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Overbidding and overspreading in rent-seeking experiments: Cost structure and prize allocation rules

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ABSTRACT

We study experimentally the effects of cost structure and prize allocation rules on the performance of rent-seeking contests. Most previous studies use a lottery prize rule and linear cost, and find both overbidding relative to the Nash equilibrium prediction and significant variation of efforts, which we term 'overspreading.' We investigate the effects of allocating the prize by a lottery versus sharing it proportionally, and of convex versus linear costs of effort, while holding fixed the Nash equilibrium prediction for effort. We find the share rule results in average effort closer to the Nash prediction, and lower variation of effort. Combining the share rule with a convex cost function further enhances these results. We can explain a significant amount of non-equilibrium behavior by features of the experimental design. These results contribute towards design guidelines for contests based on behavioral principles that take into account implementation features of a contest.

1. Introduction

Overbidding in rent-seeking contests (Tullock, 1980) is a robust phenomenon in the experimental literature. This phenomenon was first reported in experimental contest studies by Millner and Pratt (1989, 1991) and has since been replicated by many other experiments; for a comprehensive review see the survey of Dechenaux et al. (forthcoming).[1] Average effort levels in contests generally exceed the Nash equilibrium prediction, in some cases by a wide enough margin that total expenditure by all contest participants exceeds the value of the prize. Moreover, contrary to the theoretical prediction of a unique pure strategy Nash equilibrium, experimental studies document that individual efforts are distributed on the entire strategy space, and individual behavior varies substantially across repeated plays of the game. We refer to this stylized fact as 'overspreading.'

Over the last decade a number of studies have offered different explanations for overbidding and overspreading in rent-seeking contests.[2] Commonly-cited explanations for overbidding include noise and errors (Anderson et al., 1998;

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[1] Examples include Davis and Reilly (1998), Potters et al. (1998), Lim et al. (2014), Sheremeta (2010, 2011), and Sheremeta and Zhang (2010).
[2] The survey of Sheremeta (2013) discusses these in greater detail.

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Shupp et al., 2013; Lim et al., 2014; Sheremeta, 2011); judgmental biases (Amaldoss and Rapoport, 2009; Sheremeta, 2011); a non-monetary utility for winning (Sheremeta, 2010; Price and Sheremeta, 2011); and evolutionarily stable behavior (Mago et al., 2012; Wärneryd, 2012). Overspreading is usually attributed to heterogeneity in subjects' preferences towards losses (Kong, 2008), risk (Sheremeta, 2011), spitefulness (Herrman and Orzen, 2008), or winning (Sheremeta, 2010), as well as demographic differences (Price and Sheremeta, forthcoming).

In a standard lottery contest, all players exert effort in order to increase their probability of winning the prize. Higher effort implies a higher probability of winning, but they are also more costly. In equilibrium, the marginal benefit of effort is equal to the marginal cost. Therefore, a correct best-response computation requires experimental subjects to assess correctly marginal benefit, which depends on the probability of winning, and marginal cost, which depends on the convexity of the cost function. Any non-equilibrium behavior may thus simply come as a consequence of a difficult computational task (Wright, 1980; Simon, 1992; Rubenstein, 1998; Gigerenzer and Selten, 2001).

It has been well recognized, for example, that subjects may possess distorted perceptions of probabilities, which may lead to non-equilibrium behavior. As a consequence, many alternative theories have been proposed to account for such perceptions (Kahneman and Tversky, 1979; Quiggin, 1982; Chew, 1983; Tversky and Kahneman, 1992; Wilcox, 2011). Recent studies have tried to apply some of these theories to explain subject behavior in contests and auctions (Goeree et al., 2002; Baharad and Nitzan, 2008; Amaldoss and Rapoport, 2009). However, even after accounting for individual perceptions of probabilities, the aggregate patterns of overbidding and overspreading in lottery contests cannot be explained.

Another explanation for why subjects' behavior differs from theoretical predictions is based on flatness of payoff functions (Harrison, 1989; Goeree et al., 2002; Georganas et al., 2011). Harrison (1989), for instance, argues that overbidding in private value auctions relative to the Nash equilibrium may be due to the fact that the costs of such overbidding are rather small. By manipulating the cost of overbidding in the first-price and second-price winner pay auctions, Goeree et al. (2002) and Georganas et al. (2011) find support for this argument. Similarly, Müller and Schotter (2010) find that subjects overbid in private value all-pay auctions when the cost of bid function is linear but they actually underbid when the cost function is convex. The design of the experiment reported in the present study follows this approach by manipulating the relative costs of units of effort above versus below the equilibrium.

We examine whether the factors listed in the foregoing paragraphs can explain non-equilibrium behavior in contests, by manipulating design features of the context which do not affect the (risk-neutral) Nash equilibrium prediction. We consider four contest settings, organized in a 2×2 design. In one dimension, we vary whether the prize amount is indivisible and allocated stochastically, or whether it is shared proportionally; this manipulation speaks to hypotheses involving the salience of winning or limitations in reasoning about probability.[3] In the other dimension, we vary whether the cost function is linear or convex in effort; the convex cost function induces an asymmetry in the amount of earnings foregone due to efforts in excess of the best response versus those foregone due to efforts less than the best response.

We find that in contests where the prize is shared proportionally, there is less overbidding and less overspreading. Average efforts are closer to the Nash equilibrium prediction, and there is lower variation in individual efforts. A convex cost function enhances these results under the share rule. However, we find that convex costs actually exacerbate overbidding with probabilistic allocation, which we attribute to knock-on effects driven by out-of-equilibrium play. These findings illustrate the importance of considering the behavioral drivers of out-of-equilibrium play for robust design of contests, and provide some first results for guidance of contest design along these lines.

2. Theoretical background

We study a rent-seeking contest game following Tullock (1980). There are N players, indexed by i. There is a prize, worth $V > 0$. Each player i simultaneously and independently chooses an effort level $e_i \in [0, V]$. In a standard abuse of notation, we will write $e_{-i} = \sum_{j \neq i} e_j$ to denote the sum of efforts of other players. The cost of effort is given by a function $c : \mathbb{R}_+ \to \mathbb{R}_+$, which we assume to be continuous, monotonically increasing, and twice differentiable in effort. Irrespective of the outcome of the contest, all players forgo the cost of effort.

The contest success function is given by

$$p_i(e_i, e_{-i}) = \begin{cases} \frac{e_i}{e_i + e_{-i}} & \text{if } e_i + e_{-i} > 0 \\ \frac{1}{N} & \text{otherwise} \end{cases} \tag{1}$$

This function can be interpreted as either the probability that player i wins the prize, if it is allocated indivisibly to just one player, or the proportion of the prize awarded to player i. In either case, the expected payoff to player i can be written as

$$E(\pi_i) = p_i V - c(e_i). \tag{2}$$

Szidarovszky and Okuguchi (1997) show the existence and uniqueness of equilibrium of this game, where the equilibrium effort level $e^\star$ is given by the solution to the equation

[3] Another avenue to limiting the role of chance in understanding outcomes is to compare the lottery mechanism with the all-pay auction, in which the participant with the highest effort wins with certainty. This has been done by, for example, Potters et al. (1998). Moving to the all-pay auction results in a qualitative change in the strategic structure of the game, as equilibria in common-value all-pay auctions generally involve randomization.