Robust mechanism design and social preferences

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ABSTRACT

We study two classic challenges in mechanism design – bilateral trade à la Myerson and Satterthwaite (1983) and redistributive income taxation à la Mirrlees (1971) and Piketty (1993) – to show that some standard mechanism design solutions systematically fail with social preferences. We therefore introduce the notion of a social-preference-robust mechanism which works not only for selfish but also for social preferences of different nature and intensity, and characterize the optimal mechanism for this class. With the help of a series of laboratory experiments we find that behavior can indeed be better controlled with social-preference-robust mechanisms.

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1. Introduction

Inspired by Wilson (1987), Bergemann and Morris (2005) have provided a formalization of mechanisms that are robust in the sense that they do not rely on a common prior distribution of material payoffs. We add another dimension in which we seek robustness. A mechanism that works well under selfish preferences might fail under social preferences. Indeed, behavioral economics has shown that many agents behave socially. One challenge is, though, that social preferences can differ with respect to their nature and intensity, leading to different kinds of social preference models, including altruism, inequity-aversion, and intentionality (Cooper and Kagel, 2013). Because we want a mechanism to work not only for selfish preferences but also for a large set of social preferences, we introduce the notion of social-preference-robust mechanism: a mechanism must not depend on specific assumptions about the nature and intensity of selfish and social preferences.

For the applications studied in this paper, the notion of robustness due to Bergemann and Morris is equivalent to the requirement that a mechanism has a dominant strategy equilibrium. Depending on the application, this may significantly restrict the set of implementable
outcomes. Thus, there may be the concern that adding another robustness-requirement will restrict the set of admissible mechanisms even further and is therefore problematic. In our view, comparing mechanisms that, according to theory, sacrifice performance for a more robust solution concept to mechanisms that, according to theory, sacrifice robustness in return for performance, is ultimately an empirical question. Our laboratory experiments are first steps in this direction.

Throughout, we use two classic applications of mechanism design theory, a version of the bilateral-trade problem due to Myerson and Satterthwaite (1983) and versions of the optimal income tax problem due to Mirrlees (1971) and Piketty (1993) to illustrate our theoretical analysis.

1.1. The bilateral trade problem

The bilateral-trade problem provides us with a simple, and stylized setup that facilitates a clear exposition of our approach. Moreover, it admits interpretations that are of interest in public economics, environmental economics, or contract theory. The basics are as follows: a buyer either has a high or low valuation of a good produced by a seller. The seller either has a high or a low cost of producing the good. An economic outcome specifies, for each possible combination of the buyer's valuation and the seller's cost, the quantity to be exchanged, the price paid by the buyer and the revenue received by the seller. Both the buyer and the seller have private information. Thus, an allocation mechanism has to ensure that the buyer does not understate his valuation so as to get a desired quantity at a lower price. Analogously, the seller has to be incentivized so that she does not exaggerate her cost in order to receive a larger compensation.

The essence of the bilateral trade problem is that there are two parties and that each party has private information on its benefits (or costs) from a transaction with the other party. The labels "buyer" and "seller" need not to be taken literally. This environment can be reinterpreted as a problem of public-goods provision in which one party (the buyer) benefits from larger provision levels whereas the other party (the seller) bears a cost. By how much the first party benefits and the second party loses is private information. It can also be reinterpreted as a problem to control externalities. One party (the seller) can invest so as to avoid emissions which harm the other party (the buyer). The cost of the investment to one party and the benefit of reduced emissions to the other party are private information. In a principal-agent-framework, we may think of one party (the buyer) as benefiting from effort that is exerted by the other party (the seller). The size of the benefit and the disutility of effort are, respectively, private information of the principal and the agent.

Our analysis proceeds as follows: we first characterize an optimal direct mechanism for the bilateral trade problem under the standard assumption of selfish preferences, i.e. both, the buyer and the seller, are assumed to maximize their own payoff, respectively, and this is common knowledge. We solve for the mechanism that maximizes the seller's expected profits subject to incentive constraints, participation constraints, and a resource constraint. We work with ex post incentive and participation constraints, i.e. we insist that after the outcome of the mechanism and the other party's private information have become known, no party regrets to have participated and to have revealed its own information.

As has been shown by Bergemann and Morris (2005), ex post constraints imply that a mechanism is robust in the sense that its outcome does not depend on the individual's probabilistic beliefs about the other party's private information. Moreover, we use the arguments in Bergemann and Morris (2005) for our experimental testing strategy. In their characterization of robust mechanisms complete information environments play a key role. In such an environment, the buyer knows the seller's cost and the seller knows the buyer's valuation, and, moreover, this is commonly known among them. The mechanism designer, however, lacks this information and therefore still has to provide incentives for a revelation of privately held information. Bergemann and Morris provide conditions so that the requirement of robustness is equivalent to the requirement that a mechanism generates the intended outcome in every complete information environment, which in turn is equivalent to the requirement that incentive and participation constraints hold in an ex post sense.

In our laboratory approach, we investigate the performance of an optimally designed robust mechanism in all complete information environments. This approach is useful because it allows us to isolate the role of social preferences in a highly controlled setting, which eliminates complications that are related to decision-making under uncertainty. For instance, it is well-known that, even in one-person decision tasks, people often do not maximize expected utility (see Camerer (1995)), and that moreover, in social contexts, social and risk preferences may interact in non-trivial ways (see, e.g., Bolton and Ockenfels (2010), and the references therein). The complete information environments in our study avoid such complicating factors.

For the bilateral trade problem, the mechanism which maximizes the seller's expected profits under selfish preferences has the following properties: (i) the trading surplus is allocated in an asymmetric way, i.e. the seller gets a larger fraction than the buyer; (ii) whenever the buyer's valuation is low, his participation constraint binds, so that he does not realize any gains from trade; (iii) whenever the buyer's valuation is high, his incentive constraint binds, so that he is indifferent between revealing his valuation and understating it. Experimentally, we find that under this mechanism, a non-negligible fraction of high valuation buyers understates their valuation. In all other situations, deviations — if they occur at all — are significantly less frequent.

We argue that this pattern is consistent with models of social preferences such as Fehr and Schmidt (1999), and Falk and Fischbacher (2006), among others. The basic idea is the following. A buyer with a high valuation can understate his valuation at a very small personal cost since the relevant incentive constraint binds. The benefit of this strategy is that this reduces the seller's payoff and therefore brings the seller's payoff closer to his own, thereby reducing inequality. In fact, as we will demonstrate later, many social preference models would predict this behavior.

We then introduce a class of direct mechanisms that "work" if the possibility of social preferences is acknowledged. Specifically,

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1 For instance, Hagerty and Rogerson (1987) study the bilateral trade-problem due to Myerson and Satterthwaite (1983) and show that, with incentive and participation constraints that are robust in the Bergemann and Morris (2005)-sense, the set of admissible mechanisms is heavily restricted. For other applications, there is no restriction at all. For instance, for a problem of redistributive income taxation, Bierbrauer (2011) shows that there is an optimal mechanism with a dominant strategy equilibrium.

2 Throughout we focus on social choice functions, as opposed to social choice correspondences. Consequently, by Corollary 1 in Bergemann and Morris (2005), ex post implementability is both necessary and sufficient for robust implementability. Moreover, if agents are selfish, then our environment gives rise to private values so that incentive compatibility in an ex post sense is equivalent to the requirement that truth-telling is a dominant strategy under a direct mechanism for the given social choice function.

3 Thus, for our experimental testing strategy, we take for granted the equivalence between implementability in all complete information environments and implementability in all incomplete information environments. We explicitly investigate the former and draw conclusions for the latter. We also take for granted the validity of the revelation principle. That is, we only check whether individuals behave truthfully under a direct mechanism for a given social choice function. We discuss the advantages and limits of this approach in our concluding section.
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