Hiding information in open auctions with jump bids*

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Abstract

We analyze a rationale for hiding information in open auction formats. We focus on the incentives for a bidder to call a price higher than the highest standing one in order to prevent the remaining active bidders from aggregating more accurate information that could be gathered by observing the exact drop out values of the exiting bidders. Necessary conditions for the existence of jump bids with such motivations are provided. Finally, we show that there is no clear-cut effect of jump bids on efficiency and expected revenue and introduce several specific results.

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1 Introduction

One of the main characteristics of an open ascending auction format is that it allows participants to aggregate new information on top of the information available ex-ante. This is also the key feature that leads auction theorists and designers to advocate, in some environments, in favor of the use of an open auction as opposed to a sealed bid auction. Surprisingly, the existing literature ignores that the participants in the auction might have an incentive to manipulate the quality (precision) of the new information that can be aggregated. We explore this issue showing that jump bids can be used to achieve such objective.

This interest in jump bids is not uniquely explained by theoretical motivations. As a matter of fact, it is a well documented fact (see Cassady (1967), Fishman (1988), Cramton (1997)) that jump bids are quite prevalent in several auction contexts although they may be perceived as a missed opportunity to win the auction for a lower price without a clear profit to counterbalance it. We intend to provide a new explanation for the existence of jump bids based on the idea of information manipulation.

In general, the new information that bidders can gather during the auction may be of different characteristics: exogenous or endogenous, private to a bidder or available to some subset of the bidders, free or costly to acquire. Here we focus on the information that can be gathered simply by observing who is active and who is not at any given price. This information is endogenous, publicly available to all active bidders, and free. In an interdependent value setting, its knowledge affects bidders' expected valuations for the object and thus it is crucial in determining their bidding behavior. We provide a rich variety of frameworks in which jump bids are used in equilibrium to manipulate the aggregation of the new information, and show that their impact on revenue and efficiency can be drastic. The same framework can be used to show that the seller can set a reserve price to prevent the aggregation of information that would lower the expected price at which the object is allocated.

For the sake of illustration, let us consider the following example. Suppose that the right to exclusively distribute a new product is for sale. Firms 1 and 2 have an informational advantage regarding the expected market size of the new product in their areas (1 and 2, respectively).[1] Firm 3 is a big foreign distributor interested in expanding its presence over

[1] The two market could be geographically different and thus we could think of their information to be independent, or they could not. The only requirement here is that the information is not perfectly correlated.

the joint areas 1 and 2. If the expected size of both market 1 and 2 is large enough, then Firm 3 has the highest valuation for the exclusive distribution rights. Conversely, if only one of the two markets is large enough, the cost to enter the new market is too big for Firm 3 and one of the other two firms holds the highest valuation. In this setting, one of the two local firms, say Firm 1, has an incentive to place a jump bid to *hide* the exact drop out price of Firm 2 when she values the exclusivity high.[2] In fact, if Firm 2 does not match the jump bid, only the coarser information that Firm 2 valuation is between the price from which the jump bid was called and the jump bid value becomes available, leaving Firm 3 uncertain regarding whether she is the firm holding the highest valuation. The jump bid depresses the bid of Firm 3 when Firm 2's valuation is close to the value of the jump bid. The cost associated with the jump bid is that if Firm 2's valuation is close to the price from which the jump bid was called, then Firm 3 would have dropped out at a value lower than the jump bid.

Only when the benefits of providing coarser information outweigh the costs, a jump bid is placed in equilibrium. It is easy to identify trivial cases when this is the case. In the example above, for instance, it suffices to have an additional bidder whose value is known to be sufficiently high so that the cost mentioned above disappears. More generally, in order to observe a jump bid aimed at hiding information, we need, at least, three bidders with the following characteristics. At least one bidder must have initially coarser information, which can become finer by observing the exact drop out value of one or more bidders. At least one bidder must have an incentive to prevent the acquisition of this finer information, which means that 1) either the more precise information would have a more positive (or less negative) impact on some of the opponent's value rather than on the value of the bidder who jump bids; or 2) that the jump bids enables the bidder who jump bids to preserve an informational advantage that induces the less informed bidder to bid less aggressively. We illustrate that the latter is the case when an informational advantage over a common value component imposes a winner's curse on the less informed bidder. In other words, in a *standard* framework, either an asymmetry in the value structure or in the informational structure is needed.

Whenever information aggregation is considered a key issue, it is paramount to understand if and how bidders can affect it. This is particularly relevant as in practice most open auction

[2]Throughout the paper, we use the convention to refer to a bidder as "she".

formats allow the bidders or the auctioneer to call a price higher than the highest standing price, and bidders do make use of such possibility. While the example provided above is stylized, situations where an incentive to jump bid is present are common. For examples that are meant to be suggestive of the situations we have in mind, see section 5.

We see our paper as a first step towards a better understanding of bidders' strategic behavior in an open auction when the action space is larger. The enlarged action space and the resulting complexity of the environment make it more difficult to draw unambiguous predictions regarding the effect of hiding information. Still, we think that we are able to point out the main motivations behind the desire to hide information and their consequences in terms of revenue and efficiency. We show that jump bids with this motivation may arise in several environments. We also show that jump bids may have several strategically complex effects and that the possibility of calling a price, even when it is not used, may dramatically affect the outcome of the auction. Eventually, we prove that the effect of allowing jump bids on efficiency and revenue is ambiguous. Even though the *direct* effect of a jump bid on efficiency and revenue is a priori negative (a bidder calls a price in order to lower the price he pays or to win the auction in situations he would not win if the information was not hidden), *indirect* effects may more than counterbalance it.

2 Related Literature

A bidder may call a price higher than the highest standing bid moved by one of two rather opposite strategic motivations: providing more information to other bidders or hiding information to them.[3] The first motivation has already been pointed out in the existing literature on jump bidding. The second one is novel to our contribution. According to the first rationale, a jump bid provides finer information to the opponents by signaling that the private information held by the bidder who jump bids is good. Note that, in general, providing more positive information about your own signal in an interdependent value setting might not be a good idea as it increases the opponents expected valuation for the object on sale. Thus, in order to construct a signaling model two main directions are proposed by the literature. One is based on the idea that signaling may discourage the acquisition of costly information,

[3] In general, a jump bid may, at the same time, hide some information as well as signal some other.

while the other provides a pure signaling model. The first contribution suggesting the former preemptive motivation is Fishman (1988). Other related works are Hirshleifer and PNG (1989), Bhattacharyya (1992), Bernhardt and Scoones (1993), and Michelucci (2012).

Fishman (1988) presents a two-bidders independent private value model in which one of the two bidders has an informational advantage in that she is able to costly discover her valuation prior to the start of the auction, while the other bidder does not. If the first bidder's value is above some critical threshold, a jump bid that pre-empts the second bidder from investing and competing is placed. The effect of a jump bid in this setting is anti-competitive and reduces the seller's revenue. Essentially, the model introduces an entry deterrence scenario, which requires costly information acquisition to work. This model fits very nicely those applications for which discovering finer information is costly, however it cannot be applied more generally.[4]

The other leading justification for jump bidding has been proposed by Avery (1998). Using a symmetric model with affiliated valuations, he shows that jump bidding can be employed to select the strongest bidder during the first stage. During this stage, strong bidders (with private signals higher than a threshold) signal that their type is high by making a jump bid. The signaling induces asymmetric bidding behavior in the second stage of the game with a strong bidder committing to a more aggressive strategy than a weak bidder (with private signals lower than a threshold). Such equilibrium behavior can be viewed, as the author points out, as a form of implicit collusion.

In any jump bid signaling model, the receiver needs to quit earlier than she would do otherwise, regardless of the fact that in an interdependent value setting a jump bid raises her expected value. In the absence of bidding costs, this latter behavior can be part of an equilibrium strategy only if the bidder who observes the jump bid can infer that she has zero probability of winning. In this case, she is as well off quitting earlier. However, the equilibrium is typically not a Perfect Bayesian Equilibrium; see Avery (1998).

In this paper, we focus on the hiding information rationale. With our motivation, bidders simply need to rationally process the available information as it happens in a model without jump bids. The effect of a jump bid that we stress is to foreclose access to finer information

[4] The assumption of private values is restrictive. For a model that looks at the incentive to jump bid when the finer information involves a common value element; see Michelucci (2012).

so that the information that bidders get to process is coarser. There is also some information foreclosure in Fishman (1988), but there are crucial differences. First, in his model the bidder who observes the jump bid can still acquire the finer information, even if, in equilibrium, she will not. Instead, in our model, the finer information is simply no longer available. Second, we do not need costly information acquisition to generate jump bids, and so we can explain jump bids for applications where Fishman (1988)'s preemptive motive cannot be applied.

Even though there is no cost of acquiring information in our setting, in an open auction, the winner might experience ex-post regret, that is she might experience a loss when winning. The reason why a bidder might be active at a price at which she would make a loss if she were to win is that such loss is, in expected terms, more than compensated by the potential profits of winning at a higher price, later in the auction. In other words, the bidder is active at lower prices in the hope of aggregating favorable information later on. Thus we can view the mentioned expected losses as the implicit cost of aggregating information. This possibility does not arise in most of the the standard literature as some technical single crossing conditions are assumed to guarantee that the efficient outcome is implementable and no ex-post regret is experienced in equilibrium.[5] We deal with this type of environment in section 5.2 and show that jump bids can increase revenues and efficiency in cases in which the standard English auction without jump bids fails to aggregate smoothly new information.

That bidders might be active in an open auction in order to aggregate new information is a point that has also been made by Compte and Jehiel (2004a) and Compte and Jehiel (2007). Compte and Jehiel (2004a) provides a private value model where, with some probability, bidders may receive a better estimate about their private valuation at some exogenously determined random time. If there are enough bidders in the auction, it may be profitable for some bidders to *wait and see* for favorable information. Such possibility raises both efficiency and revenue compared to a sealed-bid format. A similar insight is also present in Compte and Jehiel (2007): a bidder may stay active beyond her initial expected valuation to observe the strength of the competition. If competition is not intense, she can invest to get to know her exact valuation. Instead, here we point out some limits to the ability of the English auction (without jump bids) to aggregate information. If the bidders who might *wait and see* are

[5]For an analysis of the efficiency properties of the English auction when these conditions are violated and some relevant examples, see Hernando-Veciana and Michelucci (2011).

not symmetric, a free rider problem might originate, and preclude the aggregation of new information altogether. In this case, allowing for jump bids can increase both revenue and efficiency.

The remaining of the paper is organized as follows. Section 3 introduces the model. Section 4 presents two natural environments where an equilibrium jump bid emerges. Section 5 studies strategically more complex environments, illustrates some properties of jump bids, and shows that there is no clear-cut effect of jump bids on revenue and efficiency. Section 6 discusses and extends ideas introduced in the paper. Section 7 concludes.

3 Auction setting

We analyze a modified version of the Japanese Auction (JA), which aims at capturing an element of the dynamic features of the English Auction (EA) that cannot be represented when adopting the standard JA format, the opportunity to call a price.

3.1 Environment

A set N of $i := 1..n$ bidders is present at the start of the auction. No further entry takes place after the auction has started, and the decision to exit the auction is irreversible. Bidder i's private information is represented by a unidimensional signal $t_i \in T_i$, while the vector $t_{-i} \in T_{-i}$ contains the $n-1$ signal of i's opponents. Bidders' valuations are interdependent, i.e., $v_i(t_i, t_{-i})$, with v_i weakly increasing in t_j for all arguments. We also assume quasi-linear utility so that $u_i(t_i, t_{-i}) = v_i(t_i, t_{-i}) - p$ if the bidder i gets the object and pays price p, and $u_i(t_i, t_{-i}) = 0$, if bidder i does not get the object and no payment is required.

While t_i is private to bidder i, the value functions v_i as well as the cumulative distribution functions, F_i from which the signals t_i are independently drawn[6] are common knowledge among bidders. In some of the following analysis we assume discrete type space. We find this more convenient to illustrate our points in the cleanest way, but it should be apparent that an environment with a continuous type space can always be constructed to derive the same insights.

[6]Except in some specific cases that we will mention

3.2 Auction Rules

We consider two versions of the Japanese auction. First, the standard Japanese auction without jump bids we will call the *C game*.[7] Second, the *J game*, is a Japanese Auction in which jump bids are allowed. The latter is defined as follows. The price starts from a very low value, which we normalize to zero, and it is increased at a constant pace by an exogenous device such as a clock. Bidders are considered as active only if they are currently pressing a button. At any point in time, i.e., at any price $p \geq 0$ indicated by the clock at a specific instant of time, each Bidder i faces a decision with three alternatives: exit at p by releasing the button, remain active by keeping their hands on the button and, finally, call a price. The identity of the bidders who quit is publicly revealed so that a bidder knows exactly against whom she is competing at anytime during the auction. Using her third option a bidder can interrupt the exogenous price increase. The clock is then stopped at the price indicated at that time and then reset at the price that has been called. In case more than one bidder simultaneously stops the clock, the right of calling the price is assigned randomly by the auctioneer to one of the bidders who proposed the highest called price, and her identity is made common knowledge.[8] We refer to the k-th jump bid placed by bidder i as J_i^k.[9] A jump bid, J_i^k, is defined by the pair $(\underline{p}_i^k, \overline{p}_i^k)$, where $\underline{p}_i^k$ is the price at which bidder i stops the clock to place her k-th jump bid, and $\overline{p}_i^k > \underline{p}_i^k$ is the price that is called. Let $k_i(p)$ be the number of jump bids placed by bidder i up to price p. We can then represent Bidder i's decision at p by $a_i(p) \in \{exit, active, \overline{p}_i^{k_i(p)+1}\}$. After jump bid J_i^k all the bidders that were active at price $\underline{p}_i^k$ need to independently decide whether they want to be active also at price $\overline{p}_i^k$; the identities of the bidders who do not match the jump bid are publicly revealed. The auction ends either when a price is called and no other bidder matches it or when in the continuous price increase phase the last but one bidder quits. In the first case, the winning bid is given by the price that was called, in the second, by the price at which the last but one bidder exited. We also denote by $h_i(p) \equiv (J_i(p), d_i(p))$ all the information publicly available at price p regarding Bidder i. This consists of two entries: $J_i(p)$, the set of jump bids placed by bidder i up to price p; and $d_i(p)$, which records the value p if bidder i is active at the current price, $p^{'}$ if

[7] The price continuously increases.

[8] The fact that other bidders also had stopped the clock is not revealed nor are the bidders' identity.

[9] The identity of the bidder who places the jump bid is common knowledge.

bidder i has dropped at $p' < p$, and finally $(\underline{p}_j^k, \overline{p}_j^k)$, if bidder i did not match the k^{th} jump bid of Bidder $j \neq i$. The n-dimensional vector $H(p) \equiv (h_1(p), ..., h_n(p))$ therefore records all publicly available history up to price p.

We assume the following tie-breaking rule. If the k last active bidders (with $k \geq 2$) leave the auction at the same price, p, the good is sold at price p with a probability $1/k$ to each of the k last active bidders.

For the sake of simplicity and in order to rule out less interesting equilibria, we add the following standard assumption.

Assumption 1. *Bidders do not play weakly dominated strategies, and we only consider Perfect Bayesian Equilibria.*

4 Information Aggregation and Jump Bids

This section presents natural set-ups where jump bids emerge in equilibrium and for which the rationale behind jump bidding is simple to understand from a strategic viewpoint. We leave the analysis of strategically more involved scenarios to section 5, which enables us to highlight some additional interesting features. In the introduction we argued that in order to observe jump bids in equilibrium some asymmetries are needed. In the current section, we first present a set-up where the crucial asymmetry is in the valuation structure, and then we move to a second one where the crucial asymmetry is in the information structure, which imposes a winner's curse that depresses the bid of the less informed bidder. The strategic analysis is simple in both cases because there is only one piece of information to be hidden and therefore no future opportunity to manipulate information later on.

4.1 A first illustrative example

Let us start by modeling in the most stylized way the situation described in the introduction with two local distributors competing with a bigger foreign distributor. As already noted, this is a situation where one bidder might benefit more than others from aggregating new information during the auction. A jump bid can be used to prevent this bidder from acquiring the finer information that she would need to become more competitive.

Set-up 1.

- For $i : 1, 2$, $v_i = t_i$, $t_i \in \{l, m, h\}$, $Pr(t_i = l) = Pr(t_i = m) = Pr(t_i = h) = \frac{1}{3}$.
- $v_3 = L$, if $t_1 = l$ and/or $t_2 = l$; $v_3 = H$, otherwise.
- $0 \leq L < l < m < h < H$

This simple example already captures some interesting points.

We begin with the C game, without jump bids. We first note that it is not immediate that the big distributor, Bidder 3, decides to stay active and learn finer information about the market by observing her opponents' bidding behavior.

Because of Assumption 1, in any equilibrium of the C game, Bidders 1 and 2 leave the auction when the price reaches their respective values, which is their unique weakly dominant strategy. At the beginning of the auction, Bidder 3 does not know her valuation for the good and it is not immediate that she will decide to stay active and learn finer information about the market by observing her opponents' bidding behaviors (if she observes that Bidder 1 and 2 stay active when the price is strictly higher than l, she stays active up to H). As a matter of fact, if she does so, the big distributor may incur a loss when she wins the auction and the market is not deep enough i.e. when $t_1 = t_2 = l$. Her loss in that case is equal to $L - l$ (this event has a probability $\frac{1}{9}$). Thus, she will be willing to stay active up to l only if the expected gain when the market is deep enough, $4H - 3h - m$, outweigh such losses, i.e. when $4H + L - 3h - m - l \geq 0$.[10] Therefore, we obtain the following result.

Result 1. *If $4H + L - 3h - m - l \geq 0$, in any equilibrium of the C game, Bidder 1 and Bidder 2 leave the auction when the price reaches their respective valuations for the good, Bidder 3 stays active until the auction reaches l, immediately leaves if one of the two other bidders leaves at that price and otherwise stays active until the auction reaches H. The auction is inefficient with a probability $1/9$ and the expected revenue is $\frac{5l+m+3h}{9}$.*

Now, let us consider the J game, assuming that the condition $4H + L - 3h - m - l \geq 0$ is satisfied. Before presenting an equilibrium with a jump bid, we begin by showing intuitively

[10]In that case, with probability $\frac{1}{9}$, $t_1 = t_2 = l$, and Bidder 3 loses $l - L$. With probability $\frac{3}{9}$, (t_1, t_2) is equal to (h, h), (m, h) or (h, m) and Bidder 3 earns a profit, $H - h$. With probability $\frac{1}{9}$, $t_1 = t_2 = m$ and Bidder 3 earns a profit, $H - m$. In the other cases, Bidder 3 derives a zero profit so that Bidder 3 derives a profit $\frac{4H+L-3h-m-l}{9}$ if she stays active up to l and observes other Bidders' behaviors at that price.

why the type of equilibrium that we mention for the C game may not be the only one in the J game.

Local distributors know that the big distributor only cares about distinguishing the states of the world in which at least one of them has a type l from all the other states for which she holds the highest valuation, and that she would get this information when the price reaches l.[11] By placing a jump bid from any price strictly lower than l to price m, a local distributor with the highest type, say Bidder 1, can prevent the exact drop out value of Bidder 2 from being disclosed (whenever this differs from h) in order not to allow Bidder 3 to distinguish whether t_2 is equal to l or m. In this case, after observing such a jump bid, Bidder 3 since she does not know whether $t_2 = l$ or $t_2 = m$ would leave at a price equal to $\max(m, \frac{H+L}{2})$.[12] Therefore, when $t_1 = h$, Bidder 1, rather than staying active until h without calling a price, may prefer calling price m at the beginning of the auction.

To get the intuition why Bidder 1 and Bidder 2 cannot follow the same behavior as in the equilibrium of the C game, compare the scenario where Bidder 1 with type h lets the price increase continuously with the one in which she calls a price m at the beginning of the auction, assuming that Bidder 2 never calls a price and leaves the auction when the price is equal to her valuation for the good. In the first case, the profits of Bidder 1 when $t_1 = h$ are $\pi_1^c = \frac{1}{3}(h - l)$, while in the latter they are equal to $\pi_1^j = \max(0; \frac{2}{3}(h - \max(m, \frac{H+L}{2})))$. Thus, the jump bid is profitable whenever $h + l > H + L$ and $h + l > 2m$. We also need to check that Bidder 3 stays active until l when she does not observe a jump bid.[13] Otherwise, making a jump bid would not be worthwhile. This is the case if $L - l + H - m > 0$ or equivalently $H + L > m + l$. We state this observation more formally in the following result.

Result 2. *If $h + l > H + L > m + l$ and $h + l > 2m$, there exists an equilibrium of the J game in which Bidder i, with $i = 1, 2$, when her valuation for the good is equal to h, calls price m at the beginning of the auction and then stays active until the price reaches h. If*

[11] Since Bidder 1 and 2 do not play dominated strategies and therefore do no stay active when the price is strictly higher than their valuations for the good.

[12] When Bidder 2 does not match the jump bid, Bidder 3 remains uncertain about the real depth of the market so that she drops out when the price reaches her expected valuation, i.e., at $E(\tilde{v}_3 | \tilde{t}_1 = h, \tilde{t}_2 \neq h) = \frac{H+L}{2}$. The final price may also be equal to m if $\frac{H+L}{2} \leq m$.

[13] Since Bidder i, with $i = 1, 2$, calls a price when $t_i = h$, the fact that no price is called raises the likelihood of the negative event $(t_1, t_2) = (l, l)$. Therefore, we need to check that bidder does not prefer leaving the auction before it reaches l.

her valuations differs from h, she does not call a price and stays active as long as the price is strictly lower than her valuation for the good. In this equilibrium, Bidder 3 never calls a price. If no price is called, Bidder 3 stays active until the auction reaches l, immediately leaves if one of the two other bidders leaves at that price and otherwise stays active until the auction reaches H. If m is called at the beginning of the auction, Bidder 3 stays active. If the bidder who did not call the price does not stay active, Bidder 3 leaves the auction at a price equal to $\max(m, \frac{H+L}{2})$*, otherwise she stays active until the auction reaches H.*

Proof. We consider the following strategies.

Bidder i, with $i = 1, 2$. When $t_i = l$ or $t_i = m$, she never calls a price and stays active if and only if the current price is strictly lower than t_i. When the price is higher or equal than t_i, she leaves the auction. When $t_i = h$, she calls a price m at the beginning of the auction and stays active without calling a price as long as the price is strictly lower than h.

Bidder 3 never calls a price. When no price is called, she stays active until the auction reaches l, immediately leaves if one of the two other bidders leave at that price and otherwise stay active until the auction reaches H.

Suppose that Bidders 1 and Bidder 2 are active and that one of them calls a price (p_1, p_2). If $p_2 \geq h$, Bidder 3 immediately leaves the auction. If $p_1 > l$ or $p_2 < l$, Bidder 3 follows the same strategy as when no price is called. If $p_1 \leq l \leq p_2 < m$, Bidder 3 stays active after the jump bid ; if both other bidders stay active after the jump bid, Bidder 3 stays active up to price H ; otherwise she immediately leaves the auction. If $p_1 \leq l$ and $m \leq p_2 < h$, Bidder 3 stays active after the jump bid; If both other bidders stay active after the jump bid, Bidder 3 stays active up to price H; otherwise, she leaves the auction at a price equal to $\max(p_2, \frac{H+L}{2})$.

Now, let us prove that these strategies are constitutive of an equilibrium. We begin with Bidder 1 (Bidder 2 being symmetric, we won't need to consider her case). Since leaving the auction at a price different from her valuation for the good would be a dominated strategy, it follows that we can exclude $p_2 > t_1$, that is any profitable deviation requires a jumping strategy with $p_2 < t_1$.

- $t_1 = l$. Since Bidder 2 won't leave the auction for a price strictly lower than l, Bidder 1 cannot derive a strictly positive profit and there cannot exist a profitable deviation.

- If $t_1 = m$. Calling a price higher than m would be a dominated strategy and calling a price lower than l would not affect other bidders' behavior and the outcome of the auction. Suppose that Bidder 1 makes a jump bid (p_1, p_2) with $l < p_2 < m$. Either Bidder 2 stays active after the jump bid, which means that $t_2 \neq l$ and Bidder 1 cannot derive any positive profit, or Bidder 2 leaves the auction when Bidder 1 calls the price. The latter case occurs when $t_2 = l$ but in that case, without calling a price, Bidder 1 would have obtained the good for a price $l < p_2$. Therefore a jump (p_1, p_2) with $l < p_2 < m$ cannot be profitable. No jump bid can raise Bidder 1's expected profit.

- If $t_1 = h$. Calling a price higher than h would be a dominated strategy. Calling a price lower than l would not affect other bidders' behavior and the outcome of the auction would be the same as in the C game, which we showed in the main text to yield less profits for $t_1 = h$ than the proposed equilibrium jump bid. Calling a price when the current price is higher than l cannot be profitable since all the bidders already know up to which price they will be active and a jump bid won't affect this limit price. Suppose that Bidder 1 makes a jump bid (p_1, p_2) with $p_1 < l < p_2 < m$. Either Bidder 2 stays active after the jump bid, then Bidder 3 will stay active up to H and Bidder 1 cannot derive any positive profit, or Bidder 2 leaves the auction when Bidder 1 calls the price. The latter case occurs when $t_2 = l$ but in that case, without calling a price, Bidder 1 would have obtained the good for a price $l < p_2$. Therefore a jump (p_1, p_2) with $p_1 < l < p_2 < m$ cannot be profitable. Suppose that Bidder 1 makes a jump bid (p_1, p_2) with $p_1 < l$ and $p_2 \in [m; \max(m, \frac{H+L}{2})]$. This would give exactly the same result as a making a jump bid $(0, m)$, therefore this does not raise Bidder 1's expected profit. Suppose that Bidder 1 makes a jump bid (p_1, p_2) with $p_1 < l$ and $p_2 \in (\max(m, \frac{H+L}{2}); h)$.Either Bidder 2 stays active after the jump, then Bidder 3 will stay active up to H and Bidder 1 cannot derive any positive profit or Bidder 2 leaves the auction when Bidder 1 calls the price. The latter case occurs when $t_2 = l$ or $t_2 = m$ but in that case, Bidder 1 could have called a price m and obtained the good for a price equal to $\max(m, \frac{H+L}{2})$, which is strictly lower than p_2. Therefore, this deviation is not profitable either.

Bidder 3. If no price is called and she follows the described strategy, with a probability

$\frac{1}{4}$, she derives a negative profit $L - l$ and with a probability $\frac{1}{4}$, she derives a positive profit $H - m$. Since $H + L > l + m$, her expected profit is strictly positive. Neither leaving at a price lower than l and nor calling a price (either lower or higher than l) would be a profitable deviation. If the price m is called at the beginning of the auction, staying active after the jump bid is costless since the bidder calling the price always stay active up to h. If both other bidders stay active after the jump, Bidder 3's valuation is equal to H and both other bidders will stay active up to h so that Bidder 3 cannot obtain more than $H - h$. If the local bidder who did not call the price does not stay active after the jump, Bidder 3's valuation is equally likely to be equal to H and to L, besides the bidder who called the price will stay active up to h anyway. Therefore staying active up to $\max(m, \frac{H+L}{2})$ is a best response.

■

We introduced a complete proof of the existence of an equilibrium with jump bids. Considering the length and the technical simplicity of this type of proof, in order to ease the exposition of the paper, we will only introduce the intuition of the proof for the other set ups that we will consider in the paper.

In the equilibrium of the J game of result 2, the allocation is not efficient with a probability $\frac{2}{9}$, when $(t_1, t_2) \in \{(m, h), (h, m)\}$. When $m \geq \frac{H+L}{2}$, the expected revenue is $\frac{3l+5m+h}{9}$ while, in the C game, it is equal to $\frac{5l+m+3h}{9}$ ($> \frac{3l+5m+h}{9}$ when $h + l > 2m$). When $m < \frac{H+L}{2}$, the expected revenue is $\frac{2H+2L+3l+h+m}{9}$ while, in the C game, it is equal to $\frac{5l+m+3h}{9}$ ($> \frac{2H+2L+3l+h+m}{9}$ when $h + l > H + L$).

Hence, efficiency and revenue are strictly lower with the proposed equilibrium of the J game than with any equilibrium of the C game.

Remark 1. *In this example, we considered a discrete type space. We made this choice (that we will maintain in most examples of the paper) for the sake of simplicity but it is not a necessary condition for the existence of equilibria with jump bids. We could obtain qualitatively equivalent result with a continuous type space. For instance, we can consider the following set-up (with the same economic motivation) :*

- *For* $i : 1, 2$, $v_i = t_i$, t_i *is distributed according to* F_i*, a uniform distribution on the interval* $[0, 1]$. F_1 *and* F_2 *are independent.*

- $v_3 = 1$, *if* $t_1 > 1/4$ *and* $t_2 > 1/4$ *;* $v_3 = 0$ *otherwise.*

We can show that there exists an equilibrium of the J game with this setting in which bidders 1 and 2, when their values are sufficiently high call a price strictly higher than $1/4$*, the price called being an increasing function of the value of the good for the bidder calling the price. The motivation for calling a price is the same as in the more developed example, mixing more favorable states of the world with less favorable ones.*

4.2 Jump Bids and the Winner's Curse

In this subsection, we show that the fear of suffering from the winner's curse can be exploited by another bidder through the use of a jump bid. The crucial point here is that there is asymmetric information regarding a common value element of the bidders' valuations for the object, and a jump bid may create a winner's curse issue in an environment where it would not exist without it. We also show that the level of the jump bid may partially reveal the value of the signal that the jump bid intends to hide.

We consider the following 3 bidders' framework. Bidders' valuations depend on the value of s; s is privately observed by Bidders 1 and 2, that is $t_1 = t_2 = s$. Bidder 3 does not know the realization of s, she only knows its distribution function, F. $F(0) = 0$, $F(1) = 1$ and F is continuous and strictly increasing in the interval $[0, 1]$. We also assume that Bidders 2 and 3 have extra motivations for buying the good so that valuations can be defined as follows.[14]

Set-up 2.

- $v_1 = s$
- $v_2 = s + \frac{1}{n} + \varepsilon$ with $\varepsilon > 0$ and arbitrarily small and n a strictly positive integer
- $v_3 = s + \frac{1}{n}$

We first consider the case when $n = 1$.

[14] The considered framework is close to the standard common value auction framework. Such a situation may arise, for example in the following situation. The good for sale is the exploitation rights (oil) of a maritime area. Both Bidders 1 and Bidder 2 have an access to a geological study on the wealth of this area (s). Bidders 2 and Bidder 3 already have a well established branch in the considered country ($+1$). Bidder 2 owns the exploitation rights of the closest exploitable maritime area ($+\varepsilon$).

Result 3. *In any equilibrium of the C game, Bidder 1 leaves the auction at a price equal to* s*, Bidder 2 leaves the auction at a price equal to* $s + \frac{1}{n} + \varepsilon$ *and Bidder 3 leaves the auction at a price equal to* $q + 1$*,* q *being the price at which Bidder 1 leaves the auction if it is in the interval* $[0, 1]$*. Bidder 2 obtains the good at a price equal to* $1 + s$*.*[15]

Bidders 1 and Bidder 2 have a unique weakly dominant strategy and by observing Bidder 1's behavior, Bidder 3 can perfectly infer her valuation for the good. Hence the simplicity of the equilibrium prediction. Bidder 2 always wins the auction and derives a profit ε.

We will show that the opportunity to call a price may dramatically modify the outcome of the auction.

Result 4. *There exists an equilibrium of the J game in which, whatever the value of* s *is Bidder 2 makes a jump bid to the price of 1 at the very start of the auction and Bidders 1 and Bidder 3 immediately leave the auction.*

Intuition of the proof. Suppose that Bidder 2 always calls a price 1 at the beginning of the auction. It is straightforward that Bidder 1 cannot raise her profit by staying active when the price is equal to 1 so that she will always leave immediately leave the auction when such a price is called. Now, since Bidder 2 always makes a jump bid up to 1, Bidder 3 cannot revise her belief about the value of s after observing the jump bid. If Bidder 3 stays active after the jump bid, she only obtains the good if Bidder 2 leaves the auction before her. Suppose that Bidder 2 leaves the auction when the price is equal to $s + 1 + \varepsilon$ (which is a dominant strategy). Then, if Bidder 3 wins the auction, she pays a price equal to $s + 1 + \varepsilon$, strictly higher than Bidder 3's valuation. Since winning the good will always be associated with a loss and v_3 is at least equal to 1, Bidder 3 prefers leaving the auction immediately when the jump bid is equal to 1. On Bidder 2's side, making a jump bid up to 1 is not costly since Bidder 3 will never leave the auction for a price below 1 (it is a dominated strategy for her). Besides, by calling the price she obtains the good precisely at that price.

In this example, the allocation in the equilibrium of the J game that we consider is the same as the allocation in the equilibria of the C game. In both cases, Bidder 2 always obtains

[15] One may wonder why Bidder 1 participates in the auction even though she loses with probability 1. We may design an example in which Bidder 1 wins with a strictly positive probability and still we would observe the same type of phenomena. We prefer considering this framework for the sake of simplicity.

the good. However, the jump bid may dramatically reduce the price. On average, the price reduction is equal to $E(s)$. The motivation for the jump bid builds on the winner's curse that Bidder 3 may incur in case she wins the object. Since Bidder 3's valuation is always lower than Bidder 2's, Bidder 3 knows that winning the auction against Bidder 2 cannot be profitable. Besides, because of the jump bid, Bidder 3 cannot discover the value of s without winning the auction at a price strictly higher than her valuation for the good. Therefore, she prefers leaving the auction. On Bidder 2's side, it is not costly to make a jump bid up to 1 since for any value of s, Bidder 3 never leaves the auction when the price is lower than 1. The possibility for Bidder 2 to make a jump bid allows her to fully exploit her small advantage over Bidder 3.

We now consider the $n \geq 2$ case, which is introduced to show the richer case in which the jump bid is a function of s. Another important difference with the setting of section 4.1 is that here unlike in section 4.1, the information that the bidder wants to hide (or better said make it coarser) with a jump bid is known to him. Hence, the challenge to compute a jump bid that preserves the informational advantage necessary to induce a winner's curse, while at the same time disclosing the minimum amount of information regarding the private information.

As compared to the $n = 1$ case, the unique equilibrium outcome of the C game remains unchanged.

Result 5. *There exists an equilibrium of the J game in which Bidder 2 makes a jump bid at a price equal to k/n with k being a strictly positive integer such that $s \in (\frac{k-1}{n}, \frac{k}{n}]$. Bidder 1 leaves the auction immediately after the jump bid and Bidder 3 leaves after having observed that Bidder 1 has left.*

Intuition. The main difference with the $n = 1$ case is that, now, Bidder 3 can revise her expected value conditional on observing the jump bid chosen by Bidder 2. As a matter of fact, if the jump bid is equal to $\frac{k}{n}$, Bidder 3 learns that s lies in the interval $(\frac{k-1}{n}, \frac{k}{n}]$, therefore v_3 lies in the interval $(\frac{k}{n}, \frac{k+1}{n}]$. But again, if Bidder 3 wins the auction, she knows that she is a victim of the winner's curse (considering that Bidder 2 leaves the auction when the price is equal to $s + \frac{1}{n} + \varepsilon$). Therefore, Bidder 3 prefers leaving the auction at a price equal to $\frac{k}{n}$. On Bidder 2's side, it is no longer profitable to make a jump bid equal to 1 whatever the value of

s. As a matter of fact, when $s < \frac{n-1}{n}$, Bidder 2 may obtain the good for a price strictly lower than 1 without submitting a jump bid (since $v_1, v_3 < 1$). However, it may still be profitable for Bidder 2 to hide the exact value of s by submitting jump bids. In order to do so, Bidder 2 makes different jump bids depending on the value of s. With this jump bid, Bidder 2 prevents the precise value of s from being revealed through the auction process but she also reveals in which interval $(\frac{k-1}{n}, \frac{k}{n}]$, s lies. The jump bid makes the information revelation coarser. The length of the interval is equal to the advantage of Bidders 2 and Bidder 3 over Bidder 1.

5 Strategically More Complex Environments

In the previous section, we introduced simple examples in order to show how equilibrium jump bids may emerge. In this section, we consider strategically more complex environments in order to illustrate properties of jump bids. In particular, the set-ups that follow capture some dynamic features that were absent in the settings considered earlier as there was only one bidder's type that had an incentive to jump bid at a very specific moment of the auction. More generally, instead, bidders need to anticipate that some other bidder might have an incentive to alter the transmission of information via jump bids at later stages (higher prices) of the auction and this might affect their bidding decision (quit, stay active, call a jump bid) at lower prices. We have selected specific set-ups to illustrate in the simplest possible way the most interesting effects that this extra complexity brings.

In the first subsection, we show that a bidder may be induced to jump bid by the anticipation of someone else hiding some information later on. The interesting effect that is brought about by this strategic element is that everybody may be strictly worse off in the J game than in C game. This is interesting because it is generally thought that jump bids are anti-competitive and thus should be banned by the seller, but that bidders who place them are strictly better off when jump bids are allowed. Here, instead, the bidder who calls a price is better off than letting the price increase continuously, but worse off compared to the C game.[16]

In the second subsection, we show that a bidder may be induced to quit earlier than she would otherwise, if jump bids were not allowed. Interestingly, even though no jump bids

[16]Proposition 4 below illustrates a stronger result that even if one bidder was the only one allowed the option to jump bid, it is possible that she would be willing to pay to avoid having such an option.

are observed in equilibrium, the equilibrium outcome is drastically affected by the fact that bidders do have such an option.

Finally, the third subsection illustrates that there are instances in which the C game fails to aggregate new information, while, surprisingly, allowing for jump bids raises both revenue and efficiency.

5.1 A Jump Bid to Prevent Another Jump Bid

We consider a setting in which a bidder might be induced to jump bid by the anticipation that another bidder may strategically hide some relevant information (via a jump bid) later on in the auction. In this example, this in turn induces one these two bidders to further anticipate her jump bid. The setting is therefore suggestive of the fact that the dynamic environment we study rapidly becomes strategic extremely complex once one departs from the simple examples of section 4.

An interesting feature illustrated by this subsection is that all the bidders as well as the seller are worse off with the equilibrium of the J game than with the equilibrium of the C game, that is the equilibrium of the J game is Pareto dominated by the equilibrium of the C game.

We consider the following setting:

Set-up 3.

- $t_1 \in \{8, 9, 10\}$, $p(t_1 = 8) = p(t_1 = 9) = p(t_1 = 10)$.
- $v_1(t_1) = t_1$
- $v_2(t_1 = 8) = 8.5$; $v_2(t_1 = 9) = 14$; $v_2(t_1 = 10) = 16$
- $v_3(t_1 = 8) = 0$; $v_3(t_1 = 9) = 0$; $v_3(t_1 = 10) = 20$

Let us start with the analysis of the C game. Any equilibrium of the C game as the following properties. Bidders 1 knows the value of v_1 and therefore stay active till v_1 is reached. Bidder 2 drops at 8.5 if Bidder 1 drops at 8, she drops at 14 if Bidder 1 drops at 9 and she drops at 16 if Bidder 1 drops at 10. Bidder 3 drops immediately if Bidder 1 drops at 8 or at 9 and she drops at 20 if Bidder 1 drops at 10. The expected revenue in the C game is 11.

Consider the effect of allowing jump bids in this setting. In order to decide when and to which value to jump bid, bidders need to take into account that if they let the price increase without calling a price the other bidders might have an incentive to call a price themselves at higher prices and modify the way the information is aggregated in their favor. In this case, the key element is that, once she discovers that $t_1 \neq 8$, Bidder 2 would like to prevent bidder 3 from discovering whether t_1 is equal to 9 or to 10. She can do so by calling a price 10 after having observed that Bidder 1 is still active at price 8. In that case, Bidder 1 immediately leaves, Bidder 3's expected value for the good is also 10 since she cannot distinguish between the two states $t_1 = 9$ and $t_1 = 10$ and therefore, Bidder 3 also immediately leaves the auction. In this case, Bidder 3 always makes a zero profit. However, anticipating the unfolding of the game Bidder 3 can do better by placing a jump bid from the price zero to 9. In this case, if Bidder 1 immediately leaves, Bidder 2 has an expected value of $(8.5 + 14)/2 = 45/4 > 9$, she stays active and Bidder 3 immediately leaves after having observed that Bidder 1 leaves. Bidder 2 wins the auction at a price 9 and obtains 9/4. But if Bidder 1 stays active after the jump bid (and up to 10), Bidder 3 stays active up to 20 and Bidder 2 up to 16. This yields Bidder 3 an expected profit of 4/3, making the jump bid is profitable. However, this is not yet the equilibrium. In fact, anticipating Bidder 3 jump bid from 0 to 9, Bidder 2 is better off placing a jump bid from 0 to 10 (recall that if the two jump bid are called at the same time, the highest of them is selected). In fact, this yields Bidder 2 an expected profits of $17/6 > 9/4$.

In the equilibrium of the J game, the expected revenue is 10, which is less than 11 under the J game. Bidder 3 never wins under the J game and therefore is strictly worse off. Bidder 1 never wins in either cases. Bidder 2 is also strictly worse off (in expectations) as his expected profits are 11/3 in the C game and 17/6 in the J game.

Thus, the equilibrium of the J game is Pareto worse than the equilibrium of the C game.

5.2 The Hidden Impact of Allowing Jump Bids

In this subsection and the following one, we focus on an environment where in the C game some bidders might experience ex-post regret in equilibrium (see Hernando-Veciana and Michelucci (2011)).

In this subsection, if jump bids are not allowed, the private information that bidders hold is aggregated in a very desirable way thanks to the possibility of the *wait and see* strategy described in the introduction. Allowing bidders to call a price causes both efficiency and revenue to drop. Conversely, the following subsection provides a new insight: the information fails to aggregate precisely because of the cost of staying active when other competitors are also active may lead to a free rider-problem. This results in no bidder willing to acquire finer information by staying active in the auction. The possibility of jump bidding here allows the bidder with the ex-ante higher valuation to hide the piece of information causing such free-rider problem. She may then profitably win the auction. This boosts both efficiency and revenue.

We start with the scenario where the aggregation of information is very smooth. This setting also illustrates that the anticipation of a future jump bid may induce a bidder to quit earlier than she would in the C game and that, even though no jump is observed in equilibrium, the equilibrium outcome in the J game substantially differs from the one in the C game.

Set-up 4.

- $t_1 \in \{5, 6, 7\}$ with $P(t_1 = 5) = P(t_1 = 6) = P(t_1 = 7) = \frac{1}{3}$.
- $v_1(t_1) = t_1$.
- $v_2(t_1 = 5) = 0$, $v_2(t_1 = 6) = v_2(t_1 = 7) = 9$.
- $v_3(t_1 = 5) = v_3(t_1 = 6) = 0$, $v_3(t_1 = 7) = 12$.

For both uninformed bidders, winning if $t_1 = 5$ entails a big loss as they learn that such is the state only at price $p = 5$, when both value the object at a price zero.

In the C game, the information is aggregated in a desirable way during the auction.

Result 6. *In any equilibrium of the C game, Bidder* 1 *stays active until her private value is reached. Bidder* 2 *quits as soon as Bidder* 1 *quits if that happens at a price lower than* 5*, and stays active until the price reaches* 9*, otherwise. Bidder* 3 *quits as soon as Bidder* 1 *quits if that happens at a price lower than* 6*, and stays active until the price reaches* 12*, otherwise.*

The japanese format without jump bids allows Bidders 2 and Bidder 3 to *share* the risk of winning when $t_1 = 5$, (the expected loss being $(\frac{1}{3})(\frac{1}{2})5 = \frac{5}{6}$ for each). Furthermore, the two bidders can *split* the benefits of being active at higher prices in a way that allows both bidders to recover the expected losses. In the case $t_1 = 6$, Bidder 2 gets a profit of $9 - 6 = 3$; while if $t_1 = 7$, Bidder 3 gets a profit of $12 - 9 = 3$. The expected revenue is equal to $R^C = (\frac{1}{3})5 + (\frac{1}{3})6 + (\frac{1}{3})9 = \frac{20}{3}$. The expected value of the winner is equal to $E^C = (\frac{1}{3})9 + (\frac{1}{3})12 = \frac{21}{3} = 7$.

Now, if we allow jump bids, the smooth sharing of costs and benefits becomes unattainable and given that Bidders 2 and Bidder 3 can be active at low prices only if they do so jointly, they both quit early.

Result 7. *In any equilibrium of the J game, Bidder* 1 *stays active until the price reaches her private value, Bidders* 2 *and* 3 *leave the auction at a price lower than 5.*

To understand why such behaviors arise at the equilibrium, note that as soon as the price rises just above 5, Bidder 2 learns that $t_1 \neq 5$ and thus that $v_2 = 9$. Conversely, at that price Bidder 3 is still uncertain regarding her exact value. Bidder 2 can *hide* such information from Bidder 3 by calling a price equal to 7 when the current price is still in $(5, 6)$. The jump bid pulls together the two cases, $t_1 = 6$ and $t_1 = 7$, for Bidder 3, who consequently bids up to $E(v_3|t_1 \neq 5) = 6$. With the jump bid, Bidder 2 makes a sure profit of 2 as opposed to winning only if $t_1 = 6$ if she lets the price increase continuously. The latter strategy yields $\frac{1}{2}(9 - 6) = \frac{3}{2} < 2$; therefore, Bidder 2 cannot commit not to call such a price.

But then Bidder 3 anticipating Bidder's 2 jump bid will pre-empt her from winning in the only profitable case, she is no longer willing to stay active over the price $p = 5$. Since Bidder's 3 presence is necessary for Bidder 2 (her expected gain with the jump bid strategy is $\frac{4}{3}$ but her expected loss if she does not share the risk is $\frac{5}{3}$), the equilibrium outcome is that they both quit the auction for a price lower than 5.[17] This brings a revenue lower than 5 for any value of t_1, and it inefficiently always allocates the object to Bidder 1.

In such a context, if the seller is not aware of the implications of allowing bidders to call a price, he/she may be wrongly induced to believe that the bidders' valuations were low.

We report the main results of this subsection in the two propositions below.

Proposition 1. *There may exist an equilibrium of the J game whose allocation and revenue*

[17] Any other jump bid by Bidder 2 or Bidder 3, it is also not profitable.

differ from the allocation and the revenue of any equilibrium of the C game even though in this equilibrium of the J game no price is ever called.

Proposition 2. *A bidder may be willing to pay not be allowed to call a price even in the event that she is the only bidder granted such an option.*

Proof. Take the setting above. suppose that Bidder 2 is the only bidder allowed to jump bid. Since in the J game she never wins, she would be willing to pay up to the expected profits she makes in the C game to restrict her strategies space to the choice of quitting or staying active.

■

5.3 The Free-Rider Problem and the Existence of Efficiency and Revenue Enhancing Jump Bids

In this setting, we show that in the C game perverse incentives may impede the aggregation of information and that the enlarged strategy set of the J game may alleviate such a problem and bring higher revenue and efficiency.

Set-up 5.

- $t_1 \in \{9, 10\}$, $Pr(t_1 = 9) = Pr(t_1 = 10) = \frac{1}{2}$.
- $v_1 = t_1$.
- $v_2(t_1 = 9) = 8$, $v_2(t_1 = 10) = 13$.
- $v_3(t_1 = 9) = 0$, $v_3(t_1 = 10) = 18$.

The setting is similar to the previous one in so far as both Bidder 2 and Bidder 3 may have an incentive to *wait and see*. However, here one of them, Bidder 2, has an ex-ante value strictly higher than Bidder 1's. This means that if Bidder 2 were the only bidder competing with Bidder 1, she would profitably be active over the price of 9 to be able to discover the value of t_1. Bidder 3 could potentially benefit from the active presence of Bidder 2 over the price of 9. However, if both bidders are active at that price they share the expected losses but not the expected gains. In fact, if Bidder 3 infers that $t_1 = 10$, she always wins against

Bidder 2. But then Bidder 2 prefers staying active only until the price of 8 to avoid incurring a loss. In turn, if that is the case, Bidder 3 also must quit before the price reaches 9 as her expected value is lower than Bidder 1's. Hence, no aggregation of information is possible.

Result 8. *In any equilibrium of the C game, Bidder 1 leaves the auction when the price reaches t_1. Bidders 2 leaves at a price strictly lower than 9 and higher than 8, and Bidder 3 leaves as soon as Bidder 2 leaves.*

The auction performs very poorly as Bidder 1 always wins at a price in $[8, 9)$, which implies that both revenue and efficiency would be higher if Bidder 3 were excluded from the competition. We can say that in this framework, Bidder 3 is a free rider whose presence is detrimental both for revenue and efficiency.

Now, let us consider the J game.

Result 9. *There exists an equilibrium of the J game in which Bidder 2 calls a price 10 at the beginning of the auction and no other bidder stays active at that price.*

Bidder 2, by calling a price 10, prevents all the possible information revelation. That way, she also prevents the free-rider problem. Eventually, Bidder 2 wins with probability 1 at price 10 which yields him an expected profit of $\frac{1}{2}$. That is better than in the C game where she never wins. Expected revenue goes up from $R^C \in [8; 9)$ in the C game to $R^J = 10$ in the type of equilibrium of the J game that we mention. Similarly, the expected value of the winner increases from $\frac{19}{2}$ in the C game to $\frac{21}{2}$ in the J game.

5.4 The Ambiguous Effect of Jump Bids on Efficiency and Revenue

The different environments that we introduced allow us to conclude the section with the following result.

Proposition 3. *Allowing bidders to call a price can decrease or increase revenue and efficiency depending on the considered setting.*

Proof. We only need to provide examples where all those possibilities are covered. The settings in the previous sections prove that revenue and efficiency can drop. The setting above proves that they can increase.

■

A bidder makes a jump bid to reduce information revelation either in order to obtain the good for sale in cases where she would not obtain it without the jump bid or in order to reduce the price she pays for the good. In standard cases, this leads to a drop in efficiency and revenue. However, we showed that in more complex settings, the effect of a jump bid may go in the other direction. This also means that there is no clear-cut general effect of jump bids on revenue and efficiency and that a general recommendation regarding jump bids cannot be made.

6 Discussion and Extensions

In the previous sections, we showed that when a bidder's valuation depends on signals privately observed by other agents, another bidder may call a price in order to prevent the information from being revealed during the auction process. In this section, we intend to discuss to which extent the general idea of preventing information from being revealed during the auction process can be extended to other contexts.

6.1 Bidders focusing on specific statistics

First, we assumed that the valuations of (partially) uninformed bidders precisely depend on the signals observed by informed bidders. We do not need the interdependence to be that precise. The interdependency is the unique required element. As a matter of fact, an uninformed bidder may care about the median valuation of informed bidders or the number of informed bidders with a valuation higher than a specific threshold. This type of information may also be hidden.

Consider the following example. Mister A is moving to Newtown. Mister A does not know Newtown but he wants to quickly buy an accommodation for his family in this location. He knows his preferences and has some information about the local real estate market but not much. Mister A is in a hurry and therefore has a higher valuation for any house than most local buyer. Because of his ignorance, Mister A uses a rule of thumb and does not make an offer if he does not observe that at least 3 local buyers are also making offers. In that case, a local buyer may directly call a price for a specific house in order to prevent too many other local buyers from making offers. That way, Mister A also stays out of the auction. This interpretation relies on some bounded rationality on Mister A's side. He does not distinguish that his rule of thumb is not very appropriate when jump bids are possible. However, this bounded rationality seems quite credible here.

Another related scenario that fits our setting well is the one of fashion or status goods. We illustrate it with the following admittedly limiting case whose features we believe hold much more generally. Suppose someone is interested in buying a certain status object like a painting or a historical car in an auction. The price he pays is not the only key element. He gives a higher value to an object if several experts participating in the auction show a strong interest in it. The "status" of the object is as important as the object itself. It is easy to see that, in this case also, one of these experts can place a high bid in the beginning of the auction to prevent the person from potentially aggregating the information that would make her the strongest contender for the auction.

6.2 Reserve price

Another actor of the auction who could benefit from a process close to a jump bid is the seller. As a matter of fact, in some specific instances, a reserve price may also be used as a tool to hide information that would have been revealed otherwise during the auction process. Since we have shown that jump bids may raise the expected revenue, it seems logical that an adequate reserve price may also raise revenue, even in cases when the reserve price is always matched by at least two bidders. The following example illustrates this point.

- $t_1, t_3 \in \{0, 1/2\}$, $Pr(t_1 = 0) = Pr(t_3 = 0) = \frac{1}{2}$, with the two events being independent.
- $v_1 = t_1$.
- $v_2(t_1 = 0) = \varepsilon$, $v_2(t_1 = 1/2) = 3 - \varepsilon$, with ε arbitrarily small.
- $v_3 = t_3$.
- $v_4(t_3 = 0) = \varepsilon$, $v_4(t_3 = 1/2) = 3 - \varepsilon$.

Without a reserve price and jump bids, in the unique equilibrium with non dominated strategies, Bidders 2 and 4 learn their valuations during the auction process. The allocation is efficient and the expected revenue is equal to $\frac{1}{2}\frac{1}{2} + \frac{\varepsilon}{4} + \frac{3-\varepsilon}{4} = 1$. Now, the seller can choose a reserve price in the interval $(\frac{1}{2}, \frac{3}{2} - \varepsilon)$. With such a reserve price, Bidders 1 and 3 do not take part in the auction. Bidders 2 and 4 stay active until the price reaches $\frac{3}{2}$, their expected valuation for the good. Eventually, the seller's revenue is equal to $\frac{3}{2}$.

Beyond this basic example, we observe that a reserve price may be used as a device to hide information in order to raise revenue. If bidders can manipulate information revelation during the auction process, why could not the seller also do so?

6.3 Sniping strategies

In a different perspective, jump bids may also be related to sniping strategies on eBay-like auctions (see Ockenfels and Roth (2002), Ockenfels and Roth (2006) or Bajari and Hortascu (2003)). In both cases, a bidder may manage to hide information. The key difference is that when a bidder makes a jump bid, she may hide information that another bidder would have revealed through her bidding behavior while a sniping bidder hides information about her own valuation of the good. More precisely, she prevents other bidders from reacting to this information because they do not have time to react to the last moment bid submitted by the sniping bidder. However, in both cases, bidders manage to hide information using specific bidding strategies.

6.4 Costly acquisition of information

Our work is also related to Compte and Jehiel (2004b) and Compte and Jehiel (2007). In these papers, they consider bidders who have the possibility, incurring a cost, to obtain more precise information about their valuations for the good during the auction process. Rather than paying this cost at the beginning of the auction, they may *wait and see*. They observe other bidders' valuations before deciding to pay the price for discovering their valuations. A jump bid may also be used to deter such bidders from following this *wait and see* strategy. As a matter of fact, if it takes time to observe a valuation, a strong informed bidder may call a price in order to accelerate the auction process to prevent partially informed bidders from having the required time to discover their valuations.

7 Conclusions

We have analyzed a version of the Japanese auctions that allows bidders to stop the continuous price increase and call a price at any point during the auction. We have looked at how the possibility of calling a price affects the way information is aggregated and shown that bidders may have an incentive to alter the aggregation of information by placing jump bids to hide the drop-out value of some of their opponents. This is a novel explanation to jump bidding that contrasts with the traditional one based on signaling, for which more rather than less information is available after a price jump. The general wisdom that comes with the traditional approach is that jump bids are anticompetitive. We show instead that the strategic environment is so rich that this is not always the case. Our analysis brings powerful implications as it shows that the possibility of placing jump bids severely affects (though in general ambiguously) both revenue and efficiency. Thus, when evaluating the advantages and disadvantages of open versus sealed bid formats, great care needs to be placed on whether the setting could be favorable to jump bids.

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