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Experimental design to persuade ☆

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ABSTRACT

A sender chooses ex ante how information will be disclosed ex post. A receiver obtains public information and information disclosed by the sender. Then he takes one of two actions. The sender wishes to maximize the probability that the receiver takes the desired action. The sender optimally discloses only whether the receiver's utility is above a cutoff. I derive necessary and sufficient conditions for the sender's and receiver's welfare to be monotonic in information. In particular, the sender's welfare increases with the precision of the sender's information and decreases with the precision of public information.

1. Introduction

Economists have long been interested in how an interested party can communicate her private information to a decision maker when their interests are imperfectly aligned (seminal contributions include Spence, 1973, Milgrom, 1981, and Crawford and Sobel, 1982). I study a situation in which before obtaining information, the interested party can choose a mechanism that specifies what information will be disclosed to the decision maker. This situation has been largely unexplored until recently (the pioneering articles are Rayo and Segal, 2010 and Kamenica and Gentzkow, 2011).

The drug approval process by the Food and Drug Administration (FDA) is a good example of such a situation. If a pharmaceutical company (manufacturer) wants a new drug to be approved, it has to submit a research protocol for all tests that are going to be undertaken. The research protocol includes not only tests chosen by the manufacturer but also standardized mandatory tests required by the FDA. The FDA closely monitors the record keeping and the adherence to the research protocol. So the FDA essentially observes both the design and results of all tests. Finally, based on the results of these tests, the FDA either approves the drug or rejects it. Because of the large cost of the process and large benefits of approval, the manufacturer has strong incentives to optimally design tests to maximize the probability of the FDA's approval.[1] What is the optimal design of tests? What determines the success rate of drug trials? What determines the average quality of approved drugs?

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[1] The description of the drug approval process is taken from Lipsky and Sharp (2001).

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I give exhaustive answers to these important questions by considering the following sender–receiver game. The receiver has a binary action choice: to act or not to act. The sender's utility depends only on the action taken by the receiver, and she prefers the receiver to act. The receiver's utility depends both on his action and on information. The receiver takes an action that maximizes his expected utility given his beliefs. He forms his beliefs based on public information and information disclosed by the sender. The sender chooses ex ante how information will be disclosed to the receiver ex post. Formally, she can publicly choose any conditional distribution of messages given information. I call this distribution a *mechanism*. The sender chooses the mechanism that maximizes her expected utility – the ex ante probability that the receiver will act. No monetary transfers between the sender and receiver are allowed.

This model is a special case of Kamenica and Gentzkow (2011) who consider a general model with an arbitrary set of actions, and arbitrary utility functions for the sender and receiver. They derive some interesting properties of the optimal mechanism. To completely characterize the optimal mechanism, I impose more structure that still fits many real-life examples well. Specifically, the optimal mechanism recommends the receiver to act when the receiver's utility given the information is above a cutoff and recommends the receiver not to act otherwise, where the cutoff is chosen to make the receiver exactly indifferent between the two actions when he is recommended to act.

The main contribution of the paper, however, is general monotone comparative statics results that relate the sender's and receiver's expected utilities at an optimal mechanism to the probability distribution of information. Specifically, I provide necessary and sufficient conditions for the sender and receiver to prefer one distribution of information to another for all values of the receiver's opportunity cost of acting. I now present the main results of the paper using the drug approval process.

What factors affect the manufacturer's welfare (or equivalently the probability of the drug approval)? The manufacturer's welfare is higher if the manufacturer is able to design more informative tests (in the mean-preserving spread sense) and if better drugs enter the testing phase (in the first-order stochastic dominance sense). Interestingly, under the absence of public information, these two conditions are not only sufficient but also necessary if the manufacturer's welfare is required to be higher for all values of the FDA's opportunity cost of approving the drug. Under the presence of public information, the manufacturer's welfare is higher if (and under some additional conditions, also only if) public information is less precise and more positive about the drug's quality.

What factors affect the FDA's welfare (or equivalently the expected quality of approved drugs)? Surprisingly, the FDA's welfare remains the same if the manufacturer is able to design more informative tests. However, the FDA's welfare is higher if public information is more precise and more positive about the drug's quality. These two conditions are also necessary if the FDA's welfare is required to be higher for all values of the opportunity cost of approving the drug. Finally, the overall welfare of the manufacturer and FDA is increasing in the precision of potential information of the manufacturer but is not monotonic in the precision of public information.

Although the above monotone comparative statics results are intuitive, they do not hold in the large existing literature where the sender chooses what information to disclose when she already has her private information. In particular, they do not hold under cheap talk and verifiable communication (Green and Stokey, 2007; Ivanov, 2010). The difference is due to the sender's incentive compatibility constraint on information disclosure, which is absent in my model, because the sender chooses what information to reveal at the ex ante stage.

Public information in the model captures not only information that will literally become public, such as the results of mandatory tests, but also any verifiable private information of the manufacturer or the FDA that they have at the ex ante stage, such as the results of preclinical trials or rival applications previously submitted to the FDA. Indeed, using an argument related to the unraveling argument of Milgrom (1981), I show that such information gets fully disclosed.

1.1. Related literature

The paper is related to two strands of the literature. The first strand of the literature studies optimal information disclosure games, in which the sender can commit to an information disclosure mechanism. The most influential paper in this strand is Kamenica and Gentzkow (2011) discussed above. Rayo and Segal (2010) and Kolotilin (2014) allow the receiver to have unverifiable private information. Gentzkow and Kamenica (2012) allow many senders to disclose information. Alonso and Câmara (2014a, 2014b) allow heterogeneous priors and heterogeneous receivers, respectively. Gentzkow and Kamenica (2014a) allow mechanisms to have different costs to the sender. Bergemann and Pesendorfer (2007) characterize optimal information disclosure in certain environments in which monetary transfers are allowed.

Lerner and Tirole (2006), Brocas and Carrillo (2007), and Benoit and Dubra (2011) study information disclosure in environments similar to mine, but in their models, the sender is exogenously constrained in choosing a mechanism; so they characterize a constrained, rather than unconstrained, optimal mechanism. Gill and Sgroi (2008), Gill and Sgroi (2012), Perez-Richet and Prady (2012), and Perez-Richet (2014) characterize constrained optimal mechanisms chosen by a privately informed sender. Glazer and Rubinstein (2004) characterize constrained optimal mechanisms chosen by the receiver rather than sender.

The second strand of the literature compares information structures in games. An information structure is associated with a distribution of types given the state. A seminal work of Blackwell (1953) shows that an information structure gives a higher optimal payoff than another one for all one-player games if and only if the latter is a garbling of the former.