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Risk attitudes and heterogeneity in simultaneous and sequential contests☆

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ABSTRACT

We prove existence and uniqueness of equilibrium in rent-seeking contests in which players are heterogeneous in both risk preferences and production technology. Given identical linear production technology, if the number of risk-loving players is large enough, the aggregate investment in equilibrium will exceed the rent and all risk-neutral and risk-averse players will exit the contest. In simultaneous and sequential contests with two players, we can identify the favorite and underdog based on both players' preference parameters. Our theoretical results suggest that subjects in some recent contest experiments behaved as if they were risk-loving.

1. Introduction

Tullock (1980) introduces a seminal framework to analyze winner-take-all contests in which each player competes with one another to win a given prize (also called rent). The winning probability of each player is determined by his irreversible investment relative to the total investment by all players participating in the contest. In this paper, we study a class of rent-seeking contests with heterogeneity in players' risk preferences and production technology. To the best of our knowledge, this paper is the first to show that there is a unique equilibrium in rent-seeking contests where some players are risk-averse and some are risk-loving. We first assume a class of utility functions that are bivariate, i.e., a player's utility is a function of two variables, his final wealth and the prize received from the contest. This functional form allows us to identify an equilibrium in a contest that awards the winner with a non-monetary prize. For contests with a cash prize, as a special case, we can write each player's utility function as a univariate function which exhibits constant absolute risk aversion (CARA). Since each function could be concave, linear, or convex, we call this class of utility functions "generalized CARA."

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In addition to proving existence and uniqueness of equilibrium given heterogeneous players, we expand the literature of rent-seeking contests in three directions. First, we theoretically show that, under Expected Utility Theory, rent over-dissipation or under-dissipation may occur in equilibrium (i.e., total rent-seeking investment by all participants may or may not exceed the rent) depending on number of players and each player's preference parameters. While rent over-dissipation seems to be a more important issue to economists and policy makers since it implies excess social waste, both rent over-dissipation and under-dissipation are empirically supported in laboratory settings.[1] Assuming linear utility functions, Tullock (1980) uses numerical examples to show that rent may be over-dissipated given a class of convex rent-seeking production functions. However, Baye et al. (1994, 1999) argue that pure-strategy equilibrium does not exist in those cases and thus rent over-dissipation is not possible under risk neutrality.[2] Contrasting Tullock's theoretical approach in explaining rent over-dissipation, we assume linear technology and let some players be risk-loving. While Jindapon and Whaley (2015) show that the more risk-loving players participating in the contest, the more likely rent over-dissipation will occur in equilibrium, with our generalized CARA functional form, we can be more specific about the number of risk-loving players that is sufficient or necessary for rent over-dissipation. Specifically, if the number of risk-loving players is larger than a threshold, which is greater than 4, then rent over-dissipation will occur in equilibrium. Moreover, in such an equilibrium, we find that all risk-neutral and risk-averse players will not participate in the contest.

Second, this paper is the first to analyze risk attitudes in sequential rent-seeking games. Since the seminal analysis of preemptive investment by Dixit (1987), most theoretical development in the literature has been on rent-seeking technology (i.e., contest success functions) and asymmetry in reward and information[3] while players' risk attitudes have been ignored. By allowing for nonlinear utility functions, we can derive results contradicting Dixit's (1987) well-known prediction that there is no incentive to move first in a standard Tullock contest. Specifically, we find that even when both players have the same preferences and rent-seeking technology, the first mover will be the favorite to win if both players are risk-averse. On the other hand, if both players are risk-loving, the first mover will become the underdog. In a sequential contest with heterogeneous players, we find that if the first mover is less/more downside-risk-averse and the second mover is risk-averse/loving, then the first mover will be the favorite/underdog in the contest, respectively.

Finally, this paper provides important applications in empirical research. Even though risk aversion may seem to be a standard presumption of human behavior, researchers found that some decision makers especially in the laboratory or the field behaved as if they were risk-loving.[4] Focusing on pay-to-bid auctions, Platt et al. (2013) suggest that pay-to-bid auction is a mild form of gambling and allowing for risk lovingness has the biggest impact in explaining bidding behavior. To some experimental subjects, investing in a rent-seeking contest may be a form of gambling, so allowing for risk lovingness should help rationalize rent-seeking behavior as well. While recent developments in the literature suggest that different equilibrium concepts (Gneezy and Smorodinsky, 2006; Lim et al., 2014) or psychological factors (Sheremeta, 2013) can explain rent over-dissipation in the laboratory, our theoretical predictions provide a possible explanation for such a phenomenon under the canonical expected utility model.

To evaluate our nonlinear utility model in explaining empirical findings, we reexamine experimental data from simultaneous contests in Sheremeta (2011) and Lim et al. (2014). We find that, by allowing subjects to be risk-loving, we can estimate a risk parameter that yields a theoretical prediction that is much closer to average rent-seeking behavior in the laboratory than when we assume risk neutrality. We also analyze data from two-player sequential contests in Fonseca (2009). Focusing on behavior of second movers, we estimate preference parameters of these subjects based on their responses to first-mover investment and find that all second-mover subjects are risk-loving.

This paper is organized as follows. In Section 2, we prove existence and uniqueness of equilibrium in simultaneous contests given a class of bivariate utility functions. We derive sufficient conditions for rent over-dissipation and under-dissipation in equilibrium given generalized CARA players in Section 3. We prove existence and uniqueness of equilibrium in sequential contests and derive sufficient conditions for first- and second-mover advantages in Section 4. We conclude and discuss experimental evidence in Section 5.

2. Existence and uniqueness of equilibrium

Consider an n-player contest for a fixed prize R with $n \geq 2$ and $R > 0$. For $i = 1, \ldots, n$, player i has an initial wealth I_i and invests x_i in the contest. The probability that player i wins the prize depends on x_i and all other players' investment as specified in the following assumption.

Assumption 1. Player i's probability of winning the prize from investing x_i in the contest is given by

$$p_i = \frac{f_i(x_i)}{\sum_{j=1}^{n} f_j(x_j)} \tag{1}$$

[1] See Houser and Stratmann (2012) and Sheremeta (2013) for thorough reviews of experimental findings.
[2] See also Cornes and Hartley (2005).
[3] For example, Baik and Shogren (1992), Baye and Shin (1999), Morgan (2003), and Morgan and Várdy (2007).
[4] See Isaac and James (2000), Berg et al. (2005), Eckel et al. (2009), Bellemare and Shearer (2010), and Platt et al. (2013). Interestingly, Isaac and James (2000) and Berg et al. (2005) also find inconsistency in risk attitudes across institutions.