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

Salvatore Barbaro
Johannes-Gutenberg University of Mainz*

Bernd Bracht
Johannes-Gutenberg University of Mainz

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Abstract

Recent studies provide empirical evidence for sniping (i.e., waiting until the last few seconds to bid) in second-price internet auctions, particularly in auctions at `eBay`. This evidence is puzzling: How could sniping be consistent with rational behavior in second-price auctions, where theory predicts that the timing of bids plays no role and there is no incentive to bid less than one's own private value. Some papers attempted to provide explanation, by focussing for instance on technological problems, the role of "experts" or on common values. Basically, all papers who explain sniping implicitly assume that `eBay` auctions are similar to *textbook* (or Vickrey-type) second-price auctions. Resulting, optimal bidding behavior outlined in auction theory could be expected in `eBay` auctions, too.

In the present paper, we show that sniping is a rational reaction to existing `eBay` 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.

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*Corresponding author. Address correspondence to: Department of Economics (FB 03), 55099 Mainz, Germany. E-mail: barbaro@uni-mainz.de.
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1 Introduction

Since Vickrey (1961), it is common sense that optimal bidding behavior in second-price auctions is as simple as clear: each bidder should submit a bid equaling his reservation value. An important advantage of a second-price auction over most other designs is that there is no need for any bidder to estimate the number of other bidders and their values, for those have no bearing on a rational bidder's optimal bid (see e.g. Milgrom (2004, p. 10)). Consequently, a rational bidder is indifferent concerning the timing of his bid and faces a simple strategic bidding problem: he merely has to determine his reservation value and bid it.

Looking at online auctions, the worlds largest market place, `eBay`, implemented a combination of English and second-price sealed-bid auction formats. Additionally, they use a proxy bidding system.[1] Empirical evidence provided e.g. by Wilcox (2000); Roth and Ockenfels (2002) shows that the optimal bidding behavior outlined above is not being observed on internet auctions with a fixed end time (*hard close*). With fixed-deadline auctions it is typical for the vast majority of bids to be placed just at the end of an auction (late bidding, so-called: sniping). In their influential paper, Roth and Ockenfels (2002) put forward an interesting puzzle: how can sniping be consistent with the theory of rational agents?

Some papers demonstrate that sniping is rational in common-value (CV) auctions. In this line Wilcox (2000) argues that non-professional bidders try to gain additional information from more experienced bidders ("experts") in the field. The less experienced bidders observe the bids of those who frequently place bids on similar items and take these bids as an indication for the "true value" of the goods, which is not known with certainty ex ante. In anticipation of this behavior experts place their bids late. Roth and Ockenfels (2002) have witnessed similar behavior in auctions over antiques. Therefore one can assume that the expert bidders will place their bids late on goods where the "true value" is hard to determine. Despite, it does not explain well why sniping is observed in auctions, where there is no persuasive argument for the existence of a common-value auction. Recently, Wintr (2005) found (ceteris paribus) more late bidding in auctions over standardized computer components and laptops (computer category) than in auctions over antiques. The question, thus, remains: why do we observe sniping in private-value auctions, too?

Secondly, another group of authors (papers) claim that late bidding is a strategic response to multiple-bidding. Late bidding can be thought as optimal response to the "incremental bidding strategies" of others, as it does not give the incremental bidder sufficient time to respond (see e.g. Ariely et al. (2005) for experimental (lab) evidence, Roth and Ockenfels (2005); Wintr (2005) and Bajari and Hortaçsu (2003)

[1] At `eBay` auctions the winner pays the amount equaling the second highest bid and the bid amounts remain "secret" in the course of the action. This secrecy of the maximum bid is indicative of a second-price sealed-bid auction, while the sequential nature of the bidding process (bids must be ascending in price) and the possibility of multiple bidding are indicative of an English auction. `eBays` proxy bidding system carries out the reservation value strategy of the bidder as follows: the proxy keeps beating the current highest bid on behalf of the bidder as long as that bid is less than his reservation value. Actually, this second-price auction format is a hybrid of English and second-price sealed-bid auction.

for field evidence, and Roth and Ockenfels (2002) for "anecdotal evidence").

A third group of papers regard sniping as a best response to "shill bidding" (shilling), but is mainly considered with shilling in online auctions in general. 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.[2]

Chakraborty and Kosmopoulou (2004) have considered the effect of shill bidding in a common-value auction. They show that shill bidding reduces the sellers and the bidders expected profits and that it is only the auctioneer who could gain from shilling activities. They conclude that the auctioneer has an incentive to encourage shilling. Wang et al. (2001) analyzed shill bidding in multi-round private-value English auctions. They proved that there is no equilibrium without shilling. Despite, the related literature considered with shilling has little to say about last minute bidding in second-price sealed-bid private-value auctions, like those at `eBay`.

So far, only Roth and Ockenfels (2005, p. 7) ("Of course, late bidding may also be a best response to other incremental bidding (or price war) behaviors, including that of a dishonest seller who attempts to raise the price by using 'shill bidder' to bid against a proxy bidder".) and Wang et al. (2004, p. 3) ("Consequently, a bidders strategic response to shilling is to snipe—to delay his bid until the last minutes—in order to avoid disclosing information and shorten the sellers cheat time.") have mentioned the thinkable effect of shilling upon a bidders strategy. Basically, all papers who explain sniping implicitly assume that `eBay` auctions are similar to *textbook* (or Vickrey-type) second-price auctions. Resulting, optimal bidding behavior outlined in auction theory could be expected in `eBay` auctions, too.

Our paper sets out an alternative explanation on the rationality of late-bidding by considering shill bidding activities explicitly. We show that sniping is a rationalizable strategy if one takes into account additional rules of `eBay` auctions. 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 show that this in fact leads to another strategy, which we call "squeezing". By squeezing the seller uses any 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 either retracts or cancels a shill bid and then he will submit another bid this time matching the reserve price of the highest bidder. 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.

We show that late bidding is the bidder's best response to the shilling and squeez-

[2]Shill bidding has increased substantially in recent years and is probably one of the most widely publicized form of online auction fraud. Shill bidding is easy to conduct and hard to detect in the `eBay` environment, because practically `eBay` cannot hinder users (sellers) to create multiple identities under whom to submit shill bids. Despite its importance, shill bidding is hardly considered in the traditional auction literature (see e.g. Wang et al. (2001, p. 2)).

ing strategies of the seller. Using the concept of iterated deletion of weakly dominated strategies, bidders prefer to bid late. Hence, last-minute bids are rational answers to given rules of auction games. So far, these rules have not being taken into account by existing research.

In Section 2 we model an eBay auction as a single-round auction which will be conducted within three periods with independent private values (IPV). We describe this game in Section 2. In Section 3 we show that any equilibrium is an equilibrium where the bidders snipe. We demonstrate that this holds independently of whether shilling is a rational strategy for the seller or not. We conclude (Section 4) with a summary of our paper.

2 A model of an eBay second-price auction

As a rule, eBay allows to cancel any bids at any time on their auctions. Contrarily, 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 case, the transaction is considered invalid under civil law of a wide range of countries.

Secondly, eBay allows the bidder to retract any bid if the description of an item is changed.[3] Despite, bidders are not allowed to retract their bids one hour prior to the auction closing. 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 sealed-bid auction. A *shiller* may use a second registered account to bid on his 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 (actual) bidders. Through this process, he uncovers the maximum reserve price and squeezes the buyer (bidder) for the potential payoff. It is worth mentioning that eBay explicitly forbid bidding on own listings. Practically, it is fair to say that eBay can not enforce this restricting rule.

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 actual bidders are not allowed to retract their bids one hour prior to the auction closing. Thus, eBay not only gives shillers a powerful hand, but they make it more difficult for actual bidders to react strategically.

[3] 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.

2.1 Players and private valuations

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). Denote the seller by $s \in \mathcal{N}$. The complement of $\{s\}$ denotes the set of the $n-1$ actual bidders. Bidders are allowed to have different private valuations of the good. Let $v^i \in \mathbb{R}_+$ denote the valuation of bidder $i \in \mathcal{N}$ of the item, which is drawn according to a density function f, where f has support $[0, y] \subset \mathbb{R}$ and $f(y) = 0$ applies. y denotes the maximum of the bids being allowed at an auction.[4] Every player is risk-neutral. All components of the model other than the realized values are assumed to be commonly known to all bidders. In particular, the distribution F is common knowledge, as is the number of bidders. For simplicity, we assume that the seller's reservation value is equal to zero, so that his payoff equals the second-highest bid submitted in the last period.

We study the strategic behavior in a private-value auction, instead of a common-value one. Thus, we assume that the individual willingness to pay is private information and they are not correlated with each other (see Myerson, 1981) for related issues). Before the auction starts, each player receives a signal about her valuation (the reserve price for the seller) as a private information. Note that in this game of incomplete information the seller cannot observe whether the two highest valuations coincide, which becomes crucial for the ongoing analysis. We rule out the possibility of a bidder collusion (see Marshall and Marx, 2004).

2.2 Rules and Outcome

The listing begins by the seller announcing a reserve (also called minimum bid). For simplicity, we assume the seller's reserve to equal zero.[5] The auction will be conducted in 3 periods (without violating general validity), denoted by t_1, t_2, t_3.[6] At every stage all bidders simultaneously submit their bids. They may or may not differ from their private valuation. If the bid of one or more bidders are equivalent to an earlier bid, then the early bidder will be the "highest bidder". If 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, denoted by p_1, p_2, p. 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 stage t_3. We describe bids in stage t_1 as *early bids* and bids in t_2 and t_3 as *late bids*.

[4] `eBay` allows a maximum bid of 99,999,999.99 US-Dollar.

[5] In fact, `eBay` offers two types of auctions: one with a posted reserve, and the other with a secret one. The outcome of the game is not affected by the specific type of auction. Note, this assumption does not affect the payoffs and the outcome of the game.

[6] This implies that each player can submit a maximum of three bids during the game. Having limited the numbers of bids, incremental bidding cannot be modelled in a reasonable way. Therefore, we rule out the case of players pursuing an incremental-bidding strategy.

By the end of the third period the outcome of the game is public information. It will be decided `(i)` who is the winner of the auction, `(ii)` which price the winner has to pay, and `(iii)` which payoff the seller receives.

2.3 Strategy Set

The bid submitted by bidder i at stage $t \in \{1, 2, 3\}$ is denoted by $b_t^i, \forall\, i \in \mathcal{N}$. The strategy set of bidder $i \in \mathcal{N}$ consists of all possible sequences of bids which he could submit in the auction. The set is denoted by $\mathcal{S}^i \equiv \{(b_1^i, b_2^i, b_3^i)|0 \leq b_t^i \leq y\} \in \mathbb{R}_+^3\ \forall t \in \{1, 2, 3\}$. 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 cancelled in the following periods. Note that $b_2^i = 0 < b_1^i$ is possible whenever a bid was cancelled by the seller. Cutting a bid back to a lower, positive value is, according to `eBay`'s user agreement, not conceivable. Note that the strategy set also allows for "conditional strategies". With conditional strategies we label strategies where the submission of bids depends on the bid history. "An example for such a strategy is the following: bid y in t_2 or t_3 if there are no bids in t_1, and do not bid at all if there is any bid in t_1".

We will now place further limitations on the strategy set, in order to simulate the reality of an `eBay` auction: $b_3^i \geq b_2^i \geq b_1^i\, \forall\, i \in \mathcal{N} \backslash \{s\}$. This rule formalizes the `eBay`-regulation whereby a bid cannot be retracted shortly before an auction ends.[7] The formula states that the actual 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 is always allowed. Despite this, it is possible for every bidder to increase his bid in the third period. Note that these rules are not *artificial* ones in order to simplify or complicate the model, these rules are according to the `eBay`-User agreement.

Definition 1 *Every sequence of play* $\{(0, [0, y], (0, y])\} \equiv \mathcal{L} \subset \mathcal{S}^i$ *of a bidder* $i \neq s$ *will be called sniping strategy. Finally, every sequence of play with a positive bid of an actual bidder in the first period will be called early-bidding strategy* ($\mathcal{E}$).

2.3.1 Squeezing

A squeezing of existing bids will be conducted within 3 periods: `(i)` bidding of y (shilling), `(ii)` canceling the bid, `(iii)` submitting a new bid being as high as the second price in the first period, p_1.

Step `(i)` (the shilling) is used in order to reveal the bidders reserve, because the signal at the end of every period will as the second-highest bid always be the highest bid of an actual bidder. As the seller knows that nobody else can bid more than y,

[7] This special rule makes *bid shielding* impossible. Bid shielding is the inverse of shilling, artificially high bids are submitted early by two bidders (instead of the seller) in order to increase the actual price. These high bids act as a shield, keeping anyone else from bidding. Just before the end of the auction, the bidders retract the high bids and submit one new low bid (e.g. Lucking-Reiley, 2000).

the highest bid of all actual bidders will always appear as a signal to him. Because of `eBay`'s specific bidding rules (see Subsection 2.3), canceling a bid is needed to submit a new bid. Therefore, canceling the bid `(ii)` is needed for carrying out step `(iii)`. Hence, *sniping* indicates the submission of bids at the time where the seller cannot carry out his squeezing strategy successfully.

Definition 2 *We call bidding sequences* $\{(y, 0, p_1)\} \equiv \mathcal{Q} \subset \mathcal{S}^s$ *of player* $s \in \mathcal{N}$ squeezing strategies[8] *and the sequence* $(0, 0, 0) \equiv \mathcal{H} \in \mathcal{S}^s$ *the honest strategy. We speak of the seller* manipulating the auction, *if the seller does not play* $\mathcal{H}$.

2.3.2 Shilling

As already mentioned, only few authors dealt with the thinkable effects of shilling upon a bidders strategy in an `eBay` environment. Shilling occurs, if a seller (the shiller) uses another identity to bid on his own listings in order to boost the final sale price. With a certain probability he will place the shill bid just in between the range of the (unknown) final first and final second price, whereby increasing his payoff. Will the shill bid be just below the final second price, he gains nothing, but also looses nothing. Will he outbid the highest bidder, he looses p for he will not succeed selling the auctioned good.

Note, squeezing does not exclude shilling. Squeezing is a riskless type of shilling which will only be successful, if there are any early bids. A seller who conducts a squeezing strategy and solely faces late bids can always submit a shill bid during the last period of the game. Whether the expected payoff of a seller who submits shill bids is higher than the expected payoff of someone who conducts a honest strategy depends upon several variables (e.g., the density function f and the number of bidders).

We do not model explicitly under which circumstances shilling might be rational or not (it obviously depends on f, which is not specified). Despite, we allow for both possibilities and assume the rationality of shilling to be common knowledge.

$\psi_1 - p \equiv \gamma(p + \alpha \cdot \delta)$ denotes the seller's expected payoff from shilling (instead of abstain from shilling). γ denotes the probability of placing a shill bid just in between the range of the final first and second price. If the shill bid is in between the range, the seller gains a share from shilling, $\alpha \cdot \delta$. In this case, instead of δ, the winner of the auction receives an expected payoff of $\psi_2 \equiv \gamma\left[(1 - \alpha)\delta\right]$. Note that with probability $(1 - \gamma)$ the seller as well as all bidders receive a payoff equal to zero.

Definition 3 *We call bidding sequences with a shill bid in* t_1 *"early-shilling strategy" (eSh) and every sequence of play with a shill bid in* t_2 *or* t_3 *"late-shilling strategy" (ℓSh).*

[8] Recall that p_1 denotes the actual second-price at the end of t_1.

2.4 Payoffs

At the end of the auction, bidders who have not submitted the highest bid will receive a payoff equal to 0. The highest bidder i will receive a payoff $\mathcal{P}^i \equiv v^i - p$, $\forall i \in \mathcal{N} \setminus \{s\}$ where $p \equiv \max_{j \neq i} b_3^j$. We henceforth refer to this difference as $\delta \in \mathbb{R}_+$. Note that we have imposed the assumption that the seller's reservation value is equal to zero, so that his payoff equals p (and zero if he submits a shill bid that is not outbidden by an actual bidder).

Summing up, we have characterized a game of incomplete information which consists of `(i)` a finite set $\mathcal{N}$ of players (bidders), `(ii)` for each player $i \in \mathcal{N}$ a nonempty set $\mathcal{S}^i$ of actions, `(iii)` for each player a set of signals (valuations, v), `(iv)` for each player a payoff function and, finally, `(v)` a probability distribution F over the set of signals.

This formulation postulates the following timing of events. Firstly, the signals v^i are drawn according to F and player i is told the realization of his signal (valuation). Secondly, armed with the knowledge about their valuation each player chooses an action $s^i \in \mathcal{S}^i$. Finally, based on the signals of all the players and their actions s^i, payoffs are realized.

3 Solving the game

Obviously, no actual bidder will place a bid above or below his valuation in t_3. Hence, we can delete a wide range of strategies from the bidders strategy set as dominated[9] by bidding one's reserve according to the basic insight by Vickrey (1961). Consequently, not bidding, i.e. $b^i = (0, 0, 0)$ is a dominated strategy for any actual bidder. Also, bidding y in t_3 is a dominated strategy by the seller as well as playing $(0, y, 0)$. Having deleted dominated strategies, the remaining bidder's strategy set is as following:

- Early Bidding ($\mathcal{E}$)
- Late Bidding ($\mathcal{L}$)
- "bid late if there is an early bid and do not bid at all if there are no early bids" (c_1)
- "bid late if there are no early bids and do not bid at all if there is any early bid." (c_2)

It is easy to verify that either bidding in t_2 or t_3 yields the same payoffs for both parties, the seller and the bidder.

The remaining set of the seller's strategies are as following:

- Squeezing ($\mathcal{Q}$)

[9]For ease of notation, we speak of "dominated" and "dominant" strategies, meaning "weakly dominated" and "weakly dominant" strategies.

- Honest Strategy ($\mathcal{H}$)
- "Start pursuing the squeezing strategy by playing y in t_1 and 0 in t_2. If shill bidding in t_3 is rational, submit a shill bid in t_3. If not, bid p_1 in t_3." ($\mathcal{K}$)
- (c_3): "Bid y if there is no early bid, otherwise, do not bid at all".
- Late Shilling: (ℓSh)[10]
- Early Shilling: (eSh)
- "Shill (late) if there is an early bid. Otherwise do not shill" (c_5)
- "Shill (late) if there is no early bid. Otherwise do not shill" (c_6)

Table 1 contains these strategies. We call it a normal-form representation of the truncated `eBay` game, because we have already deleted the obviously dominated strategies mentioned at the beginning of this section.

Bidder i is the highest bidder. No actual bidder knows, if he will be the highest bidder. In any case, there are only two options: he will be or he will be not. If he will be not, his payoff will always equal zero. If he will be, then the normal-form game in Table 1 applies.

s \ i	$\mathcal{E}$	$\mathcal{L}$	c_1	c_2
$\mathcal{Q}$	$p+\delta, 0$	p, δ	p, δ	$0, 0$
$\mathcal{H}$	p, δ	p, δ	$0, 0$	p, δ
$\mathcal{K}$	$p+\delta, 0$	ψ_1, ψ_2	ψ_1, ψ_2	$0, 0$
c_3	p, δ	$0, 0$	$0, 0$	$0, 0$
eSh	ψ_1, ψ_2	ψ_1, ψ_2	ψ_1, ψ_2	$0, 0$
ℓSh	ψ_1, ψ_2	ψ_1, ψ_2	$0, 0$	ψ_1, ψ_2
c_5	ψ_1, ψ_2	p, δ	$0, 0$	ψ_1, ψ_2
c_6	p, δ	ψ_1, ψ_2	$0, 0$	ψ_1, ψ_2

Table 1: Normal-form representation of the truncated `eBay` game

Looking at the normal-form representation of the game, we can easily state the following useful Lemma:

Lemma 1 *Neither sniping nor squeezing are dominant strategies for the bidder and the seller, respectively.*

Because it is not the best reply to c_2, squeezing ($\mathcal{Q}$) is no dominant strategy. Similarly, sniping ($\mathcal{L}$) is not the best response to c_3.

[10] According to Definition 3, late shilling contains every sequence of play with a shill bid in t_2 or t_3. It is easy to verify that either shilling in t_2 or t_3 yields the same payoffs for both parties.

Comparing c_3 and the honest strategy ($\mathcal{H}$) reveals that c_3 is dominated by $\mathcal{H}$. Furthermore, c_1 is dominated by $\mathcal{L}$. Similarly, $\mathcal{L}$ dominates c_2 (because $\psi_2 < \delta$). Having deleted c_1, c_2, c_3, squeezing ($\mathcal{Q}$) dominates the honest strategy. This implies the following

Proposition 1 *In an* `eBay`*-form game, the seller always has an incentive to manipulate the auction.*

Case 1: Shilling is rational. If shilling is rational, i. e. if $p + \delta \geq \psi_1 > p$, the strategies c_5, c_6 are dominated by the unconditional shilling strategies $eSh, \ell Sh$. In this case, however, both unconditional shilling strategies are dominated by $\mathcal{K}$, which dominates the squeezing strategy. Having deleted all dominated strategies, the seller will play $\mathcal{K}$ and the bidder will snipe, because sniping ($\mathcal{L}$) is the bidder's best reply to $\mathcal{K}$.

Proposition 2 *If shilling is rational, the pair of strategies that will survive the iterative deletion of dominated strategies is* $(\mathcal{K}, \mathcal{L})$.

Case 2: Shilling is not rational. If shilling is not rational (i.e. $\psi_1 - p < 0$), the seller will not submit a shill bid. In this case, after having eliminated the dominated strategies c_1, c_2 (see above), squeezing dominates all other strategies of the seller. Having deleted all dominated strategies, the seller will play $\mathcal{Q}$ and the bidder will snipe, because sniping ($\mathcal{L}$) is the bidder's best reply to $\mathcal{Q}$.

Proposition 3 *If shilling is not rational, the pair of strategies that will survive the iterative deletion of dominated strategies is* $(\mathcal{Q}, \mathcal{L})$.

Summarizing, after deletion of dominated strategies, sniping is the bidders best response to the shilling and squeezing strategies of the seller. The outcome of the game differs, depending on the rationality of shilling. However, in both cases, the bidder will snipe.

4 Concluding remarks

Why do we not observe in practice what auction theory predicts? Since Roth and Ockenfels (2002) put forward an interesting puzzle, several attempts have been made to give a rationale for late bidding. In order to explain bidding behavior in online auctions we considered specific rules of `eBay` auctions. We modelled shill bidding activities explicitly and discovered a new strategy, which we called squeezing. While shilling is a risky activity, squeezing is riskless and allows the seller to cream off possible gains the bidder might have. Squeezing fails if the bidders submit late bids (sniping).

We were able to show the seller's incentive to manipulate the auction. We proved that sniping is the bidder's best response to any manipulated auction. Therefore, we established a new type of reasoning that might explain a fair degree of late-bidding behavior being observed in online auctions. Finally, our analysis suggests the importance of modeling the specific rules of `eBay` auctions in explaining bidding behavior.

References

Ariely, D., Ockenfels, A., Roth, A. E., 2005. An experimental analysis of ending rules in internet auctions. RAND Journal of Economics 36 (forthcomming).

Bajari, P., Hortaçsu, 2003. The winner's curse, reserve prices, and endogenous entry: empirical insights from ebay auctions. RAND Journal of Economics 34, 329–355.

Chakraborty, I., Kosmopoulou, G., 2004. Auctions with shill bidding. Economic Theory 24, 271–287.

Lucking-Reiley, D., 2000. Auctions on the internet: What's beeing auctioned, and how? Journal of Industrial Economics 48, 227–252.

Marshall, R. C., Marx, L. M., 2004. Bidder collusion, mimeo.

Milgrom, P., 2004. Putting Auction Theory to Work. Cambridge, Cambridge.

Myerson, R. B., 1981. Optimal auction design. Mathematics of Operation Research 6, 58–73.

Roth, A. E., Ockenfels, A., 2002. Last-minute bidding and the rules for ending second-price auctions: Evidence from eBay and Amazon auctions on the internet. American Economic Review 92, 1093–1103.

Roth, A. E., Ockenfels, A., 2005. Late bidding in second price internet auctions: Theory and evidence concerning different rules for ending an auction. Games and Economic Behavior 50 (forthcomming).

Vickrey, W., 1961. Counterspeculation and competitive sealed tenders. Journal of Finance 16, 8–37.

Wang, W., Hidvègi, Z., Whinston, A. B., 2001. Shill bidding in multi-round online auction, mimeo (this version: December 20, 2001).

Wang, W., Hidvègi, Z., Whinston, A. B., 2004. Shill-proof fee (spf) schedule: the sunscreen against seller self-collusion in online english auctions, mimeo (this version: October 20, 2004).

Wilcox, R. T., 2000. Experts and amateurs: The role of experience in internet auctions. Marketing Letters 11, 363–374.

Wintr, L., 2005. Some evidence on late bidding in eBay auctions, Paper presented at the Youth Economists Meeting, Geneve.