Laboratory Testbeds and Nonmarket Valuation: The Case of Bidding Behavior in a Second-price Auction with an Outside Option

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Abstract

Researchers now use the lab to examine the behavioral underpinnings of valuation before the field application which some argue has less experimental control. But lab valuation work raises its own set of concerns when it uses private goods to explore nonmarket valuation behavior because private goods have substitutes often unaccounted for in the lab. Therefore, the lab as a tool to testbed field valuation work may be limited. Herein we design an induced valuation experiment to explore bidding behavior in a second-price auction with an outside option that is a perfect substitute for the auction commodity. Theory predicts that rational bidders will consider the prices of outside options when formulating bidding strategies, and will reduce their bids whenever their resale value exceeds the price of the outside option. Our results suggest that bidders account for outside options, but not to the extent dictated by rational choice theory. In addition, we provide initial evidence concerning hypothetical versus actual behavior with induced values—the data suggest that behavior is similar across real and hypothetical settings.

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1. Introduction

Laboratory experiments have become a popular tool to explore the behavioral underpinnings in non-market valuation.[1] Researchers use the experimental control of the lab to investigate how people react to design incentives behind valuation questions prior to field application (see Coursey and Schulze, 1986). But lab valuation work raises its own set of concerns when it uses private goods to examine nonmarket valuation behavior because private goods have substitutes often unaccounted for in the lab. Consequently, the lab as a tool to testbed field valuation may suffer. If the concerns over uncontrolled incentives in the lab are accurate, then laboratory findings in the lab are as open to challenge as the field work the lab research criticizes.

Herein we explore whether lab valuation work with private goods suffers from a lack of control due to market substitutes acting as an outside option. Our general concern in this study is with experiments designed to elicit individual values for a private good. The problem we consider arises from the observation that lab valuation exercises usually do not explicitly account for the behavioral implications of field substitutes for the lab commodity.[2] A researcher might view the lab auction as producing bids and values for a unique good, when in fact the bidding behavior reflects the price of an unmeasured outside option.[3] With the loss of control, valuation results from the lab may be less instructive for non-market valuation than previously thought.

The problem is illustrated with an example. Neill et al. (1994), for instance, use the classic incentive-compatible second-price auction to examine the disparity between hypothetical and real bids for a work of art (Vickrey, 1961). Figure 1 shows the *baseline demand curve* for the art piece, D_V, as the schedule of individual values v_i *in the absence of* *an outside option.* If the artwork is unique, each bidder's dominant strategy is to bid v_i. But if bidders know the artwork is for sale at a local gallery, each high-value bidder's new dominant strategy is to shave his bid downward to the outside option price (assuming zero transactions costs). In effect, the demand curve for the art shifts inward due to the introduction of the perfect substitute sold at *choke price* p_{oo}, yielding the *choked-demand* curve, D_{00}.[4]

It remains an open question whether bidders actually account for an outside option when bidding in the lab. That is, which demand curve is being observed in the lab, D_V or D_{00}? Moreover, is the answer invariant to the elicitation mechanism? The answer matters to the interpretation of bidder behavior. Some observers have suggested that the lab may be capturing D_{00} when payments are real, and D_V when payments are hypothetical (Smith, 1994; p. 141). If true, the existence of uncontrolled outside options might explain the oft-observed gap between hypothetical valuation statements and real economic commitments.

In this paper we design an induced valuation experiment to explore whether bidders in both hypothetical and actual second-price auctions consider the existence of outside options when formulating bid strategies. Induced values allow us to control the baseline and choked demand curves, and thereby focus attention on bidding behavior rather than on the elicitation of unobservable private valuations or perceived outside option prices, or both. And while hypothetical and actual behavior has received considerable attention in the literature, to the authors' knowledge this study provides the first comparison of such behavior in an induced valuation setting. Our major results are threefold: (a) bidders consider outside options when formulating bids, and this behavior is more likely with experience. This result is consistent with comparative static predictions—a lower outside option price results in lower bids; (b) the second-price auction overestimates the choked demand; and (c) bidding behavior in the presence of the outside option is consistent across real and hypothetical auctions.

2. Experimental Design and Bidding Behavior

Our experiment used a 2x3 treatment design to test for bid shaving in the presence of an outside option. The treatment conditions involved real or hypothetical payments, and three uniform outside option prices; \$2, \$4 or \$6. All other design features were the same across treatments–ten bidders and ten rounds, and in each round a 'good' was sold in a Vickrey second-price auction, in which the highest bidder wins and pays the second-highest bidder's bid.[5]

In each round, the monitor assigned each bidder his or her unique induced baseline value for the good, or *resale value* v_i. The resale value is the price at which the bidder could sell the good to the monitor after the auction. We used ten private resale values to create the baseline induced demand curve D_V – \$8.4, 7.6, 7.1, 6.8, 6.5, 5.3, 3.8, 2.4, 1.8, 0.9. Each bidder was assigned a different resale value in each round of bidding. In addition, there was an outside option that allowed each bidder the opportunity to buy the good in a secondary market at a posted uniform price (either \$2, \$4 or \$6) with no transaction costs.

Bidders used a bid slip that served three purposes. The bid slip (i) informed the bidder of his resale value; (ii) was the bid mechanism for the auction; and (iii) indicated whether a losing bidder wanted to buy the good in the secondary outside option market. At the end of each round, the monitor collected bid slips, calculated profits for each bidder, recorded the individual results on the bid slip, and returned the slips to the bidders so they could follow the results of their actions. Profits equaled the difference between the resale value and the price the bidder paid for the good, either in the auction or in the secondary market. If a bidder did not purchase the good, his profit was zero for that round. In the real payments sessions, total profits for all ten sessions were paid to bidders in cash at the end of the experiment. Only the winner saw the two highest bids.[6]

Theory says that in a second-price auction without an outside option, a rational bidder's dominant strategy is to bid his resale value v_i (Vickrey, 1961). But, with an outside option, his optimal bid strategy b_i now depends on whether the price of the outside option p_{oo} exceeds v_i. *Strictly rational* bidding behavior can be characterized as follows

$$b_i = \begin{cases} v_i & \text{if } p_{oo} \geq v_i \\ p_{oo} & \text{if } p_{oo} < v_i \end{cases}$$

Holding the baseline demand curve constant, simple comparative statics suggest that as the price of the outside option falls, bids will decrease. Aggregate baseline demand is computed as the summation of resale values, or \$50.6 per round. For the \$2 option price treatments, *strictly rational* bid behavior would yield about 37 percent of the baseline demand, (8*\$2+\$1.8+\$0.9 = \$18.7 of \$50.6). Similarly, for the \$4 and \$6 treatments, strictly rational bidding would produce about 65 percent of baseline demand, (6*\$4+3.8+2.4+\$1.8+\$0.9 = \$32.9 of \$50.6); and about 87 percent of baseline demand, (5*\$6+\$5.3+\$3.8+2.4+\$1.8+\$0.9 = \$44.2 of \$50.6).

3. Results

Three useful results emerge. First, bid shaving exists, as measured by the percentage of total bids per round relative to the baseline demand of \$50.6 per round. Table 1 shows that this behavior is relatively robust across treatments for both experienced and inexperienced bidders, ranging between a low of 49.6 percent of baseline demand in round 4 of treatment A to a high of 114.4 percent in round 6 of treatment C. Summing across rounds of the real treatments A-C, the real auction elicited 76 percent of baseline demand ($1149.9 of $1518 (=$50.6x10x3)); summing across rounds of the hypothetical treatments D-F, the hypothetical auction captured 77 percent of baseline demand ($1162.5 of $1518). Using a Robust Rank-order double sided test, we reject the hypothesis of equality between the real and baseline demand (z = 5.81), and the hypothetical and baseline demand (z = 5.90) at the p < .01 level.[7]

Table 1 also shows that bid shaving was consistent with comparative static predictions—as the outside option price decreases, bid shaving increases. Comparing observed behavior in round 10 of the real auctions, for instance, shows that as price increased from $2 to $4 to $6, total bids decreased from $48.6 to $34.4 to $25.2. This pattern was consistent across all rounds in the real treatments A-C, and in seven rounds in the hypothetical treatments D-F. Overall, the bulk of evidence suggests that bidders, in general, considered the outside option when formulating their bid strategies, and shaved their bids accordingly.

Our second major finding is that, although bid shaving exists, bidding behavior is not *strictly rational*; bidders who shaved bids do not necessarily bid *exactly* the price of the outside option. Table 2 reveals that *strict rationality* is relatively low for both real (17.9 percent, or 34 of 190 predicted bids) and hypothetical bids (18.4 percent; 35 of 190 predicted bids).[8] Statistical tests suggest that both real and hypothetical bidding schedules are significantly above the choked demand curve (in a Robust Rank-order double sided procedure: z = 2.42 for real and z = 3.50 for hypothetical). This result is consistent with the general observation from previous induced value experiments that overbidding tends to occur in second-price auctions (see Kagel's 1995 overview).

Somewhat broader definitions of rationality better organize bidding behavior. *Weak rationality* allows for experimentation (+/-10 cents around the outside option price), and captures 36.3 percent (69 of 190) of real bids, and 33.2 percent (63 of 190) of hypothetical bids. *Prudent rationality* accounts for extra cautious behavior (within 10 cents above or anywhere below the outside option price), and accounts for 55.8 percent of real bids (106 of 190), and 43.2 percent of hypothetical bids (82 of 190). These statistics suggest that subjects shave bids according to outside option prices, but not to the precision dictated by rational choice theory.

Our third result is that bid shaving is equally likely in real and hypothetical auctions. The hypothetical auctions elicited 84.4 percent ($1281.8) of the baseline demand; or 76.5 percent ($1161.8) if we omit two bids ($90 and $30) as outliers. Using a Robust Rank-order test, we find no significant difference between the hypothetical and actual auctions ($z = 1.18$). A comparison of mean bids between the hypothetical and actual contexts using a t-test yields a similar conclusion. These results hold with or without the two outlier bids.

This third finding does not support Smith's (1994) suggestion that the existence of outside options may help explain differences in laboratory behavior when payments are real relative to when payments are hypothetical.[9] Bidders confronting an outside option were not more likely to bid their baseline value in a hypothetical context relative to the real context. But this finding is what one should expect if bidders take market incentives seriously, even in a hypothetical setting. To argue that bidders shave real bids subject to outside options, but not hypothetical bids, is to argue that they selectively ignore key components of the construct market—in this case, the outside option. We see no convincing reason why bidders who treat hypothetical primary markets seriously would not regard all incentives seriously, including hypothetical secondary markets. In fact, if we had not observed bid shaving in the hypothetical treatments, one would have reason to question the internal validity of bidding behavior within this context (see Diamond, 1996).

We reinforce the unconditional real/hypothetical result using a Probit model:

$$\psi = \alpha + \beta_1 T + \beta_2(D_h T) + \beta_3 Resale + \beta_4(D_h Resale) + \sum \Phi_i Z_i + \varepsilon, \qquad (1)$$

where $\psi = 1$ if rationality is observed, 0 otherwise; D_h represents a dichotomous variable that equals 1 for hypothetical bids, 0 otherwise; T represents a time trend (1,2,3,…10); $\beta_1 T$ is the time trend for the real auctions, and therefore $(\beta_1 + \beta_2)T$ is the learning time trend deviation in the hypothetical auctions; $\beta_3 Resale$ and $\beta_4(D_h Resale)$ control for the subject's resale value in each round; $\sum \Phi_i Z_i$ are treatment effects that capture specific variation systematically related to the treatment; α is the estimated intercept, and ε is the well-behaved error term.

Table 3 presents estimation results from equation (1) for each of the definitions of rationality.[10] We split the sample based on the bid strategy decision rule, resale>outside option and resale<outside option, and present empirical results for the three classifications of rationality when subjects are expected to shave bids.[11] Overall, parameter estimates – which are marginal effects computed at the overall sample means – confirm our previous unconditional results and suggest that bidders are equally likely to shave bids whether or not the context is hypothetical or real. For 14 of the 15 treatment coefficient estimates, we find that the \$2, \$4, and \$6 dichotomous regressors are not different from the \$2 hypothetical baseline at conventional significance levels. The sole significant dummy is the *Hypothetical \$4* variable in the *Prudent* specification. Our empirical results also suggest some subjects

learned to shave bids with experience, as parameter estimates on the time trends are consistently positive, although only one is significantly different from zero at conventional levels (the *Weak* specification).

5. Concluding Comments

This note evaluates one key issue in the use of laboratory experiments to testbed field non-market valuation exercises: we consider how an outside option affects aggregate and individual bidding behavior in a second-price auction. Our results support the view that people in second-price auctions do in fact consider outside options when formulating bid strategies. Bidders shave bids toward the price of the outside option, although they tended to bid higher than that predicted by the rational choked demand curve.

The implications for future nonmarket valuation research are two-fold. First, the results reject outside options as the explanation of the gap between hypothetical statements and real economic commitments often observed in the laboratory valuation literature. Real and hypothetical bid shaving was observed in near equal proportions, as should be expected if one believes that rational bidders treat real and hypothetical incentives with equal seriousness. Second, bid shaving is a specific case of the more general valuation question on how unobserved private actions (e.g., personal skill in reducing job or environmental risk) can affect revealed preferences for collective policies (see Shogren and Crocker, 1991). The results herein support the general idea that uncovering otherwise hidden private actions deserves more attention in non-market valuation work.

Notes

[1] Examples include laboratory validation of hypothetical survey methods (e.g., Neill et al., 1994; Cummings et al., 1995; List and Shogren, 1998), examination of the WTP/WTA disparity (e.g., Kahneman et al., 1990; Shogren et al., 1994), new product valuation (e.g., Hoffman et al., 1993), and elicitation of individual discount rates (e.g., Benzion et al., 1989; Coller and Williams, 1999).

[2] Two exceptions are Coller and Williams (1999) and Harrison et al. (1999), in which the experimenters elicit subject perceptions of the price of alternative field substitutes and then control for these variables in the data analysis. Harrison (1989) and Smith (1994) take field substitutes into account when interpreting experimental data.

[3] Harrison (1989) introduced the argument, and then expanded it in Harrison et al. (1995).

[4] This exposition is simplified in the sense that we do not consider the existence of imperfect substitutes or diverse subject perceptions of outside option prices and/or transactions costs. These technical complications do not affect the general implications of the present study, or are they germane to our experimental design, so their discussion is suppressed here.

[5] To minimize ending round effects, no information was provided to the subject regarding the number of rounds the experiment would last.

[6] Bidders were recruited campus-wide from the student body at the University of Wyoming. Participation was voluntary and not part of their class evaluation. Written instructions were distributed and read aloud. A written quiz followed with a subsequent discussion to ensure bidders understood the dominant strategy of the second-price auction. Each experimental session lasted about an hour and the average bidder earned $20.

[7] We use the Robust Rank-order double sided test to determine whether the elicited demand curve is statistically different from the induced demand curve (Siegel and Castellan, 1988). The responses were pooled with the induced values and ranked in order of size. The test statistic is:

$\overline{U} = \dfrac{mU(YX) - nU(XY)}{2\sqrt{V_X + V_Y + U(XY)U(YX)}}$ where X denotes the induced values, Y denotes the distribution of subject's bids, n and m denotes the sample sizes of Y and X, V_x and V_Y denote the variance of the rank in samples X and Y, and $U(YX) = \sum_{j=1}^{n} U(YX_j)\frac{1}{n}$ is the number of Y observations with a lower rank than each X observation. For sample sizes larger than 12, $\overline{U}$ approaches a normal distribution, (Siegel and Castellan, 1988). The estimated test statistic is equal to 5.81, so we reject the hypothesis of equality between the two demand curves.

[8] Comparing proportions over all subjects, 190 bids should be censored across all rounds in the real treatment, and likewise for the hypothetical treatment.

[9] For more discussion on the gap between hypothetical and real behavior, see for example Neill et al. (1994), List et al. (1998), Fox et al. (1998), Johannesson (1997), or Harrison and Rutström (1999).

[10] Overall, χ^2 tests of model significance suggest that the bidding model explains a significant amount of the variation in the regressand, as a majority of the model types are significant at conventional levels (critical values of χ^2(9 d.f.) = 14.68 (10%), 16.92 (5%), and 21.67 (1%).

[11] Results for resale<outside option is consistent with those presented for resale>outside option.

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Figure 1. Baseline (D_V) and Choked (D_{OO}) Demand

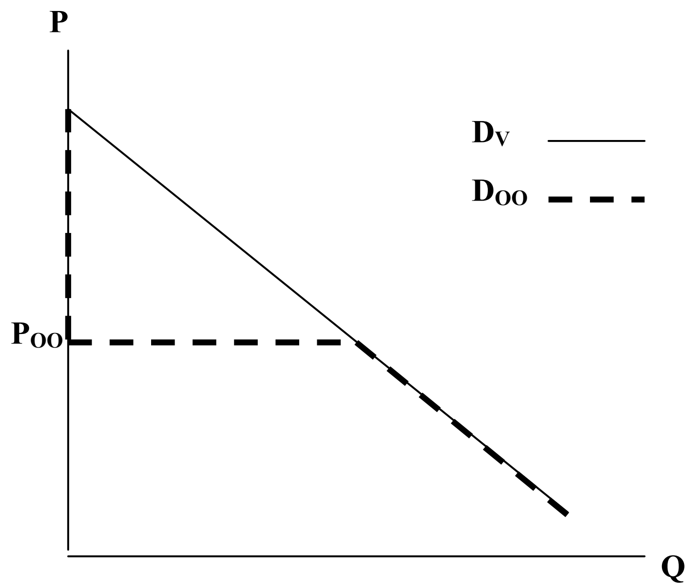

Table 1. Aggregate Bidding Behavior by Treatment and Round[a,b,c,d]

Treat-ment	Real or Hypo-thetical Bid	Price of Outside Option	Aggregate Choked Demand	Observed Aggregate Bids — Round 1	2	3	4	5	6	7	8	9	10	Total
A	Real	$2	$18. 7	$29.4	29.2	25.4	25.1	25.9	30.6	32.1	28.2	29.7	25.2	$280.8
			37%[a]	58.1	57.7	50.2	49.6	51.2	60.5	63.4	55.7	58.7	49.8	55.5
B	Real	$4	$32. 9	$38.8	49.0	25.2	47.5	30.3	25.3	28.3	35.4	32.3	34.4	$346.5
			65%	76.7	96.8	49.8	93.4	59.9	50.0	55.9	70.0	63.8	68.0	68.5
C	Real	$6	$44.2	$51.2	49.3	48.0	51.9	55.9	57.9	54.8	48.4	56.6	48.6	$522.6
			87%	101.2	97.4	94.9	102.0	110.5	114.4	108.3	95.7	111.9	96.0	103.3
			Subtotal											
			$95.8	$119.4	127.5	98.6	124.5	112.1	113.8	115.2	112.0	118.6	108.2	$1149.9
			63%	78.7	84.0	65.0	82.0	73.8	75.0	75.9	73.8	78.1	71.3	76
D	Hypo	$2	$18.7	$35.7	42.5	38.2	35.1	30.0	28.2	28.0	30.9	27.0	29.8	$325.4
			37%	70.6	84.0	75.5	69.4	59.3	55.7	55.3	61.1	53.4	58.9	64.3
E	Hypo	$4	$32.9	$40.6	42.1	40.4	41.1	37.1	39.6	34.6	37.3	38.3	41.4	$392.5
			65%	80.2	83.2	79.8	81.2	73.3	78.3	68.4	73.7	75.7	81.8	77.6
F	Hypo	$6	$44.2	$38.9	46.8	39.6[b]	46.5	35.8[c]	44.8	51.2	45.1	51.7	44.2	$444.6
			87%	76.9	92.5	91.0[d]	91.9	81.7[d]	88.5	101.2	89.1	102.2	87.4	87.9
			Subtotal											
			$95.8	$115.2	131.4	118.2[d]	122.7	102.9[d]	112.6	113.8	113.3	117.0	115.4	$1162.5
			63%	75.9	86.6	81.7[d]	80.8	71.0[d]	74.2	75.0	74.6	77.1	76.0	77

a. Percentage of total baseline demand (baseline demand=$50.6 per round).
b. A bid equal to $30 treated as outlier and omitted.
c. A bid equal to $90 treated as outlier and omitted.
d. Corrected for the outliers.

Table 2. Breakdown of Rational Behavior by Treatment and Round[a,b,c,]

Treat-ment	Real or Hypo-thetical	Price of outside option	Ratio-nality*	Observed Bidding Behavior Round 1	2	3	4	5	6	7	8	9	10
A	Real	$2	S	0(0) [a]	1(12)	1(12)	2(25)	1(12)	1(12)	0(0)	3(37)	0(0)	2(25)
			W	1(12)	2(25)	3(37)	4(50)	3(37)	4(50)	3(37)	5(62)	3(37)	4(50)
			P	2(25)	4(50)	4(50)	5(62)	5(62)	4(50)	5(62)	6(75)	5(62)	5(62)
B	Real	$4	S	0(0) [b]	2(33)	1(17)	2(33)	2(33)	3(50)	3(50)	3(50)	1(17)	2(33)
			W	1(17)	2(33)	3(50)	3(50)	3(50)	3(50)	4(67)	3(50)	3(50)	4(67)
			P	3(50)	4(67)	6(100)	3(50)	5(83)	5(83)	6(100)	3(50)	5(83)	5(83)
C	Real	$6	S	0(0) [c]	0(0)	1(20)	1(20)	1(20)	1(20)	0(0)	0(0)	0(0)	0(0)
			W	1(20)	0(0)	2(40)	1(20)	1(20)	1(20)	0(0)	1(20)	0(0)	1(0)
			P	3(60)	1(20)	2(40)	2(40)	1(20)	2(40)	0(0)	3(60)	0(0)	2(40)
			subtotal	0(0)	3(16)	3(16)	5(26)	4(21)	5(26)	3(16)	6(32)	1(5)	4(21)
				3(16)	4(21)	8(42)	8(42)	7(37)	8(42)	7(37)	9(47)	6(32)	9(47)
				8(42)	9(47)	12(63)	10(53)	11(58)	11(58)	11(58)	12(63)	10(53)	12(63)
D	Hypo	$2	S	1(12) [a]	1(12)	2(25)	2(25)	1(12)	2 (25)	0(0)	1(12)	2(25)	2(25)
			W	1(12)	1(12)	2(25)	3(37)	3(37)	3(37)	2(25)	3(37)	3(37)	3(37)
			P	3(37)	1(12)	2(25)	4(50)	3(37)	5(62)	3(37)	4(50)	3(37)	4(50)
E	Hypo	$4	S	0(0) [b]	1(17)	1(17)	1(17)	0(0)	2(33)	2(33)	2(33)	2(33)	2(33)
		W	0(0)	1(17)	2(33)	3(50)	1(17)	4(67)	2(33)	4(67)	4(67)	3(50)	
			P	1(17)	3(50)	3(50)	3(50)	2(33)	4(67)	4(67)	4(67)	4(67)	3(50)
F	Hypo	$6	S	0(0) [c]	2(40)	0(0)	1(0)	0(0)	1(0)	1(20)	2(40)	0(0)	1(20)
			W	0(0)	2(40)	0(0)	3(60)	0(0)	3(60)	1(20)	4(80)	0(0)	2(40)
			P	2(40)	2(40)	0(0)	3(60)	1(20)	4(80)	1(20)	4(80)	0(0)	2(40)
			subtotal	1(5)	4(21)	3(16)	4(21)	1(5)	5(26)	3(16)	5((26)	4(21)	5(26)
				1(5)	4(21)	4(21)	9(47)	4(21)	10(53)	5(26)	11(58)	7(37)	8(42)
				6(32)	6(32)	5(26)	10(53)	6(32)	13(68)	8(42)	12(63)	7(37)	9(47)

The first number in each cell represents the number of observed rational bids; the number in parentheses represents the percentage of observed rational relative to predicted rational bids.

* S-Strict rationality—high value ($v_i > p_{00}$) bidders censor at the outside option price; W-Weak rationality—high value bidders censor at +/- 10 cents of the outside option price; and P-Prudent rationality—high value bidders censor at 10 cents above or anywhere below the outside option price.

a. 8 subjects are predicted to censor their bid.

b. 6 subjects are predicted to censor their bid.

c. 5 subjects are predicted to censor their bid.

Table 3. Estimation Results for Bid Functions[a,b,c,d,e]

Variable	*Resale > Outside Option* **Strict**	**Weak**	**Prudent**
Constant	-0.21	-0.14	0.28
	(-1.7)	(-0.90)	(1.5)
Time	0.008	0.03	0.01
	(0.85)	(2.1)	(0.89)
D_h*Time*	0.004	0.01	0.01
	(0.30)	(0.64)	(0.56)
Resale	-0.009	-0.03	-0.05
	(-0.43)	(-1.10)	(-1.65)
D_h*Resale*	-0.007	-0.02	-0.04
	(-0.27)	(-0.50)	(-1.01)
Hyp. 4	0.04	0.16	0.20
	(0.60)	(1.9)	(2.22)
Hyp. 6	0.007	0.07	0.09
	(0.10)	(0.79)	(0.92)
Real 2	-0.07	0.05	-0.02
	(-0.40)	(0.21)	(-0.06)
Real 4	0.10	0.18	0.22
	(0.52)	(0.71)	(0.78)
Real 6	-0.12	-0.15	-0.19
	(-0.58)	(-0.58)	(-0.68)
χ^2(9 d.f.)	16.1	34.0	42.9
N	380	380	380

[a]Dependent variable is equal to 1 if rational, 0 otherwise.
[b]D_h represents dummy variable for hypothetical auction.
[c]*Hyp. j (Real j)* represents hypothetical (real) treatment with the jth value for the outside option and represent deviations from the baseline *Hyp. 2* treatment.
[d]Parameter estimates are marginal effects computed at the sample means.
[e]t-statistics in parentheses under coefficient estimates.