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The effect of shill bidding upon prices: Experimental evidence

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Abstract

This paper explores, through a series of experiments, the effect of shill bidding upon revenues and prices in auctions. We study the practice of shill bidding in a common value framework. Our findings are consistent with the prediction that, if bidders are aware of the possibility of seller participation in an auction, profits will be reduced on average. We also study factors that affect bidder and seller participation decisions. Shill bidding can alleviate the problem of the winner's curse by lowering the price and it can, thus, provide benefits to bidders.

JEL classification: C91; D44

Keywords: Auctions; Shill Bidding; Entry

1. Introduction

There is an increasing concern over shill bidding in Internet auctions. Shill bidding (or shilling) occurs when the seller of an item poses as a bidder and submits bids in an auction in an effort to raise its price. Auction sites spend large amounts of money to prevent this activity. The persistence of shilling can affect the popularity of Internet auctions as effective trading mechanisms. Incidents of shilling have also been reported in traditional English auctions for many years (see Cassady (1967) and Lucking-Reiley (2000)). In their study of how auctions affected trade at the beginning of the nineteenth century, Engelbrecht-Wiggans and Nonnenmacher (1999)

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reveal that this practice was widespread at that time. A change in New York's legislation in 1817 created disincentives for shillers. As a result, the activity subsided contributing to the city's rapid growth. Shill bidding has important implications for the success of markets and studying its effects is of direct policy relevance. Rothkopf and Harstad (1995) attributed the rareness of Vickrey auctions outside financial markets partly to the fear of cheating sellers.

In this paper, we report the findings of experiments that study the practice of shill bidding. We investigate its effect on the bidding behavior and revenues of the seller in common value auctions. We chose this framework because a large number of items auctioned on-line are collectibles (such as antiques, stamps, and sports memorabilia) and second-hand goods whose value is uncertain. According to Bajari and Hortacsu (2002, 2004) approximately 50% of the listings on eBay can be classified as collectibles (see also Lucking-Reiley (2000) who surveys a number of sites). Bidders estimate how much these items are worth based on their private information and the behavior of other bidders. In such auctions, the seller can enter bids to mislead other participants and intensify bidding competition. In the process, he runs the risk of developing a bad reputation that could persist in future transactions. Bidders often express worries about sellers' past suspect behavior.

The rapid increase of transactions over the Internet will create many more opportunities for shill bidding in the future because sellers can easily disguise their identities. Many bidders complain that auction sites are not doing all they can to discourage fraud. They attribute the reluctance to take action against some sellers to the fact that higher prices will ultimately generate higher commissions (see Bunker (2001) and Kauffman and Wood (2003)). Do prices really increase when bidders anticipate the behavior of the seller? A number of theoretical papers in the IPV model suggest that this is true. The recent theoretical work by Chakraborty and Kosmopoulou (2004) in a common value framework shows that shill bidding does not benefit the seller and in some cases it does not benefit the auctioneer either. Our experiments reveal that shill bidding lowers both prices and profits. In some sense, it alleviates the problem of the winner's curse evident in those auctions. The information collected from the data allowed us to explore entry decisions and the extent of observational learning.

The paper is structured as follows. Section 2 provides a review of relevant literature. Section 3 outlines the modeling framework. Section 4 describes the experiments, while Section 5 reports and evaluates the results. Section 6 summarizes our findings.

2. Literature review

The earlier theoretical literature has focused on phantom bidding (the covert bidding activity of an auctioneer) in the context of the independent private value (IPV) framework when the number of participants is known (see Graham et al., (1990), Deltas (1999), and Bag et al., (2000)). Graham et al., (1990) are among the first to show that phantom bidding can enhance the bidders' revenues when the distribution of values is asymmetric. Izmalkov (2004) extends the analysis to consider the properties of an optimal auction in an asymmetric IPV model with shill bidding. He uses the price clock auction to determine the properties of the optimal bidding function and examine robustness of his analysis to differences in specification. In the framework of the IPV model, phantom bidding (or shill bidding) can only raise the price if bidders are heterogeneous and the bidding process reveals information about the unknown distribution of values of the highest bidder. If bidders are homogeneous and the distribution of values is known, phantom bidding cannot provide any additional benefit than the selection of the reserve price ex ante. The only noted exception in the literature is when there are multiple values for the optimal reserve price[1] and the number of bidders is not known ex ante. In that framework, Wang et al., (2001) showed that shill bidding can be beneficial and introduced a Shill-Deterrent fee schedule to discourage sellers from submitting shill bids.

Rothkopf and Harstad (1995) studied Vickrey auctions in a dynamic framework in which bidders are not fully rational.[2] They showed that cheating has significant adverse effects for the seller. A trusted seller cheats when it pays and eventually destroys his reputation.

In a common value framework, Vincent (1995) examined the possibility of submitting a phantom bid as an alternative to setting a reserve price at an auction. The information that bidders can get from low, otherwise unobserved, true bids can help them reduce the winner's curse. The model does not incorporate a potential deception effect.

Chakraborty and Kosmopoulou (2004) analyzed the full consequences of shill bidding in common value auctions with rational participants. They showed that when bidders take into account the potential for seller participation at the auction, they revise their bids downwards. Their work makes the following testable predictions: (i) If bidders are aware of the possibility of seller participation in an auction, shill bidding makes the seller worse off. Sellers would prefer it if there were a well-established, strict enforcement mechanism that makes it impossible for them to participate. (ii) A mixed participation strategy on behalf of the seller should reduce prices in an auction.[3] (iii) The seller prefers a mixed participation strategy at lower shill bidding rate to a mixed participation strategy at a higher rate of shill bidding.

There are important practical difficulties in using empirical data to investigate the effect of shilling on bidding behavior and profits. Detection of shill bidding is difficult in Internet auctions. Such information, whenever it is available, is typically sensitive and is kept confidential. It is also impossible to determine what bidders know or suspect about the seller's actions. The only attempt to explore shill bidding patterns in the empirical literature has been made by Kauffman and Wood (2003). They used coin auction data from eBay to examine what they call reserve price shilling (which is an attempt of the seller to avoid paying fees associated with a reserve price). They formulated a number of behavioral assumptions that together could help identify a potential shill bid in an auction, with some degree of uncertainty.[4] Then they tested a specification that associates shill bidding with seller reputation and experience, previous shilling behavior, the level of starting bid, the time left in the auction and the value characteristic (common versus private). Their evidence suggests that shilling is more likely to lower the starting bid and to lengthen the auction. Sellers that have submitted shill bids before are more likely to submit such bids again. In our paper, we created a computerized auction environment in which we could trace the seller's participation patterns with certainty and investigate the effects of competitive shill bidding (the

[1] This can occur if the bidders' virtual valuations are not monotonic.

[2] In their model, bidders believe that the seller is completely honest until he is detected cheating. Once he is caught cheating they think he is likely to cheat again.

[3] It is assumed here that the expected value of the item increases in the number of bidders with high estimates of the value. Bidders are ex ante identical; they draw their estimates from the same distribution.

[4] They define shill bidding as follows: "(1) bidding on an auction, (2) when the same or lower bid could have been made on the exact same item in a concurrent auction, (3) when the auction bid upon ends after the other concurrent auction and (4) where the bidder did not bid on both auctions." Note that shill bidding is not confirmed here. The same pattern of behavior may have been compatible with bidders that do not search sufficiently for items and/or bidders who have personal experience with a seller. This seemingly irrational behavior of purchasing an item at a high price has been observed in price comparison sites on the internet as well (see Baye et al., 2005). In those cases, shill bidding is not an issue.

seller's act of entering bids above the reserve to run up the price). We could also control the amount of information that is available to bidders by carefully announcing the possibility of seller participation according to profit expectations.

3. Theoretical framework

This section describes in detail the main theoretical results related to prices and profits that will be tested to some extent by the experiments. These results follow from the work of Chakraborty and Kosmopoulou (2004) with a minor modification of their framework that does not change the intuition of the analysis but allows us to set up experiments in a straightforward manner. We assume that the potential number of bidders (n) is known but the actual number of legitimate bidders (M) is not. We know how many bidders will receive some relevant information with certainty but not how many will eventually decide to participate based on the information received. In their work, bidders did not know n or M. We will present a simple and illustrative version of their clock auction model with 2 possible bidder types. While the results generalize to an arbitrary number of types, the exposition becomes more cumbersome and the notation unnecessarily long.

The auctioneer uses a continuous ascending price auction to sell the item in return for a commission which is a fraction c of the sales price. The auction has a reserve price R set optimally and announced to the bidders at the beginning of the process. As in their framework, we assume that each bidder observes a private signal s_i before deciding whether to participate in the auction. The signal can be low ($s_i=0$) or high ($s_i=1$). Let M denote the number of true bidders at the auction. This number depends on the expected benefit from participation given the reserve. At the selected reserve, only bidders with a high signal will enter the auction.[5] The bidders and the seller have a common belief on the joint distribution of V and M on the support $\{V \in [0,1]$ and $M=0, 1, 2,\ldots; M \leq n\}$. The expected value of the object conditional on M bidders submitting bids at the auction is $v(M)=E[V|M]$ and it is an increasing function of the number of bidders. The marginal distribution of M is denoted here by $f(M)$.

Let L represent the number of observed participants at the auction. This number includes the seller whenever he is shill bidding. We denote by ρ the probability of seller participation. Assuming rational expectations, the bidders will anticipate the correct value of ρ in equilibrium. Let $r(L|\rho)$ be the conditional expected probability from a true bidder's perspective that the seller is bidding at the auction when altogether L participants are placing bids, with $r(1|\rho)=0$ and $r(n+1|\rho)=1$. According to Milgrom and Weber (1982) a bidder's bid if the auction continues from the reserve price is given by

$$b(L|\rho) = v(L-1)r(L|\rho) + v(L)(1-r(L|\rho)).$$

Following Chakraborty and Kosmopoulou (2004), we can show that the bidding strategy is decreasing in ρ. The seller's expected payoff depends on his participation strategy, the bidder's belief ρ, and the number of bidders at the auction. The seller has a value V_s from keeping the object. A typical case in the literature on common value auctions is the case where $V_s=0$. The purpose of shill bidding is to create the impression that there are more bidders with a high estimate of the value to intensify competition among bidders. It is assumed that a seller will behave just

[5] It is important to note that the results of the analysis can be established for any level of the reserve, R. In reality, the sellers are trying to avoid any action that would lead to a potential investigation. With this in mind, we assume here that the reserve is set at the level that would be optimal in the absence of shill bidding.

like a true bidder would at the auction to successfully manipulate the bidding outcome and avoid identification that could damage his reputation and lead to criminal charges. Based on his available information about the distribution of types, he will set the optimal reserve price ex ante and decide whether to shill bid. If there are M real bidders at the auction and the seller decides to submit a bid then the number of active bidders increases by one, i.e., $L=M+1$. With probability $1/(M+1)$, the seller wins the auction in which case he keeps the object and pays the commission on the price. With probability $M/(M+1)$, a true bidder wins and the seller receives the price minus the commission. The expected payoff to the seller from participation is

$$\pi_1(\rho) = \sum_{M=1}^{n} f(M)\left[\frac{M}{M+1}(b(M+1|\rho)(1-c)-Vs)-\frac{1}{M+1}cb(M+1|\rho)\right]-f(0)cR.$$

The payoff to the seller if he does not participate at the auction is given by

$$\pi_0(\rho) = \sum_{M=1}^{n} f(M)[b(M|\rho)(1-c)-Vs].$$

Based on these payoffs the following three results can be established as in Chakraborty and Kosmopoulou (2004):

Theorem 1. *A seller's payoff in a shill-bid equilibrium associated with $\rho<1$ exceeds his payoff in a shill-bid equilibrium associated with $\rho=1$. The smaller ρ is, the better off the seller becomes.*

Proof. It is easy to show that $\pi_1(1)-\pi_1(\rho)<0$ for any $\rho<1$. □

The seller would be better off if an enforcement mechanism was in place to prohibit him from participation.

Theorem 2. *A seller prefers a mixed strategy equilibrium with a lower shill bidding rate to a mixed strategy equilibrium with a higher shill bidding rate irrespective of his ability to shill bid.*

Sketch of the proof: Suppose that there exist two mixed strategy equilibria, one in which the seller's randomization gives rise to a $\rho=\rho^*$ and another where the seller participates with a lower probability so that $\rho=\tilde{\rho}<\rho^*$. Based on the seller's payoffs, we can establish that $\pi_0(\rho^*)-\pi_0(\tilde{\rho})<0$.

Theorem 3. *The price in a mixed strategy shill bid equilibrium will not be higher than the price formed when the seller is prohibited from bidding if (1) ex ante you don't expect at most one bidder with a high signal at the auction and (2) $v(M+1)-v(M)$ is not necessarily increasing in M.*[6]

The proof is based on a comparison of the expected price at a rate of participation ρ and the expected price when the seller is not participating i.e., by examining the difference $E[P|\rho]-E[P|0]$. The sign of the difference depends ex ante on the likelihood of observing a single true bidder with a high estimate at the auction. It also depends on whether an additional high signal is increasingly valuable. If ex ante there is a high probability of observing a single bidder with a high signal, the seller can benefit by forcing this optimistic bidder to bid aggressively. His benefit will be higher if the marginal contribution of a high signal on the perception of the value is increasing in the number of true bidders i.e., if $v(M+1)-v(M)$ is increasing in M. This means that every

[6] This is a modified version of Theorem 6 in Chakraborty and Kosmopoulou (2004) most relevant to our setting.

additional bidder with a high signal that is observed is generating increasingly greater optimism about the value of the item. Notice that the assumption of an isolated optimistic high signal implies a negative correlation in the estimates that would be unrealistic in a common value environment. Ex ante, there is no reason why in a common value auction one should expect an isolated high draw. In addition, it seems unlikely that additional high signals will be increasingly valuable. In our experimental application of this model, we assume a uniform distribution of types and a common value expressed as the average of signals. In such as setting, the price is expected to decrease at the auction.

4. Experimental design[7]

We consider a clock auction in which the highest bidder is awarded the item at the second-highest bid price. Each bidder receives an independent signal s_i taking values from a uniform distribution. The value of the item is defined as the average of the n bidders' signals:

$$V = \frac{1}{n}\sum_{i=1}^{n} S_i.$$

In this auction environment (i) there is a reserve price, (ii) entry takes place simultaneously and (iii) bidders cannot reenter once they have exited.[8]

For simplicity, we assume that the seller has no value for the item and no information that could be useful to the bidders. He has, however, the ability to participate in some auctions—and submit shill bids—if he finds it beneficial. The bidders do not know whether the seller is actually shill bidding, but know whether he can submit a bid or not.

Subjects participated in 20 sessions that lasted for one-and-a-half hour and consisted of a series of 22 auctions each.[9] They were recruited from a wide cross-section of undergraduate students at the University of Oklahoma and each participated in one session. In each auction, there were at maximum five potential players. Each player was either a true bidder or a seller. The assignment was decided at the beginning of the session from a random draw. The person chosen to be a seller remained in that capacity for the duration of the experimental session. Our intention was to evaluate how bidders learn and how they adjust their bidding strategies to the seller's behavior. The experiments were completely computerized and in each session there were two treatments: in one the seller could not participate and in the other he could.[10] Subjects received instructions for the second treatment only after the set of auctions of the first treatment was completed. The order of treatments was changed in some sessions to check for robustness of our results. Here is a detailed description of the experimental process.

(i) *The auction format*. In each auction, a single unit of a commodity was sold to the highest bidder at the second-highest bid price. We followed the "ascending clock design" in which there is a digital clock on the screen. The clock started at a particular bid (reflecting the

[7] For more information on the design, please see the instructions.

[8] This modeling framework has been previously used in many theoretical and experimental papers. Experiments include Avery and Kagel (1997), Holt and Sherman (2000), and Goeree and Offerman (2002). Theoretical work includes Albers and Harstad (1991), Bikhchandani and Riley (1991), Klemperer (1999), and Bulow et al. (1999).

[9] We performed 22 auctions, 4 of which were trial runs to familiarize the subjects with the auction environment.

[10] In all auctions, the seller could observe the outcome of the bidding process and learn as much as every bidder would.

reserve price) and moved upwards every 5 seconds. Each bidder was able to observe the clock and the process was interactive.[11]

(ii) *The distribution of values*. The values of all items were determined the same way. Prior to the auction, the bidders received signals revealing partial information about the value of the object. The average of the observed signals determined the value. Each signal was an integer drawn from a uniform distribution between 0 and 20. The signal and the distribution of signals were the only information available ex ante to bidders that could help them make decisions about entry. The seller did not receive any information ex ante that could be relevant to the bidders. The seller's value was zero.

(iii) *The instructions*. Subjects were given a set of instructions designed to help them understand the nature of each object for sale and how to calculate the common value (see the Appendix). The seller was given the opportunity to bid only in some auctions and his potential for participation, was announced to all bidders. The seller was able to observe passively the outcome of the experiments in all auctions in which he had no ability to participate. The bidders were given an initial budget of $15 to participate in the auctions.[12] We had 100 participants overall in the 20 sessions, and 20 of those were sellers. Subjects were given enough time to read the instructions that were subsequently read aloud to them. The instructions included examples that illustrated how the auctions worked, and how the subjects could determine their profits or losses.

(iv) *The bidding*. At the beginning of each auction, a reserve price (a minimum acceptable bid) was posted on the screen. After each bidder received his signal he had to decide whether or not to participate. When all bidders made their decisions the auction would start. The digital clock would appear on each screen along with information about the remaining cash balance. By clicking on a button next to the clock, marked "Bid Here," a bidder would be able to stop his clock and determine his dropout price. When a sole clock was left active, the remaining bidder obtained the object at the price shown by the clock the moment the last-but-one bidder withdrew from the auction. Subjects were paid in cash at the end of the session.

(v) *The information feedback*. The site also displayed information about the item that was auctioned off. At any point in time, when an auction was underway, the bidding history (consisting of the dropout prices of all the bidders) was posted on the site. We concealed the identity of the bidders from each other to avoid direct identification of the seller's bid at any given auction. After each round, the true value, the winning bid, profit (or loss) and updated cash balances were reported to all bidders on their screens. The number of active bidders was not announced at the beginning, but it could be inferred from the number of dropout prices at the conclusion of each auction. This is because, in many auctions (including all

[11] The ascending clock design is used widely in the literature (see among others Kagel et al. (1987) and Kagel (1995)). We did not use the format that specifies an ending time for these auctions for two reasons. First and foremost, in a common value auction the fixed ending time rule posed an incentive problem: bidders should wait until the last minute to avoid revealing their private information (see Lucking-Reiley (2000)). According to Bajari and Hortacsu (2004): " If all bids arrive at the last minute, a bidder will not be able to update his beliefs about the common value V using the bids of others, hence his bidding decision would be equivalent to that of a bidder in a sealed-bid second price auction." It turns out that, theoretically, the fixed ending time rule would render shill bidding ineffective in equilibrium since the seller would run the risk of becoming the highest bidder of the item without having the benefit of raising the expected price conditional on sale. The second, less important and more practical reason (which is relevant in traditional English auctions) is that the auctions ended in a matter of minutes.

[12] To cover for 'bankruptcies' and 'no-showers,' we had extra bidders (up to two) in each experimental session. The active bidders in each session were selected on a 'first-come-first-serve' basis. We did not observe any bankruptcies. Extra bidders were paid a $5 show-up fee.

Internet auctions), the actual number of participants is not known ex ante (see also the discussion in McAfee and Vincent (1992)).

The auction experiments were performed using the ascending clock design. Bidders could observe the 'drop out' prices of their competitors and learn from their bidding patterns. As bidders bid, they revealed private information about the object to be sold. Therefore, the remaining bidders could update their information about the object and bid accordingly. The possibility of seller participation was carefully announced to the bidders, in half the auctions within every session. It was made clear that this was the seller's choice and not a certainty. The payoff functions and the feedback information on dropout prices could help them formulate and update their beliefs about the seller's participation strategy.[13] Garvin and Kagel (1994) point out that, bidders learn to adjust their strategies through their own experiences and observational learning. Cooper and Kagel (2003) emphasize the importance of getting feedback regarding the outcomes of earlier auctions. They conclude that this information will help bidders adjust their 'judgmental failures'. The data obtained from this experiment allowed us to investigate the effect of shill bidding on winning prices and payoffs and bidders' learning within a session. We could investigate if the sequential format of these auctions has any effect on the bidding pattern and whether observational learning plays an important role in formulating strategies.

5. Experimental results

In order to familiarize the subjects with the auction process and let them gain some bidding experience, we did two dry runs each time and also used up the first two paid auctions as trial experiments. From each session, we collected information for data analysis from 18 auctions, 9 with and 9 without the possibility of seller participation. All items received at least one bid and were eventually sold at a price equal to or above the reserve. We collected 81 observations from each session. We have a total of 1616 observations from 359 auctions.[14] From this set of data, we could identify the winner of each auction, the second-highest bid, the number of bidders per auctions, the value, the sellers' profits and participation patterns, each bidder's identity, profit, signal, dropout price, and cash balance.

Based on these observations, in the following sections, we trace the participation patterns and the response of the bidders to changes in the bidding environment. We study the seller's entry strategy and measure profits. We analyze the effect of shill bidding on winning prices and the variance of prices and examine if the entry decision of bidders was optimal or not. Finally, we test the robustness of the results to changes in the environment.

5.1. Entry decision

The number of subjects who participated and submitted bids at these auctions was larger than the number predicted by economic theory but on par with other experimental findings (Kagel and

[13] As an alternative to the approach we took, we thought of having the program simulate the behavior of the seller so that we could explicitly announce the probability of participation, in anticipation of optimal bidding behavior. However, since the bidder's behavior is not always optimal (according to the experimental evidence in Kagel and Levin (1986) participants' behavior significantly differs from the Nash equilibrium behavior), such a seller's fixed strategy would not be optimal either. As a result, any conclusion drawn from such an analysis would be useless with any slight deviation from the Nash equilibrium bidding strategies. We decided instead to let the bidders and the seller make their own decisions and evaluate qualitatively the outcome.

[14] In one session, however, an error occurred when a bidder entered an auction other than the one under way at the time. We did not observe a winner at this auction. The bidders' cash balance was not updated and, as a result, we omitted the auction from our analysis.

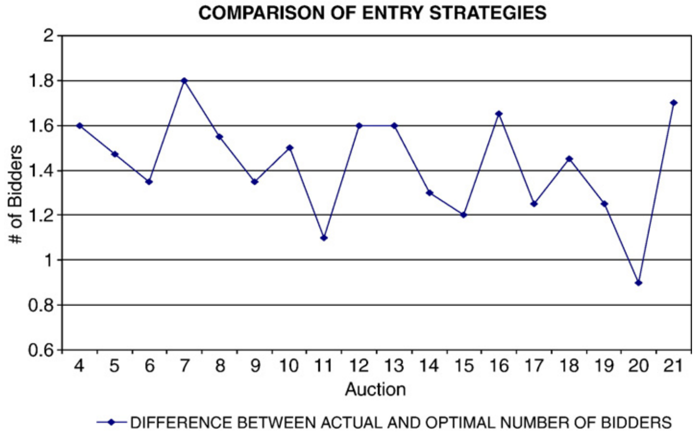

Fig. 1. Number of entrants.

Levin (1991)). The seller's shill bidding action was influenced by the bidders' observed past behavior and the parameters of the auction environment. The data analysis that follows focuses on two tests:

Hypothesis 1. The bidder's entry decision is not affected by the seller's ability to participate.

Hypothesis 2. Shill bidding is more likely at a lower reserve price.[15]

In a common value auction, a bidder should enter if the expected value of the item conditional on winning at the reserve exceeds the reserve price. If the seller does not have any valuable information to share with the bidders (here he does not receive a signal and this is common knowledge), the calculation of the value ex ante is based on expectations about the signals of the legitimate bidders and remains the same irrespective of the seller's ability to participate. This would be true in any auction with a reserve, when the decision to enter is made before any bid is observed. In our case, with four potential bidders, the optimal reserve price is 5.5. At this reserve, any bidder with a signal greater than or equal to 9 should enter the auction.[16] The data collected from ten sessions, at the reserve of 5.5 reveal that the number of bidders who submitted bids in an auction exceeded the optimal number by 1.313. This is a considerable deviation, given the fact that there are 4 bidders at maximum that received signals and about 50% are expected to enter optimally in any given auction. Based on this information, we performed ten additional sessions at the marginally higher reserve of 6.25.[17] Fig. 1 presents the mean deviations from the optimal entry level in the auction sequence for all 20 sessions.

[15] This hypothesis is supported by field evidence provided in Kauffman and Wood (2003) and implied by the work of Vincent (1995).

[16] It was calculated to maximize profits when the bidders choose their optimal bidding strategies. We assume in this calculation that the bidders are fully rational. See the Appendix for more details.

[17] At this reserve, optimally, only bidders with a signal greater than or equal to 10 should participate in the auctions. See McAfee and Vincent (1992) on the issue of updating the reserve price. Some researchers have speculated that the thrill of playing might be the dominant factor affecting the entry decision of some bidders. Since there is no hard evidence on what motivates bidders to enter in larger proportions than the optimal strategy would dictate, we were reluctant to raise the reserve too much in our comparative statics exercise to avoid introducing a reserve that would be sub-optimally high.

Table 1
Basic participation statistics

Variable	Reserve 5.5			Reserve 6.25		
	All auctions	Auctions without seller	Auctions with seller	All auctions	Auctions without seller	Auctions with seller
Optimal number of bidders	2.067	2.063	2.093	1.928	1.756	2.100
	(.388)	(.374)	(.481)	(.341)	(.188)	(.381)
Average number of bidders	3.380	3.396	3.367	3.539	3.478	3.600
	(.772)	(.717)	(.827)	(.663)	(.707)	(.614)
Probability of bidder participation	.845	.848	.841	.885	.869	.900
	(.363)	(.359)	(.367)	(.320)	(.337)	(.300)

Table 1 presents participation statistics at two reserve prices used to do a comparative study.

The announcement of seller participation did not have a significant impact on the number of participants. The number of legitimate bidders only changed from 3.396 to 3.367 at the reserve of 5.5 and from 3.478 to 3.600 at the reserve of 6.25. The probability of bidder participation at the reserve of 5.5 was 0.848 when the seller was not allowed to participate and .841 when he was. A test of these proportions reveals that their difference is statistically insignificant (with a z statistic of .258). The difference in the probability of bidder participation between the two treatments at the reserve of 6.25 is statistically insignificant as well (with a z statistic of -1.302). The evidence in Table 1 is corroborated by the probit analysis, performed in Table 2.

In column 1 of Table 2, we examine a bidder's probability to submit a bid as a function of bidder and auction-specific independent variables. This model allows us not only to test for differences in the probability to submit a bid across the two treatments but also to account for

Table 2
Probability of bidding (marginal effects from probit model)

Independent variable	For bidders (1)	For sellers (2)
Signal	.019**	
	(.001)	
Seller's potential entry	−.008	
	(.017)	
The seller was observed to shill bid at the conclusion of the previous auction	−.047*	
	(.029)	
Order of auction in the sequence	.001	.092**
	(.002)	(.033)
Number of bidders in the previous auction	.017*	.071*
	(.009)	(.037)
Reserve	.020*	−.766**
	(.012)	(.170)
Balance	−.002*	−.009**
	(.001)	(.003)
Observations	1436	179
χ^2	315.81	16.53
Log likelihood	−410.670	−93.745

** Denotes 95% significance and * denotes 90% significance.

other observed patterns of behavior in the sequence of auctions. The detailed description of the variables used in this regression is in the Appendix.

The table reports marginal effects evaluated at the means of all independent variables. The results of the analysis show that the seller's potential to enter lowers the bidder's probability to submit a bid only by 0.8 percentage points and this effect is statistically insignificant. The evidence is supporting Hypothesis 1. The order of auctions in the sequence and the implied observational learning has no effect on the participation decision. The higher the signals the bidders received, the higher the probability of submitting a bid. The observation of shilling activity in one auction discouraged entry in the subsequent auction. From the reputation mechanisms established in online auctions we have learned that negative feedback has adverse effects but is not a significant deterrent of activity primarily because the number of bidders experiences continuous growth (see Bajari and Hortacsu (2004)). Here our maximum number of participants is constant within an auction and the effect that verified cheating has on the entry decision is significant. When the seller cheats and that is observed by the bidders at the end of the auction, the probability of bidder participation in the subsequent auction is expected to decrease by 4.7%, holding all other variables constant at their mean values. Contrary to what we expected, however, the probability of participation was 2% higher at the higher reserve price.

The second column of Table 2 presents the results of a probit regression for the seller as a function of auction specific variables and the cash balance. The results suggest that among the factors influencing a seller's behavior in an auction are the order of auctions in the sequence and the number of bidders that have submitted bids in the previous auction. Shill bidding was observed more often in auctions performed later in a session. The larger the number of observed participants in the past and the lower the cash balance, the more frequently do sellers tend to bid. As in Kauffman and Wood (2003) the reserve price has a significant impact on the probability to submit a shill bid. As the reserve price increases from 5.5 to 6.25, the probability of seller participation is expected to decrease by 76.6%, when we evaluate all other variables at their mean values. This evidence supports Hypothesis 2. The relationship between the seller's decision to submit a bid and the reserve price is also providing support to the theory of Vincent (1995).

In conclusion, we find evidence in support of both Hypotheses 1 and 2. Despite the fact that bidders did not make optimal entry decisions (as shown in Fig. 1), the number of entrants was invariant to the possibility of seller participation. There is more evidence of shill bidding at the lower reserve price. The excessive entry of bidders in these auctions is likely to induce aggressive bidding that could worsen the problem of the winner's curse.

5.2. The effect of shill bidding on prices and profits

In this section, we first present a graph and basic statistics on relative bids and profits. Then we use the least squares estimation procedure to statistically analyze our data. Our primary goal is to test the following three hypotheses:

Hypothesis 3. The problem of the winner's curse is alleviated by the potential participation of the seller.

Hypothesis 4. The auctioneer is worse off with the shill bidding equilibrium than with the no shill bid outcome.

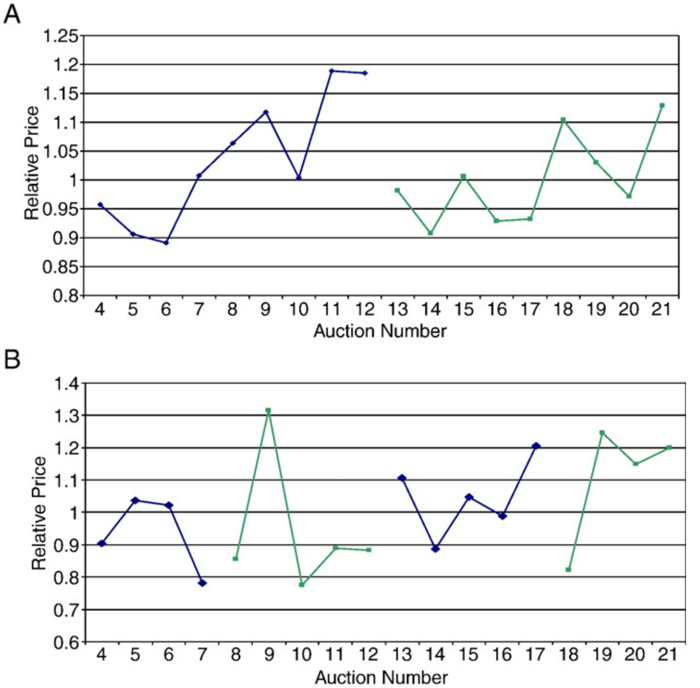

Fig. 2. A: Relative prices based on 15 sessions performed at the reserve price of 5.5 and 6.25. The potential of participation was announced in auctions 13–21. B: Relative prices based on 5 sessions performed at the reserve price of 5.5. The potential of participation was announced in auctions 8–12 and 18–21.

Hypothesis 5. The lower the rate of participation the better off the seller becomes.[18]

Fig. 2A and B show relative prices (price as a fraction of the value) in all sessions.

For every auction in the sequence, the estimates presented are obtained by averaging out the corresponding quantities across the sessions.[19] The graphs reveal that the bidders suffer from the winner's curse, since the price frequently exceeds the value of the item. Fig. 2A suggests that this is more so when the seller is not given the option to participate. In the analysis that follows, we examine this issue more thoroughly. The problem of the winner's curse is prevalent in common value auctions and arises from the failure of the bidders to optimize correctly. It was first discussed by petroleum geologists Capen et al. (1971) who described the bidding outcome in OCS lease sales for a period 1954–1969. Since then, additional evidence has been found at the lab and in the field that bidders do not always adjust their bids to the optimal level (see among other Kagel and Levin (2002) and Wilson (1990), Brannman et al. (1987), and Hendricks et al. (1987)). We will show here that, even though bidders do not avoid the winner's curse problem as a theory

[18] Hypothesis 3 is testing the theoretical result that the price will not increase following from Theorem 3 in Section 2. Hypothesis 4 is testing Theorem 1, and Hypothesis 5 is testing Theorem 2.

[19] In 15 sessions, at the reserve of 5.5 and 6.25, we ran 9 consecutive auctions without the possibility of seller participation followed by 9 consecutive auctions with the possibility of seller participation. Five additional sessions were performed in a different format to check the robustness of the behavior to changes in the design. In those, the seller had to be passive in auctions 4–7 and 13–17 and could be active in the remaining auctions. The regression analysis and the table statistics include all data and allow consideration of the effect of the change in format.

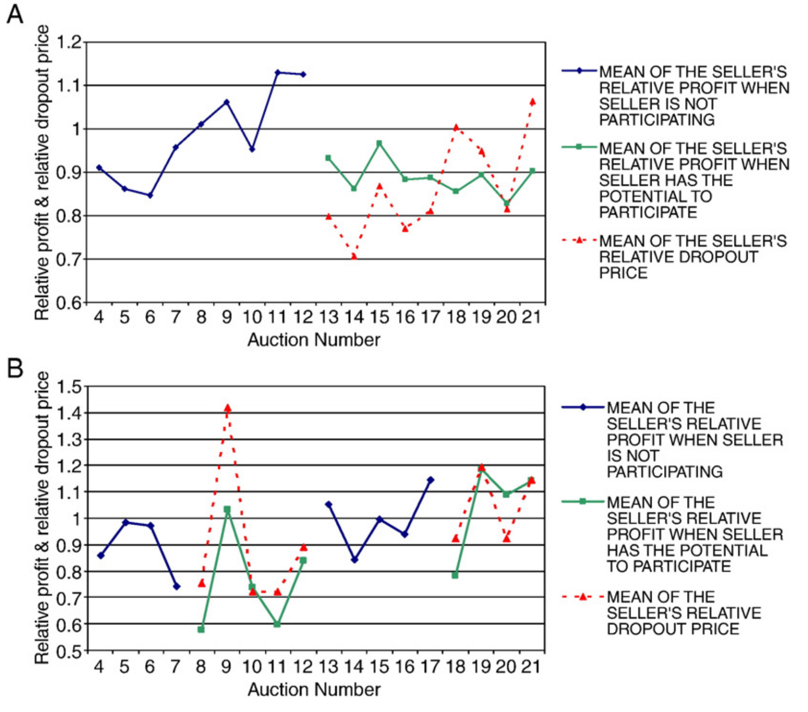

Fig. 3. A: Seller's relative profit and bidding patterns based on 15 sessions performed at the reserve price of 5.5 and 6.25. The potential of participation was announced in auctions 13–21. B: Seller's relative profit and bidding patterns based on 5 sessions performed at the reserve price of 5.5. The potential of participation was announced in auctions 8–12 and 18–21.

of rational optimizing bidders would predict, they make an adjustment to avoid the seller's effort to run up the price. Qualitatively, the result of the theory related to the consequences of the seller's participation hold independent of whether bidders adjust fully for the winner's curse or not as long as the bidding function is an increasing function of the signals. These two issues are taken separately into account in the profit maximizing effort.

Fig. 3A and B show the relative profits and dropout prices (or bids) for the sellers. Consistent with the relative price pattern of Fig. 2A, sellers' relative profits presented in Fig. 3A seem higher,

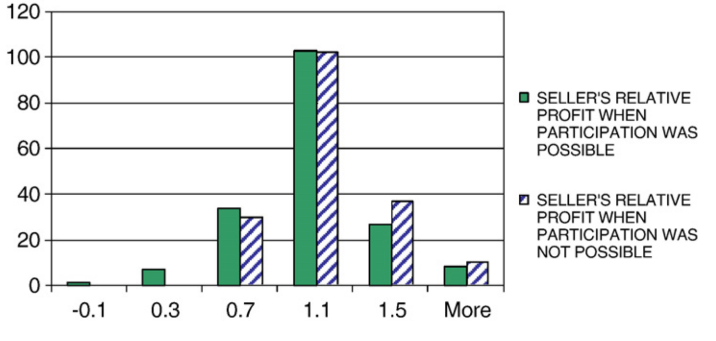

Fig. 4. Historgram of the seller's relative profit.

Table 3
Relative prices and profits

Variable	All auctions	Auctions without seller	Auctions with seller
Average relative winning price for bidders	1.004	1.026	.981
	(.357)	(.405)	(.300)
Average relative profit for bidders	−.004	−.026	.019
	(.357)	(.405)	(.300)
Average relative dropout price for sellers			.881
			(.368)
Average relative profit for sellers	.932	.975	.889
	(.369)	(.385)	(.347)

on average, in the first 9 auctions of each session. In the last 9 auctions, sellers were mixing their participation strategies; on average they submitted bids with a probability of 74.3%. The contrast is less evident in Fig. 3B where the order of announcements changed in the sequence.

Fig. 4 is based on the entire sample of 20 sessions and provides a comparison of the distribution of the seller's relative profit between auctions with and without the possibility of seller participation. The figure shows that the frequency of low relative profits is higher when the seller could participate and the frequency of high relative profits is higher when he could not participate. It provides evidence that the distribution of the seller's relative profits when participation was not possible stochastically dominates the corresponding distribution when participation was possible.

Table 3 provides statistics on relative prices and profits for all auctions.

According to this table, the average relative profit of the seller went down from 97.5% to 88.9% of the value. Our test revealed that the difference is statistically significant (t statistic is 2.232). Both the test and Fig. 4 support Hypothesis 4. The average relative winning price for the bidders dropped from 102.6% to 98.1% of the value, which is a statistically significant difference of 4.5% (t statistic is 2.223). The main drop was observed right after the first announcement of the potential for seller participation was made. The bidders' profits were, on average, 2.6% of the value in the auctions without seller participation and 1.9% of the value in the auctions when the potential of seller participation was announced.[20] The problem of the winner's curse was exacerbated when the seller was not allowed to participate in an auction, which provides support for Hypothesis 3.

Table 4 presents averages of prices and profits conditional on the actions of the seller. We also report the number of observations that fall within each category. The seller generated higher profits when he was forced to abstain from participation. When he had the opportunity to participate, he was better off not submitting bids; the difference in the average profit between auction in which the seller was allowed to participate but did not bid and auctions in which he submitted a bid but a bidder won the item is statistically significant (t statistic = 23.626).

[20] Our analysis examines qualitatively the effect of shill bidding on prices and profits without concentrating on comparison of individual bids to equilibrium bids. We compare entry decisions to equilibrium behavior only, where such an approach is feasible. Notice that, once a bidder enters, each bid submitted is conditioned on information that is obtained by inverting the bidding function and uncovering the other bidders' signals. This process requires knowledge on our behalf of the bidders' beliefs about the probability of the seller's participation. This is information we do not have and we cannot get through a calibration exercise due to the fact that the bidders suffer the winner's curse. As a result, even though they take shill bidding into consideration and adjust for it in the direction predicted by the theory, their behavior does not fully conform to the equilibrium bidding relationship derived by the theory. Nevertheless, qualitatively the result of the theory related to the consequences of the seller's participation hold independent of whether bidders adjust fully for the winner's curse or not as long as the bidding function is an increasing function of the signals.

Table 4
Summary statistics for the seller

Measures in:	Relative winning price			Relative profit		
	All auctions	Reserve at 5.5	Reserve at 6.25	All auctions	Reserve at 5.5	Reserve at 6.25
Auctions where the seller won his own item	1.472 (.613) 8	1.261 (.169) 5	1.823 (.982) 3	−.074 (.031)	−.063 (.008)	−.091 (.049)
Auctions where the seller submitted a bid but a bidder was awarded the item.	.949 (.299) 125	.995 (.358) 61	.904 (.223) 64	.903 (.285)	.950 (.341)	.859 (.212)
Auctions in which the seller was allowed to participate but did not submit a bid.	1.064 (.288) 46	1.050 (.352) 23	1.079 (.212) 23	1.011 (.273)	.997 (.335)	1.025 (.201)
Auctions without the potential for seller participation	1.026 (.405) 180	.992 (.325) 90	1.060 (.470) 90	0.975 (.385)	.942 (.309)	1.007 (.447)

Standard deviations are in parentheses. Number of observations is below the standard deviation.

Despite the value of information provided in Tables 3 and 4, the basic statistics appearing in them do not provide any controls for a variety of other factors that affect prices and profits. For that reason, we use a simple OLS regression with White-corrected standard errors to analyze the effect of shill bidding on the expected value of winning prices and profits, the two dependent variables used in our analysis. The basic structure of the regression model is as follows:

$$y_i = XB + Z\Gamma + \varepsilon_i.$$

The independent variables include controls for auction specific quantitative (X) and qualitative variables (Z). The description of those variables and their construction is detailed in the Appendix. The set of quantitative variables consists of the item's value, the number of bidders in the previous auction and the order of auctions in the sequence. Since the number of bidders in an auction is not known before its conclusion, we used a variable on the observed number of participants in the last auction to infer the aggressiveness of opponents based on patterns of past participation. Such an inference is meaningful here because the expected value of each item in the sequence is the same. The theory suggests that this variable should have a negative effect on prices in common value auctions (see Kagel and Levin (1986)). In the literature, there have been many studies documenting increasing and decreasing patterns of prices in sequential auctions. The most relevant study for the present framework is by Milgrom and Weber (2000) predicting that, in a model with common values, prices will rise in the sequence. We use a variable to control for the order of auctions in the sequence and test if there is a trend in the price.

We also use a set of qualitative variables, described in Table 5 and the Appendix, to control for announcements, the sellers' actual participation patterns, changes in the reserve price and changes in auctions structure. According to Chakraborty and Kosmopoulou (2004), the announcement of the seller's potential participation should have a negative effect on both prices and profits. The study of various reputation mechanisms established in web auctions has shown that negative feedback can have adverse effects on prices. Those effects vary and may depend also on the value of the object

Table 5
Regression results

Independent variable	Dependent variable				
	Price		Seller's profit		
	(1)	(2)	(3)	(4)	(5)
Constant	4.90**	3.874**	4.720**	3.66**	4.206**
	(.742)	(.804)	(.707)	(.731)	(.582)
Value	.295**	.350**	.277**	.350**	.280**
	(.033)	(.041)	(.032)	(.042)	(.033)
Number of bidders in the previous auction	.136	.147	.140	.215	.276**
	(.161)	(.162)	(.154)	(.135)	(.112)
Order of auction in the sequence	.125**	.122**	.109**	.123**	.113**
	(.027)	(.036)	(.025)	(.036)	(.024)
Seller's potential entry	−.875**	−1.144**	−.764**	−.346	−.259
	(.258)	(.358)	(.243)	(.395)	(.339)
The seller is participating in the auction				−1.210**	−.709**
				(.358)	(.313)
The seller was observed to shill bid at the conclusion of the previous auction	.366	−.160	.270		
	(.351)	(.442)	(.329)		
Design	−.141	−.213	−.088	−.240	−.082
	(.296)	(.345)	(.278)	(.338)	(.277)
Reserve	.111	.133	.107	.085	.079
	(.213)	(.258)	(.198)	(.255)	(.196)
Seller wins the auctions			−9.032**		−8.820**
			(.466)		(.470)
Observations	359	359	359	359	359
Adjusted R^2	.268	.226	.523	.248	.529

**Denotes 95% significance. White heteroscedasticity corrected standard errors are in parentheses.

sold (Ba and Pavlou (2002)). We accounted here for a seller's participation in the previous auction when 5 bidders were observed and the shill bidding activity was common knowledge. In addition, in columns 3, 4 and 5 of Table 5 we introduced a set of variables capturing actual participation patterns which are not directly observed by the bidders. In all of the specifications, we accounted for variations in the reserve price and changes in the order of announcement.

There are 359 observations of prices and profits in the sample. The regression results in column 1 of Table 5 suggest that the value of the item has a positive effect on the price. The bidders bid higher and higher in the sequence of items auctioned off in a session as Milgrom and Weber (1982) predict. The price systematically increases by 0.125 on average from one auction to another. The potential of seller participation affects bidding behavior and leads to lower prices. It alleviates the problem of the winner's curse and provides additional support for Hypothesis 3. The winning price decreases on average by 0.875. The change in the reserve price does not have a significant effect on the average price. The order of the treatments does not affect the outcome of the bidding process.

Column 2 of Table 5 indicates that the seller's profit is higher with the value of the item to the bidders and the order of auctions in the sequence. The increase in the reserve does not have a statistically significant effect on the seller's profit. The announcement of the potential of seller participation has a negative effect on profit. The profit decreased by 1.144 on average with the announcement, as is shown in column 2. As Chakraborty and Kosmopoulou (2004) have shown, shill bidding makes the seller worse off. Bidders make adjustments to avoid the seller's effort to run up the price. Any out-of-auction mechanism that would force sellers to abstain from participation

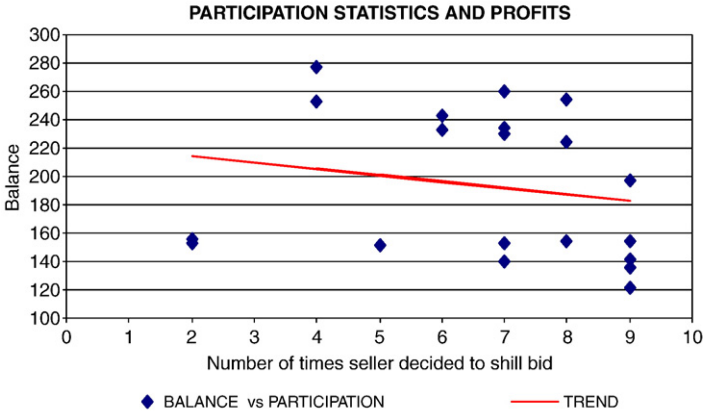

Fig. 5. Seller's participation and cumulative profit per session.

could increase their profits. The experimental results provide support to Hypothesis 4. In addition, the effect is so strong that when the variable "Seller Wins the Auction" is introduced in the profit equation (in column 3 of Table 5) to isolate the instances in which the seller is awarded the item and suffers a substantial loss, the variable "Seller's Potential Entry" remains significant (the profit decreases by 0.764 when there is an announcement of potential participation and the seller is not bidding extremely high to miss the opportunity of a real sale). This suggests that a seller is not losing only because he submits the highest bid by mistake, but because bidders discount the information that is revealed by other bids to account for the seller's manipulation.

In columns 4 and 5 of Table 5, we included a variable to capture the actual participation patterns of sellers. In these specifications, one variable controls for instances in which the seller has the opportunity to participate (Seller's potential entry), and another (Seller is participating in the auction) controls for his true actions, which are not observable by the rest of the bidders. This analysis aims at enhancing the picture drawn by the previous results. The control group represents auctions in which the seller is not allowed to enter. These results also suggest that the seller is better off with an enforcement mechanism that reduces his ability to participate. His payoff, however, is the lowest when he enters and bids at the auction (the profit decreases by 1.210 on average, and 0.709 if he is not the highest bidder). We would expect that, conditional on the probability of participation, the seller would be indifferent between submitting a bid or not if he is mixing between these strategies. This is not what happens here. Furthermore, the observation of shill bidding at the conclusion of an auction did not have a statistically significant effect on either prices or profits in the subsequent auction.[21] The bidders' beliefs played a more important role than the sporadic evidence of action.

We also tested the robustness of our results to changes in the order of announcements. From the graphs, one could suspect that the order of announcement plays a role in the bidding strategies. The results indicate that in controlling for other important factors determining prices and profits, the order of announcement does not make any statistically significant difference. The results are robust across all specifications.

[21] We also run the same set of regressions with an alternative variable showing the number of times a seller was caught cheating in previous auctions; that is, the number of times 5 bidders were observed submitting bids in the past. The results remained statistically insignificant and are not reported explicitly in the tables.

Chakraborty and Kosmopoulou (2004) compare profits at different rates of participation. They show that the lower the rate of participation in equilibrium the better off the seller is. Fig. 5 presents the seller's cumulative profit as a function of the number of times he has participated within a session. Each seller had the opportunity to shill bid at maximum 9 times. The actual number of times a seller submitted shill bids in a session ranges from 2 to 9 with a mean of 6.65 and a median of 7 times. The trend line passing through the data indicates that on average profits were slightly lower for those who decided to participate more often at auctions. This trend is, however, not significant and we don't find enough supporting evidence for Hypothesis 5.

6. Conclusions

This paper examines the effect of shill bidding in online auctions on the seller's payoff and on the price. Shill bidding makes the seller worse off as it was predicted in Chakraborty and Kosmopoulou (2004). Unlike their model, bidders suffer the winner's curse but prices decrease as they anticipate the behavior of sellers and adjust their bidding strategies. Shill bidding is more likely at a lower reserve price (as in Kauffman and Wood (2003)) and with a large number of bidders. Bidders' entry decisions are invariant to the announcement of seller participation even though their bidding strategies are not. Observational learning plays some role in decision making. The observation of consistently large past bidder participation affects profits. The observation of shill bidding at the conclusion of an auction had an effect on the entry decisions in the subsequent auction, but not on prices or profits. As Milgrom and Weber (2000) predicted, overall there is an increasing pattern of prices in the sequence. We conclude that the possibility of shill bidding to some extent alleviates the problem of the winner's curse and becomes beneficial for bidders but harmful for the seller.

Acknowledgment

We thank Charles Noussair, Ron Harstad, Jamie Kruse, George Deltas, Wijesuriya P. Dayawansa, the participants of the North American meetings of the Economic Science Association and the participants of the seminar series at Tulane University for helpful discussions and comments. The financial assistance of the University of Oklahoma Research Council is gratefully acknowledged.

Appendix A. Calculation of the optimal reserve

We need to determine the minimum entering signal s that allows the seller to maximize his profit given the bidding strategies. The expected price at the auction conditional on this cutoff signal is:

$$\begin{aligned}E[p|s] &= E[P|y_3 < s \le y_4] + E[P|y_2 < s \le y_3] + E[P|y_1 < s \le y_2] + E[P|s \le y_1]\\ &= \left(-\frac{5(-21+s)s^4}{388962} + \frac{s^2(17220+1448s-255s^2+7s^3)}{388962}\right.\\ &\quad -\frac{(-21+s)^2 s(-2080-90s+9s^2)}{777924}\\ &\quad \left. + \frac{(104482560-13481368s+198765s^2+42205s^3-2235s^4+33s^5)}{11668860}\right)\end{aligned}$$

where y_1,y_2,y_3,y_4 are order statistics.

Choosing s to maximize this expression yields a value of $s=8.57977$. Since we have discrete signals $s=9$. Based on this we can calculate the optimal reserve to be

$$r = \frac{9 + 3 \times \sum_{i=0}^{91} \frac{i}{9+1}}{4} = 5.625.$$

Since the clock goes up in increments of 0.25, we set the reserve at 5.5.

Definitions of the variables

Dependent variables	Description and construction of the variable
Price	The 'Price' is the drop out price of the second highest bidder.
Seller's profit	Seller's profit is the price minus a commission of 5% that goes to the auctioneer as payment for the services rendered. If a seller does not participate at all or if he participate and he is not the highest bidder, then the seller will receive the price minus the commission. If the seller becomes the highest bidder in an auction then he will not receive any payment on this item but he will still have to pay 5% as the commission even if the item is not sold to an actual bidder.
Quantitative independent variables	
Value	This is the value of the item to the bidders. This value is constructed as the average of the bidder's signals.
Number of bidders in the previous auction	This variable represents the observed number of participants in the last auction. It allows us to control for the aggressiveness of opponents based on observed patterns of participation.
Order of auction in the sequence	The variable captures effects that relate to the sequential nature of the auction in each session.
Balance	This variable captures the updated money balances carried forward by the bidders and sellers.
Qualitative independent variables	
Seller's potential entry	This is a dummy variable that takes the value of 1 in auctions in which the potential of participation is announced and zero when the seller is not allowed to participate.
The seller was observed to shill bid at the conclusion of the previous auction	This is dummy variable, which takes the value of 1 if there were 5 bidders in the previous auction and therefore, the bidders observed with certainty the shiller bidding and zero otherwise
Design	This dummy variable controls for the change in the order of treatments. For 5 of the experimental sessions performed at the reserve of 5.5 and 10 performed at the reserve of 6.25 the rules were as follows: the seller had to be passive in the first half of the auctions that took place. For 5 sessions performed at the reserve of 5.5, we changed the order of announcement to check if our results are robust. The seller had to be passive in auctions 1–5 and 10–13 and he could be active in the remaining auctions. For those five sessions the design dummy takes the value of 1 and 0 in all other sessions
Reserve	This is a dummy that takes the value of 1 when the reserve is 6.25 and zero when it is 5.5.
Seller wins the auctions	This is a dummy variable which takes the value 1 when seller wins the auction. This variable is introduced only in the profit equation to control for the instances in which the seller is awarded the item. Further, it allows the variable on potential entry announcement to isolate the effect of seller participation on the price the bidders pay.
The seller is not allowed to participate	This variable takes the value of 1 in auctions in which we announced that the seller could not participate. This variable is used only when the seller's profit is analyzed.

(continued on next page)

Appendix A (*continued*)

Dependent variables	Description and construction of the variable
The seller is participating	This is a dummy variable that takes the value of 1 if the seller participated in an auction. Note that, the rest of the bidders do not observe when the seller actually participates. This variable was used only for a seller's profit estimation.

Appendix B. Instructions

(The instructions were read to all participants.)

B.1. Initial Set of Instructions

Instructions to the bidders:

Welcome to the experiment! We will hold a series of online auctions following the same rules each time. The instructions are simple. If you read them carefully, take into account the reasoning of the other players and decide sensibly, you will make some money. Your profit depends on your success. Participation is voluntary. You are by no means obliged to participate in the experiment but if you do, you will get the chance to make some money if you make the right decisions. For each point that you will obtain in the experiment you will receive a quarter.

The game. The game will be played by groups of 4 people. If you decide to participate you will receive a starting balance of 60 points (That's $15). We will auction off 22 items, one at a time. Each item will be auctioned off to the highest bidder. The rules are slightly different than the rules of the standard auctions that you see online. Here are the differences:

The value. Every one of the 22 items has a different value. The value of each item is determined as follows: Each person will receive a signal at the beginning of each auction. The signal could be any integer between 0 and 20. All these numbers are equally likely. A person only knows his/her own signal. The value of the item is the same for all bidders; it is the average of the signals received by the 4 bidders. For example, if you received a signal of 0 and the signals received by the rest of the bidders are 9, 6, and 17, the common value of the item to all bidders will be: $(0+9+6+17)/4=8$. Your signal will be shown at the top border of your screen. You will always get information about your own signal. You will not get to know the signals of the other bidders before the end of the auction. When all members of a group receive their signal, the object is auctioned off.

The rules of the auction. When the auction begins a reserve price (a minimum acceptable bid) will be posted on your screen. After you receive your signal you will have a minute to decide whether to participate. If you decide to participate you have to press the button that says "participation" and wait for the rest of the bidders to make a decision. This is the only chance you will get to decide whether you are going to participate and bid in this particular auction. (If you don't find it profitable to participate in this auction, based on the information that you received on this item, you can still participate in the next round of auctions.) The value of the item depends on the signal of all 4 people no matter whether they decided to participate or not.

In the middle of the screen, you will see a button that shows a bid slowly counting upwards like a clock. Every active participant sees the same clock on his or her screen. When you press this button on your screen that says "Bid Here" your clock with stop counting up and you will leave the auction. The bid at which you pressed the button is called the "dropout price". The auction will continue with the participants that have not yet pressed their own buttons. When only one person remains in the auction, this person leaves automatically and obtains the object at the price that is currently indicated i.e., the dropout price of the second highest bidder that left the auction. For example, if there are two bidders remaining active in the auction and the one decides to dropout at the price of 7, the other bidder is awarded the item at 7.

The person that manages to obtain the object receives a certain amount of points on his or her account; this amount is determined by the common value of the item to all bidders minus the bid of the second highest bidder that left the auction. In the previous example, if the (common) value of the item is 8 (i.e., the average of the signal of all four bidders) and the dropout price of the second highest bidder is 7 then the highest bidder will earn a profit of $8-7=1$ that will be added to his account. If the dropout price of the second highest bidder was 11, however, the person that is awarded the item will lose $11-8=3$ that will be subtracted from his account balance.

Bankruptcy policy. As we mentioned before, you will have a 60-point balance in you account available for bidding. This is the maximum amount of points you can use bidding in these auctions. If at some point of time you lose all points overbidding on a series of items you will not get a chance to reenter and bid in subsequent rounds.

Useful information on the screen. As you decide on your strategy take into account the behavior of other participants. The dropout prices of the other participants are reported on the screen in the column that has the title bidding history. As soon as any player leaves the auction his dropout price becomes an entry in the bidding history. At the end of every round your remaining cash balance and the profit or loss will be displayed on the screen. You will also see the winning bid and the value of the item to the bidders.

To enter the experiment logon to http://129.15.117.138/NewDB/Georgia/page1.asp

Good luck!

Instructions to the seller:

For the first 12 rounds you will have the opportunity to observe the outcome in each auction, the bids and values of the items auctioned off. After the end of the first 12 auctions in the session, the rules will change and you will be given the opportunity to participate if you wish. You will receive further instructions at the end of round 12. Logon to http://129.15.117.138/NewDB/Georgia/page33.asp to observe the bidding process during the first 12 auctions.

B.2. Additional Instructions

Instructions to Bidders:

For the next set of auctions the seller has the opportunity to enter and bid if he finds it beneficial. The seller does not have any signal that could convey additional information about the value of the item to you. Whether the seller decides to participate or not and his/her identity will not be revealed during these auctions.

Instructions to the Seller:

Your value of the item is zero and it is independent of the value of other participants. Your initial cash balance will be 60 points. For each point that you will obtain in the experiment you will receive a dime. At this point in the experiment you have the opportunity to enter and participate if you wish. Every time an item is auctioned off to one of the bidders, independent of your participation decision, you will receive the price minus a commission of 5% that goes to the auctioneer as payment for the services rendered. If you become the highest bidder in an auction you will not receive any payment on this item but you will still have to pay 5% as the commission even if the item is not sold to an actual bidder. For example, if you are the last active person at the auction and the second highest bidder dropped out at a price of 9 you will have to pay 5% of 9 which is 0.45. If you do not participate at all or if you participate and you are not the highest bidder you will receive the price minus the commission. For example, if the second highest dropout price is 6 you will receive 6 and you will pay 5% of the price to the auctioneer. As a result your net profit will be 5.7. The bankruptcy policy that applies to the bidders applies to you too.

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