Journal of Economic Behavior & Organization 99 (2014) 155–167

Contents lists available at ScienceDirect

Journal of Economic Behavior & Organization

journal homepage: www.elsevier.com/locate/jebo

Bounded rationality and group size in Tullock contests: Experimental evidence☆,☆☆

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ARTICLE INFO

Article history:
Received 20 June 2012
Received in revised form 13 August 2013
Accepted 14 December 2013
Available online 14 January 2014

JEL classification:
C72
C92
D72

Keywords:
Contests
Rent-seeking
Laboratory experiments
Bounded rationality

ABSTRACT

We explore how models of boundedly rational decision-making in games can explain the overdissipation of rents in laboratory Tullock contest games. Using a new series of experiments in which group size is varied across sessions, we find that models based on logit choice organize the data well. In this setting, logit quantal response equilibrium (QRE) is a limit of a cognitive hierarchy (CH) model with logit best responses for appropriate parameters. While QRE captures the data well, the CH fits provide support for relaxing the equilibrium assumption. Both the QRE and CH models have parameters which capture boundedness of rationality. The maximum likelihood fits of both models yield parameters indicating rationality is more restricted as group size grows. Period-by-period adjustments of expenditures are more likely to be in the earnings-improving direction in smaller groups.

1. Introduction

Tullock (1980) introduced a simple model of competition, in which competitors irreversibly expend costly resources in the hope of obtaining a prize of fixed value. The winner of the prize is determined stochastically, with a competitor's chances of victory increasing as he expends more resources. Variations of the basic model can be applied to settings ranging from lobbying for political influence, to research and development races, to fund-raising lotteries. This broad applicability has

☆☆ We have benefited from comments by Kyung Hwan Baik, Maya Bar-Hillel, Subhashish Modak Chowdhury, David Cooper, Sergei Izmalkov, Peter Moffatt, Thomas Palfrey, Svetlana Pevnitskaya, Tim Salmon, Jorgen Weibull, and Huan Xie; seminar participants at University of South Carolina, Florida State University; University of Nevada, Reno; Higher School of Economics (Russia); New Economic School (Russia); and University of Nottingham; conference participants at the International Research Workshop "Rationality, Behavior and Experiments" (Russia) and the 20th International Conference on Game Theory, Stony Brook, as well as those of the co-editor and two anonymous referees. We gratefully acknowledge financial support from University of Pittsburgh for Central Research Development Fund award.

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http://dx.doi.org/10.1016/j.jebo.2013.12.010

supported a vibrant literature on studying these games in the laboratory. A majority of laboratory studies find that subjects on average exceed the risk-neutral Nash equilibrium predictions for resource expenditure. Morgan et al. (2012), in their Table 1, provide an excellent summary of the literature which illustrates the robustness of this result. Millner and Pratt (1989), Davis and Reilly et al. (1998), Fonseca (2009), Morgan et al. (2012), and Fallucchi et al. (2012), among others, observe higher-than-Nash average expenditure using a variety of designs.

A number of explanations have been advanced to attempt to account for the overdissipation of rents in these contests. Amaldoss and Rapoport (2009) and Sheremeta (2011) propose biases in judgment lead to aggressive play. Parco et al. (2005), Sheremeta (2010) and Sheremeta (2011) investigate the extent to which a non-monetary preference for winning can account for high expenditure levels. Mago et al. (2012) and Wärneryd (2012) develop the idea that higher expenditures form an evolutionarily stable behavior.

In the analysis in this paper, our focus will be on statistical models of boundedly rational behavior, supposing that play is noisy and that participants do not calculate or play best responses precisely. This approach has been considered in the past in Tullock contests by Sheremeta (2011) and Schmidt et al. (2013), as well as by Bullock and Rutstrom (2007) in a transfer-seeking game presented using a matrix frame.[1] Our model is founded on a logit-response assumption, which underlies a noisy cognitive hierarchy model in the spirit of Camerer et al. (2004), and a quantal response equilibrium (QRE) model (McKelvey and Palfrey, 1995). The model relaxes Nash equilibrium in two ways: (1) by permitting players to hold incorrect beliefs about the play of others, and (2) by assuming players may not choose best replies with probability one. Logit quantal response equilibrium, cognitive hierarchy with exact best responses for higher-order thinkers, and Nash equilibrium are all special cases of our model. In particular, in our estimation we do not need to impose the mutual-consistency assumption inherent in Nash equilibrium or logit QRE.

A criticism of statistical models of the sort we consider is that they are often employed in a post-hoc fashion, with less attention given to the ability of models to organize data across treatments. Haile et al. (2008) point out that quantal response-type models can capture essentially arbitrary distributions of play, unless further restrictions are imposed. In our model, there are two parameters, capturing the mean number of degrees of iterative reasoning, and the precision of best responses. Results in McKelvey and Palfrey (1995) and Rogers et al. (2009) show that when fitting parameters in models similar to ours across games, the resulting estimates can vary substantially.

In our experiment, the treatment variable is the number of players participating in the contest. We consider contests with two, four, and nine players, in an across-subjects design. The Nash equilibrium prediction is that the expenditure per player decreases as the number of players increases, while the total expenditure of all players increases, converging to full dissipation of the rent from below. In our model, individual expenditure is less sensitive to group size than Nash equilibrium predicts. For model parameterizations far from Nash equilibrium, total group expenditure rises more rapidly as the number of players increases, to levels well in excess of full dissipation of the value of the prize.

There are three previous studies which directly or indirectly consider the effect of group size on behavior in Tullock contests. Anderson and Stafford (2003) provide the most direct manipulation. In a one-shot contingent-choice design, participants are asked to formulate contest expenditures in each of six possible settings, which vary both in the number of players as well as heterogeneity of costs. They find that in general a larger number of opponents results in lower expenditures, although in their data average expenditure in five-player contests actually exceeds that in two-player and four-player games. Sheremeta (2011) investigates, among other treatments, whether total expenditure is larger in a grand contest involving four players, versus two sub-contests, involving two players each, each for a prize worth one-half as much. He finds that individual expenditure relative to the prize is lower for the four-player contests. Morgan et al. (2012) study contests where potential participants may choose to enter, or to sit out the contest and accept an outside option payoff. This generates contests with different numbers of players, depending on the entry decisions of the subjects. They also generally find that when the number of players is larger, individual expenditure falls.[2]

Our experiment is the first to consider the effect of group size in an across-subjects design with repeated trials and holding constant the size of the prize and endowment. Qualitatively consistent with our model, and generally in contrast to previous results, we find that the group size has little effect on average expenditure levels. However, we do find treatment effects in terms of the distribution of expenditures, with expenditures being more dispersed in larger groups. Because average individual expenditures do not respond to the group size, the result is that aggregate expenditures are significantly larger in larger groups, with nine-player groups spending on average almost three times the value of the prize.

Because in our experiment the earnings-maximizing best response depends only on the total expenditure of other players, and not on the number of players per se, our experiment allows us to ask whether the bounded rationality parameters of our model are stable within a class of games, and an experimental environment, where as much as possible is held constant. Previous results in such domains are mixed; Gronberg et al. (2012) report stable estimates of the logit QRE parameter across two treatments in a public goods game, whereas Sheremeta (2011) reports QRE parameter estimates which vary across

[1] In addition, Morgan et al. (2012) and Potters et al. (1998) display distributions of expenditures in Tullock contests which are qualitatively consistent with the predictions of our model. Those authors do not pursue modeling the heterogeneity in their data. Gneezy and Smorodinsky (2006) study the related all-pay auction and find some support for the predictions of QRE from Anderson et al. (1998a).

[2] In addition, there are several studies which consider the effects of the number of players in all-pay auctions and in tournaments, which share some characteristics of the Tullock contest game. See Dechenaux et al. (2012) for a survey of these results.