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Innovation contests with entry auction

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ABSTRACT

We consider innovation contests for the procurement of an innovation under moral hazard and adverse selection. Innovators have private information about their abilities, and choose unobservable effort in order to produce innovations of random quality. Innovation quality is not contractible. We compare two procurement mechanisms—a fixed prize and a first-price auction. Before the contest, a fixed number of innovators is selected in an entry auction, in order to address the adverse selection problem. We find that – if effort and ability are perfect substitutes – both mechanisms implement the same innovations in symmetric pure-strategy equilibrium, regardless of whether the innovators' private information is revealed or not. These equilibria are efficient if the procurer is a welfare-maximizer.

1. Introduction

BellKor's Pragmatic Chaos is the name of the team that won the $1,000,000 *Netflix Grand Prize* in 2009. The prize was awarded at the end of an innovation contest, to the team that submitted "the best *collaborative filtering algorithm* to predict user ratings for films, based on previous ratings without any other information about the users or films".[1] In the end, the innovation was too successful. The winning algorithm's predictive power was so great, that a planned follow-up contest was cancelled, due to privacy concerns and lawsuits. This is just one example of the nowadays widespread adoption of innovation contests.[2]

In this paper, we study theoretical properties of innovation contest mechanisms. We consider the following procurement setting. A buyer needs an innovative good that can potentially be developed by many innovators. Innovation is a random process and results in solutions of varying quality. An innovation of any quality serves the procurer's needs but higher quality is preferred. (In the *Netflix* contest described above, the team "Lanterne Rouge" submitted the worst-performing algorithm.) The quality of a given innovation can only be observed between the respective innovator and the buyer, but is not verifiable and therefore not contractible.

We assume that innovators are heterogeneous. They have private information about their ability to solve the buyer's innovation problem. Moreover, producing an innovation requires unobservable effort, and higher effort stochastically increases innovation quality.

The literature has recommended the use of entry auctions in order to select suitable participants for the innovation contest. Apart from dealing with the adverse selection problem, the auction restricts entry to the contest. Typically, there is an optimal number of entrants.[3] Admitting more contestants increases the expected quality of the best innovation due to a larger sample size. A lower number of contestants avoids cost duplication and provides higher incentives for each innovator due to a higher probability of winning.

In principle, a fixed entry fee can solve the selection problem, based on the idea that only the strongest contestants are willing to pay the entry fee. However, setting the right entry fee requires a considerable amount of information while getting it wrong either leads to too many or too few contestants.

The nature of the innovation restricts the set of feasible procurement mechanisms.[4] Innovation quality is typically not easily verifiable by third parties. This rules out scoring auctions with second- (or higher) price payment rules, where the price paid to the winner depends on the score, and therefore quality, of other contestants' innovations. A first-score auction (also called a

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[1] See http://en.wikipedia.org/wiki/Netflix_Prize (last accessed Sep 19, 2013).

[2] *The Economist*, a newspaper, has been awarding its own innovation awards for more than ten years. Innovation contests have a long tradition. Many interesting historical examples can be found in the literature, see, e.g., Scotchmer (2006).

[3] There are, however, contests with free entry, by design or because it cannot be avoided. For a recent analysis of contests with endogenous entry see, e.g., Fu and Lu (2010).

[4] See, e.g., the discussion in Fullerton and McAfee (1999) and Che and Gale (2003).

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first-price auction in the procurement setting), does not rely on unverifiable information: The buyer selects a winner and the winner is paid its own (observable and verifiable) financial bid in return for the innovation.

Another prominent and widely used contest design with low informational requirement is the fixed-prize contest. There, a fixed prize is announced and is paid to the contest winner.

The present paper contributes to the strand of the literature that compares innovation contests with fixed-prize and first-price auction rules. Typically this literature has either focused on the effects caused by the randomness of innovations, or on the heterogeneity of innovators, but not on both. This paper is a first attempt to compare the two mechanisms in the simultaneous presence of adverse selection and moral hazard.

The main result is that under the assumed "perfect substitutes" innovation technology both mechanisms implement the same innovations. Both have a symmetric pure-strategy equilibrium where strategies are independent of rival contestants' private information. In these equilibria, expected payoffs of the buyer and the sellers are equal, and it does not matter whether or not the sellers' private information is revealed before the contest starts. Moreover, these equilibria are efficient for a given number of contestants. Thus, a welfare-maximizing buyer can implement the first-best innovations. Potential other equilibria will be briefly discussed under different informational assumptions.

2. Literature

The theoretical and experimental analysis of contests has become a very large and active field. For an overview, we refer the reader to the excellent and recent survey literature.[5] Adamczyk et al. (2012) provide a very detailed classification of results on innovation contests.

This section concentrates on recent literature that is closely related to the problem studied in this paper. Throughout the paper there are more references that are relevant for certain aspects of the analysis.

Taylor (1995) studies innovation as an optimal stopping problem. He analyzes a fixed-prize contest among symmetric innovators who repeatedly draw innovations of random quality within a specified time period. He demonstrates the importance of restricting entry to the contest. To this end he employs an entry fee. Che and Gale (2003) determine the optimal procurement mechanism in a setting with heterogeneous innovators of commonly known type. They show that the first-price (first-score) auction with two bidders, with handicapping of the more efficient innovator, is optimal within a large class of contest mechanisms. Schöttner (2008) compares a fixed-prize contest with a first-price auction in a model with symmetric players. Entry fees are by assumption not feasible and innovations are random draws from a common distribution. She finds that the relative performance of both mechanisms depends on the nature of randomness. If there is more randomness then the auction tends to be less profitable for the buyer. This is because in expectation the winner has a much better innovation than the loser(s) and can therefore demand a higher quality premium.

Similar to Schöttner (2008), Koh (2013) compares the two contest mechanisms, assuming random innovation, symmetric players, and infeasibility of entry fees. The author focuses on the optimal number of contestants. He explains the tradeoff between the 'sampling effect' (a stochastically better innovation due to more innovators) and the incentive effect (higher efforts due to a lower number of contestants). Again, which mechanism is optimal depends on the degree of randomness of the innovation. If randomness is large, then there should be many contestants and the buyer prefers the fixed prize. If, however, randomness is sufficiently low, then the auction performs better and the buyer should reduce the number of contestants accordingly.

Fullerton et al. (2002) is a combined theoretical and experimental comparison of fixed-prize contest and first-price auction. The model is based on the optimal stopping model of Taylor (1995). The theoretical as well as the experimental results are overwhelmingly in favor of the auction.

Fullerton and McAfee (1999) introduce entry auctions in order to efficiently deal with the adverse selection problem due to innovators' private information. In their model, contestants make innovation draws from a distribution that is a function of effort. They assume a fixed-prize contest. The focus of their work is on demonstrating that many standard auction mechanisms are generally inefficient as contestant selection mechanisms. They present an efficient auction, based on an all-pay auction, and show that in many contests, the optimal number of contestants is two, highlighting the need to select the right contestants.

As mentioned, several of the above contributions exclude entry fees by assumption, but they discuss the effects that adding entry fees to their models would have. Since these models either assume symmetric players (Schöttner, 2008; Koh, 2013) or commonly known types (Che and Gale, 2003), optimal entry fees would typically enable the extraction of rents ex ante. This is relevant when one compares results between those papers and the present one.

The model in the present paper is very close to that of Fullerton and McAfee (1999). The major difference is that we model the innovators' heterogeneity not as different marginal effort cost, but as a parameter that affects the distribution of innovations. This has several implications for the results. These will be discussed in detail throughout the paper.

The innovation technology in our model assumes that innovators have differences in their skill levels, which can be compensated with effort. We assume however, that all innovators are sufficiently qualified to solve the procurer's problem. This is reflected in the assumption that every innovation draw from the respective distributions are valid solutions to the procurer's problem, with varying quality. Thus, we emphatically do not assume that effort can completely replace skill or vice versa in an innovative process. We want to capture the natural idea that less skilled innovators can compete by investing more resources. We also require that even the most skilled innovator needs non-negligible effort in order to produce an innovation. There is a longstanding controversy about the role of effort and ability for performance, and about the question whether 'talent' exists at all. For an overview of the discussion, see, e.g., Ericsson et al. (1993), Ericsson and Charness (1994), Howe et al. (1998). Kräkel (2012) makes an assumption similar to ours (among others). The regulation literature is also using an analogous assumption. For instance, Laffont and Tirole (1986) simultaneously study moral hazard and adverse selection, modeling a firm's *effective* cost as the difference between type and effort. Thus, their cost reduction effort can perfectly substitute for lower cost.[6] Depending on the context, innovation usually has a 'pure production' component, see, e.g., Che and Gale (2003) who assume that the innovative good is produced in a deterministic process.

The following section introduces the model. In Sections 4 and 5 we analyze the two mechanisms. Section 6 presents the main result. In Section 7 we discuss welfare implications. Section 8 provides a discussion and Section 9 concludes. The Appendix contains the more technical proofs, some results on order statistics that we use throughout the paper, and an example based on uniform distributions.

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[5] See, e.g., Corchón (2007), Konrad (2009) and Dechenaux et al. (2012) on contest theory and experimental results, and Scotchmer (2006) on the economics of innovation.

[6] The author thanks Jianpei Li for pointing out this connection.

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