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Auctions with contingent payments — An overview

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A R T I C L E I N F O

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A B S T R A C T

I survey a literature on auctions with contingent payments, that is auctions in which payments are allowed to depend on an ex-post verifiable variable, such as revenues in oil lease auctions. Based on DeMarzo et al. (2005), I describe a partial ranking of auction revenues for auctions that differ in terms of contract forms, pricing rules and seller commitment and why the revenue equivalence theorem does not apply even in an independent private values setup. I discuss models that incorporate adverse selection, moral hazard, competition between auctioneers, common values and the sale of multiple units.

1. Introduction

In some auctions the value of the good being auctioned is completely subjective. For example, in a charity auction for a dinner with a local celebrity, the value to bidders cannot be observed. In other situations while values/costs are objective, they cannot be easily verified. For example, in auctions selecting contractors to repair a highway, the costs of completing the project are hard to verify. On the other hand, in many commercial settings, the value of an asset/contract is at least partially observed. For example, in oil-lease auctions, if the winner explores the field, the government can measure revenue obtained from the exploration. It is a common practice around the world for the government selling the rights to drill for oil or natural gas to collect additional revenue in the form of royalties.

Auctions with contingent payments describe situations where either via a formal auction or informal negotiations a set of players compete to either purchase an asset or obtain a contract to deliver a service and the payments to the auctioneer/seller/procurer are at least partially contingent on future outcomes. Theoretical analysis of such auctions has received a lot of attention in recent years. This paper offers a selected survey of that literature. The core of this paper (including the benchmark model and its analysis presented in Sections 3 and 4) is based on DeMarzo et al. (2005), henceforth DKS.

The plan of the paper is as follows. I first describe some markets where auctions with contingent payments are common. Then I discuss the benchmark model of DKS with independent private values as in the setup of the revenue equivalence theorem. I explain why that theorem does not apply to auctions with contingent payments and why revenue in such auctions is higher than in cash auctions. Then I discuss the ranking of auctions with different types of contracts if the seller restricts bidders to a single-dimensional set of contracts. Next, I describe a model without seller commitment and explain why in that environment bidders would choose offers that "flat". Combining these two sections leads to a conjecture that sellers prefer auctions with "steep" contracts while buyers prefer auctions with "flat" contracts. In Section 5 I review papers that enrich the benchmark model with important real-life considerations (for example, moral hazard, entry of bidders into auctions, adverse selection of buyers, and private information of the seller). These considerations bring up new economic tradeoffs which change the predictions of the basic model.

This is not a comprehensive survey. There are some topics I do not cover at all. For example, in all of the paper I assume bidders and the seller are risk neutral which ignores the importance of contingent payments for risk sharing.

1.1. Auctions with contingent payments in practice

It is useful to divide the practical examples into two categories: formal and informal auctions. The major difference between these two types is the level of commitment by the seller. In an informal auction, bidders choose what forms of payments to offer and then the seller selects the most attractive offer. Such informal auctions contain the

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elements of a signaling game because evaluating offers, the seller may infer bidder's private information, and hence the value of the offer, from the type of contract offered by that bidder. For example, an author of a book may be worried about the private information of a publisher who offers a higher-than-usual royalty rate but a lower-than-usual advance.

In a formal auction, the seller restricts bidders to use contracts from a pre-specified ordered set and commits ex-ante to choose a bidder with the highest bid according to that order. The seller is committed to disqualify any offers outside this set. The seller also commits to an auction format, such as a first-price or a second-price auction.[2]

The best known example in the economic literature of formal auctions with contingent payments is the oil and gas lease auctions. See for example Hendricks and Porter (1988), Hendricks et al. (2003) and Haile et al. (2010). In the U.S., bidders typically compete in cash for the right to drill oil in some area and if they find oil, they pay $\frac{1}{6}th$ of revenues in royalties. There is a large variation across countries in the royalty rate used and even in the U.S. some fields are sold with different rates than $\frac{1}{6}$ (for example, $\frac{1}{8}$ has been employed in areas perceived as risky). The U.S. Mineral Management Service experimented in the 1970s with other auction formats, some of them allowing bidders to compete on royalty rates and others allowing the bidders to deduct estimated costs before royalties were computed. Additionally, the 1995 Deepwater Royalty Relief Act exempted bidders for deep water tracks from royalty payments on production up to a cap. From the point of economic analysis, auctions to allocate a limited number of business licenses (for example, electronic gambling machines), are similar to the royalty auctions because future profits from the use of these licenses are usually taxed at some pre-specified rate. In both cases the level of royalties/taxes affects bidding and overall revenue in these auctions.

In procurement auctions, it is common to use incentive contracts that speculate a pre-specified cost-sharing rule for cost over-runs. For example, as described in McAfee and McMillan (1988), in the 1980s and 1970s, the U.S. military used auctions with such incentive contracts with cost-sharing parameter varying between 0.5 and 0.9, with 0.8 being typical.

Another example of formal auctions is auctions to select a lead-plaintiff in class-action suits and to determine a formula for setting legal fees (see Fish, 2001, 2002). In some build-operate-transfer highway construction contracts seller revenue/cost depends on the terms offered by the bidders.[3] When the FCC ran auctions for wireless spectrum licenses with preferences for small businesses (for example, FCC Auctions 5 and 10); winners did not have to pay immediately but in installments. Formally, their bids were debt obligations and the debt was to a large extent secured by the licenses won. Indeed, many of the winners defaulted on the payments later and the licenses were re-auctioned (the most prominent example is NextWave, see Board, 2007b; Zheng, 2001).

Finally, in many online advertising auctions bidders pay per click or per conversion. If the seller and bidders are equally informed about the click or conversion rates, as assumed in the main papers on this topic, then the information linkage discussed in this paper is not present. Symmetric information about click rates seems to be a good assumption for publisher/audience/advertiser combinations with large volumes that allow for a quick and precise estimation of these click rates. It is probably less good assumption in low-volume sub-markets.

Informal auctions with contingent payments are common in the private sector. The most studied example is corporate takeovers and intercorporate asset sales (see, among others, Betton et al., 2008; Martin, 1996 on the forms of payments, as well as references on stapled finance in Povel and Singh, 2010). Firms bidding to acquire another company commonly mix cash and equity in their offers and raise debt backed at least partially by the asset being transacted. Another example in financial markets is entrepreneurs who participate in informal auctions with contingent payments at different stages of the growth of their companies to obtain venture capital/angel funding (see Kaplan and Stromberg, 2003 and discussion in Kogan and Morgan, 2010).

In the arts/entertainment industries, authors selling publishing rights (Caves, 2003) or experienced actors in motion pictures (Chisholm, 1997) commonly obtain a contract with some revenue sharing and advance. McMillan (1991) describes that bidders for broadcast rights to Olympic Games used revenue sharing offers.

2. The model

We start with the benchmark model of auctions with contingent payments presented in DKS. There is a seller and N bidders (all risk-neutral). Bidders are ex-ante symmetric and have independent private values.[4] The seller runs an auction for a project that requires the winner to make an up-front investment $X > 0$.[5] If bidder i wins the project, it generates verifiable revenue/cashflow Z_i. Before the auction nobody knows Z_i's. Each bidder has private information about his expected cashflow, z_i. The estimates/types, z_i, are distributed independently and symmetrically according to some distribution $f(z_i)$ over a range $[\underline{z}, \overline{z}]$, where $\underline{z} \geq X$. Conditional on z_i, bidder i cashflow is distributed according to an atomless distribution $h(Z_i|z_i)$.[6]

We assume that $h(Z_i|z_i)$ has full support $[0,\infty)$ and satisfies the strict Monotone Likelihood Ratio Property (SMLRP).[7] That is, for $z > z'$, the likelihood ratio $h(Z|z)/h(Z|z')$ increases in Z (a higher estimate implies a stronger distribution of cashflow realizations). Normalize $E[Z_i|z_i] = z_i$, so that a bidder type is his expected revenue if he wins.

If the seller runs a standard cash auction, this model is equivalent to the textbook symmetric independent private values model in which bidder valuations are $v_i = z_i - X$.

Throughout the analysis, a (feasible) bid is an offer of a contingent payment to the seller as a function of the realized cashflow, $S(Z_i)$. Canonical examples of such bids are royalty contracts (or equity in a finance application), debt and call option (or royalty rate combined with an advance) and hence we refer to such contingent payments as *contracts* or *securities* or *security bids* (so we also use terms *security-bid auction* or *contract-bid auction*).

We restrict attention to bids that satisfy that $S(Z)$ and $Z - S(Z)$ are increasing and $S(Z) \geq 0$ (so the seller cannot subsidize the bidders).[8] Some of the analysis also assumes that bidders do not have cash and have limited liability so that $S(Z) \leq Z$.

Define $ES(z) \equiv E[S(Z)|z]$. Our assumptions imply that $ES(z)$ is continuously increasing (SMLRP implies first-order stochastic dominance)

[2] The seller commits to no renegotiation of the terms of the awarded contract (renegotiations sometimes do happen in the oil and gas lease contracts). Also, the seller commits not to contract with losing or non-participating bidders, a problem discussed in Ding and Wolfstetter (2011).

[3] Moreover, in such auctions the government commonly offers guarantees to the winners and renegotiations are common (see Engel et al., 1997, 2003), making these auctions to be somewhat between the extremes of formal and informal auctions.

[4] See DKS for discussion of affiliated private values. See Abhishek et al. (2012) for the analysis of second-price auctions with risk-averse bidders.

[5] For example, exploring an oil field requires costly preparation work and operation of a rig. X may be a required cash investment or it may represent the alternative cost of winner's asset/effort necessary for the project to succeed.

[6] The realizations of Z_i can be correlated across bidders if they depend on a common ex-post shock that no bidder has private information about. Independent private values mean that the estimates z_i are independent and z_{-i} is not informative about Z_i.

[7] Additionally, $h(Z|z)$ is twice differentiable in both arguments and functions $Zh(Z|z)$, $|zh_z(Z|z)|$, $z|h_{zz}(Z|z)|$ are integrable on the domain of Z, so the expected values and derivatives we discuss are well-defined. An example of such a distribution is $Z_i = \theta z_i$ where θ is a log-normally distributed random variable with mean 1.

[8] These are standard assumptions in security design literature and are motivated by limited liability and moral hazard considerations. See for example Nachman and Noe (1994) and DeMarzo and Duffie (1999). As discussed below, monotonicity of $Z - S(Z)$ is used to establish existence of a monotone equilibrium.