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Abstract

In an Internet auction, bidders sequentially decide whether or not to enter, and each bidder has to pay a participation cost. In this paper we model an Internet auction with a *temporary* buyout option. Our main result shows that under certain condition, offering a temporary buyout price would encourage entry of risk neutral bidders, and hence enable the seller to increase expected payoff.

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1 Introduction

This paper is motivated by Internet auctions[1], in which buyout options are present. This option allows a bidder to stop auction and immediately obtain the object by exercising a pre-determined price. Mainly, there are two types of "buyout option": the first is a permanent buyout option, which remains available throughout the whole auctioning competition and was offered on Yahoo. The second is a temporary buyout option and active as long as no bid has been put in the auction, which is offered on eBay, called "Buy-It-Now". This temporary option will be disappeared after first bid is placed and then the object keeps being auctioned. In this paper, we only focus on temporary buyout option.

From eBay's quarterly reports for 2007-2008, it shows that fixed price trading, mainly consisting of "Buy-It-Now" purchases, accounts for more than 40% of gross merchandise volume. Moreover, accross different product categories, percentage of augmenting Internet auctions with a buyout option would be between 20% and 60%. Our main interest is to investigate in which case it is attractive for the seller to combine an auction with a temporary buyout option.

As the leading innovation of Internet commerce, Internet auctions have some common characteristics. First, not like in simultaneous-bidding framework, usually an Internet auction lasts online a few days in order to attract bidders as many as possible. During this auctioning period, each bidder will sequentially arrive in the auction house and endogenously decide whether to put a bid in the auction or not. Second, bidders cannot "physically" meet seller in an Internet auction. Therefore, before entry, each bidder has to spend some effort, money and time identifying seller's reliability and level of service, and also the opportunity cost of time associated with bidding, all which can be seen as an participation cost for each bidder[2]. Bajari and Hortacsu (2003) have shown significantly empirical evidence of entry cost from eBay auctions, and also suggested that this cost would be one of the main determinant factors of entry.

In this paper, we construct a simple two-valuation model with two bidders to illustrate how a temporary buyout price might be profitable for a seller. First, we characterize bidders' participation strategies when partic-

[1]Mainly, Internet auctioning mechanism is constrained to use sealed-bid second price auction.

[2]Even thought eBay has a feedback system to assess sellers' reputation, eBay still suggests potential bidders to contact with the seller and check his creditability before bidding, since this reputation system might be easily manipulated by sellers.

ipation is costly and bidders sequentially decide whether or not to enter the auction. Furthermore, given two bidders' entry strategies, we analyze optimal reserve price and payoff for the seller. Then, in the same scenario, we allow the seller to offer a temporary buyout option. The participation cost C still needs to be paid whether the object is acquired through bidding or exercising the buyout option. We show that under certain condition, the buyout option would attract risk neutral bidders into the auction, which consequently increases the seller's expected payoff.

So far, the explanation of buyout option is mainly based on risk aversion of either sellers or bidders. Budish and Takeyama (2001); Mathews and Katzman (2006); Hidvégi, Wang, and Whinston (2006); Reynolds and Wooders (2009) argue that by augmenting a temporary or permanent buyout option a (risk averse) seller can extract more profit from risk averse bidders. In the literature, some theoretical analysis on participation cost in an auction have been discussed by Tan and Yilankaya (2006); McAfee and McMillan (1987); Levin and Smith (1994); Samuelson (1985). Furthermore, Bulow and Klemperer (2009) discuss jump bidding in the case of costly participation and sequential entry in the auction.

2 The model

Consider a seller S selling an object by employing an Internet auction. The auction will be proceeded online for a few days, in which there is a queue of risk neutral bidders sequentially arriving, but the total number of entry of potential bidders is uncertain. In order to simplify the model, we assume that there are only two risk neutral bidders (i : 1 and 2) competing for the object, and the sequence of both bidders arriving in the auction is exogenous given such that bidder 1 is the leading bidder and bidder 2 is the following bidder. Furthermore, we also assume that after a bidder decides not to put a bid, he leaves the auction and cannot revisit.

Before making a decision of participation, each bidder's valuation V_i is independently drawn from $\{V_L, V_H\}$, where $0 < V_L < V_H$. Let α represent the probability a bidder is of type V_L. In order to submit a bid, each bidder has to incur a participation cost C, i.e., money and time associated with bidding, where $C \in (0, \Delta)$, $\Delta = V_H - V_L$ and $V_L - C > 0$. This cost is the same across both bidders[3]. The seller values zero to the object and can

[3]Obviously, if biding cost is zero in the auction, auctioning result should be the same between sequential and simultaneous entry of bidders.

choose a reserve price R on the interval $[0, V_H]$ to maximize his profit[4].

2.1 Bidders' participation strategies

In this section we analyze bidders' participation decisions. For each bidder, he will enter the auction iff his expected payoff is equal or greater than the participation cost C. Obviously, there would exist many equilibria in the model, but here we only restrict our attention to the "credible" equilibrium in which each bidder bids his valuation conditional on entering the auction[5]. Given reserve price R from seller, we characterize bidders' entry strategies.

Given parameters in the auction, bidder 1's entry strategy is mainly depended on which reserve price R the seller sets. Thus, we characterize bidder1's entry strategy in terms of which valuation he has would enter the auction. If $\alpha(V_L - R) < C$, only bidder 1 with V_H would enter the auction. If $\alpha(V_L - R) \geq C$, bidder 1 with both values would participate in the auction.

Bidder 2 is the following bidder. When she arrives in the auction, she observes leading bidder's entry decision and has a information update, then decides whether or not to incur the cost to participate in the auction.

After observing bidder 1 puts a bid in the auction, bidder 2, according to reserve price and entry strategies bidder 1 would have, will have different corresponding entry strategies. Therefore, conditional on bidder 1 in the auction, we characterize bidder 2's entry decision in following two cases: If $\alpha(V_L - R) < C$, which implies that bidder 1's valuation is V_H, then bidder 2 always chooses not to enter. If $\alpha(V_L - R) \geq C$, which implies that bidder 1's valuation could be either V_H or V_L with corresponding probabilities of α and $(1 - \alpha)$, then bidder 2 will enter if $V_2 = V_H$ and $\alpha(V_H - V_L) \geq C$, otherwise chooses not to enter.

When bidder 1 is not in the auction, bidder 2 will enter and obtain the object by paying R iff $V_2 \geq R + C$.

Compared to bidder 2's entry strategy, bidder 1 has relatively advantage of entry, which shows that after entering the auction, bidder 1's bid can

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[4] We see that the maximum reserve price R the seller can charge is $V_H - C$. If $R > V_H - C$, then no bidder can enter at all.

[5] We would see other equilibria in the model. For example, there is an equilibrium in which bidder 1 always bids V_H if his valuation is greater than $(R + C)$, otherwise chooses not to participate. Bidder 2 enters iff bidder 1 is not in the auction and $V_2 \geq (R + C)$. In this equilibrium, only one bidder enters the auction and wins the object by paying reserve price. If $(R + C) \leq V_L$, there also can be another equilibrium in which bidder 2 always bids V_H, and bidder 1 never enters the auction. In this equilibrium, bidder 2 obtains the object by paying reserve price. A large literature has been discussed about selection of "reasonable" equilibria in a sequential game. Riley (2001) gives a survey in this literature.

(partially) deter the entry of bidder 2 and increase the possibility of winning the object.

Proposition 1. *Given that bidder 1 is in the Internet auction, bidder 2 enters the auction iff* $V_2 = V_H$, $\alpha(V_L - R) \geq C$ *and* $\alpha(V_H - V_L) \geq C$.

2.2 Optimal reserve price and seller's payoff

From the previous discussion, bidders' entry strategies are also depended on which reserve price the seller proposes. Now we discuss optimal reserve price, denoted as R^*. The seller maximizes his expected payoff by choosing R^*.

No matter in which case, type-V_L bidder 2 always cannot participate in the auction. Thus, when the seller sets optimal reserve price R^*, the key point will be to distinguish whether or not type-V_H bidder 2 would have possibility to enter the auction conditional on bidder 1 putting a bid, which only depends on whether $\alpha(V_H - V_L)$ is greater or less than C. Therefore, given these two bidders' strategies, we separate the analysis in two cases: $\alpha(V_H - V_L) \geq C$ and $\alpha(V_H - V_L) < C$. Moreover, in each case, whether or not type-V_L bidder 1 can enter the auction, depending on the reserve price, yields different expected payoffs to the seller. Thus, in either of both cases, we separately investigate R^* and payoff for the seller in terms of whether $\alpha(V_L - R)$ is greater or less than C.

Firstly, we consider the case $\alpha(V_H - V_L) \geq C$, the seller will choose R^* to maximize his profit. If $\alpha(V_L - R) \geq C$, the maximum reserve price the seller can charge is $V_L - \frac{1}{\alpha}C$ and then bidder 1 with both valuations and bidder 2 with V_H would enter the auction, which yields expected payoff $(1-\alpha)^2 V_H + \alpha(2-\alpha)V_L - C$. If $\alpha(V_L - R) < C$, the maximum reserve price the seller can charge is $V_H - C$ and only one bidder with V_H will enter the auction. This gives expected payoff $(1-\alpha^2)(V_H - C)$ to the seller. Therefore, in this case, the seller will choose R^* between $V_L - \frac{1}{\alpha}C$ and $V_H - C$, depending on which expected payoff is greater.

For another case $\alpha(V_H - V_L) < C$, we still keep using the same logic to analyze R^*. If $\alpha(V_L - R) \geq C$, the maximum reserve price is $V_L - C$ and then bidder 1 with both valuations enters and bidder 2 cannot enter at all, which yields payoff $(V_L - C)$. If $\alpha(V_L - R) < C$, the maximum reserve price is $V_H - C$ and only one bidder with V_H will enter the auction, which yields payoff $(1 - \alpha^2)(V_H - C)$. Thus, in this case, the seller will choose R^* between $V_L - C$ and $V_H - C$ by simply comparing two expected payoffs.

Proposition 2. *Optimal reserve price R^* and expected payoff for the seller:*

Given	*If the condition holds*	*R^* equals*	*Payoff*
$\alpha(V_H - V_L) \geq C$	$\frac{\alpha}{2}(2V_H - V_L - C) < V_H - V_L$	$V_H - C$	$(1-\alpha^2)(V_H - C)$
	$\frac{\alpha}{2}(2V_H - V_L - C) \geq V_H - V_L$	$V_L - \frac{1}{\alpha}C$	$(1-\alpha)^2 V_H + \alpha(2-\alpha)V_L - C$
$\alpha(V_H - V_L) < C$	$\alpha^2(V_H - C) < V_H - V_L$	$V_H - C$	$(1-\alpha^2)(V_H - C)$
	$\alpha^2(V_H - C) \geq V_H - V_L$	$V_L - C$	$(V_L - C)$

2.3 Temporary buyout option

In this section we consider the same scenario but the seller can offer a temporary buyout option, denoted as B. The auction will stop immediately when B is exercised. When a bid is put in the auction, the buyout option will be disappeared and following bidder only can choose whether to enter or leave. The participation cost C needs to be paid for either exercising B or putting a bid. From proposition 2, there are four cases for the seller to maximize his profit. Therefore, we separately discuss in which case the seller offers a buyout option would be profitable and how to set up a buyout price.

When the conditions for $R^* = V_H - C$ hold, only a type-V_H bidder enters in the auction. In this case, if the seller wants to offer a buyout option, the maximum buyout price can be R^* and there is no difference for the type-V_H bidder to put a bid or exercise the option. Thus, the buyout option yields the same expected payoff as auction without buyout option.

If the conditions for $R^* = V_L - \frac{1}{\alpha}C$ hold, bidder 1 with both values participates in the auction, and bidder 2 will enter if $V_2 = V_H$. In this case, the auction attracts bidders as many as it can. Thus, it is unnecessary to set up a buyout option, or the seller can choose a buyout price high enough such that no bidder exercises.

In the last case, given the conditions for $R^* = V_L - C$, only bidder 1 will be in the auction and bidder 2 cannot enter. However, in this case, offering a temporary buyout option would improve the signal of bidder 1's entry to bidder 2, and hence increase the seller's expected payoff. First, we know that bidder 2 holds a belief $\{\alpha, 1-\alpha\}$ regarding bidder 1's valuations. Then, given bidder 2's belief, let the seller set a buyout price B and a reserve price R' such that $V_H - B = \alpha(V_H - R')$ and $\alpha(V_L - R') - C = 0$. Solving the equations we have $B = (1-\alpha)V_H + \alpha V_L - C$ and $R' = V_L - \frac{1}{\alpha}C$. We see that only type-$V_H$ bidder 1 can exercise the buyout option B. If the buyout option is not exercised, it implies that bidder 1's valuation should be V_L and then this information encourages type-V_H bidder 2 to enter the auction.

Also, given this possibility of more entry from bidder 2, type-V_H bidder 1 has to exercise the buyout option and obtains the object immediately[6]. In this case, offering a buyout option in the auction yields expected payoff $(1-\alpha)^2 V_H + \alpha(2-\alpha)V_L - C$ to the seller, which is strictly greater than $(V_L - C)$.

Proposition 3. *A temporary buyout option would encourage entry of bidders, which consequently increases the seller's expected payoff, if the following condition holds:*

$$(V_H - V_L) < \min\left\{\alpha^2(V_H - C),\ \frac{1}{\alpha}C\right\} \tag{1}$$

Remark 1. A temporary buyout option encouraging entry of bidders would still hold if we assume more general circumstances.

Example: Suppose that three-type valuations are $\{5, 6, 7\}$ with probabilities of $\left\{\frac{3}{8}, \frac{3}{8}, \frac{2}{8}\right\}$. Let the participation cost C equal $\frac{1}{2}$. Two bidders still decide in turn whether or not enter the auction. Without a temporary buyout option, it is easy to check that the optimal reserve price R^* should be $\frac{16}{3}$, and the seller's expected payoff equals $\frac{19}{4}$. Moreover, when bidder 1 is in the auction, bidder 2 will enter iff $V_2 = 7$.

Now we introduce a temporary buyout option in the auction such that $7 - B = \frac{3}{8}(7 - R') + \frac{3}{8}(7 - 6)$ and $\frac{3}{8}(5 - R') = \frac{1}{2}$. Solving the equations we have $R' = \frac{11}{3}$ and $B = \frac{43}{8}$. In this case only type-7 bidder 1 will exercise the buyout option. In bidder 2's turn, if the buyout price is not exercised, he knows that bidder 1's valuation should be less than 7, which encourages the entry of bidder 2 (who with both valuations 6 and 7 will enter the auction). Finally, we have that the seller's expected payoff equals $\frac{317}{64}$, which is greater than $\frac{19}{4}$, and it is profitable to offer a temporary buyout price in the auction.

3 Conclusion

Our main result shows that under certain condition, offering a temporary buyout option would increase the possibility of entry of bidders in an Internet auction, which increases the seller's expected payoff.

[6] If type-V_H bidder 1 bids his valuation but does not exercise B, type-V_H bidder 2 believes that he faces type-V_L bidder 1 and still participates in the auction, which reduces bidder 1's payoff.

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