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2018

Document Version:
Other version

Link to publication

Citation for published version (APA):
Ingebretsen Carlson, J., & Wu , T. (2018). *Shill Bidding and Information in Sequential Auctions: A Laboratory Study*. (Working Papers; No. 2018:18).

Total number of authors:
2

Working Paper 2018:18

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June 2018

Shill Bidding and Information in Sequential Auctions: A Laboratory Study*

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June 18, 2018

Abstract

Second-price auctions with public information, such as those on eBay, provide an opportunity for sellers to use the information from finished and ongoing auctions when acting strategically in future auctions. Sellers have frequently been observed to bidding on their own item with the intent to artificially increase its price. This is known as shill bidding. Using lab experiments with two sequential auctions, we study the effect of shill bidding when the seller can choose to shill bid in the second auction. We also study the impact of different information revelation policies regarding the provision of the first auction bidding history to the seller. The experimental data confirm that shill bidding in the second auction affects outcomes in both auctions. Our findings are consistent with the predictions that the threat of shill bidding in the second auction does increase the bidders' final bid in the first auction. However, providing the seller with the bidding history from the first auction does not affect any important outcome variables.

*We are thankful for the constructive comments received from Ola Andersson, Jordi Brandts, Dan Levin, Antonio Miralles, Rosemarie Nagel, Erik Wengström and seminar participants at Universitat Autònoma de Barcelona, Lund University and at the CNEE 2017 meeting in Lund. We also thank Lluis Puig for helping us in conducting the experimental sessions. We gratefully acknowledge financial support from the Jan Wallander and Tom Hedelius Foundation [P2016-0126:1].

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1 Introduction

Sellers who auction an item often participate and act strategically. One such example is the possibility for the seller to choose a reservation price, which is the lowest price at which the seller is willing to sell the good. It has also been noticed that sellers participate in ways that are prohibited. In online auctions, it has frequently been observed that sellers bid on their own items with the aim of increasing the price of the item (see, e.g., Engelberg and Williams (2009); Grether et al. (2015); Kauffman and Wood (2005)). This practice is known as shill bidding and is commonly observed in online auctions partly since it is fairly difficult to be detected and because the auctions typically use the second price rule for determining the price of the item. The second price rule specifies that the price of the item equals the second highest bid that was submitted in the auction. A seller who shill bids can therefore increase the second highest bid, and thus the price of the item, without winning the auction. In this way, shill bidding can increase the seller's earnings. The existence of shill bidding can harm bidders trust in, and the effectiveness of, online auctions.

Second-price auctions are typically used because they are strategically simple for the bidders. Vickrey (1961) showed that bidders with independent private values who participate in a second-price auction have a dominant strategy which is to submit a bid equal to their private value. This strategic simplicity of a second-price auction does not change when the seller acts strategically, as long as only one item is auctioned. The reason for this is that, for any shill bid or reservation price submitted by the seller, the bidders can do no better than bidding their private value, as long as this is not lower than the current price (see Graham et al. (1990); Izmalkov (2004); Riley and Samuelson (1981)). However, in many instances similar items are sold in separate auctions that end at different points in time. The dutch flower auctions and online auctions are economically important examples where this occurs. Selling items sequentially gives sellers the possibility to use the information submitted by bidders in early auctions when acting strategically in future auctions. On eBay for example, sellers have access to the bidding history from finished and ongoing auctions, which gives them information about the demand for their items.[1] The sellers can then make use of this information

[1]In the bidding history, each bidder is assigned an anonymous ID. However, this ID is kept the same in all auctions, thus making it possible to track individual bidders and their bids.

when acting strategically in order to artificially increase the price of the item. As a response to this, bidders may be reluctant to provide information to the sellers in the early auctions by shading their bids.[2] Consequently, a seller who acts strategically in sequential auctions makes it more complicated for the bidders to decide on a strategy.

In this paper, we experimentally investigate the effects of sellers who act strategically in sequential auctions, using an English out-cry auction, which is reminiscent of the widely used eBay auction. In particular, we investigate how bidders in an early auction react to the threat of shill bidding as sellers can choose to submit shill bids in a future auction, and how this affects outcomes in early and future auctions. In addition to this, we study the impact of providing the sellers with different amounts of bidding information from the early auction, before they decide whether or not to shill bid in the future auction. The English out-cry auction format was chosen in order to more closely replicate the online auction environment, which is where shill bidding has been observed to frequently occur. In each round of the experiment, two items are sold using two distinct auctions, which are carried out sequentially. As on eBay, the auctions use the second price rule: the bidder who wins the item pays the price equal to the second highest bid submitted by a different bidder. Therefore, the sellers can increase their payoffs by shill bidding. We employ the following between-subjects experimental design with three treatments. The seller cannot shill bid in the first auction in any treatment. In the baseline treatment, the seller cannot shill bid in the second auction either. In the other two treatments, the seller can choose to participate and submit shill bids in the second auction. The two shill bidding treatments differ by the amount of information that is provided to the seller. The seller is provided with either the complete bidding history or no information at all from the first auction. When provided, the information is given to the sellers before they choose whether or not to participate as shill bidders in the second auction.

Using a simple theoretical framework, we derive two testable hypotheses regarding bidders' behavior in the first auction. First, the threat of shill bidding in the second auction ought to raise the bid in the first auction when no information is provided to the seller. This is similar to a competition effect. Second, by providing the shill bidding seller with the complete bidding

[2] A theoretical result of this can be found in Appendix A of this paper and in Katsenos (2010).

history from the first auction, bidders ought to lower their bids in the first auction. The reason for this is that the seller can infer the bidders' private values from the bidding history and thus submit shill bids in the second auction which extract all the surplus from the winning bidder. Therefore, submitting a lower bid in the first auction can be profitable for the bidders. In our experimental design, only the bidders who do not win the item in the first auction participate in the second auction. Consequently, the subjects who are participating in the shill bidding treatment in which information is provided have to trade off the possibility of winning the first auction by submitting a high bid with losing the first auction and providing the seller with more information. This Information can be used by the seller when shill bidding in the second auction.

The experimental data show that shill bidding in future auctions affects behavior and outcomes. Prices are higher in the first and second auctions when the seller can participate as a shill bidder. In spite of this, bidders do not earn less in the first auction, but so in the second auction. Sellers earn more in the first auction and, on average, the sellers are the winners of shill bidding in sequential auctions. An interesting finding is that shill bidding raises the efficiency of, in particular, the first auction. The reason for this is that the threat of shill bidding in the second auction makes bidders with a higher private value for the items bid higher than the corresponding bidders who do not experience this threat. Our rich behavioral data supports the hypothesis that bidders bid higher in the first auction when there is a threat of shill bidding in the second auction. Interestingly, providing the seller with the complete first auction bidding history does not affect the magnitude of the bidders' first auction bids. Ariely et al. (2005); Ockenfels and Roth (2006); Roth and Ockenfels (2002) analyzed the occurrence of last-minute bidding, also known as sniping, in the eBay and Amazon auctions. They found that sniping occurs more in the eBay auctions than in the Amazon auctions due to the use of a fixed deadline. The authors suggest that a potential reason for bidders to use sniping is to protect themselves from shill bidding. Interestingly, we find no difference in the timing of the bids between the treatments in the second auction, which is when the shill bidding occurs. Finally, providing the sellers with the complete bidding history from the first auction has no impact on any important outcome variables such as seller payoff or the probability of submitting a successful shill bid.

1.1 Related literature

The experimental literature on shill bidding is scarce. To the best of our knowledge, Kosmopoulou and De Silva (2007) have conducted the only experimental study on this topic. The authors investigated shill bidding when a single unit is auctioned and where bidders have common private values. The study supports the theoretical prediction that shill bidding is harmful for sellers as prices are lower in the English auction.

The issue of information disclosure in auctions is a more studied topic. However, most of these studies are focused on the information that is revealed to the bidders. Information disclosure becomes important when an auction is run many times. This has been initially studied by Dufwenberg and Gneezy (2002), who test different information disclosure policies in first-price sealed-bid auctions with a common value setting. They found that when bidders are informed about the losing bids in previous periods, prices are higher than the theoretical prediction. When information is not revealed, bids are closer to the theoretical prediction. Cason et al. (2011) reports a laboratory experiment that investigatedwhether bidders account for the trade-off between the desire to learn and the desire to prevent an opponent from learning private information, using a sequential procurement auction with private costs. The experimental results show that bidders prevent others from learning when complete information is revealed. Another related study was conducted by Katuščák et al. (2015). The study focuses on the impact of different types of posterior feedback on bidders' decision making in one-shot first-price auctions. The authors found that, while knowing the winning bid increases the bidders' bids, the bidders' ex ante knowledge of posterior feedback type has no systematic effect on the average bid/value ratio.

The eBay auction has been studied experimentally by, Ariely et al. (2005), previously mentioned. However, they implemented a version of the eBay auction in the lab in which time was discrete. This is different from our auction environment in which the subjects are given one minute to bid for the items. A study that implements a version of the eBay auction in the lab, which is similar to ours, was conducted by Wang (2006), who studied sequential sealed-bid second-price auctions as well as the eBay auction when the two highest bids from the early auctions are revealed to the bidders.[3]

[3]This auction format is often named an out-cry auction since the bidders can submit any number of bids during the auction. For more studies that implement a version of the out-cry auction see e.g. Elmaghraby et al. (2012); Gonçalves and Hey (2011); Kwasnica

The experimental results are in line with the theoretically derived bidding functions and a significant occurrence of sniping is observed.

The empircal literature on sequential auctions has found frequently that prices of similar items that are sold in a sequence decrease over time. Ashenfelter (1989) and Preston and Daniel (1993) were the first to observe this phenomenon in second price auctions and it has been named the decreasing price anomaly or the afternoon effect.[4] This is regarded an anomaly since economic intuition suggests that the law of one price should hold (see e.g. Milgrom and Weber (1999)). Our experimental study also finds decreasing prices over time in all three treatments. This is particularly interesting in the Baseline treatment in which there is no shill bidding and, thus, less uncertainty about future prices. This would also be the environment that is most similar to that studied by Milgrom and Weber (1999).

The outline of this paper is as follows: Section 2 explains the experimental design and the hypotheses which we will test using the experimental data. The results from the laboratory experiment are presented and discussed in Section 3. Finally, Section 4 concludes the paper.

2 Experimental design and hypotheses

In this section we explain the design of the experiment and our hypotheses. We start by outlining the auction environment, which is used in all treatments of the experiment, in Section 2.1. In Section 2.2 we explain the different treatments employed in the laboratory study. Then, in Section 2.3, we state and discuss our hypotheses. Finally, the details of the experiment are presented in Section 2.4.

2.1 Experimental auction environment

At the start of each round of the experiment, subjects are randomly matched into groups of five, which consist of one seller and four bidders.[5] Hence,

and Katok (2007); Sherstyuk and Dulatre (2008); Strecker (2010).

[4]For more studies that document the afternoon effect, see e.g. Andersson and Andersson (2017); Genesove (1992); Beggs and Graddy (1997); Ginsburgh (1998); Van Den Berg et al. (2001)

[5]Four (three in the second auction) bidders are chosen in order to avoid the potential problem of collusion. We follow Dufwenberg and Gneezy (2000), whose experimental evidence suggests that three bidders are enough to avoid collusion.

the seller is also a subject. We refer to such a group as a Market. The seller is selling two identical items using two auctions. The two auctions are conducted sequentially, which means that the second auction (SA) is conducted once the first auction (FA) is completed. Before the start of a round, each bidder receives a private value, which is the same for the two items that are to be sold in the FA and the SA. It is publicly known that the bidders' private values are independently drawn from a uniform distribution of integers between 0 to 100 experimental currency units (ECUs). A bidder's private value is displayed on the screen during the auctions.[6] Bidders have unit demand, which implies that the winner of the FA will not participate in the SA. All subjects start with a budget of 100 ECUs and they maintain their roles throughout the experiment.

The FA and the SA are designed as English out-cry auctions, which are reminiscent to the widely used eBay auction. We chose this auction format in order to more closely replicate the environment in which shill bidding has been frequently observed empirically. In any experimental auction, bidders are allowed to submit any number of bids for the item during one minute.[7] The auctions use the second price rule: the bidder who submits the highest bid, before the end of the 60 seconds, wins the auction and pays a price equal to the second highest bid that is submitted by a different bidder.[8] A winning bidder receives ECUs equal to his/her private value minus the price of the item and the losing bidders get zero.

In order for a bid to be accepted it must be greater than any previously accepted bid which was submitted by that subject. In addition to this, the bid needs to be greater than the current price, which equals the second highest bid at that moment. The current price starts at 1 ECU in any auction. The current price is displayed on the bidders' screens and is continuously updated as new bids are accepted. The bidding history, consisting of all past current prices from the auction, will be displayed to the bidders. However, the bids will be anonymous.[9] Moreover, the bidding history will be continuously updated as bidders submit more bids. If a subject has submitted the highest

[6]See Appendix D for screenshots from the different interfaces the subjects were shown during the experiment.

[7]A fixed deadline is chosen to closer replicate the eBay auction.

[8]In the case of several bidders submitting the same highest bid, the bidder who submitted it first wins the item.

[9]This differs from the eBay auction and is done in order to ensure a seller is not to easily detected when submitting a shill bid in the second auction.

bid at any moment, then the words “You are winning” will appear on the screen. Otherwise, the words “You are not winning” are displayed.

After completing any auction, the bidders are informed whether they have won the item or not, of their payoffs and their updated balance in ECU. In cases in which a bidder has incurred losses, a message to warn the bidder of this appears. Between the FA and the SA, bidders will be informed whether or not they will participate in the SA. The sellers receive a payoff equal to the price of the item in one of the FA or SA. A lottery with equal probability assigned to each auction is used to determine this payoff. This is done in order to minimize the wealth effect of the FA price on the sellers' shill bidding behavior. If the seller gets the price from the SA as a payoff and he won the SA by shill bidding, then as the seller pays the price to himself, the payoff is 0. The sellers will be informed about their payoffs and balances at the end of each round.

2.2 Treatments

The experiment has three distinct treatments to which subjects are randomly assigned. All treatment differences are with respect to the sellers and the specifics of a treatment are only told to the bidders of that treatment in the instructions.[10] The treatments differ in whether or not the seller can shill bid in the SA and which information the seller is given from the FA. In all three treatments, the seller is allowed neither to participate in nor watch the FA. As we are investigating how shill bidding in future auctions, and information, affect behavior in early auctions, the seller is only allowed to shill bid in the SA in the shill bidding treatments. Table 1 gives an overview of the treatments and their differences.

[10] A questionnaire also checked that the subjects had understood the specifics of the treatment they were in. See Appendix D for more details.

Table 1: Overview of the treatments employed in the experiment

Treatment	Shill bid FA	Information	Shill bid SA
Baseline	No	Yes	No
Treatment 1	No	Yes	Yes
Treatment 2	No	No	Yes

Notes: Deciding to shill bid is the sellers' choice and Information refers to the complete bidding history of all current prices from the FA and whether this is displayed to the seller before deciding to shill bid in the SA.

Baseline treatment: No shill bidding in the SA and information from the FA to the seller.

The sellers cannot actively participate in any of the auctions. During the FA the sellers will be shown a blank screen. Between the FA and the SA, the complete anonymous bidding history of all current prices (any bid that was ever the second highest bid) from the FA is provided to the seller. The seller watches the bidding live during the SA.

Treatment 1: Shill bidding in the SA and information from the FA to the seller.

During the FA, the sellers will be shown a blank screen. The complete anonymous bidding history of all current prices from the FA is displayed to the seller between the FA and the SA. Before the start of the SA, the sellers can choose to participate in the SA, in which they can choose to submit shill bids. Participating in the SA costs 1 ECU[11] and the rules for bidding, as well as the information displayed, are the same as for the bidders. The bidders are informed that it is the seller's choice whether or not to participate and submit shill bids in the SA. This information is only given to the bidders in the instructions. If a seller chooses not to participate in the SA, then the seller watches the bidding live during the SA.

[11]The cost is introduced in order to more clearly identify sellers who have an intent to shill bid.

Treatment 2: Shill bidding in the SA and no information from the FA to the seller.

This treatment is identical to Treatment 1 except that the complete anonymous bidding history of all current prices from the FA is not displayed to the seller between the FA and the SA. Between the FA and the SA, the seller is only informed whether or not the item in the FA was sold.

Treatment 1 is the environment which most resembles the situation in online auctions today and is, thus, the treatment in which we are most interested. When comparing Treatment 1 to the Baseline we can distinguish the effect of shill bidding and, by comparing Treatment 1 to Treatment 2, it is possible to single out the effect of the sellers' information. Moreover, we did not conduct a second baseline treatment in which the sellers had no information and in which they could not shill bid. The reason for this was, partly, because we are mostly interested in Treatment 1, with which we compare the other two treatments. Also, we believe that the behavior in the Baseline treatment should not differ much from such a "second baseline treatment" since the only difference is that the non-participating seller is observing the bidders' FA bids. As three other bidders already observe a bidder's bids in the FA and since these bids are anonymous, we believe that the additional observation effect of the non-participating seller is small.

2.3 Hypotheses

In addition to analyzing the overall effects of shill bidding and information, by conducting this experiment, we aim to address the following three main questions regarding bidder and seller behavior:

1. How does a potentially shill bidding seller in the SA affect the bidders' final FA bids?

2. Does disclosing the bidding history from the FA to a seller who is potentially shill bidding in the SA affect the bidders' final FA bids?

3. Does disclosing the bidding history from the FA to a seller who is shill bidding in the SA affect the seller's ability to submit a successful shill bid and to extract a higher payoff?

In the following, we will present three research hypotheses, which address one question each. Regarding bidders' behavior we will present the intuition for our two hypotheses in this section. However, in Appendix A, we present the theoretical results that support this intuition, using a simplified theoretical model.[12]

Starting from the SA, the bidders have a dominant strategy to submit a bid equal to their private value. This is unaffected by whether or not the seller is shill bidding in the SA. As for any shill bid submitted by the seller, the bidders can do no better than bidding their private value, as long as this is not lower than the current price (see Graham et al. (1990); Izmalkov (2004); Riley and Samuelson (1981)). Turning to the FA, a bidder is trading off the possibility of winning an item now or waiting to possibly acquire an item in the SA. In a case in which the seller cannot shill bid, it turns out that the bidders optimal strategy is to submit a bid equal to what they expect to pay in the SA, conditional on winning the SA. This implies that the bidders who participate in the Baseline treatment should bid below their private value in the FA to account for less competition in the SA. Allowing the sellers to shill bid in the SA, but not giving them the complete bidding history from the FA, gives rise to a "competition effect". The bidders should still submit a bid equal to the expected payment in the SA. However, we assume that with a positive probability, p, the bidders believe that the seller will submit a successful shill bid. A successful shill bid is a shill bid that raises the price of the item in the SA. Consequently, with probability $1 - p$, the bidders expect to pay the price that would hold if the seller could not shill bid, and with probability p, the bidders expect to pay a higher price. Therefore, the expected payment in the SA is higher when the sellers are allowed to shill bid. We arrive at our first hypothesis:

Hypothesis 1. *When the sellers are allowed to shill bid in the SA, but are not given the FA bidding history, then the bidders' FA final bids are higher than when the sellers are not allowed to shill bid in the SA.*

Consequently, we expect the bids to be higher in Treatment 2 than in the Baseline.

Now we turn to the situation in Treatment 1 in which, before submitting a shill bid in the SA, the seller can observe all bids that were ever the current price in the FA. In this scenario, the sellers can use the bidding information

[12]As the English-outcry auction is complicated to analyze theoretically, we make the key simplifying assumption that each auction is conducted as a sealed-bid second-price auction.

from the FA to more accurately calibrate their shill bids in the SA and thereby extract more of the bidders' surplus. Since the seller is allowed to shill bid, the expected payment in the SA is raised, which thus also raises the bidders' FA bids in this scenario relative to when the seller cannot shill bid. However, because the seller is shown the FA bidding history before shill bidding in the SA, the bidders have an incentive to under-report their FA bids relative to this strategy.[13] Based on this, we hypothesize that informing the sellers of all bids that were ever the current price in the FA before shill bidding in the SA will decrease the bidders' final FA bids relative to when the shill bidding sellers do not have this information.

Hypothesis 2. *When a seller who has the possibility to shill bid in the SA is provided with the complete bidding history from the FA, the bidders' FA final bids are lower than when the shill bidding seller has no such information.*

In line with this, we expect that the FA final bids are lower in Treatment 1 than in Treatment 2.[14] When comparing Treatment 1 to the Baseline the two effects from Hypothesis 1 and Hypothesis 2 are present and go in opposite directions. Thus, we have no clear prediction between these two treatments and which effect is stronger will be investigated using the experimental data.

In addition to the bidders, the sellers themselves may be affected by being shown the bidding history from the FA. Our experimental setting allows us to analyze the effects of information on sellers' behavior since the sellers are subjects and not programmed by a computer. It seems intuitive that having access to more information about bidders' submitted bids in the FA increases the probability that the sellers submit a successful shill bid in the SA. In addition to this, more information ought to make it easier for sellers to extract a higher surplus from the bidders and to decide when to abstain

[13]In the theoretical model, we assume that the bidders follow a symmetric and strictly increasing bidding function in the FA. If the bidders follow this strategy, then the sellers can infer the private values of the bidders from the FA bidding history by inverting the bidding function. Therefore, the bidders expect a 0 payoff in the SA if they follow this symmetric bidding strategy. Consequently, the bidders have an incentive to deviate from any such FA bidding strategy by under-reporting in order to increase their possible earnings in the SA.

[14]In the case in which the bidders believe that the expected payment is greater in Treatment 1 than in Treatment 2, then this might counteract the effect of providing the seller with the FA bidding history and bids may be higher in Treatment 1 than in Treatment 2. By testing Hypothesis 2, we thus take a conservative approach in testing whether providing the seller with the FA bidding history has an effect on bidders' FA bids.

from shill bidding. Therefore, we hypothesize that the sellers' payoff will be higher when they are given the complete bidding history from the FA. Thus, we have our third hypothesis:

Hypothesis 3. *Shill bidding sellers who observe the bidding history from the FA submit more successful shill bids and earn a higher payoff in the SA than shill bidding sellers who are not allowed to see the FA bidding history.*

2.4 Details of the experiment

We ran nine sessions during April 2017 at the Autonomous University of Barcelona. Each session consisted of 20 participants and we had 180 participants in total. Participants were students at the Autonomous University of Barcelona and were recruited using the Online Recruitment System for Economic Experiments (ORSEE). All sessions were computerized and programmed using the z-Tree software (Fischbacher, 2007). Instructions were read aloud, questions were answered in private, and no communication was allowed between subjects. Before starting the experiment, subjects had to pass a comprehension test and complete two test rounds (See Appendix C for the instructions and Appendix D for the comprehension test). The experiment consisted of 20 rounds, for which the subjects were paid. To increase the number of independent observations, we created, within each session, two groups of ten subjects with two sellers and eight bidders in each. Throughout the paper, we will refer to any such independent observation as a Group. After the end of an experimental round, subjects were randomly re-matched within their Group while maintaining their roles. Subjects were told that they were re-matched, but not about the specifics of the rematching procedure. To equalize payments across roles, at the end of the experiment, 100 ECU was converted to 1 euro for bidders and 0.4 euros for sellers. Average earnings were 15.68 euros and subjects spent approximately two hours in the lab. Table 2 summarizes the structure of our experimental design.

3 Experimental Results

In this section, we present the experimental results of our study. We start by analyzing the overall effects of shill bidding in Section 3.1. Then, we continue by exploring bidder behavior in Section 3.2 and seller behavior in Section 3.3. We will sometimes refer to the Baseline as B, Treatment 1 as T1

Table 2: Overview of experimental design

Treatment	Independent Groups	Markets/ Group	Subjects/ Market	Number of Subjects	Number of Periods
Baseline (No shillbid & Info)	6	2	5	60	20
Treatment 1 (Shillbid & Info)	6	2	5	60	20
Treatment 2 (Shillbid & No info)	6	2	5	60	20
Total Number of Subjects	180				

and Treatment 2 as T2. When we test for differences in means accross the treatments, we will use the Mann-Whitney U rank sum test on the independent Group averages. The p-values for this test will be denoted by p_{MWU}. Sometimes we will also test for mean differences within treatments, then we will use the Wilcoxon matched-pairs signed-ranks test on the independent Group averages. The p-values for this test will be denoted by p_{SR}. Finally, some, but not all, of the regression analysis can be found in Appendix B. A complete description of all variables that have been used in the regression analysis can be found in Table 6 and Table 7 of Appendix A.1.

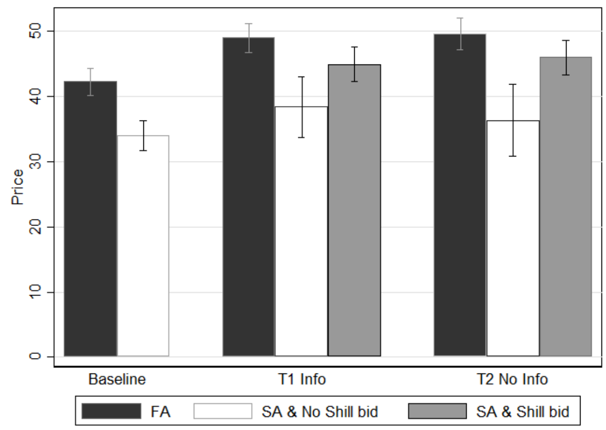
3.1 The effects of shill bidding

We start by analyzing the effects of shill bidding on prices, payoffs and efficiency. Tables 8, 9 and 10 in Appendix B, present the results from various regressions which confirm the results of this section.

Figure 1 shows, by treatment, the average final prices in the FA and average final prices in the SA divided by whether or not the seller shill bidded. From Figure 1, we can conclude that shill bidding affects the average final prices in both the FA and the SA. The FA average final prices are signficantly higher in the shill bidding treatments (48.9 in T1 and 49.5 in T2) than in the Baseline (42.2) (B vs T1, $p_{MWU} = 0.0374$ and B vs T2, $p_{MWU} = 0.0782$). The same is true for the SA average final prices, which are 33.9, 43.0 and 43.7 in B, T1 and T2, respectively (B vs T1, $p_{MWU} = 0.0303$ and B vs T2, $p_{MWU} = 0.0547$). This amounts to a price increase in the shill bidding treatments of around 17% in the FA and 27% in the SA.

The sellers submitted at least one shill bid in 71.3% of the SAs in T1 and 76.7% in T2. The SA final prices are 44.9 in T1 and 45.9 in T2 when the seller shill bids. Therefore, average SA final prices are higher in both shill bidding treatments when the seller shill bids compared to the average SA final price in the Baseline (33.9) (B vs T1, $p_{MWU} = 0.025$ and B vs T2, $p_{MWU} = 0.0104$).

Figure 1: Average final prices



Notes: The lines show 95% confidence intervals. There are 240 observations for the FA of each treatment and the SA in the Baseline. For SA & No Shill bid, 68 observations are used in T1 and 56 for T2. Consequently, for SA & Shill bid, 172 observations are used for T1 and 184 for T2.

However, there are no statistically significant differences in SA final prices between the Baseline and the shill bidding treatments when the seller did not choose to shill bid. Furthermore, comparing the two shill bidding treatments, average final prices are not different. This is particularly interesting in the SA, as having access to previous bidding history does not increase the ability of the shill bidding seller to increase the final price. Finally, prices are higher in the FA than in the SA. In fact, for each Group, the average final price is higher in the FA than in the SA. As Ashenfelter (1989); Preston and Daniel (1993) and others, we find evidence of the declining price anomaly in all three treatments. In relation to this we find that the average FA price in the Baseline is close to the theoretically expected price of 40[15]. As prices are predicted to be the same in both auctions, the average SA prices in the Baseline are lower than expected in theory. In Table 8 of Appendix B, we

[15]40 is the expected private value of the bidder with the third highest private value. It is equal to the expected third order statistic of the uniform distribution, when there are four draws. Since the price of the item is expected to be determined by the bidder with the the third highest private value in the SA and each bidder has a dominant strategy to bid their private value in the SA, the expexted price is thus 40 in the SA. The FA price is also expected to be 40 as the two prices should be the same.

provide the results from OLS regressions, which confirm these results.

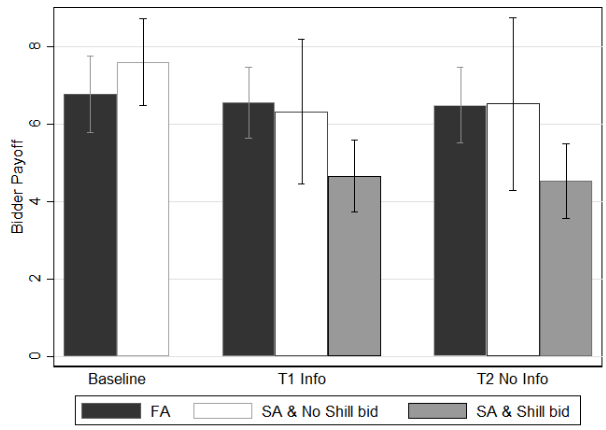
Result 1. *Prices:* ***(i)*** *Shill bidding in the second auction increases prices in both the first and the second auctions.* ***(ii)*** *In the second auction, prices are higher when the sellers shill bid compared to when they do not.* ***(iii)*** *Prices are higher in the first auction than in the second auction in all three treatments.*

As a seller's payoff in the FA equals the FA price, the seller earns more from the FA in the two shill bidding treatments than in the Baseline.[16] However, even though Figure 1 displays higher SA auction prices in the two shill bidding treatments, the sellers' average payoff from the SA is not different across any of the three treatments. The reason for this is that the sellers sometimes win the item in the SA, in which case the payoff is 0.[17] Out of all the SAs in which the seller shill bids, the seller won the item in 14.6% of the cases in T1 and 17.4% in T2. As the sellers' average SA payoffs are 33.9 in Baseline, 38.6 in T1 and 37.3 in T2, shill bidding does not hurt the seller on average. Conditional on the seller shill bidding, the SA average final prices are not different when the sellers win the SA (42.1 in T1 and 47.4 in T2) compared to when they do not win the SA (45.4 in T1 and 45.6 in T2). Therefore, as can be seen in Figure 1, shill bidding succesfully raises the SA payoff when the seller does not win the item in the SA in both shill bidding treatments (B vs T1, $p_{MWU} = 0.025$ and B vs T2, $p_{MWU} = 0.0104$). GLS random effects regressions confirming these results are shown in Table 9 of Appendix B.

[16]In the analysis of sellers payoff we include the payoff of the sellers from both auctions and thus disregard that the sellers were only paid one of the two prices, which was chosen by a lottery at the end of the round.

[17]In the experiment, there was a cost of 1 ECU for sellers participating as a shill bidder. This cost is disregarded in this analysis.

Figure 2: Average bidder payoff



Notes: The lines show 95% confidence intervals. There are 960 observations for the FA of each treatment and the SA in the Baseline. For SA & No Shill bid, 272 observations are used for T1 and 224 for T2. Consequently, for SA & Shill bid, 688 observations are used for T1 and 736 for T2.

Figure 2 shows the average bidder payoffs in the FA as well as in the SA conditional on whether or not the seller shill bidded, by each treatment. Surprisingly, we can see that, in spite of the higher FA average prices in the shill bidding treatments, bidders' FA payoffs are not different between any of the three treatments. The bidders' average FA payoffs are 6.7 in B, 6.5 in T1 and 6.2 in T2. As expected, however, the bidders' average SA payoffs are lower in the shill bidding treatments compared to the Baseline (B vs T1, $p_{MWU} = 0.025$ and B vs T2, $p_{MWU} = 0.0104$). The bidders' average SA payoff were 7.3 in the Baseline, 5.1 in T1 and 4.5 in T2. Analyzing the effects of shill bidding on the bidders' SA payoffs, we find that payoffs are lower in the shill bidding treatments when the seller shill bids (4.6 in T1 and 4.4 in T2) compared to the Baseline (B vs T1, $p_{MWU} = 0.0163$ and B vs T2, $p_{MWU} = 0.0104$). Comparing when the sellers do not shill bid, there are no differences across the treatments. Table 10 in Appendix B presents the GLS random effects regressions results regarding bidder payoffs.[18]

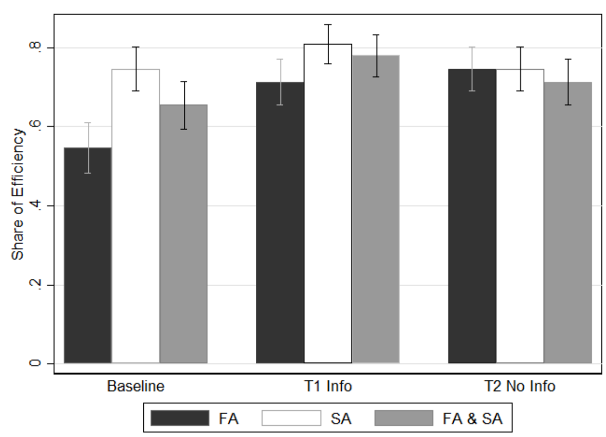
[18]The GLS random effects regressions confirm the results. However, in models (4) and (6), with bidder SA payoff as a dependent variable, the coefficients of the shill bidding treatments are negative but not statistically significant.

Finally, as prices are decreasing over time within a round, sellers earn more in the FA than in the SA. Bidders also earn more in the FA than in the SA in T1 ($p_{SR} = 0.0277$). For the Baseline and T2, there are no significant differences in the bidders' payoffs between the FA and SA.

Result 2. *Payoffs: Due to shill bidding in the second auction,* ***(i)*** *sellers' payoffs are increased in the first auction and are not lowered in the second auction; and* ***(ii)*** *bidders' payoffs are not affected in the first auction, but their second auction payoffs are lower.*

The somewhat surprising result that bidders' FA payoffs are not lower in the shill bidding treatments compared to the Baseline can be explained by differences in efficiency across the different treatments. Figure 3, shows the average efficiency for the FA, the SA, and for both the FA and SA together, by the different treatments. The FA (or SA) is efficient if the bidder with the highest private value among the participating bidders of that auction wins the item. The FA and SA are both said to be efficient together if the bidders with the highest and second highest private values in that Market win the items. Thus,the order in which they win the items is unimportant.

Figure 3: Average efficiency



Notes: The lines show 95% confidence intervals. All means are calculated using 240 observations.

As can be seen in Figure 3, the average efficiency is higher in the FA for the shill bidding treatments compared to the Baseline (B vs T1, $p_{MWU} = 0.0159$

and B vs T2, $p_{MWU} = 0.0127$). The difference is sizeable as, while the average FA efficiency is 54.6% in the Baseline, it is 71.3% in T1 and 74.6% in T2. As bidders with the highest private value win the FA, to a larger extent, in the shill bidding treatments than in the Baseline, this counteracts the increase of the average final prices in the shill bidding treatments on the bidders' average earnings in the FA. There are no treatment differences in SA efficiency. Taking both the FA and SA together, shill bidding in Treatment 1, but not in Treatment 2, increases efficiency compared to the Baseline (B vs T1, $p_{MWU} = 0.0526$). Both the FA and SA are efficient in 65.4% of the cases in the Baseline, 77.9% in T1 and 71.3% in T2. Furthermore, the averages shown in Figure 3 include all SAs in which the sellers win the item and efficiency is never lower in any of the two shill bidding treatments compared to the Baseline.

Result 3. *Efficiency: Shill bidding in the second auction,* ***(i)*** *increases efficiency in the first auction; and* ***(ii)*** *does not lower efficiency in the second auction nor both auctions together.*

3.2 Bidder behavior

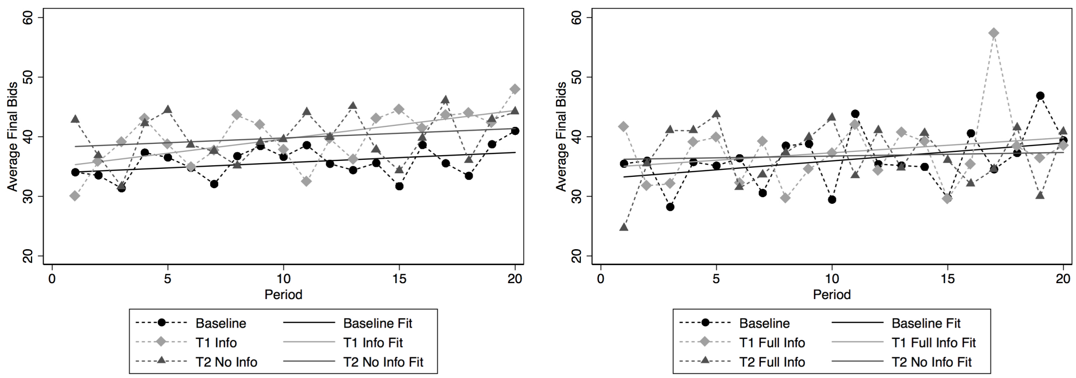
In this section we look deeper into how the bidders behaved in the experiment. We start by analyzing the bidders' final bids and then we continue with the timing of the bids.

Figure 4 shows the bidders' FA and SA average final bids in each of the 20 periods, as well as a fitted trend, by each treatment.

Figure 4: Bidders' average final bids over time

(a) First auction

(b) Second auction



Even though the average FA bid is higher in the shill bidding treatments (39.9 in both) compared to the Baseline (35.8), the Mann-Whitney U tests on the Group averages show that there are no statistically significant treatment differences. Thus, on average, we do not find support for either Hypothesis 1 or Hypothesis 2. One reason for this might be that bidders may be unable to submit their desired final bid in our auction environment. This is most likely to happen to bidders with a low private value since the other bidders may push the current price above their desired final bid before they submitted this bid. In cases in which this happens, the bidders with a low private value are unable to submit their desired final bids. Figure 5 shows the FA and SA average final bids by private value.

Figure 5: Average final bids by private value

(a) First auction (b) Second auction

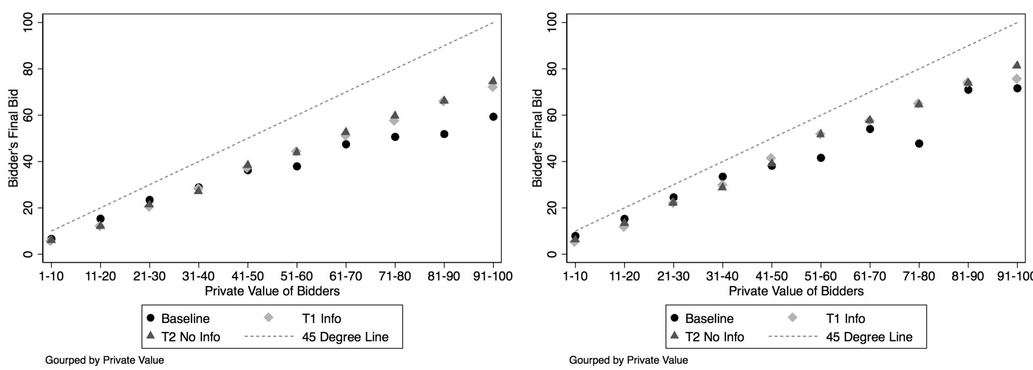


Figure 5a suggests that bidders with a private value above 50 increase their FA final bid more in the shill bidding treatments compared to the corresponding bidders in the Baseline. Moreover, the bidders with a private value of 50 and above are less likely to be unable to submit their desired final bid.[19] Hence, Figure 5a suggests that shill bidding in the SA increases the FA bids of the bidders who have a higher probability of actually winning the item in the FA. Table 3, which shows the results of several GLS random effects regressions with FA final bid as dependent variable, confirms this picture.

[19]A crude measure of this is to count the number of bidders for whom the FA final price is higher than or equal to their private value and who do not submit the highest or second highest bid. By doing this, only 9.5% of the bidders with a privatevalue above 50 are unable to submit their desired bid. For the bidders with a private value of 50 or less, this number is 73.5%.

Table 3: GLS random effects regressions with bidders' FA final bids as dependent variable

	(1)	(2)	(3)	(4)
	Final FA bid	Final FA bid	Final FA bid	Final FA bid
T1	4.148*	1.625	-5.552**	-7.555**
	[2.294]	[2.179]	[2.630]	[3.386]
T2	4.144*	2.453	-5.123**	-7.436**
	[2.511]	[2.633]	[2.119]	[3.092]
Private value * T1			0.181***	0.184***
			[0.0612]	[0.0576]
Private value * T2			0.186***	0.199***
			[0.0528]	[0.0512]
Private value		0.662***	0.567***	0.533***
		[0.0328]	[0.0426]	[0.0378]
Nr of previous shill bidding SA		0.290		0.272
		[0.199]		[0.202]
Nr bids FA		1.288***		1.324***
		[0.188]		[0.198]
% of earlier wins FA		3.887*		4.160*
		[2.129]		[2.325]
% of earlier wins SA		3.258		2.848
		[2.054]		[2.043]
Last period balance		-0.0123		-0.0127
		[0.00863]		[0.00901]
Period		0.235		0.252
		[0.218]		[0.225]
Constant	35.72***	-2.849	7.223***	3.505
	[1.695]	[2.644]	[2.035]	[2.933]
Observations	2,880	2,880	2,880	2,880
Number of Subject	144	144	144	144
Clusters	18	18	18	18

Notes: Robust standard errors clustered at Group level in brackets

*** p<0.01, ** p<0.05, * p<0.1

The results of model (4) show that the effect of an increase in the private value on FA final bid is 34.5% larger in T1 (Private value * T1) and 37.3% larger in T2 (Private value * T2) compared to the Baseline (Private value). In model (4), we add several control variables, which does not affect the estimates. Models (1) and (2) suggest that FA bids are weakly higher, on average, in the shill bidding treatments (T1 and T2) compared to the Baseline. However, we find no significant differences between T1 and T2. Hence, giving the seller access to the FA bidding history does not change the magnitude of the FA bids submitted by the bidders. In summary, we find support for Hypothesis 1, at least for the bidders with a private value above average, but not for Hypothesis 2.

Result 4. *Bidders' first auction final bid:* ***(i)*** *Partly in line with the prediction of Hypothesis 1, shill bidding in the second auction increases the first auction final bid, at least for bidders with a private value greater than average.* ***(ii)*** *Contrary to Hypothesis 2, providing the seller with the complete bidding history from the first auction does not lower the bidders' first auction final bid.*

Figure 4b shows the bidders' average final bid in the SA in each period. As can be seen, there are virtually no treatment differences in the average SA final bids, which is confirmed by the Mann-Whitney U tests on the Group averages. Dividing the bidders by private value, Figure 5b shows a somewhat similar picture in the SA as in the FA: bidders with a higher private value bid higher in the shill bidding treatments compared to the Baseline. However, GLS random effects regressions with the SA final bid as the dependent variable show that this effect is weaker in the SA than in the FA. The results are displayed in Table 4, in which only the bidders who did not win the FA are included. In model (3) of Table 4, the effect of private value is only significant for T1 (Private value * T1) and at the 10% level. The effect is also smaller in magnitude compared to the FA. Including controls for the seller submitting shill bids in the SA and their interactions with private value (Seller shill bids * Private value * T1 and Seller shill bids * Private value * T2), model (5) suggests that the effect of private value is stronger when the seller submits shill bids. This is particularly true for T2.

Table 4: GLS random effects regressions with bidders' SA final bid as dependent variable

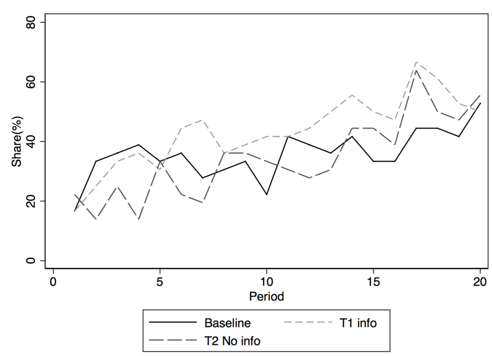
	(1)	(2)	(3)	(4)	(5)
	Final SA bid	Final SA bid	Final SA bid	Final SA bid	Final SA bid
T1	1.334	3.838	-4.433**	-2.247	-0.350
	[2.725]	[3.152]	[1.917]	[2.024]	[2.464]
T2	0.702	4.124	-3.893**	-1.675	2.299
	[3.038]	[3.368]	[1.693]	[1.964]	[2.131]
Seller shill bids * T1					-2.870
					[2.706]
Seller shill bids * T2					-5.519**
					[2.215]
Seller shill bids * Private value * T1					0.0856
					[0.0698]
Seller shill bids * Private value * T2					0.142***
					[0.0507]
Private value * T1			0.147*	0.138*	0.0789
			[0.0859]	[0.0820]	[0.0956]
Private value * T2			0.138	0.132	0.0259
			[0.0886]	[0.0879]	[0.0958]
Private value		0.784***	0.711***	0.697***	0.697***
		[0.0375]	[0.0778]	[0.0765]	[0.0767]
Nr of previous shill bidding SA		-0.167		-0.154	-0.137
		[0.168]		[0.161]	[0.159]
Nr bids SA		1.198***		1.172***	1.164***
		[0.238]		[0.228]	[0.228]
% of earlier wins FA		-0.205		-0.0454	0.129
		[2.253]		[2.294]	[2.268]
% of earlier wins SA		0.495		0.391	0.303
		[2.631]		[2.563]	[2.526]
Last period balance		0.0214***		0.0214***	0.0214***
		[0.00535]		[0.00561]	[0.00551]
Period		0.0969		0.0896	0.0761
		[0.123]		[0.121]	[0.119]
Constant	36.10***	-7.536***	5.112***	-3.584*	-3.459*
	[2.348]	[2.578]	[1.503]	[1.967]	[1.957]
Observations	2,164	2,164	2,164	2,164	2,164
Number of Subject	144	144	144	144	144
Clusters	18	18	18	18	18

Notes: Robust standard errors clustered at Group level in brackets

*** p<0.01, ** p<0.05, * p<0.1

The fact that we found no (or very small) treatment differences in the bidders' SA behavior is expected as the bidders have a dominant strategy in all treatments, which is to submit a final bid equal to their private value. The question of whether bidders actually do this or not naturally arises. Figure 6 shows the share of bidders in the SA who submitted a bid equal to their private value by treatment and period. There are no significant treatment differences, but bidders seem to learn over time. While only 18.7% of the bidders submitted a bid equal to their private value in the first period, 52.8% did so in the last period.[20]

Figure 6: Share of bidders who submitted a final bid equal to private valuein the second auction



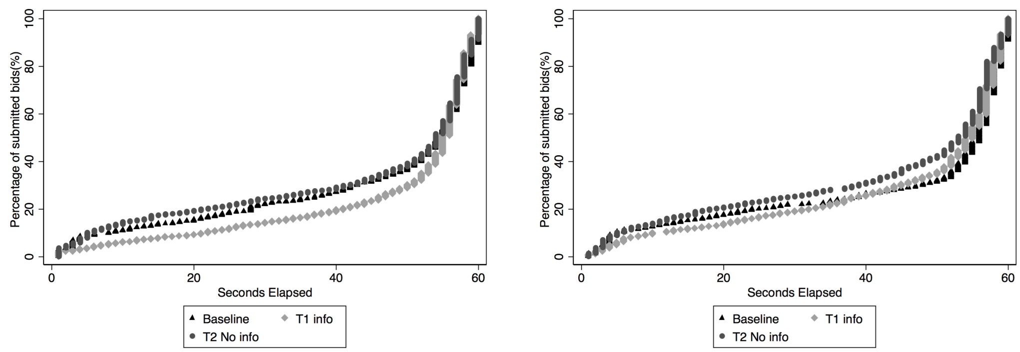
Finally, by comparing Figure 5a and Figure 5b, it is possible to see that bidders bid higher relative to their private value in the SA than in the FA. In particular, if we look at the bidders who participated in both the FA and the SA, all Group averages for SA bids are higher than their FA counterparts.

Result 5. *Bidders' second auction final bid:* ***(i)*** *In line with what is expected, there are no treatment differences in bidders' SA final bids.* ***(ii)*** *Bidders seem to learn, as they use their optimal strategy, which is to submit a final bid equal to their private value, more over time. However, the majority of bidders does not use this strategy, on average.*

[20]In the FA, bidders submit a bid equal to their private value more often in the later auctions in T1 and T2, but not in the Baseline. This could be interpreted as the bidders learning about the threat of shill bidding in the SA and, therefore, bid high in the FA in order to avoid participating in the SA".

Figure 7: Cumulative distributions of bidders' submitted final bids over time in first and second auctions

(a) First auction (b) Second auction



Now we turn to the timing of the bidders' bids. Ariely et al. (2005); Ockenfels and Roth (2006) and Roth and Ockenfels (2002) analyzed the occurence of last-minute bidding, also known as sniping, in the eBay and Amazon auctions. Their studies found that sniping occured frequently in the eBay auctions, but not in the Amazon auctions. The reason for this, they argued, was that eBay auctions had a fixed ending time, while Amazon auctions did not. The authors suggest that one potential reason for bidders to use a sniping strategy is to protect themselves from shill bidding. As Roth and Ockenfels (2002), we analyze this by comparing the distribution of submitted final bids over time. Figure 7 shows the cumulative distributions of the bidders' submitted final bids over time in the FA and SA respectively, by each treatment. We can conclude that a lot of late bidding occurs in both the FA and the SA. However, from Figure 7b, it is possible to conclude that there are virtually no treatment differences in the SA. This is particularly interesting since these are the auctions in which the shill bidding actually occurs in T1 and T2. Table 11 in Appendix B shows probit regressions with the probability of submitting a late SA bid as a dependent variable exluding the bidders who won the FA. As the auctions in our experiment only last for one minute, a late bid is defined as either occuring after 50 (models (1) and (2)) or 55 seconds (models (3) and (4)). If anything, the results of Table 11 show that bidders are less likely to use a sniping strategy in the shill bidding treatments. Turning to the FA, Figure 7a suggests that bidders submit their

FA final bid later in T1 than in T2 and the Baseline. However, the results of the probit regressions for FA late bidding, which are displayed in Table 12 in Appendix B, suggest that there are no such differences.

Result 6. *Late bidding (sniping): A lot of sniping is observed, but shill bidding does not increase the amount of sniping.*

3.3 Seller behavior

The first thing that can be noted about sellers is that they behave differently compared to bidders in many respects. Conditional on shill bidding, sellers submit fewer late bids and more early bids than bidders. They also submit more bids in general and sellers' early bids are smaller than bidders' early bids. However, there are no differences in the magnitude of final SA bids between bidders and sellers (For regression results, see Table 13 and Table 14 in Appendix B).

Table 5: Means of descriptive statistics for sellers by the two shill bidding treatments

Variables	Treatment 1 - Full info	Treatment 2 - No info
P. Second auctions seller shill bids (%)	71.3	76.7
	(45.35)	(42.38)
P. Second auctions seller shill bids and wins (%)	14.6	17.7
	(35.43)	(42.38)
P. Successful shill bid	30.41	25
	(46.14)	(43.42)
Average final bid in second auction	38.03	35.19
	(18.63)	(21.92)
Number of bids in second auction	4.64	3.72
	(2.62)	(2.42)
P. bid in last 10 seconds (%)	50.3	39.7
	(50.15)	(49.06)
Average first bid in second auction	13.89	14.53
	(11.57)	(14.69)
P. first bid in second auction (%)	60.8	48.9
	(48.96)	(50.12)

Notes: P. stands for Percentage of. All averages except for P. Second auctions seller shill bids are calculated conditional on the seller shill bidding. Standard errors within parentheses.

Table 5 shows, by the two shill bidding treatments, the means of the following descriptive statistics for sellers: the percentage of SAs in which the seller shill bidded, the percentage of SAs in which the seller shill bidded and won the item, the percentage of successful shill bids, the average final SA bid, the number of submitted bids in the SA, the percentage of bids submitted in the last 10 seconds, the average magnitude of the first bid in the SA and the percentage of first bids submitted. All averages except the percentage of SAs in which the seller shill bidded are calculated conditional on the seller shill bidding. A successful shill bid is defined as a bid that is equal to the second highest bid and, thus, the price of the item. Using Mann-Whitney U tests on the Group averages to test for treatment differences, none of the statistics in Table 5 are statistically different across the two shill bidding treatments. In Section 3.1, we saw that there were no differences in the sellers' payoff between the two shill bidding treatments. Consequently, providing the seller with the complete bidding history from the FA does not affect behavior or outcomes for the seller and, hence, we find no support for Hypothesis 3.

Result 7. *Information and sellers: Providing the seller with the complete bidding history from the first auction* ***(i)*** *does not alter the sellers' behavior,* ***(ii)*** *nor does it improve their performance or payoff. Hence, we find no support for Hypothesis 3.*

4 Conclusion

We conducted a laboratory experiment to test the effects of shill bidding in sequential auctions. The experiment replicates a real-world issue in online auctions that has been observed by previous researchers. We simplifyed the complicated real-world market by using two second-price out-cry auctions, which were conducted sequentially, in each round and ran them in a repeated game framework. The seller could never shill bid in the first auction and our experiment employed a between-subjects design with one baseline, in which the seller could not shill bid in the second auction, and two treatments in which the seller could choose to shill bid in the second auction. The two shill bidding treatments differed by whether or not the seller was provided with the complete bidding history of all bids that were ever the current price from the first auction.

We find that shill bidding in the second auction affects outcomes in both auctions. Prices are higher in both auctions and sellers earn more from the first auction. Bidders earn less in the second auction, but since shill bidding increases the efficiency of the first auction, bidders do not earn less in the first auction. The behavioral data show that bidders with a private value above average increase their first auction bids more in the shill bidding treatments than in the Baseline. Providing the seller with the bidding history from the first auction has very little effect and we find few differences between the two shill bidding treatments. Particuarly interesting is the fact that sellers who are provided with this information neither earn more nor shill bid better. This suggests that the information provided during the second auction matters more than the bidding history from the first auction.

Our experiment suggests a few open questions for future research. A natural extension to our experimental design is to compare shill bidding to the case in which the seller chooses a reservation price before the start of the second auction. In this case, we hypothesize that, since the sellers only act before the auctions start, bidders' behavior will be less affected compared to shill bidding. We also believe that giving the seller the bidding history from the first auction will, at least, have more impact on the behavior and outcomes of the sellers. Another path could be to compare the effects of seller participation in sequential auctions using different auction formats such as eBay, sealed-bid, and English auctions. In reality, shill bidding sellers who win their own item have the possibility to resell it. Accomodating this into an experimental design would lower the cost of shill bidding and we would, consequently, expect more shill bidding. Finally, intentionally, we only informed the bidders that the seller would be provided with the bidding history from the first auction in the instructions. Hence, informing the bidders about this during the experiment also could possibly alter the results.

Appendices

A Simplified theoretical model

As the English out-cry auction is complicated to analyze theoretically, we make the simplifying assumption that each auction is conducted as a sealed-bid second-price auction. In each round two items are sold by a seller who uses two sequential sealed-bid auctions with n bidders. The bidders have unit demand and the winner of the FA will therefore not participate in the SA. Each bidder i has a private value, v_i, which is the same for both items. The private value is drawn from a uniform distribution on (0,1). For any bidder i, let $Y_1, \ldots, Y_{n-1}$ denote the private values of the other $n-1$ bidders, where $Y_1 > Y_2 > \ldots > Y_{n-1}$. Moreover, let Y be the payment a bidder makes conditional on winning an auction in which there is no shill bidding. Let $\beta_1(v_i)$ be a bidding function determining how much a bidder with private value v_i bids in the FA. Similarly, $\beta_2(v_i)$ is a bidding function for the SA. We assume that $\beta_1(v_i)$ and $\beta_2(v_i)$ are symmetric and strictly increasing. This implies that the bidder with the highest private value wins the FA and the bidder with the second highest private value wins the SA. We let $p \in [0, 1]$ be the probability that a seller submits a successful shill bid in the SA, which is common knowledge among the bidders. A successful shill bid, denoted c, is a bid that raises the price of the item without the seller being the highest bidder. Therefore, a successful shill bid is expected to be greater than the expected second highest bid submitted by the bidders.

We start by considering the case in which the seller cannot shill bid. This is equal to the standard model of Milgrom and Weber (1999) and $p = 0$. As the SA is equal to a standard sealed-bid second-price auction, the bidders have a dominant strategy of submitting a bid equal to their private value. Thus, $\beta_2(v_i) = v_i$. Turning to the FA, the bidder is trading off the possibility of winning an item now or waiting to possibly acquire an item in the SA. Therefore, the expected payoff, U_i, for a bidder in the FA is:

$$U_i = v_i^{n-1}\left(v_i - E\left[Y|Y_1 < v_i\right]\right) + \left(1 - v_i^{n-1}\right) v_i^{n-2}\left(v_i - E\left[Y \mid Y_2 < v_i < Y_1\right]\right),$$

where, since the bidders valuations are independently drawn from a uniform distriubtion on (0,1), v_i^{n-1} is the probability that bidder i wins the FA.[21]

[21] $\left(1 - v_i^{n-1}\right) v_i^{n-2}$ is thus the probability that bidder i loses the FA and wins the SA.

Also, note that $E[Y \mid Y_1 < v_i] = \mathrm{E}[\beta_1(Y_1) \mid Y_2 < Y_1 < v_i]$. Since $\beta_1(\cdot)$ is the same for all bidders, it follows that $\beta_1(v_i) = E[Y|Y_2 < v_i < Y_1]$. Thus, any bidder submits a bid equal to the expected payment in the SA conditional on winning the SA. In the case of uniformly distributed private values it turns out that:

$$\beta_1(v_i) \quad = \quad \frac{n-2}{n-1} \times v_i.$$

Now we introduce the possibility for the seller to submit a shill bid in the SA. We assume that the bidders believe that there is a positive probability of a succesfull shill bid and, thus, $p \in (0,1]$. However, for now, the seller does not have any information regarding the bids submitted in the FA. The bidders' dominant strategy in the SA does not change due to this introduction. Regardless of whatever shill bid the seller submits, it is still optimal for the bidders to bid their private value in SA . In the FA, the expected payoff for a bidder is:

$$\begin{aligned} U_i =& v_i^{n-1}\left(v_i - E[Y|Y_1 < v_i]\right) \\ &+ \left(1 - v_i^{n-1}\right) v_i^{n-2}\left(\left(v_i - E[Y \mid Y_2 < v_i < Y_1]\right)(1-p) + (v_i - c)p\right), \end{aligned}$$

where $c \in (\frac{n-2}{n-1}, v_i]$ is the expected payment in the SA conditional on the seller submitting a successful shill bid. Following the same logic, as above, we have:

$$\beta_1(v_i) \quad = \quad E[Y|Y_2 < v_i < Y_1] = \left(\frac{n-2}{n-1}(1-p) + cp\right) \times v_i.$$

Hence, as p (and c) increases so does the bid in the FA. Comparing Treatment 2 to the Baseline treatment, we expect that potential shill bidding in the SA weakly increases the bidders' expected payment in this auction.

Now we turn to the situation in which, before submitting a shill bid in the SA, the seller can observe all except the winning bid from the FA. Since the bidders are assumed to use $\beta_1(\cdot)$, the seller can perfectly infer the private values of the bidders who will participate in the SA from the bids they submitted in the FA by inverting $\beta_1(\cdot)$. Therefore, if the seller decides to shill bid in the SA, then the payment to the bidder who wins this auction is equal to this bidder's private value. While leaving the dominant strategy in the SA unchanged, this gives the bidders incentives to report a low private value in the FA. Consequently, $\beta_1(\cdot)$ does not exist in this scenario:

Proposition 1. *If $p > 0$ and the seller is informed of the losing bidders' bids in the FA, then there does not exist a strictly increasing symmetric bidding function $\beta_1(v_i)$ for any bidder i.*

Therefore, we expect that giving the seller the complete anonymous bidding history from the FA, as in Treatment 1, will decrease the bidders' bids in the FA compared to Treatment 2. The proof of 1 follows closely the proofs of Proposition 9 and Proposition 10 in Katsenos (2010). The proof is mainly given here for completeness. The proof builds on the idea that since the seller is informed of the bidders' bids in the FA and the bidders follow a symmetric strategy, the seller can extract all surplus from the bidders in the SA. This gives incentives for the bidders to report a lower private value as this makes it possible to expect a positive surplus also from the SA.

Proof. If a bidder i follows the symmetric strategy $\beta_1(v_i)$, then her expected payoff is:

$$\begin{aligned} U_i =& v_i^{n-1} \left(v_i - \mathrm{E}\left[\beta_1\left(Y_1\right) \mid Y_2 < Y_1 < v_i\right]\right) \\ &+ \left(1 - v_i^{n-1}\right) v_i^{n-2} \left(v_i - E\left[Y \mid Y_2 < v_i < Y_1\right]\right) (1-p) + p \times 0 \end{aligned}$$

Now assume that the bidder is misrepresenting his private value by $x \geq v_i$ in the FA, then his expected payoff is:

$$\begin{aligned} U_i' =& x^{n-1} \left(v_i - \mathrm{E}\left[\beta_1\left(Y_1\right) \mid Y_2 < Y_1 < x\right]\right) \\ &+ \left(1 - x^{n-1}\right) v_i^{n-2} \left(v_i - E\left[Y \mid Y_2 < v_i < Y_1\right]\right) (1-p) \end{aligned}$$

Note that, if the seller submits a shill bid, the bidder gets zero. This is because the bidder has reported a higher private value, which leads the seller to shill bid higher and the seller will therefore win the item in the SA.

Let $\Delta U = U_i' - U_i$, then, for a deviation to not be profitable, it must be that $\partial \Delta U / \partial x \leq 0$.

$$\begin{aligned} \partial \Delta U / \partial x =& v_i - \mathrm{E}\left[\beta_1\left(Y_1\right) \mid Y_2 < Y_1 < x\right] - v_i^{n-2} \left(v_i - E\left[Y \mid Y_2 < v_i < Y_1\right]\right) (1-p) \\ \leq& 0 \end{aligned}$$

or

$$v_i - \mathrm{E}\left[\beta_1\left(Y_1\right) \mid Y_2 < Y_1 < x\right] \leq v_i^{n-2}\left(v_i - E\left[Y \mid Y_2 < v_i < Y_1\right]\right)(1-p) \quad (1)$$

If the bidder instead reports a lower private value $x \leq v_i$, then the expected payoff of the bidder is:

$$\begin{aligned} U_i' = & x^{n-1}\left(v_i - \mathrm{E}\left[\beta_1\left(Y_1\right) \mid Y_2 < Y_1 < x\right]\right) \\ & + \left(1 - x^{n-1}\right) v_i^{n-2}\left(\left(v_i - E\left[Y \mid Y_2 < v_i < Y_1\right]\right)(1-p) + (v_i - c)p\right) \end{aligned}$$

where $c \in (\frac{n-1}{n-2}, v_i)$ i is the expected payment conditional on the seller submitting a successful shill bid. By misrepresenting by a lower private value, the bidder induces the seller to use a lower shill bid in the SA. Therefore, the bidder can expect a positive payoff even when the seller shill bids, and thus $c < 1$. For a deviation not to be profitable, it must be that $\partial \Delta U / \partial x \geq 0$.

$$\begin{aligned} \partial \Delta U / \partial x = & x^{n-1}\left(v_i - \mathrm{E}\left[\beta_1\left(Y_1\right) \mid Y_2 < Y_1 < x\right]\right) \\ & - v_i^{n-2}\left(\left(v_i - E\left[Y \mid Y_2 < v_i < Y_1\right]\right)(1-p) + (v_i - c)p\right) \geq 0 \end{aligned}$$

or

$$v_i - \mathrm{E}\left[\beta_1\left(Y_1\right) \mid Y_2 < Y_1 < x\right] \geq v_i^{n-2}\left(\left(v_i - E\left[Y \mid Y_2 < v_i < Y_1\right]\right)(1-p) + (v_i - c)p\right) \quad (2)$$

Combining Equation (1) and (2) we get:

$$\begin{aligned} & v_i^{n-2}\left(\left(v_i - E\left[Y \mid Y_2 < v_i < Y_1\right]\right)(1-p) + (v_i - c)p\right) \leq \\ & \quad v_i^{n-2}\left(v_i - E\left[Y \mid Y_2 < v_i < Y_1\right]\right)(1-p), \end{aligned}$$

which equals:

$$v_i^{n-2}(v_i - c)p \leq 0 \quad (3)$$

Equation (3) can never be true as $p > 0$ and $c < v_i$. □

A.1 Description and construction of variables used in regressions

Table 6: Description of variables used in regression analysis

Variable	Description and construction of the variables
Ave private value	Ave private value is the average private value among the participating bidders in an auction.
Bidder	A dummy variable that takes the value 1 if the subject is a bidder and 0 otherwise.
FA (SA) payoff (bidders)	Bidder's payoff is their private value minus the final price if they are the winner of an auction and it is 0 if they lose the auction. There is one payoff for the first auction (FA payoff) and one for the second auction (SA payoff).
FA (SA) payoff (sellers)	A seller's payoff in an auction equals the final price of that auction. There is one payoff for the first auction (FA payoff) and one for the second auction (SA payoff)
FA (SA) price	The FA (SA) price is the final price that the winning bidder pays to the seller, which is determined by the second highest bid submitted before the end of that auction. There is one price for the first auction (FA price) and one price for the second auction (SA price).
FA (SA) 50 and FA (SA) 55	These variables measure late bidding by subjects and are divided by if the last submitted bid was submitted in the last 10 seconds (FA50 and SA50) or last 5 seconds (FA55 and SA55) in each auction. FA and SA refers to the first auction and the second auction.
Final FA (SA) bid	Final bid takes the value of the last bid that bidders and sellers successfully submitted before the end of each auction. Final bid is divided by first (Final FA bid) and second auction (Final SA bid).
First bid SA	This variable measures the magnitude of bidders' and sellers' first bid in the second auction.
Last period balance	This is the experimental currency balance of the last period. This is showed to the subjects at the end of each auction for bidders and each round for sellers.
Last period shill bid	This is a dummy variable that takes the value of 1 if the seller submitted at least one shill bid in the second auction of the previous round and zero otherwise.
Nr bids FA (SA)	The Nr bids variables summarize the number of bids that a bidder or a seller submitted in each auction. This variable is divided by the first (Nr bids FA) and second auction (Nr bids SA).

Table 7: Description of variables used in regression analysis continued

Variable	Description and construction of the variables
Nr of previous shill bidding SA	This variable represents the number of previous rounds in which the sellers submitted at least one shill bid in the second auction.
Period	Period takes the value of the current round that subjects are participating in. There are 20 periods in total.
Pr first bid SA	The probability that a subject submits the first bid in the second auction.
Private value	The private value is assigned randomly to each bidder at the beginning of each round from a uniform distribution of 0 to 100.
Seller	A dummy variable that takes the value of 1 if the subject is a seller and 0 otherwise.
Seller shill bids	Is a dummy variable that takes the value of 1 if the seller submits at least one shill bid in the second auction of that round and 0 otherwise.
Seller wins SA	This is a dummy variable that takes the value of 1 if the seller shill bids and wins the item and zero otherwise.
T. first bid	This variable records the timing, in seconds, that subjects submit their first bid in the second auction.
T1	A dummy variable that takes the value of 1 if the subject is in Treatment 1 in which the seller can shill bid and is given the complete bidding history from the first auction.
T2	A dummy variable that takes the value of 1 if the subject is in Treatment 2 in which the seller can shill bid, but is not given the complete bidding history from the first auction.
% of earlier wins FA (SA)	This is defined as the percentage of the auctions that a bidder or seller won in the previous rounds. There is one variable for the first auction (% of earlier wins FA) and one for the second auction (% of earlier wins SA).

B Additional analysis and regression tables

Table 8: OLS regressions with FA and SA final prices as dependent variables

	(1)	(2)	(3)	(4)	(5)
	FA price	FA price	SA price	SA price	SA price
T1	6.688**	6.031**	9.117**	4.864	4.484
	[2.982]	[2.589]	[3.447]	[4.129]	[3.683]
T2	7.325**	7.430**	9.750***	2.364	4.140
	[3.443]	[3.115]	[3.282]	[4.517]	[3.068]
Seller shill bids * T1				5.969**	7.437***
				[2.684]	[1.791]
Seller shill bids * T2				9.634**	9.328***
				[3.662]	[1.177]
Period		0.239**			0.257**
		[0.0990]			[0.103]
Ave private value		0.821***			0.799***
		[0.0353]			[0.0446]
Constant	42.20***	-1.610	33.90***	33.90***	-3.955
	[2.096]	[3.012]	[2.669]	[2.673]	[2.608]
Observations	720	720	720	720	720
R^2	0.034	0.472	0.055	0.077	0.549
Clusters	18	18	18	18	18

Notes: Robust standard errors clustered on Group level in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table 9: GLS random effects models with sellers' FA and SA payoff as dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)
	FA payoff	FA payoff	SA payoff	SA payoff	SA payoff	SA payoff
T1	6.688**	4.790*	4.733	5.680	4.429	3.339
	[2.982]	[2.628]	[2.903]	[4.501]	[3.574]	[3.639]
T2	7.325**	6.156*	3.429	2.017	4.032	3.770
	[3.443]	[3.421]	[3.221]	[4.354]	[3.021]	[2.749]
Seller shill bids * T1				-1.329	0.203	4.588*
				[4.618]	[3.321]	[2.545]
Seller shill bids * T2				1.841	0.531	4.695***
				[3.031]	[2.002]	[1.528]
Ave private value		0.820***			0.892***	0.774***
		[0.0347]			[0.0444]	[0.0382]
Last period balance		0.0220**			0.0124	0.0159
		[0.00979]			[0.0138]	[0.0103]
Last period shill bid		-0.794			-0.0302	-0.321
		[1.988]			[2.434]	[1.286]
Nr bids SA					0.139	0.444
					[0.409]	[0.290]
% of earlier wins SA		8.642			-0.808	6.612
		[5.900]			[6.512]	[4.241]
Period		-0.637			-0.188	-0.361
		[0.406]			[0.546]	[0.426]
Seller wins SA						-36.50***
						[2.342]
Constant	42.20***	-2.197	33.90***	33.90***	-8.942***	-3.460*
	[2.096]	[2.911]	[2.669]	[2.673]	[2.294]	[2.066]
Observations	720	720	720	720	720	720
Number of Subject	36	36	36	36	36	36
Clusters	18	18	18	18	18	18

Notes: Robust standard errors clustered at Group level in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table 10: GLS random effects models with bidders' FA and SA payoff as dependent variable

	(1)	(2)	(3)	(4)	(5)	(6)
	FA payoff	FA payoff	SA payoff	SA payoff	SA payoff	SA payoff
T1	-0.175	0.596	-2.386***	-1.186	-1.130	-0.624
	[0.443]	[0.836]	[0.780]	[1.160]	[0.784]	[1.218]
T2	-0.491	0.608	-2.690***	-1.232	-1.614*	-0.583
	[0.708]	[1.239]	[0.746]	[1.095]	[0.891]	[1.058]
Seller shill bids * T1					-1.764***	-0.966
					[0.537]	[0.735]
Seller shill bids * T2					-1.404*	-1.024
					[0.739]	[0.795]
Nr of previous shill bidding SA		-0.175		-0.133		-0.114
		[0.124]		[0.0983]		[0.104]
Private value		0.250***		0.191***		0.191***
		[0.0126]		[0.0150]		[0.0149]
Nr bids FA		-0.236**				
		[0.111]				
% of earlier wins FA		4.436***		-0.304		-0.319
		[1.468]		[1.753]		[1.755]
% of earlier wins SA		0.345		0.389		0.390
		[1.951]		[1.740]		[1.748]
Last period balance		-0.00772**		0.0137***		0.0136***
		[0.00311]		[0.00421]		[0.00429]
Period		0.188**		-0.146*		-0.151*
		[0.0943]		[0.0827]		[0.0828]
Nr bids SA				1.037***		1.031***
				[0.134]		[0.135]
Constant	6.717***	-6.445***	7.461***	-5.931***	7.461***	-5.817***
	[0.353]	[1.093]	[0.680]	[1.668]	[0.681]	[1.706]
Observations	2,880	2,880	2,880	2,880	2,880	2,880
Number of Subject	144	144	144	144	144	144
Clusters	18	18	18	18	18	18

Notes: Robust standard errors clustered at Group level in brackets

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 11: Probit regressions with the probability of submitting a late final SA bid in the last 10 and 5 seconds as dependent variable

	(1)	(2)	(3)	(4)
	SA 50	SA 50	SA 55	SA 55
T1	-0.220	-0.0232	-0.249	-0.0317
	[0.191]	[0.284]	[0.153]	[0.251]
T2	-0.352*	-0.245	-0.372**	-0.179
	[0.206]	[0.302]	[0.169]	[0.304]
Seller shill bids * T1		-0.360**		-0.313***
		[0.162]		[0.111]
Seller shill bids * T2		-0.213		-0.242
		[0.137]		[0.171]
Nr of previous shill bidding SA		0.0141		0.00346
		[0.0196]		[0.0216]
Private value		0.0190***		0.0142***
		[0.00170]		[0.00143]
Nr bids SA		0.145***		0.0958***
		[0.0237]		[0.0198]
% of earlier wins FA		-0.150		-0.0558
		[0.270]		[0.264]
% of earlier wins SA		-0.0128		0.0199
		[0.199]		[0.221]
Last period balance		0.00162**		0.00118*
		[0.000667]		[0.000665]
Period		-0.00929		0.00255
		[0.0170]		[0.0174]
Constant	0.383**	-1.009***	0.0853	-1.083***
	[0.179]	[0.225]	[0.137]	[0.183]
Observations	2,164	2,164	2,164	2,164
Clusters	18	18	18	18

Notes: Robust standard errors clustered at Group level in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table 12: Probit regressions with the probability of submitting a late final FA bid in the last 10 and 5 seconds as dependent variable

	(1)	(2)	(3)	(4)
	FA 50	FA 50	FA 55	FA 55
T1	0.169	0.0700	0.126	-0.000638
	[0.170]	[0.221]	[0.173]	[0.216]
T2	-0.0316	-0.134	-0.0555	-0.181
	[0.174]	[0.225]	[0.185]	[0.224]
Nr of previous shill bidding SA		0.0197		0.0208
		[0.0158]		[0.0167]
Private value		0.0165***		0.0143***
		[0.00130]		[0.00123]
Nr bids FA		0.136***		0.0772***
		[0.0350]		[0.0226]
% of earlier wins FA		-0.131		0.0666
		[0.219]		[0.196]
% of earlier wins SA		-0.0833		-0.00911
		[0.243]		[0.224]
Last period balance		-0.000166		8.76e-05
		[0.000939]		[0.000880]
Period		-0.00171		-0.00971
		[0.0170]		[0.0167]
Constant	0.152	-0.962***	-0.131	-1.039***
	[0.162]	[0.182]	[0.166]	[0.206]
Observations	2,880	2,880	2,880	2,880
Clusters	18	18	18	18

Notes: Robust standard errors clustered at Group level in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table 13: Probit regressions with probability of submitting a late bid and of submitting the first bid as dependent variables

	(1)	(2)	(3)	(4)	(5)	(6)
	SA 50	SA 50	SA 55	SA 55	Pr first bid SA	Pr first bid SA
Bidder * T1	0.132	0.119	0.124	0.116	-0.145**	-0.165**
	[0.125]	[0.148]	[0.123]	[0.144]	[0.0706]	[0.0797]
Seller * T1	-0.163	-0.693**	-0.388*	-0.691***	0.951***	0.471**
	[0.228]	[0.303]	[0.216]	[0.258]	[0.201]	[0.202]
Seller * T2	-0.293	-0.688***	-0.551***	-0.768***	0.513**	0.143
	[0.200]	[0.226]	[0.163]	[0.220]	[0.239]	[0.242]
Ave private value		0.00942***		0.00519*		-0.000915
		[0.00207]		[0.00270]		[0.00131]
Period		0.0115		0.0124		-0.0275**
		[0.00792]		[0.0127]		[0.0117]
Last period balance		0.000493		0.000264		0.000714
		[0.000329]		[0.000519]		[0.000521]
Nr bids SA		0.177***		0.0971***		0.155***
		[0.0283]		[0.0182]		[0.0232]
Constant	0.0311	-1.006***	-0.287***	-0.938***	-0.540***	-0.763***
	[0.104]	[0.162]	[0.101]	[0.144]	[0.0399]	[0.0565]
Observations	1,799	1,799	1,799	1,799	1,424	1,424
Clusters	12	12	12	12	12	12

Notes: Robust standard errors clustered at Group level in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table 14: GLS random effects models with Number of bids, Final bid, magnitude of first bid and timing of first bid

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Nr bids SA	Nr bids SA	Final SA bid	Final SA bid	First bid SA	First bid SA	T.first bid	T. first bid
Bidder * T1	0.0855	0.0686	0.630	-0.328	-0.728	-1.040	0.333	0.315
	[0.316]	[0.314]	[2.411]	[2.158]	[2.810]	[2.359]	[2.290]	[1.946]
Seller * T1	1.915***	1.522***	-0.151	-4.306	-6.560***	0.0514	-16.56***	-14.09***
	[0.196]	[0.129]	[3.446]	[2.999]	[2.261]	[2.154]	[1.412]	[1.233]
Seller * T2	1.245***	0.835**	-2.709	-5.542	-7.738***	-3.323	-14.41***	-12.85***
	[0.416]	[0.375]	[4.105]	[4.495]	[2.144]	[2.728]	[1.433]	[2.142]
Ave private value		0.0148***		0.680***		0.435***		0.111***
		[0.00480]		[0.0269]		[0.0443]		[0.0368]
Period		-0.0336***	0.116	0.230		0.415***		0.515***
		[0.0123]	[0.102]	[0.184]		[0.0992]		[0.109]
Last period balance		0.00150***		-0.00290		-0.00619		0.000743
		[0.000559]		[0.00967]		[0.00473]		[0.00459]
Nr bids SA				2.723***		-2.245***		-1.505***
				[0.330]		[0.344]		[0.268]
Constant	2.397***	1.805***	35.58***	-0.168	21.22***	5.297***	22.04***	15.41***
	[0.220]	[0.220]	[2.237]	[2.328]	[2.668]	[1.790]	[1.803]	[2.689]
Observations	1,799	1,799	1,799	1,799	1,637	1,637	1,637	1,637
Number of Subject	120	120	120	120	120	120	120	120
Clusters	12	12	12	12	12	12	12	12

Notes: Robust standard errors clustered at Group level in brackets

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

C Instructions for the experiment

These instructions are for the all the treatments together and have been translated from Spanish .

INSTRUCTIONS

Welcome to the experiment! The purpose of this experiment is to study how individuals make decisions in a certain context. The experiment consists of several rounds of auctions. The instructions are simple and if you follow them carefully you will at the end of the session earn money. The amount of money you earn depends on the decisions you and others make in the experiment. If you have any questions, please do not hesitate to ask us by raising your hand. Apart from these questions, any kind of communication is prohibited and may lead to your immediate exclusion from the experiment.

Overview:

In this experiment you will make decisions in a number of auctions. At the beginning of the experiment you will be randomly assigned a role as either a bidder or a seller. You will keep the same role throughout the whole experiment.

The experiment consists of 20 rounds and in each round you will participate in two auctions. At the beginning of each round, you are randomly matched in a group of five participants including one seller and four bidders. In each round, the seller has two identical items which will be sold in two separated auctions. The two auctions will be conducted sequentially meaning that the second auction starts when the first auction is finished. Bidders are only allowed to buy one item in each round. Therefore, the bidder who wins the first auction will not participate in the second auction of that round. However, once a new round starts they can bid again.

At the beginning of every round, each bidder will be given a private value which is how much the bidder values the two items that are to be sold in this round. This private value will be an integer between 0 and 100 which is randomly picked by a computer. Any integer in this interval is equally likely to be given to a bidder. A bidder's private value is always displayed on the bidder's screen. Furthermore, a bidder's private value is not known by any other participants in the experiment.

Once a round is completed and before the start of a new round, you will be randomly re-matched into a new group of one seller and four bidders, while maintaining your role. Moreover, the bidders will be given a new private value. Given that no participant will be given any identity number, all the actions that you take during the experiment will be absolutely anonymous.

Each participant receives a €5 show up fee. The additional payment depends on the outcome of the auctions. All participants start with a balance of 100 Experimental Currency Unit (ECU) to which gains and losses will be added and subtracted during the course of the experiment.

The auction environment:

To Bidders:

Each round consists of two auctions and before the start of the first auction, bidders will be shown their private value on the screen. In order to proceed to the first auction, all participants must press the "Continue" button.

In each auction one item is to be sold by the seller. An auction lasts 60 seconds during which it is possible for you to submit bids for the item. A bid is submitted by writing an integer number in the "Your bid" box followed by clicking the "Make bid" button.The winner of the item is the bidder who has submitted the highest bid before the auction ends. In case several bidders submit the same highest bid, the bidder who submitted the bid first will win the item. However, the winner only needs to pay the second highest bid which was submitted by one of the other bidders before the auction ended. The final second highest bid is thus the price of the item. A bidder who wins an auction will receive an amount of ECUs equal to his/her private value minus the price of the item. A bidder who does not win an auction gets 0 ECU.

You can start bidding and/or react to other bidders bids at any time during the 60 seconds.If you submit a bid which at that moment is the highest bid, the words "Winning" appears on the screen. Otherwise the words "Not winning" will be shown. Furthermore, the highest bid will never be shown on the screen of any participant. However, when some other bidder submits a higher bid, then the old highest bid becomes the second highest bid and is displayed on the screen as the current price. Furthermore, you are allowed to submit any number of bids. However, there are two restrictions:

1) Any submitted bid must be greater than the current price. At the beginning of the auction, the current price is set to 1 (ECU). During the auction, the current price will be updated in accordance with the submitted bids and it will always be shown on the screen. Remember, the final price of

the item is determined by the final second highest bid.

2) Any submitted bid of yours must be greater than the your previously submitted bids.

During an auction the following information will be displayed on a bidder's screen: Your private value, the time left before the auction ends, if you are the current winner of the item or not, the current price and a history of all bids which were the current price at some point during the auction. In the history of prices, no information regarding the ID of the bidder who submitted the bid will be displayed. Furthermore, the history of current prices is updated as new second highest bids are submitted.

After the end of the first auction the bidders are informed of their payoff in ECUs and whether they will be able to bid in the second auction or not. Only the bidder who wins the item in the first auction will not be able to bid in the second auction. In order to proceed to the second auction, all participants must press the "Continue" button.

Payoff: After the second auction is finished, all participants will be displayed their payoff from the current round and their updated balance in ECUs. Note that a bidder may lose money by submitting a bid which is higher than his/her private value. If a bidder has lost money in a round, a message warning the bidders will appear. When all participants have pressed the "Continue" button, a new round starts unless you have completed all 20 rounds. When the 20 rounds are finished, the accumulated ECUs from all auctions will be converted into euros at a rate of 100 ECU = €2 for the bidders. If a bidder has a negative balance when the 20 rounds are finished, then the bidder will only earn the show up fee.

To Sellers:

Baseline: Sellers have no active part in the auction. During the first auction, the seller will be shown a blank screen. Between the first and the second auction, the seller will be shown the complete history of all the current prices from the recently finished first auction of the same round. During the second auction, the seller will be able to view the auction live. Specifically, the current price and the constantly updating history of current prices will be shown to the seller.

Payoff: The seller's payoff is only displayed once the second auction is finished. The seller gets a payoff in ECUs which is equal to the final price in one of the two auctions. A random draw from the computer, with 50 %

probability assigned to each of the two auctions, determines which final price is paid out to the seller.

Treatment 1: During the first auction the seller will be shown a blank screen. Between the first and the second auction, the seller will be shown a blank screen as well. Before the second auction starts, the seller can choose to join the second auction, which gives him/her the possibility to bid on his/her own item. Joining the auction costs 1 ECU and the seller will then be presented with the same screen as the bidders where the seller can submit bids. The rules for bidding are the same for the seller as for the bidders. If the seller does not join the second auction, the seller will be able to view the second auction live. This includes the information of the current price and the constantly updating history of prices. The bidders are not told whether the seller decided to join the auction or not.

Payoff: The seller's payoff is only displayed once the second auction is finished. The seller gets a payoff in ECUs which is equal to the final price in one of the two auctions. A random draw from the computer, with 50 % probability assigned to each of the two auctions, determines which final price is paid out to the seller. Hence, only one of the two prices is paid out to the seller in each round. Moreover, if the seller decided to join the second auction, 1 ECU is deducted from the payoff. Furthermore, if the seller wins the auction by bidding on his own item, he/she gets a payoff of -1 as the cost of joining the auction is paid.

Treatment 2: During the first auction, the seller will be shown a blank screen. Between the first and the second auction, the seller will be shown the complete history of all the current prices from the recently finished first auction of the same round. Before the second auction starts, the seller can choose to join the second auction, which gives him/her the possibility to bid on his/her own item. Joining the auction costs 1 ECU and the seller will then be presented with the same screen as the bidders where the seller can submit bids. The rules for bidding are the same for the seller as for the bidders. If the seller does not join the second auction, the seller will be able to view the second auction live. This includes the information of the current price and the constantly updating history of current prices. The bidders are not told whether the seller decided to join the auction or not.

Payoff: The seller's payoff is only displayed once the second auction is finished. The seller gets a payoff in ECUs which is equal to the final price in one of the two auctions. A random draw from the computer, with 50 % probability assigned to each of the two auctions, determines which price is paid out to the seller. Hence, only one of the two prices is paid out to the seller in each round. Moreover, if the seller decided to join the second auction, 1 ECU is deducted from the payoff. Furthermore, if the seller wins the auction by bidding on his own item, he/she gets a payoff of -1 as the cost of joining the auction is paid.

After the second auction is finished, all participants will be displayed their payoff from the current round and their updated balance in ECUs. When the 20 rounds are finished, the accumulated ECUs from all auctions will be converted into euros at a rate of 100 ECU = €1 for the sellers. You need to fill the blank in the receipt paper on your table and sign it. An experiment assistant who has your payment information will give your earnings in cash after your filled out receipt has been turned in to him/her.

Good luck!

Example

Before starting the experiment, please go over an example of one round to ensure that you understand how your payment is determined. Assume that the winner of the first auction has a private value 90. We will now consider three different final prices in order to illustrate how these affects the winner's payoff. Assume that the three different final second highest bids (prices) submitted are 20, 50 and 70. The earnings for the winning bidder in this round, by varying second highest bid (SHB), are as shown in the table below:

Private Vvalue	*SHB*	*First*	*Second*	*Earnings in this round*
90	20	$90 - 20 = 70$	0	70
90	50	$90 - 50 = 40$	0	40
90	70	$90 - 70 = 20$	0	20

Notice that the winning bidder in the first auction earns 0 in the second auction since he/she is not allowed to participate in it.

Then another bidder wins the second auction and assume that this bidder's private value is 84. Once again we consider the same three different second highest bids (prices) of 20, 50 and 70. So the earning for this bidder in this round by varying the second highest bid (SHB) are like the table below:

Private Vvalue	*SHB*	*First*	*Second*	*Earnings in this round*
84	20	0	$84 - 20 = 64$	64
84	50	0	$84 - 50 = 34$	34
84	70	0	$84 - 70 = 14$	14

Notice that since the bidder did not win the first auction, he/she gets 0 from first auction.

Now lets look at the earnings of the seller in this round. Since the computer will randomly pick a final price in one of the two auctions in this round to be paid out to the seller, the seller either get the final SHB of the First auction or the final SHB of the second auction. Hence, the seller earns on average more if the items in both auctions are sold by a high final price.

D Comprehension test and experimental screenshots and post-experiment questionnaire

Comprehension Test

Q1. Suppose that you are a bidder and that your private value is 60. Moreover, you bid 55 and win the second auction and the current second highest bid is 45. What is your earnings in this auction?

Q2. What is the seller's earnings if the outcome of the auction in question 1. is paid out?

Q3. Suppose that the seller joins the second auction in question 1 and submits a bid equal to 53 and that this bid becomes the final second highest bid. If this auction is paid out, how much does the seller earn?

Q4. Before starting the second auction, the seller will see the bidders' bidding history from the first auction of the same round. (True=1 or False=0)\

Q5. The seller can affect the final price of an item in the first auction by bidding. (True=1 or False =0)

Q6. The seller can affect the final price of an item in the second auction by bidding. (True=1 or False=0)

Q7. I will face the same bidders and sellers in all the rounds. (True=1 or False=0)

Q8. It is only possible to bid once in an auction. (True=1 or False=0)

Q9. How many bidders will participate in the first auction?

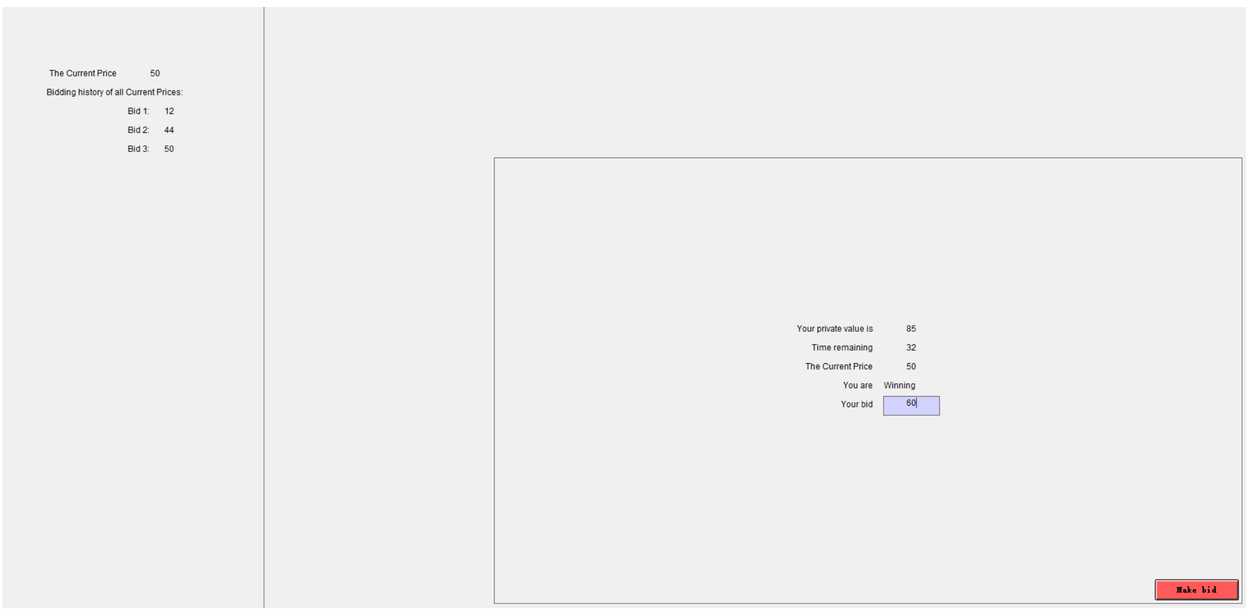
Q10. If the first item is sold, how many bidders will participate in the second auction?

Q11. How many auctions are there in each round?

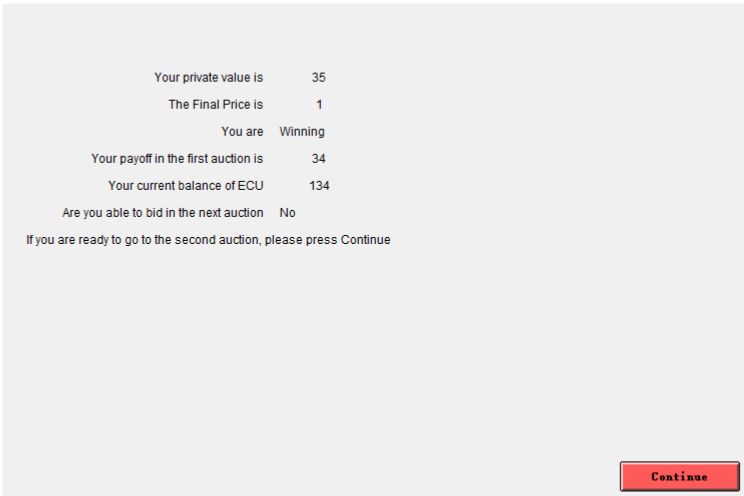
Q12. What is the total number of auctions that you will participate in during the entire experiment?

The second part of this appendix reports the main screenshots used during the experiment. The screen have been translated from Spanish to English.

Screen 1 : Bidding Screen

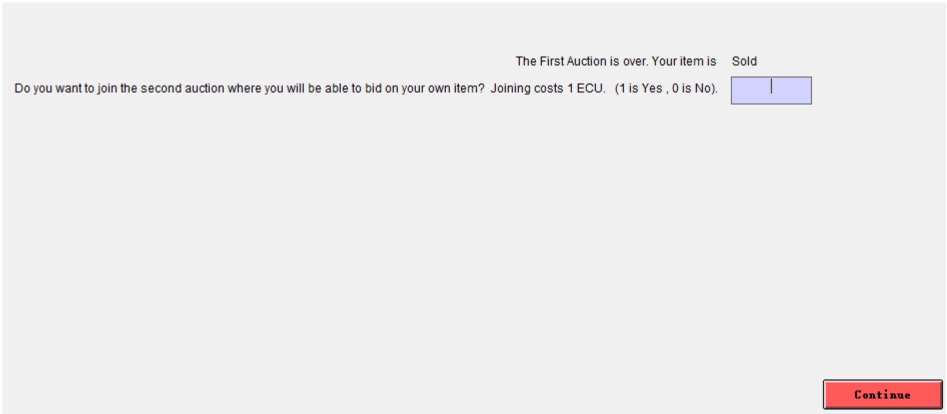


Screen 2 : Information stage for bidders



Screen 3: Information stage for sellers in Full information Treatment 1

Screen 4: Information stage for sellers in No Information Treatment 2



Screen 5 : Post-questionnaire stage

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