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Principal-Agent and Peer Relationships in Tournaments

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Abstract

Social preferences explain competitive behavior between agents and reciprocity towards a principal but there is no insight into the interaction of competition and reciprocity. We conducted a laboratory experiment with two treatments to address this issue. In a conventional tournament, an agent receives either the full prize or no prize at all. The other treatment provides the same incentives but the actual payment of an agent equals her expected payment. In both treatments the principal chooses between a low and a high guaranteed payment. Standard economic theory predicts the same effort provision in all situations. Our results show that inequity between agents' payoffs and generosity of the principal determines the effectiveness of tournaments. Moreover, the data reveal that agents focus their preferences either on the principal or on the agent.

JEL-Codes: M52, D03, C90

Keywords**:** Tournament, Envy, Inequity, Agency problem.

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1. Introduction

A tournament is an effective mechanism to induce effort from otherwise unmotivated agents.[1] Tournaments induce particularly high effort among agents with social preferences like envy because of the large spread in prizes.[2] However, agents are sensitive to the generosity of the principal.[3] The use of a tournament to motivate agents may then lead to low effort levels when the principal chooses a low guaranteed payment complementary to the incentive scheme.[4] Yet, there is surprisingly little evidence on the interaction between these two types of social preferences. We investigate in this paper to which extent effort choices in tournaments reflect reciprocity towards the principal and envy towards the other agent.

Our paper contributes to the understanding of behavior in competitive environments and the efficiency aspects of tournaments. According to Lazear and Rosen (1981), it is the spread between wages but not the absolute value of the lowest possible wage that determines the effort of agents. A well-specified wage spread implements the efficient allocation. The absence of low effort choices suggests that this theory, based on the assumption of rational selfish decision makers, provides a sufficient explanation for the behavior in tournaments. Most relevant articles support this point of view (for example, Bull, Schotter and Weigelt, 1987) but previous research provides insufficient information on the impact of social

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[1] For evidence in the field, see Bognanno (2001), Ehrenberg and Bognanno (1990), Eriksson (1999), Knoeber and Thurman (1994), Main, O'Reilly III and Wade, (1993). For laboratory experiments, see Bull, Schotter and Weigelt (1987), Harbring and Irlenbush (2003), Dohmen and Falk (2011), Eriksson, Teyssier and Villeval (2009), Orison, Schotter and Weigelt (2004), Schotter and Weigelt (1992).

[2] Grund and Sliwka (2005) and Demougin and Fluet (2003) show theoretically that agents with social preferences make higher effort in tournaments than agents without. Öncüler and Croson (2005) or Dechenaux, Kovenock and Sheremeta (2012) provide a literature review on overprovision of effort in tournaments. Balafoutas, Kerschbamer and Sutter (2012) and Eisenkopf and Teyssier (2013) specifically relate high contest expenditure to envy.

[3] Fehr and Gächter (2002) and Güth, Schmittberger and Schwarze (1982) focus on negative reciprocity whereas Fehr, Kirchsteiger and Riedl (1998) and Fehr, Kirchler, Weichbold and Gächter (1998) focus on positive reciprocity. Harbring and Irlenbusch (2011) use a tournament setting with sabotage. Gächter and Herrmann (2009) provide a survey on the topic.

[4] Another explanation for low effort choice is collusion. Bandiera, Barankay and Rasul (2005) show that employees collude in a tournament only if they can monitor each other. Harbring and Irlenbusch (2003) observe low effort of some participants in tournaments involving two persons. We find few theoretical studies on collusion in tournament. Chen (2006) and Ishiguro (2004) investigate instruments to stop collusion when it is in place. Amegashie (2006) shows in a repeated setting that collusion should be easier when contestants are equal.

preferences. Agents may adjust their effort supply by comparing their own expected payoffs with those of the principal and the other agents.

We concentrate on two types of social preferences and their interaction: social preferences regarding a peer, i.e. *horizontal* social preferences, and social preferences regarding a principal, i.e. *vertical* social preferences. The strict separation between winners and losers in a tournament can cause envy between the competitors, which in turn leads to highly competitive behavior, i.e., high effort. Second, the generosity of the principal (with respect to unconditional payments) can positively affect the effort level of the competitors. Therefore, our experiment focuses on two aspects of tournaments which have been largely neglected in previous studies. We look at whether the separation between winners and losers intensifies agents' competitive behavior. We also investigate whether the generosity of the principal has an impact on this competitiveness. Moreover, we investigate how these social preferences interact with each other.

In our experiment, subjects are organized in groups of three: one principal and two agents. Principals and agents differ in their payoff function. The principal chooses between an *equal* and an *unequal* contract. Each contract consists of a guaranteed payment and an effort-related prize. The prize is identical in the equal and the unequal contracts but the equal contract contains a higher guaranteed payment to the agent. Standard equilibrium predictions suggest that the equal contract leads to the same expected payoffs for the principal and each agent. The choice of the principal is not revealed. Via the strategy method, agents exert virtual, but costly, effort for both the equal and the unequal contract. The principal's payoff increases in the agents' effort. The experiment is repeated for twenty periods and the groups are identical in all periods. This 'partner matching' allows for reciprocal interaction between the agents over time. In order to avoid wealth effects, we paid only one randomly chosen period.

Each subject participates in one out of two treatments. In the *winner-takes-all* treatment, which resembles a conventional tournament, the prize goes to one person. The winner is determined by the highest performance which depends on the provided effort levels and independent but identically distributed random variables. In the *winner-takes-more* treatment, the prize is distributed among agents. For given effort choices, an agent's share of the prize in the winner-takes-more treatment is identical to the probability of winning the entire prize in the winner-takes-all treatment. This type of competition is similar to a bonus scheme in a firm in which the sum of all bonuses is fixed. Since the winner-takes-more treatment implies a lower financial risk for the agents, we also elicit risk preferences at the beginning of the experiment.

Independent of the treatment, time, and contract choice, a risk-neutral *homo oeconomicus* always provides the same effort. Instead we find that agents provide, on average, higher effort in the winner-takes-all treatment than in the winner-takes-more treatment even though most subjects are risk averse. The disparity in income prevents them from coordinating on a low effort level in the winner-takes-all treatment. Second, agents choose, on average, a higher effort in the equal than in the unequal contract. The situation leading to the highest effort provision is the equal contract in the winner-takes-all treatment while an unequal contract in the winner-takes-more treatment elicits the lowest effort. Therefore, our results show that both generosity of the principal and the strict separation between winners and losers increase the effort level in competition.

Regarding the relationship between horizontal and vertical social preferences we find that subjects who respond in kind to the principal's generosity do so in a similar way in both treatments. The subjects who do not reward the principal's generosity behave differently. In the winner-takes-all treatment, they exert a higher effort level than in the winner-takes-more treatment. This result suggests that agents who have horizontal social preferences do not have vertical social preferences. They focus their social preferences only on one person.

The paper is structured as follows: We present the experimental design and procedures in section 2. The theoretical predictions are shown in section 3 and experimental results in section 4. Section 5 concludes.

2. Experimental design and procedure

2.1. Design

We designed the experiment to identify two determinants of agents' behavior. The experiment tests whether the level of effort depends on *(i)* the generosity of the principal regarding the agents and *(ii)* the distribution of the prize between competitors. We investigate these questions with the main game.[5] A further task elicits the risk preferences of the participants based on the design of Dohmen et al. (2011). Instructions of the main game (Part 2) can be found in appendix A (see Dohmen et al., 2011, for instructions of the elicitation of risk aversion, i.e. Part 1).

Main game

In the main game of the experiment, subjects are divided into groups of three persons: a participant A, B, and C. Participant A is the principal while participants B and C are in the role of the agents. The game is repeated for twenty periods with identical groups. However, payments depend only on the decisions in one randomly chosen period.

Each period consists of two stages. In the first stage, participant A (the principal) chooses between two different contracts. In the second stage, participants B and C (the agents) decide

[5] Because inequity aversion is not always consistent between games (Blanco, Engelmann and Normann, 2011), we designed the main game of our experiment in a way that reveals subjects' horizontal and vertical social preferences by their actions.

about their effort contribution for each contract. At the end of each period, the contract choice, the relevant effort levels and the resulting income of each group members are revealed to all three participants. In both contracts the sum of performance related payments are identical but the fixed payments differ. We distinguish between an *equal* contract and an *unequal* contract.

First stage: contract choice of the principal

The principal's (participant A) task is to make the payment to agents by choosing one of two contracts denoted by k, $k \in \{f, u\}$. Each contract consists of two payments, a guaranteed payment, m_k, and a performance-related prize, M. In theory the equilibrium effort level of risk-neutral agents depends on the distribution of the performance-related payments but not on the absolute value of the guaranteed payment. We kept this prize identical in both contracts such that $M = 16$ points. In the equal contract, we denote the guaranteed payment with $m_f = 17$ points, in the unequal contract, we use $m_u = 13$ points. The agents compete for the prize M.

Second stage: effort choice of the agents

The agents (participants B and C) generate output by providing some virtual effort, e_i. The principal receives this generated output. Each agent chooses an effort level among integers between 0 and 20. It is costly for agents to provide effort. The cost function is convex ($c(e_i) = \frac{e_i^2}{20}$). The distribution of the prize $M = 16$ points differs across the treatments. In both treatments, an agent's expected benefit from the prize increases in her effort choice. This benefit is distorted by a random term, ε_i, which is identically and independently distributed according to the uniform function over the interval $[-8, +8]$ ($\varepsilon_i \sim U[-8, +8]$ witht $E(\varepsilon_i) = 0$).

Winner-takes-all treatment (Tournament)

In the winner-takes-all treatment, the prize is not shared between agents. The winner of the tournament receives all 16 additional points. Participant B wins the tournament against participant C if $e_B + \varepsilon_B > e_c + \varepsilon_c$. Vice versa, participant C wins if $e_B + \varepsilon_B < e_c + \varepsilon_c$. The probability of winning is thus $\Pr(\varepsilon_B - \varepsilon_c > e_c - e_B)$ for participant B and $\Pr(\varepsilon_C - \varepsilon_B > e_B - e_C)$ for participant C. We note p the probability of agent B winning the tournament, $p = \Pr(\varepsilon_B - \varepsilon_c > e_c - e_B)$, and $(1 - p)$ the probability of agent C of winning the tournament, $(1 - p) = \Pr(\varepsilon_C - \varepsilon_B > e_B - e_C)$.

The payoff of agent i in the tournament is:

$$\Pi_i = \begin{cases} m_k + M - c(e_i) & \text{if } e_i + \varepsilon_i > e_j + \varepsilon_j \\ m_k - c(e_i) & \text{if } e_i + \varepsilon_i < e_j + \varepsilon_j \end{cases} \quad i, j \in \{B, C\}, j \neq i \text{ and } k \in \{f, u\} \qquad (1)$$

Winner-takes-more treatment (Proportional payment)

This treatment differs from the winner-takes-all treatment only by the actual distribution of the prize. The 16 points are shared between the two agents. An agent's share equals her probability of winning if she had been assigned to the winner-takes-all treatment. We denote the share of the 16 points received by participant B with γ ($1-\gamma$ for participant C). We have $\gamma = \Pr(\varepsilon_B - \varepsilon_c > e_c - e_B)$ and $1-\gamma = \Pr(\varepsilon_C - \varepsilon_B > e_B - e_C)$. Therefore, γ is equal to agent B's probability to win the prize in the winner-takes-all treatment, p, i.e. $\gamma = p$.

The payoff of participant B in the winner-takes-more treatment is:

$$\Pi_B = m_k + \gamma M - c(e_B) \qquad k \in \{f, u\} \tag{2}$$

The payoff of participant C in the winner-takes-more treatment is:

$$\Pi_C = m_k + (1-\gamma)M - c(e_C) \qquad k \in \{f, u\} \tag{3}$$

It is important to note that the actual payoffs of agents in the winner-takes-more treatment are equal to their expected payoffs in the winner-takes-all treatment. Therefore, the differences between the treatments do not affect the equilibrium predictions if all participants are fully rational, selfish and risk neutral (see next section).

A real-world analogy to this treatment is a bonus pool for employees which is predetermined and independent of the overall performance of the firm. Employees compete to get more out of the pool. It is not our objective to stretch this analogy too far. It is precisely the advantage of experiments that they allow for creating somewhat counterfactual realities to identify behavioral mechanisms.

Benefit of the Principal

Under both treatments, we assume that the benefit of the principal from efforts of agents is linear. Therefore, the principal's payoff is such that:

$$\Pi_A = 50 + e_B + e_C - 2m_k - M \qquad k \in \{f, u\} \tag{4}$$

The principal receives an endowment of 50 points plus the sum of agents' effort levels in his group minus the wages he pays to agents, depending on his contract choice. The principal's endowment and the guaranteed payments to the agents have been chosen to ensure that negative payoffs and concerns about limited liability are irrelevant. Note that the principal's payoff is not affected by the random term, ε_i, in order to exclude risk aversion as a contract choice motif for the principal. A real world equivalence to this random variable is an error in performance measurement which does not affect the underlying production function.

To summarize, Table 1 shows the earning functions of all the participants depending on the contract choice and the treatment group.

[Table 1 here]

Elicitation of risk aversion

The volatility of the payment scheme is not affected by the fixed payment chosen by the principal and we assume that the difference of 4 points in the base salaries of the equal and unequal contracts does not generate significant wealth effects. Hence, risk aversion of agents should not induce different effort levels in the equal and the unequal contracts. Nevertheless, the winner-takes-all and the winner-takes-more treatments differ in terms of risk. The subjects in the winner-takes-more treatment face a smaller risk because they receive the expected payoff rather than either the guaranteed payment plus the prize or the guaranteed payment only as in the winner-takes-all treatment. Therefore, we control for the effect of risk aversion of the subjects on their effort decision.

Risk preferences have been measured for all subjects. We use the method suggested in Dohmen et al. (2011). The subjects had to make 20 decisions between an alternative a and an alternative b. In each of the 20 decisions, alternative b implied a payment of either 0 or 20 points to the subject (50% probability each). Alternative a implied a fixed payment between 0 points (decision 1) and 19 points (decision 20). We measure risk aversion among participants by counting the number of decisions in which a subject has chosen the safe option, i.e., alternative a. A subject who chooses the safe option more often is considered to be more risk averse than a subject with more risky choices. Lazear and Rosen (1981) show that risk averse people reduce their effort with increasing risk. As the volatility of payments is larger in the winner-takes-all treatment, we expect a lower equilibrium effort level in the winner-takes-all treatment.

2.2. Procedure

The experiment was computerized with the software "z-Tree" (U. Fischbacher, 2007). The recruitment was conducted with the software "ORSEE" (B. Greiner, 2004). Subjects were students from the University of Konstanz. All sessions took place at the University of Konstanz. 102 subjects participated in the experiment, 51 in each treatment.

The risk elicitation task was played before the main game task. At first all subjects received identical instructions regarding the risk elicitation task, including comprehension questions. Then all subjects made their decisions in this task. Afterwards the subjects received written instructions for the main game, including comprehension questions. Subjects had been randomly assigned a role as player A, B, or C upon arrival at the lab that they kept for the entire session. All treatments were framed in a neutral manner.

For payment in the risk elicitation task, the computer randomly chose one of the 20 decisions subjects answered and we paid subjects according to their chosen alternative in this specific decision. In the main game task, at the end of the experiment, the computer randomly chose one of the twenty periods played and the decisions in the chosen period determined the payoffs for all members of the group. The payoffs in both tasks were revealed at the end of the entire experiment. The sessions lasted for about 100 minutes. Each experimental point was converted into 0.7 €.[6] Additionally, each subject received a show up fee of 4 €.

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[6] At the time of the experiment, it cost about 1.5 US-Dollar to buy one Euro.

3. Predictions

When agents are selfish (homo oeconomicus), it is straightforward to show that the equilibrium effort level should be identical for every agent in all treatments and contracts. Each agent exerts an effort level of 10 in equilibrium in the both treatments irrespective of the principal's contract choice. Moreover, the effort level should be constant across the periods because the interaction is finite and we pay only one period. Moreover, the equilibrium effort level of 10 coincides with a focal point which should enhance uniform choices across the treatments. In return, such a focal point provides a more conservative identification of treatment differences and the focus of this paper is on these differences.

We now suppose that social preferences are based on the distributive consequences of the actions of principal and agents. In appendix B we provide analytic results on the role of social preferences of agents, captured as inequity aversion in the sense of Fehr and Schmidt (1999). Hence we assess the effect of *horizontal* social preferences by comparing agents' behavior in the winner-takes-all and in the winner-takes-more treatments. For given effort level by the agents both treatments provide the same expected payoffs but the winner-takes-all treatment induces much larger ex-post differences because the entire prize is awarded to one person. Correspondingly, we measure *vertical* social preferences via the comparison of agents' behavior under the equal and unequal contracts. The equal contract leads to equal expected payoffs between the principal and agents when agents exert the *homo oeconomicus* equilibrium effort level, i.e. 10 (in this case the expected payoffs of agents and the principal are equal to 20). Nevertheless, expected payoffs between the principal and agents are different in the unequal contract if agents exert effort level 10 (agents earn, on average, 16 while the principal earns 28).

Vertical social preferences imply the following prediction:

Prediction 1: We expect lower average effort if the principal chooses the unequal contract rather than the equal one.

Once the principal chooses the unequal contract inequity-averse agents provide, ceteris paribus, a lower effort in order to reduce the inequality in payoffs between themselves and the principal. Note that intention-based theories of reciprocity (such as Dufwenberg and Kirchsteiger, 2004, Rabin, 1993 or Falk and Fischbacher, 2006) lead to the same prediction because the choice of the unequal contract is unkind.

This prediction does not suggest any behavioral differences between the treatments. In contrast, the assumption of horizontal social preferences between the agents implies the following prediction

Prediction 2: Under the assumption of horizontal social preferences of agents, we expect lower average effort in the winner-takes-more treatment rather than in the winner-takes-all treatment.

In the winner-take-all treatment envious people invest in precautionary effort to avoid being worse off than their competitor. The winner-takes-more treatment differs from the winner-takes-all treatment with respect to the ex-post inequality between agents' payoffs. With horizontal social preferences multiple symmetric equilibria exist because equalizing agents' payoffs by choosing the same effort is possible in this treatment while it is not in the winner-takes-all treatment.[7] Because of horizontal social preferences and the Pareto-dominance of low effort equilibria in the winner-takes-more treatment, we expect the effort level in the winner-takes-more treatment to be lower than those in the winner-takes-all treatment,

[7] In the winner-takes-more treatment, the lower bound of the range of equilibrium effort levels is decreasing in agents' compassion regarding the other agent and the higher bound is increasing in agents' envy regarding the other agent. Envy toward the principal reduces the higher bound of the range of equilibrium effort levels. Because of the economy on effort costs, lower equilibrium effort levels Pareto-dominate high equilibrium effort levels when we only consider agents' payoffs.

whatever the contract choice of the principal. This second prediction resembles the predictions in Grund and Sliwka (2005).

Because of the multiple equilibria and the resulting coordination problem between agents, the effort levels are likely to change over time. For example, if one agent observes that the other agent responds to unequal contract with lower effort she might do so as well. This argument suggests that the treatment differences become more prominent over time.

Note also that the consideration of risk preferences alters prediction 2. As Lazear and Rosen (1981) have shown risk-averse agents choose lower effort levels in a tournament. In the winner-takes-more treatment the risk is much lower than in the winner-takes-all treatment. Selfish, risk-averse agents would therefore choose lower effort levels in the latter treatment.

We have analyzed horizontal and vertical social preferences separately. Existing theories of social preferences do not suggest a clear prediction regarding the interaction between both types of preferences. The tournament setting provides an interesting setup for analyzing this interaction. Any retaliation against unequal contract choices of the principal implies a positive externality towards the other agent. Likewise, any reward for an equal contract decreases the expected payoff of the other agent. In this context we can test for specific relationships between vertical and horizontal social preferences.

- Envy towards the other agent might mitigate the behavioral impact of envy towards the principal. If this relationship holds then the differences in effort choice between equal und unequal contracts should be larger in the winner-takes more treatment because the actual payoff-differences between the agents are smaller in this treatment.
- An unequal contract choice of the principal decreases envy (or increases solidarity) between agents. In this case we should observe reversed treatment differences. The

differences in effort choice between equal und unequal contracts should be larger in the winner-takes all treatment.

- Horizontal and vertical social preferences are independent phenomena. If this prediction holds we should observe no treatment differences in the effort gap between unequal and equal contracts.

4. Results

In our empirical analysis we look at first at the behavior of the agents, in particular the effort provision. We then investigate the relationship between the horizontal and vertical social preferences among the agents. Finally we look at the behavior of the principal and the distribution of payoffs between the principal and the agents.

4.1. Effort level

Table 2 displays the mean and standard deviation of effort contributions for the different contracts (equal and unequal) and treatments (winner-takes-all and winner-takes-more).

[Table 2 here]

Predictions from standard economic theory only hold for equal contracts in the winner-takes-more. In both treatments, the average effort across all periods is significantly lower in case of the unequal contract than in case of the equal contract (Wilcoxon signed rank test, $z=3.822$, $p<0.01$, $z= 3.800$, $p<0.01$, respectively for winner-takes-all and winner-takes-more treatments). This result supports our first prediction regarding vertical social preferences.[8] Choosing the unequal contract leads to lower average effort.

[8] One could argue that the average effort is significantly higher in the equal contract than in the unequal contract because agents want to avoid losses and then simply exert effort that causes costs approximately equal to the loser price. However, this explanation is ruled out by our data as the average effort in the winner-takes-all treatment is largely lower than the effort guarantying no losses to agents in both the equal and the unequal

Second, the average effort across all periods in the winner-takes-all treatment is significantly higher than in the winner-takes-more treatment, independent of the contract (Mann-Whitney test, $z= 1.993$, $p<0.05$, $z= 1.742$, $p<0.10$, respectively for the unequal and the equal contracts). Again, this result goes in favour of our behavioural expectations (prediction 2). Effort levels exerted by agents are lower when the prize is shared between agents. This result is particularly strong because most agents are risk averse (see appendix C). In the winner-takes-all treatment, risk averse agents should provide lower effort than risk neutral agents.[9] Therefore, generosity of the principal and inequality between ex-post payoffs prevent agents from exerting low effort.

Figure 1 shows the evolution of effort levels over time. While effort levels do not differ initially across the treatments they decline more strongly in the winner-takes-more treatment. In this treatment horizontal social preferences give scope for multiple equilibria. This result suggests that the agents require time to coordinate on the more efficient equilibria.

[Figure 1 here]

Although agents exert lower effort in the unequal contract, they provide higher effort in the unequal winner-takes-all than in the equal winner-takes-more (Mann-Whitney test, $z= 2.110$, $p<0.05$). At the aggregate level, this result suggests that horizontal social preferences are stronger than vertical ones. The lowest average effort is observed in the unequal winner-takes-more and the highest average effort in the equal winner-takes-all. The standard deviation of efforts being not different between contracts and treatments, the only relevant measure to classify the efficiency of contracts and treatments is the average effort.

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contracts. The effort guarantying no losses to agents is equal to 18.4 and 16.1 respectively in the equal and unequal contracts.

[9] In total, i.e. including subjects playing as a principal in the main game, the subjects chose around 10.6 times the safe option. 33.3% of the subjects are risk neutral, 19.6% are risk lover and 47.1% are risk averse. The distribution of subjects for each decision is represented in appendix C. For the large majority of subjects (98 out of 108), there is a single value where they switch from the lottery to the fixed payment.

Tobit regressions clustered on groups in Table 3 confirm our results. Model (1) provides the impact of the two central explanatory variables, i.e., the treatment and the type of the contract and their interaction. Model (2) controls for the observed behavior of the partner and the choice of the principal in the previous period. Model (3) takes the observed behavior of the partner and the choices of the principal in the two previous periods. All models take the evolution of effort choice across the periods and risk preferences of the subjects into account. Risk preferences are measured through the number of safe choices in the risk elicitation task.

[Table 3 here]

The results on the effect of the principal's generosity and of the distribution of payments in competition are reinforced by this econometric analysis, in particular if one takes the dynamics of the experiment across the periods into account. According to model (1), the effort exerted by agents is lower in the unequal contract by 1.3 compared to the equal contract. In the winner-takes-all treatment, the effort is higher by 1.9 compared to the winner-takes-more treatment, but this effect is not significant.

When adding observed behavior of others at the previous period, we note that the treatment effect is significant (*p-value = 0.054*). There is a significant positive impact of the partner's observed effort in the previous period. Model (2) shows that for an increase of 1 of the partner's effort in the previous period, the agent increases his effort by 0.5. This result suggests some reciprocity between subjects. We also observe that agents' effort is not influenced by the principal's choice of contract in the previous period.

Finally, model (3) includes behavior of the two previous periods as explanatory variables. The effect of the partner's observed effort is lower in the winner-takes-all treatment than in the winner-takes-more treatment. Coordination between agents in the winner-takes-all treatment is less prevalent than in the winner-takes-more treatment. All regressions also show that risk aversion does not significantly affect the effort decision of agents.[10]

From the analysis of agents' effort, we conclude that it is easier for agents to reach a low effort level if the principal is unequal and when the prize is shared between agents in function of their effort provision, i.e., in the winner-takes-more treatment. These results confirm our behavioral predictions.

4.2. Interaction of preferences

We investigate now whether social preferences between agents are related with social preferences towards the principal. The results documented in Table 3 reveal no significant interaction between the principal's generosity and the treatment. These results suggest that horizontal and vertical preferences are independent phenomena.

We now explore this independence in greater detail. We classify agents in order to identify types. The classification of agents is based on the average of the difference between their effort in the equal contract and their effort in the unequal contract and on its standard deviation, i.e., on the reaction of agents to the principal's generosity. We apply the hierarchical Ward method (Ward, 1963), as it is used in Eriksson et al. (2009). This method is based on the minimization of the intra-group variance in effort choice. We identify three types of subjects. Subjects from the first type do not react to the principal's generosity. We call them "No Vertical SP" with SP meaning Social Preferences. Subjects from the second type react to the principal's fairness and are stable over time while subjects from the third type

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[10] We added the cross variable treatment and risk aversion in the regressions but its effect is not significant suggesting that the effect of risk aversion is not more significant in one treatment than in the other one. Moreover, we ran separated regressions for the winner-takes-all and the winner-takes-more treatments and the effect of risk aversion is not significant in both cases.

react to the principal's fairness but are unstable over time; they are called "Stable Vertical SP" and "Unstable Vertical SP" respectively.[11]

[Table 4 here]

Regarding the distribution of subjects, we observe that about 50% of the agents take the generosity of the principal into account. Figure 2 shows the average effort for agents with and without vertical social preferences in both contracts and treatments.[12]

[Figure 2 here]

Agents who do not react to the generosity of the principal do so in different ways in the different treatments. In the winner-takes-all treatment, these agents exert an average effort of about 9.3 while in the winner-takes-more treatment, their effort level is around 5.7. These average effort levels are significantly different in both contracts (Mann-Whitney test, $z=8.696$, $p<0.01$ in the unequal contract and $z=8.695$, $p<0.01$ in the equal contract). Hence, agents who do not care about the payoff of the principal exert a significantly higher effort if the prize is fully rewarded to one person rather than if it is shared between the agents. Theoretically, this behavior corresponds to the behavior of agents who have horizontal social preferences. Therefore, at the aggregate level, we conclude that agents who are eager to beat the other agent in the group are not affected by the principal's situation.

In contrary, agents in the category stable or unstable Vertical SP, i.e., agents who react to the principal's generosity, exert about the same effort in both treatments (Mann-Whitney test, $z=0.540$, $p=0.5892$ in the unequal contract and $z=0.221$, $p=0.8247$ in the equal contract). Agents who are affected by the principal's generosity, i.e., agents with vertical social preferences, do not behave differently depending on the distribution of payments in the competition. These agents do not feel envious regarding the other agent in the group.

[11] One subject in the tournament and one subject in the proportional payment have been excluded as they do not fit into any category.

[12] For sake of simplicity of the figure, we pulled together stable IA principal and non-stable IA principal agents as the data are not different for these two types.

To summarize, the data do not just show no meaningful interaction between vertical and horizontal social preferences. Both preferences seem to be very distinct: Agents who do not react to the principal's generosity react to the distribution of payments in competition and agents who react to the principal's generosity do not react to this distribution. This analysis shows that subjects focus their social preferences on one person. Either they are envious towards the principal or they are envious towards their competitor.

4.3. Principal's behavior

Although agents respond in kind to a generous principal, most principals prefer the unequal contract to the equal contract. The equal contract is chosen by the principal in only 24% of cases in the winner-takes-all treatment and in 21% of cases in the winner-takes-more treatment. There is no systematic variation in the provision of equal contracts over time (see Figure 3).

[Figure 3 here]

We conducted a probit regression to understand what explains the principal's choice of contract, equal or unequal. Table 5 shows the marginal coefficients of a probit regression estimating the choice of the equal contract by the principal based on the impact of the period, the treatment, the effective average effort of both agents in the previous period and the interaction between effort and treatment respecting the actual contract in the previous period.

[Table 5 here]

The results of the regression show that the choice of the principal to offer the equal or the unequal contract depends on the effort exerted by agents at the previous period. When the average effort of agents at the previous period increases by 1, the likelihood of the principal to choose the equal contract at the following period is increased by 3.5%. Nevertheless, this positive effect of average efforts at the previous period is limited when the principal has chosen the unequal contract at the previous period.

4.4. Profits of principals and agents

Table 6 shows the potential profit of principals and agents depending on the contract and the treatment.

[Table 6 here]

The average profits reflect the effort level decisions of agents. Nevertheless, although agents always provide a higher effort in the equal contract, the principal earns significantly lower average profits across all periods in the equal contract compared to the unequal contract (Wilcoxon signed rank test, $z=3.527$, $p<0.01$, $z= 3.337$, $p<0.01$, respectively for winner-takes-all and winner-takes-more treatments): The sum of payments paid by the principal to the agents in the equal contract is higher than the benefit from a higher effort provision by the agents. On average across all periods, agents are better off in the equal contract (Wilcoxon signed rank test, $z=4.898$, $p<0.01$, $z= 4.932$, $p<0.01$, respectively for winner-takes-all and winner-takes-more treatments). Moreover, although the results are not significant, we observe that, in both contracts, the average profits across all periods of the principal are always higher in the winner-takes-all treatment than in the winner-takes-more treatment (Mann-Whitney test, $z= 1.498$, $p=0.134$, $z= 1.430$, $p=0.153$, respectively for the unequal and the equal contracts). Therefore, the principal seems to benefit from the inequality in outcomes imposed on the agents in the winner-takes-all treatment. The difference between agents' profits in the two treatments is small but significant (Mann-Whitney test, $z= 2.073$, $p<0.05$, $z= 1.650$, $p<0.10$, respectively for the unequal and the equal contracts). Figure 4 presents the evolution over periods of the average of effective profits of principals and agents in each contract and each treatment.

[Figure 4 here]

This analysis emphasizes again that fully distributing the prize to one person prevents agents from exerting low effort. Under high inequality between ex-post payoffs, agents do not manage to reduce their effort to get higher profits. Thus, the principal gains from this behavior in the winner-takes-all treatment.

5. Conclusion

We examined the effect of the principal's generosity and of the strict separation between winners and losers on effort provision in tournaments. We devised an experiment which properly controls for the impact of social preferences in tournaments where agents are confronted to their competitor's decisions and also to the principal's choices. We distinguished social preferences regarding a peer from social preferences regarding a decision-maker which we called horizontal and vertical social preferences respectively.

We observe that effort levels depend on the principal's generosity and inequity in outcomes between agents. A principal who is not generous favors coordination of agents on low efforts. A low inequality in ex-post payoffs, i.e., if the prize is shared between the agents, has the same effect. Principals who use tournaments with high inequality in ex-post payoffs benefit from the envy of their agents regarding their competitor.

Additionally, we find that agents who react to the generosity of the principal exert on average identical effort levels in both treatments. Meanwhile those agents who do not react to the generosity of the principal exert on average higher effort levels in the winner-takes-all treatment rather than in the winner-takes-more treatment. Our experimental results therefore suggest that vertical and horizontal social preferences are independent phenomena. Agents apparently focus their comparison either on the competitor or on the other agent. Arguably the provision of competitive incentives encourages such a selective approach because agents cannot be cooperative towards the other agent and reciprocal towards the principal at the same time. Higher effort is harmful for the competitor but beneficial for the principal while lower effort increases the expected payoffs of the other agent and decreases those of the principal.

Appendix

Appendix A – Instructions

Instructions for Participants in the Winner-takes-More-Treatment
(*Text in italics shows the different instructions for participants in the Winner-Takes-All-Treatments*)

This experiment has two parts. These are the instructions for the second part. Depending on the decisions of you and the other participants in this experiment, you may receive additional payments.

Therefore we recommend to study these instructions in detail. If you have any question, please contact us **before** the experiment starts. All participants receive the same instructions.

You must not talk with other participants during the experiment. Otherwise you are excluded from the experiment and receive no payments at all.

During the experiment we talk about points instead of Euros. At first, all your revenues are calculated in points. We exchange the final score into Euros at the end of the experiment. The exchange rate is

1 Point = 70 Eurocents.

At the end of this experiment, you receive payments for all your received points in both parts of the experiment **and** the 4 Euros for participation in **cash**.

Now we explain the procedure of the experiment on the following pages in detail.

Part 2 of the Experiment

1. Design of the experiment

In this part of the experiment you and two other persons form a group. Each group contains a participant A, a participant B and a participant C. The assignment to the groups is random and anonymous, You will see on the screen if you are a participant A, B or C.

This part of the experiment continues for 20 periods. During all periods you remain in the same group and in the same role (A, B, or C). In each period you make a decision which can influence your payoff. At the end of the experiment, the computer chooses randomly one period. We will pay you for this randomly selected period. All other periods are payoff irrelevant.

Each period is divided into two phases:

1. Participant A chooses between two payments, 1 or 2, for participants B and C. In return, A receives contributions of B and C which are conditioned for each payment. At the end of the period, B and C will learn which payment has been chosen by A.
2. Now, participants B and C make their decisions for each possible payment.
   - At first, B and C choose simultaneously a contribution in case that A has opted for payment 1.
   - Then B and C choose simultaneously a contribution in case that A has opted for payment 2.

At the end of the experiment the choice of A and the relevant contributions of B and C are revealed to all participants.

Now, we will explain the relationship between payment, contributions and the resulting earnings at the end of the period in detail.

2. *The decision of participant A*

Participant A has an endowment of 50 points and chooses between payments 1 and 2.

- Payment 1:
  - B and C receive 13 points each.
  - 16 additional points will be distributed between B and C. *16 additional points will be given either to B or C. The other participant does not receive any additional points.*
  - Participants B and C increase their share in these 16 points by increasing their contribution to A. If, for example, B contributes more than C she will also earn more points. Note that a higher contribution also implies higher costs. *Participants B and C increase their probability of getting these 16 points by increasing their contribution to A. If, for example, B contributes more than C she is more likely to get these points. Note that a higher contribution also implies higher costs.*
- Payment 2:
  - B and C receive 13 points each.
  - 24 additional points will be distributed between B and C. Out of these 24 points each participant receives at least 4 points. *24 additional points will be given to B and C. One participant receives 20 additional points, the other participant receives 4 additional points.*
  - Participants B and C increase their share in these 24 points by increasing their contribution to A. If, for example, C contributes more than B she will also earn more points. Note that a higher contribution also implies higher costs. *Participants B and C increase their probability of getting 16 points more by increasing their contribution to A. If, for example, B contributes more than C*

she is more likely to get these points. Note that a higher contribution also implies higher costs.

The costs of a contribution and the sharing rules for *(probabilities of receiving)* the 16 points are identical for both payments (see below). When making her decision, participant A will see the following screen. Participant A chooses between payments 1 and 2 by typing the relevant number in the field. The decision is irreversible once A has clicked the OK button.

3. *The decisions of participants B and C*

In phase 2, participants B and C make two decisions each. These decisions differ only with respect to the subsequent payments. Otherwise the following explanation hold for both decisions in the same way. In the end earnings and costs will be realized only for the payment chosen by participant A.

- Participants B und C choose an individual contribution between 0 and 20 (only integers are possible).
- These contributions are transferred to participant A.
- A contribution implies a cost which has to be borne by the contributing participant. For example, a contribution of 8 points costs 3.20 points. A contribution of 12 points costs 7.20 points. Table 1 provides an overview over the contribution and their associated costs.

Table 1: The costs of contribution to A for the contributing participant (B or C)

Contribution	Cost	Contribution	Cost
0	0.00	10	5.00
1	0.05	11	6.05
2	0.20	12	7.20
3	0.45	13	8.45
4	0.80	14	9.80
5	1.25	15	11.25
6	1.80	16	12.80
7	2.45	17	14.45
8	3.20	18	16.20
9	4.05	19	18.05
		20	20.00

- Via a higher contribution, a participant can increase her share in the 16 points. *Via a higher contribution, a participant can increase her probability of getting the 16 points.* Table 2 shows the shares.

  Example 1: Participant C contributes 5 points more than participant B (In table 2: Contribution B – Contribution C = -5).In this case, B's share is 23.63%. The share of C is 76.37% or 12.22 points. *In this case, B's probability is 23.63%. The probability of C is 76.37%.*

  Example 2: Participant B contributes 3 points more than participant C (In table 2: Contribution B – Contribution C = -5).In this case, B's share is 66.99% or 10.72 points. The share of C is 33.01% or 5.28 points. *In this case, B's probability is 66.99%. The probability of C is 33.01%.*

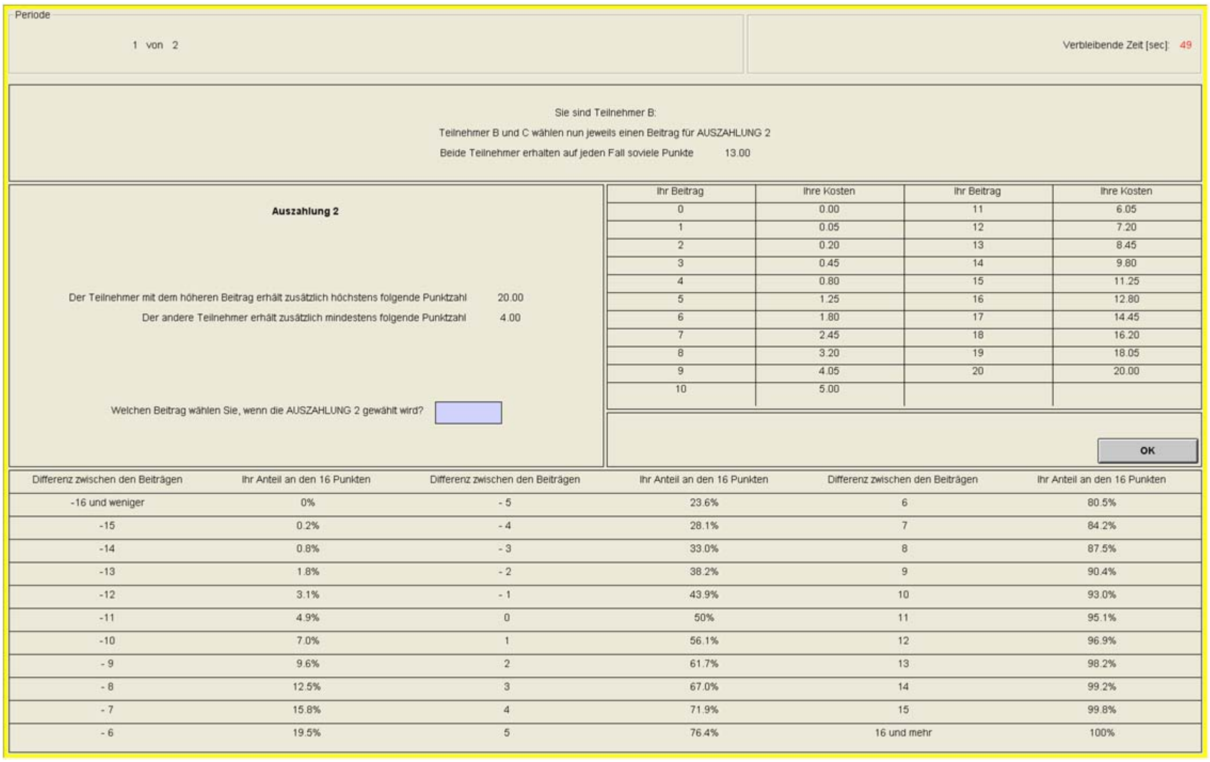
Table 2: The difference in contributions between participants B and C and the resulting share of the distributed 16 points.

Table 2: The difference in contributions between participants B and C and the resulting probability of getting 16 points.

Differences in the contributions	**Share of the 16 points** ***Probability of getting 16 points***		**Differences in the contributions**	**Share of the 16 points** ***Probability of getting 16 points***	
Contribution B – Contribution C	*Participant B*	*Participant C*	*Contribution B – Contribution C*	*Participant B*	*Participant C*
-16 and less	0.00%	100.00%	0	50.00%	50.00%
-15	0.20%	99.80%	1	56.05%	43.95%
-14	0.78%	99.22%	2	61.72%	38.28%
-13	1.76%	98.24%	3	66.99%	33.01%
-12	3.13%	96.88%	4	71.88%	28.13%
-11	4.88%	95.12%	5	76.37%	23.63%
-10	7.03%	92.97%	6	80.47%	19.53%
-9	9.57%	90.43%	7	84.18%	15.82%
-8	12.50%	87.50%	8	87.50%	12.50%
-7	15.82%	84.18%	9	90.43%	9.57%
-6	19.53%	80.47%	10	92.97%	7.03%
-5	23.63%	76.37%	11	95.12%	4.88%
-4	28.13%	71.88%	12	96.88%	3.13%
-3	33.01%	66.99%	13	98.24%	1.76%
-2	38.28%	61.72%	14	99.22%	0.78%
-1	43.95%	56.05%	15	99.80%	0.20%
			16 and more	100.00%	0.00%

- On the computer screen the decision situation looks like this for B and C. At first, each participant decides about a contribution for payment 1. On the next screen each of them decides about a contribution for payment 2. B and C make each decision simultaneously.

The following screenshot shows the decision situation of B and C for payment 2. On top to the left, you will find the field in which you state your contribution. To the right, you see how much a contribution costs. The lower half of the screen shows the shares of the 16 points *(the probabilities of getting 16 points)*, depending on how much the contributions differ between the two participants.



Periode

1 von 2

Verbleibende Zeit [sec]: 49

Sie sind Teilnehmer B:

Teilnehmer B und C wählen nun jeweils einen Beitrag für AUSZAHLUNG 2

Beide Teilnehmer erhalten auf jeden Fall soviele Punkte 13.00

Auszahlung 2

Der Teilnehmer mit dem höheren Beitrag erhält zusätzlich höchstens folgende Punktzahl 20.00

Der andere Teilnehmer erhält zusätzlich mindestens folgende Punktzahl 4.00

Welchen Beitrag wählen Sie, wenn die AUSZAHLUNG 2 gewählt wird?

Ihr Beitrag	Ihre Kosten	Ihr Beitrag	Ihre Kosten
0	0.00	11	6.05
1	0.05	12	7.20
2	0.20	13	8.45
3	0.45	14	9.80
4	0.80	15	11.25
5	1.25	16	12.80
6	1.80	17	14.45
7	2.45	18	16.20
8	3.20	19	18.05
9	4.05	20	20.00
10	5.00		

OK

Differenz zwischen den Beiträgen	Ihr Anteil an den 16 Punkten	Differenz zwischen den Beiträgen	Ihr Anteil an den 16 Punkten	Differenz zwischen den Beiträgen	Ihr Anteil an den 16 Punkten
-16 und weniger	0%	- 5	23.6%	6	80.5%
-15	0.2%	- 4	28.1%	7	84.2%
-14	0.8%	- 3	33.0%	8	87.5%
-13	1.8%	- 2	38.2%	9	90.4%
-12	3.1%	- 1	43.9%	10	93.0%
-11	4.9%	0	50%	11	95.1%
-10	7.0%	1	56.1%	12	96.9%
- 9	9.6%	2	61.7%	13	98.2%
- 8	12.5%	3	67.0%	14	99.2%
- 7	15.8%	4	71.9%	15	99.8%
- 6	19.5%	5	76.4%	16 und mehr	100%

4. The determination of revenues and costs for each participant.

This experiment has 20 periods. Only one randomly chosen period will be paid. In this period the following aspects are relevant for the final payments,

- The payment chosen by participant A (1 or 2)
- The contributions of B and C for this payment.
- The costs of these contributions.

The contributions for the payment which has not been selected are irrelevant.

Costs and revenues of participant A:

Participant A has an endowment of 50 points at the beginning of the period. Additionally she receives the contributions of B and C. Participant A has to make the assigned payments to B and C.

Costs and revenues of participant B and C:

Participants B and C each receive a payment from A. In payment 1, 16 points are distributed between B and C. In payment 2, 24 points are distributed between B and C, but each participant receives at least 4 of these 24 points. The size of the additional payment depends on the difference in the contributions. The costs of the contribution are withdrawn from these revenues.

Participants B and C each receive a payment from A.In payment 1, either B or C get 16 points. In payment 2, one participant gets 24 points and the other gets 4 points. The probability of getting the higher payment depends on the difference in the contributions. The costs of the contribution are withdrawn from these revenues.

Example 3 for a random period:

Participant A selects payment 1. Participant B chooses a contribution of 11 points for payment 1 and 9 points for payment 2. Participant C chooses a contribution of 10 points for payment 1 and 13 points for payment 2. The contributions for payment 2 are irrelevant.

In payment 1, B contributes 1 point more than C. Her share is therefore 56.05% (8.97 points). The share of C is 43.95% (7.03 points, see Table 2). *In payment 1, B contributes 1 point more than C. Her probability of getting 16 points is therefore 56.05%. The probability of C is 43.95% (see Table 2).*

The resulting revenues for A are:

Endowment	50 points
Contribution B	11 points
Contribution C	10 points
Sum	71 points

The costs of A for payment 1 are:

Guaranteed Payment to B	13 points
Guaranteed Payment to C	13 points
Additional Payment to B	8.97 points *16 or 0 points*
Additional Payment to C	7.03 points *16 or 0 points*
Sum	42 points

Therefore the final profit of participant A is 29 points (71-42).

The revenues for B are:

Guaranteed Payment from A	13 points
Additional Payment (56,05% from 16 points)	8.97 points
Sum	21.97 points

Guaranteed Payment from A	*13 points*
Additional Payment of 16 points (56,05% probability)	*16 points*
Sum	*13 or 29 points*

The costs of participant B are the costs of her own contribution (11), i.e. 6.05 points (see table 1)

Therefore the final profit of participant B is 15.92 points (21.97-6.05).
Therefore the final profit of participant B is either 6.95 points (13-6.05, with a probability of 43.95%) or 22.95 points (29-6.05, with a probability of 56.05%).

The revenues for C are:

Guaranteed Payment from A	13 points
Additional Payment (43.95% from 16 points)	7.03 points
Sum	20.03 points

Guaranteed Payment from A	*13 points*
Additional Payment of 16 points (43.95% probability)	*16 points*
Sum	*13 or 29 points*

The costs of participant B are the costs of her own contribution (10), i.e. 5 points (see table 1)

Therefore the final profit of participant C is 15.03 points (20.03-5).
Therefore the final profit of participant B is either 8 points (13-5, with a probability of 56.05%) or 24 points (29-5, with a probability of 43.95%).

Example 4 for a random period:

Participant A selects payment 2. Participant B chooses a contribution of 8 points for payment 1 and 5 points for payment 2. Participant C chooses a contribution of 7 points for payment 1 and 7 points for payment 2. The contributions for payment 2 are irrelevant.

In payment 1, B contributes 2 point less than C. Her share is therefore 38.28% (6.12 points). The share of C is 61.72% (9.88 points, see Table 2). *In payment 1, B contributes 2 points less than C. Her probability of getting 16 points is therefore 38.28%. The probability of C is 61.72% (see Table 2).*

The resulting revenues for A are:

Endowment	50 points
Contribution B	5 points
Contribution C	7 points
Sum	62 points

The costs of A for payment 2 are:

Guaranteed Payment to B	13	points
Guaranteed Payment to C	13	points
Additional Guaranteed Payment to B	4	points
Additional Guaranteed Payment to C	4	points
Additional Payment to B	6.12	points
	16 or 0 points	
Additional Payment to C	9.88	points
	16 or 0 points	
Sum	50	points

Therefore the final profit of participant A is 12 points (62-50).

The revenues for B are:

Guaranteed Payment from A	13	points
Additional Guaranteed Payment from A	4	points
Additional Payment (38.28% from 16 points)	6.12	points
Sum	23.12 points	

Guaranteed Payment from A	*13*	*points*
Additional Guaranteed Payment from A	*4*	*points*
Additional Payment of 16 points (38.28% probability)	*16*	*points*
Sum	*17 or 33 points*	

The costs of participant B are the costs of her own contribution (5), i.e. 1.25 points (see table 1)

Therefore the final profit of participant B is 21.87 points (23.12-1.25).

Therefore the final profit of participant B is either 15.75 points (17-1.25, with a probability of 38.28%) or 31.75 points (33-1.25, with a probability of 61.72%).

The revenues for C are:

Additional Guaranteed Payment from A	4 points
Guaranteed Payment from A	13 points
Additional Payment (61.72% from 16 points)	9.88 points
Sum	26.88 points

Guaranteed Payment from A	*13 points*
Additional Guaranteed Payment from A	*4 points*
Additional Payment of 16 points (61.72% probability)	*16 points*
Sum	*17 or 33 points*

The costs of participant C are the costs of her own contribution (7), i.e. 2.45 points (see table 1)

Therefore the final profit of participant C is 24.43 points (26.88-2.45).
Therefore the final profit of participant B is either 14.55 points (17-2.45, with a probability of 38.28%) or 30.55 points (33-2.45, with a probability of 61.72%).

Questionnaire

Please answer the questions carefully and raise your finger if you have a question or you have answered all questions. We use these questions to ensure that all participants understand the experiment in the same way.

Question 1:

Please mark if the following statements are correct or not

	Ja	Nein
Participant A chooses the payments for B and C.		
In each period the composition of a group changes.		
If Participant B chooses a higher contribution than C she will always get more points from A.		
Each participant receives the average of her earnings from all periods.		
The revenues of A increase in the contributions of B and C		
The payments of A and B remain the same, if B and C both choose a contribution of 8 points or if both of them choose a contribution of 12.		
Participant B chooses a contribution of 12. His costs for this contribution are 7.33 points.		
Participant B chooses a contribution of 11, C a contribution of 19. The share of B from the 16 points is 12.50%. *In the winner takes all treatment: B's probability of winning the 16 points is 12.50%*		
The experiment has 20 periods		

Question 2:

Participant B chooses a contribution of 8 points for payment 1 and a contribution of 8 points for payment 2. Participant C chooses a contribution of 14 points for payment 1 and a contribution of 14 points for payment 2.

Determine B’s share from the 16 points. *In the winner takes all treatment: Determine B’s probability of winning the 16 points.*

Determine the costs for B and C (see table 1)

Determine the final profit for all three participants,

- If A has chosen payment 1;

- If A has chosen payment 2.

Question 3:

Participant B chooses a contribution of 10 points for payment 1 and a contribution of 4 points for payment 2. Participant C chooses a contribution of 6 points for payment 1 and a contribution of 8 points for payment 2.

Determine C’s share from the 16 points for payment 1 (Table 2).

In the winner takes all treatment: Determine C’s probability of winning the 16 points for payment 1.

Determine B’s share from the 16 points for payment 2 (Table 2).

In the winner takes all treatment: Determine B’s probability of winning the 16 points for payment 2.

Participant A has chosen payment 1. Determine the final profit for all three participants.

Appendix B – Behavioral predictions for a one-shot game with Fehr-Schmidt preferences

We assume homogeneous agents that are characterized by four dimensions of inequity aversion. There is common knowledge about these preferences. Disadvantageous and advantageous inequity aversion regarding the agent's competitor are represented by α_a and β_a, respectively, with $\alpha_a \geq 0, \alpha_a \geq \beta_a$ and $0 \leq \beta_a < 0.5$. Disadvantageous and advantageous inequity aversion regarding the agent's principal are represented by α_p and β_p, respectively, with $\alpha_p \geq 0, \alpha_p \geq \beta_p$ and $0 \leq \beta_p < 0.5$.[13] We will use indifferently envy and compassion as disadvantageous and advantageous inequity aversion, respectively (Grund and Sliwka, 2005). Strictly speaking, $\alpha_a = \alpha_p$ and $\beta_a = \beta_p$ should hold because participants are randomly assigned to their roles of principal or agent. Nevertheless, agents may have different *ex ante* expectations on the principal's and the other agent's behaviors and also on their relative power on her own payoffs. This would lead to different horizontal and vertical social preferences of agents. Agents maximize their expected utility to determine their effort level. The expected utility of agent i, when matched with agent j, with $i, j \in \{A, B\}$ and $j \neq i$, is as follows:

$$EU_i = E(x_i) + \varphi_i + \phi_i, \tag{5}$$

with the expected payoff $E(x_i) = p(m_k + 16) + (1-p)m_k - \frac{e_i^2}{20}$. An agent's expected utility depends on his expected payoff and also on his inequity aversion regarding both the other agent in the group and the principal. The variable φ_i represents how the expected payoff of agent i is affected by her inequity aversion regarding the other agent in the group. The variable ϕ_i indicates how the expected payoff of agent i is affected by her inequity aversion regarding the principal.

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[13] We restrict the space of advantageous inequity aversion to the interval [0,0.5) in order to avoid tedious case distinctions. This restriction does not change the results and the interpretation of the effect of advantageous inequity aversion regarding the competitor and the principal.

We derive the equilibrium effort in the winner-takes-all treatment as Grund and Sliwka (2005) do, but consider additionally, that agents may care about the payoff of the principal. The expected payoff of agent *i* is the same for both treatments.

$$E(x_i) = p(m_k + 16) + (1-p)m_k - \frac{e_i^2}{20}$$

With p being agent *i*'s probability to win, i.e. $p = Prob\big(e_i + \varepsilon_i > e_j + \varepsilon_j\big)$.

$$p = \begin{cases} \frac{1}{2} + \frac{e_i - e_j}{2 \times 8} + \frac{\left(e_i - e_j\right)^2}{8 \times 8^2} & \text{if } e_i < e_j \\ \frac{1}{2} + \frac{e_i - e_j}{2 \times 8} - \frac{\left(e_i - e_j\right)^2}{8 \times 8^2} & \text{if } e_i \geq e_j \end{cases}$$

In the winner-takes-all treatment, inequity aversion regarding the other agent affects agent i's expected utility in the following manner:

$$\varphi_i = \begin{cases} p\left[-\beta_a\left(16 - \frac{e_i^2}{20} + \frac{e_j^2}{20}\right)\right] + (1-p)\left[-\beta_a\left(16 - \frac{e_i^2}{20} + \frac{e_j^2}{20}\right)\right] & \text{if } \frac{e_i^2 - e_j^2}{20} < -16 \\ p\left[-\beta_a\left(16 - \frac{e_i^2}{20} + \frac{e_j^2}{20}\right)\right] + (1-p)\left[-\alpha_a\left(16 - \frac{e_j^2}{20} + \frac{e_i^2}{20}\right)\right] & \text{if} -16 \leq \frac{e_i^2 - e_j^2}{20} \leq 16 \\ p\left[-\alpha_a\left(16 - \frac{e_j^2}{20} + \frac{e_i^2}{20}\right)\right] + (1-p)\left[-\alpha_a\left(16 - \frac{e_j^2}{20} + \frac{e_i^2}{20}\right)\right] & \text{if } \frac{e_i^2 - e_j^2}{20} > 16 \end{cases}$$

Inequity aversion regarding the principal affects the agent's expected utility as follows:

$$\phi_i = \begin{cases} -\beta_p\left(\frac{3}{2}(2m_k + 16) - \frac{e_i^2}{20} - 50 - e_i - e_j\right) & \text{if } e_i + e_j + \frac{e_i^2}{20} < -50 + \frac{3}{2}(2m_k + 16) \\ -\alpha_p\left(-\frac{3}{2}(2m_k + 16) + \frac{e_i^2}{20} + 50 + e_i + e_j\right) & \text{if } e_i + e_j + \frac{e_i^2}{20} \geq -50 + \frac{3}{2}(2m_k + 16) \end{cases}$$

With $e^{WTA*} \in [0,20]$, the equilibrium resulting of the first order conditions is given by:

$$e^{WTA*} = e_i^{WTA*} = e_j^{WTA*} = \max\left\{-20 + \sqrt{30(-4 + 2m_k)}, \frac{20\big(1 + \alpha_a - \beta_a - \alpha_p\big)}{2 + \alpha_a - \beta_a + 2\alpha_p}\right\}$$

In the winner-takes-more treatment, the only difference with the winner-takes-all treatment concerns the ex-post inequality between agents' payoffs. Therefore, inequity aversion regarding the other agent affects agent i's expected utility as follows:

$$\varphi_i = \begin{cases} -\beta_a \left[-16(1-2p) - \dfrac{e_i^2 - e_j^2}{20} \right] & \text{if } 0 \le e_i < -160 + 9e_j \text{ or } e_j < e_i < \dfrac{160 + e_j}{9} \\ -\alpha_a \left[16(1-2p) + \dfrac{e_i^2 - e_j^2}{20} \right] & \text{if} - 160 + 9e_j \le e_i \le e_j \text{ or } \dfrac{160 + e_j}{9} \le e_i \le 20 \end{cases}$$

ϕ_i is identical as in the winner-takes-all treatment.

There exist multiple symmetric equilibria because equalizing agents' payoffs by choosing the same effort is possible in this treatment while it was not in the winner-takes-all treatment.

With $e^{WTM*} \in [0,20]$, the equilibria are such as:

$$e^{WTM*} = e_i^{WTM*} = e_j^{WTM*} \in \left[\min\left\{ -20 + \sqrt{30(-4 + 2m_k)}, \frac{10(1 - 2\beta_a + \beta_p)}{1 - \beta_a - \beta_p} \right\}, \max\left\{ -20 + \sqrt{30(-4 + 2m_k)}, \frac{10(1 + 2\alpha_a - \alpha_p)}{1 + \alpha_a + \alpha_p} \right\} \right]$$

It gives, for the equal contract:

$$e^{WTM_f*} \in \left[\min\left\{ 10, \frac{10(1 - 2\beta_a + \beta_p)}{1 - \beta_a - \beta_p} \right\}, \max\left\{ 10, \frac{10(1 + 2\alpha_a - \alpha_p)}{1 + \alpha_a + \alpha_p} \right\} \right]$$

Examples of equilibrium effort levels depending on agents' social preferences: α_a, β_a, α_p and β_p:

α_a	β_a	α_p	β_p	Equal WTA	Unequal WTA	Equal WTM	Unequal WTM
0	0	0	0	10	10	[10,10]	[10,10]
1	0	0	0	13.33	13.33	[10,15]	[10,15]
1	0.4	0	0	12.31	12.31	[3.33,15]	[3.33,15]
0	0	0.8	0	10	5.69	[10,10]	[5.69,5.69]
0	0	0.8	0.2	10	5.69	[10,10]	[5.69,5.69]
1	0	0.8	0	10	5.69	[10,10]	[5.69,7.86]
1	0	0.8	0.2	10	5.69	[10,10]	[5.69,7.86]
1	0.4	0.8	0	10	5.69	[3.33,10]	[3.33,7.86]
1	0.4	0.8	0.2	10	5.69	[10,10]	[5.69,7.86]
0	0	0.2	0	10	6.67	[10,10]	[6.67,6.67]
0	0	0.2	0.1	10	6.67	[10,10]	[6.67,6.67]
1	0	0.2	0	10.59	10.59	[10,12.73]	[6.67,12.73]
1	0	0.2	0.1	10.59	10.59	[10.12.73]	[6.67,12.73]
1	0.4	0.2	0	10	9.33	[3.33,12.73]	[3.33,12.73]
1	0.4	0.2	0.1	10	9.33	[6.12,12.73]	[5.69,12.73]

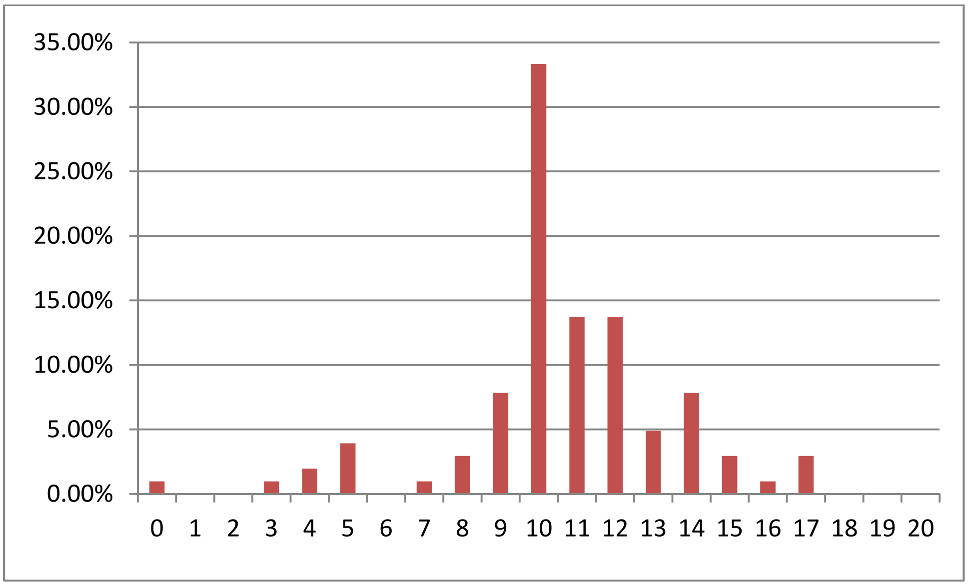
The first row of the table indicates the equilibrium effort levels when agents do not take into account neither the other agent's payoff nor the principal's payoff. The effort level is identical in both treatments and both contracts and is equal to 10.

When the agent is envious regarding the other agent but does not care about the principal, her equilibrium effort level is higher than 10, i.e. 13.33, in the winner-takes-all treatment and equilibria belong to [10,15] in the winner-takes-more treatment. Compassion regarding the other agent decreases a little bit the equilibrium effort level in the WTA treatment that is equal to 12.31. In the WTM treatment, the range of equilibria is larger with the lowest equilibrium equal to 3.33 and the highest equal to 15.

The following rows indicate how inequity aversion regarding the principal modifies agents' effort equilibrium. It appears clearly that envy toward the principal decreases the equilibrium effort level in the unequal contract in both the WTA and the WTM treatments. For instance, when the agent is only envious toward the principal ($\alpha_p = 0.8$), the equilibrium effort level remains 10 in the equal contract in both the WTA and the WTM treatment but is 5.69 in the unequal contract in both treatments.

Appendix C – Distribution of risk preferences across subjects

On the x-axis: the number of safe choices, on the y-axis: the share of subjects who made the specific amount of safe choices.



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TABLES

Table 1: Earning functions of the participants in the different contracts and treatments

<table>
<tr><td colspan="3">Winner-takes-all treatment (Tournament)</td></tr>
<tr><td></td><td>Equal Contract</td><td>Unequal Contract</td></tr>
<tr><td>The principal (A)</td><td>$50 + e_B + e_C - 2 * 17 - 16$</td><td>$50 + e_B + e_C - 2 * 13 - 16$</td></tr>
<tr><td colspan="3">When the winner of the tournament is agent B: $e_B + \varepsilon_B > e_c + \varepsilon_c$</td></tr>
<tr><td>Agent B</td><td>$33 - \frac{1}{20} {e_B}^2$</td><td>$29 - \frac{1}{20} {e_B}^2$</td></tr>
<tr><td>Agent C</td><td>$17 - \frac{1}{20} {e_C}^2$</td><td>$13 - \frac{1}{20} {e_C}^2$</td></tr>
<tr><td colspan="3">When the winner of the tournament is agent C: $e_B + \varepsilon_B < e_c + \varepsilon_c$</td></tr>
<tr><td>Agent B</td><td>$17 - \frac{1}{20} {e_B}^2$</td><td>$13 - \frac{1}{20} {e_B}^2$</td></tr>
<tr><td>Agent C</td><td>$33 - \frac{1}{20} {e_C}^2$</td><td>$29 - \frac{1}{20} {e_C}^2$</td></tr>
<tr><td colspan="3">Winner-takes-more treatment (Proportional payment: $\gamma = Pr\ (\varepsilon_B - \varepsilon_c > e_c - e_B)$)</td></tr>
<tr><td></td><td>Equal Contract</td><td>Unequal Contract</td></tr>
<tr><td>The principal (A)</td><td>$50 + e_B + e_C - 2 * 17 - 16$</td><td>$50 + e_B + e_C - 2 * 13 - 16$</td></tr>
<tr><td>Agent B</td><td>$17 + \gamma 16 - \frac{1}{20} {e_B}^2$</td><td>$13 + \gamma 16 - \frac{1}{20} {e_B}^2$</td></tr>
<tr><td>Agent C</td><td>$17 + (1 - \gamma)16 - \frac{1}{20} {e_C}^2$</td><td>$13 + (1 - \gamma)16 - \frac{1}{20} {e_C}^2$</td></tr>
</table>

Table 2. Average effort by contract and treatment (standard deviation in parentheses)

	Winner-takes-all (Tournament)	Winner-takes-more (Proportional Payment)
Equal contract	9.574 (5.154)	7.831 (5.098)
Unequal contract	8.393 (5.322)	6.609 (4.758)

Table 3: Tobit estimations of effort provision across contracts and treatments

		Dependant variable: Effort level		
Independent Variables	Description	Model (1)	Model (2)	Model (3)
Period	1 to 20	-.186*** (.043)	-.109*** (.031)	-.060* (.031)
Unequal	1 = unequal; 0 = equal	-1.265** (.590)	-1.805*** (.666)	-1.953*** (.733)
Winner-takes-all	1 = Winner-takes-all treatment; 0 = winner-takes-more treatment	1.691 (1.074)	3.168* (1.634)	3.378** (1.721)
Interaction	*Unequal × Winner-takes-all*	-.121 (.772)	-.224 (.827)	-.230 (.872)
$Contract_{t-1}$	Contract choice of the principal in the previous period: 1 = unequal; 0 = equal		-.507 (.506)	-.590 (.493)
$Effort_{t-1}$	Observed effort of the partner in the previous period (0 – 20)		.507*** (.110)	.349*** (.068)
$EffWTA_{t-1}$	*$Effort_{t-1}$ × Winner-takes-all*		-.244 (.161)	-.183* (.111)
$Effunequal_{t-1}$	*$Effort_{t-1}$ × Unequal*		.073 (.058)	.055 (.046)
$Contract_{t-2}$	Contract choice of the principal two periods earlier: 1 = unequal; 0 = equal			-.752 (.581)
$Effort_{t-2}$	Observed effort of the partner two periods earlier (0 – 20)			.318*** (.061)
$Efftreat_{t-2}$	*$Effort_{t-2}$ × Winner-takes-all*			-.109 (.078)
$Effunequal_{t-2}$	*$Effort_{t-2}$ × Unequal*			.035 (.047)
stablechoice	*$Choice_{t-1}$ = $Choice_{t-2}$*			-.824 (.509)
riskpref	# of safe choices in task 1 in the experiment	-.230 (.164)	-.159 (.132)	-.146 (.129)
Constant		12.104*** (1.881)	6.922*** (1.706)	4.052*** (1.720)
Observations		2720	2584	2448
Left-censored		298	292	290
Right-censored		32	30	29
Prob > F		.000	.000	.000
Pseudo R^2		.014	.039	.048

Significance levels: * p < .1; ** p < .05; *** p < .01; in parenthesis standard errors adjusted for 34 clusters in group.

Table 4. Classification of agents according to their reaction to the principal's fairness

	Share in the population	Average effort difference equal/unequal	Within SD effort difference equal/unequal	Between SD effort difference equal/unequal	Effort in unequal contract	Effort in equal contract
Winner-takes-all tr.						
No Vertical SP	54.55%	0.23	1.62	0.51	9.24	9.47
Stable Vertical SP	24.24%	3.31	1.46	1.35	6.99	10.30
Unstable Vertical SP	21.21%	2.26	6.15	0.89	7.49	9.75
Winner-takes-more tr.						
No Vertical SP	45.45%	0.18	1.11	0.53	5.67	5.85
Stable Vertical SP	21.21%	2.61	1.77	0.59	8.05	10.66
Unstable Vertical SP	33.34%	2.79	5.20	2.34	6.52	9.31

Table 5. Probit estimations of the principal's contract choice

Dependent variable: Choice of the equal contract	
Variables	Model
Period	.000 (.004)
Winner-takes-all	-.004 (.110)
Average effort$_{t-1}$	.035*** (.008)
Average effort$_{t-1}$ × *Winner-takes-all*	-.002 (.010)
Average effort$_{t-1}$ × *Unequal$_{t-1}$*	-.020*** (.006)
Observations	646
Prob > χ^2	.000
Pseudo R^2	.101

Significance levels: * p < .1; ** p < .05; *** p < .01; in parenthesis standard errors adjusted for 34 clusters in group.

Table 6. Average profits by contract and treatment

		Winner-takes-all (Tournament)	Winner-takes-more (Proportional Payment)
Principals	Equal contract	19.15	15.66
	Unequal contract	24.79	21.22
Agents	Equal contract	19.09	20.64
	Unequal contract	16.06	17.69

FIGURES

Figure 1: Evolution of average effort by contract and treatment

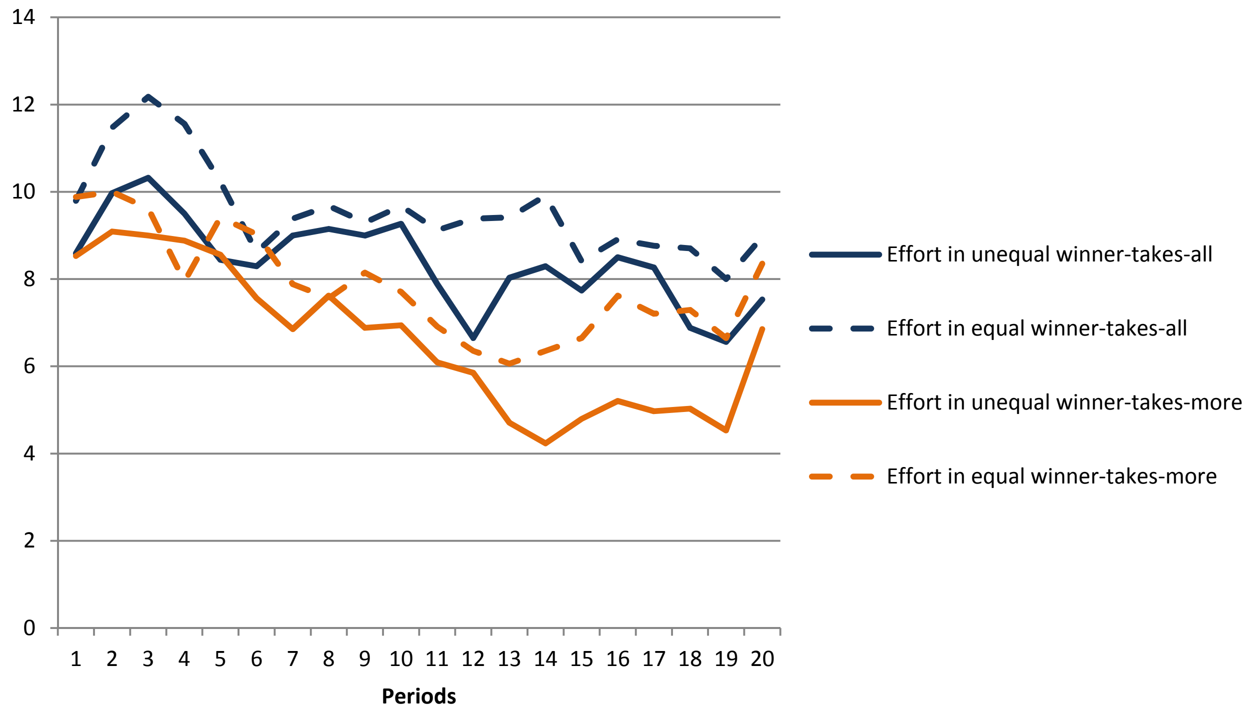

Figure 2. Average effort of agents with and without vertical social preferences

by contract and treatment

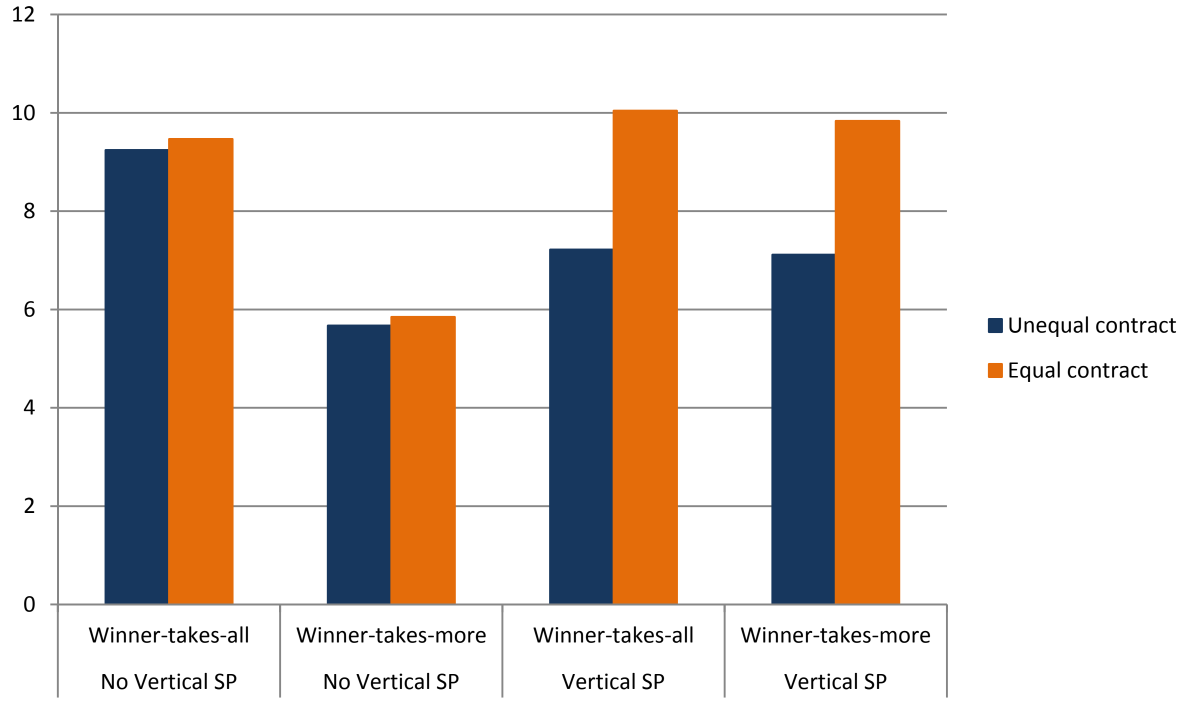

Figure 3: Share of the equal contracts in each of the 20 periods

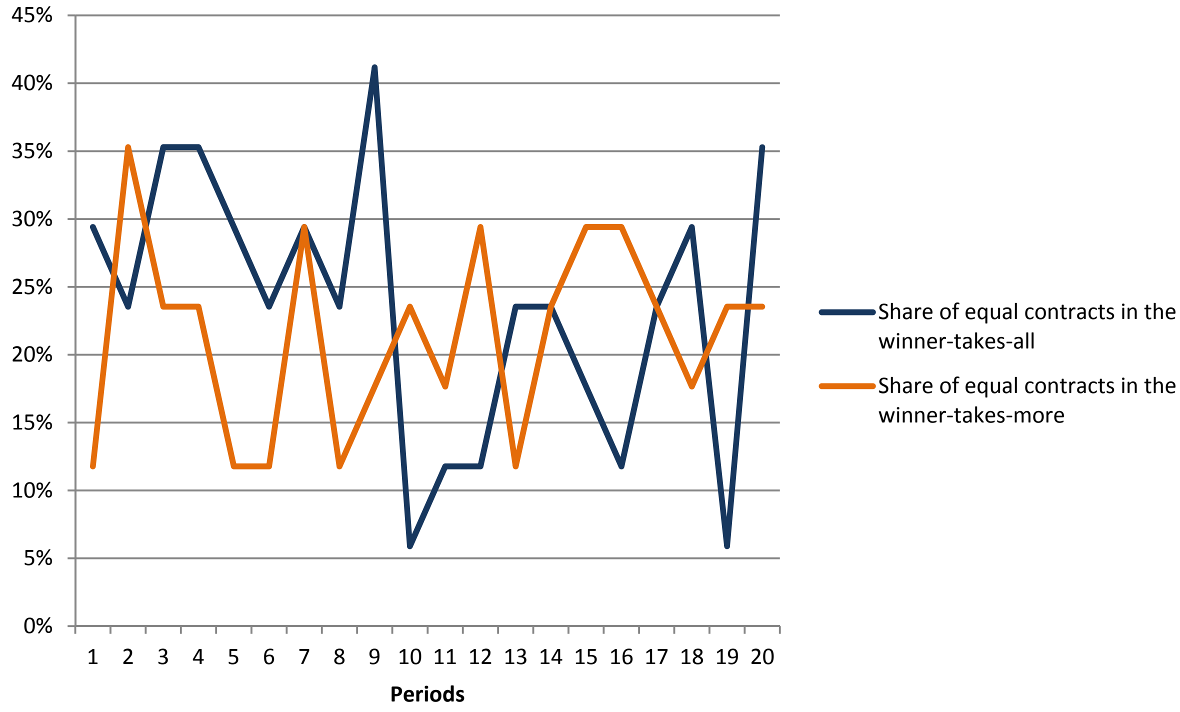

Figure 4. Effective profits by treatment