



Contents lists available at ScienceDirect

International Journal of Industrial Organization

www.elsevier.com/locate/ijio



Incentive and sampling effects in procurement auctions with endogenous number of bidders



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ARTICLE INFO

Article history:

Received 1 July 2016

Revised 8 November 2016

Accepted 14 February 2017

Available online 11 April 2017

JEL classification:

D44

H57

L15

O32

Keywords:

Procurement

Contest

Auction

Innovation

Quality

ABSTRACT

We study an auction contest for a procurement of innovation. Firms exert effort and the resulting quality of innovation is ex ante uncertain. Given this uncertainty, there is a trade-off regarding the number of participating firms in the contest: increasing the number of firms reduces each firm's chance of winning the auction, leading the firms to reduce effort level; meanwhile, the chance of obtaining a high quality of innovation increases with the number of firms due to the randomness of the quality. Thus, the procurer faces a nontrivial problem of how many firms to invite. We show that in the high level of randomness, it is optimal for the procurer to invite many firms. As the randomness vanishes, however, inviting only two firms is optimal. We also show that a fixed-prize tournament may outperform the auction when the randomness is large.

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1. Introduction

Firms and governments increasingly rely on procuring goods and services from outside sources. In particular, they often seek to procure innovations, and the innovative activities require firms to undertake investments. For instance, when the Department of Defense procures a weapon system, defense contractors often make R&D investments to produce

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prototypes and then participate in the procurement process.¹ Although the quality of innovation depends on firms' investment level, it is often the case that the quality is not solely determined by the exerted investment, making it *ex ante* uncertain. Moreover, if a firm's investment cost cannot be recovered unless it wins the contract, then firms may refrain from exerting investments.² A typical way of the procurer to maintain firms' investment incentives is limiting the number of participants. For example, in procurement auctions funded by the World Bank, the procurer puts a limited number of contractors on a "short list" (see [Fan and Wolfstetter, 2008](#)).

In this paper, we study a procurement of innovation in that the buyer can decide how many firms to invite. We consider a first-score auction in which the quality of a firm's innovation stochastically depends on its investment, and the buyer procures an innovation from the firm who offers him the most favorable price-quality combination, called "score." Such a scoring auction has served as a prominent contest mechanism. For instance, the US government procures highway constructions, as well as weapon systems, via scoring auctions, and the European Union mandates the use of scoring auctions for public procurements (see [Asker and Cantillon, 2008](#)).

In such procurement auctions, the procurer is often restricted to specify the number of offers to elicit.³ That is, the buyer faces a nontrivial problem of how many firms to invite. If there are many competitors, participants may be discouraged from making any substantial investment for fear of losing the entire investment in case they do not win. We call this an *incentive effect*. On the other hand, due to the randomness on the quality realization, the more firms the buyer invites, the higher the chance he has of having a high quality innovation. We call this a *sampling effect*. Intuitively, if the randomness is negligible, limiting the number of participants is beneficial for the buyer. Otherwise the firms' investment level would be low. For a large randomness, however, the sampling effect may prevail over the incentive effect, so it can be the case that inviting many firms is optimal. We will investigate how the optimal number of contestants varies depending on the degree of randomness.

To isolate the trade-off between the two effects, we restrict our attention to an environment in which (i) firms invest nonmonetary efforts, (ii) the level of investment and the resulting quality of innovation are unverifiable, (iii) firms are liquidity-constrained, and (iv) there is no outside market for the firms except selling the innovation to the buyer.⁴

¹ [Piccione and Tan \(1996\)](#) and [Jeitschko and Wolfstetter \(2000\)](#) study procurement auctions in that bidders invest in quality before they place their bids.

² This is true if the outcome of the investment per se does not have a market value. The investment costs can be understood as nonmonetary efforts or opportunity costs.

³ For instance, the World Bank is bounded by its procurement rule to shortlist a limited number of firms (typically up to six) and only those firms are invited to bid. Similarly, the European Investment Bank also sends invitations to tender for a procurement only to shortlisted firms. The European Investment Bank states in its guideline for public-private partnerships that "The purpose of shortlisting is to reduce the number of bidders to generally between three to five. [...] Just as the presence of too few bidders results in poor competition, the presence of too many bidders on the shortlist may reduce the interest in participating and cause good bidders to drop out" ([European Investment Bank, 2011](#)).

⁴ When the quality is verifiable, the terms of contracts can be made contingent on the realized quality of innovation. Any optimal mechanism selects the firm who delivers the highest quality at a minimal cost

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