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An experimental study of sorting in group contests

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HIGHLIGHTS

- We study experimentally sorting in contests between groups of heterogeneous players.
- Lower inter-group variation in ability leads to higher aggregate effort as predicted.
- Despite strong overbidding, relative aggregate efforts are consistent with theory.

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ABSTRACT

We study experimentally the effects of sorting in contests between groups of heterogeneous players whose within-group efforts are perfect substitutes. The theory predicts that higher aggregate effort will be reached when variation in ability between groups is lower, i.e., by a more balanced sorting. In the experiment, we assign subjects to four types – A, B, C, and D – ranked by their cost of effort, with A having the lowest and D having the highest cost, and conduct contests between two groups of two players each. In the Balanced treatment, (A,D) groups (i.e., groups comprised of a type A and a type D player) compete with (B,C) groups, whereas in the Unbalanced treatment, (A,B) groups compete with (C,D) groups. We find substantial heterogeneity and overinvestment of efforts by all types in both treatments, including the "underdog" (C,D) group which surprisingly is not demoralized by the unbalanced matching. Despite strong overbidding, *relative* aggregate efforts are consistent with equilibrium predictions both between treatments and between groups within each treatment. The results confirm the prediction that balanced sorting leads to higher aggregate effort.

1. Introduction

Organizations often use tournaments, or contests, between employees whereby the best-performing individual or group is rewarded with a bonus or a promotion. Contests can be especially effective when it is difficult or impossible to observe and/or quantify the employees' effort, or in the presence of common productivity shocks (see, e.g., reviews by Lazear, 1999; Connelly et al., 2014).[1]

Contests often occur between groups. For example, in a field experiment Bandiera et al. (2013) study the effect of contest incentives on output in teams of fruit pickers. Similarly, a Korean grocery store chain E-Mart Everyday used a sales competition between branches to increase its sales of U.S. beef.[2] These groups may be heterogeneous in terms of their ability, both at the individual and aggregate level.

In this paper we use a laboratory experiment to explore the effect of *sorting* of heterogeneous players into competing groups on contest efficiency.[3] The most direct application of our results is to an organizational setting where the manager has information about the abilities of her employees and would like to assign them to competing groups in a way that maximizes aggregate effort. In other cases, when sorting into groups is endogenous, our results can inform policy makers on optimal

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[1] More generally, contests are environments in which participants compete for a valuable prize by spending resources. Other examples include competition for research grants, innovation races, lobbying, political campaigns, rent-seeking, warfare and sports. Given the ubiquity of contests and the variety of contexts they can be found in, the literature on contests is vast and spans disciplines, modeling approaches, and methodologies. For a review of the literature on rent-seeking, see Lockard and Tullock (2001) and Congleton et al. (2008); for a review of theoretical contributions, see Corchón (2007) and Konrad (2009). For a recent review of the experimental literature on contests see Dechenaux et al. (2012). For a review of the literature on contest design in sports, see Szymanski (2003); for a discussion of contest models in application to the economics of warfare and conflict resolution, see Garfinkel and Skaperdas (2007).

[2] See http://www.agweb.com/article/sales_competition_boosts_u.s._beef_at_korean_grocery_chain_NAA_News_Release/.

[3] We use the term "sorting" to denote the exogenous assignment of players to groups. There is a separate literature on endogenous sorting in contests between individuals that focuses on players' contest entry decisions (e.g., Anderson and Stafford, 2003; Morgan et al., 2012) or selection into a particular contest mechanism (Cason et al., 2010).

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sortings that can be induced indirectly through regulation. For example, a research funding agency can encourage collaborations in groups with certain ability profiles through its proposal evaluation process.

We focus on situations when the resources spent by each member of a competing group are perfect substitutes and the prize is shared equally among the members of the winning group.[4] Theoretically, such contests are interesting in that they provide incentives for players to compete and free-ride at the same time. By exerting effort, a player imposes a negative externality on the members of other groups and provides a public good for the members of her own group (Baik, 1993). When players are heterogeneous and costs of effort are linear, the predicted free-riding is extreme: only the most able players in each group are active, while all other players exert zero effort in equilibrium (Baik, 2008). For strictly convex effort costs, equilibrium effort levels of all players are positive, and marginal costs of effort are equalized within each group; therefore, more able players still exert higher efforts, although the free-riding by less able players is not as extreme (Esteban and Ray, 2001; Ryvkin, 2011).

Given the average level of ability, various assignments of players to groups, or sortings, differ by the degree of ability *balance* across groups: balanced sortings would roughly equalize the amount of talent in different groups while unbalanced sortings would concentrate talent disproportionately in some groups. Ryvkin (2011) shows theoretically that, under fairly general conditions, aggregate effort should be higher in a competition of more balanced groups.

In this paper, we test the prediction of Ryvkin (2011) experimentally. Players' efforts are perfect substitutes within groups, and the probability of each group winning is given by the lottery contest success function of Tullock (1980). Players are assigned to four types – A, B, C and D – ranked by ability (cost of effort), with A being the highest ability (lowest cost) type and D being the lowest ability (highest cost) type. We then conduct contests involving two groups of two players each. There are two treatments that differ by sorting of players into groups. In the *Balanced* treatment, groups comprised of types A and D compete against groups comprised of types B and C. This sorting minimizes variation in ability between groups and is predicted to yield the highest aggregate effort. In the *Unbalanced* treatment, groups with types A and B compete against groups with types C and D. This sorting, in turn, maximizes variation in ability between groups and is predicted to result in the lowest aggregate effort.[5]

The existing experimental literature on group contests has mostly focused on the case of symmetric players (see, e.g., Nalbantian and Schotter, 1997; Abbink et al., 2010; Ahn et al., 2011). Abbink et al. (2010) and Ahn et al. (2011) use the lottery contest success function and find, in line with most studies of lottery contests between individuals, substantial overbidding as compared to theoretical predictions (Sheremeta, 2013).

The most relevant study for comparison to ours is Sheremeta (2011a) who explores lottery contests between groups of heterogeneous players. The main focus of Sheremeta (2011a) is on the impact of different within-group aggregation technologies, the perfect-substitutes technology being one of them. Each group consists of one strong and two weak players that differ by their prize valuations. In the symmetric treatment, two groups with valuations (60,30,30) compete with each other, while in the asymmetric treatment, a group with valuations (90,15,15) competes against a group with valuations (60,30,30). Thus, average valuation is kept constant across groups, and the within-group variance in valuations changes. Another important feature of Sheremeta's design is the linearity of effort costs. As in Baik (2008), it leads to the equilibrium predictions involving positive efforts exerted only by the strong player in each group; thus, the competition effectively reduces to a contest between two individuals with valuation 60 in the symmetric treatment and individuals with valuations 90 and 60 in the asymmetric treatment. In contrast, in our study we focus on the variance in abilities *between* groups. By considering different sortings, we allow for competition between groups with different average abilities in the Unbalanced treatment. We also use a strictly convex effort cost function, which leads to equilibrium predictions involving positive efforts exerted by all player types.

We find, in accordance with the theoretical predictions, that aggregate effort is higher when sorting is balanced. In addition to this directional prediction being confirmed, and despite substantial overinvestment of effort by all types, we find a remarkable quantitative agreement between theory and experiment in terms of *relative* aggregate efforts, both between treatments and between groups within each treatment.

The rest of the paper is organized as follows. In Section 2, we present the theoretical model and predictions. Experimental design and procedures are described in Section 3. Section 4 presents experimental results, and Section 5 contains a discussion and concluding remarks.

2. Model and predictions

Consider a contest between $n > 1$ groups of $m \geq 1$ risk-neutral players in each group. Player j in group i chooses effort $e_{ij} \geq 0$ that costs her $c_{ij}g(e_{ij})$. Here, $c_{ij} > 0$ are commonly known individual-specific cost parameters and $g(\cdot)$ is a commonly known, smooth, strictly increasing and strictly convex function, with $g(0) = 0$. Let $E_i = \sum_{j=1}^{m} e_{ij}$ denote the total effort exerted by the players of group i. The probability of group i winning the contest is $p_i = E_i / \sum_{k=1}^{n} E_k$.[6] If a player's group wins, the player gets a prize $V > 0$; otherwise, the player gets zero.

Thus, player j in group i has the expected payoff

$$\pi_{ij} = \frac{VE_i}{\sum_{k=1}^{n} E_k} - c_{ij} g\left(e_{ij}\right).$$

Let e_{ij}^* and E_i^* denote the Nash equilibrium individual and group effort levels. As shown by Ryvkin (2011), this game has a unique equilibrium with all players exerting positive efforts characterized by the system of first-order conditions

$$\frac{V\sum_{k \neq i} E_k^*}{\left(\sum_{k=1}^{n} E_k^*\right)^2} = c_{ij} g'\left(e_{ij}^*\right), \qquad i = 1, \ldots, n; \;\; j = 1, \ldots, m. \tag{1}$$

In this paper, we are interested in the effects of *sorting* of players into groups. Let $\bar{c} = (nm)^{-1} \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij}$ denote the average cost parameter among all players. The (relative) *ability* of player j in group i can be defined as $a_{ij} = \left(\bar{c} - c_{ij}\right)/\bar{c}$; and group i's aggregate ability can be defined as $\alpha_i = \sum_{j=1}^{m} a_{ij}$. The configuration of group abilities α_i can be manipulated by sorting of players into groups. The degree of ability *balance* across groups can be characterized by the sample variance in group ability $S_\alpha^2 = (n-1)^{-1} \sum_{i=1}^{n} \alpha_i^2$. The lower S_α^2 the more balanced groups are in terms of aggregate ability.

As shown by Ryvkin (2011), under a wide range of conditions the aggregate equilibrium effort $E^* = \sum_{i=1}^{n} E_i^*$ is a decreasing function of S_α^2. Thus, a more balanced sorting yields a higher aggregate effort.

In the experiment, we use contests of two groups with two players each, $n = m = 2$, and let $g(x) = 10x^\gamma$ with $\gamma = 1.2$. The prize each player of the winning group receives is $V = 1000$. There are four player types –

[4] Other types of group "production functions," i.e., the technologies through which individual efforts are aggregated to produce group effort, and other prize sharing rules, have been discussed in the literature as well. For a discussion of group contests with weakest-link aggregation see, e.g., Lee (2012); for a discussion of "best-shot" aggregation (where group effort is determined by the maximum of all players' efforts) see Chowdhury et al. (2013); see also Sheremeta (2011a) for an experimental comparison of different group aggregation technologies. See, e.g, Gunnthorsdottir and Rapoport (2006) and Sutter (2006) for a study of alternative prize sharing rules.

[5] Kimbrough et al. (2014) study conflict resolution by a random device in contests between heterogeneous individuals. Their Balanced and Unbalanced treatments refer to the degree of heterogeneity between the individuals.

[6] We assume that $p_i = 1/n$ if $\sum_{k=1}^{n} E_k = 0$.