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Disclosure policies in all-pay auctions with bid caps and stochastic entry[☆]

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ABSTRACT

This paper examines the effects of disclosing the actual number of bidders in contests with stochastic entry and with resource constraint. We study an all-pay auction with complete information. The auction entails one prize and n potential bidders. Each potential bidder has an exogenous probability of participation and faces an exogenous bid cap. It is shown that the contest organizer prefers fully concealing the information about the number of participating bidders. We extend the result to a case with endogenous entry.

Introduction

Many real-world competitions, such as rent-seeking, political campaigns, R&D competitions, and job promotions, are commonly viewed as contests. In these contests, participants spend resources in order to win some prizes. In many competitions, an individual has no information about the actual number of competitors she has to face. For instance, when an individual seeks a job promotion, she has to compete not only with colleagues whom she knows but also anonymous candidates from outside.

The existing literature models such competitions as standard contests and auctions but with stochastic entry and has discussed the effect of disclosing the actual number of contestants on the expected total bid.[1] Lim and Matros (2009) and Fu et al. (2011) study information disclosure policies in Tullock contests in which each potential contestant has an exogenous probability of participation. They find that optimal disclosure policy depends on the curvature of a characteristic function.[2] Chen et al. (2017) go beyond these papers by introducing interdependent valuations of the prize with private and affiliated signals.[3] They link optimal disclosure policy with the curvature of the cost function under both exogenous and endogenous probabilities of participation. McAfee and McMillan (1987) and Feng and Lu (2016) relate optimal disclosure policy to bidders' risk attitudes in a first price auction.

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1 There is another literature that studies the effects of contestants' abilities (e.g., Morath and Münster, 2008; Fu et al., 2014; Zhang and Zhou, 2016; Lu et al., 2018; Chen, 2019c,a).

2 Fu et al. (2016) study disclosure policies in a Tullock contest with two asymmetric agents.

3 See Matthews (1987), Levin and Ozdenoren (2004), Levin and Smith (1994), and Ye (2004) for studies on auctions with a stochastic number of bidders.

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On the other hand, what all above studies have overlooked is that in many competitions, contestants face enforced constraints on the maximal bid or effort they could exert. U.S. Federal law limits both congressional election campaign contributions and spending. Job promotion candidates cannot work more than 24 h per day even if they would like to do so. Recently, to control the housing price, the Chinese government enforced bid caps in land auctions. While the effects of bid caps have received wide attention and have been thoroughly examined by researchers (Che and Gale, 1998, 2006; Szech, 2015; Gavious et al., 2002; Olszewski and Siegel, 2019; Einy et al., 2016; Chen, 2019b), none of the former above mentioned studies addresses this constraint when considering optimal disclosure policies.

This paper contributes to the above literature by providing a comprehensive examination of the effect of disclosing the actual number of bidders on the expected total bid in all-pay auctions in which bidders face bid caps. The model is in the spirit of Che and Gale (1998) (an all-pay auction with complete information) but with exogenous stochastic entry. The key finding is that fully concealing the number of bidders dominates fully revealing the number in terms of expected revenue to the organizer. The key insight is that there are no high bids to mitigate low bids of a bidder under full disclosure if bidders' bids are capped, which leads to an overall lower expected revenue than that under full concealment. We show that the result extends to a setting with endogenous entry in a two-potential-bidder case.

1. Model

Consider a contest with a set $N = \{1, 2, \dots, n\}$ of potential risk neutral bidders and one indivisible prize. The value of the prize is common to all potential bidders and is normalized to 1. Each potential bidder participates in the contest with an independent probability $p \in (0, 1]$. The number of participants is only observable to the contest organizer, and the organizer has to announce publicly and commit to his disclosure policy — either to **fully conceal (Policy** C**)** or **fully reveal (Policy** D**)** the information about the number of participating bidders.

Each participating bidder i faces an exogenously given bid cap h and submits a bid $b_i \le h$. Bids are submitted simultaneously and independently of each other. The bidder with the highest bid wins the prize, but all participating bidders pay their bids. Ties are resolved by random allocation with equal probabilities. When there is a subset M of participating bidders, each bidder bids b_i and the payoffs are:

$$W_i = \begin{cases} 1 - b_i & \text{if } b_i > \max_{j \in M \setminus \{i\}} b_j \\ -b_i & \text{if } b_i < \max_{j \in M \setminus \{i\}} b_j \\ \frac{1}{\#\{k \in M : b_k = b_i\}} - b_i & \text{if } b_i = \max_{j \in M \setminus \{i\}} b_j . \end{cases}$$

In detail, the model has the following timing:

1. The contest organizer commits to reveal or conceal her private information before the contest starts.
2. Nature chooses the number of participating bidders.
3. The organizer learn the number of participants and implements his commitment.[4]
4. Bidders submit their bids privately.
5. The one with the highest bid wins the prize, and ties are resolved by fair lotteries.

[4] It is beyond the scope of our paper to provide a thorough analysis on the issue of commitment.

2. Results

We first consider the subgame in which the organizer commits to policy C. In this case, the organizer conceals the actual number of bidders before the participating bidders make their bids.

Proposition 2.1 (*Full Concealment*). *Consider the subgame that follows policy C. There is a unique symmetric equilibrium, in which each bidder's equilibrium distribution of bids is given by*

$$F(x) = \begin{cases} \left[[x + (1-p)^{n-1}]^{1/(n-1)} - (1-p) \right] / p & \text{for } x \in [0, c] \\ \left[[c + (1-p)^{n-1}]^{1/(n-1)} - (1-p) \right] / p & \text{for } x \in (c, h) \\ 1 & \text{for } x = h, \end{cases}$$

where the critical value $c = c(h)$ is defined by

$$c = 0 \text{ if } h \le \frac{1 - (1-p)^n}{np} - (1-p)^{n-1};$$

$$h = \frac{1 - [c + (1-p)^{n-1}]^{n/(n-1)}}{n\left[1 - [c + (1-p)^{n-1}]^{1/(n-1)}\right]} - (1-p)^{n-1}$$
$$\text{if } h \in \left(\frac{1 - (1-p)^n}{np} - (1-p)^{n-1}, 1 - (1-p)^{n-1}\right].$$

The expected payment of a participating bidder is

$$EP^C = \begin{cases} h & \text{if } h \le \frac{1-(1-p)^n}{np} - (1-p)^{n-1}; \\ \frac{1-(1-p)^n}{np} - (1-p)^{n-1} & \text{if } h \in \left(\frac{1-(1-p)^n}{np} - (1-p)^{n-1}, 1 - (1-p)^{n-1}\right]. \end{cases}$$

The key observation in the above proposition is that the expected payment of a participating bidder (as well as the expected revenue of the organizer) is not affected by a bid cap unless the cap is below the threshold $\frac{1-(1-p)^n}{np} - (1-p)^{n-1}$, which makes the critical value $c(h)$ equal to 0.

We next consider the subgame in which the organizer commits to policy D. In this case, the organizer reveals the actual number of bidders before the participating bidders make their bids. The equilibrium behavior, in this case, is a degenerate case of Proposition 2.1.

Corollary 2.1 (*Full Revealing*). *Consider the subgame that follows policy D. If there is $m = 1$ participating bidder, the only participating bidder will bid 0. Consider a contest among $m \ge 2$ bidders. There is a unique symmetric equilibrium, each bidder's equilibrium distribution of bids is given by*

$$F_m(x) = \begin{cases} x^{1/(m-1)} & \text{for } x \in [0, c_m] \\ c^{1/(m-1)} & \text{for } x \in (c_m, h) \\ 1 & \text{for } x = h, \end{cases}$$

where the critical value $c_m = c_m(h)$ is defined by

$$c_m = 0 \text{ if } h \le 1/m;$$

$$h = \frac{1 - c_m^{m/(m-1)}}{m[1 - c_m^{1/(m-1)}]} \text{ if } h \in (1/m, 1].$$

The expected payment of a participating bidder is

$$EP_m = \begin{cases} h & \text{if } h \le 1/m; \\ 1/m & \text{if } h \in (1/m, 1]. \end{cases}$$

As a result, for $m = 1$, the expected revenue of the organizer is 0; for $m \ge 2$, the expected revenue is not affected by a bid cap and is equal to 1, unless the cap is below the threshold $1/m$, which makes the critical value $c_m(h)$ equal to 0. Hence, given a bid cap, the expected revenue under full concealment is lower than that in any case with more than 1 participating bidder