THE ROLE OF RANDOM NOISE ON EFFORTS IN GROUP CONTESTS

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ABSTRACT

THE ROLE OF RANDOM NOISE ON EFFORTS IN GROUP CONTESTS

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We theoretically and experimentally study the effect of random noise on effort level in individual and three different types of group contests: perfect-substitutes, best-shot, and weakest-link. Subjects compete for either a high prize value or a low prize value in individual contests. The theoretical model shows that individual effort increases with prize value but decreases with noise variance. Our experiment finds that in individual contests, subjects who compete for a low prize decrease their efforts as noise variance rises, as theoretically predicted. Contrary to the theoretical prediction, there is no effect of noise variance on the efforts of subjects who compete for a high prize. For group contests, each group has two heterogeneous players, one with a high prize valuation, named as a strong player, and one with a low prize valuation, named as a weak player. The theoretical model predicts both strong and weak players' efforts decrease while noise variance increases in all group contests, except for weak players in best-shot contests. Our experimental analysis could not confirm the theoretical predictions for perfect-substitutes and weakest-link contests. We find no effect of noise variance on both strong and weak players' efforts. In best-shot contest, in line with the theoretical prediction, strong players' efforts decrease as the noise variance increases. Contrary to prediction, weak players' effort choices are higher than 0 in both high and low noise variances, yet their efforts also decrease with random noise. Finally, we compare how subjects' efforts differ from individual contests to group contests. We find that in all group contests, players exert effort as much as in individual contests.

Keywords: Contest, rank-order tournaments, random noise, prize valuations, group impact functions

ÖZ

GRUP YARIŞMALARINDA ŞANSIN EFOR ÜZERİNE ETKİSİ

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Bu çalışmada, şans varyansının bireysel yarışmalarda ve üç farklı grup yarışmasında, mükemmel ikameler, en iyi atış ve en zayıf halka, efor seçimlerini nasıl etkilediğini teorik ve deneysel olarak inceliyoruz. Katılımcılar, derecelendirmeli bireysel yarışmalarda yüksek bir ödül değeri veya düşük bir ödül değeri için yarışırlar. Teorik model, bireysel eforun ödülün değeri ile arttığını, ancak şans varyansı ile azaldığını öngörmektedir. Deneyimiz, bireysel yarışmada, teorik olarak tahmin edildiği gibi düşük ödül değeri için yarışan oyuncuların şansın varyansı arttıkça eforlarını azaltmaktadır. Teorik tahminin aksine, şans varyansın yüksek ödül değeri için yarışan bireylerin eforları üzerinde hiçbir etki yoktur. Grup yarışmaları için, her grubun iki heterojen oyuncusu vardır: Bir tane yüksek ödül değerlemesi olan güçlü oyuncu ve bir tane düşük ödül değerlemesi olan zayıf oyuncu. Teorik model, en iyi atış yarışmalarındaki zayıf oyuncular hariç tüm grup yarışmalarında şansın varyansı artarken hem güçlü hem de zayıf oyuncuların eforlarının azalmasını öngörmektedir. Teorik beklentinin aksine, mükemmel ikameler ve en zayıf halka yarışmalarında şans varyansının hem güçlü hem de zayıf oyuncuların eforları üzerinde bir etkisi yoktur. Beklentimize uygun olarak, en iyi atış yarışmasında şansın varyansı arttıkça güçlü oyuncuların eforları azalır. Tahminin aksine, zayıf oyuncuların efor seçimleri hem yüksek hem de düşük şans varyansları altında 0’dan yüksektir ve eforları şans varyansı ile azalmaktadır. Son olarak, şans varyansının etkisiyle yarışmacıların eforlarının bireysel yarışmalardan grup yarışmalarına nasıl farklılaştığını karşılaştırıyoruz. Tüm grup yarışmalarında oyuncular bireysel yarışmalarda olduğu kadar efor harcamaktadırlar.

Anahtar Kelimeler: Yarışma, derecelendirmeli turnuvalar, şans, ödül değerlemeleri, grup üretim fonksiyonları

Dedicated to
my beloved mother, father, and brother.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Many economic, political, or social situations can be characterized as contests. In contests, individuals or groups spend finite and costly resources, such as effort, money, or time, to win a specific reward. In the literature, three canonical models of contests have been designed: lottery contest (Tullock, 1980), rank-order tournament (Lazear & Rosen, 1981), and all-pay auction (Hillman & Riley, 1989).[1] Even though the underlying assumptions of these models differ, all three contest models assume that while competing for a prize, the cost of effort is subtracted from contestants' payoffs, and players' probability of winning depends on their relative expenditures. This study uses rank-order tournaments, in which a player with the highest performance wins the contest prize with certainty.[2] The main reason for our focus on rank-order tournaments is that in real-world situations, not only the efforts of individuals but also random noise determines the winner. For example, in warfare, not only the sizes of armies but also the geography and prevailing weather conditions of the battleground could affect the result. These conditions can be characterized as random noise, affecting the whole group simultaneously, not players of the group one by one.[3] Despite extensive studies on rank-order tournaments (for an extensive review, see Dechenaux et al., 2015), the effect of

[1] Tullock lottery contest has commonly been used to model rent-seeking and R&D races; rank-order tournament has been used in principal-agent, contract design, and labor literature; lastly, all-pay auction has been used to model the process of litigation or lobbying and military combat.

[2] Performance is a function of effort and random noise. The random noise represents luck that individuals cannot control.

[3] A similar situation can be thought for individual contests. For instance, a golf professional's probability of winning could be changed based on the golf course. This golf course can be thought of as a random noise that affects players' efforts.

random noise on effort in group contests has remarkably little attention.[4] Therefore, we study the effect of noise variance on effort level in three different types of group contests: perfect-substitutes, best-shot, and weakest-link (Hirshleifer, 1983). In *perfect-substitutes contests*, the group effort[5] depends on the joint efforts of all members within that group (Katz et al., 1990; Baik, 1993, 2008). In *best-shot contests*, the effort of a group depends only on the best performer within that group (Chowdhury et al., 2013; Barbieri et al., 2014). In *weakest-link contests*, only the weakest performer within a group represents the group effort (Lee, 2012). We also run individual contests under random noise to understand how effort level changes from individual contests to group contests.

For our individual contest, we use the deterministic winner-take-all contest[6] of Cason et al. (2020). They consider an individual contest where two risk-neutral and symmetric individuals compete for a prize. After each individual exerts effort given a noise variance, the effort levels are multiplied by a random noise to determine their individual performance. The better-performing individual receives the whole prize while the other receives nothing. In our study, the theoretical model predicts that individuals increase their effort choices with the prize valuation and decrease with the noise variance in individual contests.

In the theoretical model, for group contests, we assume each symmetric group has two risk-neutral and heterogeneous individuals, one with a high prize valuation, named as a strong player, and one with a low prize valuation, named as a weak player.[7] We focus on the effect of random noise on group members' effort decisions

[4] Chen and Lim (2017) use the rank-order contest model in group contests. They do not examine the role of random noise yet just compare players' efforts across different contests.

[5] The group effort is characterized as a function of all group members' efforts, which changes with group impact functions.

[6] In their paper, a simple deterministic winner-take-all contest is similar to the rank-order tournament of Lazear and Rosen (1981) when the sensitivity parameter in contest success function $r = \infty$.

[7] We call *heterogeneous* to describe within-group composition, and *symmetric* to define contests between individuals or those between groups. All information is common knowledge.

in three different group impact functions. Our model determines group performance by the multiplication of random noise and group effort that varies with the group impact functions.

Our model predicts that for group contests, both strong and weak players exert positive efforts in perfect-substitutes contests, yet strong players' effort choices are higher than the weak players' efforts. In best-shot contests, only strong players expert positive effort while weak players free-ride by exerting 0-effort. In weakest-link contests, strong players exert as much effort as the weak players. According to the theoretical model, strong players' effort levels decrease as random noise rises in all group contests. Except in best-shot contests, weak players decrease their efforts with random noise.

We use a laboratory experiment to test theoretical predictions of our model since in the field, (1) observation of effort levels is difficult, (2) random noise cannot be measured, and (3) in group contests, positive or negative feelings toward group member(s) may exist, and these feelings are hard to measure.

We vary whether participants compete individually or in a group by using a within-subject design. Additionally, we change noise variable[8] and group impact functions across sessions by using a between-subject design. Our experiment consists of five parts. In the first part, subjects participate in a real-effort task which determines prize valuations for which they will compete. In the second part of the experiment, two symmetric contestants compete for a prize in an individual contest, yet the valuation of the prize differs from one pairing to another.[9] After each player simultaneously and independently exerts effort, efforts are multiplied with an individual random noise to determine their own individual performance. Only the better-performing

[8] The noise variable has high variance in one treatment and low variance in another treatment.

[9] The pairing is occurred according to their rank of performances in the real-effort task. The best performers in the first part compete for high prize value, and the lowest ones compete for low prize value.

individual receives the contest prize.[10] In the third part, a group competes with another group. Each group has two heterogeneous players with different valuations of a prize, which are determined according to their ranks in the first part, and it is common knowledge. After group efforts are calculated based on the group impact function and multiplied with a group random number, group performances are determined. The better-performing group receives the contest prize. In the winning group, the strong player has a high valuation for the prize, and the weak player has a low valuation. In the fourth part, we conduct an individual contest with a prize of 0 to observe subjects' joy of winning (Sheremeta, 2010). In the last part of the experiment, we elicit subjects' risk preferences by using multiple price listing (Holt & Laury, 2002).

Our main empirical findings can be summarized as follows: First, in individual contests, except for the efforts of individuals who compete for a high prize in low noise variance, subjects' average effort levels are higher than equilibrium predictions given the noise variance. When we look at the role of random noise on individuals' efforts, we replicate Cason et al.'s (2020) findings for the low prize contests, but we do not for the high prize contests. In particular, as noise variance rises, subjects who compete for a low prize value decrease their effort levels, but subjects who compete for a high prize value do not. Given the noise variance, efforts of subjects with high and low prize valuations do not differ in individual contests.

Second, when we compare the actual effort choices with the equilibrium efforts in group contests, we find that given the noise variance, both strong and weak players exert more effort than the equilibrium effort in perfect-substitutes contests. Given the noise variance, in best-shot contests, weak players exert more effort than the equilibrium effort while strong players' efforts are not different from the equilibrium prediction. In weakest-link contests with high noise variance, both strong and weak players exert more effort than the equilibrium effort levels. In contrast, in the low noise variance, their efforts are not different from the equilibrium efforts. Contrary to the theoretical predictions, there is no effect of noise on both strong and weak

[10] Individual performance is defined as a multiplication of his effort and random noise.

players' efforts in perfect-substitutes and weakest-link contests. In best-shot contests, in line with the prediction, strong players' efforts decrease as noise variance increases. Unlike the theoretical prediction, weak players also decrease their efforts with random noise in best-shot contests. When we look at the effect of prize valuation on effort in group contests given the noise variance, contrary to the predictions, strong and weak players' efforts do not differ in perfect-substitutes contests. Contrary to the theoretical prediction, there is no difference between the efforts of strong and weak players in best-shot contests. In line with the theoretical prediction, strong and weak players expend similar efforts in weakest-link contests.

Third, when we compare the effort levels in individual contests and those in group contests, our model predicts that the total effort levels of players with high and low prize valuations decrease from individual contests to group contests. Contrary to the prediction, in all group contests, both strong and weak players exert effort as much as in individual contests. Lastly, in addition to these analyses, we checked whether male and female players respond to random noise differently in individual and group contests. While males decrease their efforts with noise variance in individual, best-shot, and weakest-link contests, female players do not. In perfect-substitutes contests, neither males nor females respond to noise variance.

Overall, our study has two important contributions to the literature. The first contribution of this study is that we extend group contest literature by providing a theoretical and experimental framework to compare group contests with different group production functions under random noise. The second contribution is that our study compares efforts in rank-order individual and group contests as random noise changes.

The remainder of this study is organized as follows. In Chapter 2, we review the literature. In Chapter 3, we theoretically examine how random noise affects effort in individual and group contests. In Chapter 4, we describe our experimental design with our research hypotheses and give details of the experimental procedures. In Chapter 5, we report the results of the experiment. Finally, in Chapter 6, we make our concluding remarks.

CHAPTER 2

LITERATURE REVIEW

Our study is broadly related to two main branches of contests literature. First, it is related to the literature on individual contests for which there are extensive theoretical and empirical studies (for a comprehensive review of this literature, see Konrad, 2009 and Dechenaux et al., 2015). Among three canonical models of contests, our model is closely related to the rank-order tournament of Lazear and Rosen (1981), where a player with the highest performance wins the entire prize with certainty.[11] In such contests, performance is denoted as a function of effort choice and random noise.[12] In this study, we examine the effect of noise variance and prize valuations on individuals' effort choices in the individual contests. Several studies examine the impact of noise on efforts in individual contests. Bull et al. (1987) report that players' efforts decrease as random noise increases in their laboratory experiments, and many experimental studies have replicated this finding (Dechenaux et al., 2015).

Of these studies, the recent study of Cason et al. (2020) is the closest one to our study. They analyze how random noise affects a risk-neutral contestant's effort by comparing three canonical types of contests: deterministic winner-take-all, probabilistic-prize, and proportional-prize. They find that contestants' efforts in all three contests formats decrease as the noise variance increases. Our study replicates the effect of random noise variance on efforts in individual contests by using their

[11] Other models are the following: (1) *Tullock lottery contest* in which the probability of winning is a ratio of a player's effort to the sum of the players' efforts in the contests; (2) *All-pay auction* in which a player exerting the highest effort wins the prize with certainty.

[12] Lazear and Rosen (1981) characterized random noise as any random factor that is out of individuals' control yet affects their positions in the contest.

deterministic winner-take-all contest model[13] and compares the effect of noise variance on subjects' efforts in group contests with different impact functions.

When we consider the effect of prize valuations on effort choices in the individual contests, the model predicts that individuals' efforts increase with the size of a prize value. Several experimental studies which investigate the effect of prize spread in tournaments have shown that subjects increase their efforts in response to an increase in the winner's prize (Bull et al., 1987; Harbring & Irlenbusch, 2005; Harbring & Lünser, 2008; Falk et al., 2008).

Second, our study builds on the growing literature on group contests. As group contests unfold, the three most frequently used functional rules arise: perfect-substitutes, best-shot, and weakest-link (Hirshleifer, 1983). In the literature, there have been several theoretical studies about the effect of group impact functions on effort. Baik (2008) generates heterogeneity within a group by varying valuations of a prize in perfect-substitutes contests. When the cost of effort is linear, and the Tullock lottery contest success function is used, he theoretically shows that only the one who has a high valuation of the prize exerts positive effort while weak players with low prize valuations exert zero effort at a Nash equilibrium. Lee (2012) considers a contest where two groups with two heterogeneous players compete against under the Tullock lottery contest success function. He uses the weakest-link impact function to define the group performance. He theoretically shows that neither strong nor weak players free-ride in the equilibrium of weakest-link contests. Chowdhury et al. (2013) analyze a group contest with the best-shot impact function by using the Tullock lottery contest success function. Their theoretical model shows that although there can be a set of possible equilibria depending on the different prize valuations, only one player within a group exerts positive effort in each equilibrium. In particular, strong players exert positive effort in equilibrium while weak players within that group free ride by exerting no effort.

[13] The reason why we choose their deterministic winner-take-all contest for our individual contest model is that the most significant change in the effort levels was observed in this type of contest due to a change in the random noise variance in the study of Cason et al. (2020).

For the comprehensive experimental reviews, see Dechenaux et al. (2015) and Sheremeta (2018b). Sheremeta (2011b) experimentally compares efforts in all three group contests, perfect-substitutes, best-shot, and weakest-link, by using the Tullock lottery contest success function. Each group consists of three risk-neutral players, one strong player with a higher prize valuation and two weak players with lower valuations. He reports that effort levels depend on the group impact function in different contests between groups. For instance, in perfect-substitutes contests, both strong and weak players exert higher effort than theoretical predictions. In best-shot contests, strong players expend most of their efforts while weak players tend to free-ride. Finally, in weakest-link contests, all members in the same group generate similar positive efforts at the group Pareto dominant equilibrium, so there is almost no free-riding problem. Even though we use all three group impact functions as in Sheremeta (2011b), we use the rank-order contest model rather than the Tullock contest model. We aim to examine the effect of random noise on efforts across these different group contests.

To our best knowledge, up until the study of Chen and Lim (2017), random noise has not been used at all in group contests. They design a setting where a group of players competes with another group under the rank-order contest model. They set up a model that each individual's performance in a group is measured as his effort level, random noise (demand shock), and ability endowment. They examine the effect of the composition of group members and different types of group contests on subjects' effort levels. Their theoretical model predicts that when there are two homogeneous players within a group, the group effort levels do not differ in all group contests. When players within a group are heterogeneous, strong and weak players' efforts are not different in perfect-substitutes contests. Strong players exert lower effort than weak players in weakest-link contests, yet strong players' efforts are higher than weak ones' effort levels in best-shot contests. Their experimental results support their theoretical predictions. Similar to our study, Chen and Lim (2017) use two heterogeneous subjects within a group in one part of their works and rank-order contest model. However, our study has three differences from theirs. First, we make the heterogeneity within groups based on valuations of the prize instead of an additive ability endowment parameter. Second, the noise variable in our model is multiplicative and affects group effort. Lastly, and more importantly, we aim to explore the effect of different noise parameters on efforts in individual contests and three different types of group contests.

Finally, our study extends the literature in which effort choices in individual and group contests are compared. Chen and Lim (2013) examine the effort levels in individual and perfect-substitutes group contests with or without communication. Both individual and group contests are symmetric under the rank-order contest model. They use additive noise at the individual level in individual and group contests. Each group has two homogeneous players in group contests. They report that when contestants do not communicate with each other, efforts in perfect-substitutes contests are not different from efforts in individual contests. If participants are allowed to communicate, the degree of guilt aversion to group members rises, and efforts in group contests are higher than those in individual contests. Our study has four differences from theirs. First, in our model, each group is composed of one strong and one weak player. Second, in individual contests, we use two different prize valuations for each competing pair. Third, since efforts are not always aggregated by perfect-substitute technology in real life, we also use other group impact functions. Finally, we use a multiplicative noise variable on the production function at the individual level in individual contests and the group level in group contests.

CHAPTER 3

THEORETICAL MODEL

In the next two sections, we provide our theoretical models for symmetric individual contests (in Section 3.1) and for symmetric group contests (in Section 3.2), respectively.

3.1 Individual Contests

Consider an individual contest in which two risk-neutral and symmetric players compete for a prize v. Both players simultaneously and independently expend individual efforts e_1 and e_2. The performance y_i of player *i*, where *i* = 1, 2, is determined by the following production function,

$$y_i(e_i|\varepsilon_i) = e_i\varepsilon_i \tag{3.1}$$

The random component ε_i can be interpreted as random error, imperfect information about performance, production luck, random noise, measurement error, or an unknown ability. We assume that the independent stochastic term, ε_i, is *i.i.d.* and uniformly distributed over the interval $[1-\alpha, 1+\alpha]$, where $\alpha \in [0,1]$ scales the distribution's variance.[14] We also assume that exerting effort e_i has a cost, and the cost of effort is calculated as $c(e_i) = e_i{}^2/b$,[15] where $c(0) = 0$, and $c'(e_i)$, $c''(e_i) > 0$.[16]

[14] We should emphasize that the mean of this multiplicative distribution, ε_i, is 1 as opposed to the mean of 0 when the noise is additive (Gerchak & He, 2003). The reason is that when the mean of the multiplicative noise is 1, a player's effort is the same with his or her performance. This result can be observed as 0-mean when the noise variable is additive.

[15] The constant *b* is a restriction about players' abilities on the quadratic cost function as in Cason et al. (2020).

[16] The strictly increasing and convex cost function ensures the existence and uniqueness of an equilibrium in which all players exert positive effort. In the experimental contest literature, quadratic

Given Equation 3.1, the expected payoff for player *i*, where *i* = 1, 2, can be described as:

$$E(\pi_i) = p_i(e_1, e_2 \mid \varepsilon_1, \varepsilon_2)v - c(e_i) \tag{3.2}$$

The better-performing individual wins the prize with certainty in the individual contest. In the rank-order tournaments of Lazear and Rosen (1981), the probability of winning for player 1 can be written as $p_1(e_1, e_2 \mid \varepsilon_1, \varepsilon_2) = \Pr(e_1\varepsilon_1 > e_2\varepsilon_2) = Pr\left(\frac{e_1\varepsilon_1}{e_2} > \varepsilon_2\right) = \int F\left(\frac{e_1}{e_2}\varepsilon\right) f(\varepsilon)d\varepsilon$ where F(.) is the cdf of ε. Taking the first-order conditions, the pure-strategy Nash equilibrium effort in the rank-order tournaments can be obtained from

$$v \int \varepsilon\big(f(\varepsilon)\big)^2 \, d\varepsilon = c'(e)e \tag{3.3}$$

The equilibrium effort in the individual contest is given by:

$$e_1^* = e_2^* = e^* = \left(bv\frac{1}{4\alpha}\right)^{1/2} \tag{3.4}$$

The equilibrium effort in Equation 3.4 depends on the value of the prize v, the cost parameter b, and the variance of the noise parameter α. Comparative statics shows that an increase in the size of the prize increases the equilibrium effort. On the other hand, increase in the level of noise decreases the equilibrium effort, $\partial e^*/\partial\alpha < 0$.

The expected payoff with the equilibrium effort in Equation 3.4 is:

$$E(\pi^*) = \frac{v}{2}\left(1 - \frac{1}{2\alpha}\right) \tag{3.5}$$

An individual's expected payoff depends on the value of prize v and the variance of noise variable α.

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cost function has been commonly used (Bull et al., 1987; Harbring & Irlenbusch, 2003; Eriksson et al., 2009; Agranov & Tergiman, 2013; Cason et al. 2020).

3.2 Group Contests

Consider a group contest where two symmetric groups, Group A and B, compete in order to win a prize. Each group has two heterogeneous players with different valuations of the prize. In particular, we assume $v_{1A} > v_{2A} > 0$ in Group A and $v_{1B} > v_{2B} > 0$ in Group B.[17] All prize valuations are common knowledge. We assume that strong players are symmetric with each other $v_{1A} = v_{1B} = v_s$; $e_{1A} = e_{1B} = e_s$ and weak players are symmetric with each other $v_{2A} = v_{2B} = v_w$; $e_{2A} = e_{2B} = e_w$. Hence, the group contest prize is equal to $v_s + v_w$ for both groups. Players in Group A (Group B) simultaneously and independently exert costly efforts e_{1A} and e_{2A} (e_{1B} and e_{2B}) respectively.

The group performance y_i, where *i* = A, B, is determined by the multiplication of the group impact function $f_i(.)$ and a random variable ε_i:

$$y_i = f_i(e_{1i}, e_{2i})\varepsilon_i \tag{3.6}$$

The random component ε_i is *i.i.d.* and uniformly distributed over the interval $[1-\alpha, 1+\alpha]$ where $\alpha \in [0,1]$ scales the distribution's variance. The expected payoff for player *j*, where *j* = 1, 2, in Group A can be written as:

$$E(\pi_{jA}) = p_A(e_{1A}, e_{2A}, e_{1B}, e_{2B} \mid \varepsilon_A, \varepsilon_B)v_{jA} - c(e_{jA}) \tag{3.7}$$

After each player in Group A and Group B choose their efforts, and y_A and y_B are compared, only the better performing group wins the prize with certainty. The probability of Group A wins the prize is $p_A(e_{1A}, e_{2A}, e_{1B}, e_{2B} \mid \varepsilon_A, \varepsilon_B) = Pr(f_A(e_{1A}, e_{2A})\varepsilon_A > f_B(e_{1B}, e_{2B})\varepsilon_B) = Pr\left(\frac{f_A(e_{1A},e_{2A})}{f_B(e_{1B},e_{2B})}\varepsilon_A > \varepsilon_B\right) = \int F\left(\frac{f_A(e_{1A},e_{2A})}{f_B(e_{1B},e_{2B})}\varepsilon\right) f(\varepsilon)\, d\varepsilon.$ The first term of the expected payoff, $p_A(e_{1A}, e_{2A}, e_{1B}, e_{2B} \mid \varepsilon_A, \varepsilon_B)v_{jA}$, is the probability of Group A winning the prize times player j's prize valuation in that group. The second term, c(e_{jA}), is the cost of player *j*'s effort and calculated as c(e_{jA}) = ${e_{jA}}^2/b$.

[17] Player 1A and player 1B will be called "strong players", and other players, 2A and 2B are "weak players".

Three group impact function forms are considered in group contests: perfect-substitutes, best-shot, and weakest-link (Hirshleifer, 1983). In the next subsections, we will solve for equilibrium behavior of weak and strong players by inserting group impact functions into Equation 3.7.

3.2.1 Perfect-Substitutes Contests

Definition 1. *In contests characterized by a perfect-substitutes function, the effort of a group depends on the sum of all group members' efforts,* $f_A(e_{1A}, e_{2A}) = \sum_{j=1}^{2} e_{jA}$.

The group performance y_i, where *i* = A, B for perfect-substitutes contests is that:

$$y_i = f_i(e_{1i}, e_{2i})\varepsilon_i \tag{3.8}$$

The group performance for Group A is defined as

$$y_A(e_{1A}, e_{2A} \mid \varepsilon_A) = (e_{1A} + e_{2A})\, \varepsilon_A \tag{3.9}$$

By inserting Equation 3.9 into Equation 3.7 and solving for e_{1A}, we find e_{1A} to be

$$e_{1A}^{*} = \frac{1}{2} v_{1A} \left(\frac{b}{\alpha\,(v_{1A} + v_{2A})}\right)^{1/2} \tag{3.10}$$

By solving for e_{2A}, we find e_{2A} to be

$$e_{2A}^{*} = \frac{1}{2} v_{2A} \left(\frac{b}{\alpha\,(v_{1A} + v_{2A})}\right)^{1/2} \tag{3.11}$$

Comparative statics shows that an increase in the valuation of the prize increases the equilibrium effort. Since $v_{1A} > v_{2A}$, strong players' efforts in the equilibrium are higher than weak players' efforts. Additionally, both strong and weak players' effort levels decrease with the noise variance parameter α.

The expected payoff of strong players at the equilibrium is:

$$E(\pi_{1A}^{*}) = \frac{1}{2} v_{1A} \left(1 - \frac{v_{1A}}{2\alpha(v_{1A} + v_{2A})}\right) \tag{3.12}$$

The expected payoff of weak players at the equilibrium is:

$$E(\pi_{2A}^{*}) = \frac{1}{2} v_{2A} \left(1 - \frac{v_{2A}}{2\alpha(v_{1A} + v_{2A})}\right) \tag{3.13}$$

The expected payoffs change for both strong and weak players according to the valuations of the prize.

3.2.2 Best-Shot Contests

Definition 2. *In contests characterized by a best-shot function, the effort of a group depends only on the best performer within that group,* $f_A(e_{1A}, e_{2A}) = max\{e_{1A}, e_{2A}\}$.

The group performance y_i, where *i* = A, B, for the best-shot contests is that:

$$y_i = f_i(e_{1i}, e_{2i})\varepsilon_i \tag{3.14}$$

The group performance for Group A is written as

$$y_A(e_{1A}, e_{2A} \mid \varepsilon_A) = max\{e_{1A}, e_{2A}\}\, \varepsilon_A \tag{3.15}$$

By inserting Equation 3.15 into Equation 3.7 and solving for e_{1A}, we find e_{1A} to be

$$e_{1A}^{*} = \left(bv_{1A} \frac{1}{4\alpha}\right)^{1/2} \tag{3.16}$$

Strong players' equilibrium effort level decreases with the noise variance parameter α. In the equilibrium, weak players free-ride and exert 0 effort.

The strong players' expected payoff at the equilibrium is:

$$E(\pi^*_{1A}) = \frac{1}{2} v_{1A} \left(1 - \frac{1}{2\alpha}\right) \tag{3.17}$$

Their expected payoffs depend on their prize valuations v_{1A} and the noise variance parameter α.

Weak players' expected payoff at the equilibrium is:

$$E(\pi^*_{2A}) = \frac{1}{2} v_{2A} \tag{3.18}$$

Their expected payoff depends only on their prize valuations v_{2A}.

3.2.3 Weakest-Link Contests

Definition 3. *In contests characterized by a weakest-link function, a group effort depends only on the worst performer within that group,* $f_A(e_{1A}, e_{2A}) = min\{e_{1A}, e_{2A}\}$.

The group performance y_i, where *i* = A, B, for the weakest-link contests is that:

$$y_i = f_i(e_{1i}, e_{2i})\varepsilon_i \tag{3.19}$$

The group performance for Group A is written as

$$y_A(e_{1A}, e_{2A} \mid \varepsilon_A) = min\{e_{1A}, e_{2A}\}\, \varepsilon_A \tag{3.20}$$

By inserting Equation 3.20 into Equation 3.7 and solving for e_{2A}, we find all players in Group A exert the same efforts in the equilibrium.

$$e^*_{1A} = e^*_{2A} = \left(b v_{2A} \frac{1}{4\alpha}\right)^{1/2} \tag{3.21}$$

Both strong and weak players' equilibrium effort levels depend on weak players' prize valuation v_{2A}. Additionally, their efforts decrease as noise variance rises.

The expected payoffs at the equilibrium are different between strong and weak players because of the prize valuations.

$$E(\pi_{1A}^{*}) = \frac{1}{2}\left(v_{1A} - \frac{1}{2\alpha}v_{2A}\right) \tag{3.22}$$

Their expected payoffs depend on their prize valuation v_{1A}, weak players' prize valuation v_{2A} and the noise variance parameter α.

Given Equation 3.21, the weak players' expected payoff at the equilibrium can be defined as:

$$E(\pi_{2A}^{*}) = \frac{1}{2}v_{2A}\left(1 - \frac{1}{2\alpha}\right) \tag{3.23}$$

In Equation 3.23 weak players' expected payoff depends only on their own prize valuations v_{2A} and the noise variance parameter α.

CHAPTER 4

EXPERIMENTAL SETUP

4.1 Experimental Design and Predictions

We employ a 2x2x3 factorial design in our experiment. We change whether the contests are between individuals or between groups as a within-subject design variable in one dimension. In the second dimension, we vary the variance of random noise (high or low noise variance) as a between-subject design variable. In the third dimension, we use three different group impact functions (perfect-substitutes, best-shot, and weakest-link) as another between-subject design variable.

Table 4.1 Theoretical Predictions in Individual Contests

Treatment	Noise Variance Parameter, α	Valuation of Prize	Equilibrium Effort of Player	Equilibrium Payoff of Player
IND-L	0.5	120	77.46	0.0
IND-H	1	120	54.77	30.0
IND-L	0.5	80	63.25	0.0
IND-H	1	80	44.72	20.0

Note: IND-L defines individual contests with low noise variance while IND-H represents individual contests with high noise variance.

In all treatments, the restriction on the convex cost function in the previous chapter is b = 100, and subjects face two different noise variances: (i) low noise variance (L) and (ii) high noise variance (H). When low noise variance (L) is effective in a contest, the random noise, ε_i, is uniformly distributed on the interval [0.5, 1.5]. On the other hand, in high noise variance (H), ε_i is uniformly distributed on the interval [0, 2]. Since we replicate Cason et al. (2020) for the individual contest part, we set the parameters as they did in their study.[18] Table 4.1 shows noise variance parameters on the interval $[1-\alpha, 1+\alpha]$[19], valuation of prizes, equilibrium efforts and expected payoffs in individual contests.

Table 4.2 Theoretical Predictions in Group Contests

Treatment	Noise Variance Parameter, α	Valuation of Prize		Equilibrium Effort of Player		Equilibrium Payoff of Player	
		Strong	Weak	Strong	Weak	Strong	Weak
PS-L	0.5	120	80	60.0	40.0	24.0	24.0
PS-H	1	120	80	42.43	28.28	42.0	32.0
BS-L	0.5	120	80	77.46	0.0	0.0	40.0
BS-H	1	120	80	54.77	0.0	30.0	40.0
WL-L	0.5	120	80	63.25	63.25	20.0	0.0
WL-H	1	120	80	44.72	44.72	40.0	20.0

Note: In the treatments PS-L, BS-L, and WL-L, subjects participate in perfect-substitutes, best-shot and weakest-link, respectively and face low noise variance while in PS-H, BS-H, and WL-H treatment, contestants face high noise variance.

Table 4.2 summarizes noise variance parameters on the interval $[1-\alpha, 1+\alpha]$, valuations of players, equilibrium efforts of individual and expected payoffs in all group contests. Similar to individual contests, subjects face either low noise variance (L) or high noise variance (H) in one of the group contests: perfect-substitutes (PS),

[18] We choose different valuations of prizes since we prefer to use heterogeneity within a group to overcome possible coordination problems in group contests.

[19] In low noise variance, the noise variance parameter α = 0.5, whereas α = 1 in high noise variance.

best-shot (BS) and weakest-link (WL) contests.[20] Each group has two heterogeneous players, one strong player with a high prize valuation of 120 and one weak player with a low prize valuation of 80.

The theoretical predictions for both individual and group contests motivate the following hypotheses:

Hypothesis 1a. *Efforts of players in individual contests decrease as random noise increases.*

Hypothesis 1b. *Efforts of players in group contests, except for weak players in best-shot contests, decrease as random noise increases.*

Hypothesis 2a. *Given the noise variance, individuals whose prize valuation is 120 exert higher effort than individuals whose prize valuation is 80 in individual contests.*

Hypothesis 2b. *Given the noise variance, strong players exert higher effort than weak players in perfect-substitutes and best-shot contests.*

Hypothesis 2c. *Given the noise variance, strong players exert effort as much as weak players in weakest-link contests.*

Hypothesis 3. *Given the noise variance, the sum of strong and weak players' efforts decreases from individual contests to group contests.*

4.2 Experimental Procedures

We conducted fourteen sessions at Middle East Technical University (METU) to test theoretical predictions stated in the Hypotheses above. The experiment was coded in z-Tree (Fischbacher, 2007). We conducted the sessions at METU-FEAS Behavioral and Experimental Laboratory (BEL) in late October and early November 2021. No subject participated in more than one session. A total of 124 subjects

[20] These treatments are termed according to the group impact functions.

participated.[21] Throughout the experiment, payoffs were described in terms of "francs". The earnings were converted into Turkish Lira at the rate of 40 francs to 3 TL. On average, subjects earned approximately 32.77 TL, including a 10 TL participation fee.[22] The sessions lasted for about 50 minutes.

The design is summarized in Table 4.3. Before each group contest, we ran individual contests. In the half of the sessions, we ran high variance treatments, and in the other half of the sessions, we ran low variance treatments. At the end of each session, we asked subjects to fill out a questionnaire that consists of questions about demographic characteristics on gender, age and major.

Table 4.3 Treatment Conditions & Number of Participants

	PS Contests	Bs Contests	WL Contests
High Noise Variance	2 sessions – 5 groups	2 sessions – 5 groups	2 sessions – 5 groups
Low Noise Variance	2 sessions – 5 groups	3 sessions – 5 groups	3 sessions – 6 groups

Note: Before each group contest, individual contest was played. Each group has 4 individuals. Depending on the number of students who signed up for that session, the number of session changes.

The invitation e-mail was sent to undergraduate and graduate students of the university. Upon arrival, the participants were randomly assigned to a computer and signed a consent form. Each experimental session proceeded in five parts. Instructions about each part were read aloud by the experimenter just before that

[21] Most students were from the economics department (37.90%). While 51.61% of the participants were male, 48.39% were female. The subjects' ages range mostly between 20 and 25 (87.10%).

[22] In 2021, the hourly minimum salary in Turkey is 15.90 TL.

part.[23] In the first part, participants answered some multiple-choice questions.[24] In the second part, subjects participated in individual contests against the same opponent for 10 periods. In the third part, players who have the same partners compete against the same opponents in group contests for 10 periods.[25] In the final two parts of each session, additional information about individual preferences, such as the joy of winning and risk preferences, were collected. At the end of each session, subjects were paid the sum of the following payoffs: 1 out of 10 periods in the second part, 1 out of 10 periods in the third part, the single decision made in part four, and 1 out of 15 decisions made in part five of the experiment.

In the first part of the experiment, subjects participated in an earning task, which was a general knowledge quiz with 20 multiple-choice questions. Each question had only one correct answer among five answer choices. Each subject received the same set of questions in the same order. All subjects had 25 seconds to answer each question. If a subject did not answer a question within that time limit, the unanswered question was counted as incorrect. Subjects' performance was calculated as the sum of correct answers. At the beginning of this part, the subjects only knew that their performance would affect the other parts of the experiment, but they did not know how it would affect. This effect was explained to them just before the second and third parts of the experiment. Once the first part was finished, subjects were ranked according to their performances, and their prize valuations were determined for the contests in the second and third parts by their ranks. In particular, their prize valuations differed depending on whether they were in top 50% or bottom 50% of their groups in the session: The ones in the top (bottom) 50% competed for prize 120 (80) francs in the second part (individual contests). In the third part (group contests), each group had two players: one from the top 50% and

[23] The instructions were prepared in Turkish. We provide full instructions translated to English and can be found in Appendix A.

[24] The multiple-choice questions were translated to English and can be found in Appendix B.

[25] In particular, we used the partner-matching protocol in the second and third parts of the experiment.

one from the bottom 50%.[26] In the case of winning, the ones in the top (bottom) 50% got a share of 120 (80) francs.

Note: Subjects could calculate the possible cost of their bids through a calculator on the decision screen in the second, third, and fourth parts of the experiment.

Figure 4.1 Decision Screen in Individual Contest

In the beginning of the second part, subjects with the same prize valuation were randomly and anonymously paired, i.e., the contests were symmetric. Each period subjects were given an initial endowment of 100 francs. We asked them to submit a bid between 0 and 100 by using their endowments. Submitting any bid had a cost, which was calculated by dividing the square of the bid by 100.[27] Subjects were able to calculate the possible cost of their bids through a calculator on the decision screen. After subjects chose their bids, the computer multiplied each of them by a "personal

[26] We defined the players in the top 50% as strong players while the players in the bottom 50% as weak players in group contests.

[27] This information was given in the bottom box of the decision screen.

random number"[28] to determine their own performances. The personal number has been randomly and independently drawn in each period for each individual. Then, the performances of two individuals in each competing pair were compared, and the better performing contestant received the prize of 120 (80) francs while the other received nothing. For this part, the decision screen for the individual contest was as in Figure 4.1. At the end of each period, subjects received feedback about their own bids, cost of their bids, personal random numbers, their own performances, and their own earnings for that period.

In the beginning of the third part (group contest), subjects were randomly and anonymously placed into Group A or B. Each group has one strong player and one weak player. It is common knowledge that subjects could see which group and player type they were assigned to within a group. In each period, all players received an initial endowment of 100 francs. We asked them to submit a bid between 0 and 100 by using this endowment. The cost of the bid was calculated as in the second part. After all players within that group submitted their bids, group bid was calculated according to the group impact function in that treatment. The group impact function was changed from session to session. In perfect-substitutes (PS) contests, the group bid was the sum of the players' bids within a group; in best-shot (BS) contests, the group bid depended only on the highest bid of that group; and lastly, in weakest-link (WL) contests, the group bid was determined by the lowest bid of that group. The computer multiplied the group bid by a "group random number" to determine their group performance. After the two groups' performances were compared, the better performing group received the entire prize of 200 francs. In the winning group, strong player received the prize of 120 francs while weak player received the prize of 80 francs. At the end of each period, they were reminded of their own bids, cost of their bids, prize valuations, earnings, group member's bids, their group random numbers, and their group performances.

[28] The noise variance changed from treatment to treatment. Participants knew that random noise was drawn from the interval [0,2] in high noise variance, while it was drawn from the interval [0.5,1.5] in low noise variance.

In the fourth part, we examined whether or not individuals can submit a bid in order to win a prize of 0 francs. That is called as "non-monetary utility of winning" (Sheremeta, 2010). The procedure was similar to the second part of the experiment. The only difference was the value of prize. This part lasted for only one period.

Table 4.4 Lottery Choices for Risk Elicitation

	Option A (Safe)	Option B (Risky)	
#1	14 francs	0/20 of 40 francs	20/20 of 0 francs
#2	14 francs	1/20 of 40 francs	19/20 of 0 francs
#3	14 francs	2/20 of 40 francs	18/20 of 0 francs
#4	14 francs	3/20 of 40 francs	17/20 of 0 francs
#5	14 francs	4/20 of 40 francs	16/20 of 0 francs
#6	14 francs	5/20 of 40 francs	15/20 of 0 francs
#7	14 francs	6/20 of 40 francs	14/20 of 0 francs
#8	14 francs	7/20 of 40 francs	13/20 of 0 francs
#9	14 francs	8/20 of 40 francs	12/20 of 0 francs
#10	14 francs	9/20 of 40 francs	11/20 of 0 francs
#11	14 francs	10/20 of 40 francs	10/20 of 0 francs
#12	14 francs	11/20 of 40 francs	9/20 of 0 francs
#13	14 francs	12/20 of 40 francs	8/20 of 0 francs
#14	14 francs	13/20 of 40 francs	7/20 of 0 francs
#15	14 francs	14/20 of 40 francs	6/20 of 0 francs

Note: Individuals chose between Option A (14 francs with certainty) or Option B (a chance of receiving 40 or 0 francs).

Finally, in the last part, we elicited subjects' risk preferences by using a set of 15 simple lotteries shown in Table 4.4. Similar to Holt and Laury (2002), subjects stated whether they prefer Option A or Option B in each row. Option A was safe while Option B was risky. Option A yielded 14 francs payoff with certainty in each row. Option B yielded a payoff of either 40 francs or 0 francs, and the probability of receiving 40 francs payoff increased by 1/20 in each row. According to the payoff values in Table 4.4, if a subject were risk-neutral, she would choose Option A in lotteries 1 through 7 and then switch to Option B in lottery 8. Risk-seeking subject might switch to Option B earlier than lottery 7 while risk-averse subject might switch later than lottery 7.

We used neutral language in the instructions: Effort corresponded to bid, random noise corresponded to personal random number (group random number) in individual contests (group contests), match corresponded to the opponent, strong player corresponded to player 1, and weak player corresponded to player 2.

CHAPTER 5

RESULTS

In this chapter, we examine the impact of random noise on efforts in individual contests in Section 5.1 and then analyze the effect of random noise on efforts of players in all group contests in Section 5.2. In Section 5.3, we look at how the effort levels change from individual contests to group contests. Lastly, in Section 5.4, we examine whether the random noise affects males and females differently in individual and group contests.

5.1 Individual Contests

Table 5.1 summarizes the effort levels for the 2nd half and all periods in individual contests. We use the t-test to check how individuals' efforts are affected by noise variance compared to the theoretical predictions. In individual contest with high noise variance (IND-H), individuals with valuation of 120 and those with valuation of 80 exert average efforts of 64.28 and 59.70. These effort choices are significantly higher than the equilibrium efforts of 54.77 and 44.72, respectively (t-test, p-value = 0.004 and p-value = 0.00, respectively). In low noise variance (IND-L), the average effort of individuals who compete for the prize of 120 is 70.97, and it is significantly lower than the equilibrium effort of 77.46 (t-test, p-value = 0.046). In periods 6 through 10, their average effort is 73.89, which is not significantly different from the equilibrium effort of 77.46 (t-test, p-value = 0.30).[29] When the prize valuation is 80, individuals' average effort of 67.54 is significantly higher than the equilibrium effort of 63.25 (t-test, p-value = 0.045). In all treatments, we observe

[29] Since individuals can learn how to play better over time, the last periods are also examined in such games (e.g., Palfrey & Prisbrey, 1996). Therefore, we also analyze the last five periods for each contest throughout this chapter.

high standard deviation. This can be interpreted as deviation from the equilibrium (Bull et al., 1987; Eriksson et al., 2009; Cason et al., 2020).

Table 5.1 Average Efforts for 2nd Half and All Periods in Individual Contests

	High Noise Variance		Low Noise Variance	
Valuation of Prize	120	80	120	80
Equilibrium	54.77	44.72	77.46	63.25
All Periods	64.28 (16.88)	59.70 (14.39)	70.97 (17.66)	67.54 (11.59)
Period 6 - 10	64.51 (19.21)	62.35 (19.86)	73.89 (19.02)	70.16 (14.85)

Standard deviations are in parentheses.

In the contest literature, noise variable has been incorporated into the performance in two different ways: (1) additive and (2) multiplicative. The findings regarding the expenditure of effort in rank-order tournaments with additive noise are not conclusive. While some studies (Bull et al., 1987; Schotter & Weigelt, 1992; Orrison et al., 2004; Agranov & Tergiman, 2013; Eisenkopf & Teyssier, 2013) find observed efforts are not significantly different from the theoretical predictions, other studies (Chen et al., 2011; Kräkel & Nieken, 2015) find they are significantly higher than the equilibrium predictions. Different than these studies, Cason et al. (2020) use multiplicative noise as in here. Since we replicate their individual contest part, we report our results comparing with their findings. They find that individuals' efforts are not significantly different from the equilibrium effort level in high noise variance while individuals' efforts are significantly lower than the equilibrium prediction in low noise variance. Unlike their results, except for individuals with valuations of 120 in low noise variance, we find significant over-expenditure of efforts compared to the equilibrium in all treatments.

The significant over-expenditure of efforts observed in individual contest models other than rank-order contests is explained as follows (see Dechenaux et al., 2015; Sheremeta, 2018a). The first and common explanation is non-monetary utility of winning (Sheremeta, 2010; Price & Sheremeta, 2015; Mago et al., 2016; Bruner et al., 2021). According to this dimension, if an individual derives a utility from winning, he may exert positive effort even when there is no monetary prize.[30] The second explanation is based on the fact that individuals are prone to mistake and use bounded rationality (Potters et al., 1998; Sheremeta, 2010, 2011a; Camerer, 2011). The third one is that similar to mistakes, individuals exhibit judgmental biases, such as a non-linear probability weighting function and the hot hand fallacy (Parco et al., 2005; Amaldoss & Rapoport, 2009; Sheremeta & Zhang, 2010). The fourth explanation for over-expenditure of efforts in individual contests is that individuals try to maximize their relative payoffs (Herrmann & Orzen, 2008; Mago et al., 2016). The fifth explanation is receiving a free endowment in each period (Price & Sheremeta, 2011, 2015; Sheremeta, 2011a). The sixth explanation is based on demographic differences (Price & Sheremeta, 2015), and social preferences, such as risk aversion[31] (Miller & Pratt, 1991; Sheremeta, 2011a), loss aversion (Kong, 2008; Kahneman & Tversky, 2013; Bruner et al., 2021), inequality aversion (Herrmann & Orzen, 2008; Balafoutas et al., 2012) and impulsiveness (Sheremeta, 2018a). The last explanation for the over-expenditure of effort is structure of the contest in the experimental design, such as probabilistic or proportional, and different cost functions, linear or convex (Fallucchi et al., 2013; Chowdhury et al., 2014).

Our theoretical model predicts that effort levels decrease as noise variance increases. In Table 5.1, average efforts of individuals with valuation of 80 significantly decrease from 67.54 to 59.70 and average efforts of individuals with valuation of

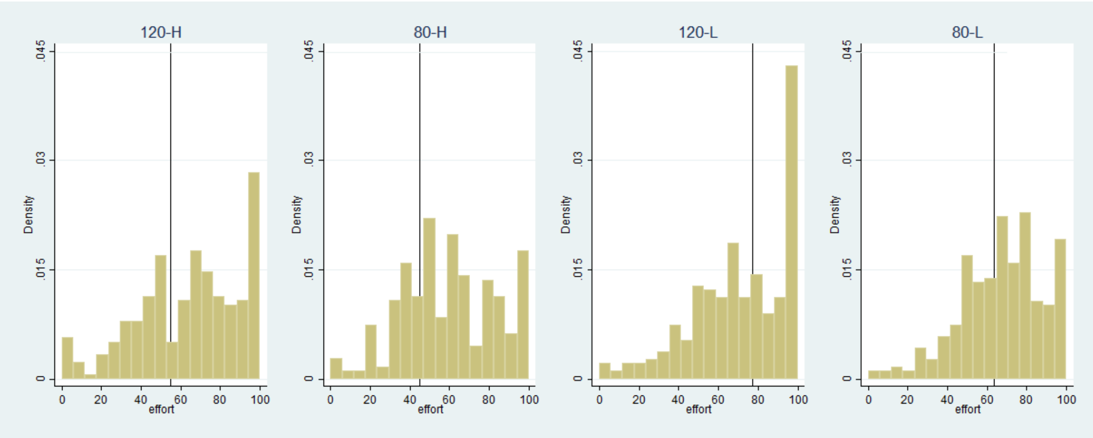
[30] To check whether the subjects' efforts in our experiment can be explained by utility of winning, we add an individual contest with value of 0. However, in the regression analysis, we do not find a significant effect on players' effort levels (see Table 5.2).

[31] To examine the effect of risk, we elicit players' risk preferences in our experiment by using a similar procedure as Holt and Laury (2002). However, we do not find a significant effect on effort levels in the regression analysis (see Table 5.2).

120 marginally significantly decrease from 70.97 to 64.28 while noise variance increases (one-tailed Wilcoxon test, p-value = 0.012, and p-value = 0.095, respectively). When the same comparison is made with data from periods 6 through 10, we find that efforts of individuals with valuations of 120 and 80 significantly decrease as noise variance rises, as theoretically predicted (one-tailed Wilcoxon test, p-value = 0.029 and p-value = 0.047, respectively). Even though all individuals with valuations of 120 and 80 significantly decrease their efforts with noise variance according to the non-parametric tests, we will show in the regression analysis that controlling for other independent variables leads to a significant effect of noise variance only on efforts of individuals with valuations of 80.

Our model predicts that given the noise variance, individuals with valuations of 120 exert more effort than individuals with valuations of 80 in individual contests. In high noise variance (IND-H), individuals with valuation of 120 exert marginally significantly higher effort than individuals with prize of 80 (one-tailed Wilcoxon test, p-value = 0.097). However, in periods 6 through 10, efforts of individuals with the valuation of 120 are not significantly different from the efforts of individuals with the valuation of 80 (one-tailed Wilcoxon test, p-value = 0.30). When the noise variance is low (IND-L) in Table 5.1, the efforts of individuals whose prize valuation is 120 are not significantly different from those of individuals with a prize of 80 (one-tailed Wilcoxon test, p-value = 0.23). A number of empirical studies (Bull et al., 1987; Schotter & Weigelt, 1992; van Dijk et al., 2001; Harbring & Lünser, 2008; Delfgaauw et al., 2013) find that effort in tournaments increases with the prize spread. Contrary to these findings, we do not find the effect of prize value on effort levels in individual contests. One possible explanation for this behavior could be peer-induced rank-based utility (Hossain et al., 2019). Since in our individual contest part, it is common knowledge that there are two competing pairs that differ according to prize value, individuals may have a desire to be better than other players in other competing groups even though they are not paid according to such performance. Using different prize valuations is the only difference from the study of Cason et al. (2020).

Result 1. *Contrary to the prediction, given the noise variance, there is no difference between the efforts of individuals who compete for prizes of 120 and 80 in individual contests.*



Note: The vertical lines show their equilibrium predictions.

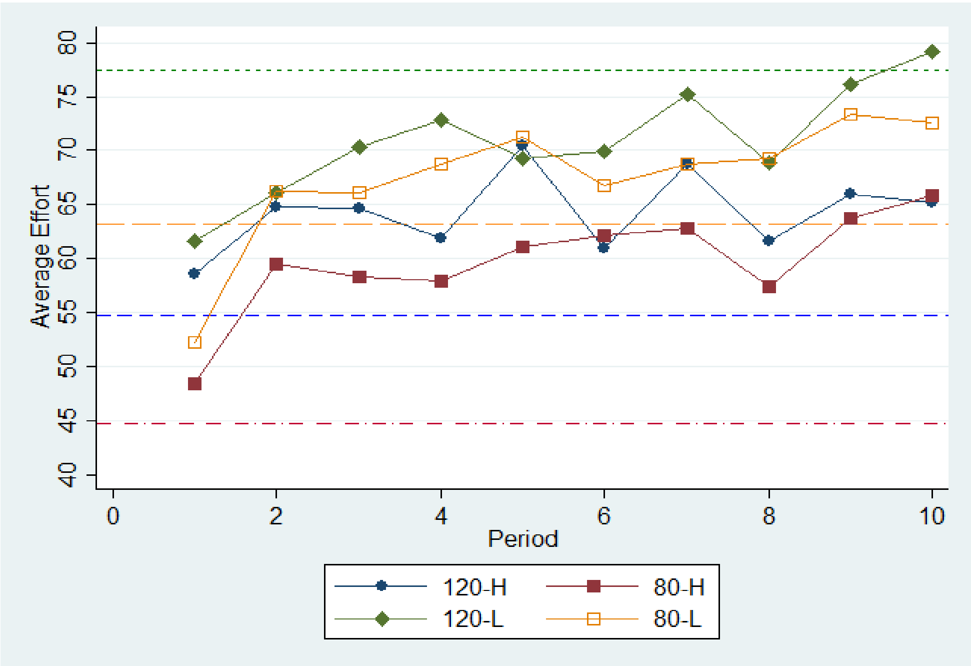
Figure 5.1 Distribution of Efforts in Individual Contests

Figure 5.1 demonstrates the distribution of efforts made by subjects in high and low noise variances. Efforts of individuals with valuations of 120 and 80 are distributed on the entire levels although we expect a pure strategic Nash equilibrium prediction. Based on Figure 5.1, except for individuals with the valuations of 120 in low noise variance, more than 60% of efforts in each case are higher than the equilibrium predictions, restating significant overbidding found above.[32] According to Kolmogorov-Smirnov test, when the prize valuation is 120, the distribution of effort levels do not significantly differ in high and low noise variances (ksmirnov test, p-value = 0.51). In contrast, when the prize valuation is 80, the distribution of effort levels significantly differs in high and low noise variances (ksmirnov test, p-value = 0.03). Given the noise variance, the distribution of effort levels of individuals with

[32] 63.67% and 73% of efforts of individuals with valuations of 120 and 80, respectively, are above the equilibrium predictions in high noise variance. 60.31% of efforts of individuals with valuations of 80 in low noise variance are higher than the equilibrium. However, only 44.69% of efforts of individuals with valuations of 120 are higher than the equilibrium in low noise variance.

valuations of 120 and those of individuals with valuations of 80 do not significantly differ (ksmirnov test, p-value = 0.59 in high noise variance, and p-value = 0.43 in low noise variance).

Figure 5.2 displays the average efforts of individuals over 10 periods of individual contest with high and low noise variances. In high noise variance, a correlation between the period and efforts of individuals with the valuation of 120 is not significant (Spearman's correlation coefficient, ρ, is 0.05, p-value = 0.37). In the rest of the treatments (120-L, 80-H, and 80-L), the correlation between the period trend and efforts of individuals is significant and positive (Spearman's correlation coefficient, $\rho > 0.15$, p-value < 0.01 for all cases).



Note: The horizontal dashed lines in the same color show their equilibrium predictions.

Figure 5.2 Individual Efforts over Time

We use a set of multivariate regressions shown in Table 5.2. The dependent variable is effort levels expended by contestants. Specification (1) uses the data from individuals with valuations of 120, and specification (2) uses the data from individuals with valuations of 80. The independent variables are the following:[33] *noise-variance* is a treatment dummy variable taking of the value 1 if the noise variance is high. *utility-of-winning* is the effort level exerted to win a prize of 0. *risk-averse* is a dummy variable equal to 1 if a subject exhibits risk aversion in the lottery choices.[34] *male* is a dummy variable equal to 1 if a subject's gender is male. *period* is the period trend to allow us to observe time effects.

According to regression results shown in Table 5.2, the *noise-variance* variable significantly reduces the efforts of individuals with the valuation of prize 80. Contrary to the theoretical prediction, there is no significant effect of noise variance on effort levels of individuals with the valuation of 120. Unlike earlier studies (Sheremeta, 2010; Cason et al., 2020), the *utility-of-winning* variable is not significant for each subject.[35] Previous experimental studies on the rank-order tournaments have found that risk-averse players expend less effort (Millner & Pratt, 1991; Eisenkopf & Teyssier, 2013; Shupp et al., 2013; Cason et al., 2020).[36] The *risk-averse* variable is negative but not significant for individuals with valuations of 120 and 80, which contradicts with the earlier studies. Lastly, *male* players with valuations of 80 exert significantly lower effort than female players with valuations of 80.

[33] These independent variables are used for every regression analysis throughout the study.

[34] If a subject is risk-averse, then the number of safe options picked in the lottery choices is higher than 8. Table C.2 in Appendix C reports the distribution of the total number of safe lottery options chosen by all subjects in the experiment.

[35] As seen in Table C.1 in Appendix C, almost 75% of subjects exert positive efforts in the 0-prize contest. However, there is no significant correlation between efforts for a prize of 0 and efforts for contest prizes in both high and low noise variances.

[36] In our data, 34 (27.42%) subjects' risk preferences are inconsistent since they switch between safe and risky options multiple times. Even if we exclude these subjects from our data, we do not find a significant effect of risk aversion on effort.

Table 5.2 Regression of Efforts in Individual Contests

	120	80
Dependent variable, effort	(1)	(2)
noise-variance	-6.516	-8.696***
(1 if noise variance is high)	(4.518)	(3.096)
utility-of-winning	-0.014	0.006
(effort for prize of 0)	(0.0680)	(0.0434)
risk-averse	-0.823	-2.599
(1 if number of safe option A > 8)	(4.388)	(3.098)
male	2.429	-5.637*
(1 if gender is male)	(4.262)	(3.185)
period	0.907***	1.339***
	(0.341)	(0.387)
constant	65.20***	64.10***
	(4.717)	(3.566)
R^2	0.031	0.078
Observations	620	620
Number of clusters	62	62

Standard errors in parentheses are clustered at the subject level. *0.10, **0.05, ***0.01

Result 2. *Consistent with the theoretical prediction, efforts of individuals with valuations of 80 decrease as the noise variance rises. However, there is no effect of noise on the effort levels of individuals with valuations of 120, which contradicts the prediction.*

While the noise parameter α goes to ∞ in our model, the effort level should be 0. Effort levels indeed decrease with the noise variance when the prize value is low. However, we do not observe such an effect when the prize value is high. It may also be the case in real-world contests.[37] For instance, in crowdsourcing contests, there are an unknown number of subjects and a large degree of noise to decide the winner

[37] Open-ended scientific problems, R&D studies, innovation contests executed by DARPA or QVC can be some examples of such contests.

(Hammon & Hippner, 2012; for the review of the literature on crowdsourcing contests, see Segev, 2020), but the effort is still positive in these.

Now, we look at how individuals respond dynamically to feedback given for the previous period. Note that participants in individual contests learn only their own efforts, their own final performance, and whether they won or lost. Table 5.3 presents estimates of a regression model in which we control the past experience. Specification (1) uses only the data from individuals with valuations of 120, and specification (2) uses only the data from individuals with valuations of 80. The dependent variable is effort levels expended by individuals and independent variables are the following. *effort-lag* is own effort in period t-1. *number-lag* is own personal random number in period t-1. *win-lag* is an indicator for whether players won in period t-1. Lastly, *period* is time trend.

Table 5.3 Dynamics of Efforts in Individual Contests

	120	80
Dependent variable, effort	(1)	(2)
effort-lag	0.567*** (0.0625)	0.476*** (0.0637)
number-lag	3.982 (2.606)	3.164 (1.933)
win-lag	-4.094* (2.289)	-2.371 (1.811)
period	0.154 (0.235)	0.084 (0.293)
constant	27.69*** (5.000)	32.68*** (4.064)
R^2	0.297	0.214
Observations	558	558
Number of clusters	62	62

Standard errors in parentheses are clustered at the subject level. *0.10, **0.05, ***0.01

As seen in Table 5.3, the *effort-lag* variable indicates that individuals with valuations of 120 and 80 significantly increase their current efforts according to their previous effort levels. Similar to our result, Cason et al. (2020) also find that the *effort-lag* variable is positive and significant to the players' efforts. The *number-lag* variable is positive but not significant for each player. The *win-lag* variable is negatively related to the effort choices of individuals with valuations of 120.[38]

5.2 Group Contests

We investigate how random noise and prize valuation parameters affect efforts in perfect-substitutes contests (in Subsection 5.2.1), best-shot contests (in Subsection 5.2.2), and weakest-link contests (in Subsection 5.2.3). All group contests are *symmetric*, and each group consists of two *heterogeneous* players, one strong player with a valuation of 120 and one weak player with a valuation of 80, which is common knowledge.

5.2.1 Perfect-Substitutes Contests

Table 5.4 shows efforts of each player for the 2nd half and all periods in perfect-substitutes contests. First, we check whether players' actual efforts are consistent with the theoretical predictions. When the noise variance is low (PS-L), the strong players' average effort of 71.93 is not significantly different from the equilibrium effort of 60.00 (t-test, p-value = 0.119). However, the weak players' average effort of 62.18 is significantly higher than the equilibrium of 40.0 (t-test, p-value = 0.008). In high noise variance (PS-H), strong players expend average effort of 70.23 and weak ones exert average effort of 69.04, which are significantly higher than the equilibrium efforts of 42.43 and 28.28, respectively (t-test, p-value < 0.001 and p-value = 0.0, respectively). We also notice that there is a high variation in players' efforts, especially in low noise variance treatment. These high standard deviations show players do not exert efforts according to Nash equilibrium predictions.

[38] When we add interactions of lag variables and noise variance in the regression analysis, we find these effects do not differ as noise variance changes according to the interaction terms.

Table 5.4 Average Efforts for 2nd Half and All Periods in Perfect-Substitutes Contests

	High Noise Variance		Low Noise Variance	
Player	Strong	Weak	Strong	Weak
Equilibrium	42.43	28.28	60.0	40.0
All Periods	70.23 (14.59)	69.04 (14.36)	71.93 (21.92)	62.18 (20.55)
Period 6 - 10	76.72 (14.62)	71.0 (13.86)	69.16 (32.81)	63.81 (26.61)

Standard deviations are in parentheses.

In the literature, there have been three different explanations for significant over-expenditure of efforts in group contests (Sheremeta, 2018b). The first explanation is that individuals can be overly competitive in a simple individual contest (Millner & Pratt, 1989, 1991; Sheremeta, 2013, 2015, 2016). Such over competition between individuals could lead to over-expenditure of efforts in group contests by enhancing between-group competition. Another explanation for over-expenditure of efforts is that individuals could be more cooperative when they participate in social dilemmas and collective action games, such as public good games (Ledyard, 1995; Chaudhuri, 2011). Such overly cooperation could increase players' effort levels in a group. Lastly, the most likely explanation for the over-expenditure of efforts in group contests is social group identity (Tajfel & Turner, 1979; Akerlof & Kranton, 2000; Chen & Li, 2009; Sutter, 2009; Chowdhury et al., 2016). According to this explanation, individuals may identify themselves as part of a group (Kugler et al., 2010), and this recognition leads them to focus on altruistic group-maximizing behavior instead of individual self-interest. These explanations are acceptable for our perfect-substitutes contests.[39]

[39] In addition to these explanations, Sheremeta (2011b) also claim that non-monetary of winning and receiving a free endowment in each period could also explain the significant over-expenditure of efforts in perfect-substitutes contests. However, according to the regression analysis in Table 5.5, we do not find a significant effect of utility of winning on players' effort levels.

Now, we examine the impact of noise variance on the player's efforts in perfect-substitute contests. In Table 5.4, although strong players' average efforts decrease from 71.93 to 70.23, this difference is not significant (one-tailed Wilcoxon test, p-value = 0.33). Weak players' average efforts increase from 62.18 to 69.04, but this increase is not significant (one-tailed Wilcoxon test, p-value = 0.25). In the last 5 periods, strong and weak players' efforts do not significantly differ with noise variance (one-tailed Wilcoxon test, p-value = 0.94 and p-value = 0.76, respectively). Under both noise variances, there may be a utility for each player that comes from the social group identity. This utility may not change with noise variance and may be higher than the negative effect of random noise. As a result, we cannot observe a significant effect of noise variance on both players' effort levels in perfect-substitutes contests.

The model predicts that given the noise variance, strong players exert higher efforts than weak players in perfect-substitutes contests. In high and low noise variances (PS-H and PS-L), strong players' efforts are not significantly different from weak players' efforts (one-tailed Wilcoxon test, p-value = 0.38 and p-value = 0.18, respectively). There are two conflicting findings about the role of prize valuations on players' effort in perfect-substitutes contests. The first finding is similar to ours; weak players exert as much effort as strong players. For example, Katayama and Nuch (2011) examine the casual effect of within-group salary disparity on group performance by using the game-level data on NBA. They report that salary dispersion does not affect the group performance, so group members' effort does not differ by their salaries. Chen and Lim (2017) use an additive noise variable at the individual level and introduce heterogeneity in a group as a constant ability endowment. Despite being different from our model, they also find that the efforts of strong and weak players are not significantly different in perfect-substitutes contests. The second one is that strong players exert more than weak players, as in the theoretical prediction. Sheremeta (2011b) find that strong players' effort choices are higher than weak players' efforts under the Tullock contest success function.

Result 3. *Contrary to the theoretical prediction, given the noise variance, strong and weak players' efforts do not differ in perfect-substitutes contests.*

Table 5.5 reports the regression results. Specification (1) uses the data from strong players, and specification (2) uses the data from weak players. For every group contest regression analysis, we cluster standard errors at the group level, where two players within group are counted as one observation.[40] The estimation results of the *noise-variance* restate the findings of non-parametric tests found above. That is, there is no significant effect of noise variance on efforts of strong and weak players in perfect-substitutes contests.

Table 5.5 Regression of Efforts in Perfect-Substitutes Contests

	Strong	Weak
Dependent variable, effort	(1)	(2)
noise-variance	-1.456	7.221
(1 if noise variance is high)	(8.291)	(10.68)
utility-of-winning	-0.147	0.011
(effort for prize of 0)	(0.128)	(0.107)
risk-averse	8.432	0.474
(1 if number of safe option A > 8)	(7.908)	(11.01)
male	-4.478	1.895
(1 if gender is male)	(8.644)	(7.711)
period	0.704	0.643
	(0.886)	(0.694)
constant	70.86***	56.92***
	(9.695)	(14.05)
R^2	0.052	0.027
Observations	200	200
Number of clusters	20	20

Standard errors in parentheses are clustered at the group level. *0.10, **0.05, ***0.01

[40] We used partner-matching procedure, i.e., participants competed with the same group member and opponent group during the group contests.

Result 4. *Contrary to the prediction, there is no effect of noise variance on both strong and weak players' efforts in perfect-substitutes contests.*

5.2.2 Best-Shot Contests

Table 5.6 summarizes the effort levels of each player for the 2nd half and all periods in best-shot contests. Strong players expend average efforts of 50.04 in high noise variance (BS-H) and 76.49 in low noise variance (BS-L). These effort levels are not significantly different from the equilibrium effort of 54.77 and 77.46, respectively (t-test, p-value = 0.45 and p-value = 0.87, respectively). However, weak players exert an average effort of 51.86 in BS-H and 65.81 in BS-L, which are significantly higher than the equilibrium efforts of 0 in both high and low noise variances (t-test, p-value < 0.001 and p-value = 0.00, respectively).

Table 5.6 Average Efforts for 2nd Half and All Periods in Best-Shot Contests

	High Noise Variance		Low Noise Variance	
Player	Strong	Weak	Strong	Weak
Equilibrium	54.77	0.0	77.46	0.0
All Periods	50.04 (18.87)	51.86 (26.67)	76.49 (18.28)	65.81 (17.99)
Period 6 - 10	50.67 (23.35)	48.32 (31.72)	74.18 (18.0)	60.78 (26.13)

Standard deviations are in parentheses.

To overcome potential coordination problems in group contests, we have group members with different prize valuations. As in our theoretical model, Sheremeta (2011b) finds that if a group has heterogeneous players in best-shot contests under Tullock lottery contest success function, the player with high prize valuation exerts positive efforts, and the rest of the players with low valuations tend to free-ride.[41]

[41] Sheremeta (2011b) finds that only 28% of weak players' efforts are above the 0-effort in best-shot contests, while this percentage is 70 in perfect-substitutes contests.

We also predict a similar result for rank-order best-shot group contests. Contrary to the literature and our predictions, we observe that weak players exert positive efforts instead of free-riding.[42] Chen and Lim (2017) also observe a positive effort level from weak players in best-shot contests (an average of 21.7 out of 100). They claim that it is because weak players do not want to feel psychologically averse to contributing 0-effort to their group. In addition to that, we believe that it is because weak players try to encourage strong players to exert more effort by showing that they are also paying a certain amount of cost.

For the impact of noise variance on efforts in best-shot contests, our model predicts that only strong players decrease their efforts as noise variance rises. In Table 5.6, the average effort of strong players significantly decreases from 76.49 to 50.04 (one-tailed Wilcoxon test, p-value = 0.006). Weak players' average efforts decrease from 65.81 to 51.86, but this difference is not significant (one-tailed Wilcoxon test, p-value = 0.163). When we make the same comparison for the last 5-period, these results persist (one-tailed Wilcoxon test, p-value = 0.012 for strong players, and p-value = 0.182 for weak players). Although weak players' efforts do not significantly decrease with noise variance, we find a significant effect of noise variance on the efforts of both strong and weak players in the regression analysis that also controls for other independent variables.

Our model predicts that given the noise variance, strong players exert more effort than weak players in best-shot contests. As seen in Table 5.6, in low noise variance (BS-L), strong players' average effort of 76.49 is marginally significantly higher than weak players' average effort of 65.81 (one-tailed Wilcoxon test, p-value = 0.099). In high variance (BS-H), there is no significant difference between strong and weak players' efforts (one-tailed Wilcoxon test, p-value = 0.33). Periods 6 through 10, strong players' average efforts are not significantly different from weak players' average efforts in high and low noise variances (one-tailed Wilcoxon test, p-value = 0.44 and p-value = 0.11, respectively). Even though Sheremeta (2011b) and Chen and Lim (2017) use different contest models in their studies, they find that

[42] In total, 7.5% of weak players exert 0-effort in best-shot contests.

strong players' efforts are higher than weak players' effort in best-shot contests. Sheremeta (2011b) reports that weak players tend to free-ride while most of the positive effort is exerted by strong players in best-shot contests under the Tullock contest success function. The reason why the behavior of the weak players in our study differs from Sheremeta's (2011b) is that each group has only one weak player instead of two weak players. This may lead to an increase in pressure on weak players in our game compared to his.

Result 5. *Contrary to the theoretical prediction, given the noise variance, strong and weak players' effort choices do not differ in best-shot contests.*

Table 5.7 Regression of Efforts in Best-Shot Contests

	Strong	Weak
Dependent variable, effort	(1)	(2)
noise-variance	-26.05***	-18.53***
(1 if noise variance is high)	(7.706)	(6.310)
utility-of-winning	0.146	0.274***
(effort for prize of 0)	(0.102)	(0.0790)
risk-averse	0.944	-8.678
(1 if number of safe option A > 8)	(8.105)	(6.330)
male	-12.30	-19.72**
(1 if gender is male)	(7.275)	(8.198)
period	-0.691	-1.413*
	(0.542)	(0.729)
constant	83.20***	80.29***
	(7.071)	(6.673)
R^2	0.276	0.355
Observations	200	200
Number of clusters	20	20

Standard errors in parentheses clustered at the group level. *0.10, **0.05, ***0.01.

According to the estimation result of *noise-variance* in Table 5.7, both strong and weak players' efforts significantly decrease as the noise variance increases. The *utility-of-winning* variable is associated with higher effort for strong and weak players, whereas the estimation is significant only for weak ones. Weak *male* players exert significantly lower effort than weak female players. Finally, based on the result of *period* variable, weak players significantly decrease their efforts over time, but not strong players.

Result 6. *According to regression results, strong and weak players' efforts decrease as noise variance rises in best-shot contests.*

5.2.3 Weakest-Link Contests

Table 5.8 reports the efforts of each player for the 2nd half and all periods in weakest-link contests. In weakest-link contest with high noise variance (WL-H), strong players' average effort of 67.79 and weak players' effort of 58.49 are significantly higher than the equilibrium efforts of 44.72 for both players (t-test, p-value = 0.001 and p-value = 0.004, respectively). When the noise variance is low (WL-L), the strong players' average effort is 67.14, and weak players' average effort is 64.87, which are not significantly different from the equilibrium prediction of 63.25 for both of them (t-test, p-value = 0.35 and p-value = 0.58, respectively).

Table 5.8 Average Efforts for 2nd Half and All Periods in Weakest-Link Contests

	High Noise Variance		Low Noise Variance	
Player	Strong	Weak	Strong	Weak
Equilibrium	44.72	44.72	63.25	63.25
All Periods	67.79 (15.83)	58.49 (11.50)	67.14 (13.80)	64.87 (9.83)
Period 6 - 10	67.82 (17.25)	58.80 (13.37)	70.20 (16.44)	67.78 (10.81)

Standard deviations are in parentheses.

We investigate the impact of noise variance on players' efforts in the weakest-link contests. In Table 5.8, strong players' average efforts increase from 67.14 to 67.79

as noise variance rises, which is not significant (one-tailed Wilcoxon test, p-value = 0.49). Weak players' average efforts decrease from 64.87 to 58.49 as noise variance rises, yet it is not significant (one-tailed Wilcoxon test, p-value = 0.12). In the last 5 periods, weak players' average effort marginally significantly decreases as noise variance increases (one-tailed Wilcoxon test, p-value = 0.07), yet the effect of random noise on strong players' efforts is still not observed (one-tailed Wilcoxon test, p-value = 0.39). According to the regression analysis which also controls other independent variables, we do not find a significant effect of noise variance on strong and weak players' effort choices in weakest-link contests.

Our model predicts that given the noise variance, strong and weak players' effort levels do not differ in weakest-link contests. As seen in Table 5.8, there is no significant difference between strong and weak players' actual efforts in high and low noise variances (one-tailed Wilcoxon test, p-value = 0.11 and p-value = 0.35, respectively). This finding implies that strong and weak players commonly coordinate their efforts under both noise variances. By using Tullock success function and comparing effort levels across group contests, Sheremeta (2011b) also find strong and weak players exert similar effort. Although Chen and Lim (2017) use rank-order group contests as we do, the results are different. They find that strong players expend lower effort than weak players in the weakest-link contest. Unlike our study, the random noise in their paper is additive and applied independently to each group member's effort choices.

Result 7. *As predicted, given the noise variance, strong and weak players' efforts are not different in weakest-link contests.*

Table 5.9 reports the regression results. There is no significant effect of *noise-variance* on both strong and weak players' effort choices. The *utility-of-winning* variable is systematically associated with higher effort of strong players. The *risk-averse* variable is not significant for either strong or weak players. The *period* variable is positively related to effort choices, but it affects only weak players' efforts significantly.

Result 8. *Contrary to theoretical predictions, there is no effect of noise variance on both strong and weak players' efforts in weakest-link contests.*

Table 5.9 Regression of Efforts in Weakest-Link Contests

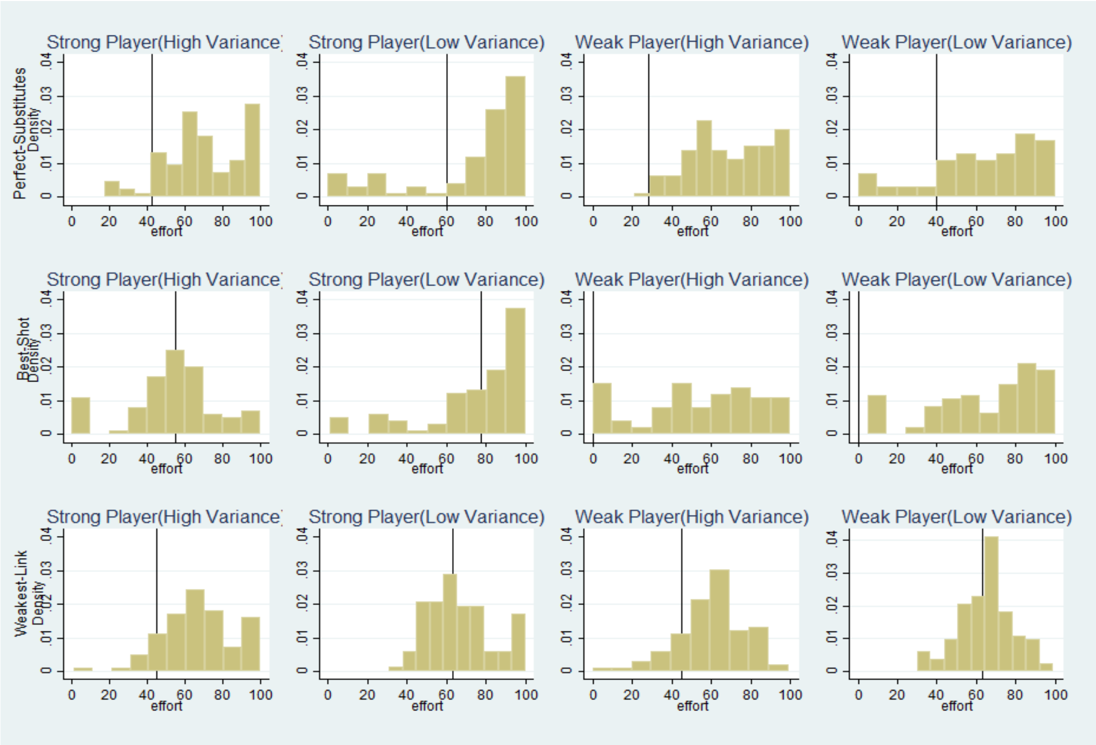
	Strong	Weak
Dependent variable, effort	(1)	(2)
noise-variance	1.387	-5.716
(1 if noise variance is high)	(5.617)	(4.284)
utility-of-winning	0.132*	0.093
(effort for prize of 0)	(0.0723)	(0.0619)
risk-averse	2.574	0.432
(1 if number of safe option A > 8)	(7.076)	(4.809)
male	-6.005	-5.720
(1 if gender is male)	(6.147)	(4.739)
period	0.531	0.793*
	(0.390)	(0.395)
constant	60.48***	57.98***
	(7.586)	(4.148)
R^2	0.137	0.135
Observations	220	220
Number of clusters	22	22

Standard errors in parentheses are clustered at the group level. *0.10, **0.05, ***0.01

5.2.4 Comparison of Group Contest Structures

Figure 5.3 presents histograms of efforts of all players in different types of group contests.[43] We observe in the first row that given the noise variance, strong and weak players exert substantial efforts according to the equilibrium in perfect-substitutes

[43] The average efforts of each player in all group contests are summarized in Table C.3 in Appendix C.



Note: In the first line, distribution of strong and weak players' efforts in perfect-substitutes contests with high and low noise variances. Similarly, distribution of all players' efforts in the second line for best-shot contests and in the last line for weakest-link contests.

Figure 5.3 Distribution of Efforts in Group Contests

contests. As seen in the second row, contrary to the theoretical prediction, weak players' efforts are positive in best-shot contests under both noise variances. Even if there are positive effort levels, more of weak players generate 0-effort in best-shot contests than other group contests.[44] Strong players' most common effort choice is around the equilibrium prediction in high noise variance, but not in low noise variance. In the last row of Figure 5.3, strong and weak players coordinate their efforts at higher than the equilibrium prediction in weakest-link contests with high noise variance, and both strong and weak players have an over-expenditure of effort. Similar coordination is observed in low noise variance. However, this time the over-

[44] 5% of weak players in PS-L, 15% of weak players in BS-H, and 1% of weak players in WL-H exert 0-effort. In PS-H, BS-L, and WL-L, none of the weak players expend 0-effort.

expenditure is lowered, and their effort levels come closer to the equilibrium.[45] We use a Kolmogorov-Smirnov test to compare the distributions of effort choices across group contests. In high noise variance, the distribution of strong players' efforts in best-shot contests is significantly different from those in perfect-substitutes and weakest-link contests (ksmirnov test, p-value = 0.055 for both cases). Except for those, the differences across groups are not significantly different (ksmirnov test, p-value > 0.1).[46]

Next, we consider how groups respond dynamically to the observed outcomes of the previous period. Recall that players learn their own efforts, their group member's efforts, their group performance, and whether they won or lost. In Table 5.10, we present a regression model in which we control the past experience for each group contest. Specifications (1) and (2) use the data that come from perfect-substitutes contests for strong and weak players, respectively. Specifications (3) and (4) use the data that come from best-shot contests for strong and weak players, respectively. Specifications (5) and (6) use the data that come from weakest-link contests for strong and weak players, respectively. In addition to the independent lag variables identified in the previous section, the definition of *number-lag* changes to group random number in period t-1 instead of personal random number; *othereffort-lag* is defined as other group member's effort in period t-1.

According to the regression results in Table 5.10, the *effort-lag* variable indicates that strong and weak players' effort choices in the current period is strongly associated with their previous period efforts in all group contests. The *othereffort-lag* variable is significant only for strong and weak players in weakest-link contests. The finding suggests that players efficiently use the feedbacks for coordination in weakest-link contests. The *number-lag* variable is positively related to the effort

[45] These interpretations are according to the mode of efforts in each case.

[46] If we compare distribution of efforts by noise variance for a given group contest and player type, we find that the distribution of strong players' effort significantly differs with the noise variance in best-shot contests, but not the distribution of weak players' effort (ksmirnov test, p-value = 0.06, and p-value = 0.76, respectively).

choices of weak players in best-shot contests and those of strong players in weakest-link contests. It is negatively related to weak players' efforts in perfect-substitutes contests. The *win-lag* significantly and negatively affects weak players' efforts in perfect-substitutes contests and strong players' efforts in weakest-link contests.

Table 5.10 Dynamics of Efforts in Group Contests

	PS		BS		WL	
	Strong	Weak	Strong	Weak	Strong	Weak
Dependent variable, effort	(1)	(2)	(3)	(4)	(5)	(6)
effort-lag	0.657***	0.628***	0.654***	0.569***	0.661***	0.451***
	(0.0998)	(0.0625)	(0.116)	(0.150)	(0.125)	(0.0816)
othereffort-lag	0.149	0.146	-0.012	0.149	0.300**	0.230***
	(0.114)	(0.121)	(0.0901)	(0.134)	(0.119)	(0.0596)
number-lag	-6.353*	3.637	0.248	7.679*	3.699*	1.967
	(3.274)	(3.382)	(3.996)	(4.128)	(1.939)	(1.850)
win-lag	2.281	-7.099*	-4.216	-6.212	-6.619***	-0.264
	(4.186)	(3.858)	(2.445)	(5.154)	(2.288)	(1.916)
period	0.431	-0.356	-0.310	-0.776	0.043	-0.291
	(0.595)	(0.417)	(0.570)	(0.472)	(0.283)	(0.346)
constant	17.53	17.16**	25.08**	15.17	3.764	19.66***
	(10.28)	(6.482)	(8.984)	(11.83)	(5.706)	(5.650)
R^2	0.465	0.380	0.388	0.339	0.508	0.353
Observations	180	180	180	180	198	198
Number of clusters	20	20	20	20	22	22

Standard errors in parentheses are clustered at the group level. *0.10, **0.05, ***0.01

5.3 Comparison of Individual and Group Contests

Our experiment's main aim is to show whether the variance of random noise affects group members' efforts in individual and group contests differently. Since each subject participated in individual and group contests, we can analyze the data using a within-subject comparison.

Table 5.11 Average Efforts in Individual and Perfect-Substitutes Contests

	High Noise Variance		Low Noise Variance	
Valuation of Prize	120	80	120	80
IND	63.25 (18.38)	61.70 (11.30)	72.35 (23.28)	65.96 (8.31)
PS	70.23 (14.59)	69.04 (14.36)	71.93 (21.92)	62.18 (20.55)

Standard deviations are in parentheses.

Table 5.11 shows efforts for each player in individual and perfect-substitutes contests. Our model predicts that given the noise variance, each subject exerts lower effort in perfect-substitutes contests than individual contests. In high noise variance, there is no significant difference between efforts of subjects with valuation of 120 in individual and perfect-substitutes contests (two-tailed Mann-Whitney U-test, p-value = 0.65). Subjects with valuation of 80 exert marginally significantly lower efforts in individual contests than in perfect-substitutes contests (two-tailed Mann-Whitney U-test, p-value = 0.08). When the noise variance is low, efforts of subjects with valuations of 120 and 80 in individual contests are not significantly different from strong and weak players' efforts in perfect-substitutes contests (two-tailed Mann-Whitney U-test, p-value = 0.76 and p-value = 0.51, respectively).

Table 5.12 Average Efforts in Individual and Best-Shot Contests

	High Noise Variance		Low Noise Variance	
Valuation of Prize	120	80	120	80
IND	59.32 (17.45)	62.62 (19.04)	79.14 (12.34)	71.64 (15.34)
BS	50.04 (18.87)	51.86 (26.67)	76.49 (18.28)	65.81 (17.99)

Standard deviations are in parentheses.

Table 5.12 summarizes the average effort levels of each player in individual and best-shot contests. In high noise variance, the average efforts of subjects with valuations of 120 and 80 in individual contests are marginally significantly higher than in best-shot contests (two-tailed Mann-Whitney U-test, p-value = 0.09 and p-value = 0.07, respectively). In contrast, in low noise variance, there is no significant difference between the average efforts of subjects with valuations of 120 and 80 in individual and best-shot contests (two-tailed Mann-Whitney U-test, p-value = 0.65 and p-value = 0.28, respectively).

Table 5.13 Average Efforts in Individual and Weakest-Link Contests

	High Noise Variance		Low Noise Variance	
Valuation of Prize	120	80	120	80
IND	70.27 (4.39)	54.79 (11.67)	63.01 (13.39)	65.43 (10.35)
WL	67.79 (15.83)	58.49 (11.50)	67.14 (13.80)	64.87 (9.83)

Standard deviations are in parentheses.

Table 5.13 reports average efforts for each subject in individual and weakest-link contests. In high noise variance, efforts of subjects with valuations of 120 and 80 in individual contest are not significantly different from strong and weak players' efforts in weakest-link contests (two-tailed Mann-Whitney U-test, p-value = 0.65 and p-value = 0.20, respectively). Similarly, in low noise variance, efforts of subjects with valuations of 120 and 80 in individual contests are not significantly different from strong and weak players' efforts in weakest-link contests (two-tailed Mann-Whitney U-test, p-value = 0.26 and p-value = 0.64, respectively).

We also conduct a set of multivariate regressions by using effort choices as a dependent variable. In Table 5.14, specifications (1) and (2) show the estimation results of effort choices from individual contests to perfect-substitutes contests

(IND-PS) for subjects with high and low prize valuations, respectively. Specifications (3) and (4) show the estimation results of effort choices from individual contests to best-shot contests (IND-BS) for subjects with high and low prize valuations, respectively. Lastly, specifications (5) and (6) show the estimation results of effort choices from individual contests to weakest-link contests (IND-WL) for subjects with high and low prize valuations, respectively. In addition to independent variables used in individual and group contests, we use treatment dummy variables, i.e., *ps-contest*, *bs-contest*, and *wl-contest*, and their interactions with the noise variance. If data come from *ps-contest*, *bs-contest,* and *wl-contest*, these dummy treatment variables equal to 1. We cluster the standard errors at the subject level.[47]

In Table 5.14, we can see that as *noise-variance* rises, individuals with valuations of 120 and 80 significantly decrease their efforts in IND-BS. Additionally, efforts of players with valuations of 80 significantly decrease in IND-WL as noise variance increases. According to the estimation results of *ps-contest*, *bs-contest,* and *wl-contest*, in all group contests, subjects exert effort as much as in individual contests. The result of *ps-contest*noise-variance* variable indicates that in high noise variance, individuals with the valuation of 80 exert significantly higher effort from individual contests to perfect-substitutes contests. The *utility-of-winning* variable is positively associated with effort levels of players with valuations of 80 in IND-BS. The *risk-averse* variable is negatively related to efforts of players with valuations of 80 in IND-BS. The efforts of *male* players with valuations of 80 are significantly lower than those of female players with valuations of 80 in IND-BS. The *period* variable is systematically associated with higher effort choices of players with valuations of 120 in IND-WL, players with valuations of 80 in both IND-PS.

Result 9. *Contrary to the prediction, efforts of players do not differ from individual contests to group contests.*

[47] In group contests, each group has one player with a valuation of 120 and one player with a valuation of 80. To observe each player's behavior from individual contests to group contests, we cluster the standard errors at the subject level.

Table 5.14 Regression of Efforts from Individual Contests to Group Contests

	IND-PS		IND-BS		IND-WL	
	120	80	120	80	120	80
Dependent variable, effort	(1)	(2)	(3)	(4)	(5)	(6)
noise-variance (1 if noise variance is high)	-7.261 (8.602)	-4.066 (6.456)	-19.21*** (6.535)	-14.06* (6.789)	7.809 (5.700)	-10.37* (5.098)
ps-contest (1 if contest is perfect-substitutes)	-0.422 (7.230)	-3.782 (5.227)	-	-	-	-
ps-contest noise-variance*	7.411 (10.46)	11.12* (6.213)	-	-	-	-
bs-contest (1 if contest is best-shot)	-	-	-2.655 (4.094)	-5.830 (6.031)	-	-
*bs-contest *noise-variance*	-	-	-6.629 (5.665)	-4.930 (7.567)	-	-
wl-contest (1 if contest is weakest-link)	-	-	-	-	4.133 (3.037)	-0.567 (3.164)
*wl-contest*noise-variance*	-	-	-	-	-6.615 (5.912)	4.264 (4.379)
utility-of-winning (effort for prize of 0)	-0.150 (0.119)	-0.031 (0.0786)	0.121 (0.0830)	0.207** (0.0754)	0.085 (0.0678)	0.045 (0.0543)
risk-averse (1 if number of safe option A > 8)	6.457 (6.064)	0.276 (8.124)	-2.020 (7.212)	-9.721* (5.179)	3.496 (6.044)	0.726 (4.248)
male (1 if gender is male)	1.331 (7.416)	0.144 (5.599)	-7.865 (6.189)	-15.00** (6.526)	-2.442 (5.700)	-2.876 (4.059)
period	0.817 (0.478)	1.502*** (0.489)	-0.0798 (0.460)	-0.0074 (0.520)	0.880* (0.425)	0.574 (0.363)
constant	66.84*** (10.30)	58.55*** (9.684)	81.45*** (6.390)	79.33*** (6.721)	54.28*** (6.587)	60.87*** (5.388)
R^2	0.062	0.053	0.230	0.284	0.079	0.076
Observations	400	400	400	400	440	440
Number of clusters	20	20	20	20	22	22

Standard errors in parentheses are clustered at the subject level. *0.10, **0.05, ***0.01

According to standard economic theory, individuals' effort levels are lower in group contests than in individual contests, since the marginal benefit of their effort is shared among group members (Katz et al., 1990; Nitzan, 1991; Lee, 1995; Ryvkin, 2011). Consistent with this theory, our model also predicts that given the noise variance, the sum of efforts of individuals with valuations of 120 and 80 decreases from individual contests to group contests. However, our data do not confirm this prediction. The reason may be that since the individuals are grouped with the same group member during group contests, they feel socially connected with the other members. This feeling may cause an increase in the group interest instead of individual self-interest. Some experimental studies show that individuals in group contests exert higher effort than theoretical predictions (for a recent review, see Sheremeta, 2018b). For instance, by using the Tullock lottery contests success function, Abbink et al. (2010) and Ahn et al. (2011) find that players' effort levels in individual contests do not significantly differ in group contests.

5.4 Gender Differences

Several experimental studies have documented that female and male players behave differently in contests (Dechenaux et al., 2015). Compared to male contestants, female players are less willing to compete, both in terms of choosing to enter tournaments (Niederle & Vesterlund, 2007, 2011), and exerting efforts in competitive environments (Gneezy et al., 2003; Gneezy & Rustichini, 2004). As a result, we also examine the role of random noise on female and male players' effort choices in individual and group contests, separately.[48]

We provide a regression analysis for individual contests in Table 5.15 to fully understand whether there is a difference in males' and females' effort responses to treatment variables. The dependent variable is effort levels, and independent variables are *noise-variance*, *prize-valuation*, *utility-of-winning*, *risk-averse*, *prize-valuation*noise-variance* and *period*. Specification (1) uses the data from female players, and specification (2) uses the data from male players in individual contests. We cluster standard errors at the subject level. The estimation result of *noise-variance* variable indicates that both female and male players decrease their effort levels as noise variance rises, yet the variable is significant only for male players.

[48] Table C.4 in Appendix C summarizes average efforts for each player in the individual and group contests based on gender.

The result of *prize-valuation* variable indicates that male players exert significantly higher efforts as prize valuation increases. These results show that male players change their effort choices in individual contests as our model predicted. The *risk-averse* female players significantly decrease their effort levels in individual contests. The *period* variable is positively related to efforts of female and male players, yet the variable is significant only for female players.

Table 5.15 Differences of Efforts in Gender in Individual Contests

	Female	Male
Dependent variable, effort	(1)	(2)
noise-variance (1 if noise variance is high)	-4.576 (4.289)	-13.42** (5.089)
prize-valuation (1 if prize valuation is 120)	-3.319 (5.507)	9.652* (5.314)
*prize-valuation*noise-variance*	7.049 (7.719)	-1.113 (8.452)
utility-of-winning (effort for prize of 0)	0.017 (0.0607)	-0.043 (0.0578)
risk-averse (1 if number of safe option A > 8)	-6.045* (3.420)	3.771 (4.028)
period	1.682*** (0.303)	0.599 (0.401)
constant	61.45*** (3.783)	62.90*** (6.251)
R^2	0.069	0.114
Observations	600	640
Number of clusters	60	64

Standard errors in parentheses are clustered at the subject level. *0.10, **0.05, ***0.01

We repeat the estimation for group contests with standard errors clustered at group level in Table 5.16. Specifications (1) and (2) show estimation results of female and male players' efforts in perfect-substitutes contests, respectively. Specifications (3)

Table 5.16 Differences of Efforts in Gender in Group Contests

	Perfect-Substitutes		Best-Shot		Weakest-Link	
	Female	Male	Female	Male	Female	Male
Dependent variable, effort	(1)	(2)	(3)	(4)	(5)	(6)
noise-variance (1 if noise variance is high)	6.902 (10.49)	16.07 (13.40)	-5.895 (6.840)	-29.28* (13.96)	2.281 (3.766)	-15.91*** (5.260)
prize-valuation (1 if prize valuation is 120)	6.766 (13.28)	18.37 (16.87)	10.23 (6.851)	19.87 (16.50)	8.280 (6.374)	-0.895 (6.520)
*prize-valuation*noise-variance*	1.317 (14.82)	-25.74 (21.80)	-15.69* (7.559)	-3.938 (20.06)	-1.477 (10.05)	16.91* (8.235)
utility-of-winning (effort for prize of 0)	-0.109 (0.0833)	0.030 (0.120)	0.154** (0.0521)	0.181 (0.148)	0.119 (0.0885)	0.0987 (0.072)
risk-averse (1 if number of safe option A > 8)	2.396 (9.586)	8.699 (9.340)	-11.03** (4.589)	9.351 (9.671)	-2.412 (5.604)	4.268 (6.817)
period	0.715 (0.749)	0.643 (0.838)	-0.454 (0.619)	-1.650** (0.686)	0.820** (0.339)	0.488 (0.544)
constant	59.75*** (12.11)	48.54*** (17.26)	73.78*** (4.918)	55.96*** (15.30)	54.43*** (3.479)	56.94*** (8.559)
R^2	0.066	0.049	0.137	0.422	0.140	0.202
Observations	170	230	200	200	230	210
Number of clusters	13	16	15	15	17	16

Standard errors in parentheses are clustered at the group level. *0.10, **0.05, ***0.01

and (4) show estimation results of female and male players' efforts in best-shot contests, respectively. Specifications (5) and (6) show estimation results of female and male players' efforts in weakest-link contests, respectively. The estimation result of *noise-variance* indicates that male players significantly decrease effort choices as noise variance increases in best-shot and weakest-link contests. This shows males respond the noise variance in best-shot and weakest-link contests as our model predicted. The *prize-valuation* variable is not significant for female and male players in each group contest. According to the *prize-valuation*noise-variance* variable, in high noise variance, strong female players significantly decrease their effort choices in best-shot contests. According to theoretical model, only strong players exert positive efforts, and their effort levels decrease with noise variance in best-shot contests. Strong female players' behavior confirms this prediction. The *utility-of-winning* variable is positively related to the efforts of female players in best-shot contests. The *risk-averse* female players significantly decrease their effort choices in best-shot contests.[49]

According to these regression analyses for individual and group contests, male players are more responsive to changes in the parameters of the contests than female players. Several studies in different fields of literature have also shown that male players act under the rationality assumption. For example, in the literature on dishonest behavior, males are more likely to be dishonest than females (Ward & Berk, 1990; Tibbetts, 1999; Jackson et al., 2002; Friesen & Gangadharan, 2012; Erat & Gneezy, 2012; for a review, see Jacobsen et al., 2018). In the literature on public goods games, male players contribute less to the public good than female players (Nowell & Tinkler, 1994; Seguino et al., 1996; for reviews, see Eckel & Grossman, 2008 and Croson & Gneezy, 2009). In the literature on dictator games, male players give less than female players (Bolton & Katok, 1995; Eckel & Grossman, 1998; Andreoni, & Vesterlund, 2001). Although the literature on ultimatum games has unclear evidence on the gender difference in bargaining, on average female players' proposals are higher than male players' (Eckel & Grossman, 2001). By conducting a field experiment, Huang and Bao (2020) find that female players respond more to the social incentives and male players respond more to the financial incentives. Lastly, Sittenthaler and Mohnen (2020) compare the effect of monetary, non-monetary and mixed incentives on individuals' efforts. They find that unlike female players, males are more responsive to monetary incentives compared to non-monetary incentives. Similar to these findings, we also find males respond to incentives more.

[49] The findings of nonparametric tests validate these regression results for female and male players.

CHAPTER 6

CONCLUSION

In this study, we theoretically and experimentally examine how random noise affects effort choices in individual contests and three different types of group contests: perfect-substitutes, best-shot, and weakest-link. The theory predicts that individuals' effort levels decrease with the random noise and increase with the prize valuation in individual contests. For group contests, our model predicts that strong players' efforts decrease as noise variance rises in all group contests. Except in best-shot contest, weak players' effort levels also decrease with noise variance. According to the group impact function, efforts of players within a group change with their types. Strong players' efforts are higher than weak players' in perfect-substitutes contests, while only strong players exert positive effort in best-shot contests, and strong players exert as much effort as weak players expend in weakest-link contests.

When we test the theoretical predictions, several insights emerge from our experiments. First, in individual contests, unlike individuals who compete for a high prize in low noise variance, subjects exert more effort than the equilibrium effort levels given the noise variance. In the contest literature, the over-expenditure of effort in individual contests has been explained by feature of experimental design (Fallucchi et al., 2013; Chowdhury et al., 2014), competitive maximization of relative payoffs (Mago et al., 2016), being prone to mistake (Sheremeta, 2010, 2011a; Camerer, 2011), judgmental biases (Parco et al., 2005; Sheremeta & Zhang, 2010), demographic differences (Price & Sheremeta, 2015), impulsiveness (Sheremeta, 2018a), loss aversion (Kong, 2008; Bruner et al., 2021), and inequality aversion (Balafoutas et al., 2012). Some of these explanations can be valid while explaining over-expenditure of effort in our study.

When we examine the effect of random noise on efforts, consistent with Cason et al. (2020) and with our theoretical prediction, we find individuals who compete for a low prize decrease their efforts as noise variance rises. However, we do not find a significant effect of noise variance on the efforts of subjects who compete for a high prize. This behavior can be observed in crowdsourcing and innovation contests. Although there is a high degree of noise, like an uncertain number of participants or an uncertain probability of success, the effort levels are still positive in these types of contests (Hammon & Hippner, 2012; Segev, 2020). Given the noise variance, contrary to the prediction, there is no significant difference between the efforts of subjects with high and low prize valuations. In high noise variance, managers may think of giving a higher prize to the employees if the effort decrease due to noise variance affects managers' revenue more than the cost of the prize.

Second, given the noise variance, both strong and weak players' effort levels are higher than the equilibrium predictions in perfect-substitutes contests. In weakest-link contests with high noise variance, both strong and weak players exert more effort than the equilibrium effort levels but not with low noise variance. In the group contest literature, the over-expenditure of efforts in group contests is explained by being overly competitive even in individual contests (Millner & Pratt, 1989, 1991; Sheremeta, 2013, 2015, 2016), overly cooperative in collective action games (Ledyard, 1995; Chaudhuri, 2011) and social group identity (Tajfel & Turner, 1979; Akerlof & Kranton, 2000; Chen & Li, 2009; Sutter, 2009). Given the noise variance, weak players exert higher than 0-effort in best-shot contests while strong players' efforts are not different from the equilibrium effort levels. We believe that the weak players exert positive efforts to encourage strong players to exert more effort by showing that they also pay a certain amount of cost.

When we examine the impact of noise on the players' effort choices in three different group contests, contrary to the theoretical predictions, random noise does not significantly affect the efforts of strong and weak players in perfect-substitutes and weakest-link contests. This could be also because of the social group identity. In best-shot contests, as predicted, strong players decrease their effort levels with random noise. Unlike our prediction, weak players' efforts also decrease with random noise. When we look at the effect of prize valuation on effort in group contests given the noise variance, contrary to the theoretical predictions, strong and weak players' effort choices do not significantly differ in perfect-substitutes contests. In best-shot contests, there is no significant difference between the efforts of strong and weak players, which contradicts with our predictions. Consistent with the theoretical prediction, strong and weak players expend similar efforts in weakest-link contests. When managers introduce a group contest during a high volatility period, it is more efficient to use perfect-substitutes contests instead of best-shot or weakest-link contests.

Third, our experimental design allows us to compare effort levels in individual and group contests. Unlike our prediction, we find that in all group contests, players exert effort as much as in individual contests. One possible explanation for this observation could be that since individuals within a group can feel socially connected with each other, they feel the group interest higher than the self-interest. It is not disadvantageous to use group contests, especially like perfect-substitutes contests, for workplaces in a highly volatile environment. The efforts of individuals decrease with noise variance in other group contests but not in perfect-substitutes contests.

Lastly, in addition to these analyses testing our theoretical predictions, we checked whether males and females respond to noise differently in the individual and group contests. We find that random noise and prize valuations affect female and male players' effort choices in individual contests differently. In individual contests, male players decrease their efforts as noise variance rises, and increase them as prize valuation increases. On the other hand, in best-shot and weakest-link contests, male players decrease their effort levels while noise variance increases. In perfect-substitutes contests, neither males nor females respond to random noise. According to these findings, we can say that males respond to incentives more in our experiment than females. This behavior is also observed in other fields of literature, such as public good games (Nowell & Tinkler, 1994; Seguino et al., 1996), dictator games (Andreoni & Vesterlund, 2001), ultimatum games (Eckel & Grossman, 2001), and dishonesty (Ward & Berk, 1990; Jackson et al., 2002; Friesen & Gangadharan, 2012; Erat & Gneezy, 2012). Managers should increase the number of female employees within a group since females are not as affected by volatility as males.[50]

One possible direction for future study would be to understand weak players' behavior in best-shot contests in more detail. For instance, if there is more than one weak player within a group, or if we allow communication among players, would we still observe the same behavior of weak players. As in Chen and Lim (2013), how allowing communication between group members affects their performance in group contests compared to individual contests. Chen and Lim (2013) compare homogeneous contestants' effort in group contests to that in individual contests by using rank-order tournament contest model. They find that when players are allowed to communicate with a group member before making effort decisions, average efforts in perfect-substitutes are higher than those in individual contests. Unlike Chen and Lim (2013), there was no communication in our study. It would be interesting to check how such communication affects subjects' behavior in best-shot and weakest-link contests. We could understand whether such communication will help weak players to communicate their intentions, or there will be a bargaining regarding who will put the effort in a period when they repeatedly play since weak players' efforts are currently wasted in the best-shot contests.

Our experiment was designed by using a basic model, with only two players and two groups as a first step to understand effect of noise on efforts. Therefore, our model could be extended by allowing more than two groups in contests or more than two players within a group. Additionally, it could be examined how random noise affects the individuals' effort choices when group contests occur between asymmetric groups since competing groups are not always symmetric in real life.

[50] To motivate females, it could be better to use nonfinancial incentive schemes (Jalava et al., 2015; Sittenthaler & Mohnen, 2020).

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APPENDICES

A. EXPERIMENTAL INSTRUCTIONS

Below we provide the English translations of instructions for **individual and perfect-substitutes contests with high noise variance treatment**. The noise variance changes session to session. The only difference in the **low noise variance** treatment is that random numbers in contests can take any value **between 0.5 and 1.5**. Moreover, we present the changes of group contests in the third part of the experiment for three different group contests: perfect-substitutes, best-shot, and weakest-link. These are specified inside square brackets with the related contest name.

GENERAL INSTRUCTIONS

Welcome to our experiment.

In this experiment, we would like to examine the process of strategic decision-making. If you follow the instructions closely, you can earn money with the decisions you make. Your earnings may differ from each other. The amount you will earn depends on your own decisions, the decisions of other participants, and the chance factor. At the end of the session, you will be instantly paid all the money you have earned in cash.

The experiment will proceed in five parts. Each part will be explained just before that part takes place. During the experiment, your earnings will be calculated in francs. The experimental currency will be converted to Turkish Liras at a rate of **40** francs to **3** Turkish Lira. In the final part of the experiment, you are asked to answer some survey questions. You will also be paid an additional fixed show-up fee of 10 TL for your participation.

Thank you for your contribution.

PART 1

In this part of the experiment, you are asked to solve a series of questions. It consists of **20** general knowledge questions. Each question has 5 answer choices and **only 1** correct answer. You will have a maximum of **25 seconds** to answer each question. If you fail to answer within 25 seconds, you will automatically move on to the next question, and the answer will count as incorrectly answered.

You will not earn francs from this part at the end of the session. However, the performance you show here will affect **other parts of the experiment**. Therefore, please try to solve each question carefully. At the end of this part, you will know neither your results nor others' results in any way.

PART 2

This part of the experiment consists of **10 decision-making periods**. At the beginning of the first period, you will be randomly and anonymously paired with another participant. You will remain paired with the same person throughout the part to win a prize. The value of this prize will be decided based on your performance in the first part and will not change during this part. You will see the amount of the prize you are competing for on the screen. That amount could be worth **80 or 120 francs**. This amount will be **the same** for both people in the competing group.

Each period, you may bid on any number **between 0 and 100** by using an **initial endowment of 100 francs**. There is a calculator button to perform your calculations at the bottom of the box, where you will enter a bid.

After you make your bid, the computer will multiply it by a "**personal random number**". This random number can take any value **between 0 and 2** and is **separately and independently** drawn for **each period** and **each person**.

Your Final Bid = Your bid x Personal random number

There is an **associated cost** for each bid.

$$Cost\ of\ Bid = \frac{Your\ Bid^2}{100}$$

After you and the other participant have chosen bids, the computer will draw the random numbers and compare your final bids. If your final bid is higher than the other participant's, you will receive a **prize of 80 or 120 francs**. Otherwise, you will receive **0 francs**. In other words:

If you win and the prize value is **120**:

Earnings = Initial Endowment + Prize – Cost of Bid = 100 + **120** – Cost of your bid

If you win and the prize value is **80**:

Earnings = Initial Endowment + Prize – Cost of Bid = 100 + **80** – Cost of your bid

If you do not win:

Earnings = Initial Endowment – Cost of Bid = 100 – Cost of your bid

<u>An Example</u>

Suppose you make a bid of 34 francs and the other participant makes a bid of 40 francs. Your personal random number is 1.20 while the other participant's random number is 0.8. Therefore, your final bid is 40.8 = 34 × 1.20 and the other participant's final bid is 32 = 40 × 0.8.

Since your final bid (40.8) is higher than the other participant's final bid (32), you receive the prize. The cost of your bid (34) is 11.56. If you compete for the prize of 120 francs, your earning is 208.44 = 100 + 120 – 11.56. If you compete for the prize of 80 francs, then your earning is 167.04 = 100 + 80 – 12.96.

At the end of each period, your bid, your random number, cost of your bid, your final bid, your reward, and your earnings for that period are reported.

At the end of the experiment, 1 of the 10 periods will be randomly chosen for your actual payment for this part of experiment and it will be converted to Turkish Lira.

PART 3 (Perfect-Substitutes)

The second part of the experiment consists of **10 decision-making periods**. At the beginning of the first period, you will be randomly and anonymously placed into **a group of two people** (Group 1 or Group 2). Your group of two people will randomly match another group of two and compete for a prize. Either Group 1 or Group 2 will receive a **prize of 200 francs** at the end of each period. After the group assignments are determined, you will be randomly assigned as **Player A or Player B** in that group. The assignments will be determined by the performance that you showed in the first part. Your group member, the other group and the assignments in each group will remain **the same** during this part.

Each period, each group member may bid any number **between 0 and 100** by using an **initial endowment of 100 francs**. At the beginning of each period, you will see which group and player type you are assigned to.

At the bottom of the box where you will enter a bid, there is a calculator button to perform your calculations.

After you and your group member have chosen bids, the computer will **sum these bids** and multiply them by a "**group random number**" to determine your group's final bid. The group random number can take any value **between 0 and 2**. This number is **separately and independently** drawn for **each period** and **each group**.

Your Group Final Bid = (Your bid + Group member's bid) x Group random number

<u>Best-Shot</u>: [After you and your group member have chosen bids, the computer will choose **the highest bid of them** and multiply it by a "group random number" to determine your group's final bid.]

Your Group Final Bid = max{Your bid, Group member's bid} x Group random number

<u>Weakest-Link</u>: [After you and your group member have chosen bids, the computer will choose **the lowest bid of them** and multiply it by a "group random number" to determine your group's final bid.]

Your Group Final Bid = min{Your bid, Group member's bid} x Group random number

For each bid, there is a cost.

$$Cost\ of\ Bid = \frac{Your\ Bid^2}{100}$$

After your group and the other group make bids, the computer will draw the random numbers and compare your group’s final bid to the other group’s final bid. If your group's final bid is higher than the other group’s final bid, your group will receive a **prize of 200 francs**. Otherwise, your group will receive **0 francs**. Each member of the winning group will earn an amount from the reward based on the participant’s name. In other words:

If your group win and the prize value is **Player A**:

Earnings = Initial Endowment + Amount Player A earns from the group winning – Cost of Bid = 100 + **120** – Cost of your bid

If your group win and the prize value is **Player B**:

Earnings = Initial Endowment + Amount Player B earns from the group winning – Cost of Bid = 100 + **80** – Cost of your bid

If your group do not win:

Earnings = Initial Endowment – Cost of Bid = 100 – Cost of your bid

<u>An Example</u>

Let’s say you have been placed into Group 1 as Player A. You make a bid of 36 francs and your group member (Player B) makes a bid of 40 francs while other group's players make bids of 40 and 60. Your group random number is 1.25 while the other group's random number is 0.8. Therefore, your group's final bid is 95 = (36 + 40) × 1.25 and the other group’s final bid is 80 = (40 + 60) × 0.8.

Since your group's final bid (95) is higher than the other group's final bid (80), your group receive the prize. Since the cost of your bid (36) is 12.96 and the reward is worth 120 francs, your earning is 207.04 = 100 + 120 – 12.96 while your group member’s earning is 167.04 = 100 + 80 – 12.96.

At the end of each period, your bid, cost of your bid, your group member’s bid, your group random number, your group’s final bid, your prize, and your earning for the period are reported.

At the end of the experiment, 1 of the 10 periods will be randomly chosen for your actual payment for this part and it will be converted to Turkish Lira.

PART 4

This part consists of **1 decision-making period** and is similar to the second part. The only difference is the worth of the prize. You will be randomly and anonymously paired and compete to receive a **prize of 0 francs**.

There is a calculator button to perform your calculations at the bottom of the box, where you will enter a bid.

After you make your bid, the computer will multiply it by a "**personal random number**". This random number can take any value **between 0 and 2** and is **separately and independently** drawn for **each person**.

Your Final Bid = Your bid x Personal random number

For each bid, there is a cost.

$$Cost\ of\ Bid = \frac{Your\ Bid^2}{100}$$

After you and the other participant have chosen bids, the computer will draw the random numbers and compare your final bids. If your final bid is higher than the other participant's, you will receive a **prize of 0 francs**. In other words:

If you win:

Earnings = Initial Endowment + Prize – Cost of Bid = 100 + **0** – Cost of your bid

If you do not win:

Earnings = Initial Endowment – Cost of Bid = 100 – Cost of your bid

PART 5

In this part, you will make a series of choices in decision problems. How much you earn will depend on **chance** and the **choices** you make. For each line, please state whether you prefer Option A or Option B. There are **15 lines** in the table but just **1 line** will be randomly selected for payment, and you will not know which line will be drawn. Thus, you should pay attention to the choice you make in every line.

Line #	Option A	Option B		Please Choose A or B
1	**14 francs**	**40 francs** never	**0 francs** if 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20	Option A Option B
2	**14 francs**	**40 francs** if 1 comes out of the bingo cage	**0 francs** if 2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20	Option A Option B
3	**14 francs**	**40 francs** if 1 or 2	**0 francs** if 3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20	Option A Option B
4	**14 francs**	**40 francs** if 1, 2 or 3	**0 francs** if 4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20	Option A Option B
5	**14 francs**	**40 francs** if 1,2,3,4	**0 francs** if 5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20	Option A Option B
6	**14 francs**	**40 francs** if 1,2,3,4,5	**0 francs** if 6,7,8,9,10,11,12,13,14,15,16,17,18,19,20	Option A Option B
7	**14 francs**	**40 francs** if 1,2,3,4,5,6	**0 francs** if 7,8,9,10,11,12,13,14,15,16,17,18,19,20	Option A Option B
8	**14 francs**	**40 francs** if 1,2,3,4,5,6,7	**0 francs** if 8,9,10,11,12,13,14,15,16,17,18,19,20	Option A Option B
9	**14 francs**	**40 francs** if 1,2,3,4,5,6,7,8	**0 francs** if 9,10,11,12,13,14,15,16,17,18,19,20	Option A Option B
10	**14 francs**	**40 francs** if 1,2,3,4,5,6,7,8,9	**0 francs** if 10,11,12,13,14,15,16,17,18,19,20	Option A Option B
11	**14 francs**	**40 francs** if 1,2,3,4,5,6,7,8,9,10	**0 francs** if 11,12,13,14,15,16,17,18,19,20	Option A Option B
12	**14 francs**	**40 francs** if 1,2,3,4,5,6,7,8,9,10,11	**0 francs** if 12,13,14,15,16,17,18,19,20	Option A Option B
13	**14 francs**	**40 francs** if 1,2,3,4,5,6,7,8,9,10,11,12	**0 francs** if 13,14,15,16,17,18,19,20	Option A Option B
14	**14 francs**	**40 francs** if 1,2,3,4,5,6,7,8,9,10,11,12,13	**0 francs** if 14,15,16,17,18,19,20	Option A Option B
15	**14 francs**	**40 francs** if 1,2,3,4,5,6,7,8,9,10,11,12,13,14	**0 francs** if 15,16,17,18,19,20	Option A Option B

FINISH

After you have completed all your choices, the computer will randomly draw a number from **1 to 15** to determine which line of the lottery will be selected for payment. If you chose Option A in that line, you would receive **14 francs**. If you chose option B in that line, you would receive either **40 francs** or **0 francs**. The computer will randomly draw a number from **1 to 20** in order to determine this earning. If the number is in the left column, you receive 40 francs. If the number is in the right column, you receive 0 francs.

B. MULTIPLE-CHOICE QUESTIONS

1. Which one is the most famous works of Tchaikovsky?
    a. Romeo and Juliet
    b. Swan Lake
    c. Giselle
    d. Sleeping Beauty
    e. None of them

2. Which of the following animal is classified as a mammal?
    a. Penguin
    b. Canary
    c. Bat
    d. Parrot
    e. Crow

3. Which of the following actors starred in the movie Fast and Furious died?
    a. Vin Diesel
    b. Paul Walker
    c. Jason Statham
    d. Dwayne Johnson
    e. Larin Aland Ly

4. Which of the following scientist is known for their work on the “Big bang” and the “Black holes”?
    a. Sir Isaac Newton
    b. Albert Einstein
    c. Stephen Hawking
    d. Thomas Bayes
    e. Felix Hausdorff

5. Which of the following days points towards the spring and fall equinoxes?
    a. March 21 - September 23
    b. March 23 - June 23
    c. April 21 - September 23
    d. September 23 - June 23
    e. June 23 - October 21

6. Which of the following is the first non-military president of the Republic of Turkey?
    a. Celal Bayar
    b. Fahri Koruturk
    c. Suleyman Demirel
    d. Cevdet Sunay
    e. Turgut Ozal

7. Which of the following is the other name of the “north” pole?
    a. Cenub
    b. Garp
    c. Simal
    d. Sark
    e. Qibla

8. When did the migration from Mecca to Medina (Hijrah) begin?
    a. 622
    b. 666
    c. 612
    d. 571
    e. 620

9. Which of the following is the city where Ataturk is registered on the Turkish ID card?
    a. Istanbul
    b. Thessaloniki
    c. Bursa
    d. Gaziantep
    e. Samsun

10. Which of the following is one of the literati of the Servet-i Funun period?
    a. Ahmet Mithat Efendi
    b. Yusuf Ziya Ortac
    c. Orhan Veli Kanik
    d. Ziya Osman Saba
    e. Halid Ziya Usakligil

11. Where does the legend of the Phoenix come from?
    a. Greeks
    b. Maya
    c. Egypt
    d. Persia
    e. Rome

12. Which of the following is the car brand that uses the logo of the winged arrow?
    a. Bentley
    b. Subaru
    c. Aston Martin
    d. Skoda
    e. Volvo

13. Which of the following is the temperature at which book paper catches fire and burns?
    a. 451 F
    b. 251 C
    c. 451 C
    d. 120 F
    e. 479 F

14. What does 2-1 mean in backgammon?
    a. Du Se
    b. Penc-i Du
    c. Seba-i Yek
    d. Cehar-i Du
    e. Yek-i Du

15. Which of the following is the writer of Animal Farm?
    a. J.R.R. Tolkien
    b. George Orwell
    c. Thomas More
    d. Orhan Pamuk
    e. Salman Rusdi

16. What is the date of liberation of Izmir?
    a. 9.09.1922
    b. 19.09.1922
    c. 9.09.1932
    d. 29.10.1923
    e. 13.10.1920

17. Which of the following varieties of clouds means "a lock of hair, a horse’s mane, a bird’s feather"?
    a. Cirrus
    b. Cumulus
    c. Stratus
    d. Nimbus
    e. Alto

18. Which of the following cities hosted the 2018 Winter Olympic Games?
    a. Mokpo
    b. Daejeon
    c. Gopyeong
    d. Chuncheon
    e. PyeongChang

19. Golden Orange Award is given for which of the following fields?
    a. Film
    b. Advertisement
    c. Music
    d. Photography
    e. Art

20. Nobel Prizes are not given for which of the following fields?
    a. Economics
    b. Literature
    c. Sociology
    d. Chemistry
    e. Physics

C. ADDITIONAL ANALYSIS

Table C.1 Elicited Utility of Winning

Effort in a Tournament with the Prize of 0	Percent of Subject
0	25.81%
0.1 - 10	20.16%
10.1 – 20	1.61%
20.1 – 30	2.42%
30.1 – 40	4.03%
40.1 – 50	6.45%
50.1 - 60	6.45%
60.1 – 70	9.68%
70.1 – 100	23.39%

Table C.2 Elicited Risk Preferences

Total Number of Safe Choices	Percent of Subject
0	0.81%
1 – 4	4.03%
5 – 6	17.74%
7 – 8	30.65%
9 – 10	25.0%
11 – 12	11.29%
13 – 15	10.48%

Table C.3 Average Efforts in All Group Contests

	High Noise Variance		Low Noise Variance	
Player	Strong	Weak	Strong	Weak
Equilibrium	42.43	28.28	60.0	40.0
PS	70.23	69.04	71.93	62.18
	(14.59)	(14.36)	(21.92)	(20.55)
Equilibrium	54.77	0.0	77.46	0.0
BS	50.04	51.86	76.49	65.81
	(18.87)	(26.67)	(18.28)	(17.99)
Equilibrium	44.72	44.72	63.25	63.25
WL	67.79	58.49	67.14	64.87
	(15.83)	(11.50)	(13.80)	(9.83)

Standard deviations are in parentheses.

Table C.4 Average Efforts of Female and Male Players in Individual and Group Contests

	High Noise Variance				Low Noise Variance			
Gender	Female		Male		Female		Male	
Prize Valuation	120	80	120	80	120	80	120	80
IND	68.09	64.21	61.73	52.94	63.84	67.91	75.25	67.06
	(15.08)	(14.85)	(17.93)	(11.04)	(17.91)	(11.11)	(16.48)	(12.59)
PS	74.46	67.41	67.42	71.49	67.90	62.14	72.94	62.21
	(15.48)	(16.21)	(14.68)	(12.94)	(16.83)	(21.56)	(23.91)	(22.02)
BS	61.83	70.22	42.18	24.33	77.19	67.75	76.02	62.90
	(11.87)	(13.13)	(19.27)	(12.72)	(13.35)	(13.52)	(22.22)	(25.44)
WL	73.26	65.93	64.13	47.33	70.08	63.21	64.20	67.18
	(18.46)	(7.87)	(14.34)	(4.06)	(17.66)	(8.33)	(9.30)	(12.24)

Standard deviations are in parentheses.

D. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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22 EKİM 2019

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Mürüvvet BÜYÜKBOYACI

Danışmanlığını yaptığınız **Mert KAYAASLAN ve Merve İNTİŞAH'ın "Takımlarda Dürüst Olmayan Davranışlar"** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **381 ODTU 2019** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

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E. TURKISH SUMMARY / TÜRKÇE ÖZET

Günlük hayatta insanlar değişik ortamlarda birbirleri ile yarışabilirler. Siyasilerin seçimi kazanmak için yarışması, maratonda koşucuların ödülü kazanmak için yarışması, satış bölümündeki çalışanların prim kazanmak için yarışması, oyuncuların futbol, basketbol veya voleybol gibi müsabakalarda kazanmak için grup olarak yarışması bu ortamlardan sadece birkaçıdır. Bu ortamların ortak özelliği insanların kendi kaynaklarını, masraflı çabalarını, harcayarak ödül için yarışmalarıdır. Literatürde bu tarz yarışma ortamları üç farklı yarışma modeli ile analiz edilmeye çalışılmıştır (Konrad, 2009; Dechenaux vd., 2015). İlk olarak, Tullock piyango yarışma (Tullock lottery contest) (Tullock, 1980) modelidir. Bu tarz yarışmalarda her oyuncunun ödülü kazanma ihtimali gösterdikleri efora bağlı olarak değişkenlik göstermektedir. Eforun masrafı kişinin kazancından düşmesine ve ödülü kazanması kesin olmamasına rağmen yarışmacı ne kadar fazla efor sağlarsa o kadar yüksek ihtimalle ödülü elde edebilmektedir. Rant arama (rent-seeking), araştırma ve geliştirme yarışmaları ve patent rekabetleri gibi yarışmalar bu modele örnektir. İkinci yarışma modeli tüm-ödeme açık arttırma (all-pay auction) (Hillman & Riley, 1989) en yüksek teklifi verenin ödülü kazandığı, fakat her katılımcının kazanmasa bile önerdiği teklifi kadar ödeme yapması gereken bir yarışma modelidir. Düzenlenmiş ve ticaret korumalı sektörlerde kiralar (rents) için lobicilik, teknolojik rekabet ve askeri çatışmalar bu yarışma modeline örnek verilebilir. Son yarışma modeli ise Lazear ve Rosen (1981) tarafından tanıtılan derecelendirmeli turnuvalardır (rank-order tournaments). İş sözleşmeleri, genel temsilci (principal agent) ve spor yarışmaları bu tür yarışma modeli için örnek verilebilir. Derecelendirmeli turnuvalarda şansın efora eklenmesiyle sonuçlanan yarışmacının performansı, eğer rakiplerine göre en iyi sıralamada yer alıyor ise o yarışmacı her zaman ödülün tamamının sahibi olurken diğer kişiler hiçbir kazanç elde edemezler. Diğer iki yarışma modellerinde de olduğu gibi ödülü kazanıp kazanmadığına bakılmaksızın eforun masrafı yarışmacının kazancından çıkarılmaktadır.

Çalışmamız derecelendirmeli yarışma modelini kullanmaktadır. Çünkü gerçek yaşam koşullarında kazananı sadece sarf ettikleri eforlar değil şans da belirlemektedir. Örneğin, savaşta sadece orduların büyüklüğü değil savaşın gerçekleştiği bölgenin coğrafi ve hava koşulları da sonucu etkilemektedir. Bu koşullar şans olarak adlandırılıp tüm grubu aynı anda etkilemektedir.[51] Literatürde çok fazla derecelendirmeli yarışma modeli üzerine çalışmalar olmasına rağmen (bakınız Dechenaux vd., 2015), grup yarışmalarında şansın efor üzerine olan etkisi oldukça az dikkat çekmektedir. Bu nedenle, üç farklı grup yarışmasında, mükemmel ikameler (perfect-substitutes), en iyi atış (best-shot), ve en zayıf halka (weakest-link), şansın çaba düzeyleri üzerindeki etkisini inceliyoruz. Mükemmel ikameler (perfect-substitutes) yarışmasında, grubun eforu grupta yer alan her üyenin eforlarının toplamına eşittir (Katz vd., 1990; Baik, 1993, 2008). En iyi atış (best-shot) yarışmasında, grupta en iyi efor gösteren kişinin eforu grup eforu olarak belirlenir (Chowdhury vd., 2013; Barbieri vd., 2014). En zayıf halka (weakest-link) yarışmasında, gruptaki en düşük efor gösteren kişinin eforu grup eforu olarak belirlenir (Lee, 2012).

Çalışmamız genel olarak yarışma literatürünün iki ana dalı ile yakından ilgilidir: bireysel yarışmalar ve grup yarışmaları. Literatürde bireylerin belli bir ödülü kazanmak için yarıştığı birçok teorik ve ampirik çalışmalar yer almaktadır. Konrad (2009) bu literatürün kapsamlı bir teorik incelemesini yaparken Dechenaux vd. (2015) deneysel çalışmaları incelemiştir. Bull vd. (1987) Lazear ve Rosen'nin (1981) teorik çalışmasını deney ortamında test etmiş ve oyuncuların eforlarının şans artıkça arttığını düştüğünü bulmuştur. Birçok ampirik çalışma bu sonucu replike etmiştir (Dechenaux vd., 2015).

Bu çalışmalardan, Cason, Masters ve Sheremeta'nın (2020) çalışması bizim çalışmamıza en yakın olandır. Cason vd. (2020) bireysel boyutta şansın riske duyarsız ve simetrik kişilerin eforlarının üzerine olan etkisini üç farklı yarışma modelinde, kazanan-tamamını-alır yarışmaları (winner-take-all contests), olasılıklı-

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[51] Benzer bir durum bireysel yarışmalar için de düşünülebilir. Örneğin, profesyonel bir golf oyuncusunun turnuvayı kazanabilme olasılığı oynanacak sahalara göre değişkenlik göstermektedir. Burada golf sahası bir şanstır ve bireylerin eforlarına etki eder.

ödül yarışmaları (probabilistic-prize contests) ve orantılı-ödül yarışmaları (proportional-prize contests), karşılaştırarak incelemişlerdir. Çalışmanın sonunda şans faktörü geniş bir aralıktan çekildiğinde bireylerin harcadığı eforun azaldığı sonucuna ulaşmışlardır. Çalışmamız, şans varyansının bireysel yarışmalardaki eforlar üzerindeki etkisini onların kazanan-tamamını-alır yarışma modelini kullanarak replike etmekte ve şans varyansının oyuncuların grup yarışmalarındaki eforları üzerindeki etkisini farklı üretim fonksiyonları ile karşılaştırmaktadır.

Deneyimizde iki farklı ödül değerlemeleri yer almaktadır. Bu ödül değerlemeleri bireysel yarışmalarda yarışan çiftler arasında farklılık göstermektedir. Ödül yayılımının (prize spread) turnuvalardaki etkisini araştıran çeşitli deneysel çalışmalar, bireylerin kazananın ödülündeki artışa ile birlikte eforlarını artırdığını göstermiştir (Bull vd., 1987; Harbring & Irlenbusch, 2005; Harbring & Lünser, 2008; Falk vd., 2008).

Çalışmanın literatürle ilgili ikinci kısmı grup yarışmalarıdır. Grup yarışmaları ortaya çıktıkça, üç işlevsel kural sıkça kullanılmıştır: mükemmel ikameler (perfect-substitutes), en iyi atış (best-shot), ve en zayıf halka (weakest-link) (Hirshleifer, 1983). Sheremeta (2011b), Tullock yarışması başarı işlevini (Tullock contest success function) kullanarak, üç grup yarışmasındaki, mükemmel ikameler, en iyi atış ve en zayıf halka, eforları deneysel olarak karşılaştırır. Her grup üç riske karşı duyarsız oyunculardan oluşmaktadır. Bir grupta yüksek ödül değerlemesine sahip bir güçlü oyuncu ve düşük ödül değerlemesine sahip iki zayıf oyuncu yer almaktadır. Oyuncuların efor düzeylerinin farklı olmasında grup üretim fonksiyonlarının önemli ölçüde bir etkisinin olduğunu bildirmektedir. Örneğin, mükemmel ikameler yarışmasında hem güçlü hem de zayıf oyuncular teorik tahminlerden daha fazla efor harcarlar. En iyi atış yarışmasında, güçlü oyuncular eforlarının çoğunu harcarken, zayıf oyuncular bedavacılık (free-riding) eğilimindedir. Son olarak, en zayıf halka yarışmasında, aynı gruptaki tüm üyeler, grup Pareto baskın dengesinde (Pareto dominant equilibria) benzer pozitif eforlar üretir. Bu yarışmada grup içindeki bedavacılık sorunu (free-riding problem) neredeyse yoktur. Sheremeta'nın (2011b) kullandığı gibi üç grup üretim fonksiyonunu bizim de kullanmamıza rağmen, Tullock yarışma modeli yerine derecelendirmeli yarışma modelini kullanıyoruz. Şansın bu üç farklı grup yarışmasındaki oyuncuların eforları üzerindeki etkisini incelemeyi amaçlıyoruz.

Bildiğimiz kadarıyla, Chen ve Lim'in (2017) çalışmasına kadar, grup yarışmalarında şans faktörü hiç kullanılmamıştır. Teorik modellerinde her bireyin bir gruptaki çıktısını (individual output) efor seviyesi, şans (talep şoku) ve yetenek bağışlarının (ability endowment) toplamı olarak hesaplamışlardır. Grup üyelerinin kompozisyonunun ve farklı grup yarışması türlerinin, mükemmel ikameler, en iyi atış ve en zayıf halka, bireylerin efor düzeyleri üzerindeki etkisini inceliyorlar. Teorik modelleri, bir grup içindeki oyuncular heterojen olduğunda, güçlü ve zayıf oyuncuların eforlarının mükemmel ikame yarışmalarında farklı olmadığını öngörür. Güçlü oyuncular en zayıf halka yarışmalarında zayıf oyunculardan daha düşük efor harcarlar. Ancak güçlü oyuncuların eforları en iyi atış yarışmalarında zayıf oyunculardan daha yüksektir. Deneysel sonuçları teorik tahminlerini desteklemektedir. Çalışmamıza benzer şekilde, Chen ve Lim (2017) bir grup içinde iki heterojen oyuncu ve derecelendirmeli yarışma modelini kullanıyor. Fakat, çalışmamızın onlarınkinden üç tane farkı vardır. İlk olarak, gruplar içindeki heterojenliği, bir katkı yeteneği bağış (additive ability endowment) parametresi yerine ödüllerin değerlemelerine dayanarak yapmaktayız. İkincisi, modelimizdeki şans değişkeni çarpımsaldır ve grup üretimini etkiler. Son olarak ve daha da önemlisi, farklı şans varyanslarının bireysel yarışmalardaki ve üç farklı grup yarışmasındaki eforlar üzerindeki etkisini araştırmayı hedeflemekteyiz.

Son olarak, bireysel ve grup yarışmalarındaki efor seçimlerini karşılaştırarak yarışma literatürünü genişletiyoruz. Chen ve Lim (2013), grup yarışmalarındaki eforların bireysel yarışmalardakinden daha yüksek olup olmadığını incelemektedir. Derecelendirmeli yarışması modelini kullanarak simetrik bireysel yarışmalar ve simetrik grup yarışmaları tasarlamışlardır. Her grubun grup yarışmalarında iki homojen oyuncusu vardır. Ayrıca, grup yarışması için mükemmel ikame üretim fonksiyonunu kullanırlar. Yarışmacılar birbirleriyle iletişim kurmadıklarında, mükemmel ikame yarışmalarındaki eforların bireysel yarışmalardaki eforlardan farklı olmadığını bildirirler. Katılımcıların iletişim kurmasına izin verilirse, grup üyelerine karşı suçluluk duygusundan kaçınma derecesi artar ve grup yarışmalarındaki eforlar bireysel yarışmalardakinden daha yüksek olmaktadır. Çalışmamızın onlarınkinden dört aşamada farklılık göstermektedir. İlk olarak, simetrik grup yarışmalarında iki heterojen oyuncu kullanıyoruz. İkincisi, bireysel yarışmalarda yarışan her çift için iki farklı ödül değeri kullanıyoruz. Üçüncüsü, eforlar gerçek hayatta her zaman mükemmel ikame teknolojisi ile oluşmadığından dolayı diğer grup üretim fonksiyonlarını da kullanıyoruz. Son olarak, çarpımsal şans faktörü değişkenini bireysel yarışmalarda bireysel düzeyde ve grup yarışmalarında grup düzeyinde kullanıyoruz.

Teorik modelimizde, grup yarışmaları için simetrik her grup iki tane riske duyarsız ve heterojen oyunculara sahiptir. Yüksek ödül değerlemesine sahip bir oyuncu güçlü oyuncu olarak adlandırılırken düşük ödül değerlemesine sahip bir oyuncu zayıf oyuncu olarak adlandırılır. Efor üreten her bireyin ödemesi gereken bir maliyet vardır. Eforun maliyeti (cost of effort) şu şekilde hesaplanmaktadır: as c(e) = e^2/b. b sabiti, bireylerin kuadratik maliyet fonksiyonundaki yetenekleriyle ilgili bir kısıtlamadır. Modelimiz her grup üretim fonksiyonundaki güçlü ve zayıf oyuncular için ayrı ayrı denge noktasındaki efor değerlerini hesaplamaktadır. Grup performansı şansın ve grup eforunun çarpımı olarak hesaplanırken grup eforları grup üretim fonksiyonlarına göre değişiklik göstermektedir.

Teorik modelimiz, bireysel yarışmalarda oyuncuların eforlarının şans varyansı ile azalacağını ama ödül değerlemeleri ile artacağını öngörmektedir. Grup yarışmaları için şunları tahmin etmektedir. Mükemmel ikameler yarışmasında hem güçlü hem de zayıf oyuncunun pozitif eforlar sarf edeceğini ama güçlü oyuncuların eforlarının zayıf oyucularınkinden daha fazla olacağını öngörmektedir. En iyi atış yarışmasında, denge noktasında zayıf oyuncular 0-efor gösterirlerken güçlü oyuncular pozitif efor sarf etmektedirler. Son olarak, en zayıf halka yarışmasında denge noktasında hem güçlü hem de zayıf oyuncular benzer eforlar göstermektedirler. Ayrıca, teorik modelimiz tüm grup yarışmalarında güçlü oyuncuların eforlarının şans varyansı artıkça azalacağını göstermektedir. En iyi atış yarışması hariç diğer iki grup yarışmalarında zayıf oyuncuların efor düzeyleri de şans varyansı ile azalacağını öngörmektedir.

Model, bireysel yarışmalardaki efor düzeyleri ile grup yarışmalarındaki efor düzeylerini karşılaştırmaya da olanak sağlamaktadır. Hem yüksek hem de düşük şans varyanslarında, mükemmel ikame yarışmalarındaki yüksek ve düşük ödül değerlemelerine sahip oyuncuların efor düzeyleri bireysel yarışmalarındaki efor değerlerinden daha düşüktür. Yüksek ödül değerlemesine sahip yarışmacılar hem bireysel hem de en iyi atış yarışmalarında benzer efor düzeyleri gösterirler. Son olarak, en zayıf halka yarışmalarındaki yüksek ve düşük ödül değerlemelerine sahip oyuncuların eforları bireysel yarışmalarda düşük ödül değerlemesi için yarışan kişilerin efor düzeyleri ile benzerlik gösterir.

Sahada (1) eforun gözlemlenmesindeki zorluk, (2) şansın ölçülememesi ve (3) grup yarışmalarında grup üyesini sevme ya da sevmeme gibi başka etkilerin olmasından dolayı çalışmamızın teorik beklentileri laboratuvar deney ortamında test etmektedir. Bir boyutta, yarışmaların bireyler arasında mı yoksa gruplar arasında mı olacağını konu içi (within-subject) tasarım modelini kullanarak değiştirdik. Diğer boyutlarda, konu arası (between-subject) tasarım modelinde iki farklı şans varyansı (yüksek ve düşük) ve üç farklı grup yarışması (mükemmel ikameler, en iyi atış ve en zayıf halka) kullanmaktadır.

Orta Doğu Teknik Üniversitesi'nde (ODTÜ) teorik öngörüleri test etmek için on dört oturum gerçekleştirilmiştir. Deney z-Tree programında kodlandı (Fischbacher, 2007). Oturumları 2021 yılında Ekim sonu ve Kasım başında ODTÜ-FEAS Davranış ve Deney Laboratuvarı'nda (BEL) gerçekleştirilmiştir. Her seans yaklaşık 50 dakika sürer. Hiçbir katılımcı birden fazla oturuma katılmamıştır. Toplam 124 ODTÜ öğrencisi deneye katılmıştır. Deneklerin %37,90'ı iktisat bölümü öğrencisidir. Katılımcıların yaşları 20 ile 25 arasında değişmekte (%87,10) ve %51,61'i erkektir. Deney boyunca, ödemeler "deney parası (francs)" cinsinden hesaplanmış. Deney sonunda deneklerin toplam kazançları Türk lirasına (TL) çevrilmiştir. Bu kazançların değişimi 40 deney parası 3 TL olacak şekilde hesaplanmıştır. Ortalama olarak denekler 10 TL katılım ücreti de dahil yaklaşık 32,77 TL kazanmıştır.

Deneyimiz beş bölümden oluşmaktadır. Birinci bölümde, katılımcılardan 20 tane genel kültür sorusu çözmeleri istenir. Oyuncuların her soruyu cevaplamak için 25 saniyeleri var. Her katılımcı aynı soru setini aynı sıralama ile alırlar. Her soru 5 şıktan oluşmakta ve sadece 1 doğru cevabı var. Eğer bir oyuncu verilen süre içerisinde soruyu cevaplayamazsa o soru boş geçip yanlış olarak kabul edilir. Katılımcıların performansları verdikleri doğru cevapların toplamı olarak hesaplanır. Bu bölümden katılımcılar herhangi bir kazanç elde edemezler. Ama burada gösterdikleri performans diğer bölümlere etki etmektedir. Bu etki ikinci ve üçüncü bölümün hemen başında anlatılmaktadır. Birinci bölüm bittikten sonra, denekler performanslarına göre sıralanır. Deneyin ikinci ve üçüncü bölümlerindeki yarışmalar için ödül değerleri bu sıralarına göre belirlenir. Bir denek oturumda grubunun birinci (ikinci) yarısında yer alırsa, ödül değerlemesi ikinci ve üçüncü kısımlarda 120 (80) deney parası olarak kabul edilir. Deneyin ikinci bölümünde (bireysel yarışma), oyuncular ödül değerlemelerine göre ikiye ayrılır. Bazı yarışmalar 80 deney parası değerindeki ödül için, bazı yarışmalar 120 deney parası değerindeki ödül için gerçekleşir. Üçüncü bölümde (grup yarışması), her grup bir yüksek sıralamalı ve bir düşük sıralamalı iki katılımcıdan oluşur ve benzer kompozisyona sahip başka bir gruba karşı yarışırlar. Bir grup yarışmayı kazanırsa, ödül değerlemelerini belirleyen ilk bölümdeki sıralarına göre grup yarışması ödülünü alırlar.

İkinci bölümde, katılımcılar bireysel yarışmaya katılırlar. Bu bölüm 10 periyottan oluşmaktadır. İki simetrik yarışmacı bir ödül için yarışmakta ve bu ödül değerlemesi yarışan çiftler arasında farklılık göstermektedir. Bu bölüm boyunca yarışmacılar aynı kişi ile aynı ödül için yarışırlar. Her periyot başında yarışmacılar 100 deney parası değerinde başlangıç parası verilir. Bu parayı kullanarak efor sarf etmeleri istenir. Her harcanan efor için bireyler belli bir miktar maliyet öderler. Bu maliyet (cost of effort) harcanan eforun karesinin 100'e bölümüyle hesaplanır. Her oyuncu bu hesaplamayı ekranlarında yer alan hesap makinası butonuna basarak yapabilirler.

Yarışmacılar aynı anda eforlarını sarf ettikten sonra, bilgisayar bu eforları kişisel rastgele numara (personal random number) ile çarparak yarışmacıların bireysel performanslarına karar verir. En yüksek performans gösteren kişi ödülün (120 ya da 80 deney parası) sahibi olurken diğer yarışmacı hiçbir şey elde edemez. Her periyot sonunda oyuncular harcadıkları eforları, kişisel rastlantı sayılarını, eforların maliyetlerini, bireysel performansları, ödülün değerlerini ve o periyottan elde ettikleri kazançları görebilmektedir. Deney sonunda 10 periyottan 1 tanesi rastgele seçilip TL cinsine çevrilerek ödeme için hesaplanır.

Üçüncü bölümde, iki simetrik grup 10 periyot boyunca birbirleri ile 200 deney parası değerinde bir ödül için yarışırlar. Her grup ödül değerlemelerine göre farklılık gösteren iki heterojen yarışmacıdan oluşmaktadır. Yüksek ödül değerlemesine (120 deney parası) sahip bir güçlü oyuncu ve düşük ödül değerlemesine (80 deney parası) sahip bir zayıf oyuncu var. Bireylerin ödül değerlemeleri birinci bölümde gösterdikleri performansa göre oluşan sıralama ile belirlenmektedir. Ödül değerlemeleri herkes tarafından bilinmektedir. Grup kompozisyonları ve yarışılan karşı grup bu bölüm boyunca değişmemektedir. Her grup üyesinden 100 deney parası değerinde başlangıç parasını kullanarak bir efor sarf etmeleri istenir. Eforların masrafları aynı ikinci bölümdeki gibi hesaplanır. Her grup üyesi eforlarını harcadıktan sonra grup eforu hesaplanır. Grup eforunun grup rastgele numarası (group random number) ile çarpılmasıyla grup performansları hesaplanır. Grup eforu, grup üretim fonksiyonlarına göre farklılık gösterir ve bu hesaplama seanstan seansa değişir. Grup eforları hesaplandıktan sonra grup performansları karşılaştırılır. En iyi grup performansına sahip olan grup ödülün sahibi olur. Kazanan grupta güçlü oyuncular 120 deney parası değerindeki ödülü alırken zayıf oyuncular 80 deney parasındaki ödülü alırlar. Her periyot sonunda oyuncular harcadıkları eforları, grup arkadaşının harcadığı eforu, grup rastlantı sayılarını, bireysel eforların maliyetlerini, grup performanslarını, ödülün değerlerini ve o periyottan elde ettikleri kazançları görebilmektedir. Deney sonunda 10 periyottan 1 tanesi rastgele seçilip TL cinsine çevrilerek ödeme için hesaplanır.

Dördüncü bölümde, bireyler 0 ödül için birbirleriyle yarışırlar. Prosedür aynı ikinci bölümdeki gibi gerçekleşir. Tek farklılık ödülün değeridir. Bu bölüm sadece bir periyottan oluşmakta ve buradaki kazanç direkt TL cinsine çevrilerek ödeme için hesaplanır. Son bölümde, katılımcıların risk tercihlerini öğrenmeyi istemekteyiz. Ekranlarındaki tabloda 15 tane satır bulunur. Holt and Laury' ye (2002) benzer bir şekilde bireylerden her satır için hangi piyangoyu tercih ettiklerini bildirmeleri istenir. Piyango A güvenlidir ve 14 deney parasını kesin olarak verir. Piyango B risklidir ve 40 veya 0 deney parasını kazanmak belli bir olasılığa sahiptir. 40 deney parası değerindeki kazanç elde etme olasılığı her satırda 1/20 artmaktadır. Deney sonunda 15 seçimden 1 tanesi rastgele seçilip TL cinsine çevrilerek ödeme için hesaplanır. Ayrıca, her seans sonunda katılımcılardan demografik bazı bilgilerin bulunduğu bir ankete katılırlar.

Şimdi, deney sonundan elde ettiğimiz temel bulgularımızı sırasıyla özetleyeceğiz. İlk olarak şans varyansının ve ödül değerlemesinin efor üzerine etkisine bireysel yarışmalarda bakıyoruz. Düşük ödül değerlemesi için yarışan bireyler şansın varyansı arttıkça eforlarını önemli ölçüde düşürürken yüksek ödül değerlemesi için yarışan deneklerin eforlarında önemli ölçüde bir değişiklik olamaz. Teorik modelimizin beklentisinin aksine hem yüksek hem de düşük şans varyanslarında, yüksek ve düşük ödül değerlemelerine sahip bireylerin efor seçimleri önemli ölçüde birbirinden farklı değildir.

İkinci adımda şans varyansının ve ödül değerlemesinin heterojen yarışmacıların eforları üzerine olan etkisine üç farklı grup yarışmasında ayrı ayrı baktık. Teorik tahminlerin aksine şans varyansının mükemmel ikame ve en zayıf halka yarışmalarındaki güçlü ve zayıf oyuncuların eforları üzerinde önemli ölçüde bir etki bulamadık. En iyi atış yarışmalarında, beklentimizin doğrultusunda, şansın varyansı arttıkça güçlü oyuncuların çabaları azaldığını gözlemledik. Teorik tahminin aksine, zayıf oyuncular en iyi atış yarışmalarında pozitif efor harcarlar ve çabaları şans varyansı ile azalmaktadır. Grup yarışmalarında ödül değerlemesinin efor seçimleri üzerindeki etkisine baktığımızda, teorik tahminlerin aksine, güçlü ve zayıf oyuncuların eforları hem yüksek hem de düşük şans varyansları altındaki mükemmel ikame yarışmalarında önemli ölçüde farklılık göstermez. Teorik tahminin aksine, yüksek ve düşük şans varyanslarına sahip en iyi atış yarışmalarında güçlü ve zayıf oyuncuların çabaları arasında önemli ölçüde fark yoktur. Teorik tahminimizle benzer olarak, güçlü ve zayıf oyuncular, yüksek ve düşük şans varyanslarına sahip en zayıf halka yarışmalarında önemli ölçüde benzer efor seçimleri gösterirler.

Deneyimizin bir diğer amacı da belli bir şans varyansı altında bireysel yarışmalarındaki oyuncuların eforları ile grup yarışmalarındaki heterojen grup üyelerinin eforlarını karşılaştırmaktır. Bir seans boyunca her bir katılımcı hem bireysel yarışmaya hem de grup yarışmasına katıldığından dolayı elde edilen verileri konu içi (within-subject) karşılaştırma kullanarak analiz edebilmekteyiz. Yapılan regresyon sonucuna göre, tüm grup yarışmalarında oyuncular bireysel yarışmalarda olduğu kadar efor harcamaktadırlar.

Son olarak, öncelikli amacımız olmasa da bireysel ve grup yarışmalarında şans varyansının kadın ve erkek oyuncuların efor seçimleri üzerindeki rolünü de ayrı ayrı inceliyoruz. Bireysel yarışmalarda, erkek oyuncular eforlarını şans varyansı arttıkça önemli ölçüde düşürürken ödül değerlemeleri arttıkça önemli ölçüde arttırmaktadırlar. Riskten kaçınan kadın oyuncuların eforlarını önemli ölçüde düşürdüğünü de gözlemlemektedir. Grup yarışmalarında efor seçimlerindeki cinsiyet farklılığına baktığımızda en iyi atış ve en zayıf halka yarışmalarındaki erkek oyuncuların eforlarının şans varyansı arttıkça önemli ölçüde düştüğü görülmektedir. Ödül değerlemesinin kadın ve erkek yarışmacıların eforları üzerinde önemli ölçüde bir etkisi yoktur. Yüksek şans varyansında, yüksek ödül değerlemesine sahip kadın oyuncular efor seçimlerini en iyi atış yarışmalarında önemli ölçüde azaltmaktadır. Fakat, yüksek ödül değerlemesine sahip erkek oyuncular efor düzeylerini en zayıf halka yarışmalarında önemli ölçüde arttırmaktadır. En iyi atış yarışmalarında riskten kaçınan kadın oyuncuların eforları önemli ölçüde azalmaktadır.

Bu çalışmada, şans varyansının bireysel yarışmalarda ve üç farklı grup yarışmasında, mükemmel ikameler, en iyi atış ve en zayıf halka, efor seçimlerini nasıl etkilediğini teorik ve deneysel olarak inceliyoruz. Genel olarak, çalışmamızın literatüre iki önemli katkısı vardır. İlk katkısı grup yarışmalarını rastgele gürültü altında farklı grup üretim işlevleriyle karşılaştırmak için teorik ve deneysel bir çerçeve sağlayarak grup yarışması literatürünü genişletmemizdir. İkinci katkı, çalışmamızın rastgele gürültü değiştikçe sıralamalı bireysel ve grup yarışmalarındaki çabaları karşılaştırmasıdır.

Teorik bir model tasarlayarak zayıf oyuncuların en iyi atış yarışmalarındaki davranışlarını incelemeyi amaçlıyoruz. Böylece gelecekteki çalışmalarda hangi durumlarda efor tercihlerinin azaldığını anlayabiliriz. Chen ve Lim (2013), grup yarışmalarındaki homojen yarışmacıların eforlarını derecelendirmeli yarışma modelini kullanarak bireysel yarışmalardaki eforlarıyla karşılaştırmaktadır. Oyuncuların efor kararları vermeden önce grup üyesiyle iletişim kurmalarına izin verildiğinde, mükemmel ikame yarışmalarındaki ortalama eforların bireysel yarışmalardakinden daha yüksek olduğunu buluyorlar. Chen ve Lim'in (2013) aksine, çalışmamızda iletişim yoktu. Eğer olsaydı, şansın etkili olduğu ortamlarda heterojen oyuncuların eforları bireysel yarışmalardan grup yarışmalarına geçerken artabilirdi. Dahası, bu tür bir iletişimin zayıf oyuncuların niyetlerini güçlü oyunculara iletmelerine ve en iyi atış yarışmalarında dengeye daha yakın davranmalarına yardımcı olup olmadığını anlayabilmemize imkan sağlayabilir. Bu soruyu gelecekteki araştırmalara bırakıyoruz.

Deneyimiz, şansın eforlar üzerindeki etkisini anlamak için ilk adım olarak sadece iki oyuncu ve iki grupla temel bir model kullanılarak tasarlandı. Bu nedenle, çalışmamız yarışmalarda ikiden fazla gruba veya bir grup içinde ikiden fazla yarışmacıya izin verilerek genişletilebilir. Ayrıca, gerçek hayatta grup yarışmalarında rakip gruplar her zaman simetrik olmadığından dolayı yarışma asimetrik gruplar arasında olduğunda şansın bireylerin efor seçimlerini nasıl etkilediğini incelenebilir.

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