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# Risk Taking in Winner-Take-All Competition*

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**Abstract**

We analyze a two-stage game between two heterogeneous players. At stage one, risk is chosen by one of the players. At stage two, both players observe the given level of risk and simultaneously invest in a winner-take-all competition. The game is solved theoretically and then tested by using laboratory experiments. We find three effects that determine risk taking at stage one – a discouragement effect, a cost effect and a likelihood effect. For the likelihood effect, risk taking and investments are clearly in line with theory. Pairwise comparison shows that the cost effect seems to be more relevant than the discouragement effect when taking risk.

**Key Words:** Tournaments, Competition, Risk-Taking

**JEL Classification:** M51, C91, D23

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# 1 Introduction

In many real-world situations, competition can be characterized as a winner-take-all contest or tournament. Typically, in sports contests there is only one winner who gets the high winner prize (Szymanski (2003)). When arranging a singing contest, only one participant wins the final round (Amegashie (2007)). In job-promotion tournaments, workers compete for a more attractive and better paid position at the next hierarchy level (Baker *et al.* (1994)). Firms and individuals invest in external or internal rent-seeking contests (Gibbons (2005)). In politics, individuals compete for being elected. Firms often compete in R&D (Loury (1979), Zhou (2006)) and invest resources for advertising to become the market leader (Schmalensee (1976), Schmalensee (1992)). Moreover, firms are involved in litigation contests for brand names or patent rights (Waerneryd (2000)). Finally, oligopolistic competition in new markets often looks like a tournament: only the firm that implements a new technical standard as a first-mover can realize substantial profits from network externalities (Besen and Farrell (1994)).

Most of the models on winner-take-all competition either build on the seminal work by Tullock (1980) or that by Lazear and Rosen (1981). These contest or tournament models usually focus on the effort or investment choices of the contestants: the higher the effort/investment of a single player relative to those of his opponents, the more likely he will win the tournament. However, in real tournaments, players also choose the risk of their strategic behavior. For example, politicians do not only invest resources during the election campaign, but also decide on the composition and, therefore, on the risk of their agenda. Athletes decide whether to switch to a new – and often more risky – training method or not. Prior to the choice of their advertising expenditures, firms have to decide on the introduction of a new product, which would be a more risky strategy than keeping the old product line. In many tournaments, contestants first have the choice between using a standard technique or solution (low risk) or switching to a new one (high risk); thereafter they decide on effort or, more generally, on input to win the tournament.

Two different situations can be observed in practice. Given a two-player game, either both players are risk takers or a single first mover chooses risk before both players decide on effort/investment. There exist several examples for such unilateral risk taking. Consider, for example, a duopoly where the incumbent firm offers its well-known product. If now a new firm enters the market, this new entrant first has to decide on the supply of a new kind of product and on an innovative marketing strategy. Thereafter, both firms compete for market leadership by choosing their advertising expenditures. As another example consider the case of two politicians competing in an election campaign. Often there is an incumbent politician that stands for a certain well-known agenda and a challenger that first has to choose the risk of his agenda before both politicians simultaneously invest their resources during the election campaign.

In our paper, we concentrate on the case of unilateral risk taking, which has neither theoretically nor experimentally been analyzed so far. At the first stage, the challenger chooses risk. At the second stage, both the challenger and the incumbent simultaneously decide on efforts or investments. We consider an asymmetric tournament game[1] with discrete choices to derive several hypotheses which are then tested in a laboratory experiment. In our asymmetric tournament, a more able player (the "favorite") competes against a less able one (the "underdog"). Suppose that the challenger is the favorite. At first sight, one would expect that the challenger does not prefer a high risk which can jeopardize his favorable position. Accordingly, if the challenger is the underdog he might strictly benefit from a high risk since he has nothing to lose but good luck may compensate for the lower ability. Our theoretical results show that this first guess is not necessarily true.

[1] Note that we do not analyze a principal-agent model where the principal optimally designs the tournament game.

Consider, for example, the situation with the challenger being the favorite. We can differentiate between three effects that determine his risk taking: first, risk taking at stage 1 of the game may influence the equilibrium investments and, hence, investment costs at stage 2 (cost effect). According to this effect, the challenger (as well as the incumbent) prefers a high-risk strategy since high risk reduces overall incentives and, therefore, investment costs at the second stage. Here, high risk serves as a commitment device for the players at the second stage, leading to a kind of implicit collusion. Second, the choice of risk by the challenger also influences the players' likelihood of winning. If equilibrium investments do not react to risk taking the more able challenger will prefer a low-risk strategy to hold his predominant position (likelihood effect). Third, if only the equilibrium investments of the incumbent do react to risk taking, the more able challenger may choose a high risk to discourage the less able incumbent (discouragement effect). In this situation, high risk destroys the incumbent's incentives at the second stage since it does not pay for him to invest as he would bear high costs but the outcome of the tournament is mainly determined by luck. However, the challenger still invests at the second stage as he has to bear significantly less costs, being the more able player. Such discouragement will be very attractive for the challenger if the gain of winning the tournament is rather large.

The theoretical results show that, in our discrete setting, all three effects will be relevant if the challenger is the favorite whereas taking high risk becomes dominant when the challenger is the underdog. For this reason, our experimental analysis focuses on risk taking by the favorite and the subsequent investment or effort choices by both players. For each effect we ran one treatment with two sessions – labeled discouragement treatment, cost treatment, and likelihood treatment. Descriptive results indicate that, contrary to the discouragement effect, both the cost effect and the likelihood effect are relevant for the subjects when choosing risk. The results from non-parametric tests and probit regressions reveal that the likelihood effect turns out to be very robust. The two other effects are not confirmed by a Binomial test, but a pairwise comparison of the treatments shows that the findings for the cost effect are more in line with theory than our results for the discouragement effect. As theoretically predicted, favorites choose significantly more investment or effort than underdogs in the discouragement treatment and the likelihood treatment. In the cost treatment, players' behavior does not significantly differ given low risk, which follows theory, but for high risk underdogs exert clearly more effort than favorites, which contradicts theory. The subjects' effort choices as reactions to given risk are very often in line with theory. Again, the likelihood treatment offers very robust findings. Interestingly, in the two other treatments, favorites tend to react more sensitively to given risk than underdogs although subjects change their roles after each round.

Previous work on risk taking in tournaments either fully concentrates on the players' risk choices by skipping the effort decisions, or considers symmetric effort choices within a two-stage game. The first strand of this literature is better in line with risk behavior of mutual fund managers or other players that can only influence the outcome of a winner-take-all competition by choosing risk (see, for example, Gaba and Kalra (1999), Hvide and Kristiansen (2003) and Taylor (2003)). The second strand of the risk-taking literature is stronger related to our paper. Hvide (2002) and Kräkel and Sliwka (2004) consider a symmetric two-stage tournament with bilateral risk taking at stage 1 and subsequent effort choices at stage 2. However, symmetry of the equilibrium at the effort stage renders one of the three main effects impossible, namely the discouragement effect. Nieken (2007) experimentally investigates only the cost effect within a symmetric setting with bilateral risk taking. On the one hand, her results show that subjects rationally reduce their efforts when risk increases. On the other hand, subjects do not behave according to the cost effect very well as only about 50% (instead of 100%)

of the players choose high risk. Our paper is most strongly related to Kräkel (forthcoming) who analyzes the three effects in an asymmetric two-stage tournament model with bilateral risk taking. Since Kräkel uses a continuous setting, the three effects can also be found for the underdog when choosing risk. Unfortunately, the continuous setting with bilateral risk taking is so complex that closed-form solutions can hardly be derived.

The paper is organized as follows. The next section introduces the game and the corresponding solution. In Section 3, we point out the three main effects of risk taking – the discouragement effect, the cost effect, and the likelihood effect. In Section 4, we describe the experiment. Our testable hypotheses are introduced in Section 5. The experimental results are presented in Section 6. We discuss three puzzling results in Section 7. Section 8 concludes.

# 2 The Game

We consider a two-stage tournament game with two risk neutral players. At the first stage (risk stage), one of the players – the challenger – chooses the variance of the underlying probability distribution that characterizes risk in the tournament. At the second stage (effort stage), both players – the challenger and the incumbent – observe the chosen risk and then simultaneously decide on their efforts. The player with the better relative performance is declared the winner of the tournament and receives the benefit $B > 0$, whereas the other one gets nothing. Relative performance does not only depend on the effort choices but also on the realization of the underlying noise term.

The two players are heterogeneous in ability. These ability differences are modeled via the players' effort costs. The more able player $F$ ("favorite") has low effort costs, whereas exerting effort entails rather high costs for player $U$ ("underdog"). In particular, both players can only choose between the two effort levels $e_i = e_L$ and $e_i = e_H > 0$ $(i = F, U)$ with $e_H > e_L$ and $\Delta e := e_H - e_L > 0$. The choice of $e_i = e_L$ leads to zero effort costs for player

$i$, but choosing high effort $e_i = e_H$ involves positive costs $c_i$ $(i = F, U)$ with $c_U > c_F > 0$. Relative performance of challenger $i$ is described by

$$RP = e_i - e_j + \varepsilon \tag{1}$$

with $\varepsilon$ as noise term which follows a symmetric distribution around zero with cumulative distribution function $G(\varepsilon; \sigma^2)$ and variance $\sigma^2$. At the risk stage, the challenger has to decide between two variances or risks. He can either choose a high risk $\sigma^2 = \sigma_H^2$ or a low risk $\sigma^2 = \sigma_L^2$ with $0 < \sigma_L^2 < \sigma_H^2$. Challenger $i$ is declared winner of the tournament if and only if $RP > 0$. Hence, his winning probability is given by

$$\text{prob}\{RP > 0\} = 1 - G\left(e_j - e_i; \sigma^2\right) = G\left(e_i - e_j; \sigma^2\right) \tag{2}$$

where the last equality follows from the symmetry of the distribution. In analogy, we obtain for incumbent $j$'s winning probability:

$$\text{prob}\{RP < 0\} = G\left(e_j - e_i; \sigma^2\right) = 1 - G\left(e_i - e_j; \sigma^2\right). \tag{3}$$

The symmetry of the distribution has two implications: first, each player's winning probability will be $G(0; \sigma^2) = \frac{1}{2}$ if both choose the same effort level. Second, if both players choose different effort levels, the one with the higher effort has winning probability $G(\Delta e; \sigma^2) > \frac{1}{2}$, but the player choosing low effort only wins with probability $G(-\Delta e; \sigma^2) = 1 - G(\Delta e; \sigma^2) < \frac{1}{2}$. Let

$$\Delta G\left(\sigma^2\right) := G\left(\Delta e; \sigma^2\right) - \frac{1}{2} \tag{4}$$

denote the *additional winning probability* of the player with the higher effort level *compared to a situation with identical effort choices* by both players. Note that $\Delta G(\sigma^2) \in \left(0, \frac{1}{2}\right)$. We assume that increasing risk from $\sigma_L^2$ to $\sigma_H^2$ shifts probability mass from the mean to the tails so that $G(\Delta e; \sigma_L^2) >$

$G(\Delta e; \sigma_H^2)$, implying

$$\Delta G\left(\sigma_L^2\right) > \Delta G\left(\sigma_H^2\right). \tag{5}$$

When looking for subgame-perfect equilibria by backward induction we start by considering the effort stage 2. Here, both players observe $\sigma^2 \in \{\sigma_L^2, \sigma_H^2\}$ and simultaneously choose their efforts according to the following matrix game:

| | $e_F = e_H$ | $e_F = e_L$ |
|---|---|---|
| $e_U = e_H$ | $\frac{B}{2} - c_U$ , $\frac{B}{2} - c_F$ | $B \cdot G(\Delta e; \sigma^2) - c_U$ , $B \cdot G(-\Delta e; \sigma^2)$ |
| $e_U = e_L$ | $B \cdot G(-\Delta e; \sigma^2)$ , $B \cdot G(\Delta e; \sigma^2) - c_F$ | $\frac{B}{2}$ , $\frac{B}{2}$ |

The first (second) payoff in each cell refers to player $U$ ($F$) who chooses rows (columns).
Note that $(e_U, e_F) = (e_H, e_L)$ can never be an equilibrium at the effort stage since

$$B \cdot G\left(-\Delta e; \sigma^2\right) \geq \frac{B}{2} - c_F \Leftrightarrow c_F \geq B \cdot \left(\frac{1}{2} - G\left(-\Delta e; \sigma^2\right)\right)$$
$$\Leftrightarrow \quad c_F \geq B \cdot \left(\frac{1}{2} - \left[1 - G\left(\Delta e; \sigma^2\right)\right]\right) \Leftrightarrow c_F \geq B \cdot \Delta G\left(\sigma^2\right)$$

and

$$B \cdot G\left(\Delta e; \sigma^2\right) - c_U \geq \frac{B}{2} \Leftrightarrow B \cdot \Delta G\left(\sigma^2\right) \geq c_U$$

lead to a contradiction as $c_U > c_F$. Combination $(e_U, e_F) = (e_H, e_H)$ will be an equilibrium at the effort stage if and only if

$$\frac{B}{2} - c_i \geq B \cdot G\left(-\Delta e; \sigma^2\right) \Leftrightarrow B \cdot \Delta G\left(\sigma^2\right) \geq c_i$$

holds for player $i = F, U$. In words, each player will not deviate from the high effort level if and only if, compared to $e_i = e_L$, the additional expected gain $B \cdot \Delta G(\sigma^2)$ is at least as large as the additional costs $c_i$. Similar considerations for $(e_U, e_F) = (e_L, e_L)$ and $(e_U, e_F) = (e_L, e_H)$ yield the following result:

**Proposition 1** *At the effort stage, in equilibrium players $U$ and $F$ choose*

$$(e_U^*, e_F^*) = \begin{cases} (e_H, e_H) & \text{if} \quad B \cdot \Delta G(\sigma^2) \geq c_U \\ (e_L, e_H) & \text{if} \quad c_U \geq B \cdot \Delta G(\sigma^2) \geq c_F \\ (e_L, e_L) & \text{if} \quad B \cdot \Delta G(\sigma^2) \leq c_F \end{cases} \tag{6}$$

Our findings are quite intuitive: the favorite chooses at least as much effort as the underdog because of higher ability and, hence, lower effort costs. If the additional expected gain $B \cdot \Delta G(\sigma^2)$ is sufficiently large, it will pay off for both players to choose a high effort level. However, for intermediate values of $B \cdot \Delta G(\sigma^2)$ only the favorite will prefer high effort, and for small values of $B \cdot \Delta G(\sigma^2)$ neither player exerts high effort.
At the risk stage 1, the challenger chooses risk $\sigma^2$. Equations (2) and (3) show that risk taking directly influences both players' winning probabilities. Furthermore, Proposition 1 points out that risk also determines the players' effort choices at stage 2. We obtain the following proposition:

**Proposition 2** *(i) If $B \leq \frac{c_F}{\Delta G(\sigma_L^2)}$ or $B \geq \frac{c_U}{\Delta G(\sigma_H^2)}$, then the challenger will be indifferent between $\sigma^2 = \sigma_L^2$ and $\sigma^2 = \sigma_H^2$, irrespective of whether he is the favorite or the underdog. (ii) Let $B \in \left(\frac{c_F}{\Delta G(\sigma_L^2)}, \frac{c_U}{\Delta G(\sigma_H^2)}\right)$. When $F$ is the challenger, he will choose $\sigma^2 = \sigma_L^2$ if $B < \frac{c_U}{\Delta G(\sigma_L^2)}$ and $\sigma^2 = \sigma_H^2$ if $B > \frac{c_U}{\Delta G(\sigma_L^2)}$. When $U$ is the challenger, he will always choose $\sigma^2 = \sigma_H^2$.*

**Proof:** See Appendix.
The result of Proposition 2(i) shows that risk taking becomes unimportant if the benefit $B$ is very small or very large. In the first case, it never pays for the players to choose a high effort level, irrespective of the underlying

risk. In the latter case, both players prefer to exert high effort for any risk level since winning the tournament is very attractive. Hence, the risk-taking decision is only interesting for moderate benefits that do not correspond to one of these extreme cases.

Proposition 2(ii) deals with the situation of a moderate benefit. Here, the underdog always prefers the high risk when being the challenger. The intuition for this result comes from the fact that $U$ is in an inferior position at the effort stage according to Proposition 1 (i.e., he will never choose a higher effort than player $F$), irrespective of the chosen risk level. Therefore, he has nothing to lose and unambiguously gains from choosing the high risk: in case of good luck, he may win the competition despite his inferior position; in case of bad luck, he will not really worsen his position as he has already a rather small winning probability. The favorite is in a completely different situation when being the challenger at the risk stage. According to Proposition 1, he is the presumable winner of the tournament (i.e., he will never choose less effort than player $U$) and does not want to jeopardize his favorable position. However, Proposition 2(ii) shows that $F$'s preference for low risk will only hold if the benefit is smaller than a certain cut-off value. If $B$ is rather large, then it will pay for the favorite to choose high risk at stage 1. By this, he strictly gains from discouraging his rival $U$: given $\sigma^2 = \sigma_L^2$, we have $(e_U^*, e_F^*) = (e_H, e_H)$ at the effort stage, but $\sigma^2 = \sigma_H^2$ induces $(e_U^*, e_F^*) = (e_L, e_H)$.

# 3 Discouragement Effect, Cost Effect and Likelihood Effect

The results of Proposition 2 have shown that the risk behavior of player $U$ is rather uninteresting in this simple discrete setting as he has a (weakly) dominant strategy when being the challenger. Therefore, the remainder of this paper focuses on the strategic risk taking of player $F$. As an illustrating example, consider the case of liberalization of monopoly where a new private entrant can challenge a former public enterprise. In this situation, the former monopolist is typically the weaker player with higher costs whereas the challenger can be roughly characterized as the favorite.[2]

Recall that risk taking may influence both the players' effort choices and their winning probabilities. As already mentioned in the introduction, in particular three main effects determine the challenger's risk taking. The first effect is called *discouragement effect*: if $F$'s incentives to win the tournament are sufficiently strong, that is if $B > \max\left\{\frac{c_F}{\Delta G\left(\sigma_H^2\right)}, \frac{c_U}{\Delta G\left(\sigma_L^2\right)}\right\}$, he wants to deter $U$ from exerting high effort. From the proof of Proposition 2, we know that low risk $\sigma_L^2$ leads to $(e_U^*, e_F^*) = (e_H, e_H)$, but high risk $\sigma_H^2$ induces $(e_U^*, e_F^*) = (e_L, e_H)$. Hence, when choosing high risk at stage 1, the favorite completely discourages his opponent and increases his winning probability by $G\left(\Delta e; \sigma_H^2\right) - \frac{1}{2} = \Delta G\left(\sigma_H^2\right)$, compared to low risk. This effect is shown in Figure 1.

[Figure 1 about here]

Low risk makes high effort attractive for both players since effort has still a real impact on the outcome of the tournament, resulting into a winning probability of $\frac{1}{2}$ for each player. Switching to a high-risk strategy $\sigma_H^2$ now increases the effort difference $e_F^* - e_U^*$ by $\Delta e$, which raises $F$'s likelihood of winning by $\Delta G\left(\sigma_H^2\right)$ without influencing his effort costs.

The second effect can be labeled *cost effect*. In our discrete setting, this effect will determine $F$'s risk choice if $\frac{c_U}{\Delta G\left(\sigma_L^2\right)} < B < \frac{c_F}{\Delta G\left(\sigma_H^2\right)}$.[3] In this situation, $\sigma^2 = \sigma_L^2$ leads to $(e_U^*, e_F^*) = (e_H, e_H)$ at stage 2, but $\sigma^2 = \sigma_H^2$ implies $(e_U^*, e_F^*) = (e_L, e_L)$. Hence, in any case the winning probability of either

[2] Such situation is typical for the liberalization of network industries in the European Union, in particular for the telecommunication market and the airline sector; see, among many others, Geradin (2006). For economic modeling of the new entrant as the low-cost firm and the incumbent being the high-cost firm, see, for example, Caplin and Nalebuff (1986).

[3] See the proof of Proposition 2 in the Appendix.

player will be $\frac{1}{2}$, but only under low risk each one has to bear positive effort costs. Consequently, the challenger prefers high risk at stage 1 to commit himself (and his rival) to choose minimal effort at stage 2 in order to save effort costs. Concerning the cost effect, both players' interests are perfectly aligned as each one prefers a kind of implicit collusion in the tournament, induced by high risk.

The third effect arises when $\frac{c_F}{\Delta G(\sigma_H^2)} < B < \frac{c_U}{\Delta G(\sigma_L^2)}$.[4] In this situation, the outcome at the effort stage is $(e_U^*, e_F^*) = (e_L, e_H)$, no matter which risk level has been chosen at stage 1. Here, risk taking only determines the players' likelihoods of winning so that this effect is called *likelihood effect*. If $F$ chooses risk, he will unambiguously prefer low risk $\sigma^2 = \sigma_L^2$. Higher risk taking would shift probability mass from the mean to the tails. This is detrimental for the favorite, since bad luck may jeopardize his favorable position at the effort stage. By choosing low risk, his winning probability becomes $G(\Delta e; \sigma_L^2)$ instead of $G(\Delta e; \sigma_H^2)$ $(< G(\Delta e; \sigma_L^2))$. A technical intuition can be seen from Figure 2.

[Figure 2 about here]

There, the cumulative distribution function given high risk, $G(\cdot; \sigma_H^2)$, is obtained from the low-risk cdf, $G(\cdot; \sigma_L^2)$, by flattening and clockwise rotation in the point $\left(0, \frac{1}{2}\right)$. Note that at $\Delta e$ the cdf describes the winning probability of player $F$, whereas $U$'s likelihood of winning is computed at $-\Delta e$. Thus, by choosing low risk instead of high risk, the favorite maximizes his own winning probability and minimizes that of his opponent.

To sum up, the analysis of risk taking by the favorite points to three different effects at the risk stage of the game. These three effects were tested in a laboratory experiment which will be described in the next section.[5] There-

[4] See again the proof of Proposition 2.

[5] Note that we will not consider the case $B < \min\left\{\frac{c_F}{\Delta G(\sigma_H^2)}, \frac{c_U}{\Delta G(\sigma_L^2)}\right\}$ in the lab. Here, low risk would imply a higher winning probability at higher effort costs for the favorite. Hence, we would have a mixture of the likelihood effect and the cost effect, which would

after, we will present the exact hypotheses to be tested and our experimental results.

# 4 Experimental Design and Procedure

We designed three different treatments corresponding to our three effects – the discouragement effect, the cost effect, and the likelihood effect. For each treatment we conducted two sessions, each including 5 groups of 6 participants. Each session consisted of 10 trial rounds and 5 rounds of the two-stage game. During each round, pairs of two players were matched anonymously within each group. After each round new pairs were matched in all groups. The game was repeated five times so that each player interacted with each other player exactly one time within a certain group. This perfect stranger matching was implemented to prevent reputation effects. Altogether, for each treatment we have 30 independent observations concerning the first round (15 pairs, 2 sessions) and 10 independent observations based on all rounds.
Before the 5 rounds of each session started, each participant got the chance to become familiar with the complete two-stage game of Section 2 for 10 rounds. During the trial rounds, a single player had to make all decisions on his own so that he learned the role of the favorite as well as that of the underdog. Within the 5 rounds of the experiment the participants got alternate roles. Hence, each individual either played three rounds as a favorite and two rounds as an underdog or vice versa.
In each session, the players competed for the same benefit ($B = 100$) and chose between the same alternative effort levels ($e_L = 0$ and $e_H = 1$). We used a uniformly distributed noise term $\varepsilon$ for each session which was either distributed between $-2$ and 2 ("low risk"), or between $-4$ and 4 ("high risk").[6] Hence, we had $\Delta G(\sigma_L^2) = \frac{1}{4}$ and $\Delta G(\sigma_H^2) = \frac{1}{8}$. However, we varied

not lead to additional insights when testing in an experiment.

[6]Random draws were rounded off to two decimal places.

the effort costs between the treatments. In the *discouragement treatment* (focusing on the discouragement effect) we used $c_U = 24$ and $c_F = 8$, in the *cost treatment* (testing the cost effect) we had $c_U = 24$ and $c_F = 22$, and in the *likelihood treatment* (dealing with the likelihood effect) we had $c_U = 60$ and $c_F = 8$. It can easily be checked that these three different parameter constellations satisfy the three different conditions for the benefit corresponding to the discouragement effect, the cost effect and the likelihood effect, respectively. All parameter values $B$, $e_L$, $e_H$, $c_U$, $c_F$, as well as the intervals were common knowledge.

The experiment was conducted at the Cologne Laboratory of Economic Research at the University of Cologne in January 2008. Altogether, 180 students participated in the experiment. All of them were enrolled in the Faculty of Management, Economics, and Social Sciences. The participants were recruited via the online recruitment system by Greiner (2003). The experiment was programmed and conducted with the software z-tree (Fischbacher (2007)). A session approximately lasted one hour and 15 minutes and subjects earned on average 13.82 Euro.

At the outset of a session the subjects were randomly assigned to a cubical where they took a seat in front of a computer terminal. The instructions were handed out and read aloud by the experimenters.[7] Thereafter, the subjects had time to ask clarifying questions if they had any difficulties in understanding the instructions. Communication – other than with the experimental software – was not allowed. To check for their comprehension, subjects had to answer a short questionnaire. After each of the subjects correctly solved the questions, the experimental software was started.

At the beginning of each session, the players got 60 units of the fictitious currency "Taler". Each round of the experiment then proceeded according to the two-stage game described in Section 2. It started with player $F$'s risk choice at stage 1 of the game. He could either choose a random draw

[7] The translated instructions can be found in the Appendix.

out of the interval $[-2, 2]$ ("low risk") or from the interval $[-4, 4]$ ("high risk"). When choosing risk, player $F$ knew the course of events at the next stage as well as both players' effort costs. At the beginning of stage 2, both players were informed about the interval that had been chosen by player $F$ before. Then both players were asked about their beliefs concerning the effort choice of their respective opponent. Thereafter, each player $i$ ($i = U, F$) chose between score 0 (at zero costs) and score 1 (at costs $c_i$) as alternative effort levels. Next, the random draw was executed. The final score of player $F$ consisted of his initially chosen score 0 or 1 plus the realization of the random draw, whereas the final score of player $U$ was identical with his initially chosen score 0 or 1.[8] The player with the higher final score was the winner of this round and the other one the loser. Both players were informed about both final scores, whether the guess about the opponent's choice was correct, and about the realized payoffs. Then the next round began.
Each session ended after 5 rounds. At the end of the session, one of the 5 rounds was drawn by lot. For this round, each player got 15 Talers if his guess of the opponent's effort choice was correct and zero Talers otherwise. The winner of the selected round received $B = 100$ Talers and the loser zero Talers. Each player had to pay zero or $c_i$ Talers for the chosen score 0 or 1, respectively. The sum of Talers was then converted into Euro by a previously known exchange rate of 1 Euro per 10 Talers. Additionally, each participant received a show up fee of 2.50 Euro independent of the outcome of the game. After the final round, the subjects were requested to complete a questionnaire including questions on gender, age, loss aversion and inequity aversion. Furthermore, the questionnaire contained questions concerning the risk attitude of the subjects. These questions were taken from the German Socio Economic Panel (GSOEP) and dealt with the overall risk attitude of a subject.

[8] Hence, the relative performance $RP$ is given by the final score of player $F$ minus the final score of player $U$.

The language was kept neutral at any time. For example, we did not use terms like "favorite" and "underdog", or "player $F$" and "player $U$", but instead spoke of "player $A$" and "player $B$". Moreover, we simply described the pure random draw out of the two alternative intervals without speaking of low or high risk. Instead favorites chose between "alternative 1" and "alternative 2".

# 5 Hypotheses

We tested seven hypotheses, six of them deal with the risk behavior and one of them with the players' behavior at the effort stage.
The first three hypotheses directly test the relevance of the discouragement effect, the cost effect and the likelihood effect at stage 1 of the game. Since we designed three different constellations by changing one of the cost parameters, respectively, each effect could be separately analyzed in a single treatment. The cost treatment is obtained from the discouragement treatment by increasing the favorite's cost parameter, whereas the design of the likelihood treatment results from increasing the underdog's cost parameter in the discouragement treatment.

**Hypothesis 1:** *In the discouragement treatment, (most of) the favorites choose the high risk.*

**Hypothesis 2:** *In the cost treatment, (most of) the favorites choose the high risk.*

**Hypothesis 3:** *In the likelihood treatment, (most of) the favorites choose the low risk.*

In a next step, we compare the risk choices in the different treatments. We expect that risk taking clearly differs among the three treatments. The corresponding behavioral hypotheses can be described as follows:

**Hypothesis 4:** *The favorites' risk taking in the cost treatment does not differ from that in the discouragement treatment.*[9]

**Hypothesis 5:** *The favorites choose higher risk in the discouragement treatment than in the likelihood treatment.*

**Hypothesis 6:** *The favorites choose higher risk in the cost treatment than in the likelihood treatment.*

Finally, we test the players' effort choices at the second stage of the game. Since in any equilibrium at the effort stage the favorite should not choose less effort than the underdog, we have the following hypothesis:

**Hypothesis 7:** *The favorites choose at least as much effort as the underdogs.*[10]

# 6 Experimental Results

## 6.1 The Risk Stage

We test the hypotheses with the data from our experiment, starting with Hypotheses $1 - 3$. Contrary to the discouragement treatment, the findings on the favorites' risk choices in the cost and the likelihood treatments are in line with our theoretical predictions on average (see Figure A1 in the Appendix): favorites more often choose high risk (low risk) than low risk (high risk) in the cost treatment (likelihood treatment). However, when applying the one-tailed Binomial test we cannot reject the hypothesis that

[9] Of course, we cannot test whether risk taking is identical in both treatments, but we can test whether significant differences between the treatments do exist.

[10] Our hypotheses are stated in terms of "higher" risk and effort, but tests will deal with the frequency of the appearence of the two risk and effort levels. However, the interpretation does not change. If we observe, for example, that there is a significant higher proportion of favorites than underdogs choosing the high effort level, this also means that the average effort chosen by the favorites is higher.

favorites randomly choose between high and low risk in the cost treatment in the first round. To check whether we can pool the data over all rounds, we ran different regressions (see Tables A1 to A3 in the Appendix). As the subjects play the game 5 times, we compute robust standard errors clustered by subjects and check for learning effects by including round dummies. We do not find any significant learning effects over time in all treatments since there is no significant influence of a certain round on risk taking. Additionally, we compare risk taking in round 1 with the risk taking of rounds $2-5$ for each treatment but do not find significant differences. We think that the relatively large number of 10 trial rounds at the beginning of the experiment help the subjects to study the consequences of different strategies. If there are any learning effects, these should only be relevant in this trial phase. Thus, we pooled our data over the 5 rounds. In the following we present the results of the first round and additionally our results with pooled data.
The results of the one-tailed Binomial tests concerning Hypotheses 1 to 3 can be summarized as follows:[11]

| risk choice | discouragement treatment | cost treatment | likelihood treatment |
|---|---|---|---|
| first round | high risk | high risk | low risk** |
| pooled data | high risk | high risk | low risk*** |

($^{*}0.05 < \alpha \leq 0.1$; $^{**}0.01 < \alpha \leq 0.05$; $^{***}\alpha \leq 0.01$)

**Table 1:** Results on risk taking (one-tailed Binomial tests)

**Observation on Hypotheses 1 to 3:** *Favorites more often choose low risk than high risk in the likelihood treatment, whereas the findings on high risk taking in the discouragement and the cost treatments are not significant.*

[11] Table entries indicate the predicted risk choices.

In a next step, we pairwise compare the three treatments.

**Observation on Hypothesis 4:** *Favorites' risk taking in the cost treatment significantly differs from that in the discouragement treatment* (Fisher test, two-tailed; first round: $p = 0.008$; pooled data: $p = 0.000$)

Whereas the Binomial test shows that favorites do not prefer high risk significantly stronger than low risk in the cost treatment, the relative comparison supports the initial impression from Figure A1: in the cost treatment, the proportion of favorites choosing the high risk is higher than in the discouragement treatment so that Hypothesis 4 can be clearly rejected. Therefore, the cost effect seems to be more relevant for subjects when choosing risk than the discouragement effect. In addition, we ran a probit regression with the risk choice as the dependent variable, using our pooled data set (see Table A1 in the Appendix). Here, the dummy variable for the cost treatment is highly significant which confirms our result from the Fisher test.

**Observation on Hypothesis 5:** *Favorites' risk taking in the discouragement treatment is not significantly higher than that in the likelihood treatment* (one-tailed Fisher test).

The observation on Hypothesis 5 holds for the first round as well as for the pooled data set and is in line with our previous findings: in the likelihood treatment, favorites choose low risks as theoretically expected. Since, contrary to theory, they also often choose low risk in the discouragement treatment, risk taking is not significantly higher in the discouragement treatment. Again, we ran a probit regression with the pooled data, but do not find a significant result for the treatment dummy (see Table A2 in the Appendix).

**Observation on Hypothesis 6:** *Favorites' risk taking is significantly higher in the cost treatment than in the likelihood treatment* (Fisher test, one-tailed; first round: $p = 0.018$; pooled data: $p = 0.000$)

Again, the Fisher test supports the general impression of Figure A1: favorites choose significantly higher risk in the cost treatment compared to the risk behavior in the likelihood treatment. Further confirmation comes from a respective probit regression (see Table A3 in the Appendix). Note that all three probit regressions show that risk aversion does not have a significant influence on the favorites' risk taking.

## 6.2 The Effort Stage

Given the favorite's risk choice at stage 1, the underdog and the favorite have to decide on their efforts at the second stage of the game. According to the subgame perfect equilibria, we would expect that the favorite chooses a higher effort level than the underdog in the discouragement and the likelihood treatments, whereas both players' efforts should be the same in the cost treatment. Altogether, favorites should exert more effort than underdogs on average.[12]

Recall that in the discouragement and the cost treatments different risk levels lead to different equilibria at the effort stage. Since both risk levels have been chosen at stage 1, we can test whether players rationally react to a given risk level. An overview on the aggregate effort choices is given by Figures A2 to A10 in the Appendix: in the discouragement treatment, the favorite should always choose the large effort level independent of given risk, whereas the underdog should prefer small (large) effort if risk is high (low). Figures A2 to A4 show that the experimental findings are roughly in line with our theoretical predictions. For high risk, the subjects even perfectly react to given risk in round 5 – all underdogs choose low effort, but all favorites prefer the high effort level. In the cost treatment, theory predicts that both types of players choose small efforts under high risk, but large

[12] Uneven tournaments in the notion of O'Keeffe *et al.* (1984) were also considered in the experiments by Bull *et al.* (1987), Schotter and Weigelt (1992) and Harbring *et al.* (2007). In each experiment, favorites choose significantly higher effort levels than underdogs.

efforts under low risk. Figures A5 to A7 illustrate that subjects on average indeed react as predicted. Interestingly, favorites are more sensitive to risk than underdogs although subjects change their roles after each round. In the likelihood treatment, for both risk levels favorites (underdogs) should choose large (small) effort. As for the risk stage, in the likelihood treatment subjects' behavior seems to follow theoretical predictions also most closely when choosing effort, compared to the other treatments (see Figures A8 to A10).

Next, we used a one-tailed Binomial test to check if most of the subjects of a certain type choose the predicted effort level under a given risk against the hypothesis that subjects randomly decide between the two effort levels. Again, we can pool our data over the 5 rounds because regressions including round dummies (see Tables A4 to A6 in the Appendix) as well as tests comparing the effort in round 1 with the effort of rounds $2-5$ for a particular type and particular risk do not reveal any significant learning effects at the effort stage. The following table presents all first-round observations and the results for pooled data (a table entry illustrates the predicted effort level):

| | player: data | discouragement treatment | cost treatment | likelihood treatment |
|---|---|---|---|---|
| high risk | $F$: 1st round | $e_F = 1$ | $e_F = 0^{**}$ | $e_F = 1$ |
| | $F$: pooled | $e_F = 1^{***}$ | $e_F = 0^{***}$ | $e_F = 1^{***}$ |
| | $U$: 1st round | $e_U = 0^{*}$ | $e_U = 0$ | $e_U = 0^{**}$ |
| | $U$: pooled | $e_U = 0^{***}$ | $e_U = 0$ | $e_U = 0^{***}$ |
| low risk | $F$: 1st round | $e_F = 1^{***}$ | $e_F = 1$ | $e_F = 1^{***}$ |
| | $F$: pooled | $e_F = 1^{***}$ | $e_F = 1^{***}$ | $e_F = 1^{***}$ |
| | $U$: 1st round | $e_U = 1$ | $e_U = 1^{*}$ | $e_U = 0^{*}$ |
| | $U$: pooled | $e_U = 1$ | $e_U = 1^{**}$ | $e_U = 0^{***}$ |

($^{*}0.05 < \alpha \leq 0.1$;  $^{**}0.01 < \alpha \leq 0.05$;  $^{***}\alpha \leq 0.01$)

**Table 2:** Results on effort choices (one-tailed Binomial tests)

The column corresponding to the discouragement treatment reveals that favorites' reactions to risk taking are quite in line with theory as they choose high efforts for both risk levels. However, the underdogs' behavior is not significantly different from a random draw under low risk, but in line with the theoretical prediction under high risk (first round: $p = 0.0625$, pooled: $p = 0.0004$). The column for the cost treatment confirms the initial impression from Figures A5 to A7. Whereas favorites react fairly well to different risk levels, the underdogs often choose high efforts even under high risk, which contradicts theory. The last column reports the findings for the likelihood treatment. Our results point out that subjects behave rationally at the effort stage with the exception of the favorites' effort choices in the first round given high risk.

Finally, we test the favorites' effort choices against the underdogs' behavior. We either used a one-tailed Fisher test to check if the proportion of favorites choosing the high effort is significantly larger than that of the underdogs if theory predicts a higher effort level of the favorite ($e_F > e_U$), or a two-tailed Fisher test to check if there are any (unpredicted) differences between the proportion of types in the two effort categories. We have differentiated between three cases when comparing efforts – ignoring the given risk level (first panel of the table), only considering high-risk situations (second panel), only considering low-risk situations (third panel):

| | data | discouragement treatment | cost treatment | likelihood treatment |
|---|---|---|---|---|
| both | $1^{st}$ round | one-tailed*** | two-tailed | one-tailed*** |
| risks | pooled | one-tailed*** | two-tailed | one-tailed*** |
| high | $1^{st}$ round | one-tailed* | two-tailed | one-tailed** |
| risk | pooled | one-tailed*** | two-tailed*** | one-tailed*** |
| low | $1^{st}$ round | two-tailed | two-tailed | one-tailed*** |
| risk | pooled | two-tailed*** | two-tailed | one-tailed*** |

(*$0.05 < \alpha \leq 0.1$; **$0.01 < \alpha \leq 0.05$; ***$\alpha \leq 0.01$)

**Table 3:** Results on effort comparisons (Fisher test)

Following the theoretical predictions, in the discouragement treatment favorites should only exert more effort than underdogs if risk is high. The second panel of the table fits well with this prediction for the first round ($p = 0.051$) and pooled data ($p = 0.000$), but according to the third panel subjects' behavior seems to be even different under low risk: considering the pooled data, favorites choose a significantly different effort than underdogs ($p = 0.000$), thus contradicting theory. Inspecting the data reveals that the proportion of favorites choosing the high effort is even significantly higher than the respective proportion of underdogs under low risk. In both the cost treatment and the likelihood treatment, the effort difference $e_F - e_U$ should be independent of the risk level. $e_F - e_U$ should be zero under the cost treatment, but strictly positive under the likelihood treatment. Again, the findings for the likelihood treatment are pretty in line with theory. For the cost treatment, the second panel of the table shows that the different types of players choose significantly different effort levels under high risk (pooled data: $p = 0.001$). Here, the underdogs exert clearly more effort than the favorites which is in line with our observations in Figures A5 and A7 and the findings for the Binomial test, but contrary to theory.

Finally, we ran probit regressions on the effort comparison between favorites and underdogs for the three different treatments (see Tables A4 to A6 in the Appendix). The regression results clearly support our findings for the Fisher test: whereas the player-type dummy is (highly) significant and in line with theory for the discouragement and the likelihood treatments, it is not significant or even significantly different from theoretical predictions in the cost treatment. Furthermore, we check if a player's risk attitude influences his behavior at the effort stage. None of the regressions show a significant influence of the risk attitude of the player on his choice of effort.

Altogether, we can summarize our findings for the effort stage as follows:

**Observation on Hypothesis 7:** *In the discouragement treatment and the likelihood treatment, favorites choose significantly more effort than underdogs. In the cost treatment, players' behavior does not significantly differ given low risk, but for high risk underdogs exert clearly more effort than favorites.*

# 7 Discussion

The experimental results of Section 6 point to three puzzles, which should be discussed in the following: (1) favorites choose significantly more often the low risk than the high risk in the discouragement treatment; (2) given low risk in the discouragement treatment, favorites exert significantly more effort than underdogs; (3) given high risk in the cost treatment, underdogs choose significantly more effort than favorites.

Inspection of the players' beliefs concerning their opponents' efforts shows that puzzles (1) and (2) seem to be interrelated. It turns out that in the low-risk state of the discouragement treatment, favorites' equilibrium beliefs differ from their reported beliefs in each of the five rounds of the repeated game. In the first and in the last round, 11 out of 23 favorites expect underdogs to choose a low effort level although theory predicts a high effort choice. The proportion of favorites with this belief is even higher in round 2 (10 out of 18), round 3 (10 out of 20) and round 4 (12 out of 21). Actually, about one half of the underdogs choose a low effort. Given that the favorites already had these beliefs when taking risk at stage 1, both puzzles (1) and (2) can be easily explained together: now, a favorite expecting a low effort by an underdog in both a low-risk and a high-risk state, should unambiguously prefer a high effort level in both states. The results of our Binomial test from Subsection 6.1 shows that indeed favorites highly significantly react in this way. This explains puzzle (2). When the favorites decide on risk taking at stage 1 and anticipate $(e_U, e_F) = (0, 1)$ under both risks, the underlying discouragement problem turns into a perceived likelihood problem from the viewpoint of the favorites.[13] Given a perceived likelihood problem, the favorites should optimally choose a low risk in order to maximize their winning probability (see Figure 2), which explains puzzle (1).

Concerning puzzle (3), inspection of the players' beliefs does not lead to clear results. Similarly, controlling for risk aversion, loss aversion, inequity aversion and the history of the game does not yield new insights either. Most surprisingly seems to be the missing explanatory power of the players' history in the game: intuitively, subjects might react to the outcomes of former rounds when choosing effort in the actual round. However, our results do not show a clear impact of experienced success or failure in previous tournaments. Maybe, underdogs react too strongly to the close competition with the favorites. In the cost treatment, costs for exerting high effort were

[13] See also the observation on Hypothesis 5 in Subsection 6.1.

$c_U = 24$ and $c_F = 22$. Hence, the cost difference is rather small – in particular compared to the two other treatments –, and the underdogs might have chosen high efforts due to perceived homogeneity in the tournament. The underdogs' beliefs about the favorites' effort choices indicate that this effect might be relevant under high risk. In the first and third round, 7 (out of 18 and 15 respectively), and in the fourth round 8 (out of 19) underdogs expect favorites to choose high efforts, too.[14] However, in the concrete situation given $\sigma^2 = \sigma_H^2$ and $e_F = 1$, an underdog should prefer $e_U = 1$ to $e_U = 0$ if and only if $\frac{B}{2} - c_U > B \cdot G(-\Delta e; \sigma_H^2) \Leftrightarrow B \cdot \Delta G(\sigma_H^2) > c_U$, and for our chosen parameter values this condition (12.5 Talers > 24 Talers) is clearly violated.[15] To sum up, as we can see from Figures A5 and A6 underdogs reduce their efforts when risk increases, which is qualitatively in line with the cost effect, but it remains puzzling why underdogs do not react as strongly as favorites to different risks although subjects changed their roles after each round in the experiment.

# 8 Conclusion

In many winner-take-all situations, a challenger first decides whether to use a more or less risky strategy and then both players choose their investments or efforts. In this case, risk taking at the first stage of the game determines both the optimal investment or effort levels at stage two and the players' likelihood of winning the competition. We find three effects that mainly determine risk taking – a discouragement effect, a cost effect, and a likelihood effect. Our experimental findings point out that the impact of risk taking on the likelihood of winning (i.e. the likelihood effect) is very important

[14] In the other two rounds the proportion of underdogs who believe the favorite to choose the high effort is somewhat lower: second round: 3 out of 13; last round: 4 out of 17.

[15] Note that in terms of converted money payments, subjects have to compare 1.25 Euro to 2.40 Euro. Given $e_F = 0$, high effort would only be rational for the underdog if 1.25 Euro > 2.40 Euro which is clearly not satisfied.

for subjects at stage one. Moreover, optimal investments for given risk are clearly in line with theory under the likelihood effect. Furthermore, in most of the rounds even the beliefs of the favorites seem to follow the theoretical beliefs in the likelihood treatment. In addition, the beliefs of the underdogs are in line with the theory in all rounds. We obtain mixed results for the cost effect and the discouragement effect, but pairwise comparison of treatments reveals that the cost effect seems to be more relevant for subjects than the discouragement effect. Interestingly, the players very often react to given risk according to theory when investing into the winner-take-all competition.

As a by-product, the results of our questionnaire point to an important finding on the concept of inequity aversion[16] as introduced by Fehr and Schmidt (1999) in the literature. Grund and Sliwka (2005) applied this concept to rank-order tournaments. If one player has a higher (lower) payoff than another player, the first (second) realizes a disutility from compassion (envy). In a tournament, players typically compare their relative payoffs and the tournament winner (loser) will feel some compassion (envy) when being inequity averse. Both Fehr-Schmidt and Grund-Sliwka assumed that envy is at least as strong as compassion. This assumption is central for the results in Grund and Sliwka (2005) since it directly implies that inequity averse contestants exert more effort than players who are not inequity averse. Using a sign test,[17] our findings point out that in each treatment subjects feel significantly more compassion than envy (one-tailed, discouragement treatment: $p = 0.000$, cost treatment: $p = 0.000$, likelihood treatment: $p = 0.000$).[18] According to this result, inequity aversion would not lead to stronger com-

[16] We used the same two games as Dannenberg *et al.* (2007) to measure the subjects' inequity preferences. In contrast to Dannenberg *et al.* (2007), not all subjects received a payoff for their decisions. After the subjects indicated their decisions, we randomly determined for which game and which row of that particular game two randomly selected subjects received a payoff according to their decisions. Furthermore, the respective player role of the selected subjects was randomly determined.

[17] Subjects with inconsistent behavior were excluded from the analysis.

[18] A similar finding is made by Dannenberg *et al.* (2007) running experiments on public good games.

petition in tournaments. On the contrary, competition would be weakened as any contestant anticipates to suffer from strong compassion in case of winning.

**Appendix**

*Proof of Proposition 2:*
(i) We can rewrite (6) as

$$(e_U^*, e_F^*) = \begin{cases} (e_H, e_H) & \text{if} \quad B \geq \frac{c_U}{\Delta G(\sigma^2)} \\ (e_L, e_H) & \text{if} \quad \frac{c_U}{\Delta G(\sigma^2)} \geq B \geq \frac{c_F}{\Delta G(\sigma^2)} \\ (e_L, e_L) & \text{if} \quad B \leq \frac{c_F}{\Delta G(\sigma^2)}. \end{cases} \tag{6'}$$

Since we have two risk levels, $\sigma_L^2$ and $\sigma_H^2$, there are four cutoffs with $\frac{c_F}{\Delta G\left(\sigma_L^2\right)}$ being the smallest one and $\frac{c_U}{\Delta G\left(\sigma_H^2\right)}$ the largest one because of (5). Hence, both players will always (never) choose high effort levels if $B \geq \frac{c_U}{\Delta G\left(\sigma_H^2\right)}$ ($B \leq \frac{c_F}{\Delta G\left(\sigma_L^2\right)}$), irrespective of risk taking in stage 1.
(ii) We have to differentiate between two possible rankings of the cutoffs:

$$\begin{array}{ll} \text{scenario 1:} & \dfrac{c_F}{\Delta G\left(\sigma_L^2\right)} < \dfrac{c_F}{\Delta G\left(\sigma_H^2\right)} < \dfrac{c_U}{\Delta G\left(\sigma_L^2\right)} < \dfrac{c_U}{\Delta G\left(\sigma_H^2\right)} \\ \text{scenario 2:} & \dfrac{c_F}{\Delta G\left(\sigma_L^2\right)} < \dfrac{c_U}{\Delta G\left(\sigma_L^2\right)} < \dfrac{c_F}{\Delta G\left(\sigma_H^2\right)} < \dfrac{c_U}{\Delta G\left(\sigma_H^2\right)}. \end{array}$$

If $B < \min\left\{\frac{c_F}{\Delta G\left(\sigma_H^2\right)}, \frac{c_U}{\Delta G\left(\sigma_L^2\right)}\right\}$, then in both scenarios the choice of $\sigma_L^2$ will imply $(e_U^*, e_F^*) = (e_L, e_H)$ at stage 2, whereas $\sigma^2 = \sigma_H^2$ will lead to $(e_U^*, e_F^*) = (e_L, e_L)$. In this situation, a $F$-challenger prefers $\sigma^2 = \sigma_L^2$ since

$$B \cdot G\left(\Delta e; \sigma_L^2\right) - c_F > \frac{B}{2} \Leftrightarrow B > \frac{c_F}{\Delta G\left(\sigma_L^2\right)}$$

is true. However, a $U$-challenger prefers $\sigma^2 = \sigma_H^2$ because of

$$\frac{B}{2} > B \cdot G\left(-\Delta e; \sigma_L^2\right).$$

If $B > \max\left\{\frac{c_F}{\Delta G\left(\sigma_H^2\right)}, \frac{c_U}{\Delta G\left(\sigma_L^2\right)}\right\}$, then in both scenarios the choice of $\sigma_L^2$ will result into $(e_U^*, e_F^*) = (e_H, e_H)$ at stage 2, but $\sigma^2 = \sigma_H^2$ will induce $(e_U^*, e_F^*) = (e_L, e_H)$. In this case, a $F$-challenger prefers the high risk $\sigma_H^2$ since

$$B \cdot G\left(\Delta e; \sigma_H^2\right) - c_F > \frac{B}{2} - c_F.$$

Player $U$ has the same preference when being the challenger because

$$B \cdot G\left(-\Delta e; \sigma_H^2\right) > \frac{B}{2} - c_U \Leftrightarrow \frac{c_U}{\Delta G\left(\sigma_H^2\right)} > B$$

is true.

Two cases are still missing. Under scenario 1, we may have that

$$\frac{c_F}{\Delta G\left(\sigma_H^2\right)} < B < \frac{c_U}{\Delta G\left(\sigma_L^2\right)}.$$

Then any risk choice leads to $(e_U^*, e_F^*) = (e_L, e_H)$ at stage 2 and a $F$-challenger prefers $\sigma_L^2$ because of

$$B \cdot G\left(\Delta e; \sigma_L^2\right) - c_F > B \cdot G\left(\Delta e; \sigma_H^2\right) - c_F,$$

but $U$ favors $\sigma_H^2$ when being active at stage 1 since

$$B \cdot G\left(-\Delta e; \sigma_H^2\right) > B \cdot G\left(-\Delta e; \sigma_L^2\right).$$

Under scenario 2, we may have that

$$\frac{c_U}{\Delta G\left(\sigma_L^2\right)} < B < \frac{c_F}{\Delta G\left(\sigma_H^2\right)}.$$

Here, low risk $\sigma_L^2$ implies $(e_U^*, e_F^*) = (e_H, e_H)$, but high risk $\sigma_H^2$ leads to $(e_U^*, e_F^*) = (e_L, e_L)$. Obviously, each type of challenger prefers the choice of high risk at stage 1. Our findings are summarized in Proposition 2(ii).

## References

J.A. Amegashie. American idol: Should it be a singing contest or a popularity contest? Unpublished manuscript, 2007.

G. P. Baker, M. Gibbs, and B. Holmström. The wage policy of a firm. *Quarterly Journal of Economics*, 109:921–955, 1994.

S.M. Besen and J. Farrell. Choosing how to compete: Strategies and tactics in standardization. *Journal of Economic Perspectives*, 8(2):117–131, 1994.

C. Bull, A. Schotter, and K. Weigelt. Tournaments and piece rates: An experimental study. *Journal of Political Economy*, 95:1–33, 1987.

A.S. Caplin and B.J. Nalebuff. Multi-dimensional product differentiation and price competition. *Oxford Economic Papers*, 38:129–145, 1986.

A. Dannenberg, T. Riechmann, B. Sturm, and C. Vogt. Inequity aversion and individual behavior in public good games: an experimental investigation. ZEW Discussion Paper No. 07-034, 2007.

E. Fehr and K. M. Schmidt. A theory of fairness, competition, and cooperation. *Quarterly Journal of Economics*, 114:817–868, 1999.

U. Fischbacher. z-tree - zurich toolbox for readymade economic experiments. *Experimental Economics*, 10:171–178, 2007.

A. Gaba and A. Kalra. Risk behavior in response to quotas and contests. *Marketing Science*, 18:417–434, 1999.

D. Geradin. The liberalization of network industries in the european union: Where do we come from and where do we go? Prime Minister's Office, Economic Council of Finland, September 2006.

R. Gibbons. Four formal(izable) theories of the firm? *Journal of Economic Behavior and Organization*, 58:200–245, 2005.

B. Greiner. An online recruitment system for economic experiments. In K. Kremer and V. Macho, editors, *Forschung und wissenschaftliches Rechnen*, pages 79–93. GWDG Bericht 63, Göttingen: Gesellschaft für Wissenschaftliche Datenverarbeitung, 2003.

C. Grund and D. Sliwka. Envy and compassion in tournaments. *Journal of Economics and Management Strategy*, 14:187–207, 2005.

C. Harbring, B. Irlenbusch, M. Kräkel, and R. Selten. Sabotage in corporate contests - an experimental analysis. *International Jounal of the Economics of Business*, 14:367–392, 2007.

H. K. Hvide and E. G. Kristiansen. Risk taking in selection contests. *Games and Economic Behavior*, 42:172–179, 2003.

H. K. Hvide. Tournament rewards and risk taking. *Journal of Labor Economics*, 20:877–898, 2002.

M. Kräkel and D. Sliwka. Risk taking in asymmetric tournaments. *German Economic Review*, 5:103–116, 2004.

M. Kräkel. Optimal risk taking in an uneven tournament game between risk averse players. *Journal of Mathematical Economics*, forthcoming.

E. P. Lazear and S. Rosen. Rank-order tournaments as optimum labor contracts. *Journal of Political Economy*, 89:841–864, 1981.

G.C. Loury. Market structure and innovation. *Quarterly Journal of Economics*, 94:395–410, 1979.

P. Nieken. On the choice of risk and effort in tournaments - experimental evidence. unpublished manuscript, 2007.

M. O'Keeffe, W. Viscusi, and R. Zeckhauser. Economic contests: Comparative reward schemes. *Journal of Labor Economics*, 2:27–56, 1984.

R. Schmalensee. A model of promotional competition in oligopoly. *Review of Economic Studies*, 43:493–507, 1976.

R. Schmalensee. Sunk costs and market structure: A review article. *Journal of Industrial Economics*, 40:125–134, 1992.

A. Schotter and K. Weigelt. Asymmetric tournaments, equal opportunity laws, and affirmative action: some experimental results. *Quarterly Journal of Economics*, 107:511–539, 1992.

S. Szymanski. The economic design of sporting contests. *Journal of Economic Literature*, 41:1137–1187, 2003.

J. Taylor. Risk-taking behavior in mutual fund tournaments. *Journal of Economic Behavior & Organization*, 50:373–383, 2003.

G. Tullock. Efficient rent seeking. In *Buchanan, J.M., R.D. Tollison, and G. Tullock, Eds., Toward a Theory of the Rent-Seeking Society, College Station, 97-112*, 1980.

K. Waerneryd. In defense of lawyers: Moral hazard as an aid to cooperation. *Games and Economic Behavior*, 33:145–158, 2000.

H. Zhou. R & D tournaments with spillovers. *Atlantic Economic Journal*, 34:327–339, 2006.

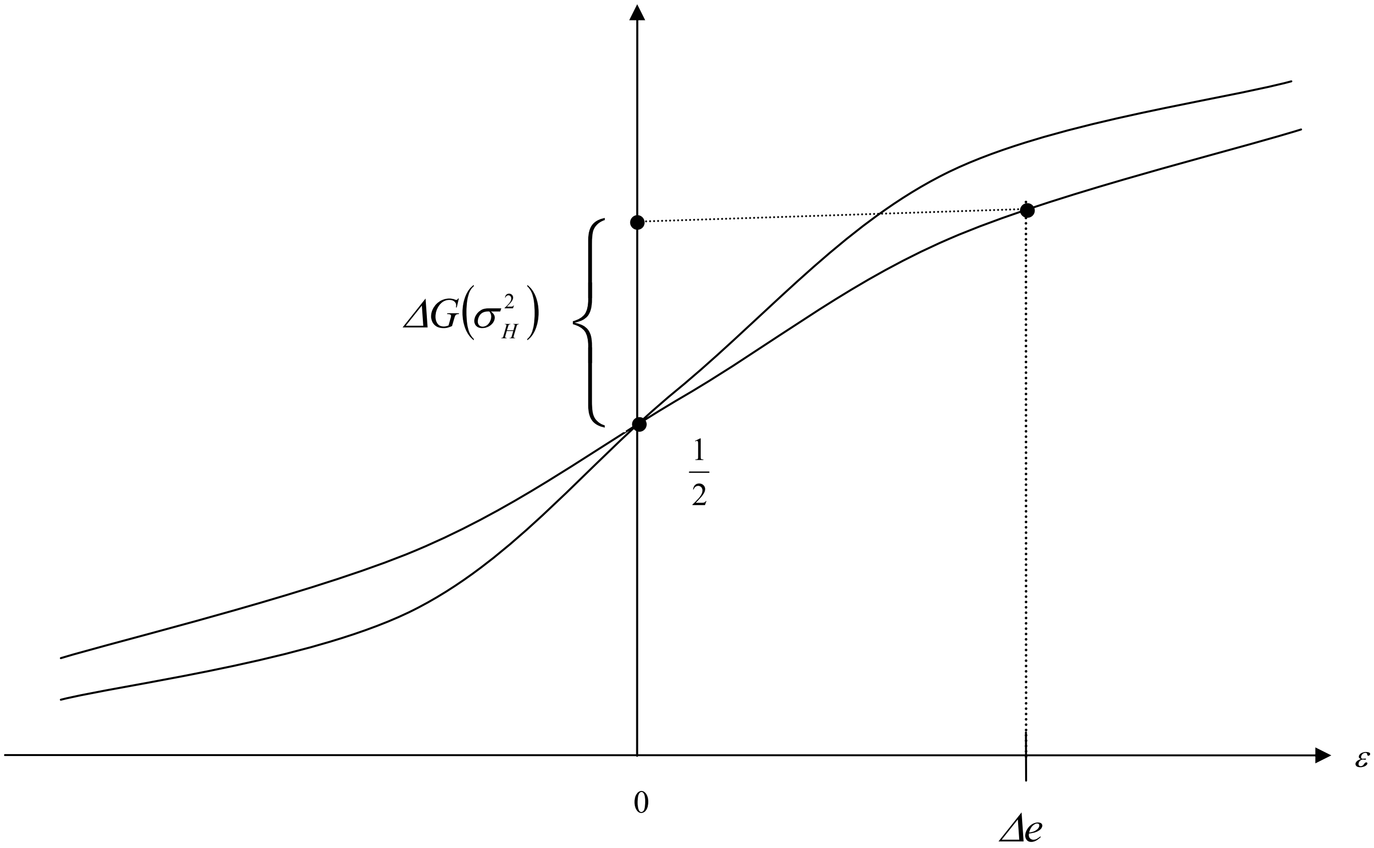



**Figure 1:** discouragement effect

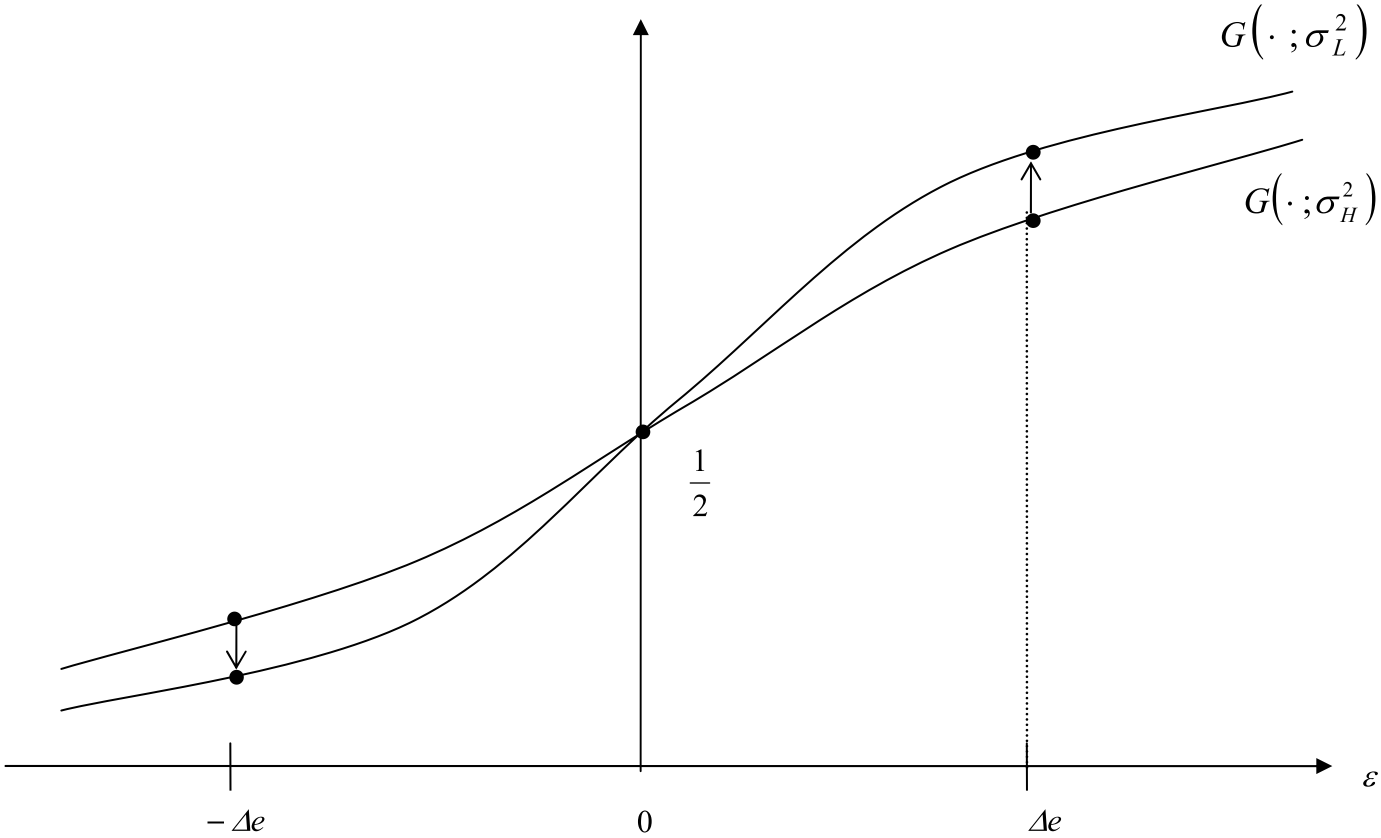
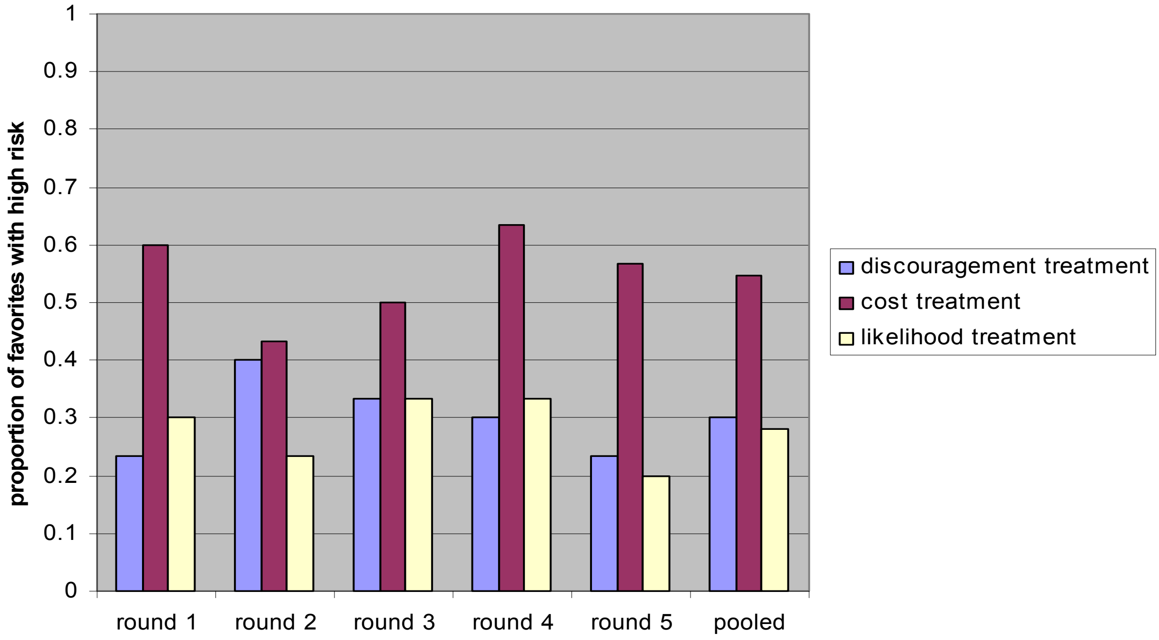



**Figure 2:** likelihood effect




<u>Number of favorites choosing the high risk</u>

| | round 1 | round 2 | round 3 | round 4 | round 5 | pooled |
|---|---|---|---|---|---|---|
| discouragement treatment | 7 out of 30 | 12 out of 30 | 10 out of 30 | 9 out of 30 | 7 out of 30 | 45 out of 150 |
| cost treatment | 18 out of 30 | 13 out of 30 | 15 out of 30 | 19 out of 30 | 17 out of 30 | 82 out of 150 |
| likelihood treatment | 9 out of 30 | 7 out of 30 | 10 out of 30 | 10 out of 30 | 6 out of 30 | 42 out of 150 |

**Figure A1:** Comparison of the favorite's risk choices over treatments

| | (1) | (2) |
|---|---|---|
| Dummy Cost Treatment | 0.643*** | 0.631*** |
| | (0.20) | (0.20) |
| Risk Attitude | | -0.0398 |
| | | (0.044) |
| Dummy Round 2 | 0.00849 | 0.00614 |
| | (0.24) | (0.24) |
| Dummy Round 3 | 0.00517 | 0.0133 |
| | (0.20) | (0.20) |
| Dummy Round 4 | 0.136 | 0.128 |
| | (0.17) | (0.17) |
| Dummy Round 5 | -0.0449 | -0.0401 |
| | (0.21) | (0.22) |
| Constant | -0.546*** | -0.349 |
| | (0.19) | (0.29) |
| Observations | 300 | 300 |
| Pseudo $R^2$ | 0.0479 | 0.0514 |
| Log Pseudolikelihood | -194.61582 | -193.89994 |

Robust standard errors in parentheses are calculated by clustering on subjects

*** p<0.01, ** p<0.05, * p<0.1

**Table A1:** Probit regression Hypothesis 4

| | (1) | (2) |
|---|---|---|
| Dummy Likelihood Treatment | -0.0584 | -0.0561 |
| | (0.22) | (0.22) |
| Risk Attitude | | 0.0125 |
| | | (0.045) |
| Dummy Round 2 | 0.145 | 0.147 |
| | (0.24) | (0.24) |
| Dummy Round 3 | 0.192 | 0.190 |
| | (0.19) | (0.19) |
| Dummy Round 4 | 0.146 | 0.149 |
| | (0.19) | (0.19) |
| Dummy Round 5 | -0.161 | -0.164 |
| | (0.23) | (0.23) |
| Constant | -0.593*** | -0.657** |
| | (0.20) | (0.32) |
| Observations | 300 | 300 |
| Pseudo $R^2$ | 0.0080 | 0.0084 |
| Log Pseudolikelihood | -179.19263 | -179.17939 |

Robust standard errors in parentheses are calculated by clustering on subjects

*** p<0.01, ** p<0.05, * p<0.1

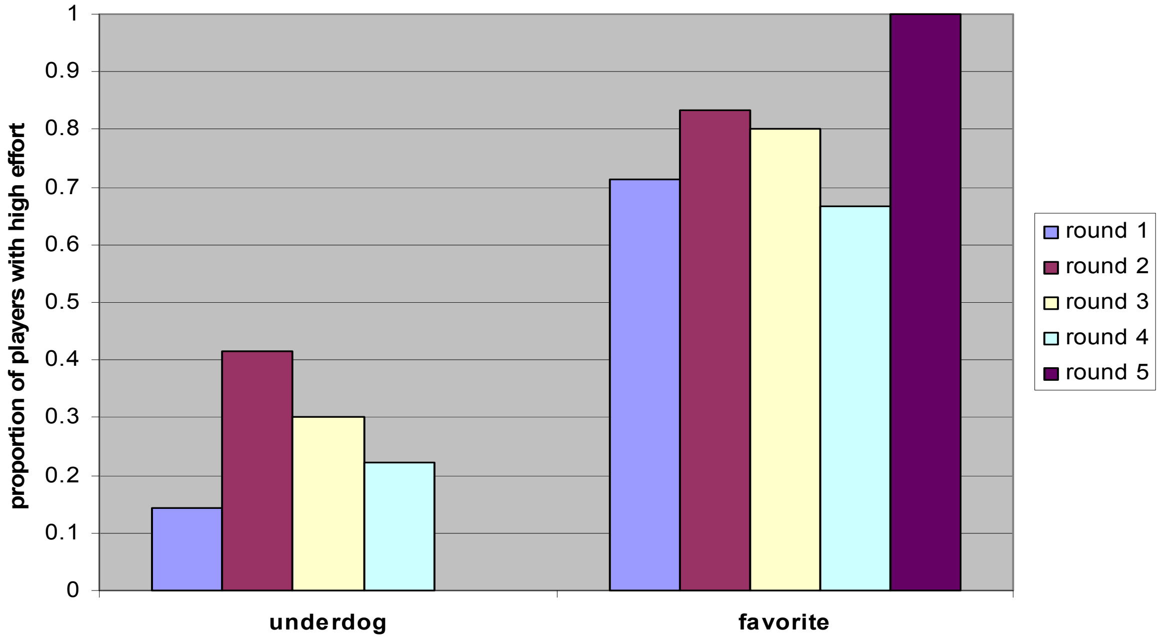
**Table A2:** Probit regression Hypothesis 5

| | (1) | (2) |
|---|---|---|
| Dummy Cost Treatment | 0.707*** | 0.708*** |
| | (0.21) | (0.21) |
| Risk Attitude | | 0.00557 |
| | | (0.047) |
| Dummy Round 2 | -0.321 | -0.318 |
| | (0.24) | (0.24) |
| Dummy Round 3 | -0.0868 | -0.0862 |
| | (0.19) | (0.19) |
| Dummy Round 4 | 0.0896 | 0.0912 |
| | (0.17) | (0.17) |
| Dummy Round 5 | -0.186 | -0.184 |
| | (0.21) | (0.21) |
| Constant | -0.488** | -0.516* |
| | (0.20) | (0.29) |
| Observations | 300 | 300 |
| Pseudo $R^2$ | 0.0637 | 0.0638 |
| Log Pseudolikelihood | -190.44806 | -190.43411 |

Robust standard errors in parentheses are calculated by clustering on subjects

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

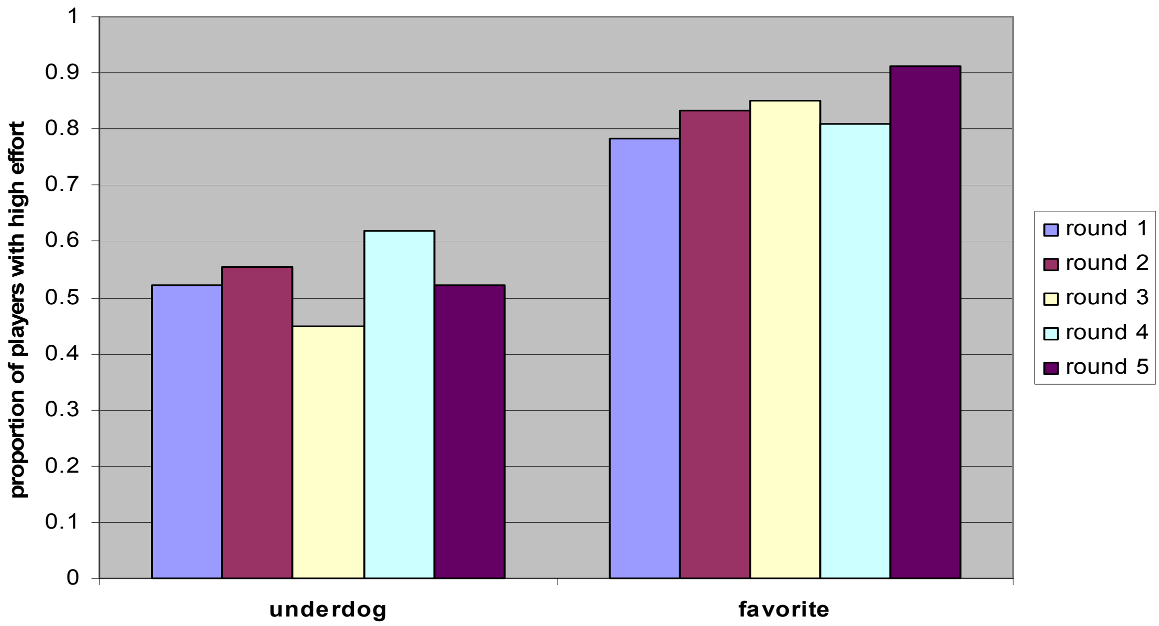
**Table A3:** Probit regression Hypothesis 6




Number of players choosing high effort

| | round 1 | round 2 | round 3 | round 4 | round 5 |
|---|---|---|---|---|---|
| underdog | 1 out of 7 | 5 out of 12 | 3 out of 10 | 2 out of 9 | 0 out of 7 |
| favorite | 5 out of 7 | 10 out of 12 | 8 out of 10 | 6 out of 9 | 7 out of 7 |

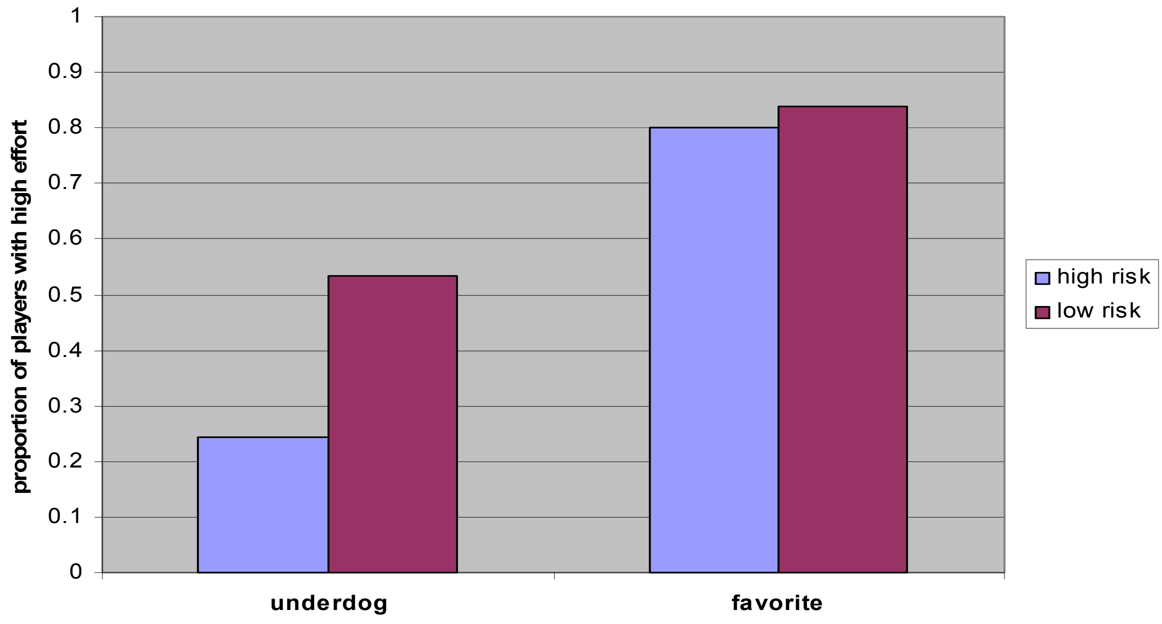
**Figure A2:** Effort choices in the discouragement treatment with high risk




Number of players choosing high effort

| | round 1 | round 2 | round 3 | round 4 | round 5 |
|---|---|---|---|---|---|
| underdog | 12 out of 23 | 10 out of 18 | 9 out of 20 | 13 out of 21 | 12 out of 23 |
| favorite | 18 out of 23 | 15 out of 18 | 17 out of 20 | 17 out of 21 | 21 out of 23 |

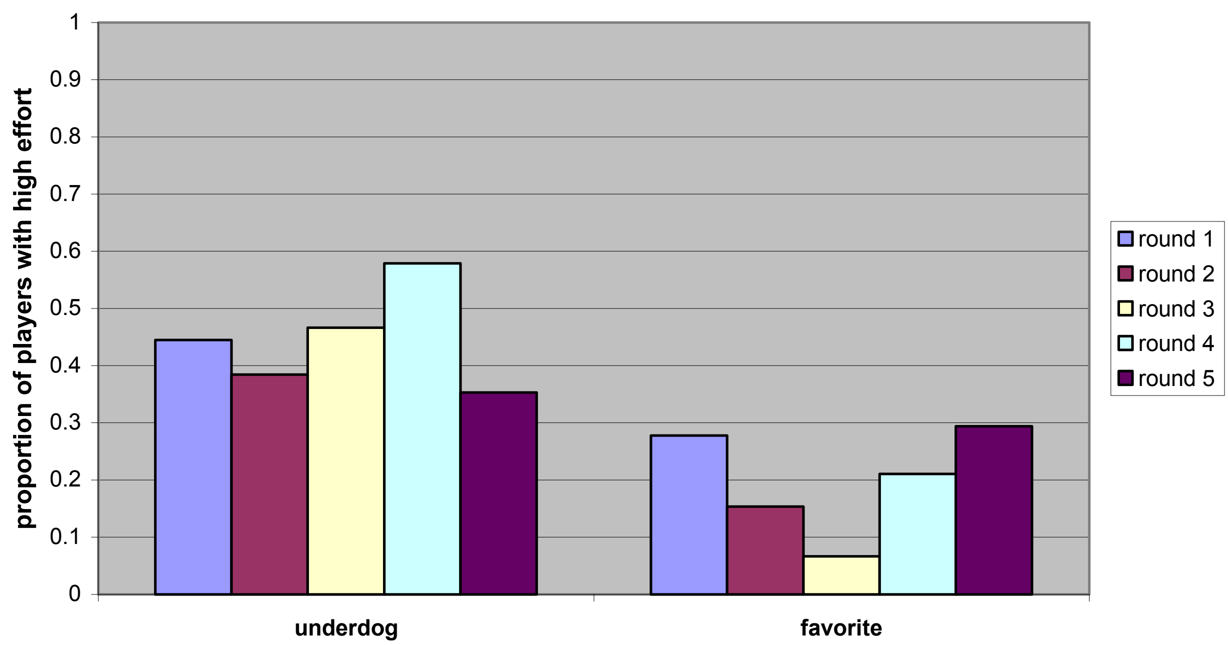
**Figure A3:** Effort choices in the discouragement treatment with low risk




Number of players choosing high effort

| | high risk | low risk |
|---|---|---|
| underdog | 11 out of 45 | 56 out of 105 |
| favorite | 36 out of 45 | 88 out of 105 |

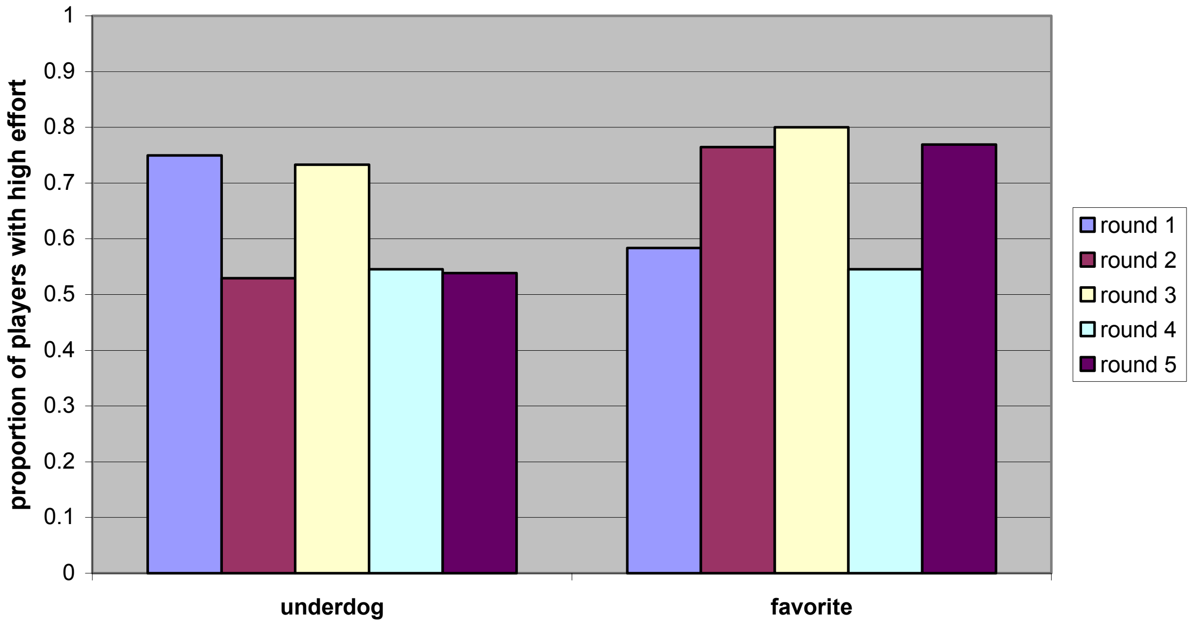
**Figure A4:** Effort choices in the discouragement treatment with pooled data




Number of players choosing high effort

| | round 1 | round 2 | round 3 | round 4 | round 5 |
|---|---|---|---|---|---|
| underdog | 8 out of 18 | 5 out of 13 | 7 out of 15 | 11 out of 19 | 6 out of 17 |
| favorite | 5 out of 18 | 2 out of 13 | 1 out of 15 | 4 out of 19 | 5 out of 17 |

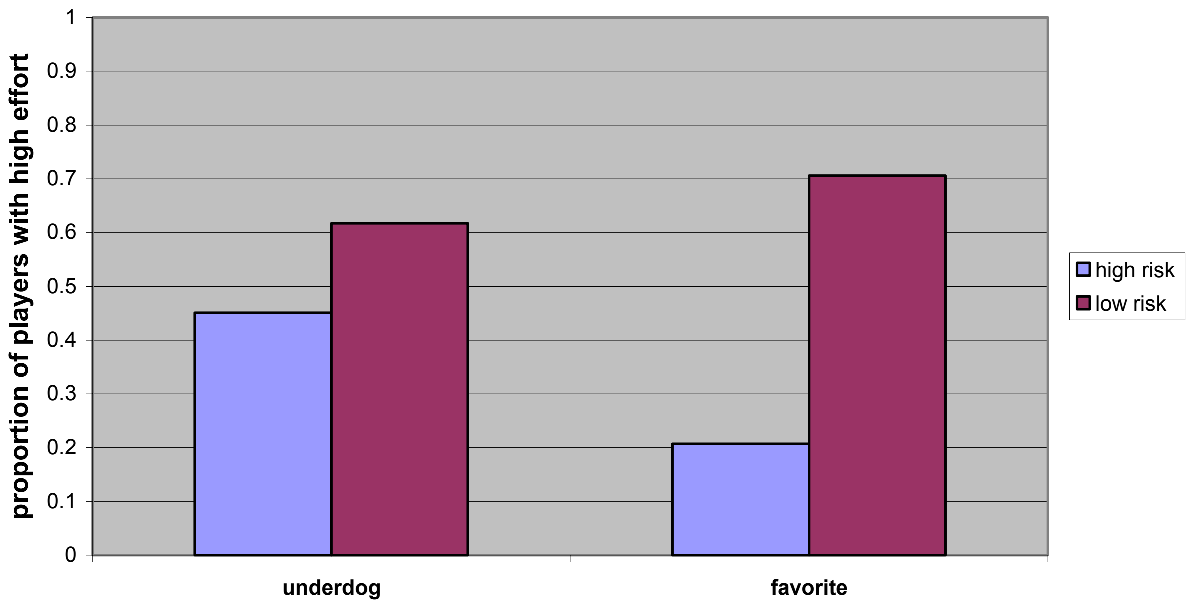
**Figure A5:** Effort choices in the cost treatment with high risk




Number of players choosing high effort

| | round 1 | round 2 | round 3 | round 4 | round 5 |
|---|---|---|---|---|---|
| underdog | 9 out of 12 | 9 out of 17 | 11 out of 15 | 6 out of 11 | 7 out of 13 |
| favorite | 7 out of 12 | 13 out of 17 | 12 out of 15 | 6 out of 11 | 10 out of 13 |

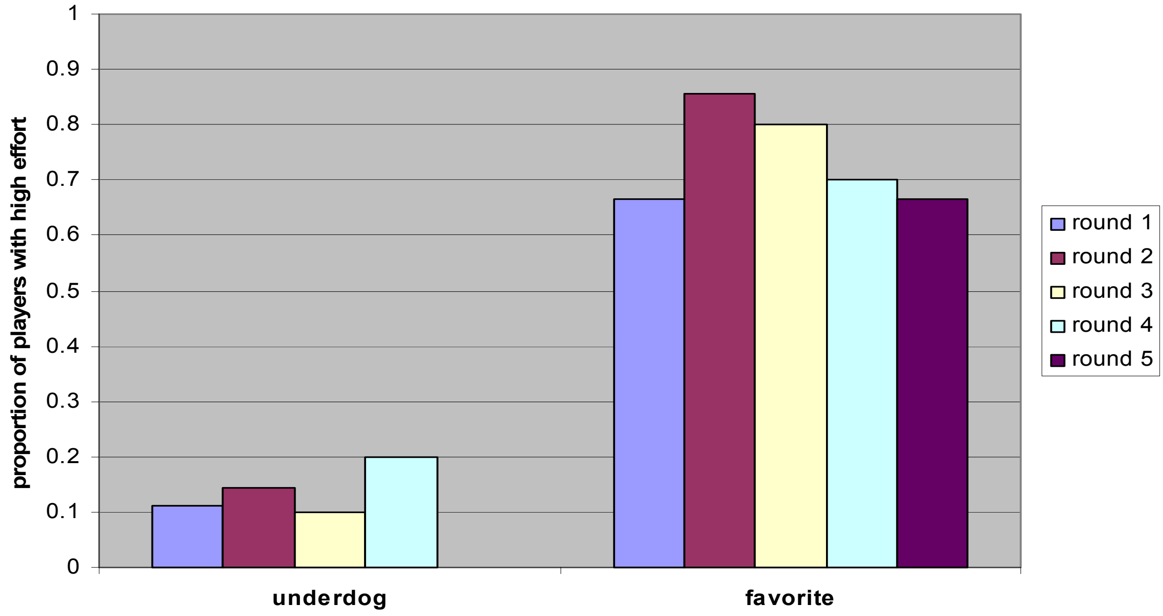
**Figure A6:** Effort choices in the cost treatment with low risk




Number of players choosing high effort

| | high risk | low risk |
|---|---|---|
| underdog | 37 out of 82 | 42 out of 68 |
| favorite | 17 out of 82 | 48 out of 68 |

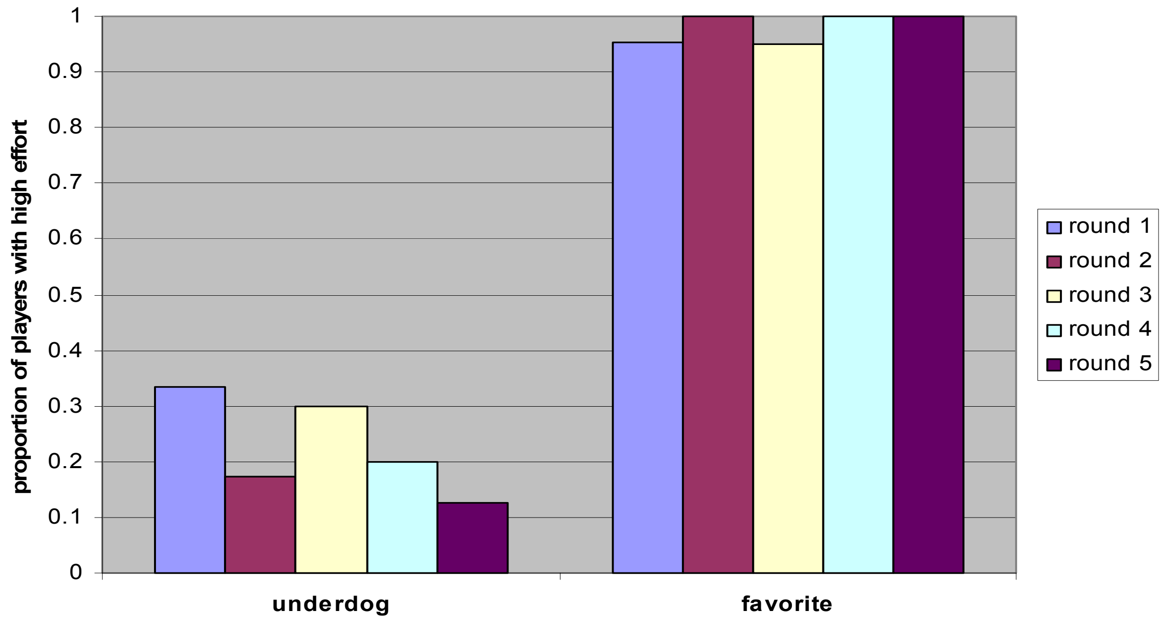
**Figure A7:** Effort choices in the cost treatment with pooled data




Number of players choosing high effort

| | round 1 | round 2 | round 3 | round 4 | round 5 |
|---|---|---|---|---|---|
| underdog | 1 out of 9 | 1 out of 7 | 1 out of 10 | 2 out of 10 | 0 out of 6 |
| favorite | 6 out of 9 | 6 out of 7 | 8 out of 10 | 7 out of 10 | 4 out of 6 |

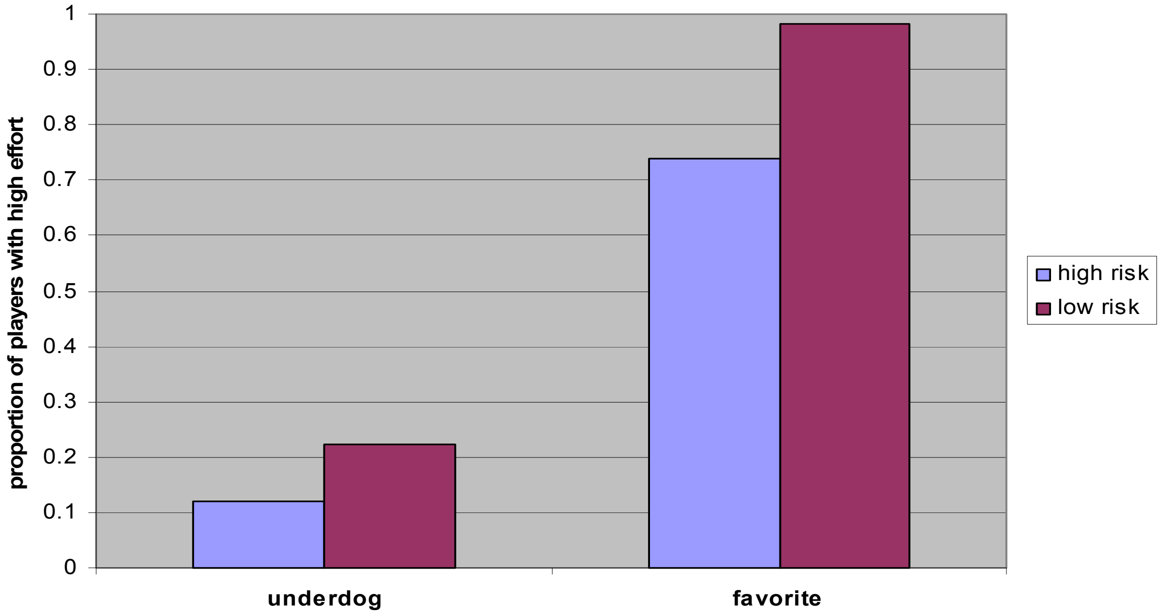
**Figure A8:** Effort choices in the likelihood treatment with high risk




Number of players choosing high effort

| | round 1 | round 2 | round 3 | round 4 | round 5 |
|---|---|---|---|---|---|
| underdog | 7 out of 21 | 4 out of 23 | 6 out of 20 | 4 out of 20 | 3 out of 24 |
| favorite | 20 out of 21 | 23 out of 23 | 19 out of 20 | 20 out of 20 | 24 out of 24 |

**Figure A9:** Effort choices in the likelihood treatment with low risk




Number of players choosing high effort

| | high risk | low risk |
|---|---|---|
| underdog | 5 out of 42 | 24 out of 108 |
| favorite | 31 out of 42 | 106 out of 108 |

**Figure A10:** Effort choices in the likelihood treatment with pooled data

| | High risk | High risk | Low risk | Low risk |
|---|---|---|---|---|
| Dummy Favorite | 1.580*** | 1.611*** | 0.907*** | 0.889*** |
| | (0.33) | (0.33) | (0.25) | (0.25) |
| Risk Attitude | | 0.0477 | | 0.0527 |
| | | (0.098) | | (0.071) |
| Dummy Round 2 | 0.664 | 0.630 | 0.132 | 0.148 |
| | (0.46) | (0.45) | (0.27) | (0.27) |
| Dummy Round 3 | 0.415 | 0.425 | 0.00406 | -0.00410 |
| | (0.39) | (0.39) | (0.21) | (0.21) |
| Dummy Round 4 | 0.0635 | 0.0344 | 0.186 | 0.193 |
| | (0.50) | (0.50) | (0.20) | (0.20) |
| Dummy Round 5 | 0.247 | 0.233 | 0.220 | 0.226 |
| | (0.40) | (0.39) | (0.23) | (0.23) |
| Constant | -1.037*** | -1.276* | -0.0249 | -0.278 |
| | (0.38) | (0.67) | (0.22) | (0.40) |
| Observations | 90 | 90 | 210 | 210 |
| Pseudo $R^2$ | 0.2600 | 0.2640 | 0.0931 | 0.1006 |
| Log Pseudolikelihood | -46.098419 | -45.847656 | -118.55264 | -117.5752 |

Robust standard errors in parentheses are calculated by clustering on subjects

*** p<0.01, ** p<0.05, * p<0.1

**Table A4:** Probit regression Hypothesis 7: discouragement treatment

| | High risk | High risk | Low risk | Low risk |
|---|---|---|---|---|
| Dummy Favorite | -0.704*** | -0.702*** | 0.247 | 0.231 |
| | (0.20) | (0.21) | (0.23) | (0.23) |
| Risk Attitude | | 0.0487 | | 0.0899 |
| | | (0.072) | | (0.066) |
| Dummy Round 2 | -0.281 | -0.279 | -0.0463 | -0.0324 |
| | (0.30) | (0.31) | (0.31) | (0.32) |
| Dummy Round 3 | -0.306 | -0.315 | 0.304 | 0.352 |
| | (0.27) | (0.28) | (0.30) | (0.30) |
| Dummy Round 4 | 0.0858 | 0.0792 | -0.314 | -0.315 |
| | (0.22) | (0.22) | (0.34) | (0.34) |
| Dummy Round 5 | -0.101 | -0.113 | -0.0278 | 0.0131 |
| | (0.27) | (0.28) | (0.28) | (0.29) |
| Constant | -0.0219 | -0.237 | 0.306 | -0.126 |
| | (0.25) | (0.40) | (0.26) | (0.40) |
| Observations | 164 | 164 | 136 | 136 |
| Pseudo $R^2$ | 0.0641 | 0.0691 | 0.0235 | 0.0395 |
| Log Pseudolikelihood | -97.256424 | -96.739882 | -84.97257 | -83.579976 |

Robust standard errors in parentheses are calculated by clustering on subjects

*** p<0.01, ** p<0.05, * p<0.1

**Table A5:** Probit regression Hypothesis 7: cost treatment

| | High risk | High risk | Low risk | Low risk |
|---|---|---|---|---|
| Dummy Favorite | 1.859*** | 1.907*** | 2.856*** | 2.868*** |
| | (0.35) | (0.35) | (0.36) | (0.35) |
| Risk Attitude | | -0.0816 | | -0.0270 |
| | | (0.088) | | (0.061) |
| Dummy Round 2 | 0.422 | 0.553 | -0.236 | -0.230 |
| | (0.51) | (0.46) | (0.38) | (0.38) |
| Dummy Round 3 | 0.223 | 0.274 | -0.0915 | -0.0928 |
| | (0.44) | (0.41) | (0.35) | (0.35) |
| Dummy Round 4 | 0.240 | 0.292 | -0.160 | -0.161 |
| | (0.53) | (0.53) | (0.31) | (0.31) |
| Dummy Round 5 | -0.265 | -0.171 | -0.385 | -0.391 |
| | (0.45) | (0.41) | (0.40) | (0.40) |
| Constant | -1.352*** | -1.022* | -0.592* | -0.469 |
| | (0.44) | (0.62) | (0.31) | (0.40) |
| Observations | 84 | 84 | 216 | 216 |
| Pseudo $R^2$ | 0.3259 | 0.3379 | 0.5415 | 0.5424 |
| Log Pseudolikelihood | -38.67116 | -37.981438 | -66.571261 | -66.439407 |

Robust standard errors in parentheses are calculated by clustering on subjects

*** p<0.01, ** p<0.05, * p<0.1

**Table A6:** Probit regression Hypothesis 7: likelihood treatment

**Instructions** (here: for the discouragement treatment):

## Welcome to this experiment!

You are taking part in an economic decision making experiment. All decisions are anonymous, that means that none of the other participants gets to know the identity of someone having made a certain decision. The payment is also anonymous, that is none of the participants gets to know how much others have earned. Please read the instructions of the experiment carefully. If you do not understand something, look at the instructions again. If you are still having questions then give us a hand signal.

## Overview about the experiment

The experiment consists of 5 rounds. Before the experiment starts, you have the possibility to get familiar with it in ten trial rounds. These trial rounds have no influence on your payment and conduce to a better understanding of the experiment.
Each round consists of two stages: **Stage 1 and Stage 2**. In each round of the experiment you play together with a second person. All participants are divided into groups of 6 persons, out of which pairs for one round are chosen. If you have played together with a particular person in one round, you cannot meet this person in any further round again. Please notice that you are **only paid for one of the 5 rounds**. The computer randomly selects the round for which you are paid. Therefore please think carefully about your decisions because each round might be selected. Your decisions and the decisions of the other person with whom you play influence your payment. All payments resulting of the experiment are described in the fictitious currency Taler. The **exchange rate** is **1 Euro for 10 Talers**.

In the beginning of the experiment, an amount of 60 Talers will be credited to your experiment account. If you get further payments out of the randomly selected round, they will be added to your account and the whole sum will be paid out. If your payoff from the selected round is negative, it will be offset with your initial payment.

In the experiment there are 2 different player roles, **player role A** (player A in the following) and **player role B** (player B in the following). In the beginning, you are randomly assigned to one of these roles. In each round, you can be assigned to another role. You are then playing with a person who has the other player role. For both persons **a score is counted at the end of each round.** The player's score, depending on the player role, is influenced by several components which are presented in the following:

## In case of player A:

Your score at the end of a round (after stage 2) is calculated as following:

**Score A =** $\boldsymbol{Z_A + x}$

$\boldsymbol{Z_A}$ is a number that you select as player A in stage 2. You can choose between $\boldsymbol{Z_A = 0}$ and $\boldsymbol{Z_A = 1}$. The selected value will be taken into account for the calculation of your score. Dependent on the choice of $\boldsymbol{Z_A}$ , several costs occur: If you choose $\boldsymbol{Z_A = 0}$**,** this costs you nothing. If you choose $\boldsymbol{Z_A = 1}$**,** this costs you $\mathbf{C_A = 8}$ Talers.

## Influence of *x*:

As **player A** you decide **between two alternatives** at **stage 1:**

**Alternative 1:**

If you choose **alternative 1**, *x* is randomly selected out of the interval from -2 to 2 (each value between -2 and 2 has the same probability). The randomly chosen *x* is specified on two decimal places.

**Alternative 2:**

If you choose **alternative 2**, *x* is randomly selected out of the interval from -4 to 4 (each value between -4 and 4 has the same probability). The randomly chosen *x* is specified on two decimal places.

The randomly selected *x* influences your score at stage 2 (see above).

**<u>In case of player B</u>:**

If you act as player B, you do not make any decision in stage 1.

Your score at the end of stage 2 is calculated as following:

**Score B = $Z_B$**

$Z_B$ is a number that you select at stage 2. You can choose between $Z_B = 0$ and $Z_B = 1$. The selected value will be taken into account for the calculation of your score. If you choose $Z_B = 0$, this costs you nothing. If you choose $Z_B = 1$, this costs you $C_B = 24$ Talers.

At the end of stage 2, the scores of both players are compared. The person with **the higher score** gets **100 Talers**. The other person gets **zero Talers**. If both persons have the same score, the higher one will be determined at random. In any case the costs of a chosen number will be subtracted from the already achieved Talers.

## Course of a round

**<u>Stage 1:</u>**

First you get the following **information**:

- which of the roles A and B is assigned to you
- in case of acting as **player A**: Information about your own costs $C_A$ which occur if you choose $Z_A = 1$ at stage 2 and about the costs $C_B$ of the other player that occur if he chooses $Z_B = 1$ at stage 2.
- in case of acting as **player B**: Information about your own costs $C_B$ which occur if you choose $Z_B = 1$ at stage 2 and about the costs $C_A$ of the other player that occur if he chooses $Z_A = 1$ at stage 2.

If you act as **player A**, at stage 1 you will be asked which of **the alternatives 1 or 2** you want to choose. After you have selected one of the alternatives, stage 2 of the experiment begins.

**Stage 2:**

At stage 2, both players are **informed** about the chosen **alternative of player A.**

After that, you and the other player are asked what you think, which number Z the other one will choose. **If your guess is correct you will get 15 Talers, otherwise nothing.**

Then both players choose a **number Z**.

- in case of being **player A**, you can choose between $Z_A$ **= 0** and $Z_A$ **= 1**. This influences your score. If you choose $Z_A$ **= 1**, costs of $C_A$ occur.
- in case of being **player B**, you can choose between $Z_B$ **= 0** and $Z_B$ **= 1**. This influences your score. If you choose $Z_B$ **= 1**, costs of $C_B$ occur.

After that, you and the other player are informed about the decisions and the scores, *x* is randomly selected and the player with the higher score is announced. In addition, you get informed how many Talers you would earn if this round were selected later. Hence, you get the following information:

| |
|---|
| **Your score:**<br>**Score of the other player:**<br><br>**The player with the higher score is player___.**<br>**Your guess was correct/false. Additionally, you would get ___ Talers.**<br>**Altogether, you would get ___ Talers in this round.** |

Then the next round begins with the same procedure. Altogether you play 5 rounds. At the end of round 5, it is randomly chosen which round to be paid out. Thereafter, a questionnaire appears on the screen which you are to answer.

**<u>Overview about the possible payments</u>**:

| **Payment for the player with the higher score:** | **Payment for the player with the lower score:** |
|---|---|
| **100 Talers**<br>**− costs $C_A$ or $C_B$ respectively, if $Z = 1$ was chosen**<br>**+ 15 Talers for a correct guess of the other player's choice of *Z*** | **0 Talers**<br>**− costs $C_A$ or $C_B$ respectively, if $Z = 1$ was chosen**<br>**+ 15 Talers for a correct guess of the other player's choice of *Z*** |

The payments will be added to your experiment account. In addition you are paid 2.50 Euro for participating in our experiment.

Now please answer the comprehension questions below. As soon as all participants have answered them correctly, the 10 trial rounds will start.

Please stay on your seat at the end of the experiment until we invoke your cabin number. Bring this instruction and your cabin number to the front. Only then the payment for your score can begin.

**Thanks a lot for participating and good luck!**