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Essays on auctions

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Publication date
2010

[Link to publication](#)

Citation for published version (APA):

Hu, X. (2010). *Essays on auctions*. [Thesis, fully internal, Universiteit van Amsterdam]. Thela Thesis.

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Introduction

1.1 Overview

The past few decades have witnessed a remarkable expansion of auctions activities, along with a remarkable expansion of the literature on auctions. From the sales of mobile-phone licences and industrial goods, to the privatization of formerly state-owned enterprises, auction mechanisms have been employed to enhance revenue and efficiency in otherwise imperfectly competitive markets. The growth of e-commerce has greatly facilitated business-to-business transactions through auctions, inspiring at the same time research and innovations toward new auction designs.

“An auction is a market institution with an explicit set of rules determining resource allocation and prices on the basis of bids from the market participants.” (McAfee and McMillan, 1987, p. 701). Although the auction rules may vary – in practice or in design – they share a common objective to find out the highest possible value of the object for sale.¹ This is done

¹As usual, for expositional convenience I shall assume that there is a seller facing a number of competing buyers. The parallel conclusions of this thesis can be drawn straightforwardly for the cases

by encouraging or inducing competition among the potential buyers, who typically have private information that could influence the prices. As competition tends to go hand-in-hand with efficient allocation of resources, this explains the popularity of auctions in practice and the prominence of the auction related topics in the economics literature (e.g., Milgrom, 2004; Klemperer, 2004; Krishna, 2009; and the references contained therein). However, although “[e]conomists are proud of their role in pushing for auctions,” important issues remain as to why “many auctions—including some designed with the help of leading academic economists—have worked very badly.” (Klemperer, 2002, p. 169). Klemperer has identified various practical reasons that may cause an auction to fail, including bidder collusion, entry deterrence/predation by a bidding firm, inadequate reserve prices set by the seller, and other political or institutional pitfalls.

In this thesis, I will devote some in-depth analyses on the role of explicit or implicit reserve prices, as well as the role of risk attitudes of the participants, in a number of standard and non-standard auctions. Many of the practical concerns of the sellers, such as those mentioned above, can be mitigated by properly set reserve prices; whereas failure of such reserve prices could seriously damage the expected outcome of an auction. For example, in its sales of four third-generation mobile-phone licenses in November 2000, the Swiss government collected a total amount of revenue that was worth only one-fifteenth of what had been expected. The major reason for this disastrous outcome is that the Swiss government had set a ridiculously low reserve price prior to the auction (Klemperer, 2002, pp. 174-175).

Most of the studies in the auctions literature begin with the assumption that the bidders are risk neutral—or that they have a linear utility function for income. A well-known result obtained under this assumption is the revenue equivalence theorem (e.g., Vickrey, 1961; Myerson, 1981; Riley and Samuelson, 1981; Krishna and Maenner, 2001; and Milgrom and

where a single buyer faces a number of competing sellers, such as the cases with several firms bidding for a procurement contract with the government.

Segal, 2002). The theorem predicts that when bidders have independent private information or signals, the payment rules do not matter under the same allocation rule. Another well-known result under these circumstances is that for bidders who are ex ante symmetric, the optimal reserve price that maximizes the seller's expected revenue will be the same in the standard auctions such as the English auction, the second-price sealed bid auction, the first-price sealed bid auction, or the Dutch auction.² Because under the optimal reserve price the lowest bidder is indifferent between winning and losing, by the revenue equivalence theorem the allocation rule uniquely determines the expected payment by the buyers and hence the expected revenue to the seller. Clearly, these results, despite their elegance, are unable to explain the variety of auction policies adopted under different circumstances—let alone to answer the question why some auctions perform better or worse than the others in raising revenue.

Another well-known prediction derived under risk neutrality is due to Milgrom and Weber (1982) who predict that, when bidders have interdependent values and affiliated signals, the English auction generates a higher expected revenue than the second-price auction, which in turn generates a higher expected revenue than the Dutch and first-price auctions. None of the above predictions, however, is robust to changes in the bidders' risk preferences. Existing studies (e.g., Holt, 1980; Riley and Samuelson, 1981; Harris and Raviv, 1981; Milgrom and Weber, 1982; Matthews, 1983,

²The English (ascending) auction and the Dutch (descending) auction are open-bid auctions. In the former, the price for the object(s) for sale increases until all but one bidder remains, who will then be awarded the object(s) and pay for the stopping price. In the latter, the price decreases and stops as soon as one bidder shows willingness to pay for the object(s) to become the winner and pay the stopping price.

The first-price and second-price (Vickrey) auctions refer to the sealed-bid auctions, both of which invite the bidders to submit sealed bids, with the understanding that the highest bidder will win the object(s). They differ only in the payment rule: the winner pays his own bid in the former and the second-highest bid in the latter. These auctions are conventionally viewed as the standard auctions (e.g., Maskin and Riley, 1984).

It can be shown that in the independent private values settings, the English and second-price auctions are strategically equivalent, so are the Dutch and first-price auctions (see Milgrom and Weber (1982) for detailed arguments).

1987; Maskin and Riley, 1984; Cox et al., 1982, 1988) show that in symmetric independent private values settings, bidders submit higher bids in the first-price auction when they are risk averse rather than risk neutral. This implies that the expected revenue is higher in the first-price auction than it is in the second-price auction, as the bids in the second-price auction are unaffected by the risk attitudes of the bidders. This unambiguous result has two immediate consequences. First, it suggests that a risk neutral seller would prefer the Dutch or first-price auctions to the English or second-price auctions when bidders are risk averse and have symmetric independent private values. Second, even if the bidders' values are interdependent and signals affiliated, by a continuity argument the seller's preference for the Dutch or first-price auctions may continue to hold, as long as the interdependence of the bidders' information and valuation is not "too" strong. Since these results are at variance with those of Milgrom and Weber's, they suggest that the risk preferences of the bidders can be an important factor that will affect an auction's outcome.

Although most of the attention has been directed to the seller's expected revenue in the auctions literature, there also exists some work on how risk aversion affects the expected utilities of the bidders under different auction policies. For instance, Matthews (1987) shows that in symmetric independent private values settings, the buyers who exhibit constant Arrow-Pratt absolute risk aversion have the same expected utilities in any of the standard auctions: English, Dutch, first-price, or second-price. This result suggests that "payoff equivalence" from the buyers' viewpoint is not necessarily a result of buyer risk neutrality, as it can hold for certain type of risk averse buyers (see Milgrom, 2004). Matthews further shows that if the buyers exhibit decreasing (increasing) risk aversion, then they have strictly higher (lower) expected utilities in the English and second-price auctions than in the Dutch and first-price auctions. Understanding the buyers' preferences over auction formats can be important because even though an individual bidder may not have much power to influence the auction design, he has nevertheless the choice to "vote with his feet." This

possibility is relevant to the seller especially where the potential bidders are few and they face certain costs of participating in the auction (e.g., Smith and Levin, 1996).

With few exceptions (e.g., Myerson, 1981; Riley and Samuelson, 1981; Levin and Smith, 1994; Waehrer et al., 1998), the existing studies of auctions assume either that there is no reserve price,³ or that the same reserve price is exogenously given under different auction formats. Departing from these assumptions, Chapter 2 of this thesis will study how the optimal reserve prices can be determined in the standard auctions, assuming that both the seller and the buyers are risk averse. An implicit assumption in this chapter is that the seller is capable of committing to a reserve price prior to the auction.

In some other situations, the seller may not have sufficient knowledge about, or the ability of commitment to, a proper reserve price. Implicit reserve prices could then be derived through a two-stage auction such as the Anglo-Dutch auction proposed by Klemperer (2002). Chapter 3 will study such cases in a non-standard premium auctions setting, where the seller pays a number of highest bidders a cash reward according to some pre-specified rule. Such auctions typically proceed in two stages (Goeree and Offerman, 2004). The first stage will generate a reserve price for the second stage, and the two highest bidders in the first stage will enter the second stage to continue bidding. The auctions we consider differ from the Anglo-Dutch auction mainly in that the second-stage bidders are entitled of the premium to be paid by the seller. The objective of this chapter is to study the possibility of using the premium tactics to deter collusion among the buyers.

Chapter 4 continues the study of two-stage premium auctions in the preceding chapter, extending the analysis to the case in which the partici-

³The term “no reserve price” is in fact inaccurate because most of the auctions do have a reserve price, as pointed out by Milgrom and Weber (1982). It is more adequate to say that “the reserve price is not binding” instead, meaning that bidders with the lowest possible value (or willingness to pay) for the auctioned object is not prevented from bidding.

pants (both the seller and the buyers) can be risk averse or risk loving. The focus of this chapter is then placed on the interplay between the premium and the bidders' risk preferences in terms of how they affect the seller's and the bidders' expected utilities.

1.2 Summary of Main Results

1.2.1 Chapter 2

This chapter focuses on the effects of buyer *and* seller risk aversion on the seller's optimal reserve price in standard Dutch or first-price auctions (FPA) and English or second-price auctions (SPA). Sharp results are obtained by restricting attention to the otherwise simplest setting, that of symmetric and independent private values.

The main conclusions of this chapter are as follows.

- When the seller and/or the buyers are risk averse, the seller's optimal reserve price will be lower in the FPA than in the SPA. Risk aversion thus makes the FPA, in general, more ex post efficient than the SPA.
- In either auction, a more risk averse seller sets a lower reserve price. Thus, the more risk averse the seller, the more ex post efficient are both auctions.
- In fairly general cases, the seller sets a lower reserve price in the FPA if the bidders are more risk averse.

The general conclusion of this chapter is that risk aversion can be a disguised blessing in terms of ex post efficiency, as it induces the seller to lower the reserve price, resulting in a higher probability that the object is allocated to the one who values it most. It is worth noting that the comparative efficiency implications of the FPA and the SPA would be absent if the players were all risk neutral, in which case the seller would choose the same reserve price in both auctions (e.g., Myerson, 1981).

1.2.2 Chapter 3

This chapter examines the potential of the English premium auctions (EPA) in deterring bidder collusion. The main idea is that a premium auction can discourage “strong” bidders (e.g., those who have a serious interest in acquiring the object for sale) to form a cartel because “weak” bidders (e.g., “fortune hunters”), in quest of the premium, may be attracted to the auction and bid aggressively to spoil the potential profits of the cartel. For tractability the bidders in this chapter are assumed to be risk neutral. The collusive properties of the first-price, English, and the English premium auctions are then investigated using a laboratory experiment.

The main findings of this laboratory experiment reported in this chapter are as follows.

- When the cartel members do not defect, the FPA appears to be more conducive to collusion than other auctions. This result may be due to the possibility that the subjects were actually risk averse. Then, consistent with the results of Chapter 2, without collusion the competitive bidders would bid most aggressively in the FPA. The incentive to collude was therefore the highest under this auction policy.
- We also observe that the English auction is very conducive to collusion—almost as strongly as in the FPA.
- Whenever collusion is possible, the revenue dominance of the FPA over the English auction, as usually reported in experimental private value auctions, completely disappears.
- Even though the model considered in this chapter involves multiple equilibria in the EPA, the subjects (weak bidders) in the experiment are found to focus on the more aggressive equilibrium, which makes collusion unattractive.

Therefore, the experiment confirms the theoretical prediction that the EPA is less conducive to collusion than the other auction formats. The chapter concludes that the EPA can outperform the English and first-price auctions in avoiding collusion and generating higher expected revenue.

1.2.3 Chapter 4

This chapter provides a theory of the English premium auction (EPA) for the canonical case in which risk averse or risk loving bidders with symmetric private values compete. The aim of this chapter is to sharpen and enrich our understanding about the premium auctions, which have been studied mainly under the assumption of risk neutrality in the literature so far. The chapter shows how bidding behavior and the expected utilities of the participants can be affected by the bidders' risk attitudes as well as the premium.

A particularly noteworthy result in this chapter is what we call the “net-premium effect.” This effect says that, given any arbitrary premium rule, as the price rises in an EPA and the bidders update their information about the other bidders' value distributions, the conditional expected utility for the premium from the ongoing auction is always equal to the bidder's utility for the premium should he quit at the current price. The net-premium effect implies that every bidder's conditional expected utility for the premium equals zero until he enters the second stage of EPA. This finding is interesting on its own, as it adds a new insight into the revenue equivalence theorem. Namely, as long as the allocation rule remains the same, adding a premium to the English (or Vickrey) auction always results in a zero-expected utility for the premium for the bidders *ex ante*. While offering a useful tool for comparative welfare analysis of the premium auctions beyond the risk neutrality assumption, this effect predicts revenue equivalence when the bidders are risk neutral.

The main conclusions of this chapter are as follows.

- Under plausible conditions, there exists a unique EPA symmetric equilibrium. In this equilibrium, all bidders bid higher than their

private values—except the one who has the highest possible value and whose bid will be equal to his value.

- Incentive compatibility implies a net-premium effect that is key to the main conclusions of this chapter.
- For any arbitrary premium rule, the expected payment by any bidder decreases as the bidders become more risk averse. Hence, a risk neutral seller is better (worse) off to offer a premium when the bidders are risk loving (averse).
- Under plausible conditions, the bidders prefer the EPA to the English auction if and only if they are risk averse. Therefore, the conventional wisdom that premium auctions tend to attract risk-seeking speculators does not hold in our symmetric auction environment.
- The premium tends to reduce the riskiness of the payment. Hence, a risk averse (loving) seller may like (dislike) the premium policy when the bidders are risk neutral.

Indeed, these results suggest a conflict of interests between the revenue-maximizing seller and the bidders over the use of premiums, and this conflict of interests continues to hold when the seller is risk averse but the bidders are risk loving, or vice versa. However, the seller and the bidders may simultaneously prefer the EPA to the English auction when the bidders are risk neutral or marginally risk averse, and the seller is sufficiently risk averse.