Shilling, Squeezing, Sniping: Explaining late bidding in online second-price auctions

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Abstract

In a recent study, Roth and Ockenfels (2002) provided empirical evidence for sniping in second-prize internet auctions but also a puzzle: How could sniping be consistent with rational behavior in such auctions? Given a perfect second-prize auction, the timing of bids plays no role and there is no incentive to bid less than one's own private value. How can this gap between the predictions from theory and empirical evidence be explained? By focusing on technological problems, Roth and Ockenfels (2005) have already made an attempt in understanding this puzzle. In the present paper, we aim to show why sniping is a rational reaction to existing rules not considered hitherto: by retracting or canceling bids in online auctions the seller has a powerful hand allowing to cream off possible gains the winner might have. Neither the consequences nor the rational strategy of *squeezing* of the bidder to his highest bid have been considered before. In looking at the problem we have also sought its solution. One solution could be the introduction of compensation to the buyer, i.e. to the highest bidder, and secondly to make auctions totally anonymous.

Keywords: auction setting, sniping, squeezing
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1 Introduction

In auction theory, the superiority of second-price auctions over first-price auctions is common sense since the seminal paper of Vickrey (1961). In a perfectly functioning second-price auction with private values it is a rational strategy for each bidder to submit his reserve price at any time. Not surprising the worlds largest market place for internet auctions, `eBay`, implements a second-price auction buy using a proxy bidding system. Empirical evidence provided by Roth and Ockenfels (2002) shows that the perfectly functioning second price auction is not being observed on internet auctions with a *hard close*. With *hard close* auctions it is typical for the vast majority of bids to be placed just at the close of an auction. In their influential article Roth and Ockenfels (2002) put forward an interesting puzzle. How can sniping, be consistent with the theory of rational agents?

Wilcox (2000) argues that potential buyers try to get additional information from *experts* in the field.[1] The bidders observe the bids of those who frequently place bids on similar items and take these bids as an indication for the market price of the goods. In anticipation of this behavior *experts* place their bids late. Roth and Ockenfels (2002) have witnessed similar behavior in auctions over antiques. Yet with other auctioned goods, for example computer devices, this behavior has not been observed. Therefore one can assume that the *expert bidders* will place their bids late on goods where the market value is hard to determine.

Secondly, another reason for sniping (or late bidding) is that bidders try to protect themselves against the *incremental bidding strategies* of others. Ariely et al. (2005) found lab evidence for incremental bidding behavior in second-price internet auctions. Thereby, they increase the actual price of the auctioned good to bring it closer to its real reserve price. This line of reasoning assumes that bidders bid incrementally, which is not consistent with the rational behavior outlined in Vickrey's (1961) pioneering work.

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[1] A similar approach has been put forth by Rasmussen (2003).

Thirdly, snipping can be seen as a strategy to protect oneself of *shill bidding*.[2] Nevertheless, sellers using *shill-bidding* strategies face uncertainties as one may also have to pay a transaction fee to the auctioneer running the market place. Wang et al. (2001, 2004) were able to demonstrate under which circumstances shilling would be a utility maximizing strategy. Our paper closely relates to the important work of Roth and Ockenfels (2005). They were the first to to show that sniping is consistent with rational behavior in a private-value framework. They argue that by late bidding one may face the risk of not being able to hand in your bid at all, due to technological problems (i.e. network delay uncertainties). Despite this risk, if there are at least two bidders, late bidding is a dominant strategy for every bidder. Yet a player might not bid at all, if his private valuation is lower than the reserve price set by the seller. In this case, the expected payoff of a late bid is smaller than the payoff of the earlier bid. They conclude by this reasoning that there is no dominant strategy and therefore incremental bidding is not dominated strategically. However, a late bid could be the best response to an incremental bidding strategy.

Our paper sets out an alternative explanation on the rationality of late-bidding. We do not deal with external technological factors. Instead we show that sniping is the (weakly) dominant strategy, if one takes into account additional rules of online auctions like those in `eBay`. We are dealing with the possibilities of retracting a potential buyers bid or canceling a bid by the seller themselves. We demonstrate that this retracting or canceling adds another dimension to ones existing strategies. We believe that this in fact leads to another strategy, which we call *squeezing*, which is a riskless type of shill bidding. It allows the seller to use his second `eBay` account to bid in his favor, in order to uncover the sealed bid of potential buyers. By *learning* the reserve price of the highest bidder, the seller retracts his first bid or cancels the bid of his second identity and he will then submit another bid this time matching the reserve price (he *learned* from the highest bidder before). The unsuspecting bidder already has placed his reserve price. If he is not outbidden by a higher price he will pay his maximum price, thus not gaining any profit from the auction.

The potential payoff has been *squeezed from him* by the seller, so that the buyer makes zero profits, instead of gaining the difference between the second-highest bid and the reserve price. The best response to the squezzing strategy is to bid late, because squezzing involves time. Hence, last-minute bids are rational answers to given rules of auction games. It is these games which existing research has so far not taken into account. In Chapter 2 we outline our theory on squezzing. We will do this by modeling a game. In Chapter 3 we show that Nash equilibria with early bids submitted by honest bidders do not exist. Then, in Chapter 4, we design a mechanism to tackle the misuse of the `eBay` market place. We conclude (chapter 5) with a summary of our paper.

2 A model of second-price auctions and squeezing activities

As a rule, the retraction of bids is not allowed at `eBay`. However, in the interest of their clients and according to civil law, `eBay` introduced two circumstances where bids can be retracted. Firstly, the bidder may make a typographical error. For example, he may enter the wrong bid amount (for instance bid 1000 instead of 100). In this circumstance, the transaction is considered invalid under civil law.

The second circumstance is, a bid may be retracted if the description of an item changes significantly. For instance, if someone selling tickets to a soccer match later informs the bidders of something (for example, a pole blocking the view of the pitch considerably) which the seller feels will decrease the value (after the auction already started), this gives the bidder the right to retract the bid. In fact, `eBay` allows the bidder to retract any bid if the description of an item is changed. Sellers can also have the right to cancel any bids on their auctions. As we will show, the `eBay`-User Agreement on retractions and cancellation is open to misuse.

Take the case of the early bidder who bids his reserve price trusting in a perfectly working second-price auction. `eBay` allows the seller to have more than one registered `eBay`-account. Thus, a *shiller* may use this account to bid on their own listings in order to outbid the highest bidder. As a result he uncovers the reserve price of the previous highest bidder. He is able to cancel his own bid, submit a new bid which is as high as the top reserve price of all (honest) bidders.[3] Through this process, he uncovers the maximum reserve price and squezzes the buyer (bidder) for the potential payoff.

[2] *Shill bidding* occurs when the seller disguises as a legitimate bidder by using a second identity or account solely for the purpose of boosting the final sale price.

[3] It is worth mentioning that `eBay` explicitly forbid bidding on own listings. `eBay` originally allowed sellers to do that, but because this privilege was abused, it was eliminated.

As we note, the seller benefits greatly from the eBay-User Agreement. He is allowed to cancel bids right up to the very end of an auction. Yet, the honest bidders are not allowed to retract their bids 12 hours prior to the auction closing. Thus, eBay not only gives shillers a powerful hand, but they make it more difficult for honest bidders to react strategically.

2.1 The Game

2.1.1 Players

Denote the finite set of bidders in a (formal) second-price auction by $\mathcal{N} \equiv \{1, \ldots, n\}$. The seller is among the n bidders (a "shiller" by using another ID).[4] Denote the shiller by $s \in \mathcal{N}$. Bidders are allowed to have different private valuations of the good. Let $v^i \in \mathbb{Q}_+$ denotes the valuation of bidder $i \in \mathcal{N}$ of the item. v^i has support $[0, y) \subset \mathbb{Q}$. y denotes the maximum of the bids being allowed at an auction.[5] We assume that the individual willingness to pay is private information and they are not correlated with each other (see Myerson (1981)).

2.1.2 Rules and Outcome

The listing begins by the seller announcing a posted reserve (also called minimum bid).[6] We assume the auction will be conducted in 3 rounds (without violating general validity). Let $\mathcal{T} \equiv \{t_1, t_2, t_3\}$. At every stage all bidders simultaneously submit their maximum willingness to pay. The maximum willingness to pay may or may not differ from his private valuation. When the bid of one bidder is equivalent to an earlier bid, then the early bidder will be the "highest bidder". When two bidders bid at the same time the same amount of money the highest bidder will be chosen at random. We can think of t_1 as a period of time that runs from the beginning of an auction until that moment where there are only two conceivable options. One can think of t_2 and t_3 being the last seconds of an auction (this will be discussed later). The actual second-price will be announced at the end of each period. Given as a public information, every bidder at stage t_2 will know the second-highest bid from stage t_1 and every bidder will know the second-highest bid from the first and second period at the end of stage t_3. Furthermore, it is common knowledge if bids in pre-periods have been submitted before.[7] We describe bids in stage t_1 as *early bids* and bids in t_2 and t_3 as *late bids.*

By the end of the third period the outcome of the game is public information. It will be decided

- who is the winner of the auction.
- which price the winner has to pay,
- which payoff, $\mathcal{P}$, the winner receives, and
- which payoff the seller receives.

For the better understanding of eBay-auctions we need to consider the following rule: $b_3^i \geq b_2^i \, \forall \, i \in \mathcal{N} \backslash \{s\}$. This rule formalizes the eBay-regulation whereby a bid cannot be retracted shortly before an auction ends without the seller's agreement. The formula states that the honest bidder is not allowed to retract a bid submitted in period 2 or an unchanged bid in period 2 which had been submitted in period 1. This does not hold for those bidding on behalf of the seller, s, because canceling bids by the seller are always allowed. Despite this, it is possible for every bidder to increase his bid in the third period.

We will now place further limitations on the strategy set, in order to simulate the reality of an eBay auction. All changes of bids in periods 2 and 3 must exceed the price of the previous period, p_{t-1} (apart from bid retractions). So, the price at the end of t_1 being 100, every bidder can change his maximum bid of t_1 only if he places a higher bid (of more than 100) or retracts his bid.

[4]We exclude the case that the seller himself has multiple ID's. We only consider the case of a seller being able to bid on his own listings using just one additional account.

[5]eBay allows a maximum bid of 9,999,999,999.99 US-Dollar.

[6]We only cover that type of auction. In fact, eBay offers two types of auctions: one with a posted reserve, and the other with a secret reserve.

[7]This information is important, because if there is only one bid, the resulting second-price will be 0.

2.1.3 Strategy Set

The strategy set of bidder $i \in \mathcal{N}$ consists of of all possible sequences of bids which he could submit in the auction. The set is denoted by $\mathcal{S}^i \equiv (b_1^i, b_2^i, b_3^i) \in \mathbb{Q}_+$. The maximum willingness to pay for the item of bidder i at time $t \in \mathcal{T}$ is denoted by b_t^i, $\forall\, i \in \mathcal{N}$,.

The maximum willingness to pay, every player plays at a specific period, will be indicated by $b \in [0, y) \cup \{y\}$. For instance, let $\mathcal{S}^i = (100, 100, 100)$. It means that bidder i submitted a bid of 100 in period t_1, which was not increased or canceled in the following periods. Note that $b_2^i = 0 < b_1^i$ is possible whenever a bid was canceled by the seller. Cutting a bid back to a lower, positive value is, according to `eBay`, not conceivable.

Definition 1 *We call bidding sequences* $\{(y, 0, \cdot)\} \equiv \mathcal{B} \subset \mathcal{S}^s$ *of player* $s \in \mathcal{N}$ squeezing strategies *and the sequence* $(0, 0, 0) \subset \mathcal{S}^s$ *the honest strategy. Every sequence of play* $(0, [0, y), [0, y))$ *of a honest bidder* $i \neq s$ *will be called sniping strategy.*

Hence, *sniping* indicates the submission of bids at the time where the seller cannot carry out his squeezing strategy successfully.

2.1.4 Payoffs

At the conclusion of the auction, bidders who have not submitted the highest bid will receive a payoff equal to 0. The highest bidder will receive a payoff $\mathcal{P} \equiv v^i - \max\{b_3^j\}$, $\forall\, j \neq i$, where $v^i \in \mathbb{Q}_+$ indicates the valuation of bidder $i \in \mathcal{N} \backslash \{s\}$ for the item under consideration.

2.2 Squeezing

A squeezing of existing bids will be conducted within 3 rounds: (i) bidding of y (shilling), (ii) canceling the bid, (iii) new bid being as high as the maximum bid of the honest bidder.

Step (i) (the shilling) is used in order to reveal the bidders reserve, because the signal at the end of every round will as the second-highest bid always be the highest bid of an unsuspecting bidder. As the seller knows that nobody else can bid more than y, the highest bid of the *actual* bidder will always appear as a signal to the seller. Canceling the bid (ii) is needed for carrying out step (iii). Because of `eBay`'s specific bidding rules, the seller has always to cancel a bid before he can submit a shill bid again.

3 Solving the game

Carrying out the *squezzing strategy* will take 3 rounds. Because of this, squeezing can only be successful, if at least one unsuspecting bidder submits a strictly positive bid in period t_1.

Lemma 1 *Squeezing is a weakly dominant strategy of player s.*

Proof. There are two possibilities: (1) No honest player submits a bid in t_1. (2) At least one honest player will submit a bid. If there will be no honest bids in t_1, s will play y in vain. Despite, he can play 0 in round 2 being indifferent to his honesty strategy. Plays one bidder $b_1 > 0$ then s learns about the bid and can proceed as outlined in Subsection 2.2. On the other hand, it can be shown easily, that s will be worse off if he will not play his squeezing strategy. This will be the case, if a honest bidder i plays $b_1^i = v^i$. In this case, squeezing will be ruled out because of time restrictions. To complete the proof, we must show that $b_2^s = 0$ is rational as well. Assuming that $b_2^s > 0$ and $0 < b_2^i < b_2^s$, s could only move back to 0, but not back to b_2^s. Here, squeezing would fail. ■

Proposition 1 *Sniping weakly dominates every other strategy of an unsuspecting (honest) bidder.*

Proof. Assume that player i submits his reserve in round 1 ($b_1^i = v^i$). The best response of s will be as proofed in subsection 2.2. The payoff will equal zero in any case; because player i was either the highest bidder and was *squeezed out* for his potential payoff. Or, because there was another (honest) bidder j with a higher reserve ($v^j > v^i$). In the last case, the timing of his bid does not matter at all, because he will not win the auction anyway. However, if he is the player with the highest valuation, then he will forfeit a payoff possible as high as $v^i - \max\{v^j\}$ by not playing his sniping strategy.

The same holds, if bidder i places a bid $b_1^i < v^i$ in t_1. Not knowing the reserve of all other bidders, it is always rational to increase his bid up to v^i during the auction. When $\max\{v^j\} < b_1^i \, \forall j \in \mathcal{N} \backslash \{i, s\}$ then he will gain a payoff as high as $v^i - b_1^i$ which would be smaller than the payoff he would have gotten if he had sniped, $v^i - \max\{v^j\}$. In the case of $\max\{v^j\} > b_1^i$ he would not have gained or lost anything by submitting an early bid. ■

Summing up, the intuition of this proof is as follows: If player i bids early on, he could only be prevented by another bidder or by the shiller, (s), to gain a positive payoff. By sniping player i can rule out the second case.

Due to Lemma 1 and Proposition 1 we can conclude:

Proposition 2 *There exist no Nash equilibria with an early bid of an honest bidder.*

4 Solutions to the *squeezing problem*

The problem of shilling in second-price-auctions has been expounded first by (Vickrey, 1961, p. 22):

> The second-price method may not be automatically self-policing to quite the same extent as the top-price method, but there should be no real difficulty. [...] To prevent the use of a "shill" to jack the price up by putting in a late bid just under the top bid, it would probably be desirable to have all bids delivered to and certified by a trustworthy holder, who would then deliver all bids simultaneously to the seller.

Nowadays, thinking of online auctions, a simple counterpart to the suggestion above would be the introduction of anonymous (sealed) auctions. Neither the seller nor the buyers would be informed about the course of action. Yet, this type of auctions is not considered to be attractive. For English Auctions, Wang et al. (2004) suggest a shill-proof fee schedule, which could make shilling unattractive. In this chapter, we introduce a simple mechanism in order to implement this method for second-price online auctions.

Our starting point is the well-known Clarke tax. The Clarke tax is a mechanism which induces the submission of the true valuation (in the context of financing public goods) as a (weakly) dominant strategy. If a player understates the true valuation of a public good, then the player has to compensate the other individuals for their losses by his understatement. Roughly, this basic idea can be applied to the squeezing problem outlined in the preceding chapter.

Assuming, a bidder retracting his bid would have to compensate the winner of an auction, i.e. the buyer (i.e., the highest bidder), if the buyer has to take losses because of the squeezing. When the penalty be just high enough, then squeezing would not be a rational strategy anymore. How large should the penalty be? Looking at the Proof of Proposition 1, it is easy to see that the penalty should be as high as the difference between the buyer's valuation and the second-price, i.e $v^i - \max\{b^j\} \, \forall \, i \neq j \in \mathcal{N} \backslash \{s\}$.

The same reasoning applies if the seller cancels a bid. In this case, the seller himself should be penalized. Under civil law, a transaction is considered invalid whenever an error has occurred. Someone who made the error has to compensate the other party for the forfeited losses. Therefore, we propose compensation fees which are legally valid.

5 Concluding remarks

Why do we not observe in practice what auction theory would predict? Since Roth and Ockenfels (2002) put forward an interesting puzzle, several attempts have been made to give a rationale for late bidding. In particular, Roth and Ockenfels (2005) recently explained late bidding by focusing on technological problems. However, our paper aimed to show why sniping is a rational reaction in second-prize online auctions. Neither the consequences nor the rational strategy of squeezing of the bidder to his highest bid have been considered before in the related literature. In looking at the problem we have also sought its solution. One solution could be the introduction of compensation to the buyer, i.e. to the highest bidder, and secondly to make auctions anonymous.

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