Journal of Behavioral and Experimental Economics 67 (2017) 28–40

Contents lists available at ScienceDirect

Journal of Behavioral and Experimental Economics

journal homepage: www.elsevier.com/locate/jbee

Second-price common value auctions with uncertainty, private and public information: Experimental evidence[☆]

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ARTICLE INFO

Article history:
Received 1 August 2016
Revised 26 December 2016
Accepted 27 December 2016
Available online 4 January 2017

JEL classification:
C92
D44
D82

Keywords:
Laboratory experiments
Second-price common value auctions
Winner's curse
Level-k
Cursed equilibrium

ABSTRACT

We conduct a laboratory experiment of second-price sealed bid auctions of a common value good with two bidders. Bidders face three different types of information: common uncertainty (unknown information), private information (known by one bidder) and public information (known by both bidders), and auctions differ on the relative importance of these three types of information. We find that subjects barely differentiate between private and public information and deviate from the theoretical predictions with respect to all three types of information. There is under-reaction to both private and public information and systematic overbidding in all auctions above and beyond the standard winner's curse. The Cursed Equilibrium and Level-k models successfully account for some features of the data but others remain largely unexplained.

1. Introduction

Auctions are widespread but complex allocation mechanisms. They have received substantial attention in the theoretical and experimental literature in economics. Despite some departures from theoretical predictions, auctions are generally seen as reasonably efficient mechanisms for the allocation of items among agents. While many informational elements are present in an auction, the existing experimental literature generally focuses on one, the amount of private information. In this paper, we take a different route and study how subjects react to *three different types of information*: private information (information known by one bidder but not the other), public information (information known by both bidders) and common uncertainty (information known by no bidder). The main goal is to determine if subjects realize that optimal bidding depends not only on the information they possess/ignore but also on whether this information is possessed/ignored by other bidders.

To this purpose, we adopt the experimental design first introduced by Brocas et al. (2015) in the context of a first-price sealed bid auction, add some small variants, and study behavior in a second-price sealed bid auction. Formally, we assume that the value of the good is the sum of N independent "components." Each bidder observes only a subset of these components and knows which components are and are not observed by the other bidder. By varying the number of components observed by each bidder, we parsimoniously change the information structure of the auction. We consider five information structures. Three have only one type of information: only common uncertainty, only private information, and only public information. The remaining structures have two types of information: one has private information and common uncertainty and the other has private information and public information.

Brocas et al. (2015) show that more than half of the subjects in the first-price auction do not differentiate between types of information and that departures from equilibrium predictions occur with respect to all three types. As we will develop below, we also find that a majority of subjects in our second-price auction react similarly to private and public information. They also react differently from what theory predicts under all information struc-

☆ We gratefully acknowledge the financial support of the National Science Foundation grant SES 1425062, the LUSK Center for Real Estate, the Microsoft Corporation and the Fundacao para a Ciencia e Tecnologia from the Portuguese Ministry of Science and the Consolider Program from the European Research Council.

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http://dx.doi.org/10.1016/j.socec.2016.12.008
2214-8043/

tures. Taken together, the two papers point to a general behavioral anomaly regarding information processing: subjects do not act optimally given their information because they do not realize that possessing information matters, nor that it matters whether or not their rival possesses that information. Overall, while the literature on adverse selection has extensively documented that informational asymmetries result in suboptimal choices (Samuelson and Bazerman, 1985; Charness and Levin, 2009; Carrillo and Palfrey, 2009; 2011), this and our companion paper are the first to explicitly show that inefficient choices occur because many subjects behave similarly when information is private or public.

A key distinguishing feature between the two studies is that the symmetric Nash Equilibrium (NE) bidding strategy in the second price auction can be decomposed into additively separable parts, each related to a type of information. Therefore, the individual effects of each type of information on the bidding strategy can be analyzed separately.[1] With respect to private information, subjects must bid their strategically estimated valuation (which is twice their signal as in the typical second-price common value auction à la Milgrom and Weber, 1982). With respect to common uncertainty and public information, subjects compete à la Bertrand and bid the expected value and the realized value, respectively. As a result, we can study the marginal effect of each change in the information structure on the bid. The separability property also lends itself to a structural estimation of behavioral models. To assess the behavior of subjects and compare it with the NE prediction, we analyze our experimental data from three different angles: we perform an aggregate descriptive analysis, we run a regression analysis to explain the bid as a function of the information known by the subject (public and private), and we perform a structural estimation of two behavioral theories, Level-k (Lk) and Cursed Equilibrium (CE).

The main conclusions of our analysis are the following. As mentioned above, the first and arguably most robust result is that the subjects' reaction to new information depends only marginally on its type. In other words and complementing Brocas et al. (2015), bidders treat private and public information much more similarly than they should. The second finding is that the observed behavior departs from NE regarding the three types of information and these departures depend on the information revealed. There is overbidding of common uncertainty which increases with total information. The reaction to private information is significantly smaller than predicted by theory and it increases with total information. Finally, the reaction to public information is constant and slightly smaller than NE. Significant departures occur even in auctions with no information and full information. The third conclusion relates to behavioral theories. Both the CE and Lk models can be seen as successful in that they parsimoniously explain some important features of the data, namely overbidding when the value of the private information is small and under-reaction to increases in that information. However, both models fail to capture the extra overbidding (above and beyond the winner's curse) and the substantial heterogeneity observed in our sample. It suggests that there is still room for improvement on existing theories.

Our analysis relates to two strands of the experimental literature: common value auctions and auctions with variable information. Second-price common value auctions have been extensively studied in the laboratory. In the typical setting (e.g., Kagel et al., 1995), the good is drawn from some distribution and bidders receive independent signals centered around the true realization. In our study, we model the value of the good as the sum of N independent signals, and each of them may or may not be observed by bidders. This is formally closer to Albers and Harstad (1991); Avery and Kagel (1997) and Klemperer (1998).[2] As noted above, our paper is different in that we explicitly model components characterized by different types of information for which subjects bid independently, and we vary the relative importance of those components for comparative statics of bids and payoffs.

A few experimental articles study auctions with different amounts of information. Andreoni et al. (2007) study private value first- and second-price auctions in which bidders know their own valuation and the valuation of some other bidders. Naturally, the private value setting precludes any winner's curse problem. Mares and Shor (2008) analyze common value first- and second-price auctions with constant informational content but distributed among a varying number of bidders. The paper explores the trade-off competition vs. precision of estimates. Grosskopf et al. (2010) vary the number of bidders who receive a signal about the common value of the good in a first-price auction. They find that the winner's curse increases with private information. However, they do not consider how other types of information may affect the bidding strategy of the subjects.

The paper proceeds as follows. The theoretical framework is developed in Section 2 and the experimental setting and hypotheses are presented in Section 3. The aggregate analysis of the experimental data, including the regression analysis, is discussed in Section 4. Behavioral models are tested in Section 5 and conclusions are presented in Section 6.

2. Theoretical model

Consider a single common value good made of N components (with N even and greater than or equal to four). Each component $i \in \{1, \dots, N\}$ has a value x_i independently drawn from a continuous distribution with positive density $g(x_i)$ on $[\underline{x}, \bar{x}]$ and cumulative distribution $G(x_i)$. The total value of the good is the same for every individual and equal to the sum of the components, $V = \sum_{i=1}^{N} x_i$.

Two risk-neutral bidders, A and B indexed by j, bid for this good in a second-price sealed bid auction with no reserve price. Before placing their bids, A observes the first r components of the good, $\{x_1, \dots, x_r\}$, and B observes the last r components of the good, $\{x_{N-r+1}, \dots, x_N\}$, where $r \in \{1, \dots, N\}$. We also consider the case where bidders A and B observe none of the components of the good, which we denote by $r = 0$.

In this model, each bidder observes exactly r components and does not observe exactly $N - r$ components, and each bidder knows which components are and are not observed by the other bidder. We can define three types of information: *private information*, the components that only one bidder observes; *public information*, the components that both bidders observe; and *common uncertainty*, the components that no bidder observes. Notice that there is only common uncertainty when $r = 0$, only private information when $r = N/2$ and only public information when $r = N$. There is common uncertainty and private information when $r \in \{1, \dots, N/2 - 1\}$ and private information and public information when $r \in \{N/2 + 1, \dots, N - 1\}$. For the rest of the analysis, it is useful to introduce the following notation.

- $X_A^r = \sum_{i=1}^{\min\{r, N-r\}} x_i$: sum of A's private information when $r \in \{1, \dots, N - 1\}$
- $X_B^r = \sum_{i=\max\{N-r+1, r+1\}}^{N} x_i$: sum of B's private information when $r \in \{1, \dots, N - 1\}$

[1] By contrast, in a first-price auction, as information about certain components gets revealed, the bidding strategy changes for all the components of the good (and not only for the components affected by the change). It is therefore difficult to pinpoint the contribution of each component to the bidding strategy.

[2] In the first of these studies the value of the good is the sum of N signals and each of the N bidders observes one signal. In the last two studies, each of two bidders has one private signal. The value of the good is the sum of signals for one bidder and the sum of signals plus a private value component for the other bidder. When the private value component is zero, their model is equivalent to our treatment with only private information.