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Implementing second-best environmental policy under adverse selection

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ABSTRACT

A key obstacle to practical application of mechanism design theory to regulation is the difficulty of obtaining consistent beliefs regarding information that theoretical models assume to be commonly held. This article presents a solution to this problem by developing an easily implemented empirical methodology with which the government can use available data to develop beliefs regarding the technology and distribution of types in a regulated sector characterized by hidden information. Results are used to calibrate a second-best land conservation mechanism and evaluate its cost relative to simpler alternatives.

1. Introduction

The theoretical literature on optimal regulation under adverse selection has grown tremendously in the past three decades. In spite of this progress, actual policies implementing even the most basic optimal mechanisms remain scarce. Here, "optimal" refers to a mechanism that achieves the best outcome for the regulator subject to information and other constraints. In an adverse selection context, such mechanisms can be typically characterized as a set of contracts offered to regulated firms in which payments vary with an observable action in a non-linear way [3]. For example, a system of French regulatory contracts paying firms for installation of industrial wastewater treatment equipment may be optimal if there is private information regarding abatement cost [31]. Auctions are gaining popularity as a means of mitigating information problems. Auctions, however, are not necessarily optimal allocation mechanisms since they do not take advantage of all the information at the government's disposal [19].

One obstacle to the transition from mechanism design theory to practice is the difficulty of obtaining information that theoretical models assume to be commonly held. Models typically characterize a second-best (as opposed to the full information first-best) menu of contracts stipulating payments and allocations among which the regulated firms choose. The precise terms of each contract are defined up to commonly held beliefs regarding: (a) the production technology and (b) the probability distribution of firm types.[1] The optimal values of the contract terms can vary greatly depending on these two sets of beliefs. From the standpoint of applied theory, the development of consistent beliefs regarding these items is therefore of paramount importance. Unfortunately, the extant literature provides little guidance in this regard.

In this article, I show how to calculate the terms of a second-best mechanism by modeling type as a source of heterogeneity that is unobserved both to the regulator and the econometrician. Such a methodology has a wide range of potential applications for general principal-agent problems characterized by adverse selection. It is particularly relevant in

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[1] Type refers to a productivity parameter that is private information to each firm.

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regulatory applications that fit into the general framework of [3]. With respect to environmental policy, this framework readily applies to cases in which environmental benefits are privately provided or in which firms have an effective right to pollute.

As an application, I consider the problem of designing a hypothetical program to encourage owners to set aside a targeted amount of land from agricultural production at least cost to the government. Land conservation payments are becoming popular in both the developed and developing world. Prominent examples include the Wetlands Reserve Program and Conservation Reserve Program (CRP) in the U.S., Australia's Bush Tender program, and Costa Rica's Pago de Servicios Ambientales (payment for environmental services) program. Such programs share the characteristics that participation is voluntary, and that opportunity costs of participation are both heterogeneous across landowners and not directly observable to the government.[2]

There are several policy instruments available to the government for meeting a given land set aside target. The choice of instrument involves a trade-off between simplicity and cost-effectiveness. At one extreme is a uniform Pigouvian-style subsidy. This instrument is relatively simple to administer, but involves potentially large excess payments to those landowners with low participation costs. At the other extreme is first-degree price discrimination. This instrument is difficult to implement. It requires the government to obtain perfect information regarding costs and to design a contract tailored to each landowner. It is cost effective, however, since it results in an efficient allocation with each owner receiving a payment exactly equaling his opportunity cost. Between these extremes lie third-degree price discrimination (geographically differentiated Pigouvian subsidies) and second-degree price discrimination (the Baron and Myerson mechanism).

Theory can rank these instruments by expected cost. Textbook environmental economics policy prescriptions such as Pigouvian taxes and subsidies or emissions markets are sub-optimal in a world characterized by asymmetric information and a social cost of raising public funds [22]. With the empirical tools provided in this paper, however, one can go a step further towards making an informed choice between instruments based on the magnitude of cost differences.

Such analysis also contributes to the discussion in the mechanism design literature surrounding the "Wilson doctrine." In an influential piece, [34] notes the prevalence of simple rather than theoretically optimal trading rules in markets with asymmetric information. As noted above, the terms of a second-best contract mechanism are highly dependent upon the regulator's beliefs regarding the production technology and distribution of types. In contrast, some mechanisms (like Pigouvian instruments and some types of auctions) are always allocatively efficient, even if they do not optimize the regulator's objective. Proponents of the Wilson doctrine argue that such mechanisms (which also have the virtue of simplicity) are therefore preferable to a complicated mechanism that is optimal only if the regulator's beliefs are correct. Here I provide policy-makers an easily implementable means of evaluating the magnitude of potential gains offered by theoretically optimal mechanisms.

To identify both the production technology and the distribution of types, the empirical methodology uses a two-part additive error structure in the spirit of the stochastic frontier models [1,23]. One part of the error is stochastic noise (e.g., measurement error or random shocks), while the other represents firm types.[3] This econometric model extends the stochastic frontier literature by adapting robust generalized method of moments (GMM) estimation techniques recently developed in other contexts.

Previous research attempting to identify production technology and distribution of types under adverse selection can be divided into two branches. One branch of the empirical contract theory literature assumes that existing regulations are already optimal in a second-best sense [21,31,35]. The optimality conditions provide equations that can be econometrically estimated with observable data. In an analysis of regulated California water utilities, [35] derives the regulator's optimal choice for a menu of contracts stipulating firms' transfers and capital stock. He then uses these equations to estimate firm production technology and distribution of types. Similarly, [31] uses the equilibrium regulatory contract terms (emissions and transfers) to estimate the parameters of a distribution of types and production technology for French industrial firms under wastewater emission contracts. Using the equation characterizing the optimal contract terms to conduct a semi-parametric estimation of the abatement technology, [21] also examines wastewater abatement.

This line of research is descriptive rather than prescriptive. It may describe regulator beliefs regarding commonly held information. However, parameter estimates are consistent only under the assumption that the regulator is in fact already behaving optimally conditional on her pre-existing beliefs. It provides no guidance to a regulator as to how she might develop these beliefs in the first place.

In contrast, the methodology developed here is designed to inform a regulator who is designing a new policy or reforming an existing one, and thus cannot use the optimality of pre-existing contract terms as a basis on which to conduct

[2] Although the data used in the application are for U.S. agricultural producers, the program modeled here is not intended to mimic the rich detail of the actual CRP. For example, the CRP is a dynamic game, with auctions repeated almost every year, whereas the program modeled here is static. Moreover, existing programs typically do not have a simple explicit goal such as cost minimization. Rather than provide a blueprint for the CRP (or any other existing program), the primary goal of this paper is to develop a methodology for how to incorporate regulated firms' private information into environmental policy design.

[3] The stochastic frontier literature typically refers to the second component of the error term as a firm's "technical efficiency." The contract theory literature typically attributes private information to unobserved (to the regulator) differences in efficiency. Different efficiency levels correspond to different "types" of firms. The interpretation of type used in this article is with that of technical efficiency in the stochastic frontier literature.