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An externality-robust auction: Theory and experimental evidence ☆

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ABSTRACT

Behavioral robustness is essential in mechanism design. Existing papers focus on robustness as captured by dominant strategies. This paper studies the novel concept of externality-robustness, which addresses players' motives to affect other players' monetary payoffs. One example is externalities due to spite, which has been used to explain overbidding in second-price auctions. We show theoretically and experimentally that a trade-off exists between dominant-strategy implementation and externality-robust implementation. In particular, we derive the externality-robust counterpart of the second-price auction. Our experiments replicate the earlier finding of overbidding in the second-price auction, but we find that average bids equal value in the externality-robust auction. Our data also reveal that both auctions produce the same level of efficiency, suggesting that both dimensions of robustness are equally important. Our results are relevant for mechanism design in general, because the concept of externality-robustness is applicable to arbitrary mechanism design problems.

1. Introduction

The mechanism design literature has realized early on that its practical success will depend on the robustness of the mechanisms it engineers. Wilson (1987) was one of the first authors to criticize the assumption of common knowledge of many details of both the environment and the behavioral model. Mechanisms that are designed under such assumptions might be infeasible or produce unpredictable outcomes in real-world applications, where the mechanism designer or the agents typically lack substantial knowledge about the other parties involved. In the subsequent literature, robustness is often equated with more demanding equilibrium concepts such as dominant strategies.[1] However, robustness in this sense is only one dimension worth investigating. Recent work has made progress on robustness in the dimension of non-standard and

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[1] More precisely, the prevalent robustness requirement of Bergemann and Morris (2005) is implied by implementation in ex-post equilibrium, which in turn is equivalent to implementation in dominant strategies with independent private values.

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possibly interdependent preferences.[2] In this paper, we study the trade-off between dominant-strategy implementation and externality-robust implementation in a simple auction environment.

The second-price sealed-bid auction (SPA) is the most prominent example of a dominant-strategy mechanism. As Vickrey (1961) has shown, in theory the SPA achieves Pareto-efficiency in private information environments without requiring strategic sophistication of the bidders. Experimental studies reveal, however, that the actual performance of the SPA can differ substantially from the theoretical prediction (e.g. Kagel, 1995): overbidding is regularly observed, such that Pareto-efficiency of the outcome is not guaranteed. Among the candidates that can explain overbidding, spiteful preferences have received much attention (e.g. Morgan et al., 2003; Brandt et al., 2007; Andreoni et al., 2007; Cooper and Fang, 2008; Nishimura et al., 2011; Kimbrough and Reiss, 2012). Spiteful bidders have an incentive to overbid in the SPA, because the own bid can affect the price that a winning opponent has to pay. In this sense, the SPA is not robust to the possibility that the bidders have interdependent preferences.

In the first part of the paper, we derive the externality-robust counterpart of the SPA, the externality-robust auction (ERA). The concept of externality-robustness works as follows. Suppose that the selfish Bayes–Nash equilibrium of a mechanism satisfies that unilateral deviations (e.g. to overbidding in an auction) leave the expected payoffs of all non-deviating agents unaffected. Then this equilibrium will continue to exist for very general preference interdependencies, because the bidders cannot manipulate each other's payoffs. In addition to spitefulness, the class of externalities for which robustness is implied also contains motives such as inequality aversion (Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000), intention-based social preferences (Rabin, 1993; Dufwenberg and Kirchsteiger, 2004), altruism (Andreoni, 1989), or cross-shareholdings between firms (Ettinger, 2003; Dasgupta and Tsui, 2004; Chillemi, 2005). Given the degrees of freedom in designing ex-post transfers of Bayesian incentive-compatible mechanisms, it is possible to make any mechanism externality-robust without changing either its allocation rule or its expected revenue. The resulting ERA is a first-price auction augmented by bonus payments to elicit larger bids. Specifically, every bidder obtains a bonus that is increasing in the own bid but independent of the others' bids and the event of winning or losing the auction. The bonus schedule is designed so as to induce truthful bidding. Unilateral deviations from truthful bidding then have no effect on the other bidders' payoffs, because (*i*) their bonus payments are unaffected and (*ii*) winning the auction generates no additional rents that can be manipulated. Since the modification of transfers destroys the dominant-strategy property of the SPA, the ERA is no longer robust in this sense.

In the second part of the paper, we test the two auction formats SPA and ERA experimentally. Our goal is to evaluate the trade-off between the two different robustness concepts, i.e., the trade-off between robustness in the dimension of beliefs about other players' strategies and robustness in the dimension of payoff externalities. From the previous discussion we obtain several qualitative predictions about bidding behavior. First and foremost, we expect to find average overbidding in the SPA but not in the ERA, since spitefulness among experimental subjects can manifest itself in overbidding in the SPA but not in the ERA. Importantly, overbidding in the SPA can disrupt the efficiency of the auction outcome, as the auction winner will not necessarily be the one with the highest valuation. Second, since it is reasonable to assume that not all bidders have correct equilibrium beliefs, we expect to observe variance around the true value in bidding behavior in the ERA, which will also disrupt the efficiency of the auction outcome. Our experimental data reveal that both SPA and ERA achieve ex-post efficiency in about 90 percent of all cases. This suggests that the two notions of robustness are equally important from an efficiency perspective.

Our experimental data further show that bids are on average about 10 percent above values in the SPA. Average overbidding in the ERA, by contrast, is not different from zero. This suggests that spiteful preferences indeed affect bidding behavior in the SPA but not in the ERA. To further verify that the behavioral differences between SPA and ERA are in fact due to their different robustness properties, we conducted additional treatments where subjects interact with a computer instead of another subject. The important property of these control treatments is that interaction with a computer directly eliminates the possibility that a bidder can influence the payoff of another bidder.[3] If spitefulness is indeed the (only) reason for overbidding in the SPA, we should not observe overbidding in the SPA against the computer (SPA-C). For the ERA, in contrast, where no externalities exist by design, we should observe no change in bidding behavior when the human opponent is replaced by the computer (ERA-C). Our data show that average overbidding is significantly reduced (to about 4 percent) in the SPA-C. We also find that average overbidding remains indistinguishable from zero in the ERA-C. Even though some overbidding persists in SPA-C, these results provide clean evidence that a large part of the difference in average bidding behavior between the SPA and the ERA is driven by spitefulness and the property of externality-robustness of the ERA.

The SPA and the ERA also differ in their distributional implications. The seller benefits from overbidding at the expense of the buyers, which is reflected in average revenues that are about 12 percent larger in the SPA compared to the ERA. The fact that a mechanism may coincidentally generate high revenues for some behavioral trait to which it is not robust – such as the SPA for spiteful preferences – does only underline the importance of understanding robustness in mechanism design. For instance, seemingly desirable outcomes of a non-robust mechanism turn into undesirable outcomes when the behavioral

[2] The robustness concept applied in this paper is due to Bierbrauer and Netzer (2016). See Bierbrauer et al. (2015) for an extensive discussion of the different aspects of robustness that can be traced back to Wilson (1987).

[3] Replacing human opponents by a computer is a standard experimental technique to eliminate social contexts, see e.g. Bohnet and Zeckhauser (2004) for a trust game and van den Bos et al. (2008) for a common value auction. Note that the SPA against the computer bidder is a variant of the Becker–DeGroot–Marschak mechanism (Becker et al., 1964), which is often used to elicit the willingness to pay of a single buyer.