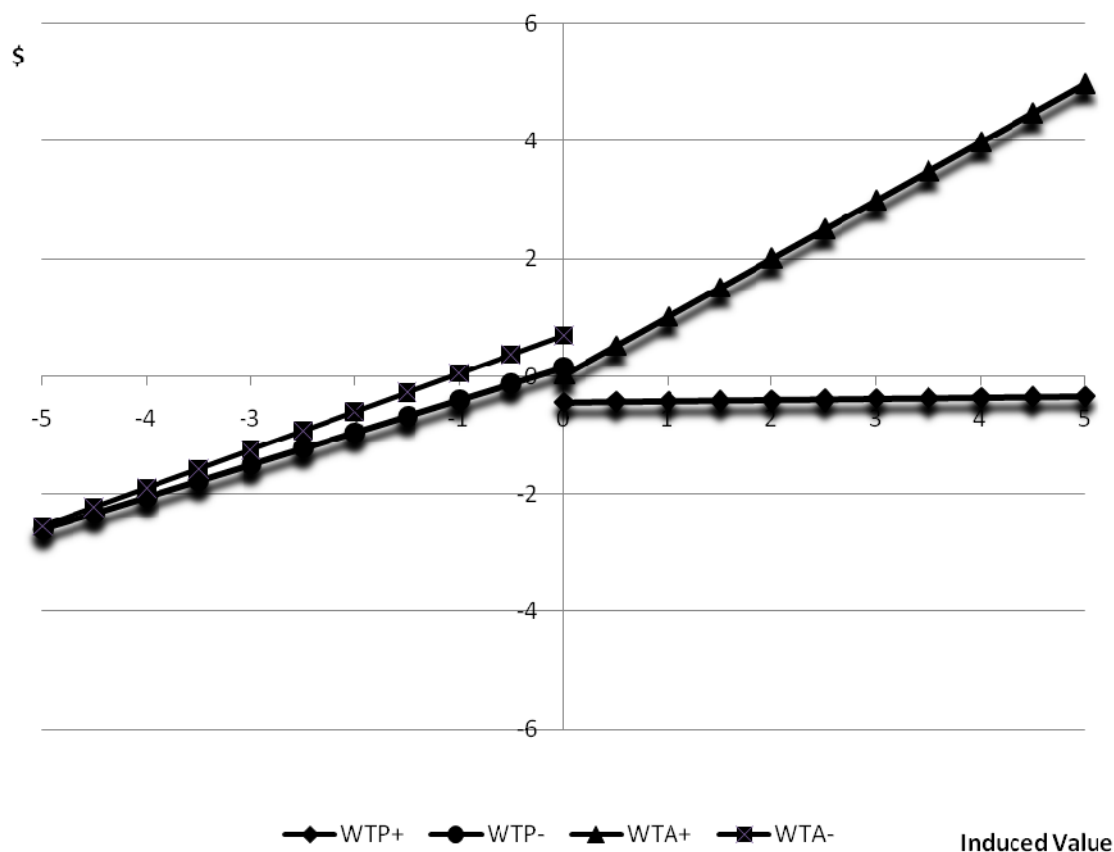
Figure 1. Forecasted Expected Profit Floor—Uninformed

Note: Expected profits: WTP is IV minus bid, WTA is IV plus bid.

WTP auction, aggressive bidding occurred for negative value, whereas positive value bids were nearly demand-revealing. In the WTA auction, behavior depended on the sign of the induced value. For negative values, bidding behavior is similar to the WTP behavior—bidders bid aggressively, risking negative profits ($W = 2.04$, p-value = 0.64). But for positive values, bidding behavior differed from anything observed previously. Now people bid conservatively, apparently running from the possibility of negative profits—i.e., the expected profit floor was statistically different at the 1 percent level.[16]

Two competing explanations can be put forth to help explain this pattern of bidding in the WTA auction, and its deviation from the WTP bidding. First, people could be bidding strategically, attempting to collude with other subjects through tacit communication—moving towards the market compensation (Parkhurst, Shogren, and Dickinson 2004, Sherstyuk 1999); or people may have auction-specific self-serving biases (Plott and Zeiler 2005); or the behavior may be a result of off-margin bidding (Knetsch, Tang, and Thaler 2001, Shogren et al. 2001). In WTP auctions, the

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[16] Subjects could have been underbidding strategically, seeking excess rents by driving up market compensation. Such a strategy would require the group to cooperate tacitly. Possible evidence of tacit collusion would be on-margin bids converging to market price over time. An analysis of variance comparing bids by induced value across time pro-

vides no evidence of tacit collusion. Alternatively, the evidence supports the movement of bids towards the optimal bid with additional rounds. With additional experience, subjects were learning to bid their dominant strategy. However, we do note that statistical tests on price show significant differences between market price and the comparable market compensation (see Table 6). Market compensation was set at a larger value than expected.

Table 5. Tests of Joint Hypotheses

INDUCED VALUES	WTP AUCTION Dependent = δ Intercept = 0, Slope = 0
All	$\chi_2^2 = 49.24$, p-value < 0.01
Positive	$\chi_2^2 = 2.70$, p-value = 0.26
Negative	$\chi_2^2 = 54.99$, p-value < 0.01

INDUCED VALUES	WTA AUCTION Dependent = δ Intercept = 0, Slope = 0
All	$\chi_2^2 = 328.81$, p-value < 0.01
Positive	$\chi_2^2 = 166.91$, p-value < 0.01
Negative	$\chi_2^2 = 50.98$, p-value < 0.01

Note: Hypotheses tests for all, positive, and negative induced values were calculated using regression results from equation (3).

optimal bidding strategy is to bid one's induced value. In contrast, the optimal strategy in the WTA auctions is to bid (-1) times one's induced value. Although the two strategies seem straightforward in theory, the decision costs might be significant for people in the lab (Irwin et al. 1998), which is consistent with bounded rationality arguments made in other experimental contexts (Lusk and Hudson 2004). We now explore these two explanations in more detail.[17]

Additional Results

One approach to investigating the cognitive burden of the optimal strategies of the two auctions is to run an additional treatment in which subjects are told the optimal strategy for the auction.[18] Comparisons can be made between treatments— subjects are informed of the optimal strategy relative to when they are uninformed. If bidding behavior does not differ between treatments, then strategic bidding likely explains our observed

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[17] Performing nonparametric tests which disentangle these two explanations by separating the data into four subsamples—WTA(+), WTA(-), WTP(+), and WTP(-)—and testing two indicators of behavior—the percentage of bids with the incorrect sign, and the percentage of bids in the zero intervals—indicates that bidding behavior was not consistent across subsamples and warrants further investigation. The nonparametric test results and data description are available upon request from the authors.

[18] Noussair, Robin, and Ruffieux (2004) note that explaining the optimal strategy to students is less effective than "techniques that allow them to learn on their own."

bidding behavior in the WTA auction. If bidding behavior changes between the informed and uninformed treatments, support is extended to the hypothesis of cognitive burden. If bidding behavior differs between the informed and uninformed treatments but bidding differences persist between the informed WTA and informed WTP treatments, then a hybrid explanation of cognitive burden and strategic bidding—each explaining a portion of the differences in aggregate bidding behavior—is appropriate.

We first compare bidding behavior in the informed and uninformed treatments for each auction type. We estimate equation (4) using a two-way random effects model:

$$(4)\ bid_{it} = \alpha + \phi IN_{it} + \beta_1 \times OPT_{it} + \beta_2$$
$$\times OPT_{it} \times IN_{it} + \beta_3 \times Neg_{it} + \beta_4 \times OPT_{it}$$
$$\times Neg_{it} + \beta_5 \times Neg_{it} \times IN_{it} + \beta_6 \times Neg_{it}$$
$$\times OPT_{it} \times IN_{it} + u_i + \varphi_t + \varepsilon_{it}\,,$$

where Bid_{it}, IN_{it}, Neg_{it}, $Neg_{it} \times IN_{it}$, u_i, φ_t, and ε_{it} are the same as in equation (2). OPT_{it} is a dummy variable: if individual i participated in the informed auction treatment in round t, $OPT_{it} = 1$; otherwise, 0. The variables $OPT_{it} \times Neg_{it}$, $OPT_{it} \times IN_{it}$, and $Neg_{it} \times OPT_{it} \times IN_{it}$ are interaction terms and allow slope and intercept changes across treatment and positive and negative induced values. If bidding behavior is independent of whether an individual is informed or not informed of the dominant strategy, we expect all estimated slope and intercept coefficients for controls that include OPT to be statistically zero. The GLS estimated equation with two-way random effects for the WTP auction is

$$bid_{it} = \underset{(0.29)}{0.43} + \underset{(0.09)}{0.98} \times IN_{it} - \underset{(0.41)}{0.39} \times OPT_{it}$$
$$+ \underset{(0.12)}{0.05} \times OPT_{it} \times IN_{it} - \underset{(0.38)}{0.40} \times Neg_{it}$$
$$+ \underset{(0.53)}{0.24} \times OPT_{it} \times Neg_{it} - \underset{(0.12)}{0.48} \times Neg_{it}$$
$$\times IN_{it} + \underset{(0.17)}{0.16} \times Neg_{it} \times OPT_{it} \times IN_{it}\,,$$

where standard errors are in parentheses.

Overall, a joint test on all *OPT* and *OPT* interactive terms being equal to zero reveals a signifi-

cant difference between the bidding behavior of subjects in the informed treatment relative to the uninformed treatment (p-value < 0.01). For positive induced values, we see that no statistical difference exists (p-value = 0.61) between WTP bidding behavior of informed relative to uninformed subjects. However, a statistical difference is evidenced in WTP bids over negative induced values for informed relative to uninformed participants (p-value = 0.01). Informing subjects of their dominant strategy had no effect on subjects' bidding behavior over positive induced values (on-margin bidders), but did affect the subjects' bids for negative induced values (off-margin bidders). For negative induced values, subjects informed of the dominant strategy came closer to bidding truthfully than did uninformed subjects, but did not bid in a manner that was perfectly demand-revealing.

Estimating equation (4) for the WTA sample yields the following results:

$$bid_{it} = \underset{(0.36)}{-0.05} + \underset{(0.12)}{0.03} \times IN_{it} - \underset{(0.47)}{0.33} \times OPT_{it}$$

$$- \underset{(0.17)}{0.62} \times OPT_{it} \times IN_{it} + \underset{(0.53)}{0.84} \times Neg_{it}$$

$$- \underset{(0.73)}{0.37} \times OPT_{it} \times Neg_{it} - \underset{(0.17)}{0.37} \times Neg_{it}$$

$$\times IN_{it} + \underset{(0.24)}{0.25} \times Neg_{it} \times OPT_{it} \times IN_{it}.$$

Standard errors are in parentheses. Using a Wald test, we reject the joint hypothesis of no difference between bidding behavior of informed versus uninformed subjects at the 1 percent significance level (p-value < 0.001). For positive induced values, a statistical difference between informed and uninformed WTA bidding behavior is witnessed (p-value < 0.01). Positive induced value bidders informed of the dominant strategy in the WTA auction bid (= -0.38 − 0.59 × IN_{it}) closer to theoretical prediction of intercept 0, slope = -1, than do their uninformed counterparts (= -0.05 + 0.03 × IN_{it}). We see that in negative induced value space, bidding behavior is also statistically different for the informed (= 0.09 − 0.71 × IN_{it}) relative to the uninformed (= 0.79 − 0.34 × IN_{it}) WTA subjects (p-value = 0.04).

We capture the conclusions from the above regressions in Figures 2a and 2b. We see that, mapping the predicted bid lines for WTP and WTA auctions for optimal strategy for informed
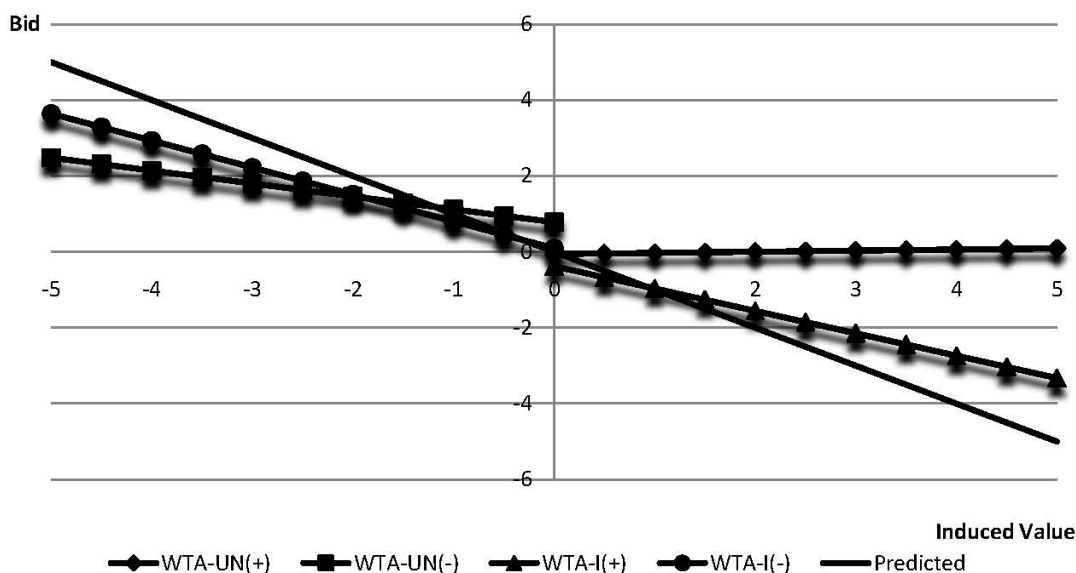
and uninformed subjects, bidding behavior comes closer to theoretical predictions for informed subjects than for uninformed subjects in the WTA auction, but informed WTA bidding behavior still falls short of being demand-revealing. Also, informed bidding behavior in the WTP auction for negative induced values is not demand-revealing, but improves on the bidding behavior of uninformed subjects. For positive induced values, both informed and uninformed subjects are demand-revealing.

We now estimate equation (3) for the informed WTA bidding behavior relative to the informed WTP bidding behavior to address the following question: Does bidding behavior in negative and positive induced value space differ across auction types for informed subjects? Recall that we normalize the data by calculating the expected profit floor [equation (2)]. The estimated two-way random effects regression equation for the informed data is

$$\delta_{it} = \underset{(0.27)}{-0.04} - \underset{(0.10)}{0.02} \times IN_{it} - \underset{(0.36)}{0.26} \times D_{it}$$

$$+ \underset{(0.14)}{0.40} \times D_{it} \times IN_{it} + \underset{(0.14)}{0.15} \times Neg_{it}$$

$$+ \underset{(0.60)}{0.12} \times D_{it} \times Neg_{it} + \underset{(0.14)}{0.31} \times Neg_{it}$$

$$\times IN_{it} - \underset{(0.20)}{0.43} \times Neg_{it} \times D_{it} \times IN_{it}.$$

Standard errors are in parentheses. From the regression results, we see that the regression line for the positive induced value WTP profit floor is as expected—zero intercept and zero slope. For negative induced values, the estimated WTP regression line is steeper than expected, with a slope of 0.29. The regression lines also have non-zero slopes for both positive and negative WTA regression lines—0.38 and 0.26.

We now answer the question of interest: Does bidding behavior differ across auction types for informed subjects? Using a Wald test we reject the null hypothesis of identical bidding behavior between informed WTP and informed WTA over all induced values (p-value < 0.01). We also reject the null hypothesis of identical bidding behavior between informed WTA and WTP treatments for positive induced values (p-value < 0.01). Informed subjects in the WTA auction bid conservatively, foregoing potentially profitable outcomes,

Figure 2a. Bid Lines—Uninformed (UN) versus Informed (I) Willingness to Accept

Note: Predicted bidding behavior is represented by a 45 percent line with slope -1 for WTA. Lines with square identifiers represent informed subjects, and hourglass identifiers represent uninformed subjects. Note that bidding behavior of informed subjects shifts towards theoretical predictions.

whereas in the WTP auction subjects' bids are demand-revealing. However, for negative induced values, no statistical difference in bidding behavior emerges (p-value = 0.95). Informed subjects with negative induced values bid aggressively in both WTA and WTP auctions.

Discussion

We diminish the cognitive burden of discerning the optimal bidding strategy by informing subjects of their optimal strategy and providing illustrative examples. And although informed subjects' bids are closer to being demand-revealing in aggregate, we find that the differences in bidding behavior that emerged in the uninformed treatment persisted in the informed treatment. Reducing the cognitive burden mitigated the differences in on-margin bidding behavior, but did not alleviate them. On-margin (positive induced values) subjects in the WTA auction tended to bid conservatively relative to the WTP auction, regardless of whether they were informed or uninformed of the optimal strategy. Informed and uninformed off-margin (negative induced values) bidders bid aggressively in both auctions, though the

bids of informed subjects were closer to being demand-revealing. Cognitive burden explains some of the variation in bidding behavior between auction types; however, it does not explain all the variation.

From examining Figures 1, 2a, and 2b, one might surmise that deviations from optimal bids are a manifestation of *loss aversion*. Loss aversion implies that a person is willing to pay a premium to avoid a certain loss. However, in a Vickrey auction a subject who plays his dominant strategy avoids all possibility of incurring a loss. For loss aversion to have explanatory power in this situation, it must be that negative values are perceived as a loss, while positive values are seen as a gain.[19] We take great care in the instructions to mitigate this possibility. Our WTA auction instructions state[20]

   A. If the market compensation is positive, say $x.yz = $400,

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[19] The typical approach of testing loss aversion in Vickrey auctions is to establish a reference point, X, and then ask subjects their willingness to pay to move from X to $(X + Y)$, and their willingness to accept moving from X to $(X - Y)$ [see Brookshire and Coursey (1987) and Viscusi, Magat, and Huber (1987)].

[20] Parallel examples are used in the instructions for the WTP auction.
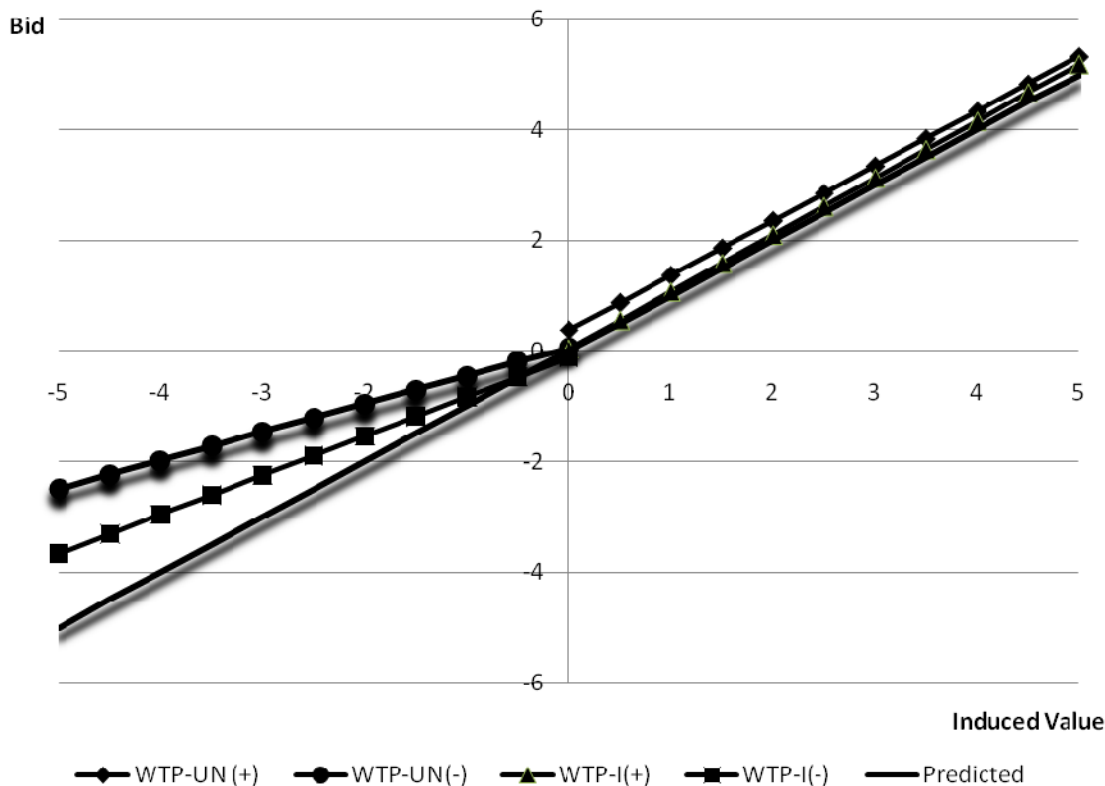
Figure 2b. Bid Lines—Uninformed (UN) versus Informed (I) Willingness to Pay

Note: Predicted bidding behavior is represented by a 45 percent line with slope 1 for WTP. Lines with square identifiers represent informed subjects, and hourglass identifiers represent uninformed subjects.

- then you make a *positive* profit if your resale value is greater than -$400. If your resale value equals -$300, then your profits equal $100 [= $400 + (-$300)]
- then you make a *negative* profit if your resale value is less than -$400. If your resale value equals -$600, then your profits equal -$200 [= $400 + (-$600)].

B. If the market compensation is negative, say $x.yz = -$400,

- then you make a *positive* profit if your resale value is greater than $400. If your resale value equals $500, then your profits equal $100 (= -$400 + $500)
- then you make a *negative* profit if your resale value is less than $400. If your resale value equals $200, then your profits equal -$200 (= -$400 + $200).

Another manifestation of loss aversion is the *endowment effect*. Here, subjects endowed with a good must be compensated a greater value to give up the good than they would pay to acquire the same good when not endowed (Kahneman, Knetsch, and Thaler 1990). In this experiment no

difference in endowment occurs. A subject's induced value becomes endowed only if he wins the auction, regardless of auction type. If the subject does not win the auction, he earns zero profits for that round. Further, induced values and cash are perfect substitutes (Smith 1976), which implies that compensating and equivalent variation are of equal magnitude, which should negate the endowment effect (Hanemann 1991).

Off-margin bidding could be another explanation for differences in bidding behavior between auctions for both positive and negative induced values. Here, the conjecture is that in a kth-price uniform auction, off-margin bidding behavior can occur at both extremes of the distribution (Knetsch, Tang, and Thaler 2001). The comparable observation is the bidding behavior of on-margin bidders (Shogren et al. 2001). To test this hypothesis, we use the market price and market compensation data from Table 6 to create on-

Table 6. Market Price Information (all rounds)

	Predicted Market Price WTP	Uninformed Market Price WTP	Informed Market Price WTP	Predicted Market Compensation WTA	Uninformed Market Compensation WTA	Informed Market Compensation WTA
Mean	$2.02	$2.37	2.05	$-2.02	$-0.20	-1.78
Variance	0.50	0.72	0.55	0.50	1.10	0.79
Mode	1.30	3.00	1.30	-1.30	1.00	-2.90
Median	2.00	2.55	2.00	-2.00	0.05	-1.40
Minimum	1.30	1.00	1.00	-2.90	-2.90	-3.10
Maximum	2.90	5.50	3.10	-1.30	1.80	0.00
Auction efficiency	1.00	0.72	0.86	1.00	0.42	0.70
Rounds 1–5	1.00	0.67	0.87	1.00	0.33	0.65
Rounds 6–10	1.00	0.77	0.85	1.00	0.50	0.75

margin intervals by treatment.[21] Controlling for auction type we observe a significant difference in bidding behavior for on-margin bidders for intervals greater than 1 standard deviation. On-margin bidders in the WTA auction bid conservatively, foregoing profitable opportunities, whereas the WTP bids of the on-margin bidders are demand-revealing.

Tacit collusion is another possible explanation for the conservative bids witnessed in the WTA auction for positive values. Positive induced valued subjects (projected winners) increase overall profits by driving up market compensation through conservative bidding. To work, tacit collusion requires a concerted effort by all participants in the auction. A deviation from the collusive outcome by one subject could trigger deviations by all subjects (see Sherstyuk 1999). For tacit collusion to be effective, projected winners should win the auction, and that market compensation would be greater than expected. From Table 7 we see that market compensation exceeds expected levels in both informed and uninformed treatments; however, market efficiency (the per-

centage of projected winners who win) is low at 70 percent and 42 percent for informed and uninformed subjects, respectively. Also, a Fisher's exact test of proportions across auction types indicates that market efficiency is greater for the WTP auction in both the informed (p-value < 0.01) and uninformed treatments (p-value < 0.01). We do not find evidence in our data to support tacit collusion as an explanation for the observed WTA bidding behavior over positive induced values.[22]

One could conjecture that elicitation mechanism design may evoke emotions or otherwise trigger mechanism-specific heuristics that influence behavior by creating a *misconception* or *self-serving bias*—for example, an attitude of toughness in bargaining environments. In auctions, terminology specific to a particular elicitation procedure—i.e., the words "buy" or "sell"—can create a gap between observed and optimal bidding behavior, where deviations from predicted

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[21] Market price and compensation intervals are established using the calculated mean and standard deviation for each treatment. At a confidence interval of plus or minus 1.05 standard deviations around the market price and market compensation, we note statistically different bidding behavior (p-value = 0.03). At an interval of plus or minus 2 standard deviations, bidding behavior for on-margin bidders is statistically different at less than the 1 percent significance level. Regression results are available from the authors upon request.

[22] Tsur (2009) suggests that the disparity between WTA and WTP is the result of a *selectivity effect*. This selectivity effect results from subjects overemphasizing bad experiences in previous purchasing decisions and as such reducing their WTP for a good that yields uncertain future benefits. On the flip side, the benefits derived from a good already in one's possession are certain, and WTA bids are accurate on average (Tsur 2009). Our results, though not designed specifically to test the selectivity effect, do not support this conjecture. We observe an institutional effect as opposed to a selectivity effect. Our results indicate that people are more accurate in bidding their values in a WTP auction and tend to overbid their values in the WTA auction, which may stem from their inexperience and naïveté in the role of a seller in the market.

Table 7. GLS (random effects) Estimation Results—Positive and Negative Induced Values

VARIABLE	WTP Uninformed	WTP Informed	WTA Uninformed	WTA Informed
CONSTANT	0.38 (0.35)	0.03 (0.23)	-0.06 (0.41)	-0.31 (0.31)
IN	0.99*** (0.09)	1.03*** (0.08)	0.03 (0.13)	-0.62*** (0.11)
NEG	- 0.32 (0.42)	- 0.17 (0.33)	0.84 (0.57)	0.32 (0.49)
NEG × IN	- 0.48*** (0.14)	- 0.32*** (0.11)	-0.37** (0.18)	-0.11 (0.16)
Hausman	p-value = 0.50	p-value = 0.72	p-value = 0.27	p-value = 0.17
Joint hypotheses of *NEG* = 0, *NEG × IN* = 0	p-value < 0.01	p-value = 0.02	p-value =0.02	p-value =0.58
JOINT HYPOTHESES OF THEORY CONFORMITY				
Positive	p-value = 0.42	p-value = 0.78	p-value < 0.01	p-value < 0.01
Negative	p-value < 0.01	p-value < 0.01	p-value < 0.01	p-value < 0.01
R^2	0.61	0.34	0.13	0.50
N	400	400	400	400

Note: Standard errors are in parentheses. *** represents significance at the 1 percent level, ** represents significance at the 5 percent level, and * represents significance at the 10 percent level.

bidding behavior may result from biases endogenous to the elicitation procedure. Plott and Zeiler (2005) note that biases (or misconceptions) in bidding behavior may result from "simply being in a situation that calls for selling behavior." Further, people have more experience as buyers than sellers. This suggests that mechanism-induced biases could differ for WTA auctions relative to WTP auctions. These biases can be removed with proper controls such as anonymity, elicitation mechanism, practice, and training (Plott and Zeiler 2005). In this set of experiments, telling bidders the optimal strategy and allowing them to assess that strategy over consecutive rounds and to adjust their bidding behavior, reduces the mechanism-induced biases with minimal risk of implanting the researchers' preferences on the auction participants' preference map.[23]

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[23] Sudgen (2009) illuminates one issue that could arise when instructing experiment subjects of optimal strategies. The researcher could implant his preferences (and perhaps the preferences he wishes to observe) in the subjects' decisions. Subjects can be influenced by the emphasis placed on different words. The only difference between our informed and uninformed treatments was the inclusion of the optimal strategy, three examples at the end of the instructions, and one open-ended question on the quiz. All quiz questions were answered prior to the initiation of the paid rounds. One could argue that "soft paternal-

Conclusion

Over the last decade, the experimental mindset has thrived within resource and environmental economics. The desire to understand policy questions that stretch the limits of theory and empirical analysis finds a natural home in lab and field work that stresses the need to balance control and context. Given the controversial nature of many environmental programs and policy, researchers also must consider how to design rules and elicit values given both intrinsic and extrinsic motives. Herein we use the experiment method to explore bidding behavior for a controversial good under two property rights regimes. Our results suggest that we should use caution when employing uniform WTA auctions to elicit private values for controversial goods. People willing to pay to keep the *status quo* or who assign a negative value to the presumed improvement may represent them-

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ism" was incorporated into our treatments; perhaps, but if so, it was incorporated into both the WTA and the WTP treatments equally. We did not help students to reevaluate their decisions after each round, although we did ensure that they calculated their profits and losses accurately. We did not implement the full controls in Plott and Zeiler (2009), which could explain why we did not see a similar convergence in WTP and WTA.

selves as indifferent between the two goods. This misrepresentation of preferences could cause the researcher to overstate the social benefits that would result from implementation of the controversial program. This result is one example of the experimental method—if you remain skeptical, rerun the experiment with a new sample; redesign it to better capture key variables you believe are missing: define new measures of success and failure based on economic or policy criteria. That is the ultimate beauty of the experimental mindset—new insight into asking better questions and reframing environmental policy debates.

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