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Optimal selling mechanisms under moment conditions ☆,☆☆

Vinicius Carrasco [a,*], Vitor Farinha Luz [b], Nenad Kos [c], Matthias Messner [d], Paulo Monteiro [e], Humberto Moreira [e]

[a] *Department of Economics, PUC-Rio, Brazil*
[b] *University of British Columbia, Canada*
[c] *Bocconi University, Department of Economics and IGIER, Italy*
[d] *University of Cologne, Germany*
[e] *FGV EPGE Brazilian School of Economics and Finance, Brazil*

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Abstract

We study the revenue maximization problem of a seller who is partially informed about the distribution of buyer's valuations, only knowing its first N moments. The seller chooses the mechanism generating the best revenue guarantee based on the information available, that is, the optimal mechanism is chosen according to maxmin expected revenue. We show that the transfer function in the optimal mechanism is given by non-negative monotonic hull of a polynomial of degree N. This enables us to transform the seller's problem into a much simpler optimization problem over N variables. The optimal mechanism is found by choosing

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* Corresponding author.
E-mail addresses: vncarrasco@gmail.com (V. Carrasco), vitor.farinhaluz@ubc.ca (V. Farinha Luz), nenad.kos@unibocconi.it (N. Kos), messner@wiso.uni-koeln.de (M. Messner), pklm@fgv.br (P. Monteiro), humberto.moreira@fgv.br (H. Moreira).

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the coefficients of the polynomial subject to a resource constraint. We show that knowledge of the first moment does not guarantee strictly positive revenue for the seller, characterize the solution for the cases of two moments and derive some characteristics of the solution for the general case.

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1. Introduction and related literature

Following Wilson (1987)'s critique, a recent literature has studied the role of beliefs in mechanism design problems (see Bergemann and Morris, 2005). Most of this literature explores the impact of mechanism participants' common knowledge and higher order beliefs on implementable outcomes. On the other hand, rather little attention is paid to the fragility of a mechanisms' revenue performance with respect to changes in the designer's prior.[1]

In statistics, the virtual impossibility of fully quantifying or eliciting prior distributions is a common criticism to Bayesian Analysis. Without a full specification of the prior, the critiques go, a standard Bayesian procedure cannot be conducted. In response to such criticism, the literature on robust Bayesian analysis proposes that one should, in fact, conduct a Bayesian analysis which is robust to prior's misspecification. This, in turn, amounts to deriving bounds on the relevant objective function over the range of all priors compatible with the features of the prior that decision maker is able to elicit (see, for example, Berger, 1982, 1984; Smith, 1995 and Betrò and Guglielmi, 2000). In this paper, we follow the robust Bayesian approach and consider a design problem in which a principal, being unable to fully specify the distribution of types of an agent, maximizes expected payoffs under the worst-case distribution of values compatible with the (partial) information elicited about the prior. This is in line with Wilson (1987)'s critique: mechanisms with good performance over a wide range of possible prior distributions should be preferable.

We study the optimal robust trading rule in an environment where a revenue maximizing seller is selling an indivisible good to a single buyer. The seller has very limited information about the buyer's valuation: he is armed merely with the knowledge of a finite number of moments of the value distribution. The seller is pessimistic and evaluates any mechanism by the worst possible performance generated by a value distribution consistent with the known moments. In other words, the seller is a maxmin expected revenue maximizer.[2]

One may interpret the seller as having access to a limited amount of data. In order to avoid the "curse of dimensionality", the seller might prefer to rely on estimates of finitely many moments instead of estimating the density function, which lies in a infinite-dimensional space.[3] Instead

[1] Some notable exceptions are Bergemann and Schlag (2008, 2011) who study optimal mechanism for sale of an object by a seller under minmax regret and maxmin preferences. We provide a more substantial overview of the literature below.

[2] For an overview and references of partial identification of probability distributions and use of bounds on moments in econometrics see Manski (1995) and Manski (2003).

[3] One of the first topics covered in basic Econometrics lectures is how to estimate the mean, which is a very simple procedure. With finite samples, the most common density estimation procedures require the ad-hoc selection of parameters such as bandwidth and the kernel function (Jones et al., 1996).