Relative Performance Pay in the Shadow of Crisis

Matthias Kräkel† Petra Nieken‡

Abstract

We analyze whether incentives from relative performance pay are reduced or enhanced if a department is possibly terminated due to a crisis. Our benchmark model shows that incentives decrease in a severe crisis, but are boosted given a minor crisis since efforts are strategic complements in the former case but strategic substitutes in the latter one. We tested our predictions in a laboratory experiment. The results confirm the effort ranking but show that in a severe crisis individuals deviate from equilibrium significantly stronger than in other situations. This behavior contradicts the benchmark model and leads to a five times higher survival probability of the department. We develop a new theoretical approach that might explain players' behavior.

Keywords: crisis; incentives; strategic complements; strategic substitutes; tournament

JEL Classification: C9; J3; J6; M5

∗We would like to thank the participants of the research seminar at the European Business School (Wiesbaden), the brown bag seminar on personnel economics at the University of Cologne, the MAXLab Academic Frontiers Workshop in Magdeburg, the Personnel Economics Meeting in Zurich, the conference on Tournaments, Contests and Relative Performance Evaluation in Raleigh, the Symposium of the German Economic Association of Business Administration in Zurich, the Annual Conference of the Collaborative Research Center "Governance and the Efficiency of Economic Systems" in Tutzing, and in particular Benjamin Bental, Dominique Demougin, Guido Friebel, Oliver Gürtler, Bernd Irlenbusch, Jenny Kragl, Daniel Müller, Patrick Schmitz, Dirk Sliwka, and Michael Waldman for helpful comments. Financial support by the Deutsche Forschungsgemeinschaft (DFG), grant SFB/TR 15, is gratefully acknowledged.

†University of Bonn, Department of Economics, Adenauerallee 24-42, D-53113 Bonn, Germany, tel: +49 228 733914, fax: +49 228 739210, e-mail: m.kraekel@uni-bonn.de.

‡University of Bonn, Department of Economics, Adenauerallee 24-42, D-53113 Bonn, Germany, tel: +49 228 739213, fax: +49 228 739210, e-mail: petra.nieken@uni-bonn.de.
"Crisis can bring out the best in a company and its people. Rather than yield to pessimism, our organization has moved forward with a renewed sense of purpose to succeed. Through hard work and tough choices, we made significant progress during the past 365 days." (Sergio Marchionne, CEO Chrysler Group LLC, The Wall Street Journal, 2010)

1 Introduction

During the recent economic crisis in the U.S. and Europe, companies had to deal with a reduction of demand for their products and reduced profits. Even though the local governments induced "recovery packages" including for instance the option for short-time working, companies often decided to shut down parts of their facilities or to generally downsize their workforce (for more details check Glassner and Galgoczi, 2009). For example, Foot Locker closed 208 of its U.S. stores in 2008 to increase overall efficiency and profits. In the same year, the coffee retailer Starbucks proclaimed to shut down 600 of its underperforming shops in the U.S.. In January 2010, the large European drugstore chain Schlecker announced to eliminate 500 locations, while GAP decided to close 189 retail stores in the U.S. in 2011. These and other cases show that, for technological reasons, companies prefer closing an entire organizational unit or a department to dismissing a certain number of workers at different units. As Bewley (1999) documents, companies with a single location also prefer dissolving whole departments.1

Generally, if a company is facing a crisis, workers might lose their jobs or will have to accept substantial wage cuts. The job insecurity perceptions during such a downsizing process lead to a reduction of performance and increased stress (Sverke et al., 2002) a phenomenon which can also be observed in the advance notice period of plant closures (Hansson and Wigblad, 2006).2 This strand of literature deals with large companies that were facing a severe crisis and in the end did not manage a turnaround and were forced to downsize or close parts of their businesses. However, little is known about the effects of a looming crisis when there is still a chance to avoid layoffs and closures. Our paper fills this gap in literature as we study the impact of different degrees of crisis on worker motivation.

Intuitively, a looming crisis might reduce incentives for workers, because they might not receive promised bonus payments or promotions even though they performed well (see, e.g., Friebel and Matros, 2005). We show that this intuition is not necessarily true and theoretically and experimentally discuss the incentive effects of a crisis for the case of relative performance pay. The theoretical results show that incentives will indeed decrease, if the crisis is sufficiently severe. However, if workers face a minor crisis, incentives will be enhanced compared to a situation without crisis. The experimental findings support the incentive enhancing effect of a minor crisis. The detrimental consequences of a severe crisis are considerably less strong than theoretically predicted, suggesting that individuals are – at least partly – motivated by the possibility to save their department by an overall high performance.

---

1Bewley (1999), chapter 13, analyzes layoffs of 235 companies during recession and finds that "many firms laid off whole departments or large portions of them" (p. 238).

2After the closedown decision is made public and the plant is shut down no matter how well it performs, the so called close-down effect leading to enhanced productivity can be observed.
In the empirical part of the paper, we rely on experimental data instead of company data as it would be very difficult to measure the perceived extent of a crisis and the individual effort reaction of workers using company data. The experiment allows us to induce different likelihoods of termination resulting from a crisis keeping all else equal. In our theoretical model we compare three different cases: no crisis, minor crisis, severe crisis. We start with the baseline case where a department does not face a crisis and the workers are motivated by relative performance pay.\textsuperscript{3} The use of relative performance pay in the form of bonus pools, sales contests or rewards is very common in companies to induce incentives.\textsuperscript{4} Moreover, nearly every company uses relative performance evaluation to fill vacant positions via job-promotion contests. In addition, many companies apply forced-ranking systems to avoid leniency and centrality biases when evaluating their employees. As Boyle (2001) reports, about 25\% of the Fortune 500 companies employ a forced-ranking system (e.g., General Electric, Intel, Cisco Systems, Sun Microsystems). Following the seminal papers by Lazear and Rosen (1981), Green and Stokey (1983), Nalebuff and Stiglitz (1983), O’Keeffe et al. (1984), Malcomson (1984), and Rosen (1986), we model workers’ relative performance pay as a rank-order tournament.\textsuperscript{5} We consider a stylized situation of a department with two workers. These two workers compete for relative performance pay, consisting of a non-negative tournament loser prize and a strictly larger winner prize.

In the second and third case we supplement relative performance pay by the possibility of termination due to a minor or a severe crisis, respectively. In both cases termination can be avoided if the performance of the department exceeds a certain threshold. Hence, the likelihood of termination is not exogenous but does depend on the workers’ efforts. If the threshold is not met, the department will be terminated and both workers will lose the tournament prizes. The combination of relative performance pay and a looming crisis leads to two opposing incentive effects for the workers. On the one hand, the incentive effect of relative performance pay leads to a negative externality with respect to the competing co-worker. The higher a worker’s effort, the lower the co-worker’s probability of winning the tournament. On the other hand, the "team effect" of collectively saving the department leads to a positive externality between the workers. If a worker exerts high effort, the department’s survival probability will increase. The presumable winner of the tournament thus benefits from this effort.

The second case — minor crisis — corresponds to a situation where the department can avoid termination relatively easily by improving its productivity. As only one worker needs to be successful to meet the department’s survival threshold, the team component of saving the department vanishes. But the negative externality of relative performance pay is still present. Our results show that in this setting efforts are strategic substitutes in the sense of Bulow et al. (1985) meaning that a higher effort of one worker decreases the effort of his opponent. Since each worker wants to make use of this strategic effect, in equilibrium both end up in a situation

\textsuperscript{3}Note that if an isolated worker was motivated by an individualized incentive scheme (e.g., bonus pay or piece rates), the interesting interplay of different individuals would be missing. For example, under a quota system, where a worker only receives a certain bonus if his output exceeds this quota, nothing but the quota would change if introducing a crisis.

\textsuperscript{4}For example, monetary incentives can be combined with relative performance evaluation (e.g., "employee of the month"), as practiced by Foot Locker.

\textsuperscript{5}More recent work comprises Santos Pinto (2010), Cason et al. (2012) and Altmann et al. (2012).
with higher effort levels compared to the baseline case without crisis.

The third case — severe crisis — corresponds to a situation where termination is very likely and can only be avoided if both workers are sufficiently successful so that the survival threshold is met. Now, the survival of the department and, hence, the positive externality between the workers become the main issue. This situation reminds of a team problem as the workers have to stick together in order to avoid termination. The important difference to the existing team literature (see, e.g., van Dijk et al., 2001 or Vandegrift and Yavas, 2011) is that the workers still participate in a tournament and therefore only one of them will be able to collect the winner prize. We show that in this setting efforts are strategic complements in the sense of Bulow et al. (1985) as less effort by one of the workers induces less effort by the other. As a consequence, the workers free-ride in equilibrium and choose lower effort levels than in the baseline case without crisis.

To sum up, we find that the severity of the looming crisis is crucial for its impact on worker motivation. If efforts are strategic substitutes as in the case of a minor crisis, workers will respond with higher effort levels than in the baseline case. If efforts are strategic complements as in the severe crisis, workers will refrain from exerting much effort compared to the baseline case. Thus, our model shows that both, reduced productivity before plant closure announcements as well as enhanced productivity, can be explained based on the plant’s (or department’s) likelihood of being terminated.

In our experiment, we test the theoretical results. We start with a winner-take-all situation where only the tournament winner receives a positive prize. In a second step we introduce a positive loser prize as a robustness check. The experimental findings are qualitatively in line with our theoretical predictions: On average, players chose highest effort given a minor crisis, but they chose higher effort in the baseline tournament without crisis than in the tournament given a severe crisis. Furthermore, the players’ best response functions indicate that efforts were strategic substitutes (complements) under a minor (severe) crisis and neither of both in a situation without a crisis. However, in either situation – minor, no, and severe crisis – players invested significantly more effort than theoretically predicted. While this observation is not unusual for experiments on tournaments (see, e.g., Orrison et al., 2004; Vandegrift et al., 2007; Sheremeta and Zhang, 2010; Harbring and Irlenbusch, 2011; and in particular Sheremeta, 2013), excessive oversupply of effort in a severe crisis compared to situations with a minor or no crisis remains a puzzle. In that situation, average effort was more than twice as high compared to the equilibrium effort level. The double amount of effort has a strong implication for the department’s survival probability, making it five times higher than in equilibrium.

We incorporate risk aversion, loss aversion, inequity aversion, or non-monetary utility of winning in our model to see if the predictions might explain our findings. The theoretical predictions of models incorporating risk aversion, loss aversion, or non-monetary utility of winning are in line with the observed effort ranking and the best response functions, but cannot explain the large oversupply of effort under a severe crisis. The theoretical prediction of a model incorporating inequity aversion is neither in line with the observed effort ranking, the best response functions, nor with the observed excessive oversupply of effort given a severe crisis. As an alternative, we develop a theoretical approach that takes into account that workers first have
to collectively achieve the survival of their department before receiving their personal incomes. This approach meets the observations in the experiment with a zero loser prize as well as the observations on players’ behavior with a positive loser prize.

2 Related Literature

Our study combines relative performance payment with the threat of a crisis which leads to tournament incentives on the one hand and a team component on the other. Thus, our study is related to different strands of literature. We start with a short overview of the work on the threat of bankruptcy and its effect on incentives before we discuss experimental studies investigating tournaments and in particular those addressing oversupply of effort. Because of the underlying team-problem in our set-up, we relate our work to experimental studies on threshold public good games as well as work on team incentives.

Termination of a department due to poor performance given a crisis is similar to a shutdown of a company following bankruptcy. Both cases typically lead to a collective dismissal of workers. Grossman and Hart (1982) and Hart (1995) point out that issuing debt and, thereby, generating a positive probability of bankruptcy can be a powerful instrument to discipline managers. Since bankruptcy is accompanied by the loss of their jobs, managers have strong incentives to exert high effort and make profitable investments. Schmidt (1997) analyzes the disciplining of managers via firm liquidation without explicitly addressing the role of debt. He shows that increased market competition reduces a firm’s profits but improves managerial incentives as the likelihood of firm liquidation goes up. However, none of the papers considers relative performance pay of workers.

Some papers combine financial and personnel economic issues by analyzing optimal incentives for managers who are primarily responsible for the personnel policy of the firm. See for instance Garvey and Swan (1992a) who show that moderate debt and the corresponding risk of bankruptcy discipline the firm’s CEO to choose optimal bonuses for the divisional managers. In their companion paper, Garvey and Swan (1992b) apply their incentive scheme to a CEO who has to design tournament incentives for workers. In the paper by Gaston (1997), the CEO has full discretion of paying efficiency wages to the firm’s workers. Disciplining by debt and the risk of bankruptcy makes the CEO choose a compensation policy that is optimal from the viewpoint of the shareholders. The three papers address the disciplining role of debt for top managers but do not investigate the incentive effects for workers.

Friebel and Matros (2005) address the possibility of firm bankruptcy in a setting where workers compete in job-promotion tournaments. Since the probability of firm bankruptcy is assumed to be completely exogenous, a higher probability of bankruptcy solely implies a lower expected prize from winning the tournament, which unambiguously reduces incentives. In addition, Friebel and Matros show that promoted workers in firms with higher bankruptcy probability earn higher wages. This result is due to the assumption of competitive markets which force more risky firms to pay higher wages on higher levels to be attractive for workers. In contrast to Friebel and Matros, we let the probability of collective dismissal be endogenously determined by workers’ effort choices, leading to different scenarios in which efforts are either strategic sub-
stitutes or strategic complements. In the Friebel-Matros setting, such different scenarios cannot arise because the exogenous bankruptcy probability does not change the structure of the game.

Our study also belongs to the large field of experimental evidence on tournament incentives. For a recent and comprehensive overview on experimental studies of tournaments, contests, and all-pay auctions see Dechenaux et al. (forthcoming). Similar to the findings in our data, over-supply of effort or overbidding in contests can often be observed (see, among others Bull et al., 1987; Weigelt et al., 1989; Eriksson et al., 2009; and Price and Sheremeta, 2011). Sheremeta (2013) offers an overview about experimental studies that report overbidding in contests and discusses several explanations including non-monetary utility of winning and social preferences (see also Sheremeta, 2014).

However, empirical findings on risk aversion, loss aversion, competitiveness, and gender as driving factors of overbidding are mixed. Of course, experimental parameters such as number of players, number of repeated games, endowment, and prizes vary from study to study and might also impact behavior. Several studies (see for instance Millner and Pratt, 1991; Sheremeta and Zhang, 2010; Sheremeta, 2011; and Mago et al., 2013) report a significant impact of risk aversion on overbidding in contests while others, for instance Shupp et al. (2013), similar to us, do not find a significant effect. Shupp et al. (2013) also elicited a measure for loss aversion and find that more loss averse players purchased more tickets in a single and a multiprize contest. It seems intuitive that competitiveness and non-monetary utility of winning might also affect the behavior in a competition but again the findings in the experimental literature are mixed. Sheremeta (2010) introduced a new measure of non-monetary utility of winning. He finds that players who were willing to invest in a contest without a monetary winner prize (indicating a positive non-monetary utility of winning) also overinvested in a Tullock contest with a monetary winner prize. Altmann et al. (2012) used a questionnaire to measure competitiveness and do not find an impact on effort provision in a tournament. Similar to them, we also do not find an effect of competitiveness on effort levels in our data.

There is ample evidence on gender differences in competition (see, e.g., Gneezy et al., 2003; Gneezy and Rustichini, 2004; Niederle and Vesterlund, 2011; and Price, 2012). Most of the studies focus on the entry decision but in our setting opting out and selecting into an individual incentive scheme was not possible. Studies without an active entry decision often do not report gender coefficients or do not discuss the non-significant findings (see, among others, Harbring and Irlenbusch, 2011 or Savikhin and Sheremeta, 2013). This is in line with our findings. However, other studies investigating Tullock contests report that females overbid more than males (Price and Sheremeta, 2011).

Saving a department from termination has features of creating a public good. The extensive literature on public goods has shown that players tend to contribute even though this behavior is not rational (see for instance Ledyard, 1995 or Palfrey and Prisbrey, 1997). Our paper is more closely related to the experimental literature on threshold public good games where the public good is provided if the threshold is met but contributions will not be refunded if the threshold is not met. In such setting, individual contributions are strategically comparable to effort choices in our setting, because effort always leads to non-refundable costs. Public good games with a threshold have multiple equilibria – contribution of zero by each player is an equilibrium as
well as all combinations of contributions that exactly sum up to the threshold. Hence, the players face a coordination problem. Similar to the threshold public goods games, in case of a severe crisis, we have an equilibrium where both players exert no effort and two with positive effort levels. However, our main setting with a zero loser prize differs from a threshold public good game because we combine the public-good problem with a winner-take-all tournament. Therefore, only one player will receive a positive income if both provide the public good of saving the department while the other will receive nothing.

Isaac et al. (1989) show that a threshold public good mechanism works as poorly as a voluntary contribution mechanism where defection is the dominant strategy. The magnitude of the threshold influences contributions, but there is no clear monotonicity in players’ behavior. Similar observations on the influence of the threshold are reported by Rapoport and Suleiman (1993). The experimental findings of Erev and Rapoport (1990) and Coats et al. (2009) show that sequentially contributing to a threshold public good is more effective than simultaneous contribution. Cadsby and Maynes (1998) investigate gender effects and report that females contribute more than males and are more able to coordinate their actions. Cadsby et al. (2007) find gender and national culture differences in contributing. In our experiment, however, gender does not have a significant impact on players’ effort choices. Cadsby and Maynes (1999) consider a threshold public good game with continuous contributions. Their results show that a high threshold dampens players’ incentives to contribute, which corresponds to our finding of low efforts under a severe crisis.

As mentioned above, our paper is also related to work on team based compensation and team based targeted incentives. The seminal paper by Holmström (1982) highlights the fundamental problem of free-riding in teams which might also affect the behavior in our setting. He shows that free riding can be completely eliminated if budget breaking is allowed. As a solution, each team member receives a bonus if realized team output is at least as large as team output under efficient effort choices, but zero payment otherwise. McAfee and McMillan (1991) derive optimal team bonuses for situations with both hidden action and hidden information. Nalbantian and Schotter (1997) compare different group incentive schemes in an experiment. They show that collective tournaments among teams yield high outputs and dominate all target-based incentive schemes. Bornstein et al. (2002) and Tan and Bolle (2007) also highlight the efficacy of collective tournaments.

The findings of van Dijk et al. (2001) and Vandegrift and Yavas (2011) reveal that even though free-riding occurs in teams, the overall output is often as high as the output achieved with other forms of compensation such as for instance a piece rate. Irlenbusch and Ruchala (2008) show that inducing a bonus payment for the highest contributor in a team-based compensation scheme reduced voluntary cooperation of the players and only enhanced effort if the bonus was sufficiently high. Hence, the study indicates that our payment structure would reduce the incentives to cooperate and to save the department in case of a severe crisis which is in line with the effort ranking we observed.

Closer to our setting is the recent work of Babcock et al. (2011) who investigate social effects of team-based compensation in a real effort experiment. In the individual treatment, participants received a piece rate for each visit of the campus gym and an additional bonus if
they visited the gym five times or more. In the team treatment, the bonus was only paid if both team members managed to visit the gym five or more times. The formation of the team was exogenous but the team members were allowed to meet and communicate. Even though the risk of default in the team treatment was 43%, the rate of bonus payments was nearly equal in both treatments. A possible explanation for this finding are incentive effects of social interaction such as guilt, shame or altruism. Furthermore, self-control, precommitment or imitation might have affected behavior. In contrast to this study, our players only played the game once and were not allowed to communicate to solve the coordination problem or to negotiate side payments. Additionally, only one player received a payment if the threshold was met. We nevertheless find that the players provided more effort than theoretically predicted.

3 The Model

We consider two workers, 1 and 2, who are paid based on their relative performance and belong to the same department of a company. Typical examples for such a set-up are for instance sales contests or forced-ranking systems, which are frequently used in practice. Based on the outcome of the tournament, the two workers receive monetary prizes \( w_L \) and \( w_H > w_L \). If worker \( i \) produces a higher output than worker \( j \) (\( i, j = 1, 2; i \neq j \)) he will receive the winner prize \( w_H = w > 0 \), whereas the other worker \( j \) will receive the loser prize, which is normalized to \( w_L = 0 \).

Following Lazear and Rosen (1981), we assume that worker \( i \) produces output \( \pi_i \) according to the production function

\[
\pi_i = a_i + \theta_i.
\]

Here, \( a_i \geq 0 \) denotes effort, which is assumed to be finite, and \( \theta_i \) describes either luck or unknown ability. Whereas \( a_i \) is endogenously chosen by worker \( i \), the realization of \( \theta_i \) is exogenously given. \( \theta_1 \) and \( \theta_2 \) are assumed to be independent and identically distributed with density \( f \) and cdf \( F \). Let \( f \) be unimodal and symmetric about zero so that \( \lim_{|\theta| \to \infty} f(\theta) = 0 \). The company observes realized outputs but neither chosen effort levels nor \( \theta_i \). It, therefore, faces a typical moral-hazard problem. Effort entails costs to a worker, which are described by the function \( c(a_i) \). We assume that \( c'(a_i) > 0, c''(a_i) > 0, \forall a_i > 0, \) and \( c(0) = c'(0) = 0 \).

Contrary to the standard tournament literature, we consider a scenario in which the workers’ department might face a crisis and is possibly closed down in case of poor performance. As a consequence, both workers would be dismissed and earn zero income. The department might be closed down because it is considered unprofitable by the company. Another possible reason is that closing critical departments is part of the company policy to punish poor performance. In the following, we assume that the winner prize \( w \) will only be paid if \( \pi_1 + \pi_2 \geq \Pi \) with the threshold \( \Pi \) as the minimum department profit necessary to cope with the crisis and prevent termination. In case of \( \pi_1 + \pi_2 < \Pi \), the department cannot cope with the crisis and is dissolved resulting in zero earnings for both workers. The parameter \( \Pi \) indicates the severity of the crisis.

---

6 Note that we used a neutral language in the experiment which allows for all of these applications.

7 Unimodality is often assumed in tournament models; see, e.g., Dixit (1987), Drago et al. (1996), Hvide (2002), or Chen (2003).
– the larger the threshold Π, the more severe will the crisis be.

To guarantee the existence of pure-strategy equilibria in the tournament game, we make the technical assumption that the influence of exogenous luck is sufficiently strong (i.e., the density f is sufficiently flat) and/or the effort cost function is sufficiently steep:

\[
\sup_{a_i, a_j} -w \left( \int_{\frac{\Pi}{2}}^{\Pi - a_j} f'(\Pi - a_i - a_j - \theta_j) f(\theta_j) d\theta_j + \int_{\frac{\Pi}{2} - a_j}^{\infty} f'(a_j - a_i + \theta_j) f(\theta_j) d\theta_j \right) < \inf_{a > 0} c''(a). \tag{2}
\]

The timing of the game is as follows. First, the workers observe all parameters of the game, especially the threshold Π and the tournament prizes \( \omega = 0 \) and \( \omega = \omega > 0 \). Then they simultaneously choose efforts \( a_1 \) and \( a_2 \). Finally, outputs \( \pi_1 \) and \( \pi_2 \) are realized, and either \( w \) is paid to the winner or – in case of termination – both workers earn zero.

4 Solution to the Model

Worker \( i \) chooses effort \( a_i \) to maximize his expected utility

\[
EU_i(a_i) = w \cdot P(a_i, a_j) - c(a_i) = w \cdot P(a_i + \delta_i > a_j + \theta_j \land a_i + \theta_i + a_j + \theta_j > \Pi) - c(a_i). \tag{3}
\]

The term \( P(a_i, a_j) \) denotes worker \( i \)'s probability of receiving the winner prize \( w \). To win, worker \( i \) has to outperform worker \( j \) and, in addition, the joint output \( \pi_i + \pi_j \) has to exceed the threshold \( \Pi \). Equation (3) shows that the influence of co-worker \( j \)'s effort, \( a_j \), on worker \( i \)'s expected utility is double-edged. On the one hand, \( j \) imposes a negative externality on \( i \) because increasing \( a_j \) lowers the probability that \( i \) outperforms \( j \). On the other hand, \( j \) imposes a positive externality on \( i \) because the joint output also increases in \( a_j \), which raises the probability that the department will be able to cope with the crisis. In other words, at the same time both workers compete against each other, due to the relative performance evaluation, and have to cooperate as a team to ensure that their department will survive the crisis.

The technical assumption (2) guarantees the existence of pure-strategy equilibria and the first-order conditions

\[
EU'_i(a_i) = w \cdot \frac{\partial P(a_i, a_j)}{\partial a_i} - c'(a_i) = 0 \quad (i = 1, 2) \tag{4}
\]

describe the equilibrium behavior of the workers, \((a_1^*, a_2^*)\). We obtain the following result.\(^9\)


\(^9\)Because workers are completely homogeneous, symmetric equilibria seem to be the most plausible ones.
Hence, we follow the standard approach in the tournament literature and focus on symmetric solutions (e.g., Nalebuff and Stiglitz, 1983, pp. 26–27). However, we cannot rule out the existence of additional asymmetric equilibria. Note that in the standard Lazear and Rosen (1981) model and the examples below, only a unique equilibrium that is symmetric exists.
Proposition 1 In a symmetric equilibrium, workers choose efforts \( a_1^* = a_2^* = a^* \) according to

\[
w \cdot \left( \int_{-\infty}^{2a^*} f(\Pi - 2a^* - \theta) f(\theta) d\theta + \int_{2a^*}^{\infty} f' (\theta) d\theta \right) = c'(a^*) .
\] (5)

Effort combinations \((a_i, a_j)\) satisfying

\[
- \int_{-\infty}^{\frac{\Pi}{2}-a_j} f' (\Pi - a_i - a_j - \theta_j) f(\theta_j) d\theta_j > (\text{<}) - \int_{\frac{\Pi}{2}-a_j}^{\infty} f' (a_j - a_i + \theta_j) f(\theta_j) d\theta_j
\]

(6)

are strategic complements (substitutes). In equilibrium, efforts are strategic complements if

\[
-2 \int_{-\infty}^{\frac{\Pi}{2}-a^*} f' (\Pi - 2a^* - \theta) f(\theta) d\theta > f^2 \left( \frac{\Pi}{2} - a^* \right);
\]

(7)

otherwise they are strategic substitutes.

Proof. See the appendix.

The characterization of the equilibrium efforts by equation (5) illustrates the two kinds of externalities mentioned above (see also the discussion of (11) in the appendix). The first integral at the left-hand side indicates the positive externality arising because the joint output has to beat the threshold \( \Pi \) to ensure that the department will survive the crisis. The second integral indicates the negative externality arising from the relative performance evaluation. The upper (lower) limit of the first (second) integral increases in the threshold \( \Pi \). Thus, the more severe the crisis (i.e., the larger \( \Pi \)) the higher will the impact of the positive externality on workers’ equilibrium behavior be. However, if \( \Pi \) goes to \(-\infty\), the first integral will vanish and (5) will be reduced to

\[
w \int_{-\infty}^{\infty} f^2 (\theta) d\theta = c'(a^*) ,
\]

which is the well-known equilibrium condition in the standard Lazear-Rosen tournament, where only negative externalities between the workers exist.\(^{10}\)

Inequality (6) describes, in which situations optimal efforts react according to strategic complements or strategic substitutes in the sense of Bulow et al. (1985). Workers’ best response functions are increasing in case of strategic complements, but decrease if efforts are strategic substitutes. We are mostly interested in the shape of the best response functions around their points of intersection, which is described by (7). Condition (7) indicates that if the threshold \( \Pi \) is sufficiently large, positive externalities can become so strong that efforts are strategic complements in equilibrium like in a pure team setting. Technically, if \( \Pi \) becomes large, the right-hand side of the inequality tends to zero, whereas the left-hand side can still be positive: for sufficiently large values of \( \Pi \), we have \( \Pi - 2a^* - \theta > 0 \) for all feasible values of \( \theta \) implying that \( f' (\Pi - 2a^* - \theta) \) takes only negative values so that \(-2 \int_{-\infty}^{\frac{\Pi}{2}-a^*} f' (\Pi - 2a^* - \theta) f(\theta) d\theta > 0\).\(^{11}\) If, however, the department faces a less severe crisis (i.e., \( \Pi \) is very small), the threshold will be negligible and the team effect will diminish so that equilibrium efforts might become strategic

\(^{10}\)See, e.g., Gibbons (1992), p. 81.

\(^{11}\)Even for the highest possible value of \( \theta \) the function \( f' \) will exclusively take positive values: \( \Pi - 2a^* - (\frac{\Pi}{2} - a^*) = \frac{\Pi}{2} - a^* \), which is positive for \( \Pi \) being sufficiently large.
substitutes. Both cases are illustrated below using the standardized normal distribution.

The equilibrium condition (5) shows how the workers react to changes in the severity of a crisis (i.e., to changes in $\Pi$). The term

$$\frac{\partial P(a_i, a_j)}{\partial a_i} \bigg|_{a_i=a_j=a^*} = \int_{-\infty}^{\frac{\Pi-a^*}{2}} f(\Pi-2a^* - \theta) f(\theta) d\theta + \int_{\frac{\Pi-a^*}{2}}^{\infty} f^2(\theta) d\theta$$

at the left-hand side of (5) describes a worker’s marginal winning probability in equilibrium. By implicitly differentiating (5) and applying Leibniz’ formula, we obtain

$$\frac{da^*}{d\Pi} = -\frac{w \cdot \frac{\partial}{\partial a^*} \left( \frac{\partial P(a_i, a_j)}{\partial a_i} \bigg|_{a_i=a_j=a^*} \right)}{w \cdot \frac{\partial}{\partial a^*} \left( \frac{\partial P(a_i, a_j)}{\partial a_i} \bigg|_{a_i=a_j=a^*} \right) - c''(a^*)}$$

$$= \frac{w \cdot \int_{-\infty}^{\frac{\Pi-a^*}{2}} f'(\Pi-2a^* - \theta) f(\theta) d\theta}{w \cdot \left( 2 \int_{-\infty}^{\frac{\Pi-a^*}{2}} f'(\Pi-2a^* - \theta) f(\theta) d\theta + c''(a^*) \right)}.$$  (8)

Inspection of (7) and (8) shows that if $\int_{-\infty}^{\frac{\Pi-a^*}{2}} f'(\Pi-2a^* - \theta) f(\theta) d\theta > 0$, workers’ equilibrium efforts are strategic substitutes and we have $da^*/d\Pi > 0$, i.e., a larger threshold for the department raises overall incentives. However, $\int_{-\infty}^{\frac{\Pi-a^*}{2}} f'(\Pi-2a^* - \theta) f(\theta) d\theta < 0$ must hold as a necessary condition for efforts being strategic complements in equilibrium. In this situation, workers’ incentives will decrease if the collective threshold $\Pi$ becomes larger. To sum up, the previous findings indicate that in case of a severe crisis (i.e., $\Pi$ is large) equilibrium efforts are strategic complements and rather low, and they will further decline if the crisis becomes more severe.

In the following, we use the standardized normal distribution to illustrate the interplay between the severity of a crisis and workers’ equilibrium efforts:

**Corollary 1** Let $\theta_i \sim N(0, 1) \ (i = 1, 2)$. In equilibrium, efforts will be strategic complements (substitutes) if $\Pi > (<) 2a^*$.

**Proof.** See the appendix. ■

The results of the corollary support the conjecture of Proposition 1. If the crisis is sufficiently severe, the positive externality from the team effect will dominate the negative externality from the competition effect. In equilibrium efforts are strategic complements. In this situation, workers primarily concentrate on the survival of the department. However, efforts are strategic substitutes in equilibrium if the crisis is less severe. Now, the survival of the department is not the main issue and the workers concentrate on outperforming each other. Recall that the mean of the random component is zero. Thus, the critical value for the threshold $\Pi$ describes the expected joint output of the two workers in equilibrium.

To further illustrate the impact of the threshold $\Pi$, we concentrate on three different values of $\Pi$ corresponding to a severe, a minor, and a no crisis setting. Let the winner prize be $w = 1$ and effort costs be quadratic with $c(a_i) = ca_i^2/2$ and $c = 0.3$. As base scenario, we first look
at the best response functions in the standard Lazear-Rosen model, which describes a pure
tournament without any crisis (i.e., $\Pi = -\infty$). In that case, workers’ best response functions
are described by

$$
\int_{-\infty}^{\infty} f(a_j - a_i + \theta) f(\theta) d\theta = 0.3a_i \Leftrightarrow \frac{1}{2\sqrt{\pi}} \exp\left(-\frac{1}{4}(a_i - a_j)^2\right) = 0.3a_i
$$

with $i, j = 1, 2; i \neq j$. They are plotted in Figure 1.

Figure 1 shows that there exists a unique and symmetric equilibrium at $a^*_1 = a^*_2 = 0.94
Moreover, the best response functions do neither describe purely strategic complements nor
purely strategic substitutes. Instead, efforts switch from strategic complements to substitutes
and intersect exactly in the switching point. This observation is not specific to the Lazear-Rosen
model. It also holds for other contest-success-functions like the one introduced by Tullock (1980)
(see, e.g., Wärneryd, 2000, p. 148).

However, best response functions sharply contrast with those in the standard tournament
when introducing a crisis. Using the same specifications for the winner prize, the effort costs and
the luck distribution as before, equation (12) from the appendix, which describes the workers’
best response functions in a crisis, can be rewritten as

$$
\frac{\exp\left(-\frac{1}{4}(\Pi - a_i - a_j)^2\right) \left[\text{erf}\left(\frac{1}{2}a_i - \frac{1}{2}a_j\right) + 1\right]}{4\sqrt{\pi}}
+ \frac{\left[1 - \text{erf}\left(\frac{1}{2}(\Pi - a_i - a_j)\right)\right] \exp\left(-\frac{1}{4}(a_i - a_j)^2\right)}{4\sqrt{\pi}} = 0.3a_i.
$$

Here, $\text{erf}(x) := \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt$ denotes the error function. Given a minor crisis with $\Pi = 0.02$, the workers’ best response functions are described by Figure 2. They intersect at $a^* = a^*_1 = a^*_2 = 1.04$ with $\Pi < 2a^*$. The best response functions are monotonically decreasing showing
that efforts are strategic substitutes. However, under a severe crisis with \( \Pi = 3 \), workers’ best response functions are increasing and describe strategic complements (see Figure 3). Now, they intersect at \( a^* = a^*_1 = a^*_2 = 0.08 \) with \( \Pi > 2a^* \). Hence, equilibrium efforts are lowest under a severe crisis and highest in case of a minor crisis. Figures 1 to 3 show that in each case we have a unique and symmetric equilibrium. However, best response functions look very different and lead to very different outcomes. In case of a minor crisis (i.e., \( \Pi = 0.02 \)), efforts are strategic substitutes so that more aggressive behavior by one worker decreases the activity level of the other worker. Because each worker wants to make use of this strategic effect, in equilibrium both end up in a situation with higher effort levels compared to the base scenario of the Lazear-Rosen model. However, if workers enter a state of severe crisis (i.e., \( \Pi = 3 \)), efforts will be strategic complements. Now, less effort by one worker induces less effort by the other. As both workers make use of this strategic effect, in equilibrium they behave less aggressively than in the base scenario. In this situation, workers’ behavior is mainly determined by strong positive externalities because they need to succeed as a team, which leads to the well-known free-rider problem.

In this study we focus on the impact of a crisis on individual incentives from relative performance pay. A comprehensive analysis of the optimal incentive scheme with endogenously chosen payments goes beyond the scope of this paper. Nevertheless, from the perspective of the company, the results indicate that incentives can be improved by supplementing a tournament scheme with a termination clause that leads to a collective dismissal of the members of a department if it does not exceed a certain moderate performance threshold.

Alternatively, we can interpret \( \Pi \) as a collective target that has to be met by the workers to obtain the given tournament prizes. If individual output \( \pi_i \) is verifiable, the firm can withhold the tournament prizes in case of \( \pi_1 + \pi_2 < \Pi \). Otherwise, tournament prizes must be paid to a third party so that the important self-commitment property of Malcomson (1984, 1986) is
satisfied.\textsuperscript{12} Irrespective of whether $\pi_i$ is verifiable or not, our theoretical results highlight that for risk-neutral and limitedly liable workers (i.e., prizes have to be non-negative) the standard tournament can always be improved by complementing tournament prizes with a collective target. To increase incentives, the collective target has to be set at a moderate level so that the negative externality from tournament incentives dominates the positive externality from team incentives. Suppose that workers’ output is unverifiable. Then, a collective target can improve a standard tournament with non-negative prizes by either implementing the same effort level at lower labor costs (i.e., $w$ is reduced) or implementing higher efforts at the same labor costs (i.e., $w$ is kept). If workers’ output is verifiable, the firm will additionally profit from the fact that with probability $1 - P(a_i, a_j)$ realized labor costs will be zero.

5 Experimental Design and Set-Up

In our laboratory experiment, we investigated how players competing in a tournament react to a crisis. We are particularly interested in how the severity of a crisis influences players’ behavior. The continuous framework used in the previous section allows a rigorous theoretical analysis but exhibits a continuous degree crisis severity. For the experiment, we develop a more stylized model which captures the three polar cases we are interested in: a tournament with no crisis, with a minor crisis, and a severe crisis. The main effects are also present in this more stylized version of the set-up which is more suitable for implementation in the laboratory.

In our set-up, we assume a production technology with a binary output. With probability $a_i \in [0, 1]$ player $i$ is successful and realizes high output $\pi_i = \overline{\pi}$, with probability $1 - a_i$ the player fails and only realizes $\pi_i = \underline{\pi} \in (0, \pi)$. Hence, effort $a_i$ corresponds to a player’s success $\underline{\pi}$.

\textsuperscript{12}Suppose the workers’ output $\pi_i$ (or collective output) is unverifiable and the firm does not commit itself to pay out the tournament prizes to a third party in case of $\pi_1 + \pi_2 < \Pi$. Then, irrespective of the workers’ true performance, the firm would always claim ex post that $\pi_1 + \pi_2 < \Pi$ to save labor costs. Such opportunistic firm behavior can be anticipated by the workers, which would completely erase incentives.
probability. Effort entails costs to a worker, which are described by the function $c(a_i) = c a_i^3$ ($c > 0$). Ties are broken randomly. The winner obtains $w_H = w > 0$ and the loser $w_L \geq 0$.

We start with the case of a zero loser prize and consider $w_L \in (0, w)$ in Section 8. To guarantee that equilibrium efforts can be interpreted as success probabilities, we chose parameter values satisfying $w < 2c$. We differentiate between three scenarios: (1) There is no crisis. This base scenario is characterized by $\Pi \in [0, 2\pi]$, i.e., the threshold for the department’s profit is so low that termination will never occur. (2) The department faces a minor crisis, its survival is guaranteed if at least one of the workers realizes the high output level, i.e., $\Pi \in (2\pi, \pi + \pi]$. (3) The department experiences a severe crisis and will only survive if both workers realize a high output level, i.e., $\Pi \in (\pi + \pi, 2\pi]$. Let $a^*_s$ denote the theoretically predicted behavior of the players in scenario $s$ with $s = \text{base, minor, severe}$. These efforts can be ranked as follows:

$$a^*_{\text{minor}} > a^*_{\text{base}} > a^*_{\text{severe}}.$$  

Thus, a minor crisis boosts incentives, whereas a severe crisis leads to free-riding of the players. The results in the appendix show that efforts are strategic complements (substitutes) in case of a severe (minor) crisis but neither strategic complements nor substitutes in the base scenario without crisis. Hence, our findings for the three polar cases considered in the laboratory are qualitatively the same as those in the continuous setting of Section 4.

The experiment consisted of eight different treatments designed to test the theoretical setting described above. We conducted three main-treatments corresponding to the three scenarios: a tournament with no crisis (base-treatment), a minor crisis (minor-treatment), and a severe crisis (severe-treatment). In addition we conducted three treatments labeled base-strategy, minor-strategy, and severe-strategy where we use the strategy method (see, Fischbacher et al., 2001) to elicit a complete best response function for each player. The purpose of the treatments minor-45 and minor-90 was to study the impact of a positive loser prize on the effort decisions of the players. For a summary of treatments, experimental parameters, and predicted points see Table 1.

First, we describe the set-up for the three main-treatments base, minor, and severe before we proceed to explain the outline of the other treatments. All treatments consisted of a one-shot tournament between two players. Both contestants could either achieve state A (symbolizing $\pi$ in the experiment) or state B (symbolizing $\pi$ in the experiment), which affected the chances of winning the tournament as well as the likelihood to survive the crisis. The players simultaneously selected a number of points between zero and 100 so that $a_i = \text{points}/100$ (i.e., the chosen points divided by 100 yield the probability of the player to achieve state A rather than state B). In the experiment, we used the fictitious currency "taler," and the players received an initial endowment of 75 talers in all treatments.

Having selected their number of points, all players in the main-treatments had to state their beliefs about the chosen points of their opponents. The elicitation of beliefs about the opponent’s action allowed us to check whether players formed correct beliefs about the behavior

---

13 To obtain interior solutions, players’ effort cost functions have to be sufficiently convex. Hence, we use cubic instead of quadratic costs.

14 See the appendix.

15 See the appendix for the derivation of the respective equilibrium efforts.
of their opponents and if they selected the best response for a given belief. However, we only elicited one datapoint for each player which does not allow to calculate a complete best response function for each player. We, therefore, conducted the strategy-treatments to collect a richer dataset. The question about beliefs was not announced in the instructions. The answer was not incentivized to prevent players from hedging their incomes by strategically announcing wrong beliefs. Information about the outcome of the tournament and the payoff was not revealed until the end of the experiment to prevent possible income effects on the answers to our control variables.

Corresponding to the theoretical settings, the three main-treatments only differed in the department’s termination probability. In the base-treatment, there was no risk of termination. Here, the player who outperforms the other one or wins the tie-break received the winner prize of 100 talers while the loser received zero. Thus, if one player was in state A and the other in state B, the player in state A received 100 talers while the player in state B received zero talers. If both were in state A or both were in state B, a random draw decided which player got the winner prize. In the minor-treatment, the setting was exactly the same but at least one player had to achieve state A in order to avoid termination. If both players were in state B, they received zero talers. In contrast, both players had to achieve state A in the severe-treatment to avoid termination. If at least one player did not achieve state A, both received nothing. If both were in state A, a random draw decided who received the winner prize.

The equilibrium efforts \( a_{\text{minor}}^*, a_{\text{base}}^* \) and \( a_{\text{severe}}^* \) are derived in the appendix. For the computation of the optimal values in the experiment, we used the specifications \( c = 200 \) and \( w = 100 \). The theoretically predicted points presented in Table 1 are obtained by multiplying \( a_{\text{minor}}^*, a_{\text{base}}^* \) and \( a_{\text{severe}}^* \) by 100. In the experiment, each player chose discrete effort points from the set \( \{0, 5, 10, 15, 20, \ldots, 100\} \). By allowing steps of five we reduced the complexity of the task while also securing to leave the players sufficient scope of action. The incremental steps of 5 points led to an additional equilibrium in the severe-treatment, where both players chose 20. Note that this equilibrium as well as the equilibrium \((0, 0)\) are Pareto dominated. We, therefore, concentrate our analysis on the equilibrium \((25, 25)\). In all treatments, the costs of the chosen points were deducted from the players’ payoff.

In the three strategy-treatments, base-strategy, minor-strategy, and severe-strategy, players basically faced the same set-up as in the three main-treatments. In contrast to just making one effort decision, they had to state their choices based on a strategy method which was for instance used by Fischbacher et al. (2001) and Hermann and Orzen (2008). Based on that method all players first had to simultaneously make conditional choices and after that an unconditional choice. In the conditional choice setting, the players had to state their preferred effort choice for each of the 21 possible effort choices that were feasible for their opponent. After that, the players made their unconditional choice where they simply stated their effort choice as number of points between zero and 100.

We incentivized the decisions by informing the players that a random draw would determine

\[ 16 \text{In two sessions for each main-treatment, we incentivized the beliefs and rewarded the players for a correct belief by paying 8 talers. If the belief deviated by 5 points from the selected effort, we paid 7.5 talers. A deviation of 10 points was rewarded with 6 talers and a deviation of 15 points with 3.5 talers. A higher deviation was not rewarded. We found no significant difference between incentivized and non-incentivized beliefs.} \]
for each matched pair of players if the own unconditional choice or the unconditional choice of the opponent would be relevant for the tournament outcome. The outcome was calculated by combining the selected unconditional choice with the opponent’s preferred response to that choice (i.e., the opponent’s respective conditional choice). By using the strategy method we were able to elicit the complete best response function of every player to investigate if efforts were strategic substitutes, strategic complements, or neither of both in the different treatments. In addition, this procedure eliminated strategic uncertainty about the effort choice of the opponent. Even though the players did not know which unconditional effort level their opponent would choose, they could state their best response for every possible alternative. As a result, this procedure was a step-by-step process which might also have reduced the complexity of the task and helped players to make more sophisticated effort decisions. From a theoretical perspective, in the three strategy-treatments, the players had to play the same game as in the respective main-treatments so that the predicted efforts are identical.

The set-up of the treatments minor-45 and minor-90 was identical to the set-up of the main minor-treatment. The only difference was that we paid a positive loser prize of 45 talers in the minor-45 and of 90 talers in the minor-90-treatment to the tournament loser if at least one contestant achieved state A. In these treatments, a loser’s payment within a surviving department was now strictly different from the zero payment that was paid if the department had to be terminated. The results of these treatments enable us to check whether negative feelings from collectively losing were the driving force of behavior.

In all treatments, we elicited additional controls to investigate the impact of risk attitudes, loss aversion, competitiveness, and demographic factors on the effort decisions of the players. To retrieve control variables for risk attitude, players had to complete ten paired lottery choice decisions from Holt and Laury (2002), which were incentivized. Moreover, we used a simple set of lotteries proposed in Gächter et al. (2010) in order to measure loss aversion. Each player had to decide in six lotteries whether he wanted to participate in the lottery or not. With a 50% chance the players could win six talers while they had to pay between two and seven talers with a chance of 50%. One of the lottery choices was selected for pay. All players answered a questionnaire containing questions on competitiveness (Smither and Houston, 1992), demographic details as well as open questions, where the decision about effort could be explained.

In the three strategy-treatments we also measured the players’ willingness to invest in a lottery that had a winner prize of zero. This task was proposed by Sheremeta (2010) to measure non-monetary utility of winning. The players were matched with another player with whom they had not interacted before. They could buy lottery tickets which determined if they would be the winner of the lottery. The probability to be the winner was the number of lottery tickets the player bought, divided by the sum of the lottery tickets bought by him and the other player. As the winner prize was zero, the only "gain" of winning was to be addressed as the winner on the computer screen. As Sheremeta (2010) argues, players who invest money in such a lottery should gain a positive non-monetary utility of winning (e.g., joy of winning). To test if social preferences might influence the effort decisions, we conducted a prisoners’ dilemma using the

---

17 Additionally, in two sessions of each treatment, we elicited ambiguity aversion following the approach of Trautmann et al. (2011).
strategy method. Similar to the set-up used in Hermann and Orzen (2008), the players first had to state their conditional choice. Did they want to cooperate if the other player cooperated as well, did they want to cooperate if the other player defected? Then the players made an unconditional choice whether they wanted to cooperate or defect. As in the tournament task, a random draw determined which player’s unconditional choice would determine the payment. The final outcome was calculated by combining the selected unconditional choice of one player with the response of the other player to that choice.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Termination</th>
<th>Predicted points</th>
<th># players</th>
<th># sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>severe</td>
<td>At least one player in state B</td>
<td>25</td>
<td>202</td>
<td>9</td>
</tr>
<tr>
<td>base</td>
<td>Never</td>
<td>50</td>
<td>210</td>
<td>9</td>
</tr>
<tr>
<td>minor</td>
<td>Both players in state B</td>
<td>60</td>
<td>210</td>
<td>9</td>
</tr>
<tr>
<td>severe-strategy</td>
<td>At least one player in state B</td>
<td>25</td>
<td>48</td>
<td>2</td>
</tr>
<tr>
<td>base-strategy</td>
<td>Never</td>
<td>50</td>
<td>48</td>
<td>2</td>
</tr>
<tr>
<td>minor-strategy</td>
<td>Both players in state B</td>
<td>60</td>
<td>46</td>
<td>2</td>
</tr>
<tr>
<td>minor-45</td>
<td>Both players in state B</td>
<td>55</td>
<td>70</td>
<td>3</td>
</tr>
<tr>
<td>minor-90</td>
<td>Both players in state B</td>
<td>50</td>
<td>72</td>
<td>3</td>
</tr>
<tr>
<td>Sum</td>
<td></td>
<td>906</td>
<td>39</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Treatments, experimental parameters, and predicted points

At the outset of each session, all players were randomly assigned to a cubicle. The instructions were explained by the experimenter. We used neutral language throughout the experiment and avoided any value-laden terms like "winner," "loser," "tournament prize," or "crisis." Before the experiment started, the players completed a short quiz to check their understanding of the instructions. The players also had the opportunity to ask clarifying questions. Communications among the players were not allowed. The whole procedure took about 1.5 hours for all treatments except the strategy treatments which took about 2 hours. On average, players earned 15.95 euro (approx. 20.26 USD) in the main-treatments, 16.02 euro (approx. 20.64 USD) in the minor-45 and minor-90-treatments, and 20.86 euro (approx. 26.87 USD) in the strategy-treatments (the higher earnings were necessary because of the longer duration) including a show-up fee of four euros. The exchange rate was one euro for eight talers. We had 24 players in each session. The players received information about the outcome of the tournament only at the end of the experiment.

The experiment was conducted at the BonnEconLab, and the programming language was

---

18The complete set of instructions translated into English can be found in the "Additional Material," Part II.
19In some sessions we had fewer than 24 participants because some players did not show up.
z-tree (Fischbacher, 2007). For recruiting we used the online system ORSEE (Greiner, 2004) Altogether 906 players participated in the experiment. As we employed a between-subjects-one-shot design, each player was allowed to attend one session only. All of the participants have been enrolled as students at the University of Bonn.

6 Hypotheses

The theoretically predicted behavior for the parameterized model used in the experiment is shown in Table 1 and lead to the first hypothesis.

**Hypothesis 1:** When deciding on efforts, players select 50 points in the base scenario without crisis, 60 points in case of a minor crisis, and 25 points in case of a severe crisis.

Previous experiments have shown that players tend to oversupply effort in tournament settings so that players might systematically deviate from the theoretical efforts in our experiment as well (Sherementa, 2013). Nevertheless, the theoretical model yields a clear ordinal ranking of equilibrium efforts, which should be maintained in the experiment even if there is systematic deviation toward higher effort levels in all treatments. The following hypothesis summarizes this claim:

**Hypothesis 2:** The selected effort levels are lowest in case of a severe crisis and highest in case of a minor crisis. Hence, we expect the following order of selected points on average:

\[ \text{points in case of a severe crisis} < \text{points in case without crisis} < \text{points in case of a minor crisis}. \]

The theoretical results show that the positive externality from saving the department dominates the negative one from tournament competition in case of a severe crisis so that efforts are strategic complements. Under a minor crisis, however, the negative externality becomes dominant so that efforts are strategic substitutes.

**Hypothesis 3:** The efforts of the contestants are strategic complements in case of a severe crisis and strategic substitutes in case of a minor crisis. If there is no crisis, efforts are neither strategic substitutes nor complements.

Hypotheses 2 and 3 also hold if players are risk averse, loss averse or obtain non-monetary utility of winning (see the "Additional Material," Part I).

7 Experimental Results

We tested our hypotheses with data from the experiment starting with Hypothesis 1. First, we refer to the behavior in the main-treatments. As can already be seen in Figure 4, the average effort level in the base-treatment was 61.33, for the minor-treatment it was 66.50, and in the severe-treatment we observed an average effort level of 55.45 points. All reported effort levels
are significantly higher than the respective theoretical prediction (one sample mean comparison test: for all $p = 0.000$).\footnote{Note that the same is true for the equilibria $(0,0)$ and $(20,20)$ in the severe-treatment.}

![Figure 4: Mean of actual effort and difference of actual and theoretical effort by main-treatment](image)

Hence, we have to reject Hypothesis 1. This finding is well in line with results from previous tournament experiments (see Section 2). If we use the oversupply of effort in the base-treatment as a benchmark for the "normally expected" oversupply in a tournament, the deviation is significantly larger in the severe-treatment than in the base-treatment or the minor-treatment (see Figure 4 and pairwise Mann-Whitney-U tests: both $p = 0.000$). In fact, in the severe-treatment average effort exceeded the theoretical effort level by more than 122\%, which is a very high deviation compared to oversupply of effort in both the two other main-treatments and the findings in previous tournament experiments (see, e.g., Sherementa, 2013). If we base our comparison on the $(0,0)$ or the $(20,20)$-equilibrium as a theoretical benchmark for the severe-treatment, the oversupply is yet larger. This observation is even more remarkable when we take into account that we used a cubic cost-of-effort function, whereas previous experiments typically applied only quadratic costs.

Oversupply of effort in the two crisis-treatments severe and minor has clear consequences for the survival rates of the department in the lab. These consequences are profound for the severe-treatment. While the theoretically predicted probability of surviving is $(a_{severe}^*)^2 = 6.25\%$ in the severe-treatment, it is five times higher in the experiment (30.75\%). In contrast, the department’s survival probability in the minor-treatment is 88.78\% in the experiment which is larger than the theoretical value of $2a_{minor}^* (1 - a_{minor}^*) + (a_{minor}^*)^2 = 84\%$. The oversupply of effort in the experiment is welfare increasing. To show this, consider monetary welfare $W := 2(\pi \cdot p(a) + \pi \cdot (1 - p(a)) - c(a))$ and assume that the company has set a rational winner prize $w < \pi - \pi$ (i.e., incentive pay is smaller than the possible output increase from incentivizing workers).\footnote{Each player produces a minimum output $\pi$ at zero cost.} Then, in each treatment, experimental welfare is strictly larger than predicted equilibrium welfare (see the appendix).
Based on previous findings in experiments with relative performance evaluation, one might expect gender, risk aversion, loss aversion, or competitiveness to have an impact on the effort decision. However, the results reported in the literature are mixed (see Section 2). To study if socioeconomic or behavioral aspects drive the effort selection within the main-treatments, we executed linear regressions for each main-treatment with effort as the dependent variable. We start with OLS regressions but, because our dependent variable ranges from zero to 100, we also executed Tobit regressions as an additional robustness check (see Tables A1 and A2 in the appendix). We introduce gender, a dummy stating if a player was enrolled in economics and a measure for competitiveness as independent variables. Competitiveness was measured by an index (see, Smither and Houston, 1992) where higher values indicate higher levels of competitiveness.

In Table A1 in the appendix we also include a dummy for loss aversion, which is 1 for players with higher levels of loss aversion. Because the measures for loss aversion and risk aversion are correlated, we estimated separate regressions for both. The results including risk aversion (higher values indicating a higher level of risk aversion) are reported in Table A2 in the appendix. While none of the afore mentioned variables has a significant impact on effort in the base- and in the minor-treatment, a higher degree of loss aversion has a significantly negative impact on effort provision in the severe-treatment.

**Result 1:** *In all main-treatments, players selected significantly higher effort levels than theoretically predicted. Hence, we have to reject Hypothesis 1. The deviation from the theoretical prediction in the severe-treatment was significantly larger than the deviation in the two other main-treatments.*

To investigate Hypothesis 2, we check the ranking of efforts of the different main-treatments. The observation of Figure 4 indicates that the results support Hypothesis 2, which is confirmed by a Jonckheere-Trepstra Test (ascending order \( p = 0.000 \)) as well as pairwise two-sided Mann-Whitney-U tests (severe vs. base \( p = 0.028 \), severe vs. minor \( p = 0.000 \), and base vs. minor \( p = 0.062 \)). Further confirmation is provided by the regressions reported in Table 2. The dependent variable in all regressions is effort. We included dummy variables, which are one for the severe- resp. the minor-treatment and zero otherwise. Hence, the base-treatment serves as the reference category in these regressions. The results of the OLS regressions are reported in the first and second specification while the results of the corresponding Tobit regressions are reported in the third and fourth column of Table 2. The results do not differ qualitatively. As expected, both dummies are significant and have the expected signs. We also included several control variables for loss aversion, competitiveness, and demographic details in the regressions. None of the control variables has a significant impact on the effort selected in the experiment.

---

22 All players that rejected a gamble where they could win 6 talers with probability 1/2 and lose 5 (or less) talers with probability 1/2 are classified as loss averse. The results are qualitatively similar if we use a continuous variable to measure loss aversion.

23 The last finding is in line with the theoretical results on loss aversion; see the "Additional Material," Part I.

24 The results are stable if we use the minor-treatment as a reference category.

25 In Table A3 in the appendix we report the results of the regressions when controlling for risk aversion instead of loss aversion. The results are qualitatively the same. To check whether the result regarding loss aversion found in Table A1 in the severe-treatment is robust we also did regressions where we included an interaction effect of
OLS Tobit

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Tobit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dummy severe-treatment</strong></td>
<td>-5.888**</td>
<td>-5.806**</td>
</tr>
<tr>
<td></td>
<td>(2.648)</td>
<td>(2.651)</td>
</tr>
<tr>
<td><strong>Dummy minor-treatment</strong></td>
<td>5.167**</td>
<td>5.053**</td>
</tr>
<tr>
<td></td>
<td>(2.464)</td>
<td>(2.479)</td>
</tr>
<tr>
<td><strong>Dummy loss aversion</strong></td>
<td>-3.391</td>
<td>-3.735</td>
</tr>
<tr>
<td></td>
<td>(2.150)</td>
<td>(2.592)</td>
</tr>
<tr>
<td><strong>Competitiveness</strong></td>
<td>0.0991</td>
<td>0.164</td>
</tr>
<tr>
<td></td>
<td>(0.233)</td>
<td>(0.281)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>3.471</td>
<td>3.968</td>
</tr>
<tr>
<td></td>
<td>(2.185)</td>
<td>(2.647)</td>
</tr>
<tr>
<td><strong>Dummy study economics</strong></td>
<td>-0.520</td>
<td>-1.173</td>
</tr>
<tr>
<td></td>
<td>(2.489)</td>
<td>(2.930)</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>61.33***</td>
<td>57.13***</td>
</tr>
<tr>
<td></td>
<td>(1.873)</td>
<td>(3.737)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Tobit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Observations</strong></td>
<td>622</td>
<td>622</td>
</tr>
<tr>
<td><strong># of left censored obs.</strong></td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td><strong># of right censored obs.</strong></td>
<td>71</td>
<td>71</td>
</tr>
<tr>
<td>(Pseudo) $R^2$</td>
<td>0.03</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Dependent variable is effort. Reference category is base.
Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 2: Comparison of effort between main-treatments

**Result 2:** *The players correctly adjusted their efforts to the severity of the crisis. In the severe-treatment, the players selected significantly lower effort levels than in the minor- and the base-treatment. The highest effort levels were observed in the minor-treatment. Hence, the data support Hypothesis 2.*

The elicited beliefs in the main-treatments and the data of the strategy-treatments allow us to further analyze the driving forces of the observed behavior. Are beliefs of the players in line with theory? Did players understand that efforts are strategic complements (substitutes) in case of a severe (minor) crisis? We start by a brief analysis of the beliefs stated in the main-treatments. In the severe-treatment, players expected their opponents to select on average 57.5 points, in the base-treatment 66.5 points and in the minor-treatment 68.19 points. The ranking of beliefs is in line with the theoretical predictions (Jonckheere-Terpstra Test, ascending order $p = 0.000$), but pairwise two-sided Mann-Whitney-U tests show no significant difference between the beliefs stated in the base- and the minor-treatment ($p = 0.7944$, severe vs. base the severe-treatment dummy and loss aversion. Even though the coefficients are not significant, they have the expected signs indicating that loss aversion leads to less effort in the severe-treatment (results available upon request).
$p = 0.0001$, severe vs. minor $p = 0.000$). The beliefs are, similar to the effort levels, higher than theoretically predicted (one sample mean comparison test, for all: $p = 0.000$). Note that beliefs and effort are positively correlated (Spearman’s rank correlation: severe-treatment: $\rho = 0.6704^{***}$, base-treatment: $\rho = 0.5232^{***}$, minor-treatment: $\rho = 0.5323^{***}$). However, we have to be careful when drawing conclusions from these data because we only have one "point belief" for each player. Hence, we have no information about the probability the player assigned to his belief and we lack information how the player would have responded to other effort levels of the opponent.

We, therefore, use the data of the strategy-treatments for a deeper analysis. First, we briefly compare the actually realized effort levels of the strategy-treatments with the theoretical predictions. The actually realized effort levels consist of the unconditional effort choice of a player if this choice was selected to be relevant for payment and the corresponding conditional effort choice of the respective opponent. The ranking of efforts is as predicted by theory (Jonckheere-Trepstra Test, ascending order $p = 0.003$), players in the severe-strategy-treatment exerted significantly less effort (mean 44.90 points) than players in the base-strategy (mean 60.10, two-sided Mann-Whitney-U test, $p = 0.0341$) and the minor-strategy-treatments (mean 61.20 points, two-sided Mann-Whitney-U test $p = 0.0072$). While we find no treatment differences when comparing realized effort levels between the base (minor) and the base-strategy (minor-strategy), players in the severe-strategy-treatment exerted significantly less effort than in the severe-treatment (two-sided Mann-Whitney-U test, $p = 0.0574$). However, we still observe significant oversupply of effort compared to the theoretical prediction of the severe-strategy-treatment (one sample mean comparison test, $p = 0.000$). Thus, the reduction of complexity reduced the oversupply of effort but the large unexplained effect in case of a severe crisis is still persistent.

![Figure 5: Best response functions severe-strategy-treatment](image-url)
To develop a better understanding of the players’ strategic behavior, we investigate their best response functions. Figures 5, 6, and 7 show the best response functions derived from the model (see Section 5) as dashed lines and the average best response functions based on the data from the strategy-treatments as solid lines. In each strategy-treatment the players had to state their effort for each possible effort level their opponent might have chosen. We use this data the calculate the empirical best response function. As can be seen in the figures, the theoretical and the empirical best response functions look rather similar and it seems that players respond to the effort level of their opponents as predicted by theory.

We test if the players’ best responses to a given effort level of their opponents differ from the theoretical predictions. We estimate a linear regression for each player,

$$a_i = \beta_{e,i} \cdot e^c + \beta_{0,i} + u,$$  \hspace{1cm} (10)
with \( a^e \) as the theoretically best response for a given effort level of the opponent\(^{26} \) and \( a_i \) as the effort level (conditional choice) of the player in the experiment. Both \( \beta_{e,i} \) and \( \beta_{0,i} \) are estimated for each player separately. If all players acted as predicted by theory the individual coefficients are, \( \beta_{e,i} = 1 \) and \( \beta_{0,i} = 0 \). We can execute those regressions only for the severe-strategy and the minor-strategy-treatments because we have \( a^e = 50 \) for every given effort level of the opponent in the base-strategy-treatment. In both, the minor-strategy and the severe-strategy-treatments we cannot reject the hypothesis that on average \( \beta_{e,i} = 1 \) and \( \beta_{0,i} = 0 \) (one sample mean comparison test, for all: \( p \geq 0.2975 \)). To test whether the deviation from theory in the severe-strategy-treatment significantly differed from the deviation in the minor-strategy-treatment, we also estimate a linear regression with

\[
\hat{\beta}_{e,i} - 1 = \beta_{m_i} d_{mi} + u
\]

where \( \hat{\beta}_{e,i} \) is the individually estimated coefficient from equation (10), and \( d_{mi} \) is a dummy variable which is 1 if player \( i \) participated in the minor-strategy-treatment. If there is no difference between the treatments, we expect \( \beta_{m_i} = 0 \). Indeed, the regression shows that \( \beta_{m_i} = -0.244 \) with a robust standard error of 0.42. Hence, in both strategy-treatments players followed the theoretical predictions quite well.

<table>
<thead>
<tr>
<th>Effort opponent</th>
<th>Severe-Strategy</th>
<th>Base-Strategy</th>
<th>Minor-Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 0.438^{***} )</td>
<td>( 0.438^{***} )</td>
<td>0.0635</td>
<td>0.0635</td>
</tr>
<tr>
<td>(0.080)</td>
<td>(0.080)</td>
<td>(0.086)</td>
<td>(0.086)</td>
</tr>
<tr>
<td>Dummy loss aversion</td>
<td>( -7.410 )</td>
<td>2.885</td>
<td>( -11.06^{**} )</td>
</tr>
<tr>
<td>( (5.011) )</td>
<td>( (4.705) )</td>
<td>( (4.600) )</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>( 15.21^{***} )</td>
<td>( 19.84^{***} )</td>
<td>( 51.22^{***} )</td>
</tr>
<tr>
<td>( (4.485) )</td>
<td>( (5.446) )</td>
<td>( (4.848) )</td>
<td>( (4.843) )</td>
</tr>
<tr>
<td>Observations</td>
<td>1,008</td>
<td>1,008</td>
<td>1,008</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.197</td>
<td>0.212</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Dependent variable is effort. Robust standard errors in parentheses. \( *** p < 0.01, ** p < 0.05, * p < 0.1 \)

Table 3: Strategic effects between efforts by strategy-treatment

To test if efforts are indeed strategic complements in the severe-strategy-treatment, substitutes in the minor-strategy-treatment, and none of both in the base-strategy treatment, we use OLS regressions with the conditional effort choice as the dependent variable and the potential effort of the opponent as an independent variable.\(^{27} \) We also control for loss aversion (see Table 3), risk aversion (see Table A4 in the appendix), and prosocial preferences of players (see Table A4 in the appendix). We elicited prosocial preferences by using the strategy method in a prisoners’ dilemma. We rate all players that cooperated regardless of the other players’ choice.

---

\(^{26}\) In steps of five because players could only choose effort levels in incremental steps of five.

\(^{27}\) We also executed panel regressions with random effects and tobit regressions as an additional robustness check and the results are qualitatively the same.
(altruists 0.70%) and all players that made the same choice as the other player (conditional cooperators 48.60%) as prosocial. All players that defected regardless of the choice of the other player (egoists 50.70%) are classified as egoists.

Columns 1 – 2 of Table 3 and Table A4 in the appendix show the results for the severe-strategy-treatment. The coefficient "effort opponent" is significant and positive in all specifications indicating that indeed efforts are perceived as strategic complements by the players. Columns 3 – 4 in Table 3 and Table A4 in the appendix show the results for the base-strategy-treatment. The coefficient "effort opponent" is small and not significant indicating that efforts are not perceived as strategic complements or substitutes. As can also be seen in Figure 6, the players responded with slightly higher levels than predicted by theory but the difference to the dominant strategy is rather small. The results for the minor-strategy-treatment are reported in columns 5 – 6 in Table 3 and Table A4 in the appendix. Here, the coefficient "effort opponent" is negative, hence efforts are perceived as strategic substitutes by the players.

Result 3: The empirical best response functions of the players show that efforts are perceived as strategic complements if the crisis is severe and as strategic substitutes if the crisis is minor. If there is no threat of a crisis, efforts are neither perceived as complements nor as substitutes.

The observation that players’ realized effort exceeded theoretically predicted effort to such a high extent in case of a severe crisis compared to a minor crisis and a situation without crisis, still remains a puzzle. The following section addresses this issue.

8 Discussion

In the main severe-treatment, players’ efforts were more than twice as high compared to theory.28 This deviation from theoretically predicted effort is significantly larger than the deviations in the two other main-treatments and also larger than the deviations documented in other tournament experiments. In the following, we discuss possible explanations for this puzzle.

Inspired by the rich literature on behavioral economics (e.g., Köszegi, forthcoming), it seems natural to ask whether our empirical puzzle can be explained by modifying players’ preferences in the benchmark model discussed in Sections 4 and 5. The benchmark model assumes that players are risk neutral and maximize expected payment from the tournament minus effort costs. Theoretical outcomes might fundamentally differ, however, if players are risk averse, loss averse (Barberis et al., 2001; DeMeza and Webb, 2007; Köszegi and Rabin, 2007), inequity averse (Fehr and Schmidt, 1999), or receive a non-monetary utility of winning (Sheremeta, 2010). Risk aversion and loss aversion might drive players’ behavior in situations with rather high income uncertainty and possible income losses. Both might be relevant when introducing a crisis that leads to a possible termination of a player’s department despite individual high performance. Inequity aversion and non-monetary utility of winning can be relevant in any situation with tournament competition, because a tournament yields a winner and a loser and, thus, leads to income inequality and possibly non-monetary utility of winning ex post.

28 In the severe-strategy-treatment, players selected effort levels that were 1.8 times higher on average than predicted by theory.
Empirically, we controlled for the influence of loss aversion in our regressions in Table A1 and Table 2. We found that loss aversion has a negative impact on effort in the main-severe-treatment. Risk attitude and competitiveness did not have a significant effect on the players’ effort choices, see Table 2, Table A2 and Table A3 in the appendix. We also control for joy-of-winning (Sheremeta, 2010) and social preferences in the strategy-treatments as an additional robustness check. Both controls had no significant impact on the effort provision in the strategy-treatments.

Theoretically, we introduced risk aversion, loss aversion, inequity aversion, or non-monetary utility of winning in the benchmark model of Section 5 and solved for the respective equilibrium outcomes (see the "Additional Material," Part I). The results show that risk aversion, loss aversion, and non-monetary utility of winning lead to the same effort ranking as our benchmark model. Moreover, in the three behavioral approaches, players’ efforts are again strategic complements (substitutes) in case of a severe (minor) crisis and neither strategic substitutes nor complements without crisis. Thus, the qualitative predictions of our benchmark model are quite robust. The findings for inequity aversion, however, contradict the observations in the laboratory experiment, the results of the benchmark model, and the findings of the three other behavioral approaches. It is important to emphasize that neither of the four behavioral models helps to explain the large oversupply of effort under a severe crisis compared to a situation with a minor crisis or without crisis: risk aversion and non-monetary utility of winning might explain a general oversupply of effort in all treatments but cannot explain the extraordinary effort exertion in case of a severe crisis. If players are loss averse or inequity averse, theory even predicts lower efforts than in the benchmark model in case of a severe crisis.

Consequently, we searched for an alternative theory that is in line with our empirical results and that might particularly explain the findings for the severe crisis. Based on the feedback of the players in the lab, we suppose that players felt uncomfortable being confronted with a potential situation where zero income was paid out to both of them. Throughout the experiment, we used neutral language and did not label such a situation "termination of the department during a crisis," but the players clearly realized under which outcomes no one would earn \( w \). Therefore, we conjecture that players had negative feelings when being confronted with the possibility of collectively losing \( w \).

Technically, the players face a two-stage process. At the first stage, either the collective good "survival of the department" is produced or not. If the players succeed at the first stage, the collective good will be distributed at the second stage – the winner receives \( w \) and the loser zero. Hence, the well-being of each player is determined by a collective component at the first stage and an individual one at the second stage. Since the individual component is already incorporated into a player’s objective function via the tournament payoffs, it remains to add the collective aspect. In order to proceed in this way, we subtract the function \( \Lambda \left( w \cdot P \right) \) from (13), (15), and (19), respectively. This function characterizes a player’s negative feelings from the possible termination of the department and the expected collective loss of incentive pay, with \( P \) describing the probability of collective dismissal, which depends on the given treatment.\(^{29}\)

\(^{29}\)In case of a positive loser prize, we have \( \Lambda \left( (w_L + w_H) \cdot P \right) \), because the collective loss is now given by \( w_L + w_H \).
We assume that $\Lambda(0) = 0$ (i.e., negative feelings become zero if termination is impossible or the loss is zero). Furthermore, $\Lambda$ is assumed to be monotonically increasing. To simplify matters, we neglect higher-order marginal effects by assuming that $\Lambda'' = 0$. Note that $\hat{P}$ decreases in the players’ efforts, which allows for the natural reaction of human beings to threats, namely to strain oneself to reduce the negative feelings (e.g., Elster, 1998).

Let $\hat{a}_s^*$ denote the equilibrium effort of the players in scenario $s \in \{\text{base}, \text{minor}, \text{severe}\}$ under the new objective function, which incorporates negative feelings $\Lambda$. If players value monetary income more strongly than their negative feelings, these efforts compare as follows (see the appendix):

$$\hat{a}_{\text{minor}}^* > \hat{a}_{\text{base}}^* > \hat{a}_{\text{severe}}^*.$$ 

This ranking coincides with the ranking of observed average efforts in our experiment. The data emphasized that players deviated from predicted effort more strongly in the main-severe-treatment than in the main-minor-treatment. In fact, chosen effort was more than twice as high in the main-severe-treatment compared to the equilibrium effort level, but in the main-minor-treatment players only realized efforts that exceeded the theoretical value by about 11%. In the appendix, we show that introducing negative feelings $\Lambda$ leads to extra incentives in both the main-severe- and main-minor-treatments, but under a generally high level of chosen efforts – which is documented for all main-treatments – the effort-enhancing effect of $\Lambda$ is clearly stronger in the main-severe-treatment. Intuitively, when effort is chosen the marginal benefit of reducing one’s own negative feelings, $\partial \Lambda \left( w \cdot \hat{P} \right) / \partial a_i$, determines the extra incentives from crisis. Since this marginal benefit increases with the effort level of co-workers in the main-severe-treatment and decreases with the efforts of co-workers in the main-minor-treatment, introducing negative feelings $\Lambda$ into the benchmark model can explain the observed puzzle because efforts are high in the two crisis treatments (see Figure 4).

In order to test our new theoretical approach, we ran additional treatments with a positive loser prize $w_L > 0$. These treatments, minor-45 and minor-90, have the further advantage that a player’s income from losing a tournament now strictly differs from the zero income following collective dismissal. Equations (28) and (29), characterizing equilibrium efforts for the benchmark model in cases of minor and severe crisis with positive loser prizes, show that $a_{\text{severe}}^*$ increases in $w_L$, but $a_{\text{minor}}^*$ decreases in $w_L$. From the results reported in the appendix, we also know that extra incentives from reducing negative feelings $\Lambda$ increase in $w_L$ under both a minor and a severe crisis. Testing the case of a severe crisis with a positive loser prize is, therefore, not informative at all: if effort increases compared to average effort under a zero loser prize, this finding will be in line with both the benchmark model and the new approach; if effort decreases, this result would contradict both theoretical settings. However, if introducing a positive loser prize under a minor crisis yields larger or equal efforts compared to the setting with a zero loser prize, such a finding would contradict the benchmark model and be in line with our new approach. For these reasons, we used the case of a minor crisis instead of a severe crisis as starting point to test the new theoretical setting.

\[30\] See the appendix.

\[31\] In the appendix, we see that $\partial^2 \Lambda \left( (w_L + w_H) \hat{P} \right) / \partial a_i \partial w_L < 0$ for both a minor and a severe crisis in equations (30) and (31), respectively.
We use the minor-45 and the minor-90-treatments with a loser prize of 45 respectively 90 for our analysis. The results of the additional treatments as well as those of the main-minor-treatment are depicted in Figure 8. A pairwise comparison of the efforts of the three treatments does not show a significant difference (two-sided Mann-Whitney-U test). This result is supported by the regressions reported in Table 4. Again, effort is the dependent variable, and we control for loss aversion, competitiveness, and demographic details. The reference category is the minor-45-treatment, and we included dummy variables for the main-minor- and the minor-90-treatments. As expected, the dummy variables are not significant in the full specifications. Hence, the players did not reduce effort significantly if positive loser prizes were paid. Even if the loser prize was close to the size of the winner prize (minor-90-treatment), which sharply cuts incentives in the benchmark model, the players did not reduce effort levels.

To summarize, our findings are not in line with the prediction of the benchmark model. According to that model, the introduction of positive loser prizes should lead to a considerable decline of efforts. Such decline is a well-known stylized fact from previous tournament experiments and field studies without crisis (see, e.g., Ehrenberg and Bognanno, 1990b,a; Lynch, 2005; and Harbring and Lünser, 2008). However, our findings sharply contrast with this prediction. They support the reasoning of our new approach: since efforts in the three minor-treatments did not significantly differ, the introduction of a positive loser prize had two opposing effects, which just offset each other. The loser prize $w_L = 45$ decreased the prize spread $w_H - w_L$, which partly destroyed standard tournament incentives. At the same time, $w_L$ boosted incentives to reduce negative feelings $\Lambda \left( (w_L + w_H)^{\hat{P}} \right)$ from the threat of collective dismissal. The data indicate that both effects nearly compensated each other.

![Figure 8: Mean of effort in the main-minor-, minor-45-, and minor-90-treatments](image)

32 Note that we observe a weakly significant difference between the main-minor- and the minor-45-treatments if we only have the treatment dummies in the regression. However, this effect is not robust and not supported by nonparametric tests. We also did regressions where we controlled for the risk attitudes and found qualitatively similar results.
<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Tobit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Dummy main-minor</td>
<td>5.786*</td>
<td>5.486</td>
</tr>
<tr>
<td></td>
<td>(3.466)</td>
<td>(3.513)</td>
</tr>
<tr>
<td>Dummy minor-90</td>
<td>1.161</td>
<td>1.066</td>
</tr>
<tr>
<td></td>
<td>(4.140)</td>
<td>(4.138)</td>
</tr>
<tr>
<td>Dummy loss aversion</td>
<td>0.918</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.571)</td>
<td></td>
</tr>
<tr>
<td>Competitiveness</td>
<td>-0.121</td>
<td>-0.056</td>
</tr>
<tr>
<td></td>
<td>(0.293)</td>
<td>(0.344)</td>
</tr>
<tr>
<td>Gender</td>
<td>1.549</td>
<td>2.669</td>
</tr>
<tr>
<td></td>
<td>(2.810)</td>
<td>(3.222)</td>
</tr>
<tr>
<td>Dummy study economics</td>
<td>0.568</td>
<td>-0.119</td>
</tr>
<tr>
<td></td>
<td>(2.966)</td>
<td>(3.278)</td>
</tr>
<tr>
<td>Constant</td>
<td>60.71***</td>
<td>61.75***</td>
</tr>
<tr>
<td></td>
<td>(3.073)</td>
<td>(5.025)</td>
</tr>
<tr>
<td>Observations</td>
<td>352</td>
<td>352</td>
</tr>
<tr>
<td># left censored obs.</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td># of right censored obs.</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>(Pseudo) R²</td>
<td>0.012</td>
<td>0.014</td>
</tr>
</tbody>
</table>

Dependent variable is effort. Reference category is minor-45.
Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1

Table 4: Comparison of effort between main-minor-, minor-45-, and minor-90-treatments

Further increasing the loser prize to $w_L = 90$ in the minor-90-treatment did not lead to significantly different effort levels compared to the main-minor-treatment with zero loser prize. Here, standard tournament incentives were even lower than in minor-45, but additional incentives via $\Lambda \left( (w_L + w_H) P \right)$ increased further. Again, both effects nearly offset each other. In this situation, standard tournament incentives become negligible as the gain from winning, given by the prize spread $w_H - w_L = 10$, is only worth 1.25 euro. Nevertheless, average effort even slightly increased compared to minor-45, which shows that incentives via $\Lambda$ will be important if the stakes are rather high (i.e., incomes at risk, $w_L + w_H = 190$, corresponding to 23.75 euro, are large).

9 Conclusion

The theoretical and experimental results of our paper have shown that the severity of a crisis significantly influences worker behavior. The theoretical part of the paper shows that effort choices are strategic complements given a severe crisis, yielding rather poor incentives for the workers compared to a situation without crisis. However, efforts are strategic substitutes and highest if the workers experience a minor crisis. Our experimental findings confirm the expected
effort ranking for the three scenarios as well as the strategic effects. The experiment also points to a puzzle: workers' effort choices deviated significantly stronger from equilibrium behavior under a severe crisis than under a minor crisis or in the absence of a crisis. This deviation influenced the department’s survival probability, making it five times higher than predicted under a severe crisis. Behavioral approaches based on risk aversion, loss aversion, or non-monetary utility of winning are in line with our experimental results on effort rankings and strategic effects. However, they cannot explain the large oversupply of effort in case of a severe crisis. We, therefore, conjecture that the anticipated possibility of collective dismissal led to negative feelings for the workers. In order to decrease these feelings, they chose more effort compared to a setting with standard textbook preferences.

We tested the alternative approach on negative feelings by running two additional treatments. In the initial treatments, we normalized the loser prize to zero and considered a winner-take-all contest. In the two additional treatments, we introduced a low respectively high positive loser prize into the initial setting of a minor crisis. The resulting average efforts did not significantly differ from the average effort in the minor-treatment with zero loser prize. Even if the loser prize became so large that the tournament prize spread was negligible, incentives did not significantly differ from the initial winner-take-all treatment. These observations are in line with the negative-feelings approach, where direct monetary incentives via the prize spread are replaced by incentives to guarantee the department’s survival and thus, to protect workers' collective wage bill. Our finding has a clear implication for the wage policy of a company. Introducing prizes for tournament losers has positive incentive effects under the shadow of crisis, which clearly differ from behavior in tournaments without collective dismissal as well as predicted behavior under a minor crisis and standard textbook preferences. However, since monetary incentives and incentives from crisis just offset each other, it is still optimal for the company to save labor costs and withdraw loser prizes. Hence, a wage policy that induces high-powered incentives via relative performance pay is still optimal under the shadow of crisis as long as typical negative implications of corporate tournaments such as sabotaging and influence activities do not become too intense.

Our experimental findings have a further implication for the personnel policy of a company. In a bad economic situation, in which a department has a positive likelihood of being terminated, employees will struggle to guarantee survival of the department rather than to give up or free ride. Hence, the management should not be afraid that an initially small crisis or even the rumor on a possible crisis will end up with the department being dissolved. On the contrary, it seems realistic that if a department faces a difficult situation, this will make the employees stick together and supply additional effort to protect their collective incomes. In other words, a crisis and the possibility of collective dismissal might strengthen group coherence among the workforce.
Appendix

Proof of Proposition 1

The winning probability $P(a_i, a_j)$ can be written as

$$P(a_i, a_j) = P(\theta_i > a_j - a_i + \theta_j \wedge \theta_i > \Pi - a_i - a_j - \theta_j)$$

$$= P(\theta_i > \max\{a_j - a_i + \theta_j, \Pi - a_i - a_j - \theta_j\})$$

$$= \int_{-\infty}^{\infty} \left( \int_{\max\{a_j - a_i + \theta_j, \Pi - a_i - a_j - \theta_j\}}^{\infty} f(\alpha) d\alpha \right) f(\theta_j) d\theta_j.$$

Applying Leibniz’s formula leads to

$$\frac{\partial P}{\partial a_i} = \int_{-\infty}^{\Pi - a_j} \frac{\partial}{\partial a_i} \left( \int_{\max\{a_j - a_i + \theta_j, \Pi - a_i - a_j - \theta_j\}}^{\infty} f(\alpha) d\alpha \right) f(\theta_j) d\theta_j$$

$$= \int_{-\infty}^{\Pi - a_j} f(\max\{a_j - a_i + \theta_j, \Pi - a_i - a_j - \theta_j\}) f(\theta_j) d\theta_j. \quad (11)$$

We have $a_j - a_i + \theta_j \geq \Pi - a_i - a_j - \theta_j \iff \theta_j \geq \frac{\Pi}{2} - a_j$ so that $\partial P/\partial a_i$ can be rewritten as

$$\frac{\partial P}{\partial a_i} = \int_{-\infty}^{\Pi - a_j} f(\Pi - a_i - a_j - \theta_j) f(\theta_j) d\theta_j + \int_{\Pi - a_j}^{\infty} f(a_j - a_i + \theta_j) f(\theta_j) d\theta_j. \quad (12)$$

The first integral on the right-hand side of (11) indicates the positive externality of worker $j$’s effort on worker $i$’s winning probability. The higher $j$’s effort, the more likely the department survives – i.e., $\theta_i > \Pi - a_i - a_j - \theta_j$ is satisfied – and, hence, the more likely worker $i$ will earn the winner prize $w$ by outperforming his co-worker. The second integral on the right-hand side of (11) indicates worker $j$’s negative externality. Given that the department survives, worker $i$ will only obtain the winner prize if he outperforms $j$, i.e., if $\theta_i > a_j - a_i + \theta_j$ holds, which is less likely to be satisfied the larger $a_j$. Inserting for $\partial P/\partial a_i$ in worker $i$’s first-order condition (4) leads to

$$w \cdot \left( \int_{-\infty}^{\Pi - a_j} f(\Pi - a_i - a_j - \theta_j) f(\theta_j) d\theta_j + \int_{\Pi - a_j}^{\infty} f(a_j - a_i + \theta_j) f(\theta_j) d\theta_j \right) = c'(a_i). \quad (12)$$

Using the symmetry condition $a_i = a_j = a^*$ yields equation (5).

By implicitly differentiating (4) we obtain

$$\frac{\partial a_i}{\partial a_j} = -\frac{w \cdot \frac{\partial^2 P(a_i, a_j)}{\partial a_i \partial a_j}}{EU''_i(a_i)}.$$

Since $EU''_i(a_i) < 0$ by (2), we have

$$\text{sign} \left( \frac{\partial a_i}{\partial a_j} \right) = \text{sign} \left( \frac{\partial^2 P(a_i, a_j)}{\partial a_i \partial a_j} \right).$$

If $\frac{\partial^2 P(a_i, a_j)}{\partial a_i \partial a_j} > (\leq) 0$, the workers’ efforts will be strategic complements (substitutes). Applying
Leibniz’s formula to (11) results in

\[
\frac{\partial^2 P(a_i, a_j)}{\partial a_i \partial a_j} = -f \left( \Pi - a_i - a_j - \left( \frac{\Pi}{2} - a_j \right) \right) f \left( \frac{\Pi}{2} - a_j \right)
- \int_{-\infty}^{\frac{\Pi}{2} - a_j} f' (\Pi - a_i - a_j - \theta_j) f (\theta_j) d\theta_j
+ f \left( a_j - a_i + \left( \frac{\Pi}{2} - a_j \right) \right) f \left( \frac{\Pi}{2} - a_j \right)
+ \int_{\frac{\Pi}{2} - a_j}^{\infty} f' (a_j - a_i + \theta_j) f (\theta_j) d\theta_j
= -\int_{-\infty}^{\frac{\Pi}{2} - a_j} f' (\Pi - a_i - a_j - \theta_j) f (\theta_j) d\theta_j
+ \int_{\frac{\Pi}{2} - a_j}^{\infty} f' (a_j - a_i + \theta_j) f (\theta_j) d\theta_j.
\]

Thus, effort combinations \((a_i, a_j)\) satisfying

\[-\int_{-\infty}^{\frac{\Pi}{2} - a_j} f' (\Pi - a_i - a_j - \theta_j) f (\theta_j) d\theta_j > \left( < \right) -\int_{\frac{\Pi}{2} - a_j}^{\infty} f' (a_j - a_i + \theta_j) f (\theta_j) d\theta_j\]

are strategic complements (substitutes).

Inserting the symmetry condition \(a_i = a_j = a^*\) into \(\partial^2 P(a_i, a_j) / \partial a_i \partial a_j\) gives

\[
\left. \frac{\partial^2 P(a_i, a_j)}{\partial a_i \partial a_j} \right|_{a_i=a_j=a^*} = -\int_{-\infty}^{\frac{\Pi}{2} - a^*} f' (\Pi - 2a^* - \theta_j) f (\theta_j) d\theta_j + \int_{\frac{\Pi}{2} - a^*}^{\infty} f' (\theta_j) f (\theta_j) d\theta_j.
\]

The second integral can be solved via integration by parts:

\[
\int_{\frac{\Pi}{2} - a^*}^{\infty} f' (\theta_j) f (\theta_j) d\theta_j = f (\theta_j) f (\theta_j) \bigg|_{\frac{\Pi}{2} - a^*}^{\infty} - \int_{\frac{\Pi}{2} - a^*}^{\infty} f (\theta_j) f' (\theta_j) d\theta_j
\]

\[
\Leftrightarrow \int_{\frac{\Pi}{2} - a^*}^{\infty} f' (\theta_j) f (\theta_j) d\theta_j = -\frac{1}{2} f^2 \left. \left( \frac{\Pi}{2} - a^* \right) \right|_{\frac{\Pi}{2} - a^*}^{\infty}.
\]

Hence, efforts will be strategic complements (substitutes) in equilibrium if

\[-\int_{-\infty}^{\frac{\Pi}{2} - a^*} f' (\Pi - 2a^* - \theta_j) f (\theta_j) d\theta_j > \left( < \right) \frac{1}{2} f^2 \left( \frac{\Pi}{2} - a^* \right).\]
Proof of Corollary 1

If the \( \theta_i \) follow the standardized normal distribution, we obtain

\[
-2 \int_{-\infty}^{\Pi-a^*} f'(\Pi - 2a^* - \theta) f(\theta) d\theta
= -2 \int_{-\infty}^{\Pi-a^*} - (\Pi - 2a^* - \theta) \frac{1}{\sqrt{2\pi}} \exp \left( -\frac{(\Pi - 2a^* - \theta)^2}{2} \right) \frac{1}{\sqrt{2\pi}} \exp \left( -\frac{\theta^2}{2} \right) d\theta
= -\frac{1}{4\pi} \exp \left( -\frac{1}{4} (2a^* - \Pi)^2 \right) (\sqrt{\pi} (2a^* - \Pi) - 2)
\]

and

\[
f^2 \left( \frac{\Pi}{2} - a^* \right) = \left( \frac{1}{\sqrt{2\pi}} \exp \left( -\frac{(\Pi - a^*)^2}{2} \right) \right)^2 = \frac{1}{2\pi} \exp \left( -\frac{1}{4} (2a^* - \Pi)^2 \right).
\]

Therefore, condition (7) is reduced to \( \Pi > 2a^* \).

Solution to the set-up implemented in the laboratory \((w_L = 0)\)

In the base scenario with no crisis (i.e., \( \Pi \in [0, 2\pi] \)), there are four possible outcomes. If player \( i \) is better (worse) than player \( j \), he will be declared tournament winner (loser) and earns \( w_H = w > 0 \) \((w_L = 0)\). If both produce the same output, the winner will be determined according to a fair tie-breaking rule. In any case, \( i \) has to bear his effort cost \( ca_i^3/3 \). Altogether, player \( i \) maximizes

\[
EU_i(a_i) = wa_i (1 - a_j) + \frac{w}{2} [a_i a_j + (1 - a_i) (1 - a_j)] - \frac{c}{3} a_i^3 \tag{13}
\]

The first-order condition shows that each player chooses optimal effort

\[
a^*_i = \sqrt{\frac{w}{2c}}. \tag{14}
\]

In case of a minor crisis (i.e., \( \Pi \in (2\pi, \pi + \pi) \)), player \( i \)'s strictly concave objective function is given by

\[
EU_i(a_i) = wa_i (1 - a_j) + \frac{w}{2} a_i a_j - \frac{c}{3} a_i^3. \tag{15}
\]

Compared to equation (13), only the event is missing where both players perform poorly, because in that case the department is terminated. The first-order condition \( EU'_i(a_i) = 0 \) yields

\[
w - \frac{w}{2} a_j = ca_i^2. \tag{16}
\]

In analogy, player \( j \)'s first-order condition results in

\[
w - \frac{w}{2} a_i = ca_j^2. \tag{17}
\]

The two best response functions (16) and (17) show that efforts are strategic substitutes and
that we have a unique and symmetric equilibrium with
\[ a_i = a_j = a_{\text{minor}}^* = \frac{\sqrt{16cw + w^2} - w}{4c}. \] (18)

In case of a severe crisis (i.e., \( \Pi \in (\bar{\Pi}, 2\bar{\Pi}) \)), the department will only survive, if both players produce a high output. Player \( i \) maximizes the strictly concave function
\[ EU_i(a_i) = \frac{w}{2}a_i a_j - \frac{c}{3}a_i^3. \] (19)

Hence, when entering the state of a severe crisis, the players’ optimization problem technically resembles a team problem. However, when the players have achieved the department’s survival, they still play a tournament game with one player receiving the winner prize \( w \) and the other earning zero. Now, the first-order condition yields
\[ \frac{w}{2}a_j = ca_i^2. \] (20)

Analogously, the first-order condition for player \( j \) leads to
\[ \frac{w}{2}a_i = ca_j^2. \] (21)

(20) and (21) show that efforts are strategic complements. There is one symmetric equilibrium where each player exerts zero effort. Intuitively, if one player chooses zero effort, his probability of realizing the high output will be zero. In this situation, the other player does not have any chance to avoid the termination of the department. The best he can do is to minimize effort costs by choosing zero effort as well. However, there exists a second equilibrium. From combining (20) and (21) we obtain
\[ \frac{w}{2c} = \frac{a_i^2}{a_j} = \frac{a_j^2}{a_i}, \]

which describes a symmetric equilibrium with
\[ a_i = a_j = a_{\text{severe}}^* = \frac{w}{2c}. \] (22)

From the players’ point of view, the equilibrium \( (a_{\text{severe}}^*, a_{\text{severe}}^*) \) Pareto dominates the equilibrium where each player chooses zero effort. Hence, the theoretically predicted outcome that we expect to observe in the laboratory is \( a_{\text{severe}}^* \).

In the laboratory experiment, we use parameter values that guarantee efforts \( a_{\text{minor}}^*, a_{\text{base}}^*, a_{\text{severe}}^* \in (0, 1) \) – in particular, \( w < 2c \) – so that efforts can be interpreted as success probabilities. Comparing (14), (18) and (22) immediately leads to the ranking of equilibrium efforts described by (9).

Experimental welfare versus theoretically predicted welfare

Given the specification used in the experiment, monetary welfare reads as
\[ W = 2 \cdot \left( \bar{\pi}a + (1 - a) \frac{200}{3} a^3 \right) = 2 \cdot \left( \bar{\pi} + \Delta \pi a - \frac{200}{3} a^3 \right) \]
with $\Delta \pi := \pi - \bar{\pi}$ and $a$ being workers’ efforts. Let $W^\text{pred}_s$ denote the theoretically predicted welfare in scenario $s \in \{\text{base}, \text{minor}, \text{severe}\}$ and $W^\text{exp}_s$ the respective experimental welfare. Using the predicted points from Table 1 to compute $W^\text{pred}_s$ and experimental means from Figure 4 to compute $W^\text{exp}_s$ yields the following results:

<table>
<thead>
<tr>
<th>$s$</th>
<th>$W^\text{pred}_s$</th>
<th>$W^\text{exp}_s$</th>
<th>$W^\text{exp}_s &gt; W^\text{pred}_s$ if</th>
</tr>
</thead>
<tbody>
<tr>
<td>base</td>
<td>$2 (\bar{\pi} + 0.5\Delta \pi - 8.3)$</td>
<td>$2 (\bar{\pi} + 0.6133\Delta \pi - 15.38)$</td>
<td>$\Delta \pi &gt; 62.49$</td>
</tr>
<tr>
<td>minor</td>
<td>$2 (\bar{\pi} + 0.6\Delta \pi - 14.4)$</td>
<td>$2 (\bar{\pi} + 0.665\Delta \pi - 19.61)$</td>
<td>$\Delta \pi &gt; 80.15$</td>
</tr>
<tr>
<td>severe</td>
<td>$2 (\bar{\pi} + 0.25\Delta \pi - 1.04)$</td>
<td>$2 (\bar{\pi} + 0.5545\Delta \pi - 11.37)$</td>
<td>$\Delta \pi &gt; 33.92$</td>
</tr>
</tbody>
</table>

At first sight, a direct comparison between $W^\text{pred}_s$ and $W^\text{exp}_s$ seems impossible, because output levels $\pi$ and $\bar{\pi}$ were not part of the experiment. However, a rational company that uses relative performance pay would not offer a winner prize $w = 100$ – the value used in the experiment – that exceeds the possible increase of output induced by the incentive scheme. In other words, we must have $w = 100 < \Delta \pi$ so that all conditions in the last column are satisfied.

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th></th>
<th>Tobit</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>severe</td>
<td>base</td>
<td>minor</td>
<td>severe</td>
</tr>
<tr>
<td>Dummy loss aversion</td>
<td>$-8.664^{**}$</td>
<td>$-0.429$</td>
<td>$-0.766$</td>
<td>$-9.988^{**}$</td>
</tr>
<tr>
<td></td>
<td>(3.855)</td>
<td>(4.125)</td>
<td>(3.275)</td>
<td>(4.560)</td>
</tr>
<tr>
<td>Competitiveness</td>
<td>$-0.252$</td>
<td>$0.736$</td>
<td>$-0.144$</td>
<td>$-0.327$</td>
</tr>
<tr>
<td></td>
<td>(0.415)</td>
<td>(0.463)</td>
<td>(0.342)</td>
<td>(0.492)</td>
</tr>
<tr>
<td>Gender</td>
<td>$4.487$</td>
<td>$4.024$</td>
<td>$1.337$</td>
<td>$4.517$</td>
</tr>
<tr>
<td>Dummy study economics</td>
<td>$1.385$</td>
<td>$-2.493$</td>
<td>$0.336$</td>
<td>$0.898$</td>
</tr>
<tr>
<td></td>
<td>(4.832)</td>
<td>(4.348)</td>
<td>(3.555)</td>
<td>(5.442)</td>
</tr>
<tr>
<td>Constant</td>
<td>$61.31^{***}$</td>
<td>$51.61^{**}$</td>
<td>$67.77^{***}$</td>
<td>$62.50^{***}$</td>
</tr>
</tbody>
</table>

| Observations | 202 | 210 | 210 | 202 | 210 | 210 |
| # of left censored obs. | 22 | 13 | 7 |
| # of right censored obs. | 12 | 30 | 29 |
| (Pseudo) $R^2$ | 0.032 | 0.016 | 0.002 | 0.0034 | 0.0019 | 0.0003 |

Dependent variable is effort. Robust standard errors in parentheses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^*p < 0.1$

Table A1: Effort decisions in main-treatments: Regressions with control for loss aversion
### Table A2: Effort decisions in main-treatments: Regressions with control for risk aversion

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Tobit</th>
</tr>
</thead>
<tbody>
<tr>
<td># of safe choices (H&amp;L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>severe</td>
<td>−0.537</td>
<td>−0.632</td>
</tr>
<tr>
<td>base</td>
<td>−1.239</td>
<td>−1.158</td>
</tr>
<tr>
<td>minor</td>
<td>0.863</td>
<td>1.054</td>
</tr>
<tr>
<td>(0.993)</td>
<td>(1.166)</td>
<td>(1.039)</td>
</tr>
<tr>
<td>Competitiveness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>−0.189</td>
<td>0.729</td>
<td>0.930*</td>
</tr>
<tr>
<td>−0.090</td>
<td>−0.257</td>
<td>−0.003</td>
</tr>
<tr>
<td>(0.420)</td>
<td>(0.449)</td>
<td>(0.429)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.792</td>
<td>4.442</td>
<td>4.500</td>
</tr>
<tr>
<td>(3.887)</td>
<td>(3.483)</td>
<td>(4.154)</td>
</tr>
<tr>
<td>Dummy study economics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.859</td>
<td>−2.129</td>
<td>−3.272</td>
</tr>
<tr>
<td>−0.027</td>
<td>1.461</td>
<td>−0.473</td>
</tr>
<tr>
<td>(5.095)</td>
<td>(4.365)</td>
<td>(4.189)</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>58.31***</td>
<td>58.01***</td>
<td>59.19***</td>
</tr>
<tr>
<td>(8.297)</td>
<td>(8.525)</td>
<td>(9.827)</td>
</tr>
</tbody>
</table>

| Observations             | 202             | 210             |
| # of left censored obs.  | 22              | 13              |
| # of right censored obs.| 12              | 30              |

Dependent variable is effort. Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1

### Table A3: Comparison of effort between main-treatments controlling for risk aversion

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Tobit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dummy severe-treatment</td>
<td>−5.795**</td>
<td>−7.771**</td>
</tr>
<tr>
<td></td>
<td>(2.654)</td>
<td>(3.195)</td>
</tr>
<tr>
<td>Dummy minor-treatment</td>
<td>5.164**</td>
<td>5.561*</td>
</tr>
<tr>
<td></td>
<td>(2.471)</td>
<td>(3.014)</td>
</tr>
<tr>
<td># of safe choices (H&amp;L)</td>
<td>−0.202</td>
<td>−0.140</td>
</tr>
<tr>
<td></td>
<td>(0.539)</td>
<td>(0.648)</td>
</tr>
<tr>
<td>Competitiveness</td>
<td>0.128</td>
<td>0.199</td>
</tr>
<tr>
<td></td>
<td>(0.234)</td>
<td>(0.282)</td>
</tr>
<tr>
<td>Gender</td>
<td>3.165</td>
<td>3.618</td>
</tr>
<tr>
<td></td>
<td>(2.169)</td>
<td>(2.624)</td>
</tr>
<tr>
<td>Dummy study economics</td>
<td>−0.365</td>
<td>−1.019</td>
</tr>
<tr>
<td></td>
<td>(2.497)</td>
<td>(2.939)</td>
</tr>
<tr>
<td>Constant</td>
<td>59.27***</td>
<td>59.42***</td>
</tr>
<tr>
<td></td>
<td>(4.901)</td>
<td>(5.935)</td>
</tr>
</tbody>
</table>

| Observations             | 622             | 622             |
| # of left censored obs.  | 42              |                 |
| # of right censored obs.| 71              |                 |
| (Pseudo) R²              | 0.03            | 0.004           |

Dependent variable is effort. Reference category is base.

Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1

Table A3: Comparison of effort between main-treatments controlling for risk aversion
### Table A4: Strategic effects between efforts by strategy-treatment

<table>
<thead>
<tr>
<th>Effort opponent</th>
<th>Severe-Strategy</th>
<th>Base-Strategy</th>
<th>Minor-Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effort opponent</td>
<td># of safe choices (H&amp;L)</td>
<td>Dummy prosocial</td>
</tr>
<tr>
<td>0.438***</td>
<td>0.438***</td>
<td>0.0635</td>
<td>0.0635</td>
</tr>
<tr>
<td>(0.080)</td>
<td>(0.080)</td>
<td>(0.086)</td>
<td>(0.086)</td>
</tr>
<tr>
<td>−0.214</td>
<td>0.916</td>
<td>−2.174*</td>
<td>(1.079)</td>
</tr>
<tr>
<td>(1.079)</td>
<td>(1.388)</td>
<td>(1.188)</td>
<td></td>
</tr>
<tr>
<td>6.789</td>
<td>−3.073</td>
<td>−5.910</td>
<td>(5.252)</td>
</tr>
<tr>
<td>(5.252)</td>
<td>(4.905)</td>
<td>(4.986)</td>
<td></td>
</tr>
<tr>
<td>16.37**</td>
<td>12.24**</td>
<td>46.38***</td>
<td>52.50***</td>
</tr>
<tr>
<td>(7.195)</td>
<td>(5.131)</td>
<td>(8.700)</td>
<td>(5.563)</td>
</tr>
</tbody>
</table>

Observations: 1,008
R²: 0.197

Dependent variable is effort. Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1

### Negative feelings $\Lambda$ from the threat of collective dismissal ($w_L = 0$)

In the base scenario, subtracting $\Lambda (w \cdot 0) = 0$ from the previous objective function (13) does not alter the equilibrium effort. Hence, both workers are again expected to exert effort $a^{\ast}_{\text{base}} =: \hat{a}_{\text{base}}$, being described by (14).

Under a minor crisis, we have $\hat{P} = (1 - a_i) (1 - a_j)$ so that the modified objective function of worker $i$,

$$w a_i (1 - a_j) + \frac{w}{2} a_i a_j - \frac{c}{3} a_i^3 - \Lambda (w \cdot (1 - a_i) (1 - a_j)),$$

yields the first-order condition

$$w \left(1 - \frac{1}{2} a_j \right) + \Lambda' (w \cdot (1 - a_i) (1 - a_j)) w (1 - a_j) = ca_i^2.$$  \hspace{1cm} (23)

Implicit differentiation of (23) shows that $da_i/da_j < 0$, i.e., $a_i$ and $a_j$ are strategic substitutes. Let $\hat{a}^{\ast}_{\text{minor}}$ denote a worker’s effort choice in the corresponding symmetric equilibrium with

$$w \left(1 - \frac{1}{2} \hat{a}^{\ast}_{\text{minor}} \right) + \Lambda' \left(w \cdot (1 - \hat{a}^{\ast}_{\text{minor}})^2\right) w (1 - \hat{a}^{\ast}_{\text{minor}}) = c \cdot (\hat{a}^{\ast}_{\text{minor}})^2.$$  \hspace{1cm} (24)

Comparison with (16), with $a_i = a_j = \hat{a}^{\ast}_{\text{minor}}$, immediately shows that $\hat{a}^{\ast}_{\text{minor}} > a^{\ast}_{\text{minor}}$, due to the additional positive term at the left-hand side of (24) and the fact that the left-hand (right-hand) side of (24) monotonically decreases (increases) in $\hat{a}^{\ast}_{\text{minor}}$. (Recall that $\Lambda'' = 0$.)

In case of a severe crisis, worker $i$ maximizes

$$\frac{w}{2} a_i a_j - \frac{c}{3} a_i^3 - \Lambda (w \cdot (1 - a_i a_j)).$$
Implicit differentiation of the first-order condition

\[
\frac{w}{2}a_j + \Lambda' \left( w \cdot (1 - a_j a_j) \right) w a_j = c a_i^2
\]  

(25)

shows that \( da_i / da_j > 0 \), i.e., \( a_i \) and \( a_j \) are strategic complements. By using (25), the symmetric equilibrium \((a_i, a_j) = (\hat{a}^*_{\text{severe}}, \hat{a}^*_{\text{severe}})\) in which both workers choose positive efforts can be characterized via

\[
\frac{w}{2c} + \frac{\Lambda'}{c} \left( w \cdot \left(1 - \left(\hat{a}^*_{\text{severe}}\right)^2\right) \right) w = \hat{a}^*_{\text{severe}}.
\]  

(26)

Comparing (22) and (26) shows that \( \hat{a}^*_{\text{severe}} > a^*_{\text{severe}} \).

When comparing the three equilibrium efforts under negative feelings \( \Lambda \), we immediately obtain \( \hat{a}^*_{\text{minor}} > \hat{a}^*_{\text{base}} \), because \( \hat{a}^*_{\text{minor}} > a^*_{\text{minor}} > a^*_{\text{base}} = \hat{a}^*_{\text{base}} \). Equilibrium efforts in the base scenario are still larger than in case of a severe crisis if standard monetary incentives have a higher impact on the workers’ effort choices than negative feelings. This can be seen by inspection of (14) and (26):

\[
\hat{a}^*_{\text{base}} > \hat{a}^*_{\text{severe}} \iff \Lambda' \left( w \cdot \left(1 - \left(\hat{a}^*_{\text{severe}}\right)^2\right) \right) < \frac{1}{2} \left( \sqrt{\frac{2c}{w}} - 1 \right).
\]

Since direct monetary income should be more relevant for a worker than second-order feelings of uneasiness due to a crisis, it seems plausible that the inequality is satisfied.

The findings of our experiment emphasize that workers’ average effort exceeded the respective equilibrium effort of the benchmark model (see Section 5) considerably more in case of a severe crisis than in case of a minor crisis (see Figure 4). This major puzzle can be explained by our new theoretical approach, if the introduction of \( \Lambda \) into the workers’ objective functions shifts efforts more upwards under a severe crisis than under a minor crisis. In principle, the incentive effect of negative feelings \( \Lambda \) is larger the more a worker’s effort reduces the probability of collective dismissal, \( \hat{P} \), because \( \Lambda' > 0 \). Therefore, if for worker \( i \) the expression \( \left| \partial \hat{P} / \partial a_i \right| \) is larger in case of a severe crisis than in case of a minor crisis, incentives from trying to avoid collective dismissal will be higher in the former case than in the latter one.

In case of a minor crisis, we have \( \hat{P} = (1 - a_i) (1 - a_j) \). Differentiating with respect to \( a_i \) gives

\[
\frac{\partial \hat{P}}{\partial a_i} = - (1 - a_j).
\]

Thus, if under a minor crisis co-worker \( j \) already chooses considerable effort, worker \( i \)'s impact on the reduction of \( \hat{P} \) and, therefore, on reducing his negative feelings \( \Lambda \) will be rather low. This effect decreases worker \( i \)'s incentives to avoid termination of the department. Recall that in the laboratory experiment players indeed chose high efforts in case of a minor crisis and also state high beliefs about their co-workers’ efforts choices. Hence, the argument holds for both workers and explains the rather limited effect of negative feelings on incentives under a minor crisis. Technically, this effect can be recognized most clearly in the last term on the left-hand side of the first-order condition (23), \( 1 - a_j \), which is rather small for high values of \( a_j \).

In case of a severe crisis, however, we have just the opposite effect. Here, the probability
of collective dismissal reads as $\dot{P} = 1 - a_i a_j$, with

$$\frac{\partial \dot{P}}{\partial a_i} = -a_j.$$  

Hence, under a severe crisis worker $i$’s impact on the reduction of the dismissal probability increases in co-worker $j$’s effort level $a_j$. Consequently, under high chosen efforts and high effort beliefs in the two crisis scenarios workers have strong incentives to exert effort in order to reduce their negative feelings given a severe crisis. This effect is shown by the last term on the left-hand side of the first-order condition (25), $a_j$, which is rather large. To sum up, because realized values of $a_i$ were typically higher than $0.5$ in all main-treatments and workers chose higher efforts in case of a minor crisis than in case of a severe crisis, we have $\hat{a}_{severe} > 1 - \hat{a}_{minor}$. Incentives from trying to avoid collective dismissal – as indicated by $|\partial \dot{P}/\partial a_i|$ – were higher in case of a severe crisis than in case of a minor crisis.

In order to exemplarily illustrate individual behavior under negative feelings $\Lambda$, we use the following specification:

$$\Lambda \left( w \dot{P} \right) := \gamma \cdot w \dot{P} \quad \text{with} \quad \gamma \in (0, 1).$$

Together with the parameterization in the experiment given by $c(a_i) = \frac{200}{3} a_i^3$ and $w = 100$ we obtain

$$\hat{a}_{minor}^* = \frac{\sqrt{4 \gamma^2 + 36 \gamma + 33} - 2 \gamma - 1}{8} \quad \text{and} \quad \hat{a}_{severe}^* = \frac{2 \gamma + 1}{4}$$

as equilibrium effort levels, which both lie in the interval $(0, 1)$. We finally have to show that the introduction of $\Lambda$ increases equilibrium efforts more strongly given a severe crisis than given a minor crisis, that is

$$\hat{a}_{severe}^* - \hat{a}_{severe} > \hat{a}_{minor}^* - \hat{a}_{minor}^*$$

with $\hat{a}_{severe}^* = 0.25$ and $\hat{a}_{minor}^* = (\sqrt{33} - 1)/8 \approx 0.6$. Inserting for the equilibrium efforts in condition (27) and rearranging yields $30 \gamma - 5 \sqrt{4 \gamma^2 + 36 \gamma + 33} + 29 > 0$, which is clearly satisfied. Hence, in our example we can explicitly show that extra incentives from negative feelings due to the threat of collective dismissal are stronger under a severe crisis than under a minor crisis.

**Positive loser prizes ($w_L > 0$)**

So far, we have used a positive winner prize $w_H = w > 0$ and a loser prize $w_L$ that is normalized to zero. The following derivations extend the analysis by introducing a positive loser prize $w_L > 0$. 

40
Benchmark model with risk neutral players

In the base scenario with no crisis, player $i$ now maximizes

$$EU_i(a_i) = w_H a_i (1 - a_j) + \frac{w_H + w_L}{2} [a_i a_j + (1 - a_i) (1 - a_j)]$$

$$+ w_L (1 - a_i) a_j - \frac{c}{3} a_i^3$$

$$= \frac{w_H + w_L}{2} + \frac{w_H - w_L}{2} (a_i - a_j) - \frac{c}{3} a_i^3.$$

The first-order condition immediately leads to the optimal effort

$$a^*_\text{base} = \sqrt{\frac{w_H - w_L}{2c}}.$$

In case of a minor crisis, player $i$’s objective function is given by

$$EU_i(a_i) = w_H a_i (1 - a_j) + \frac{w_H + w_L}{2} a_i a_j + w_L a_j (1 - a_i) - \frac{c}{3} a_i^3.$$

The first-order condition $EU_i'(a_i) = 0$ yields

$$w_H - \frac{w_H + w_L}{2} a_j = c a_i^2.$$

Analogously, for player $j$ we obtain

$$w_H - \frac{w_H + w_L}{2} a_i = c a_j^2.$$

The intersection of the two best-response functions leads to a unique equilibrium with

$$a_i = a_j = a^*_\text{minor} = \sqrt{\frac{16cw_H + (w_H + w_L)^2 - (w_H + w_L)}{4c}}. \quad (28)$$

In case of a severe crisis, player $k \in \{i, j\}$ maximizes

$$EU_k(a_k) = \frac{w_H + w_L}{2} a_i a_j - \frac{c}{3} a_k^3.$$

Besides the equilibrium in which both players choose zero efforts, there exists an interior equilibrium being described by the two first-order conditions, which result in

$$\frac{w_H + w_L}{2c} = a_i^2 = a_j^2.$$

Thus, the interior solution is symmetric:

$$a_i = a_j = a^*_\text{severe} = \frac{w_H + w_L}{2c}. \quad (29)$$

Negative feelings $\Lambda$ from the threat of collective dismissal

In the base scenario, a player’s objective function does not differ from that in the benchmark
model because $\Lambda ((w_L + w_H) \cdot 0) = 0$. Hence, players’ optimal effort is $\hat{a}_{base} = a_{base} = \sqrt{\frac{w_H - w_L}{2c}}$.

In case of a minor crisis, $\hat{P} = (1 - a_i) (1 - a_j)$ so that player $i$ maximizes

$$w_H a_i (1 - a_j) + \frac{w_H + w_L}{2} a_i a_j + w_L a_j (1 - a_i) - \frac{c}{3} a_i^3 - \Lambda ((w_L + w_H) \cdot (1 - a_i) (1 - a_j)).$$

The first-order condition yields

$$w_H - \frac{w_H + w_L}{2} a_j + \Lambda' ((w_L + w_H) \cdot (1 - a_i) (1 - a_j)) (w_L + w_H) (1 - a_j) = c a_i^2. \quad (30)$$

In the corresponding symmetric equilibrium, each player chooses $\hat{a}_{\text{minor}}$ with

$$w_H - \frac{w_H + w_L}{2} \hat{a}_{\text{minor}} + \Lambda \left( (w_L + w_H) \cdot (1 - \hat{a}_{\text{minor}}^*) \right) (w_L + w_H) (1 - \hat{a}_{\text{minor}}^*) = c \cdot (\hat{a}_{\text{minor}}^*)^2.$$

In case of a severe crisis, player $k \in \{i, j\}$ maximizes

$$\frac{w_H + w_L}{2} a_i a_j - \frac{c}{3} a_k^3 - \Lambda ((w_L + w_H) \cdot (1 - a_i a_j)).$$

The first-order conditions

$$\frac{w_H + w_L}{2} a_j + \Lambda' ((w_L + w_H) \cdot (1 - a_i a_j)) (w_L + w_H) a_j = c a_i^2 \quad (31)$$

and

$$\frac{w_H + w_L}{2} a_i + \Lambda' ((w_L + w_H) \cdot (1 - a_i a_j)) (w_L + w_H) a_i = c a_j^2$$

lead to a symmetric interior equilibrium $(a_i, a_j) = (\hat{a}_{\text{severe}}, \hat{a}_{\text{severe}})$ with

$$\frac{w_H + w_L}{2c} + \frac{\Lambda' ((w_L + w_H) \cdot (1 - a_i^2))}{c} (w_L + w_H) = \hat{a}_{\text{severe}}^*.$$

References


Online Appendix for
"Relative Performance Pay in the Shadow of Crisis"

Part I: Examples with the Standardized Normal Distribution

To further illustrate the impact of the threshold $\Pi$, we concentrate on three different values of $\Pi$ corresponding to a severe, a minor, and a no crisis setting. Let the winner prize be $w = 1$ and effort costs be quadratic with $c(a_i) = ca_i^2/2$ and $c = 0.3$. As base scenario, we first look at the best response functions in the standard Lazear-Rosen model, which describes a pure tournament without any crisis (i.e., $\Pi = -\infty$). In that case, workers’ best response functions are described by

$$
\int_{-\infty}^{\infty} f(a_j - a_i + \theta) f(\theta) d\theta = 0.3 a_i \Leftrightarrow \frac{1}{2\sqrt{\pi}} \exp\left(-\frac{1}{4} (a_i - a_j)^2\right) = 0.3 a_i
$$

with $i, j = 1, 2; i \neq j$. They are plotted in Figure 1.

![Figure 1: Best response functions: no crisis](image)

Figure 1 shows that there exists a unique and symmetric equilibrium at $a_1^* = a_2^* = 0.94$. Moreover, the best response functions do neither describe purely strategic complements nor purely strategic substitutes. Instead, efforts switch from strategic complements to substitutes and intersect exactly in the switching point. This observation is not specific to the Lazear-Rosen model. It also holds for other contest-success-functions like the one introduced by Tulloock (1980) (see, e.g., Wärneryd 2000, p. 148).

However, best response functions sharply contrast with those in the standard tournament when introducing a crisis. Using the same specifications for the winner prize, the effort costs and the luck distribution as before, equation (12) from the appendix of the paper, which describes the workers’ best response functions in a crisis, can be rewritten as

$$
\frac{\exp\left(-\frac{1}{4} (\Pi - a_i - a_j)^2\right) \left[\text{erf}\left(\frac{1}{\sqrt{2}} a_i - \frac{1}{\sqrt{2}} a_j\right) + 1\right]}{4\sqrt{\pi}} + \frac{[1 - \text{erf}\left(\frac{1}{\sqrt{2}} (\Pi - a_i - a_j)\right)] \exp\left(-\frac{1}{4} (a_i - a_j)^2\right)}{4\sqrt{\pi}} = 0.3 a_i.
$$

1
Here, \( \text{erf}(x) := \frac{2}{\sqrt{\pi}} \int_0^x e^{-t^2} dt \) denotes the error function. Given a minor crisis with \( \Pi = 0.02 \), the workers’ best response functions are described by Figure 2. They intersect at \( a^* = a_1^* = a_2^* = 1.04 \) with \( \Pi < 2a^* \). The best response functions are monotonically decreasing showing that efforts are strategic substitutes. However, under a severe crisis with \( \Pi = 3 \), workers’ best response functions are increasing and describe strategic complements (see Figure 3). Now, they intersect at \( a^* = a_1^* = a_2^* = 0.08 \) with \( \Pi > 2a^* \). Hence, equilibrium efforts are lowest under a severe crisis and highest in case of a minor crisis.

Figure 2: Best response functions: minor crisis

Figure 3: Best response functions: severe crisis
Part II: Robustness Check

In the paper, we used a benchmark model with players that are risk neutral and income maximizing. In the following, we discuss if models with risk aversion, loss aversion, non-monetary utility of winning, or inequity aversion might explain the observed behavior in the experiment.

Risk Aversion

Risk averse players do not like to bear income risk. Technically, risky income does not enter a player’s utility function linearly (as in the case of risk neutral players), but is valued according to some concave utility function \( u \) with \( u' > 0 \) and \( u'' < 0 \). Hence, additional risky income increases a player’s utility but does so at a decreasing rate. In our setting, player \( i \) maximizes \( E_Y [u(Y_i) - c(a_i)] \) with \( Y_i \in \{ w, 0 \} \) as player \( i \)'s risky income and \( c(a_i) = ca_i^3/3 \) as effort cost. \( E_Y \) denotes the expectation operator with respect to \( Y_i \). Let \( u \) be standardized so that \( u(0) = 0 \).

In the base scenario, player \( i \) maximizes

\[
u(w) a_i (1 - a_j) + \frac{u(w)}{2} [a_i a_j + (1 - a_i) (1 - a_j)] - \frac{c}{3} a_i^3 = u(w) \frac{1 + a_i - a_j}{2} - \frac{c}{3} a_i^3, \tag{1}
\]

whereas his objective function in case of a minor crisis reads as

\[
u(w) a_i (1 - a_j) + \frac{u(w)}{2} a_i a_j - \frac{c}{3} a_i^3 = u(w) \frac{a_i (2 - a_j)}{2} - \frac{c}{3} a_i^3, \tag{2}
\]

and in case of a severe crisis as

\[
u(w) \frac{a_i a_j}{2} - \frac{c}{3} a_i^3. \tag{3}
\]

Thus, compared to the benchmark model of Section 5, we replace \( w \) by \( u(w) \). This leads to a downward or an upward shift of the valued winner prize, \( u(w) \), without qualitatively changing our main findings.\(^1\) Whether there is a downward or an upward shift, depends on the curvature of the utility function \( u \).

In other words, introducing risk aversion into our benchmark model with no, a minor and a severe crisis only changes the general level of all equilibrium efforts, but the ranking of equilibrium efforts remains the same and efforts are still strategic substitutes (complements) given a minor crisis (severe crisis) and neither strategic substitutes nor complements without a crisis. Either all equilibrium effort levels are shifted downward in the same way or all are shifted upward. Therefore, risk aversion might explain why the players in the laboratory experiment oversupply effort in all treatments, but it cannot explain our observation on excessively high effort choices in case of a severe crisis compared to the oversupply of effort in the two other scenarios.

Non-Monetary Utility of Winning

As Sheremeta (2010) shows, players’ behavior might be shaped by joy of winning when participating in a tournament. As a consequence, players do not only realize a utility from earning the winner prize, but directly receive some extra value \( \Delta > 0 \) as non-monetary utility of winning or joy of winning. We incorporate this in player \( i \)'s objective function in the three scenarios by replacing (1)–(3) by

\[
(w + \Delta) \frac{1 + a_i - a_j}{2} - \frac{c}{3} a_i^3,
\]

\(^1\)Within a principal-agent model, risk aversion plays an important role as contractual friction that prevents the principal from always implementing first-best effort. This role of risk aversion is absent in our setting with exogenous tournament prizes.
\[
(w + \Delta) \frac{a_i(2 - a_j)}{2} - \frac{c}{3} a_i^3,
\]
and
\[
(w + \Delta) \frac{a_i a_j}{2} - \frac{c}{3} a_i^3,
\]
respectively. Because \( w + \Delta > w \leq u(w) \), contrary to risk aversion, the non-monetary utility of winning unambiguously leads to an upward shift of the players’ equilibrium efforts in the three scenarios. Similar to risk aversion, the ranking between the equilibrium efforts of the three scenarios is the same as in the benchmark model of Section 5, and efforts are still strategic substitutes (complements) in case of a minor crisis (severe crisis) and neither strategic substitutes nor complements in the base scenario without crisis. However, non-monetary utility of winning cannot explain why players excessively oversupply effort in case of a severe crisis compared to the base scenario without crisis and the case of a minor crisis. The non-monetary utility of winning, \( \Delta \), boosts equilibrium efforts in the same way in all scenarios.

**Loss Aversion**

Loss aversion can become particularly important for players should situations arise where their incomes are lost, although they invested a very large effort and, hence, are not responsible for the loss. In the given setting, there are situations in which players lose their incomes due to the termination of the department. In addition, there are situations where both players realize a high output so that the tournament winner is determined by tossing a fair coin. Again, a player is not responsible for losing the winner prize in these circumstances. In this section, we introduce loss aversion into our benchmark model — first, based on an exogenous reference income, and thereafter letting the reference point be formed endogenously.

Suppose that players in the experiment compared their realized incomes (i.e., \( w \) or \( 0 \)) with an exogenously given reference income \( Y^R \in (0, w) \). Following Barberis et al. (2001), DeMeza and Webb (2007), p. 70, and Gill and Stone (2010), we assume that a loss averse player’s preferences can be described by a linearly kinked utility function:

\[
U(Y) = \begin{cases} 
Y + g \cdot (Y - Y^R) & \text{if } Y > Y^R \\
Y + l \cdot (Y - Y^R) & \text{if } Y \leq Y^R
\end{cases}
\]

with \( Y \in \{w, 0\} \) as a player’s realized tournament income. The parameters \( g \) and \( l \) indicate the players’ weighing of relative gains and losses, respectively. We assume \( 0 < g \leq l < 1 \) so that losses are (weakly) more important than gains, but each player mostly cares about his absolute income, which can be directly used for consumption purposes.

Without crisis, player \( i \) maximizes

\[
\left( a_i (1 - a_j) + \frac{a_i a_j}{2} + \frac{(1 - a_i)(1 - a_j)}{2} \right) \left( w + g \left( w - Y^R \right) \right) - \left( a_j (1 - a_i) + \frac{a_j a_i}{2} + \frac{(1 - a_i)(1 - a_j)}{2} \right) \left( w - Y^R - \frac{c}{3} a_i^3 \right).
\]

Rearranging the first-order condition\(^4\) leads to optimal effort \( \tilde{a}_{base}^* \), being described by

\[
\tilde{a}_{base}^* = \sqrt{\left( 1 + g \right) w + (l - g) Y^R \over 2c}.
\]

This effort is larger than in the benchmark model of Section 5 (i.e., \( \tilde{a}_{base}^* > a_{base}^* \)).

---

\(^2\)Preferences based on reference points and loss aversion are described by the prospect theory introduced by Kahneman and Tversky (1979). See Tversky and Kahneman (1991) especially on loss aversion.

\(^3\)As in the benchmark model, the tournament winner will be chosen by a fair coin toss if both players have realized identical outputs.

\(^4\)The second-order condition always holds.
In case of a minor crisis, player $i$’s objective function reads as
\[
\left( a_i (1 - a_j) + \frac{a_i a_j}{2} \right) \left( w + g \left( w - Y^R \right) \right) - \left( a_j (1 - a_i) + \frac{a_i a_j}{2} \right) l Y^R - \frac{c}{3} a_i^3.
\]
The first-order condition yields
\[
\left( w + g \left( w - Y^R \right) \right) - \frac{a_j}{2} [(1 + g) w - (g + l) Y^R] = ca_i^2.
\]
As in the benchmark model, efforts are strategic substitutes. Both players’ best response functions intersect in a unique and symmetric equilibrium \( \left( \tilde{a}_i^*, \tilde{a}_j^* \right) = (\tilde{a}_{\text{minor}}^*, \tilde{a}_{\text{minor}}^*) \) with
\[
\tilde{a}_{\text{minor}}^* = \sqrt{\frac{\left( (1 + g) w - (g + l) Y^R \right)^2 + 16c (w + g (w - Y^R))}{16c^2}} - \frac{(1 + g) w - (g + l) Y^R}{4c}.
\]
The comparison \( \tilde{a}_{\text{minor}}^* > a_{\text{minor}}^* = \frac{\sqrt{16cw + w^2 - w}}{4c} \) yields
\[
\left( \frac{\sqrt{16cw + w^2 - w}}{8c^2} \right) Y^R l + \left( 8c - \frac{\sqrt{16cw + w^2 - w}}{8c^2} \right) (w - Y^R) g > 0,
\]
which is true because
\[
8c > \left( \sqrt{16cw + w^2 - w} \right) \iff 64c^2 > 0.
\]
The finding \( \tilde{a}_{\text{minor}}^* > a_{\text{minor}}^* \) is in line with our experimental findings. When comparing \( \tilde{a}_{\text{minor}}^* \) and \( \tilde{a}_{\text{base}}^* \), we find that
\[
\sqrt{\frac{w + g (w - Y^R)}{c}} - \frac{\tilde{a}_{\text{minor}}^*}{2c} \left( (1 + g) w - (g + l) Y^R \right) > \sqrt{\frac{(1 + g) w - (l - g) Y^R}{2c}} \iff 1 > \tilde{a}_{\text{minor}}^*
\]
is true.

Finally, we have to analyze the outcome given a severe crisis under loss aversion. Player $i$ maximizes
\[
\frac{a_i a_j}{2} \left( w + g \left( w - Y^R \right) \right) - \frac{a_i a_j}{2} l Y^R - \frac{c}{3} a_i^3.
\] (5)
There are two equilibria. In the first one, both players choose zero effort: if one player realizes the low output for sure, termination of the department cannot be precluded any longer so that the other player optimally minimizes effort costs by choosing zero effort as well. The second equilibrium is characterized by the players’ first-order conditions\(^5\)
\[
\frac{a_j}{2} \left( (1 + g) w - (g + l) Y^R \right) = ca_i^2.
\]
Thus, efforts are strategic complements, as in the benchmark model. The equilibrium is symmetric with each player choosing
\[
\tilde{a}_{\text{severe}}^* = \frac{(1 + g) w - (g + l) Y^R}{2c}.
\]
We see that \( \tilde{a}_{\text{severe}}^* \) decreases in $l$, i.e., loss aversion reduces incentives in case of a severe crisis. This finding also holds when switching from a situation without loss aversion to a situation with loss averser players (i.e., \( \frac{\partial \tilde{a}_{\text{severe}}^*}{\partial l} \big|_{l=g=0} < 0 \)). At last, we compare \( \tilde{a}_{\text{severe}}^* \) and \( \tilde{a}_{\text{base}}^* \):
\[
\tilde{a}_{\text{base}}^* > \tilde{a}_{\text{severe}}^* \iff \sqrt{\frac{(1 + g) w + (l - g) Y^R}{2c}} > \frac{(1 + g) w - (g + l) Y^R}{2c} \iff l Y^R > 0,
\]
\(^5\)The second-order conditions are always satisfied.
which is true.

Altogether, introducing loss aversion into the benchmark model preserves the ranking of equilibrium efforts between the three scenarios, which is also in line with the ranking of average efforts in the experiment. However, since loss aversion diminishes incentives in case of a severe crisis, it cannot explain the large oversupply of effort in the laboratory experiment given a severe crisis.

Replacing the exogenous reference income $Y^R$ by an endogenous one will not alter our finding that loss aversion cannot explain our puzzling result under a severe crisis. Analogously to Gill and Stone (2010), we apply the concept of an choice-acclimating personal equilibrium suggested by Köszegi and Rabin (2007) and insert for $Y^R$ in (5) the expected tournament income conditional on players’ effort choices, $wa_i a_j/2$. Thus, player $i$’s objective function now reads as

$$
\frac{a_i a_j}{2} \left( w + g \left( w - \frac{a_i a_j}{2} \right) \right) - \frac{a_i a_j}{2} w \frac{a_i a_j}{2} - \frac{c}{3} a_i^3.
$$

The first-order condition yields$^6$

$$
\frac{1}{2} wa_j \left( 1 + g - (g + l) a_i a_j \right) = ca_i^2.
$$

Together with the first-order condition of player $j$ we obtain a symmetric equilibrium, in which both players choose effort

$$
\tilde{a}_{\text{severe}} = \sqrt{\frac{w^2 (g + 1) (g + l) + c^2 - c}{(g + l) w}}
$$

with

$$
\frac{\partial \tilde{a}_{\text{severe}}}{\partial l} = -\frac{w^2 (g + 1) (g + l) + 2c^2 - 2c \sqrt{w^2 (g + 1) (g + l) + c^2}}{2w (g + l)^2 \sqrt{w^2 (g + 1) (g + l) + c^2}} < 0.
$$

Equilibrium effort in case of a severe crisis under loss aversion with endogenous reference income is, therefore, decreasing in the impact of loss aversion.

**Inequity Aversion**

In their seminal paper, Fehr and Schmidt (1999) introduced the concept of inequity aversion. According to this concept, an individual feels envy if another individual has a higher income. It suffers from compassion when having a higher income than another individual. Altogether, individual $i$’s preferences including inequity aversion can be described by the objective function

$$
Y_i - \alpha \cdot \max\{Y_j - Y_i, 0\} - \beta \cdot \max\{Y_i - Y_j, 0\}
$$

with $Y_i$ as $i$’s income and $Y_j$ as the income of another individual $j$. Thus, the parameter $\alpha$ ($\beta$) measures the strength of envy (compassion). Fehr and Schmidt assume that $\alpha \geq \beta \geq 0$ (i.e., envy is at least as strong as compassion) and $\beta < 1$ (i.e., the direct benefit of a higher monetary income always outweighs a possible disutility of feeling compassion). Finally, we follow the estimates of Fehr and Schmidt (1999, p. 844) and Blanco et al. (2011, p. 331) and assume that $\alpha + \beta > 1$.

In our model, players face a binary income with $Y_i, Y_j \in \{w, 0\}$. Inequity aversion has already been combined with tournaments by Grund and Sliwka (2005). In analogy to their

---

$^6$The second-order condition is always satisfied.
framework, player $i$ maximizes

$$
(1 - \beta) w \left[ a_i (1 - a_j) + \frac{a_i a_j + (1 - a_i)(1 - a_j)}{2} \right] - \alpha w \left[ \frac{a_i a_j + (1 - a_i)(1 - a_j)}{2} + (1 - a_i) a_j \right] - \frac{c}{3} a_i^3 
$$

in the base scenario without crisis. The first line denotes the perceived expected income from winning the tournament but feeling compassion, whereas the second line describes the perceived expected income from losing the tournament and feeling envy. In any case, player $i$ has to bear his efforts costs. The first-order condition shows that each player chooses $\hat{a}_{\text{base}}$ with

$$\frac{w}{2} (1 + \alpha - \beta) = c \hat{a}_{\text{base}}^2. \quad (6)$$

in equilibrium.\(^7\) Hence, as in the Grund-Sliwka model, equilibrium effort increases with envy and decreases with compassion. As $\alpha \geq \beta$ equilibrium effort is (at least weakly) larger than in the benchmark model with risk neutral players but without other-regarding preferences. Efforts are neither strategic substitutes nor strategic complements.

In case of a minor crisis, player $i$ maximizes

$$
(1 - \beta) w \left[ a_i (1 - a_j) + \frac{a_i a_j}{2} \right] - \alpha w \left[ \frac{a_i a_j}{2} + (1 - a_i) a_j \right] - \frac{c}{3} a_i^3. 
$$

The first-order condition yields\(^8\)

$$\frac{w}{2} ((\alpha + \beta - 1) a_j + 2 (1 - \beta)) = c a_j^2. \quad (7)$$

Because $\alpha + \beta > 1$, efforts are strategic complements, which is in sharp contrast to the benchmark model, the settings with risk aversion, non-monetary utility of winning and loss aversion, and the empirical best response functions in the laboratory experiment. Let $(\hat{a}_{i,\text{minor}}, \hat{a}_{j,\text{minor}})$ denote the players’ equilibrium efforts given a minor crisis. Comparing (6) with (7) shows that $\hat{a}_{\text{base}} > \hat{a}_{i,\text{minor}}$, because

$$\frac{w}{2} (1 + \alpha - \beta) > \frac{w}{2} ((\alpha + \beta - 1) a_j + 2 (1 - \beta)) \iff a_j < 1$$

is true. In analogy, we obtain $\hat{a}_{\text{base}} > \hat{a}_{j,\text{minor}}$. This ranking of equilibrium efforts contradicts both, the previous theoretical findings and the observed behavior of the players in the laboratory experiment.

In case of a severe crisis, player $i$’s objective function is given by

$$
(1 - \beta) w \frac{a_i a_j}{2} - \alpha w \frac{a_i a_j}{2} - \frac{c}{3} a_i^3.
$$

Differentiation with respect to $a_i$ leads to

$$
(1 - \beta - \alpha) w \frac{a_j}{2} - c a_j^2.
$$

Because $\alpha + \beta > 1$, efforts are strategic substitutes. The derivative is strictly negative leading to a unique equilibrium that is a corner solution with both players exerting zero effort. Both theoretical results clearly contradict our findings in the laboratory experiment.

\(^7\)It can easily be checked that the second-order condition is satisfied.

\(^8\)Again, the second-order condition holds.
Summary

We incorporated risk aversion, non-monetary utility of winning, loss aversion, or inequity aversion into our benchmark model to check whether their theoretical predictions are a better fit for the observed behavior in the experiment. However, neither set-up helps to explain the large oversupply of effort given a severe crisis compared to the other two scenarios. Risk aversion, loss aversion, and non-monetary utility of winning lead to the same effort ranking and strategic effects (complements/substitutes) as the benchmark model. Thus, the qualitative predictions of the benchmark model in Section 5 are quite robust and also supported by the empirical data. Only the large oversupply of effort in case of a severe crisis cannot be explained by the aforementioned theoretical approaches.
Part III: Instructions for the experiment

Part 1 for the main-baseline-treatment, differences for the main-severe-, the main-minor-, minor-45, and minor-90 treatments are indicated in parentheses

Welcome to this experiment!
You are taking part in an economic decision-making experiment. All decisions are anonymous, none of the other participants learns the identity of someone having made a certain decision. The payment is also anonymous, none of the participants learns how much the others have earned. Please read these instructions carefully. If you have any questions, please look again at the instructions. If you still have any questions, please give us a hand signal.
This experiment consists of several parts. At first, you receive information about the first part. After having finished this part we will provide additional explanations for the next parts.
Overview first part
In this part of the experiment you make only one decision. You will be interacting with another player whose identity will not be revealed. You will not play with the same player for a second time during this experiment.
Your own decision as well as the decision of the other player will influence your total payment. Please think carefully about your decision.
All payments of the experiment are calculated in a fictive currency called taler. The exchange rate is 1 euro for 8 talers.
At the beginning of this part a sum of 75 talers is credited to your experimental account. If you receive any other payments in this part they will be added to the initial amount. At the end of the experiment you will receive your total payment. If you achieve any negative payments they will be subtracted from your initial amount and the remaining sum will be paid.
In this part you make a decision which influences the state you will be in at the end of this part. The player you interact with also makes a decision which influences his state. There are two possible states you might find yourself in. Either you are in State A or in State B. The same is true for the other player. If one player reaches State A and the other player reaches State B, the player in State A receives 100 talers. The player in State B receives zero talers. If both players are in the same state (either both in State A or both State B) a random draw decides which player will receive the payment of 100 talers. (severe-treatment: If at least one player is in State B this part of the experiment ends and both players receive zero talers. If both players reach State A, a random draw decides which player will receive the payment of 100 talers.)
(minor-treatment: If both players reach State A this part of the experiment ends and both players receive zero talers. If one player reaches State A and the other player reaches State B, the player in State A receives 100 talers. If both players reach State A, a random draw decides which player will receive the payment of 100 talers.)
(minor-45-treatment: If both players reach State B this part of the experiment ends and both players receive zero talers. If one player reaches State A and the other player reaches State B, the player in State A receives 100 talers and the player in state B receives 45 talers (minor-90-treatment: 90 talers). If both players reach State A, a random draw decides which player will receive the payment of 100 talers and which the 45 talers (minor-90: 90 talers).)
Course of action in the first part
At the beginning of this part you will be randomly assigned to another player you will play with in this part. Then you will choose a number of points between zero and 100 which can be selected in steps of five. This number indicates the probability of reaching State A. If you choose a score of X, the probability to reach State A is X per cent. If you choose zero, you will reach State B for sure. If you choose 100, you reach State A for sure. The higher the chosen number of points, the higher are the costs for this number. The costs will be subtracted from your payment at the end of this experiment. You find a detailed overview about the costs at the end of this instruction.
The other player also chooses a number between zero and 100 which influences his state.
After both players have made their decisions the software determines the state of both players and the amount of the according payment. For this purpose the states reached by both players will be compared. If one player reaches State A and the other player reaches State B, the player in State A receives 100 talers and the player in State B receives zero talers. If both players are in the same state, a random draw decides which player will receive the payment of 100 talers. (severe-treatment: If at least one player is in State B, both players will receive zero talers. If both players reach State A, the decision who will receive the payment of 100 talers will be made randomly.) (minor-treatment: If both players reach State B, both players receive zero talers. If one player reaches State A and the other player reaches State B, the player in State A receives 100 talers and the player in state B receives zero talers. If both players reach State A, the decision who will receive the payment of 100 talers will be made randomly.) (minor-45-treatment: If both players reach State B, both players receive zero talers. If one player reaches State A and the other player reaches State B, the player in State A receives 100 talers and the player in state B receives 45 talers (minor-90-treatment: 90 talers). If both players reach State A, the decision who will receive the payment of 100 talers and who will receive 45 talers (minor-90 treatment: 90 talers) will be made randomly.) The costs from choosing the number of points will be subtracted from the player’s experimental account in any case. After this, this part of the experiment is finished and we will hand out new instructions.

All payments will be settled with your initial endowment. Please note that you will be informed about your results and the payment of this part at the end of the whole experiment.

Overview:

<table>
<thead>
<tr>
<th>The following scenarios are possible:</th>
<th>Overview about possible payments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>One player is in State A while the other player is in State B.</td>
<td>Player in State A receives 100 talers; Player in State B receives zero talers</td>
</tr>
<tr>
<td>Both players are in State A.</td>
<td>Random draw which player receives 100 talers; the other player receives zero tarter.</td>
</tr>
<tr>
<td>Both players are in State B.</td>
<td>Random draw which player receives 100 talers; the other player receives zero tarter.</td>
</tr>
</tbody>
</table>

(For the severe-treatment:

<table>
<thead>
<tr>
<th>The following scenarios are possible:</th>
<th>Overview about possible payments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>One player is in State A while the other player is in State B.</td>
<td>Both players: 0 taler – costs for the chosen number</td>
</tr>
<tr>
<td>Both players are in State A.</td>
<td>Random draw which player receives 100 talers; the other player receives zero tarter.</td>
</tr>
<tr>
<td>Both players are in State B.</td>
<td>Both players: 0 taler – costs for the chosen number</td>
</tr>
</tbody>
</table>
The following scenarios are possible: Overview about possible payments:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Overview about possible payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>One player is in State A while the other player is in State B.</td>
<td>Player in State A receives 100 talers; costs for the chosen number</td>
</tr>
<tr>
<td>Both players are in State A.</td>
<td>Random draw which player receives 100 talers; the other player receives zero taler. costs for the chosen number</td>
</tr>
<tr>
<td>Both players are in State B.</td>
<td>Both players: 0 taler – costs for the chosen number</td>
</tr>
</tbody>
</table>

The following scenarios are possible: Overview about possible payments:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Overview about possible payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>One player is in State A while the other player is in State B.</td>
<td>Player in State A receives 100 talers; costs for the chosen number</td>
</tr>
<tr>
<td>Both players are in State A.</td>
<td>Random draw which player receives 100 talers; which player receives 45 taler. costs for the chosen number</td>
</tr>
<tr>
<td>Both players are in State B.</td>
<td>Both players: 0 taler – costs for the chosen number</td>
</tr>
</tbody>
</table>

The following scenarios are possible: Overview about possible payments:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Overview about possible payments</th>
</tr>
</thead>
<tbody>
<tr>
<td>One player is in State A while the other player is in State B.</td>
<td>Player in State A receives 100 talers; costs for the chosen number</td>
</tr>
<tr>
<td>Both players are in State A.</td>
<td>Random draw which player receives 100 talers; which player receives 90 taler. costs for the chosen number</td>
</tr>
<tr>
<td>Both players are in State B.</td>
<td>Both players: 0 taler – costs for the chosen number</td>
</tr>
</tbody>
</table>

Overview about the costs for scores between 0 and 100

Please note that the costs are given in talers. Choosing a score of zero leads to costs of zero.

<table>
<thead>
<tr>
<th>number</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>costs</td>
<td>0.01</td>
<td>0.07</td>
<td>0.22</td>
<td>0.53</td>
<td>1.04</td>
<td>1.80</td>
<td>2.86</td>
<td>4.27</td>
<td>6.08</td>
<td>8.33</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>number</th>
<th>55</th>
<th>60</th>
<th>65</th>
<th>70</th>
<th>75</th>
<th>80</th>
<th>85</th>
<th>90</th>
<th>95</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>costs</td>
<td>11.09</td>
<td>14.40</td>
<td>18.31</td>
<td>22.87</td>
<td>28.13</td>
<td>34.13</td>
<td>40.94</td>
<td>48.60</td>
<td>57.16</td>
<td>66.67</td>
</tr>
</tbody>
</table>

Good luck!
Welcome to this experiment!
You are taking part in an economic decision-making experiment. All decisions are anonymous, none of the other participants learns the identity of someone having made a certain decision. The payment is also anonymous, none of the participants learns how much the others have earned. Please read these instructions carefully. If you have any questions, please look again at the instructions. If you still have any questions, please give us a hand signal.

This experiment consists of several parts. At first, you receive information about the first part. After having finished this part we will provide additional explanations for the next parts.

Overview first part
You will be interacting with another player whose identity will not be revealed. You will not play with the same player for a second time during this experiment.
Your own decisions as well as the decisions of the other player will influence your total payment. Please think carefully about your decision.

All payments of the experiment are calculated in a fictive currency called taler. The exchange rate is 1 euro for 8 talers.
At the beginning of this part a sum of 75 talers is credited to your experimental account. If you receive any other payments in this part they will be added to the initial amount. At the end of the experiment you will receive your total payment. If you achieve any negative payments they will be subtracted from your initial amount and the remaining sum will be paid.

In this part you make decisions which influence the state you will be in at the end of this part. The player you interact with also makes decisions which influence his state. There are two possible states you might find yourself in. Either you are in State A or in State B. The same is true for the other player. If one player reaches State A and the other player reaches State B, the player in State A receives 100 talers. The player in State B receives zero talers. If both players are in the same state (either both in State A or both State B) a random draw decides which player will receive the payment of 100 talers. (severe-strategy-treatment: If at least one player is in State B this part of the experiment ends and both players receive zero talers. If both players reach State A, a random draw decides which player will receive the payment of 100 talers.) (minor-strategy-treatment: If both players reach State B this part of the experiment ends and both players receive zero talers. If one player reaches State A and the other player
reaches State B, the player in State A receives 100 talers. If both players reach State A, a random draw decides which player will receive the payment of 100 talers.)

Course of action in the first part

At the beginning of this part you will be randomly assigned to another player you will play with in this part. Then you will choose a number of points between zero and 100 which can be selected in steps of five. This number indicates the probability of reaching State A. If you choose a score of X, the probability to reach State A is X per cent. If you choose zero, you will reach State B for sure. If you choose 100, you reach State A for sure. The higher the chosen number of points, the higher are the costs for this number. The costs will be subtracted from your payment at the end of this experiment. You find a detailed overview about the costs at the end of this instruction.

The other player also chooses a number between zero and 100 which influences his state.

Your decision consists of two parts:

**Conditional Choice**

You have to state for each possible choice of the other player, which number of points you want to select. In other words, you have to decide about the number of points you want to select for each of the 21 possible actions the other player.

Example

- If the other player selects 0 points, I select __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ points.
- If the other player selects 5 points, I select __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ points.
- ...
- If the other player selects 95 points, I select __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ points.
- If the other player selects 100 points, I select __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ points.

The other player also decides about his number of points given each of your possible choices.

**Unconditional Choice**

You simply state the number of points you want to choose.

After both players have made their decisions a random draw determines if you unconditional choice or the unconditional choice of the other player is relevant for the payment. If your choice is relevant, your unconditional choice determines which state you will be in. The conditional choice of the other player, given your unconditional choice, is relevant for him.

If the unconditional choice of the other player was drawn, his unconditional choice determines which state he will be in. Your conditional choice, given the other players unconditional choice, is relevant for you. In other words, you conditional choice will determine in which state you will be in.

In the following, we will give you an example. Note that the numbers used in the example have been chosen randomly and are not a hint which numbers you should select in the experiment. The only purpose of the example is to give you a better idea of the process.

Assume that you selected 100 points as your unconditional choice and the other player selected zero as his unconditional choice. If your unconditional choice is relevant, the 100 points will determine the state you will be in. You will be in State A for sure. The conditional choice of the other player, given that you select 100 points, determines in which state he will be in. If the other player has selected 90 points given that you select 100 points, the probability that he will be in State A is 95%. If he selected 5 points given that you select 100 points, he will be in State A with a probability of 5%. His unconditional choice does not matter because yours and not his unconditional choice was selected by the random draw.

Let us look at another example and assume that the unconditional choice of the other player has been drawn. Now the zero points (his unconditional choice) determine which state he will
be in. The other player will be in State B for sure. Your conditional decision given that the other player selects zero is relevant for you. Assume that you had selected 90 points in this case. You will be in State A with a probability of 90%. If you had selected 5 points given that the other player selects zero points, you would be in State A with a probability of 5%.

Based in the players decisions the software determines the state of both players and the amount of the according payment. For this purpose the states reached by both players will be compared. If one player reaches State A and the other player reaches State B, the player in State A receives 100 talers and the player in State B receives zero talers. If both players are in the same state, a random draw decides which player will receive the payment of 100 talers. (severe-strategy-treatment: If at least one player is in State B, both players will receive zero talers. If both players reach State A, the decision who will receive the payment of 100 talers will be made randomly.) (minor-strategy-treatment: If both players reach State B, both players receive zero talers. If one player reaches State A and the other player reaches State B, the player in State A receives 100 talers and the player in state B receives zero talers. If both players reach State A, the decision who will receive the payment of 100 talers will be made randomly.) The costs from choosing the number of points will be subtracted from the player’s experimental account in any case. After this, this part of the experiment is finished and we will hand out new instructions. All payments will be settled with your initial endowment. Please note that you will be informed about your results and the payment of this part at the end of the whole experiment.

**Overview:**

<table>
<thead>
<tr>
<th>The following scenarios are possible:</th>
<th>Overview about possible payments:</th>
</tr>
</thead>
</table>
| One player is in State A while the other player is in State B. | Player in State A receives 100 talers;  
Player in State B receives zero talers  
– costs for the chosen number |
| Both players are in State A. | Random draw which player receives 100 talers;  
the other player receives zero taler.  
– costs for the chosen number |
| Both players are in State B. | Random draw which player receives 100 talers;  
the other player receives zero taler.  
– costs for the chosen number |

(For the severe-strategy-treatment:

<table>
<thead>
<tr>
<th>The following scenarios are possible:</th>
<th>Overview about possible payments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>One player is in State A while the other player is in State B.</td>
<td>Both players: 0 taler – costs for the chosen number</td>
</tr>
</tbody>
</table>
| Both players are in State A. | Random draw which player receives 100 talers;  
the other player receives zero taler.  
– costs for the chosen number |
| Both players are in State B. | Both players: 0 taler – costs for the chosen number |

(For the minor-strategy-treatment:

<table>
<thead>
<tr>
<th>The following scenarios are possible:</th>
<th>Overview about possible payments:</th>
</tr>
</thead>
</table>
| One player is in State A while the other player is in State B. | Player in State A receives 100 talers;  
Player in State B receives zero talers  
– costs for the chosen number |
| Both players are in State A. | Random draw which player receives 100 talers;  
the other player receives zero taler.  
– costs for the chosen number |
| Both players are in State B. | Both players: 0 taler – costs for the chosen number |
Overview about the costs for scores between 0 and 100

Please note that the costs are given in talers. Choosing a score of zero leads to costs of zero.

<table>
<thead>
<tr>
<th>number</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>costs</td>
<td>0.01</td>
<td>0.07</td>
<td>0.22</td>
<td>0.53</td>
<td>1.04</td>
<td>1.80</td>
<td>2.86</td>
<td>4.27</td>
<td>6.08</td>
<td>8.33</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>number</th>
<th>55</th>
<th>60</th>
<th>65</th>
<th>70</th>
<th>75</th>
<th>80</th>
<th>85</th>
<th>90</th>
<th>95</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>costs</td>
<td>11.09</td>
<td>14.40</td>
<td>18.31</td>
<td>22.87</td>
<td>28.13</td>
<td>34.13</td>
<td>40.94</td>
<td>48.60</td>
<td>57.16</td>
<td>66.67</td>
</tr>
</tbody>
</table>

Figure 5: graphical overview

Good luck!

Part 2 (Elicitation of risk preferences, identical for all treatments)

Please read these instructions carefully. If you have any questions, please look again at the instructions. If you still have any questions, please give us a hand signal.

You will have to make 10 decisions in this part of the experiment. We will show you ten lines on the screen. You will not interact with other players, hence, only your decisions have an impact on your payment.

You will have to make one decision in each line. In each decision you will have to select an alternative A or an alternative B. In each alternative, you will win a certain amount of money with probability X or another, somewhat smaller, amount of money with probability 1-X. Alternative A and alternative B only differ in the amount of money but not in the probabilities. After you have made all ten decisions, a random draw determines which decision will determine your payment. Depending on whether you selected alternative A or alternative B, either alternative A or alternative B will determine your payment. Then, a second random draw decides which amount of money you will receive from the selected alternative. You will receive the higher amount of money with probability X and the lower amount of money with probability 1-X.

You will be informed about the payment at the end of the whole experiment. The payments of all parts will be added up and you will receive your payment.

Good Luck!
Part 3 (Elicitation of loss aversion, identical for all treatments)
Please read these instructions carefully. If you have any questions, please look again at the instructions. If you still have any questions, please give us a hand signal.
In this part, you will decide in six different situations if you want to participate in the game or not. You will not interact with other players, hence, only your decisions have an impact on your payment.
In each of the thereafter presented situations you can win 6 talers with a probability of $\frac{1}{2}$. With probability $\frac{1}{2}$ you will lose X talers. X will change depending on the situation. You will have to decide for each situation if you want to participate in the game or not. If you decline to participate, you will earn zero taler.
After you have made your decision whether to participate or not, one situation will be selected randomly. This situation will be played. If you had decided against participating in the respective situation, you will earn zero taler. Otherwise you will receive 6 talers with probability $\frac{1}{2}$ and lose X talers with probability $\frac{1}{2}$.
You will be informed about the payment at the end of the whole experiment. The payments of all parts will be added up and you will receive your payment.
Good Luck!

Part 4 (Elicitation of joy of winning, only strategy-treatments, following Sheremeta (2010))
Please read these instructions carefully. If you have any questions, please look again at the instructions. If you still have any questions, please give us a hand signal.
You will be interacting with another player in this part whose identity will not be revealed. You have not interacted with this other player in the parts before. You will not interact again with the player in other parts that will follow in this experiment. You will receive an endowment of 30 talers. You can use the endowment to be the winner in a contest. The other player will also receive an endowment of 30 talers.
You can spend your endowment to buy lottery tickets. For each taler you spend, you will receive one lottery ticket. At the end of this part we will randomly draw one lottery ticket from all lottery tickets you and the other player bought. The owner of this lottery ticket is the winner of the contest. Your change to be declared the winner is the amount of lottery tickets you bought divided by the sum of lottery tickets that you and the other player have bought.
Probability to be the winner of the contest

\[
\text{Amount of lottery tickets you bought} \div \text{Sum of all lottery tickets you and the other player bought}
\]

The winner receives no winner prize. If both players buy no lottery tickets, no winner will be declared. After you and the other player have decided how many tickets you want to buy, the winner and the loser of the contest will be announced.
Your payment of this part will be the endowment of 30 taler minus the taler you spend on buying lottery tickets.
Good Luck!

Part 5 (Prisoners Dilemma, only strategy-treatments, following Hermann & Orzen (2008))
Please read these instructions carefully. If you have any questions, please look again at the instructions. If you still have any questions, please give us a hand signal.
You will be interacting with another player in this part whose identity will not be revealed. You have not interacted with this other player in the parts before. You will not interact again with the player in other parts that will follow in this experiment. You will receive an endowment of 10 taler. You can either keep this endowment for yourself or you can transfer it to the other player. If you keep the 10 taler, you will earn 10 taler in this part of the experiment. If you
transfer the 10 taler to the other player, we will double the amount and the other player will receive 20 taler from you. Therefore, there are four possible outcomes.

- You and the other player both keep the 10 taler. In this case you both earn 10 taler.
- You and the other player both transfer the 10 taler. In this case you both earn 20 taler.
- You transfer the 10 taler to the other player and the other player keeps his 10 taler. In this case you will earn zero taler and the other player will earn 30 taler.
- You keep the 10 taler and the other player transfers his 10 taler. In this case you will earn 30 taler and the other player will earn zero taler.

You and the other player have to decide simultaneously whether or not to transfer the 10 taler. However, your decision will consist of two different parts, one conditional choice and one unconditional choice.

**Conditional Choice**
You will be asked to decide whether or not to transfer the 10 taler depending on the other players decision. In other words, you have to decide what you wish to do if the other player has chosen to transfer his 10 taler to you, and what you wish to do if the other player has chosen to keep his 10 taler. The other player also has to make these decisions.

**Unconditional Choice**
You will be simply asked whether or not you wish to transfer your 10 taler or not. The other player will also have to make this decision.

After all decisions have been made, a random draw determines if your unconditional choice or the unconditional choice of the other player will be relevant. If your unconditional choice will be selected, the conditional choice of the other player will be relevant for him (given that you sent the 10 taler or not). If the unconditional choice of the other player will be selected, you conditional choice (given the other players sent the 10 taler or not) will be relevant. The process how the payment will be determined is similar to the process used in part one of this experiment.

**Good Luck!**

**Additional References**


