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# Inequality in minimum-effort coordination\*

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## Abstract

Successful coordination is key for economic and societal wealth. The rich literature on the minimum-effort game (MEG) has provided valuable insights into coordination, both theoretically and empirically. Yet, although real-world scenarios often involve asymmetric benefits and/or costs from coordination, most previous studies rely on symmetric MEGs. We investigate the effect of unequal equilibrium payoffs in the MEG. In two experiments, we observe that players are better able to coordinate on an equal rather than an unequal Pareto-dominant equilibrium. We find that the ability to coordinate on the unequal Pareto-dominant equilibrium critically hinges on the costs of miscoordination for the player who benefits most from successful coordination: when her costs are low, she seems able to stabilize the Pareto-dominant equilibrium even if payoffs are highly unequal, whereas coordination success worsens substantially when her costs are high.

**JEL Classification:** C72, C92

**Keywords:** minimum effort game, coordination, social comparison, potential games, lab experiment

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# 1 Introduction

Coordination games generically feature multiple equilibria. This impairs comparative-static analyses and the derivation of policy advice and makes coordination games an important topic in both theoretical and experimental economics.<sup>1</sup> One prominent coordination scenario is the minimum-effort game (MEG, Van Huyck, Battalio, and Beil, 1990, see also Cooper et al. 1990; 1992; Van Huyck, Gillette, and Battalio, 1992). In the MEG, actions are strategic complements in the sense that mutually higher payoffs require greater matched action profiles, often termed “efforts”. In addition, equilibria differ in the degree of (strategic) risk as higher benefits are associated with larger losses from miscoordination. Players thus aim at matching the minimum effort in their group while at the same time wanting the minimum to be high. This results in a trade-off between efficiency and risk. The Pareto-dominant equilibrium involves the highest risk while individual payoffs in the least-efficient equilibrium are independent of the actions of others and thus ‘secure’. Despite the obvious social optimum, empirical investigations of the MEG show that groups are rarely able to persistently realize the Pareto-optimal outcome in repeated interaction (Van Huyck, Battalio, and Beil, 1990; Devetag and Ortmann, 2007).

The MEG mimics numerous coordination scenarios, e.g., global public goods (Hirschleifer, 1983; Sandler, 1998; Nordhaus, 2006), computer security (Riedl, Rohde, and Strobel, 2016), and team production (Brandts and Cooper, 2006). In the financial literature, bank runs (Diamond and Dybvig, 1983), speculative attacks against exchange-rate pegs (Obstfeld, 1996), and debt crises (Cole and Kehoe, 2000) are typical coordination problems. However, while the standard MEG is symmetric, real-world scenarios often involve asymmetric benefits or costs. For example, global vaccination campaigns such as the eradication of smallpox can be modeled as MEGs as their success depends on the country that implements the weakest campaign. Barrett (2006, p.181) notes that “the real smallpox game was characterized by substantial asymmetries. By the time the eradication program began, the rich countries had already eliminated smallpox within their borders. Eradication would succeed only if the remaining endemic countries eliminated the disease.” However, rich countries still occasionally imported smallpox from poor countries due to international travel and trade. Still, while the “vaccination equilibrium” was clearly in common interest, poor countries had larger benefits from coordination on the respective equilibrium than rich countries.

This paper systematically introduces payoff inequality into the MEG framework while holding efficiency constant to study the effect of inequality aversion in this setup

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<sup>1</sup>The literature on coordination games is extensive, both theoretically and experimentally. We refer the reader to the surveys by Ochs (1995), Camerer (2003), and Devetag and Ortmann (2007).

(see also Chen and Chen, 2011).<sup>2</sup> We manipulate inequality by making use of two different types of players: a low-cost type and a high-cost type. The low-cost type has low costs of effort provision and thus always benefits more from coordination on higher effort levels than the high-cost type. The game is constructed such that the payoffs of the two types are unequal in all but one equilibrium. We say that an equilibrium is *equality-dominant* if it is the only one featuring equal payoffs.

We investigate actual behavior in two laboratory experiments with either the Pareto-dominant equilibrium being equality-dominant or the secure equilibrium being equality-dominant. In the first experiment, we make use of a game configuration where potential-game theory (Monderer and Shapley, 1996) is applicable and does not refine the set of equilibria when we assume selfish preferences to provide a setup where inequity aversion has its best chance to affect behavior. Here, a potential-game-theory model with inequity-averse preferences (Fehr and Schmidt, 1999) suggests that groups coordinate on the respective equal equilibrium.<sup>3</sup> However, empirically, whereas coordination on the Pareto-dominant equilibrium is indeed almost perfect when it has equal payoffs, coordination success only worsens little when the Pareto-dominant equilibrium has unequal payoffs. We argue that one reason for this observation may be that, in this game configuration, the low-cost type is only hardly affected by miscoordination while strongly benefiting from successful coordination. This could make her willing to stabilize the Pareto-dominant equilibrium in the repeated interaction in choosing the corresponding strategy despite occasional losses from miscoordination. We test this notion in a second experiment where we increase the possible losses from miscoordination faced by the low-cost type. In this case, coordination failure indeed frequently arises when the secure equilibrium has equal payoffs while coordination remains almost perfect when the Pareto-dominant equilibrium has equal payoffs.

Our results demonstrate the role of social comparison effects in MEG-coordination and further suggest that miscoordination caused by inequality can be mitigated by a player with low costs from miscoordination. This paper thereby complements the findings in Chen and Chen (2011) who demonstrate the effect of group identity on equilibrium selection in further emphasizing the role of social preferences in MEG-coordination. In addition, it complements the findings in Brandts et al. (2007) who observe that a strong low-cost player does not help in fostering coordination despite the authors' idea that she

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<sup>2</sup>For research investigating the effects of payoff equality in other coordination contexts see, e.g., Chmura et al. (2005), Crawford et al. (2008), Tavoni et al. (2011), López-Pérez et al. (2015), and Anbarci et al. (2018).

<sup>3</sup>We put forward a potential-game-theory model in Appendix A that predicts that any degree of inequity aversion (Fehr and Schmidt, 1999) rather than selfish preferences results in coordination on the respective equal equilibrium in this game configuration. Monderer and Shapley (1996) indeed observe that the predictions of potential-game theory often coincide with empirical behavior and both Goeree and Holt (2005) and Chen and Chen (2011) find that outcomes in a continuous symmetric MEG with groups of two players closely resemble the prediction of potential games after some learning.

might serve as a “natural leader”. We provide a possible explanation for this observation, namely that the inequality the low-cost player introduces may undermine the expected effect.<sup>4</sup>

Given the notorious problems with overcoming coordination failures in the MEG, both equality dominance and an involved player with low costs from miscoordination and high gains from successful coordination are likely relevant factors to identify scenarios in which coordination may succeed.

## 2 The (asymmetric) minimum-effort game

In the following, we present the standard MEG and discuss how we introduce inequality. The standard symmetric MEG consists of  $i \in N = \{1, \dots, n\}$  players choosing an effort level  $e_i \in E_i = \{1, 2, \dots, e^k\}$ . We denote an action profile by  $\mathbf{e} = (e_1, \dots, e_n) \in E = E_1 \times \dots \times E_n$  and an equilibrium by  $\mathbf{e}^*$ . A player’s payoff function is given by:

$$\pi_i(\mathbf{e}) = b \min\{\mathbf{e}\} - ce_i + a, \quad (1)$$

for every  $i \in N$ , where  $b > c$  is the benefit from coordination,  $c > 0$  is the effort cost, and  $a \geq 0$  is a constant.

The generic feature of game  $\text{MEG} = (N, E, \pi_i)$  is that all common effort levels are Nash equilibria. A unilateral increase in effort does not raise the minimum but only increases costs. A unilateral decrease in effort reduces the minimum but the saving in costs is less than the forfeited benefit from higher coordination because  $b > c$ . Hence, the number of pure-strategy Nash equilibria of the MEG corresponds to the number of effort levels  $|E_i|$ .<sup>5</sup> Furthermore, the equilibria are Pareto-rankable, i.e., larger equilibrium efforts generate higher payoffs. Two equilibria of the game often receive special attention: the Pareto-dominant and the secure equilibrium. In the Pareto-dominant equilibrium, all players choose the maximum effort and, hence, maximize global efficiency and individual payoffs. In the secure equilibrium, all players choose the minimum effort, thereby minimizing efficiency in equilibrium while also minimizing individual risk as the respective effort is the maximin strategy.

We modify the standard symmetric MEG by introducing heterogeneous costs of effort provision. We construct the payoff function such that all but one equilibrium

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<sup>4</sup>Specifically, Brandts et al. (2007) vary the number of high-cost and low-costs types in a MEG to test the authors’ intuition that asymmetric groups might perform better than symmetric ones due to the presence of natural leaders. However, they find that empirical outcomes are similar or even worse. Our paper provides a possible explanation for this pattern as it suggests that groups are less able to coordinate on an unequal Pareto-dominant equilibrium.

<sup>5</sup>As is standard in the experimental literature on minimum-effort coordination, we consider only pure-strategy Nash equilibria.

feature unequal payoffs and vary which of the two extreme equilibria has equal payoffs. We make sure that global efficiency is the same in each action profile irrespective of the equality-dominant equilibrium. In addition, we design the game such that it can be analyzed applying potential-game theory which has done well in predicting behavior in prior symmetric MEG experiments (see Appendix A for details).

We introduce two types of players into the standard MEG identified by  $\theta \in \{l, h\}$  with  $c_\theta$  being the cost parameter of type  $\theta$ . High types ( $\theta = h$ ) have higher costs of effort provision than low types ( $\theta = l$ ), i.e.,  $c_h > c_l$ . This causes both asymmetry in the gains from coordination and in the losses from miscoordination. The treatment indicator  $\tau \in \{\underline{\tau}, \bar{\tau}\}$  identifies the equilibrium with equal payoffs. If  $\tau = \underline{\tau}$ , the secure equilibrium is equality-dominant and if  $\tau = \bar{\tau}$ , the Pareto-dominant equilibrium is equality-dominant.

The resulting asymmetric minimum-effort game (aMEG) has the same set of players and the same action set as the standard symmetric MEG. However, the individual payoff function with heterogeneous costs now reads:

$$\pi_i^{\text{het}}(\mathbf{e}; \theta, \tau) = \begin{cases} b \min\{\mathbf{e}\} - c_l e_i + a + c_l + d(l, \tau) & \text{if } \theta = l \\ b \min\{\mathbf{e}\} - c_h e_i + a + c_h + d(h, \tau) & \text{if } \theta = h, \end{cases} \quad (2)$$

where  $b > c_h > c_l > 0$ . Hence, the set and Pareto-ranking of Nash equilibria is the same as in the symmetric MEG. The fixum  $d(\theta, \tau)$  depends on type  $\theta$  for a given value of the treatment indicator  $\tau$ . We construct the value of  $d(\theta, \tau)$  such that if  $\tau = \underline{\tau}$ , the secure equilibrium is equality-dominant. If  $\tau = \bar{\tau}$ , the Pareto-dominant equilibrium is equality-dominant.<sup>6</sup>

### 3 Experiments - General design and procedures

We first discuss the commonalities of our two experiments as well as the experimental procedures. We then present the peculiarities of the two experiments separately.

In both experiments, subjects simultaneously choose an effort level from the set  $E_i = \{1, 2, \dots, 7\}$ . Adopting the design from Goeree and Holt (2005) and Chen and Chen (2011), our subjects play the game in groups of  $n = 2$ . However, in contrast to these studies, we stick to the original discrete representation of the MEG (Van Huyck, Battalio, and Beil, 1990) which allows us to write the game in normal form. This has two advantages: First, subjects see the entire distribution of payoffs for any action profile and do not have to calculate their own or their partner's payoffs. Second, the normal form seems easier to understand compared to stating the payoffs in their functional form.

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<sup>6</sup>See Section A.1 in the Appendix for details about the construction of  $d(\theta, \tau)$ .

A total of 256 subjects participated in the two experiments.<sup>7</sup> Subjects were randomly assigned to one of the treatment groups and were only allowed to participate once. Half the subjects were low-cost types (denoted as “role X” in the instructions) and the other half were high-cost types (role Y) and they kept their role throughout the experiment.<sup>8</sup> We applied the random matching procedure as follows: Subjects were grouped in *cohorts* of  $n = 8$  individuals with four subjects in role X and four subjects in role Y.<sup>9</sup>

We apply a two-part procedure. Subjects are aware that the experiment consists of two parts but do not know ex-ante what each part is about. In the first part, subjects play the game for only one round. They are told that they receive information about the results of this part only after the completion of the second part. In the second part, subjects play the stage game for  $T = 30$  periods with random matching of persons X and Y within a cohort. Each period  $t = 1, \dots, T$  consists of two screens: (i) a decision screen and (ii) a feedback screen (see Appendix B for screenshots). After making their decisions for round  $t$ , each subject receives the following information: her own effort, the effort of her partner, her own payoff, and the payoff of her partner. Furthermore, as in Chen and Chen (2011), subjects are shown the history of play for every period  $k = 1, \dots, t - 1$ : her effort in period  $k$ , her period- $k$  partner’s effort, her own payoff in period  $k$ , and her period- $k$  partner’s payoff.

We conducted the experiment in the Cologne Laboratory for Economic Research (CLER), it was computerized via *z-Tree* (Fischbacher, 2007), and we used the recruiting system *ORSEE* (Greiner, 2004) to invite a random sample of the laboratory’s subject pool. Subjects received a hard copy of the instructions (see Appendix C) which were read out loud. Then, subjects were allowed to take as much time as needed to familiarize themselves with the experiment. Questions were answered in private. During the experiment all payoffs were stated in Experimental Currency Units (ECU). The exchange rate was 30 ECU to 1 Euro for the one-shot part and 400 ECU to 1 EUR for the repeated part. Average payment was 12.25 EUR (about 13.99 USD) for 60 minutes of experimentation.

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<sup>7</sup>Summary statistics on demographic and attitudinal variables and the specific questions used regarding risk and social preferences of our subject sample can be found in Appendix D. This data has been elicited through an unincentivized post-experimental questionnaire. Appendix D further provides an overview over the whole dataset showing the decisions of all subjects in each period as well as decisions ordered by treatment and cost-type to provide a full picture of the dataset.

<sup>8</sup>We opted for this fixed-role design to avoid that subjects are ‘equal by randomization’ which may undermine the effect of inequality. The effects of inequality would be likely less strong if subjects were randomly assigned to their role in each period.

<sup>9</sup>All non-parametric tests reported in this paper are based on comparisons of means per independent group or *cohort*. For example, in part two of the experiment, each treatment involves eight independent groups.

		Number of Y							
Role		7	6	5	4	3	2	1	
Number of X	7	X	103	91	79	67	55	43	31
		Y	103	102	101	100	99	98	97
	6	X	92	92	80	68	56	44	32
		Y	91	102	101	100	99	98	97
	5	X	81	81	81	69	57	45	33
		Y	79	90	101	100	99	98	97
	4	X	70	70	70	70	58	46	34
		Y	67	78	89	100	99	98	97
	3	X	59	59	59	59	59	47	35
		Y	55	66	77	88	99	98	97
2	X	48	48	48	48	48	48	36	
	Y	43	54	65	76	87	98	97	
1	X	37	37	37	37	37	37	37	
	Y	31	42	53	64	75	86	97	

(a) Treatment LR77

		Number of Y							
Role		7	6	5	4	3	2	1	
Number of X	7	X	133	121	109	97	85	73	61
		Y	73	72	71	70	69	68	67
	6	X	122	122	110	98	86	74	62
		Y	61	72	71	70	69	68	67
	5	X	111	111	111	99	87	75	63
		Y	49	60	71	70	69	68	67
	4	X	100	100	100	100	88	76	64
		Y	37	48	59	70	69	68	67
	3	X	89	89	89	89	89	77	65
		Y	25	36	47	58	69	68	67
	2	X	78	78	78	78	78	78	66
		Y	13	24	35	46	57	68	67
	1	X	67	67	67	67	67	67	67
		Y	1	12	23	34	45	56	67

(b) Treatment LR11

Notes: *77* indicates that the Pareto-dominant equilibrium (7,7) is equality-dominant and *11* indicates that the secure equilibrium (1,1) is equality-dominant. *LR* refers to low risk.

Figure 1: Reported is the normal form representation of treatments LR77 and LR11.

## 4 Experiment 1 - Low risk

In the following, we discuss our first experiment: the treatments that we conduct, our hypotheses, and the results. In the first experiment, we make use of a parametrization where potential-game theory does not refine set of equilibria when we assume selfish preferences to give inequality its best chance to affect equilibrium selection.

### Design and predictions

In the first experiment, the benefit factor is  $b = 12$  and the costs are  $c_l = 1$  for the low-cost type and  $c_h = 11$  for the high-cost type. The costs are chosen such that the inequality in equilibrium is maximized given the benefit factor  $b$ . The constant is  $a = 55$ . This implies that the fixum takes the value  $d = 0$  if the secure equilibrium is equality-dominant and  $d = 30$  if the Pareto-dominant equilibrium is equality-dominant. This ensures non-negative payoffs. Equality dominance has two levels indicating whether the Pareto-dominant equilibrium  $(e_i, e_j) = (7, 7)$  is equality-dominant or whether the secure equilibrium  $(1, 1)$  is equality-dominant. We call the corresponding treatments LR77 and LR11 (LR = Low Risk). Figure 1 illustrates the payoff matrices of the two treatments.

### Hypotheses

The choice of any same effort of the two players is an equilibrium in pure strategies. In addition, global efficiency in each strategy combination is identical across treatments. We still expect that empirical behavior differs due to the inequality introduced by the treatment variation. We base this idea on the literature on outcome-based social comparison



effects that assumes that people find unequal outcomes less attractive than equal ones (e.g. Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000; Fehr and Schmidt, 2006). We hence expect that higher efforts are chosen on average in case of an equal Pareto-dominant equilibrium. This is our first hypothesis:

**Hypothesis 1** [*Choices LR77 vs LR11*] *Subjects choose higher effort levels in LR77 than in LR11.*

Chen and Chen (2011) set up a potential-game-theory model to study social preferences in the symmetric MEG.<sup>10</sup> Their model assumes that members of homogenous groups in terms of social identity put more weight on the payoffs of their respective partners than members of heterogeneous groups. This should, according to their model, make the homogeneous groups better able to coordinate on higher effort levels. The authors find empirical support for this prediction which indicates that social concerns may indeed be relevant for MEG-coordination. Applying inequity-averse preferences to the asymmetric MEG that we consider here yields similar predictions.<sup>11</sup> That is, the maximum effort is played when the Pareto-dominant equilibrium is equality-dominant while the minimum effort is played when the secure equilibrium is equality-dominant (see Proposition 1 in Appendix A.3). This is our second hypothesis:

**Hypothesis 2** [*Equilibrium selection*] *Groups coordinate on the equality-dominant equilibrium, both when it is the Pareto-dominant equilibrium and when it is the secure equilibrium.*

## Results

For our analysis, we are mainly interested in effort choices, coordination success, and efficiency. We present the results of both the one-shot interaction (part one of the experiment) and the repeated interaction (part two) in each of these dimensions. We first discuss effort choices. Afterwards, we investigate how differences in choices affect coordination success and efficiency. In part one of the experiment, each of the 128 subjects generates one independent observation with regard to effort choices and each of the 64 matching groups provides one independent observation with regard to coordination success and efficiency. In part two, each subject plays the stage game for  $T = 30$  periods, generating 3840 observations clustered in 16 cohorts in a panel-structure dataset, resulting in eight independent observations per treatment.

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<sup>10</sup>See Section A.2 for details on potential-game theory in the symmetric MEG.

<sup>11</sup>We construct the game and choose the experiment's parameters in a way such that potential-game theory does not refine the set of equilibria when we assume selfish preferences. In the two-player case, the equilibrium threshold with selfish preferences is given by  $b^{\text{aMEG}} = c_l + c_h$  (see Appendix A.3 for details). Hence, we chose the experiment parameters such that the actual benefit factor is given by  $b = c_l + c_h$  and thus  $b = b^{\text{aMEG}}$ , i.e., the potential is the same in all equilibria and does not work as a refinement.

**Effort choices.** In treatment LR77, equilibrium (7, 7) is equality-dominant. In the one-shot interaction, 85.9% of the subjects choose the maximum effort level while 6.3% choose the minimum. In treatment LR11, (1, 1) is equality-dominant. In total, 79.7% of the subjects choose the maximum and 7.8% choose the minimum. Effort choices do not differ significantly between these treatments and average efforts are close to the maximum in both cases (6.47 vs. 6.28; Wilcoxon-Mann-Whitney U-test,  $p = 0.3665$ ). Hence, in the initial one-shot interaction, subjects choose high effort levels, regardless of the equality-dominant equilibrium.

Collapsing all data of part two, we find that the tendency observed in the one-shot is somewhat more pronounced and significant: we observe a higher average effort in LR77 than in LR11 (6.84 vs. 6.02, U-test,  $p = 0.0208$ ). Still, effort levels are high also in LR11 and far from the prediction that groups coordinate on the secure equilibrium when it is equality-dominant. This observation lends no support to the prediction suggested by Proposition 1 (see Appendix A.3 for details) and seems to imply that a combination of social preferences and potential-game theory does not describe behavior well in this setup.

**Result 1** [*Choices LR77 vs LR11*] *Subjects choose higher efforts in LR77 than in LR11. Mean efforts are high in both treatments.*

**Coordination and efficiency.** Differences in choices likely also translate into differences in outcomes. Van Huyck, Battalio, and Beil (1990) argue that there are two types of coordination failure in the MEG. First, players may fail to coordinate at all. That is, they may fail to anticipate their partner's effort and thus choose  $e_i \neq e_j$ . Second, players may fail to coordinate on the Pareto-optimal equilibrium and thus waste efficiency. This section reports how well subjects manage to overcome both these forms of coordination failure.

*Coordination* is achieved if both players choose the same effort level, defined by a variable that can take the values zero (no coordination) or one (coordination). Furthermore, following Chen and Chen (2011), we call *Efficiency* the difference between the sum of actual payoffs and the minimum payoffs normalized by the range of possible payoffs.

$$\begin{aligned} \text{Efficiency} &:= \frac{\text{Actual Payoffs} - \text{Minimum Payoffs}}{\text{Maximum Payoffs} - \text{Minimum Payoffs}} \\ &= \frac{(\pi_i + \pi_j) - \min_{\mathbf{e}} \{\pi_i + \pi_j\}}{\max_{\mathbf{e}} \{\pi_i + \pi_j\} - \min_{\mathbf{e}} \{\pi_i + \pi_j\}}. \end{aligned} \quad (3)$$

The lowest efficiency is realized if the high-cost player chooses the maximum while the low-cost player chooses the minimum. The highest efficiency is realized if both players choose the maximum. We will report efficiency in percentage values by multiplying equation (3) by 100%.

Regarding the one-shot decisions, treatment LR77 achieves 71.9% coordination which is only marginally larger than and not statistically different from the 68.8% in treatment LR11 (Fisher’s exact test,  $p = 1.000$ ). In terms of efficiency, treatment LR77 neither differs from LR11 (89.8% vs. 86.2%, U-test,  $p = 0.7143$ ). In the repeated interaction, we observe a higher level of successful coordination in LR77 than in LR11. In addition, if they coordinate successfully, groups in LR77 mostly coordinate on the Pareto-efficient equilibrium (7,7). In LR11 subjects also mainly coordinate on the Pareto-dominant equilibrium but are less successful as groups often miscoordinate. Specifically, the frequency of coordination on (7,7) drops from 90.0% in LR77 to 66.0% in LR11 (U-test,  $p = 0.0306$ ) and the frequency of miscoordination rises from 10.0% to 32.1% (U-test,  $p = 0.0305$ ). In addition, the frequency of coordination on the secure equilibrium (1,1) rises from 0.0% to 1.8% which is weakly significant (U-test,  $p = 0.0645$ ) but economically small. With regard to efficiency in the repeated game, we find that an equality-dominant equilibrium shapes outcomes. Groups in LR77 realize more efficiency than groups in LR11 (96.9% vs. 81.8%, U-test,  $p = 0.0156$ )

**Result 2** [*Coordination and efficiency LR77 vs LR11*] *Groups in LR77 mostly coordinate on the Pareto-dominant equilibrium. Groups in LR11 also mostly coordinate on the Pareto-dominant equilibrium but they also often miscoordinate. Efficiency is higher in LR77 than in LR11.*

Summarizing, we observe that coordination in LR77 is almost perfect. However, our findings further suggest that coordination only worsens little in LR11. Note that our model predicts that inequality averse subjects choose the equality-dominant equilibrium irrespective if it is the secure or Pareto-dominant equilibrium (Hypothesis 2). This hypothesis is not supported by the data. The results hence somewhat support Hypothesis 1 but not Hypothesis 2: inequality indeed affects behavior in the asymmetric MEG but the potential-game-theory model with social preferences fails with regard to point predictions.

We argue that this may be due to the low costs from miscoordination for the low-cost type. Prior literature suggests that deviation costs are relevant for coordination in the symmetric MEG as coordination success increases when deviation costs decrease (Cooper et al., 1990; Goeree and Holt, 2005). This effect likely works through two channels: first, people who face low deviation costs choose higher efforts because they can only lose little from miscoordination. Second, knowing that the other player faces low deviation costs may make players more confident that the other chooses higher efforts which reduces strategic uncertainty and makes them more willing to also choose higher efforts. It hence seems plausible that it is not needed that both players have low deviation costs for the respective effect to evolve but that it may be sufficient to have one player with low deviation costs to ease coordination. Hence, the low-cost type may serve as a ‘stabilizer’.

This further implies that our potential-game-theory model with social preferences may not be applicable to predict behavior in this very asymmetric context. We have chosen the parameters of this first experiment such that it can be analyzed with potential-game theory, that the theory does not refine the set of equilibria when we assume selfish preferences, and that inequality is maximized given the previous requirements. Our aim in doing so was to balance between the efficiency in the Pareto-dominant equilibrium and the security in the minimum-effort equilibrium and to give inequality its best chance to affect equilibrium selection. This is what potential-game theory indeed does well in the symmetric MEG where it has proven successful in predicting behavior (e.g., in Monderer and Shapley, 1996; Anderson et al., 2001; Goeree and Holt, 2005; Chen and Chen, 2011). However, the theory does in fact not balance a player's gains against her own losses but her gains against the other player's losses. This coincides in the symmetric version of the game which may explain the good predictive power in symmetric contexts and further points to a possible weakness of potential-game theory in asymmetric contexts: in case the potential does not refine the set of equilibria in a very asymmetric game, then minor gains from coordination for the high-cost type have to correspond to minor losses from miscoordination for the low-cost type and vice versa.

Number of X	Role	Number of Y	
		7	1
7	X	133	61
	Y	73	67
1	X	67	67
	Y	1	67

Number of X	Role	Number of Y	
		7	1
7	X	103	31
	Y	103	67
1	X	67	67
	Y	31	67

Figure 2: Reduced version of LR11 (left) and a similar symmetric MEG (right). In both cases potential-game theory does not refine the set of equilibria.

We illustrate this idea in Figure 2 where we show a two-strategy version of LR11 that considers only the highest and the lowest effort as strategies as well as a similar symmetric MEG. In both these games potential-game theory does not refine the set of equilibria when we assume selfish preferences. In addition, the global payoffs in both equilibria and the sum of off-equilibrium payoffs are identical in the two games; also the sum of gains of successful coordination and the sum of the costs of miscoordination are identical and players can, regardless of the game, achieve a secure payoff of 67. We therefore interpreted this as a case where inequality may have its best chance to affect behavior. However, the two games not only differ in the equality-dominant equilibrium but also in the distribution of gains and losses between the involved players. Specifically, while in the right game both players face substantial gains from successful coordination [+36 if they coordinate on (7,7) rather than on (1,1)], they are also both confronted with substantial losses from miscoordination (-36 if they choose the maximum than the

minimum while the other chooses minimum). In contrast, the reduced version of LR11 shows that, in the asymmetric context, the low-cost type gains a lot from successful coordination (+66) while only losing little from miscoordination (-6) whereas the high-cost type gains little from successful coordination (+6) while losing substantially from miscoordination (-66). This additional asymmetry, that is required for the asymmetric game to be a potential game, could undermine the strength of potential-game theory of weighting a decision makers' gains and risks and may support the view that it is not the potential per se that makes successful behavioral predictions but properties it fulfills in specific contexts (see Goeree and Holt, 2005, for a discussion in the symmetric MEG).<sup>12</sup>

To investigate this idea, we conduct a second experiment with two further treatments where the low-cost type has the same costs from miscoordination as the high-cost type while still gaining more from successful coordination.

## 5 Experiment 2 - High risk

We now present the design, hypothesis and results of the second experiment that introduces two further treatments that increase the costs from miscoordination faced by the low-cost type. Apart from this, it is identical to the design of the first experiment. In the following analysis, the results of the two experiments are therefore combined which leaves us with a 2x2 factorial design varying the equality-dominant equilibrium and the cost of miscoordination for the low-cost type.

### Design

For the second experiment, we introduce an additional variable into the asymmetric MEG to vary a type's off-equilibrium payoffs independently of her equilibrium outcomes. We do so by subtracting a term from her off-equilibrium payoffs that linearly increases in the difference between her own effort level,  $e_i$ , and the effort level of her partner,  $e_j$ . Specifically, the adjusted payoff is given by

$$\tilde{\pi}_{i,\theta,\tau} = \pi_{i,\theta,\tau} - \zeta_{\theta} \cdot \max\{e_i - e_j, 0\} \quad (4)$$

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<sup>12</sup>An asymmetric game that is both a potential game and ranks a player's own gains from coordination against her own losses from miscoordination is not always feasible due to the definition of the potential (see Appendix A). However, one might make use of the balancing-characteristics of a symmetric game also in an asymmetric game. For example, one can construct a game where a player's gains from coordination similarly correspond to her losses from miscoordination. Thereby, the strength of potential-game theory could be transferred to an asymmetric setup, such that no prediction is feasible when possible gains and losses are identical for all players whereas the theory would suggest coordination on the Pareto-dominant equilibrium when gains are larger than losses and coordination on the secure equilibrium when losses are larger than gains.

		Number of Y						
Number of X	Role	7	6	5	4	3	2	1
	7	X	103	81	59	37	15	-7
		Y	103	102	101	100	99	98
	6	X	92	92	70	48	26	4
		Y	91	102	101	100	99	98
	5	X	81	81	81	59	37	15
		Y	79	90	101	100	99	98
	4	X	70	70	70	70	48	26
		Y	67	78	89	100	99	98
3	X	59	59	59	59	59	37	15
	Y	55	66	77	88	99	98	97
	2	X	48	48	48	48	48	26
2	Y	43	54	65	76	87	98	97
	1	X	37	37	37	37	37	37
	Y	31	42	53	64	75	86	97

(a) Treatment HR77

		Number of Y						
Number of X	Role	7	6	5	4	3	2	1
	7	X	133	111	89	67	45	23
		Y	73	72	71	70	69	68
	6	X	122	122	100	78	56	34
		Y	61	72	71	70	69	68
	5	X	111	111	111	89	67	45
		Y	49	60	71	70	69	68
	4	X	100	100	100	100	78	56
		Y	37	48	59	70	69	68
3	X	89	89	89	89	89	67	45
	Y	25	36	47	58	69	68	67
	2	X	78	78	78	78	78	56
2	Y	13	24	35	46	57	68	67
	1	X	67	67	67	67	67	67
	Y	1	12	23	34	45	56	67

(b) Treatment HR11

Notes: 77 indicates that the Pareto-dominant equilibrium (7,7) is equality-dominant and 11 indicates that the secure equilibrium (1,1) is equality-dominant. HR refers to high risk.

Figure 3: Reported is the normal form representation of treatments HR77 and HR11.

where  $\zeta_l > \zeta_h \geq 0$  is the adjustment factor of the low-cost and high-cost type, respectively. Note that this game cannot be analyzed using potential-game theory.<sup>13</sup>

In the first experiment, low-cost and high-cost types had an identical adjustment factor of  $\zeta_l = \zeta_h = 0$ . In the second experiment, low-cost types have an adjustment factor of  $\zeta_l = 10$  and high-cost types still have an adjustment factor of  $\zeta_h = 0$ . Thereby, both cost types have the same costs from miscoordination. We again conduct one treatment with an equality-dominant Pareto-dominant equilibrium and one with an equality-dominant secure equilibrium. We call the respective treatments HR77 and HR11 (HR = High risk). Figure 2 illustrates the payoff matrix of the two treatments.

## Hypothesis

We are particularly interested in HR11 as it serves as a test whether it is actually the low risk faced by the low-cost type that makes her able to stabilize the payoff-unequal Pareto-dominant equilibrium despite the theoretical prediction that groups coordinate on the secure equilibrium in LR11. Treatment HR77 serves as a test on whether coordination on

<sup>13</sup> We cannot apply potential-game theory in the treatments with high-risk as the construction of individual payoffs in these treatments does not allow to construct a potential function (see Appendix A.2 for details). In other words, the low-risk treatments (LR11 and LR77) are potential games because they allow for a construction of a potential function according to equation A.5. The high-risk treatments (HR11 and HR77) do not allow to construct a potential function and are thus, by definition, not a potential game. However, for the latter treatments, we can compare the change in individual payoffs from a change in strategy to see how effort choice depends on the level of social preferences. Because low-cost types always profit from higher matched action profiles, we derive a threshold level of disadvantageous inequality of the high-cost type  $\alpha_h$ , above which the secure equilibrium is chosen under high risk when it has equal payoffs. If the Pareto-dominant equilibrium has equal payoffs, increased risk has no effect. See Proposition 2 in Appendix A.4 for details on the threshold level of  $\alpha$  and how it is in line with estimated values from the literature.

the Pareto-dominant equilibrium is robust to increased risk when it is equality-dominant.

We hence expect to find further evidence in line with Hypothesis 1 and Hypothesis 2 and propose the following additional hypothesis:

**Hypothesis 3** [*Choices HR11 vs LR11*] *Subjects choose lower effort levels in HR11 than in LR11 and groups coordinate on the secure equilibrium more often in HR11 than in LR11.*

## Results

For our analysis, we are again mainly interested in effort choices, coordination success and efficiency. In the combined data set, we have 7680 observations clustered in 32 cohorts in a panel-structure dataset, resulting in eight independent observations for each of the four treatments: LR77, LR11, HR77, HR11.

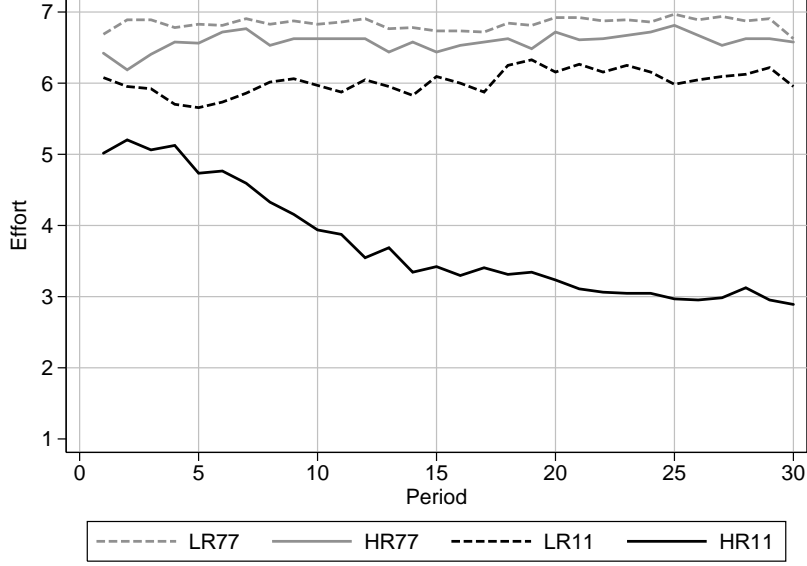
**Effort choices.** In the one-shot decisions, in HR77, a total of 87.5% choose the maximum and 3.1% choose the minimum while in HR11 54.7% choose the maximum and 17.2% choose the minimum; effort choices differ significantly (6.58 vs. 5.19, U-test,  $p = 0.0000$ ). In addition, efforts in HR11 differ from those in LR11 (5.19 vs. 6.28, U-test,  $p = 0.0021$ ) whereas choices in HR77 and LR77 do not differ significantly (6.58 vs. 6.47, U-test,  $p = 0.7649$ ). Regarding the repeated-interaction data, we also observe that effort choices in HR77 are significantly and economically larger than in HR11 (6.58 vs. 3.72  $p = 0.0046$ ) and that HR77 is not statistically distinguishable from LR77 (6.84 vs. 6.58, U-test,  $p = 0.6737$ ). Moreover, effort choices differ significantly between LR11 and HR11 (6.02 vs. 3.72, U-test,  $p = 0.0209$ ).

Figure 4 shows the mean effort chosen over all periods for each treatment. While average effort levels remain fairly constant in LR77 and HR77, the gap between LR11 and HR11 widens.

These results imply a difference in effort choices conditional on the equality-dominant equilibrium, in particular when the low-cost type faces high costs from miscoordination. Even though also in HR11 mean efforts are rather high initially, there is a strong decrease over the course of the experiment. In contrast, increased risk does not seem to affect behavior when the Pareto-dominant equilibrium is equal.

**Result 3** [*Choices I*] *Effort choices are higher in LR77 than in LR11 and subjects choose lower effort levels in HR11 than in LR11. We observe no difference between HR77 and LR77. The gap between HR11 and the other treatments widens over the course of the experiment.*

We further run parametric regressions to analyze the effect of our two variations (equality dominance and costs of miscoordination) on effort choices while controlling for



Notes: Reported are the average effort levels over periods separated by treatment.  $N = 256$ . *77* indicates that the Pareto-dominant equilibrium (7,7) is equality-dominant and *11* indicates that the secure equilibrium (1,1) is equality-dominant. *LR* refers to low risk and *HR* refers to high risk.

Figure 4: Average Effort across Treatments.

demographics and the attitudinal variables regarding risk and social preferences that we define in Appendix D.1. Dummy variable *ED11* takes value one if (1,1) is equality-dominant and zero if (7,7) is equality-dominant. *High Risk* takes value one if the costs of miscoordination for the low-cost type are high and zero if they are low. We use these two dummies and their interaction as our main explanatory variables. Their factorial crossing generates all four treatment conditions. It follows that the baseline treatment is LR77. *Period* is an integer variable indicating the period in which a decision is made. The dummy *HC Type* takes the value one for high-cost types and zero for low-cost types.

Table 1 shows the results of random-effects regressions of effort choices on the treatment factors and controls. The first two models utilize the complete data while the last two models are based on data from only the last five periods to observe behavior after some convergence. Models (I) and (III) analyze the main explanatory variables and control for period. Models (II) and (IV) control for players' types, demographics and attitudinal variables. Models (II Type) and (IV Type) examine the interaction effects of the two cost types.

The results confirm our previous analyzes and show that the effects are robust over time and against the inclusion of controls. We find that the impact of equality dominance is significant and that risk has no significant effect by itself. The coefficients have the hypothesized signs. If (1,1) is equality-dominant, subjects choose lower effort levels than if (7,7) is equality-dominant. The interaction effect between equality dominance and risk



Table 1: Repeated-Interaction Effort: Random-Effects Regressions

Model Estimation	All Periods			Last Five Periods		
	(I) GLS	(II) GLS	(II Type) GLS	(III) GLS	(IV) GLS	(IV Type) GLS
ED11	-0.818*** (0.278)	-0.657** (0.281)	-0.096 (0.161)	-0.759** (0.324)	-0.562* (0.317)	0.012 (0.216)
High Risk	-0.254 (0.234)	-0.141 (0.242)	-0.071 (0.128)	-0.241 (0.200)	-0.087 (0.219)	0.047 (0.118)
ED11 X High Risk	-2.048*** (0.768)	-2.228*** (0.705)	-2.674*** (0.678)	-2.866*** (0.851)	-3.106*** (0.760)	-3.741*** (0.800)
Period	-0.016* (0.009)	-0.016* (0.009)	-0.016* (0.009)	-0.022 (0.023)	-0.022 (0.023)	-0.022 (0.023)
HC Type		-0.682*** (0.146)	-0.285** (0.140)		-0.659*** (0.166)	-0.280** (0.123)
Age		0.003 (0.021)	0.004 (0.021)		0.001 (0.024)	0.003 (0.023)
Male		-0.151 (0.166)	-0.158 (0.161)		-0.371 (0.231)	-0.369 (0.232)
German Native		-0.337 (0.222)	-0.354 (0.223)		-0.429* (0.253)	-0.458* (0.259)
Risk-Averse		-0.416 (0.282)	-0.459 (0.291)		-0.246 (0.492)	-0.286 (0.506)
Risk-Seeking		0.298 (0.414)	0.259 (0.431)		0.365 (0.493)	0.334 (0.514)
Social Preference		-0.055 (0.039)	-0.062 (0.039)		-0.046 (0.048)	-0.052 (0.047)
HC Type X ED11			-1.107*** (0.386)			-1.129** (0.449)
HC Type X High Risk			-0.131 (0.287)			-0.258 (0.324)
HC Type X ED11 X High Risk			0.893* (0.513)			1.267** (0.614)
Constant	7.085*** (0.159)	8.088*** (0.715)	7.943*** (0.712)	7.459*** (0.644)	8.464*** (0.996)	8.307*** (0.998)
Observations	7680	7680	7680	1280	1280	1280
Subjects	256	256	256	256	256	256
Cohorts	32	32	32	32	32	32
R2	0.29	0.33	0.34	0.41	0.45	0.46

Notes: Reported are random-effects GLS regressions with random effect on subject. Dependent variable is the chosen effort. Models (I), (II), and (II Type) are based on data from all periods. Models (III), (IV) and (IV Type) are based on data from the last five periods. *ED11* indicates that (1,1) is equality-dominant. *High Risk* indicates high risk. *HC Type* indicates high-cost types. Standard errors clustered on the cohort level in parentheses. \* < 0.10, \*\* < 0.05, \*\*\* < 0.01.

is quantitatively large and significant. In line with our previous results, risk influences subjects' effort choices only if (1,1) is equality-dominant while efficient coordination is

robust to increased risk when (7,7) is equality-dominant. Regarding the control variables, we see that none of the demographic or attitudinal variables has a consistent effect on effort choices.

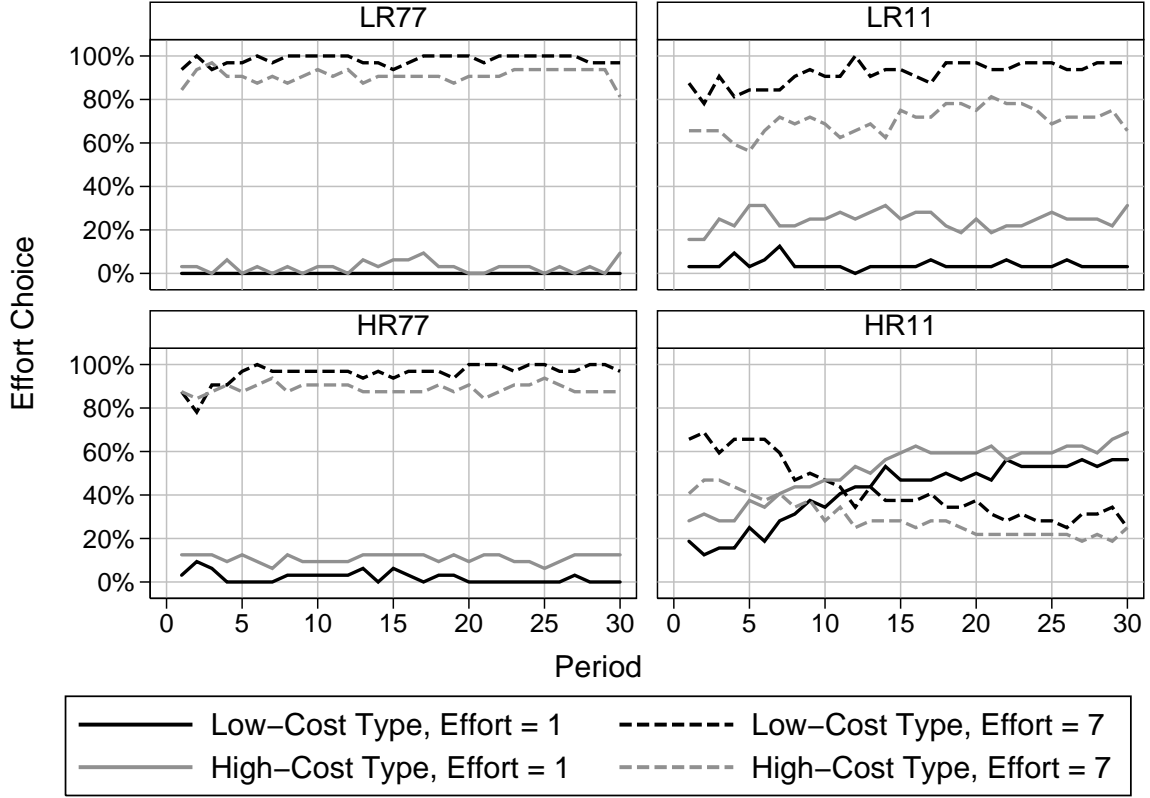
Models (II) and (IV) suggest that *HC Type* has a negative effect on effort choices, i.e., high-cost types choose lower effort levels (see also Table A.4 in the Appendix for an overview of the results conditional on the cost type). We disentangle the impact of the cost type in two further models. In Models (II Type) and (IV Type), we interact the *HC Type*-dummy with the treatment indicators. We find that the main effect of equality dominance vanishes while its interaction with risk increases in absolute terms and remains significant. The main effect of *HC Type* is now less in absolute terms but remains significant. The interaction terms including *HC Type* show that if (1,1) is equality-dominant, high-cost types choose significantly lower effort levels. The interaction between *HC Type* and *High risk* is not significant, suggesting that the two cost types do not react differently to risk. Finally, the three-way interaction confirms that the low-cost types under high costs of miscoordination abstain from choosing high effort levels if (1,1) is equality-dominant because it is getting too expensive to stabilize against the partner's choice.

This results in the convergence towards less-efficient equilibria indicated in Figure 5. The figure shows how often the minimum and maximum are chosen by the two cost types; both types most often choose the maximum effort in LR77 whereas high-cost types choose the maximum less and the minimum more often in LR11. This indicates the role of inequality. Even though low-cost types tend to generally stay with the maximum effort, some high-cost types refuse to choose the maximum when the Pareto-dominant equilibrium has unequal payoffs. This consequently results in some non-equilibrium outcomes. However, because low-cost types do not lose much from miscoordination in LR11, they continue to choose high effort levels, anticipating enough high-cost types to also choose high efforts. This strongly reduces uncertainty for the high-cost type and basically transforms the situation into an allocation decision. A large fraction of high-cost players then chooses the maximum and consequently, coordination on the payoff-unequal Pareto-dominant equilibrium is common.<sup>14</sup>

The bottom panel shows the treatments with high risk (HR). In the left graph, we observe that both types still most often choose the maximum in HR77 whereas the right graph shows how increased costs of miscoordination affect behavior when the secure

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<sup>14</sup>This is remarkable as the low-cost player achieves almost twice the payoff of the high-cost player in this case. However, it seems in line with previous results from allocation decisions. For example, Charness and Rabin (2002) provide a dictator game where decision makers choose between (400, 400) and (400, 750) for themselves and their partner, with these payoffs being very similar to our game when only comparing the Pareto-dominant and the secure equilibrium. Also in their case 69% of all decision makers go for the latter option showing the strong interest of dictators in efficiency. See also Engelmann and Strobel (2004) for similar observations.



Notes: Reported is the frequency of effort choice for the maximum (7) and the minimum (1) effort level for low-cost and high-cost types over periods separated by treatments.  $N = 256$ . 77 indicates that the Pareto-dominant equilibrium (7,7) is equality-dominant and 11 indicates that the secure equilibrium (1,1) is equality-dominant. *LR* refers to low risk and *HR* refers to high risk.

Figure 5: Frequency of Effort Choice across Treatments.

equilibrium is equality-dominant. In contrast to LR11, in HR11, it seems to get too expensive for the low-cost type to stick to the maximum when a considerable share of high-cost types chooses low efforts. It is simply too costly to stabilize coordination. Consequently, we observe that maximum efforts get less frequently chosen while minimum efforts become more prevalent.

**Result 4 [Choices II]** *Effort choices in LR77 and HR77 are high and similar throughout the experiment, regardless of the player type. In LR11, a considerable share of high-cost types does not choose the maximum but the low-cost types nevertheless almost exclusively choose the maximum. In HR11, we observe a convergence towards lower efforts as both player types choose more often the minimum and less often the maximum effort over the course of time.*

**Coordination and efficiency.** In the one-shot part, increasing risk in HR77 does not have a significant effect on coordination (75.0%) when compared to LR77 (71.9%),

Fisher’s exact test,  $p = 1.0000$ ). In contrast, coordination rates decrease when (1,1) is equality-dominant and risk is high. Treatment HR11 achieves 25.0% coordination. This 64% drop from LR11 is both economically large and statistically significant (68.8%, Fisher’s exact test,  $p = 0.0010$ ). As with coordination, efficiency is not affected by increased risk in HR77 where groups realize 85.9% (89.8% in LR77, U-test,  $p = 0.9106$ ) whereas efficiency decreases if (1,1) is equality-dominant and risk is high. Efficiency drops by around 41% to 51.1% in HR11 when compared to HR77 (U-test,  $p = 0.0001$ ).

When analyzing the repeated interaction data, increasing risk still has no significant effect on coordination if (7,7) is equality-dominant; neither in terms of the frequency to coordinate on (7,7) (90.0% vs. 85.9%, U-test,  $p = 0.6717$ ) or (1,1) (0.0% vs 0.5%, U-test,  $p = 0.1441$ ) nor in terms of the miscoordination rate (10.0% vs. 13.5%, U-test,  $p = 0.6717$ ). However, if (1,1) is equality-dominant, coordination on (7,7) drops from 66.0% to 23.1% if risk is high (U-test,  $p = 0.0208$ ) while there is no statistical difference in the frequency of miscoordination which averages 32.1% in LR11 and 34.4% in HR11 (U-test,  $p = 0.5982$ ). Coordination on (1,1) seems to get more common with high risk, increasing from 1.8% in LR11 to 36.8% in HR11 (U-test,  $p = 0.0548$ ). With regard to efficiency, we find that inequality affects outcomes in both cases. Groups in LR77 realize more efficiency than groups in LR11 (96.9% vs. 81.8%, U-test,  $p = 0.0156$ ) and groups in HR77 realize more than those in HR11 (87.3% vs. 54.6%, U-test,  $p = 0.0063$ ). Furthermore, efficiency in HR77 is again not statistically different from LR77 (U-test,  $p = 0.3713$ ). Compared to treatment LR11, treatment HR11 features a drop in efficiency which falls by around 33% to 54.6% (U-test,  $p = 0.0157$ ).

We complement the analyses on coordination outcomes and efficiency using parametric regressions in Appendix D.2, confirming these findings. In addition, these analyses provide a better understanding of learning dynamics over time as both models include a the variable ‘Period’ that shows how coordination and efficiency evolves over time. We find in both cases some indication that groups are better able to coordinate and realize efficiency over time which suggests that groups learn. Focusing only on the last 5 periods of the experiment provides a different picture as here coordination and efficiency decreases which may be due to an end-game effect.

**Result 5** *[Coordination and efficiency] Groups in HR11 coordinate more often on the secure equilibrium, less often on the Pareto-dominant equilibrium and realize less efficiency than groups in LR11. Groups in HR77 and LR77 are similar with regard to coordination success and realized efficiency. Both differ considerably and significantly in terms of behavior and efficiency from HR11 and LR11.*

Taken together, these results suggest that coordination and efficiency are hampered in case of an equality-dominant secure equilibrium. The extent of this effect crucially depends on the costs of miscoordination faced by the player who earns more from successful

coordination.

## 6 Conclusion

We investigate the effects of payoff (in)equality in a minimum-effort game with Pareto-rankable equilibria where coordination on the inefficient secure equilibrium is often observed in the repeated symmetric game. Our study is motivated by findings on social-comparison effects across a broad range of social interactions, by the poor coordination performance of groups in the repeated MEG and by the fact that real-world coordination scenarios are likely often asymmetric rather than symmetric.

We find that inequality can play an important role in MEG-equilibrium selection. When the Pareto-dominant equilibrium is also equality-dominant, subjects coordinate on the maximum effort rapidly. This outcome is robust to increasing the costs of miscoordination for the low-cost type which is remarkable because she could even make losses from miscoordination in the respective treatment. This suggests that subjects are very certain about others' behavior if the Pareto-dominant is the only equilibrium with equal payoffs. When the secure equilibrium is equality-dominant, coordination success worsens. In this case, we find a strong interaction of the costs of miscoordination faced by the low-cost type and equality dominance, often resulting in coordination on the Pareto-dominant equilibrium when her costs of miscoordination are low and in coordination on the secure and least-efficient equilibrium when her costs are high. Our experiment thereby suggests that an equal-payoff Pareto-dominant equilibrium can cause substantial efficiency gains and that a player who earns more from successful coordination while losing little from miscoordination can stabilize the play of the Pareto-dominant equilibrium even when it implies highly unequal payoffs.

Our study also provides suggestive evidence with respect to the success of potential-game theory of predicting outcomes in MEG-coordination and suggests it may not be well-suited to analyze behavior in very asymmetric minimum-effort games as an asymmetry in the gains from coordination also implies an asymmetry in the costs of miscoordination. Here, further research seems desirable to provide a clearer picture regarding the explanatory power of potential-game theory in asymmetric contexts.

An alternative ad-hoc explanation that comes to mind for our main effect is that it is not driven by an aversion to inequality but rather by the mere prominence of the equality-dominant equilibrium. In other words, the equality-dominant equilibrium might serve as a focal point. However, this notion seems at odds with our empirical results. Take treatment LR11 for example. Focality would suggest that both types select the secure and equality-dominant equilibrium. We do not observe this in the data (see Figure 5). Instead, we observe about 20% of the high-cost players choosing the minimum throughout

the experiment even though they should have learned that low-cost players generally choose the maximum effort. This seems to indicate that a substantial share of subjects displays an envious aversion to inequality rather than merely choosing the minimum effort as focal point. In HR11, this results in coordination on lower equilibria as it gets too expensive for the low-cost type to stabilize the Pareto-dominant equilibrium.

Still, focal points are certainly important drivers of behavior in our MEG as suggested for example by the small amount of intermediate strategy choices. As we add a second dimension of focality (equality) to either the focal Pareto-dominant or the focal secure equilibrium, the effect of equality in our setup may be even stronger for other equilibria as the second focality dimension might yield weaker effects. Future research could hence investigate the effect of an equal intermediate equilibrium, e.g. (4,4), in order to test whether it yields even stronger effects in MEG-coordination.

The minimum-effort game is used to model various real-world scenarios such as global public good games, computer security, or team production. However, so far, it has mainly been studied in its symmetric version. The respective research emphasizes that groups often converge towards the secure and inefficient equilibrium in repeated interaction. In the current paper, we demonstrate the relevance of considering inequality in this context. It seems important as, first, actual coordination settings are likely often asymmetric and, second, we indeed observe substantial effects of inequality on groups' ability to coordinate efficiently.

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# Appendices

## A Theoretical Appendix

### A.1 Construction of the Fixum

The fixum  $d(\theta, \tau)$  determines which of the two extreme equilibria is equality-dominant. We discuss the construction of the value of  $d(\theta, \tau)$  in the following.

**Secure Equilibrium is Equality-Dominant.** In this case,  $\tau = \underline{\tau}$  and  $d(\theta, \underline{\tau})$  is given by:

$$d(\theta, \underline{\tau}) = 0, \quad \theta = l, h. \quad (\text{A.2})$$

Hence, there is no adjustment of payoffs for  $\tau = \underline{\tau}$  and the constants  $a, c_l$  and  $c_h$  scale payoffs such that  $\underline{\mathbf{e}}^* = (e_1^0, \dots, e_n^0)$  is equality-dominant. In any other equilibrium  $\mathbf{e}^*$ , payoff inequality between the low and high-cost type is given by  $(\mathbf{e}^* - 1)(c_h - c_l)$ . Hence, the slope of inequality is constant and greater equilibria generate greater payoff inequality.

**Pareto-Dominant Equilibrium is Equality-Dominant.** In this case,  $\tau = \bar{\tau}$  and  $d(\theta, \bar{\tau})$  is given by:

$$d(\theta, \bar{\tau}) = \begin{cases} -d & \text{if } \theta = l \\ +d & \text{if } \theta = h. \end{cases} \quad (\text{A.3})$$

In treatment  $\bar{\tau}$ , the additional fixum  $d > 0$  scales payoffs such that the Pareto-dominant equilibrium has equal payoffs, i.e.,  $\bar{\mathbf{e}}^* = (e_1^k, \dots, e_n^k)$  is equality-dominant. We achieve this by setting

$$d = \frac{(|E_i| - 1)(c_h - c_l)}{2} \quad (\text{A.4})$$

such that  $d$  equals the average maximum inequality between the two types. Hence,  $d$  mirrors the previous wedge between payoffs. However, in this case, smaller equilibria generate greater payoff inequality. The slope of inequality is given by the cost difference  $c_h - c_l$  and is the same as if the secure equilibrium was Pareto-dominant. Note that due to the definition of  $d(\theta, \tau)$ , both games have the same efficiency measured by the sum of players' payoffs in each action profile.

### A.2 The Potential Minimum Effort Game

Potential games are games that admit a potential function and only Nash equilibria are local maximizers of this function (Monderer and Shapley, 1996). Applied to the MEG, the theory of potential games can serve as a refinement because it often suggests a global

maximum of the potential conditional on the gains from coordination, the costs of effort provision and the size of the group (Monderer and Shapley, 1996; Anderson, Goeree, and Holt, 2001; Goeree and Holt, 2005; Chen and Chen, 2011). The potential function hence accounts for all players' deviation incentives and in particular coincides with risk dominance in symmetric 2x2 games (Goeree and Holt, 2005).<sup>15</sup>

A potential function  $P$  maps the set of action profiles into the real numbers such that the difference from unilateral deviations is proportional to the difference in the deviator's payoff (Ui, 2001).  $P : E \rightarrow \mathbb{R}$  is called a weighted potential for game MEG if

$$\pi_i(e_i, e_{-i}) - \pi_i(e'_i, e_{-i}) = w_i(P(e_i, e_{-i}) - P(e'_i, e_{-i})) \quad (\text{A.5})$$

for every  $i \in N$  and all  $e_i, e'_i, e_{-i} \in E$ . The parameter  $w_i > 0$  is the weighting factor. An MEG is called a  $w$ -potential game if it admits a weighted potential function. The potential is unique up to an additive constant. If  $w_i = 1$  for every  $i$ ,  $P$  is an exact potential and MEG an (exact) potential game.

Potential games have several interesting features. First, every local maximizer of the potential function is a Nash equilibrium but not vice versa. Hence, the potential can refine the set of equilibria if  $P$  has a unique maximizer (Monderer and Shapley, 1996).<sup>16</sup> Second, the argmax set of  $P$  has the largest basin of attraction and several learning algorithms converge to this set. Monderer and Shapley (1996) show that every finite weighted potential game has the fictitious-play property (Brown, 1951). Fictitious play is a belief-based learning process that selects a pure strategy given the current history of an opponent's choices.<sup>17</sup> In addition, better-response dynamics (Young, 1993) as well as log-linear learning (Marden and Shamma, 2012) typically converge to the argmax set of  $P$ . Further, Ui (2001) shows that the unique maximizer of  $P$  is robust to imperfect information (Kajii and Morris, 1997).<sup>18</sup>

Monderer and Shapley (1996) show that the symmetric MEG is a potential game

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<sup>15</sup>Equilibrium selection based on strategic uncertainty is at the core of the concept of *risk dominance* (Harsanyi and Selten, 1988). Risk dominance is an equilibrium-selection criterion that incorporates the deviation incentives of each player. The risk-dominant equilibrium has the highest loss from unilateral deviation. The according risk-dominant strategy is also a best reply to a strategy that plays each action with equal probability. In symmetric 2x2 coordination games, such as the stag-hunt game, the secure equilibrium is usually also risk-dominant. Although this concept is theoretically appealing and experimentally successful (e.g., Cabrales, Garcia-Fontes, and Motta, 2000), it is not clear how to generalize it to games with larger action spaces.

<sup>16</sup> Further, if  $P$  is concave and continuously differentiable, then every mixed-strategy equilibrium profile is pure and maximizes  $P$  (see Neyman, 1997 and Footnote 4 in Monderer and Shapley, 1996).

<sup>17</sup>Fictitious play modifies the player's beliefs given the history of his opponents' choices. The player then rationally chooses an action based on these beliefs.

<sup>18</sup>An equilibrium of the complete-information game  $G$  is robust if every incomplete-information game with payoffs given by  $G$  with high probability has a Bayesian-Nash equilibrium such that the equilibrium of  $G$  is played with high probability (Ui, 2001).

with the following exact potential

$$P^{\text{MEG}}(\mathbf{e}) = b \min\{\mathbf{e}\} - c \sum_{i \in N} e_i. \quad (\text{A.6})$$

The potential in (A.6) allows to derive a threshold  $b^{\text{MEG}}$  for the benefit parameter  $b$  such that the secure equilibrium is the unique maximizer of  $P^{\text{MEG}}(\mathbf{e})$  if  $b < b^{\text{MEG}}$  and the Pareto-dominant equilibrium is the unique maximizer if  $b > b^{\text{MEG}}$ . The threshold is derived by noting that any candidate action profile to maximize the potential has to be an equilibrium action profile  $\mathbf{e}^*$  where every player chooses the same effort, i.e.,  $e_i = e$  for every  $i$ .<sup>19</sup> Hence, the equilibrium potential of game MEG is given by  $P^{\text{MEG}}(\mathbf{e}^*) = be - nce$  with threshold benefit  $b^{\text{MEG}} = nc$ . If  $b < b^{\text{MEG}}$ , then  $P^{\text{MEG}}(\mathbf{e})$  is maximized at  $\underline{\mathbf{e}}^*$  where  $e_i = e^0$  for every  $i$ . If  $b > b^{\text{MEG}}$ , then  $\bar{\mathbf{e}}^*$ , where  $e_i = e^k$  for every  $i$ , maximizes  $P^{\text{MEG}}(\mathbf{e})$ . If  $b = b^{\text{MEG}}$ , every equilibrium maximizes  $P^{\text{MEG}}(\mathbf{e})$  and the potential does not refine the set of equilibria.

Anderson, Goeree, and Holt (2001), Goeree and Holt (2005), and Chen and Chen (2011) augment this deterministic theory of potential games by allowing for decision errors in the sense of quantal responses (McKelvey and Palfrey, 1995). Introducing noise into the decision process weakens the clear-cut statements obtained from the potential and turns them more into a prediction about convergence. Both Goeree and Holt (2005) and Chen and Chen (2011) experimentally find that coordination outcomes in a continuous symmetric MEG with groups of two players closely resemble the prediction of such stochastic potential games after some learning. Thus, outcomes predicted by potential game theory in fact often coincide with empirical behavior when it comes to behavior in the MEG.

### A.3 The Asymmetric (Potential) Minimum Effort Game

As discussed in Section 2, our asymmetric minimum effort game (aMEG) has the same set of players and the same action set as the standard symmetric MEG. However, the individual payoff function with heterogeneous costs reads:

$$\pi_i^{\text{het}}(\mathbf{e}; \theta, \tau) = \begin{cases} b \min\{\mathbf{e}\} - c_l e_i + a + c_l + d(l, \tau) & \text{if } \theta = l \\ b \min\{\mathbf{e}\} - c_h e_i + a + c_h + d(h, \tau) & \text{if } \theta = h, \end{cases} \quad (\text{A.7})$$

where  $b > c_h > c_l > 0$ . Hence, the set and Pareto-ranking of Nash equilibria is the same as in the symmetric MEG.

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<sup>19</sup>This observation holds for all potentials in this paper and we thus focus on the equilibrium potential and the equilibrium benefit for clarity of exposition. Nevertheless, keep in mind that a potential has to fulfill condition (A.5).

We introduce social preferences in the form of inequity aversion into game aMEG =  $(N, E, \pi_{i,\theta,\tau})$  and analyze the effect of payoff inequality on the equilibrium threshold benefit and hence on equilibrium selection. We assume that subjects have social preferences and are in particular averse to payoff inequality. Fehr and Schmidt (1999) propose that people dislike absolute payoff differences. They distinguish advantageous inequality where the individual earns more than her peers and disadvantageous inequality where the individual earns less than her peers. Hence, in an aMEG, individual utility under Fehr-Schmidt (FS) preferences is given by:

$$u_i(\mathbf{e}; \theta, \tau, \alpha, \beta) = \pi_{i,\theta,\tau} - \alpha \frac{1}{n-1} \sum_{j \neq i} \max\{\pi_{j,\theta,\tau} - \pi_{i,\theta,\tau}, 0\} - \beta \frac{1}{n-1} \sum_{j \neq i} \max\{\pi_{i,\theta,\tau} - \pi_{j,\theta,\tau}, 0\}. \quad (\text{A.8})$$

The factor  $\beta \in [0, 1)$  weights guilt against the own monetary payoff and  $\alpha \geq 0$  weights envy for every  $i$ . Fehr and Schmidt (1999) further assume that people are loss-averse in social comparison, i.e., envy weights heavier than guilt and hence  $\alpha \geq \beta$ . Note that payoffs only differ between types but are equal within types. We abbreviate (A.8) by  $u_i$  and denote the aMEG with social preferences by aMEG-SP =  $(N, E, u_i)$ .<sup>20</sup>

We need to place some weak restrictions on the absolute levels of  $\alpha$  and  $\beta$  to ensure that only diagonal strategy vectors are equilibria, i.e., where  $e_i = e$  for every  $i$ . Otherwise, if  $\alpha$  and  $\beta$  are too extreme, social preferences outweigh individual payoffs to an extent where the model does not make reasonable predictions. For ease of exposition, consider two players (one low-cost and one high-cost player). For  $\alpha$ , note that if  $\tau = \bar{\tau}$ , the low-cost player unilaterally deviates from the diagonal action profile to the safe action if and only if  $u_i((e_i = e_j = e); l, \bar{\tau}, \alpha, \beta) > u_i((e_i = 1, e_j = e); l, \bar{\tau}, \alpha, \beta)$ . With  $e > 1$  and  $u_i(\mathbf{e}; h, \bar{\tau}, \alpha, \beta) > u_i(\mathbf{e}; l, \bar{\tau}, \alpha, \beta)$ , the inequality is equivalent to  $\alpha < (b - c_l)/c_l =: \alpha^{max}$ . With the parameters in the experiment, we get  $\alpha^{max} < 11$ .

For  $\beta$ , assume that in  $\tau = \bar{\tau}$ , the low-cost player chooses the highest effort,  $e_j = e^k$ , but the high-cost player chooses the safe action (i.e., the lowest effort,  $e_i = 1$ ). This results in the largest possible loss for the low-cost player. Further, in this case, the high-cost player has a higher payoff (because he chose the safe action). Hence, if the high-cost player has a very high level of  $\beta$  ("guilt"), he may switch from the safe action to some higher action to reduce this guilt by reducing the loss of the high-cost player. However, by switching to a higher effort level, he now faces a lower payoff than the low-

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<sup>20</sup>Charness and Rabin (2002) introduce a preference for efficiency which can be captured by an additional parameter  $0 \leq \gamma \leq 1$  that weighs total surplus. As Engelmann (2012) shows, this is equivalent to relaxing the restrictions on the inequality parameters and allowing  $\alpha < 0$  and  $\alpha < \beta$ . As we hold efficiency constant across treatments, a preference for efficiency does not explain treatment effects. Further, we cannot derive directional hypotheses without restricting the level of  $\alpha$  and  $\beta$  as this would allow to match any observed behavior in the experiment.

cost player because he has higher costs. For example, the high-cost player could move from  $e_i = 1$  to  $e_i = 2$  to reduce his guilt by forfeiting his own profit but also reducing the loss of the other player. We want to avoid such moves as they seem improbable to describe actual behavior and thus restrict the level of  $\beta$  by imposing the condition that  $u_i((e_i = 1, e_j = e^k); h, \underline{\tau}, \alpha, \beta) > u_i((e_i = 2, e_j = e^k); h, \underline{\tau}, \alpha, \beta)$  or, equivalently,  $\beta < (c_h + \alpha(c_h - c_l(e^k - 1)) - b)/(c_l(e^k - 1)) := \beta^{max}$ .

Note that these restrictions are weak in the sense that they are well in line with empirical estimates of  $\alpha$  and  $\beta$ . For example, Fehr and Schmidt (1999) estimate  $\alpha = 0.85$  and  $\beta = 0.32$  and Blanco et al. (2011) estimate  $\alpha = 0.91$  and  $\beta = 0.38$ . Given the parameters of the experiment, we get  $\alpha < 11$  and thus  $\beta^{max} = 9$ . For reasonable levels of  $\alpha = \{0.5, 0.75, 0.85, 0.91, 1\}$  we get  $\beta^{max} = \{0.25, 0.46, 0.54, 0.59, 0.67\}$ . With the standard restriction imposed above that  $\beta \in [0, 1)$ , it follows that  $\alpha \in [\beta, 1.4)$ . In summary, we only consider  $\alpha_i \in [\beta, \alpha^{max}) \subset [\beta, 1.4)$  and  $\beta_i \in [0, \beta^{max}) \subset [0, 1)$  and thus focus on diagonal equilibria.

Following our construction of aMEG, we can now use the theory of potential games to derive behavioral predictions. The potential function allows us to derive a threshold  $b^{aMEG}$  for the benefit parameter  $b$  such that the secure equilibrium is the unique maximizer of  $P^{MEG}(\mathbf{e})$  if  $b < b^{aMEG}$  and the Pareto-dominant equilibrium is the unique maximizer if  $b > b^{aMEG}$ . If  $b = b^{aMEG}$ , all Nash equilibria maximize the potential resulting in the standard multiplicity of equilibria.

**Lemma 1** [*Equilibrium Threshold Benefit of aMEG-SP*] Under the restrictions on  $\alpha$  and  $\beta$ , in the minimum-effort game with heterogeneous costs and social preferences (aMEG-SP), the equilibrium threshold benefit is given by

$$b^{aMEG-SP}(\tau) = \begin{cases} n_l c_l + n_h c_h - \beta \frac{n_l}{n-1} n_h c_l + \alpha \frac{n_h}{n-1} n_l c_h & \text{if } \tau = \underline{\tau} \\ n_l c_l + n_h c_h + \alpha \frac{n_l}{n-1} n_h c_l - \beta \frac{n_h}{n-1} n_l c_h & \text{if } \tau = \bar{\tau}. \end{cases}$$

*Proof.* Note that game aMEG =  $(N, E, \pi_{i,\theta,\tau})$  is a potential game (see A.2) admitting the following exact potential function:

$$P^{aMEG}(\mathbf{e}) = b \min\{\mathbf{e}\} - c_l \sum_{i \in N_l} e_i - c_h \sum_{i \in N_h} e_i \quad (\text{A.9})$$

where  $N_l$  is the set of low-cost types and  $N_h$  is the set of high-cost types. There are  $n_l$  low-cost types and  $n_h$  high-cost types and  $n = n_h + n_l$ . The equilibrium threshold benefit is thus  $b^{aMEG} = n_l c_l + n_h c_h$ . The interpretation of the threshold is the same as before. If  $b < b^{aMEG}$  then  $\{\underline{\mathbf{e}}^*\} = \arg \max_{\mathbf{e} \in E} P^{aMEG}(\mathbf{e})$  and the secure equilibrium maximizes the potential. If  $b > b^{aMEG}$  then  $\{\bar{\mathbf{e}}^*\} = \arg \max_{\mathbf{e} \in E} P^{aMEG}(\mathbf{e})$  and the Pareto-dominant equilibrium maximizes the potential. If  $b = b^{aMEG}$ , then the potential is the same in all

equilibria.

### Case 1: Secure Equilibrium is Equality-Dominant.

In this case,  $\tau = \underline{\tau}$ , and the payoff difference between types is given by

$$\Delta\pi_{lh}(\underline{\tau}) = \pi_{i,l,\underline{\tau}} - \pi_{j,h,\underline{\tau}} = c_h(e_j - 1) - c_l(e_i - 1) \quad (\text{A.10})$$

with  $\Delta\pi_{lh}(\underline{\tau}) \geq 0$  because only diagonal strategies are played due to the restrictions on  $\alpha$  and  $\beta$ . Players further experience differences within the same type if different efforts are chosen. Hence, the payoff differences within the same type are given by

$$\Delta\pi_{ll}(\underline{\tau}) = \pi_{i,l,\underline{\tau}} - \pi_{j,l,\underline{\tau}} = c_l(e_j - e_i) \quad (\text{A.11})$$

and

$$\Delta\pi_{hh}(\underline{\tau}) = \pi_{i,h,\underline{\tau}} - \pi_{j,h,\underline{\tau}} = c_h(e_j - e_i) \quad (\text{A.12})$$

where the player with the higher effort makes the smaller profit.

Hence, individual utility for low-cost-types under FS preferences is given by

$$\begin{aligned} u_i(\mathbf{e}; l, \bar{\tau}, \alpha, \beta) = & \pi_{i,l} - \alpha \frac{1}{n-1} \sum_{j \in N_l, e_j < e_i} (c_l(e_i - e_j)) - \beta \frac{1}{n-1} \sum_{j \in N_l, e_j > e_i} (c_l(e_j - e_i)) \\ & - \beta \frac{1}{n-1} \sum_{j \in N_h} (c_h(e_j - 1) - c_l(e_i - 1)) \end{aligned} \quad (\text{A.13})$$

where the second term is captures payoff differences against other players of the same type who chose a smaller effort, the third term captures payoff differences against other players of the same type who chose a higher effort, and the last term captures payoff differences against players of the other type.

For players of the high-cost type, individual utility reads as

$$\begin{aligned} u_i(\mathbf{e}; h, \bar{\tau}, \alpha, \beta) = & \pi_{i,h} - \alpha \frac{1}{n-1} \sum_{j \in N_h, e_j < e_i} (c_h(e_i - e_j)) - \beta \frac{1}{n-1} \sum_{j \in N_h, e_j > e_i} (c_h(e_j - e_i)) \\ & - \beta \frac{1}{n-1} \sum_{j \in N_l} (c_h(e_j - 1) - c_l(e_i - 1)) \end{aligned} \quad (\text{A.14})$$

where the terms have the same meaning as in the low-cost case.

The requirement for a potential  $P$  is given by  $\frac{\partial P}{\partial e_i} = \frac{\partial u_i}{\partial e_i}$  for all players across both

types. This requirement is fulfilled by the following potential

$$\begin{aligned}
P^{\text{aMEG-SP}}(\underline{\tau}) &= b \min\{\mathbf{e}\} - \sum_{i \in N_l} c_l e_i - \sum_{i \in N_h} c_h e_i \\
&+ \sum_{i \in N_l} \left( -\frac{\alpha}{n-1} \sum_{j \in N_l, e_j < e_i} c_l + \frac{\beta}{n-1} \sum_{j \in N_l, e_j > e_i} c_l + \frac{\beta}{n-1} \sum_{j \in N_h} c_l \right) \times e_i \\
&+ \sum_{i \in N_h} \left( -\frac{\alpha}{n-1} \sum_{j \in N_h, e_j < e_i} c_h + \frac{\beta}{n-1} \sum_{j \in N_h, e_j > e_i} c_h - \frac{\alpha}{n-1} \sum_{j \in N_l} c_h \right) \times e_i.
\end{aligned} \tag{A.15}$$

With the restrictions on  $\alpha$  and  $\beta$  only diagonal strategies are chosen, i.e.,  $e_i = e_j = e$  for all  $i, j$ . Hence, there are no differences within types and the potential reduces to

$$P^{\text{aMEG-SP}}(\underline{\tau}) = be - \sum_{i \in N_l} c_l e - \sum_{i \in N_h} c_h e + \sum_{i \in N_l} \left( \frac{\beta}{n-1} \sum_{j \in N_h} c_l \right) \times e + \sum_{i \in N_h} \left( -\frac{\alpha}{n-1} \sum_{j \in N_l} c_h \right) \times e. \tag{A.16}$$

Noting that  $\sum_{i \in N_l} c_l = n_l c_l$  and  $\sum_{i \in N_h} c_h = n_h c_h$ , we can also write

$$P^{\text{aMEG-SP}}(\underline{\tau}) = be - n_l c_l e - n_h c_h e + \beta \frac{n_l}{n-1} n_h c_l e - \alpha \frac{n_h}{n-1} n_l c_h e. \tag{A.17}$$

Hence, the equilibrium threshold benefit is given by

$$b^{\text{aMEG-SP}}(\underline{\tau}) = n_l c_l + n_h c_h - \beta \frac{n_l}{n-1} n_h c_l + \alpha \frac{n_h}{n-1} n_l c_h. \tag{A.18}$$

## Case 2: Pareto-dominant Equilibrium is Equality-Dominant.

In this case,  $\tau = \bar{\tau}$ , and the payoff difference between types is given by

$$\Delta \pi_{hl}(\bar{\tau}) = \pi_{i,h,\bar{\tau}} - \pi_{j,l,\bar{\tau}} = c_l(e_i - 1) - c_h(e_j - 1) + 2d \tag{A.19}$$

with  $\Delta \pi_{hl}(\bar{\tau}) \geq 0$ . Payoff differences within the same type are again given by (A.11) and (A.12). Hence, individual utility for low-cost-types under FS preferences is given by



$$\begin{aligned}
u_i(\mathbf{e}; l, \bar{\tau}, \alpha, \beta) = & \pi_{i,l} - \alpha \frac{1}{n-1} \sum_{j \in N_l, e_j < e_i} (c_l(e_i - e_j)) - \beta \frac{1}{n-1} \sum_{j \in N_l, e_j > e_i} (c_l(e_j - e_i)) \\
& - \alpha \frac{1}{n-1} \sum_{j \in N_h} (c_l(e_i - 1) - c_h(e_j - 1) + 2d)
\end{aligned} \tag{A.20}$$

where only the last term differs compared to Case 1.

For players of the high-cost type, individual utility reads as

$$\begin{aligned}
u_i(\mathbf{e}; h, \bar{\tau}, \alpha, \beta) = & \pi_{i,h} - \alpha \frac{1}{n-1} \sum_{j \in N_h, e_j < e_i} (c_h(e_i - e_j)) - \beta \frac{1}{n-1} \sum_{j \in N_h, e_j > e_i} (c_h(e_j - e_i)) \\
& - \alpha \frac{1}{n-1} \sum_{j \in N_l} (c_l(e_i - 1) - c_h(e_j - 1) + 2d).
\end{aligned} \tag{A.21}$$

The requirement for a potential  $P$  is given by  $\frac{\partial P}{\partial e_i} = \frac{\partial u_i}{\partial e_i}$  for all players across both types. This requirement is fulfilled by the following potential

$$\begin{aligned}
P^{\text{aMEG-SP}}(\underline{\tau}) = & b \min\{\mathbf{e}\} - \sum_{i \in N_l} c_l e_i - \sum_{i \in N_h} c_h e_i \\
& + \sum_{i \in N_l} \left( -\frac{\alpha}{n-1} \sum_{j \in N_l, e_j < e_i} c_l + \frac{\beta}{n-1} \sum_{j \in N_l, e_j > e_i} c_l - \frac{\alpha}{n-1} \sum_{j \in N_h} c_l \right) \times e_i \\
& + \sum_{i \in N_h} \left( -\frac{\alpha}{n-1} \sum_{j \in N_h, e_j < e_i} c_h + \frac{\beta}{n-1} \sum_{j \in N_h, e_j > e_i} c_h + \frac{\beta}{n-1} \sum_{j \in N_l} c_h \right) \times e_i,
\end{aligned} \tag{A.22}$$

which, given the restrictions on  $\alpha$  and  $\beta$  again reduces to

$$P^{\text{aMEG-SP}}(\underline{\tau}) = be - n_l c_l e - n_h c_h e - \alpha \frac{n_l}{n-1} n_h c_l e + \beta \frac{n_h}{n-1} n_l c_h e. \tag{A.23}$$

Hence, the equilibrium threshold benefit is given by

$$b^{\text{aMEG-SP}}(\bar{\tau}) = n_l c_l + n_h c_h + \alpha \frac{n_l}{n-1} n_h c_l - \beta \frac{n_h}{n-1} n_l c_h. \tag{A.24}$$

□

The equilibrium threshold benefit of game aMEG (no social preferences) is given by  $b^{\text{aMEG}} = n_l c_l + n_h c_h$ . By comparing this threshold with the equilibrium threshold benefit stated in Lemma 1, we arrive at the statement given in Proposition 1.

**Proposition 1** [*Equilibrium Selection Under Social Preferences*]

*Consider  $b = b^{\text{aMEG}}$ . Under social preferences, if the secure equilibrium is equality-dominant, subjects choose the minimum effort level. If the Pareto-dominant equilibrium is equality-dominant, subjects choose the maximum effort level if the aversion to disadvantageous inequality (envy) does not outweigh the cost ratio.*

*Proof.* Consider the equilibrium threshold without social preferences,  $b = b^{\text{aMEG}}$ , and note that it is the same across treatments, i.e.,  $b^{\text{aMEG}} = b^{\text{aMEG}}(\underline{\tau}) = b^{\text{aMEG}}(\bar{\tau})$ . Consider treatment  $\tau = \underline{\tau}$ . If  $\alpha > \beta \frac{c_l}{c_h}$  then  $b^{\text{aMEG-SP}}(\underline{\tau}) > b^{\text{aMEG}}$ , i.e., the equilibrium potential is maximized in the minimum-effort profile  $\underline{\mathbf{e}}^*$  and all players choose the minimum effort. Because  $\alpha > \beta$  and  $c_h > c_l$ , this condition is always fulfilled. Consider treatment  $\tau = \bar{\tau}$ . If  $\alpha < \beta \frac{c_h}{c_l}$ , then  $b^{\text{aMEG-SP}}(\bar{\tau}) < b^{\text{aMEG}}$ , i.e., the equilibrium potential is maximized in the maximum-effort profile  $\bar{\mathbf{e}}^*$  and all players choose the maximum effort. This condition implies that  $\alpha$  may not be too large that it outweighs the cost ratio between types. This relation is fulfilled by the experimental parameters which imply that  $\frac{\alpha}{\beta} < 11$  which is easily in line with the literature. For example, Fehr and Schmidt (1999) estimate  $\alpha = 0.85$  and  $\beta = 0.32$  such that  $\frac{\alpha}{\beta} = 2.66$ . Blanco et al. (2011) estimate  $\alpha = 0.91$  and  $\beta = 0.38$  such that  $\frac{\alpha}{\beta} = 2.39$ .  $\square$

## A.4 Proposition 2: Equilibrium Selection Under Varying Strategic Uncertainty

Recall that

$$\tilde{\pi}_{i,\theta,\tau} = \pi_{i,\theta,\tau} - \zeta_\theta \cdot \max\{e_i - e_j, 0\} \quad (\text{A.25})$$

where  $\zeta_l > \zeta_h \geq 0$ . Note that varying off-equilibrium payoffs this does not allow to construct a potential function fulfilling condition (A.5) for all  $e_i, e'_i, e_{-i} \in E$ . This is because changes in the potential from unilateral deviations do no longer coincide with changes in the deviator's payoff if  $e_i \neq e_j$ . Thus, we cannot analyze the role of increased risk using the theory of potential games. However, we can determine the best responses of each player given the strategy of his partner under Fehr and Schmidt (1999) preferences.

Note that low-cost type always benefits more from higher matched action profiles, hence, his strategy is to always match his partner's effort level. If the secure equilibrium is equality-dominant, the high-cost type chooses the minimum effort in our high risk setting as long as  $\tilde{\pi}_{i,h,\underline{\tau}}(1, 1) > \tilde{\pi}_{i,h,\underline{\tau}}(2, 1) > \tilde{\pi}_{i,h,\underline{\tau}}(2, 2)$  for the action profile  $\mathbf{e} = (e_l, e_h)$ .

This condition can be rewritten as  $\alpha_h > \underline{\alpha}_h(\beta_h) > 0$  where

$$\underline{\alpha}_h(\beta_h) := \frac{b - c_h}{c_h - c_l} + \beta_h \frac{c_l + \zeta_l}{c_h - c_l} \quad (\text{A.26})$$

denotes a minimum level of disadvantageous inequality for the high-cost type and  $\beta_h$  denotes the advantageous-inequality parameter of the high-cost type. This leads to the Proposition 2.

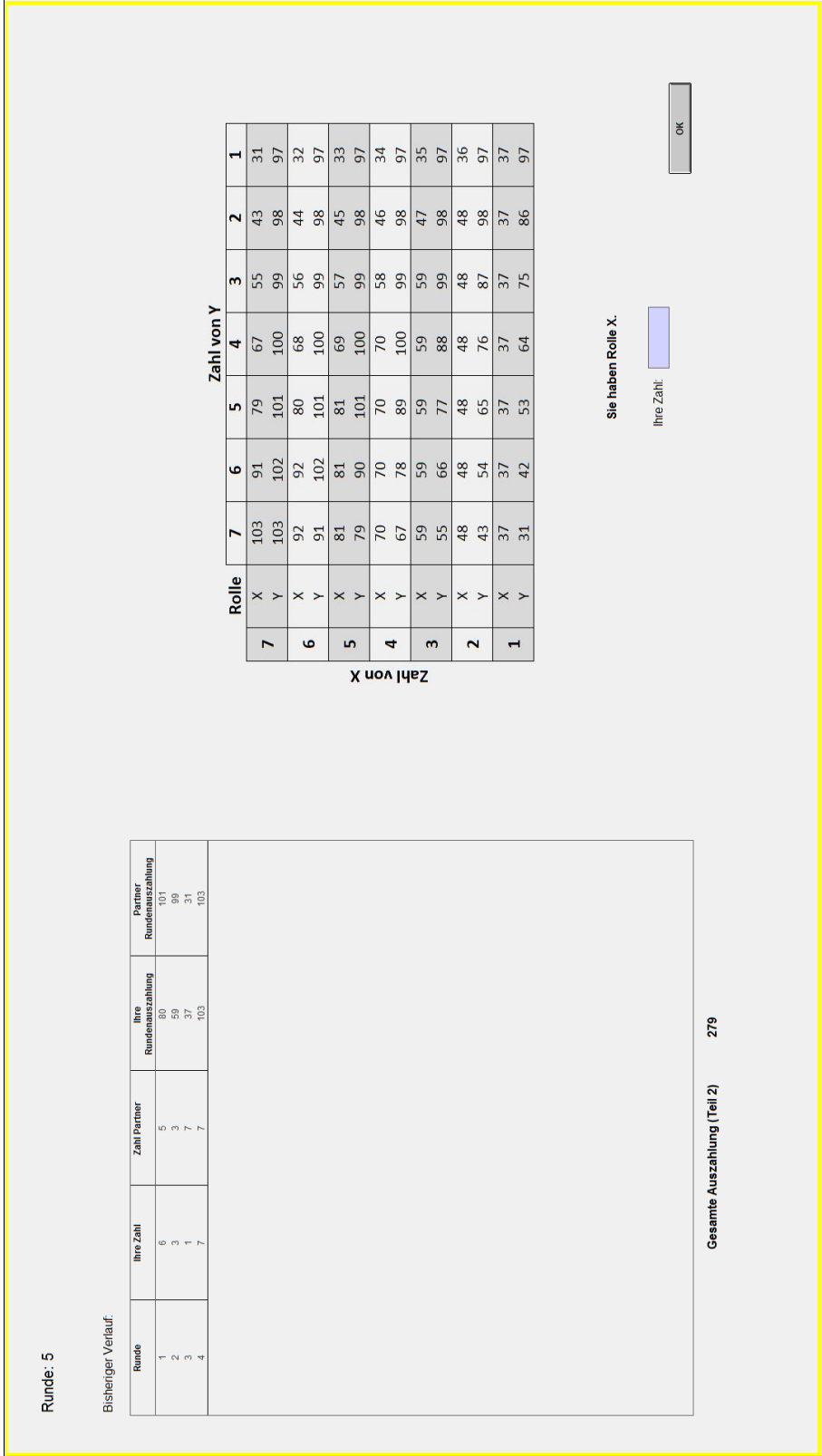
**Proposition 2** [*Equilibrium Selection Under Higher Risk*]

*If the secure equilibrium is equality-dominant, the higher higher increases coordination on the secure equilibrium if  $\alpha_h > \underline{\alpha}_h(\beta_h) := \frac{b - c_h}{c_h - c_l} + \beta_h \frac{c_l + \zeta_l}{c_h - c_l}$ . If the Pareto-dominant equilibrium is equality-dominant, increased strategic uncertainty has no effect.*

The level of  $\underline{\alpha}_h$  depends on the high-cost type's level of advantageous inequality, i.e.,  $\beta_h$ . For a value of advantageous inequality given by  $\beta = 0.3$ , we obtain a minimum level of disadvantageous inequality of  $\underline{\alpha}(0.3) = 0.43$  which is much below the average level found in the literature. For example, Fehr and Schmidt (1999) report an average  $\alpha$  of 0.85 and an average  $\beta$  of 0.32. Goeree and Holt (2000) report an average  $\alpha$  of 0.84 and an average  $\beta$  of 0.39. Blanco, Engelmann, and Normann (2011) report an average  $\alpha$  of 0.91 and an average  $\beta$  of 0.38. If the Pareto-dominant equilibrium (7,7) is equality-dominant, best responses under FS preferences coincide with best responses under standard preferences and do not refine the set of equilibria as long as  $\alpha_i, \beta_i \geq 0$ . As Engelmann (2012) shows, negative values for  $\alpha$  and  $\beta$  are equivalent to a preference for efficiency (e.g., Charness and Rabin, 2002; Charness and Rabin, 2002). In other words, agents would have to be willing to increase inequality in order to maximize efficiency.

## B Screens in the Lab Experiment

This section shows the computer screens in the repeated game. The one-shot game has a similar interface but without the history of play. In the one-shot game, subjects received information about their own and their partner's choice only at the very end of the experiment (after the repeated game was completed). In the repeated game, subjects received information at the end of each period.



Runde: 5

Bisheriger Verlauf:

Runde	Ihre Zahl	Zahl Partner	Ihre Rundenanzahlung	Partner Rundenanzahlung
1	6	5	80	101
2	3	3	59	99
3	1	7	37	31
4	7	7	103	103
5	7	1	31	97

Runde: 5

Ihre Rolle: X

Ihre Zahl: 7

Zahl Ihres Partners: 1

Ihre Rundenanzahlung: 31

Partner Rundenanzahlung: 97

Gesamte Auszahlung (Teil 2)

310

Weiter

Notes: Displayed is the input interface in the repeated game. On the left side, subjects see a history of play up to and including the current period. Reported is the period number, subject's own number, the number that the partner in that period chose, the subject's payoff, and the payoff of the partner in that period. In addition, the subject sees her cumulative payoff. On the right side, the screen displays the current period's information: the period number, the subject's role, the subject's own number, the number that the partner in the current period chose, the subject's payoff, and the payoff of the partner in the current period. Screen size and resolution: 23", Full HD 1920x1080.

Figure A.3: Input Screen in the Repeated Game.

## C Instructions

The following pages report the instructions in both German (original) and English (translated). Subjects first received the general instructions along with the instructions of part 1 and the according payoff table. Only the payoff table varied by treatment. The respective payoff tables were given on a separate sheet (referred to as “Figure 1”) and are identical to the normal form representations. Subsequently, subjects received the instructions for part two. All instructions were read out loud.

# **Allgemeine Instruktionen**

Herzlich willkommen und vielen Dank für Ihre Teilnahme an diesem Experiment. Bitte kommunizieren Sie ab sofort und bis zum Ende des Experiments nicht mehr mit den anderen Teilnehmern.

Wir bitten Sie, die Instruktionen aufmerksam zu lesen. Die Instruktionen sind für alle Teilnehmer in diesem Raum identisch. Wenn Sie nach dem Lesen oder während des Experiments noch Fragen haben, heben Sie bitte Ihre Hand. Einer der Experimentleiter wird dann zu Ihnen kommen und Ihre Frage persönlich beantworten. Ihre Auszahlung und Ihre Entscheidungen werden vertraulich behandelt.

Sie erhalten für Ihr Erscheinen eine Teilnahmepauschale in Höhe von 2,50 EUR. Zusätzlich können Sie in diesem Experiment Geld verdienen. Wie viel Sie verdienen, hängt sowohl von Ihren Entscheidungen als auch den Entscheidungen anderer Teilnehmer ab. Ihre Auszahlungen werden im Laufe des Experiments in virtuellen Geldeinheiten, den Experimental Currency Units (ECU), angegeben. Ihre Auszahlung wird nach dem Ende des Experimentes in Euro (EUR) umgerechnet und in bar an Sie ausgezahlt.

Das Experiment besteht aus zwei Teilen (Teil 1 und Teil 2). Sie erhalten zunächst die Instruktionen für Teil 1. Nach Abschluss von Teil 1 erhalten Sie die Instruktionen für Teil 2. Danach bitten wir Sie einen Fragebogen auszufüllen. Ihre Auszahlung, Ihre Entscheidungen und Ihre Antworten im Fragebogen werden vertraulich behandelt.



# Instruktionen Teil 1

## Übersicht

- Teil 1 besteht aus einer einzigen Entscheidung.
- Es gibt zwei Rollen: X und Y. Die Hälfte der Teilnehmer hat Rolle X und die andere Hälfte hat Rolle Y. Es wird zu Beginn des Experiments zufällig bestimmt, ob Sie Rolle X oder Rolle Y haben.
- Sie bilden eine Gruppe mit einem Partner, der die jeweils andere Rolle hat: Wenn Sie Rolle X haben, hat ihr Partner Rolle Y. Wenn Sie Rolle Y haben, hat ihr Partner Rolle X.
- 30 ECU entsprechen 1 EUR.

## Ablauf

- Sowohl Sie als auch Ihr Partner wählen eine Zahl aus der Menge  $\{1, 2, 3, 4, 5, 6, 7\}$ .
- Die Höhe der Auszahlungen hängt ab von:
  - Ihrer gewählten Zahl.
  - Der Zahl Ihres Partners.
  - Ihrer Rolle (X oder Y).
- Tabelle 1 zeigt die möglichen Auszahlungen. Die Entscheidung der Person in Rolle X ist hier in den Zeilen abgetragen, während die Entscheidung der Person in Rolle Y in den Spalten abgetragen ist. Die Entscheidungen beider Personen ergeben das Feld in der Tabelle, in dem Sie die Auszahlungen ablesen können. Die Auszahlung von X steht jeweils im oberen Teil eines Feldes und die Auszahlung von Y steht im unteren Teil.

## Informationen

Das Ergebnis des ersten Teils erfahren Sie nach dem Ende des zweiten Teils des Experiments. Sie erhalten dabei folgende Informationen: Ihre gewählte Zahl, die Zahl Ihres Partners, Ihre Auszahlung und die Auszahlung Ihres Partners.

# Instruktionen Teil 2

## Übersicht

- Teil 2 besteht aus 30 Runden, in denen Sie jeweils eine Entscheidung treffen.
- Jede Runde hat den gleichen Ablauf wie Teil 1 und auch die Entscheidungssituation ist die gleiche, die in Tabelle 1 dargestellt ist.
- Sie haben die gleiche Rolle wie in Teil 1 (X oder Y). Diese Rolle behalten Sie für alle 30 Runden.
- Sie bilden in jeder Runde eine Gruppe mit einem Partner, der die jeweils andere Rolle hat: Wenn Sie Rolle X haben, hat ihr Partner immer Rolle Y. Wenn Sie Rolle Y haben, hat ihr Partner immer Rolle X.
- In jeder Runde wird Ihnen zufällig ein Partner aus diesem Raum neu zugeordnet mit dem Sie in der jeweiligen Runde eine Gruppe bilden.
- 400 ECU entsprechen in diesem Teil 1 EUR. Ihre Auszahlungen aus allen Runden werden am Ende für Ihre Endauszahlung zusammengerechnet.

## Informationen

- Nach jeder Runde erhalten Sie folgende Informationen: Ihre gewählte Zahl, die Zahl Ihres Partners, Ihre Rundenauszahlung und die Rundenauszahlung Ihres Partners.
- Zusätzlich zeigen wir Ihnen Ihre vorherigen Entscheidungen, die Entscheidungen Ihrer vorherigen Partner und Ihre gesamte bisherige Auszahlung in Teil 2 an.

## Endauszahlung

Am Ende des Experiments zahlen wir Ihnen Teil 1 und Teil 2 in bar aus.

**Tabelle 1: Auszahlungen**

		Zahl von Y							
Rolle		7	6	5	4	3	2	1	
Zahl von X	7	X	103	91	79	67	55	43	31
		Y	103	102	101	100	99	98	97
	6	X	92	92	80	68	56	44	32
		Y	91	102	101	100	99	98	97
	5	X	81	81	81	69	57	45	33
		Y	79	90	101	100	99	98	97
	4	X	70	70	70	70	58	46	34
		Y	67	78	89	100	99	98	97
	3	X	59	59	59	59	59	47	35
		Y	55	66	77	88	99	98	97
	2	X	48	48	48	48	48	48	36
		Y	43	54	65	76	87	98	97
	1	X	37	37	37	37	37	37	37
		Y	31	42	53	64	75	86	97

## **General Instructions**

Welcome and thank you for participating in this experiment. From now on until the end of the experiment, please refrain from communicating with other participants.

We kindly ask you to read the instructions thoroughly. The instructions are identical for all participants in this room. If you have any questions after reading the instructions or during the experiment, please raise your hand. One of the instructors will then come to you and answer your question in person. Your payment and your decisions will be treated confidentially.

You will receive a show-up fee of 2,50€ Additionally, you can earn money in this experiment. How much you earn depends on your decisions as well as on the decisions of other participants. During the experiment your payoff will be calculated in a virtual currency: Experimental Currency Units (ECU). After the experiment, your payoff will be converted into Euros (EUR) and given to you in cash.

The experiment consists of two parts (part 1 and part 2). First, you will receive the instructions for part 1. After the completion of part 1, you will receive the instruction for part 2. Next, we ask you to complete a questionnaire. Your payoff, your decisions and the answers in the questionnaire will be treated confidentially.

# Instructions Part 1

## Overview

- Part 1 consists of a single decision.
- There are two roles: X and Y. Half of the participants take on role X and the other half takes on role Y. It will be randomly determined at the beginning of the experiment, whether you take on role X or role Y.
- You will form a group with one partner, who takes on the respective other role: If you take on role X, your partner takes on role Y. If you take on role Y, your partner takes on role X.
- 30 ECU correspond to 1 EUR.

## Procedure

- You and your partner both choose a number out of the set {1, 2, 3, 4, 5, 6, 7}.
- Your payoff is determined by:
  - Your chosen number.
  - The number of your partner.
  - Your role (X or Y)
- Table 1 shows the possible payoffs. The decision of the participant with role X is displayed in the rows and that of the participant with role Y in the columns. The decisions of both participants result in the cell of the table where you can find the payoffs. The payoff of X is displayed in the upper part of the cell, whereas the payoff of Y is displayed in the lower part.

## Information

You will learn the results of the first part of the experiment at the end of the second part. Then, you will receive the following information: Your chosen number, the number of your partner, your payoff, and your partner's payoff.

# Instructions Part 2

## Overview

- Part 2 consists of 30 rounds. In each round you will make a decision.
- Each round follows the same course as in part 1 and the decision situation is the same as displayed in Table 1.
- You take on the same role as in part 1 (X or Y). You will keep this role for all 30 rounds.
- You will form a group with one partner who takes on the respective other role: If you take on role X, your partner always takes on role Y. If you take on role Y, your partner always takes on role X.
- In each round, you will be randomly assigned a new partner from this room with whom you will form a group.
- 400 ECU correspond to 1 EUR in this part. Your payoff from all rounds will be converted and summed up at the end.

## Information

- At the end of each round, you will receive the following information: Your chosen number, the number of your partner, your payoff in this round and your partner's payoff in this round.
- In addition, we will display your previous decision, your previous-partners' decisions, and your total payoff of part 2 up to that point.

## Final Payoff

At the end of the experiment, you will receive your payment for part 1 and part 2 in cash.

## D Empirical Appendix

### D.1 Summary Statistics and Data File

Table A.2 reports summary statistics for the treatments LR77, LR11, HR77, and HR11. Panel A reports demographics. *Age* reports the age of the participant. *Male* is a dummy variable taking the value one for male participants and zero for female participants. *German Native* is a dummy variable indicating whether a participant’s mother tongue is German or not. If a participant indicated multiple mother languages including German, she is also considered German native.

Table A.2: Summary Statistics by Treatment: Demographics and Attitudinal Variables.

Treatments	LR77	LR11	HR77	HR11	Total
<i>Panel A. Demographics</i>					
Age	23.86	23.48	24.45	24.08	23.97
	(5.65)	(3.90)	(3.17)	(7.56)	(5.33)
Male	35.9%	50.0%	51.6%	45.3%	45.7%
German Native	53.1%	76.6%	70.3%	67.2%	66.8%
<i>Panel B. Attitudes</i>					
Risk-Averse	75.0%	85.9%	84.4%	76.6%	80.5%
Risk-Neutral	12.5%	6.25%	6.25%	1.56%	6.64%
Risk-Seeking	12.5%	7.81%	9.38%	21.9%	12.9%
Social Preference	4.25	4.25	3.98	5.25	4.43
	(2.64)	(2.14)	(2.24)	(2.31)	(2.38)

Notes: Reported is the mean or the share of demographic and attitudinal variables by treatment. Standard deviations in parentheses.  $N = 256$ . All information were surveyed through a post-experimental questionnaire.

Because coordination games feature strategic risk by construction and, in addition, payoffs in our game are generally unequal, we also ask unincentivized questions on risk preferences and on social preferences regarding income inequality. Panel B reports these attitudes. *Risk-Averse* is a dummy indicating whether the participant was classified as risk-averse, *Risk-Neutral* is a dummy indicating whether the participants was classified as risk-neutral, and *Risk-Seeking* is a dummy indicating whether the participant was classified as risk-seeking.<sup>21</sup> *Social Preference* takes values from one to ten where one

<sup>21</sup>Risk preferences were obtained by asking participants to choose between a certain payoff of \$50 and a gamble that pays with equal probability either \$100 or \$0. Because the gamble is a mean-preserving spread of the certain payoff, we classify subjects as being *risk-averse* if they indicate to prefer the certain outcome, as *risk-neutral* if they indicate to be indifferent, and as *risk-seeking* if they indicate to prefer the gamble.

indicates that income should be made more equal and ten indicates that income differences need to be larger as incentives for individual effort.<sup>22</sup>

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<sup>22</sup>The social preference question is taken from the World Values Survey (WVS), Wave 6: “How would you place your views on this scale? 1 means you agree completely with the statement on the left; 10 means you agree completely with the statement on the right; and if your views fall somewhere in between, you can choose any number in between. [1] Incomes should be made more equal, ..., [10] We need larger income differences as incentives for individual effort.” In the questionnaire, we used the translation provided in the German version of the WVS.



Table A.3: Data File: All choices made in the experiment

Subject	Treat	Type	Cohort	Shot		One- P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25	P26	P27	P28	P29	P30	Mean
1	LR11	Low	1	4	4	4	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	1	7	7	7	7	7	7	7	7	7	7	7	7	7	6.6
2	LR11	Low	1	7	7	5	1	4	5	4	1	4	7	6	6	7	7	5	6	3	6	3	7	7	7	2	7	7	7	7	1	4	7	7	7	5.2
3	LR11	Low	1	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0
4	LR11	Low	1	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0
5	LR11	Low	2	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0
6	LR11	Low	2	5	6	7	7	7	7	5	6	5	7	7	7	7	7	1	7	7	7	7	7	7	7	1	7	7	7	7	7	7	7	7	7	6.4
7	LR11	Low	2	7	7	5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6.9	
8	LR11	Low	2	7	7	6	2	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6.8	
9	LR11	Low	3	7	7	7	7	7	7	5	1	1	7	4	4	5	7	5	7	7	4	5	7	7	7	7	7	7	7	7	7	7	7	7	7	6.0
10	LR11	Low	3	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
11	LR11	Low	3	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
12	LR11	Low	3	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
13	LR11	Low	4	6	7	6	7	6	5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6.9	
14	LR11	Low	4	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
15	LR11	Low	4	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
16	LR11	Low	4	7	4	6	7	7	7	7	1	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6.7	
17	LR11	Low	17	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
18	LR11	Low	17	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
19	LR11	Low	17	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
20	LR11	Low	17	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
21	LR11	Low	18	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
22	LR11	Low	18	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
23	LR11	Low	18	7	7	7	6	1	1	6	7	7	7	7	7	7	7	7	7	1	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6.3	
24	LR11	Low	18	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
25	LR11	Low	19	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
26	LR11	Low	19	7	7	7	7	1	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6.8	
27	LR11	Low	19	1	1	1	7	1	5	1	1	1	1	1	1	7	7	1	7	1	7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.9
28	LR11	Low	19	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
29	LR11	Low	20	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
30	LR11	Low	20	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
31	LR11	Low	20	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
32	LR11	Low	20	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
33	LR11	High	1	7	7	7	7	7	1	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6.8
34	LR11	High	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0	
35	LR11	High	1	6	6	3	2	4	1	1	4	4	7	7	7	1	1	1	1	1	1	1	7	6	1	7	7	7	7	1	1	1	1	1	6	3.5
36	LR11	High	1	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	
37	LR11	High	2	7	4	4	7	4	4	4	4	4	4	4	4	4	4	4	4	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	5.7	
38	LR11	High	2	4	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.0	
39	LR11	High	2	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7.0	











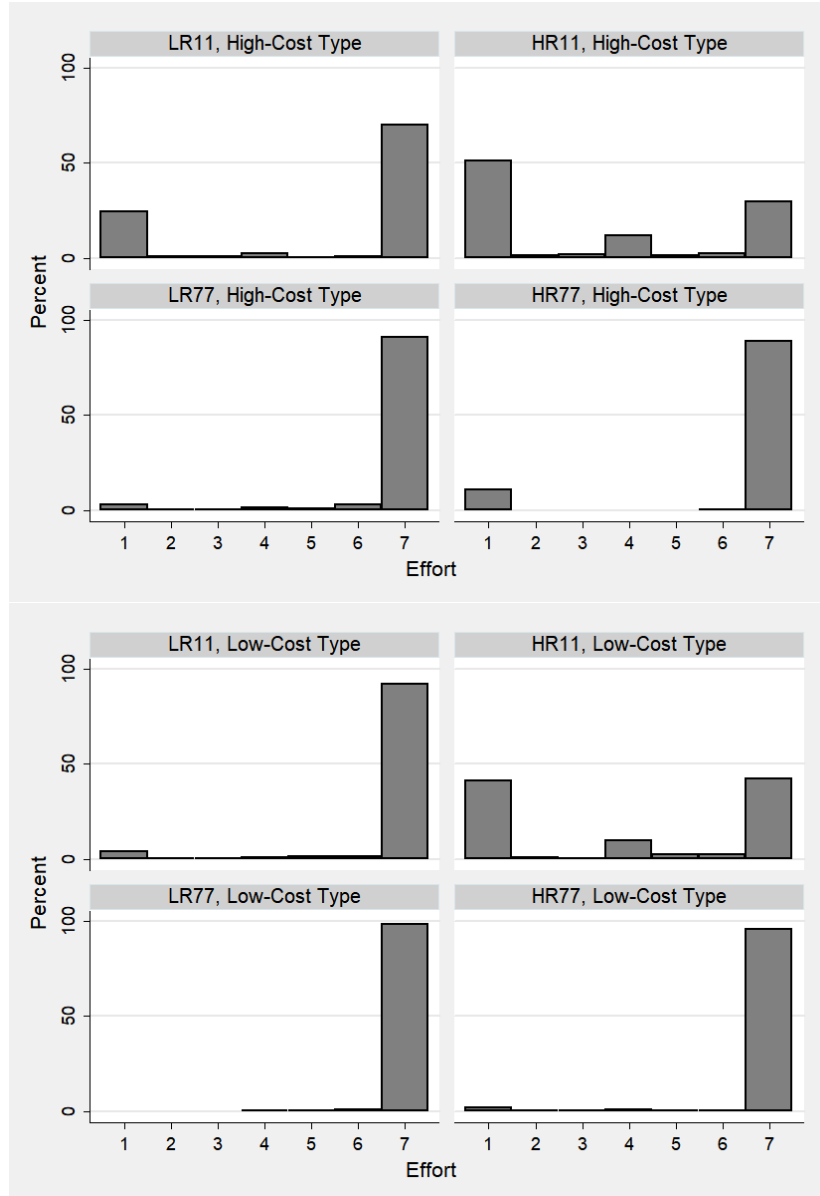


Table A.4: Distribution of Effort Choices by Cost-type and Treatment.

High-Cost-Type					
Effort	LR11	HR11	LR77	HR77	Sum
1	236	494	28	105	863
2	8	14	2	0	24
3	7	19	4	0	30
4	22	114	15	0	151
5	5	14	7	0	26
6	8	22	31	2	63
7	674	283	873	853	2683
Sum	960	960	960	960	3840
Low-Cost-Type					
Effort	LR11	HR11	LR77	HR77	Sum
1	38	398	0	19	455
2	2	7	0	1	10
3	2	5	0	2	9
4	10	95	3	11	119
5	12	23	4	1	40
6	13	26	9	4	52
7	883	406	944	922	3155
Sum	960	960	960	960	3840

Notes: Reported are all effort choices across all periods by cost-type and treatment. In the upper half of the table the decisions of the high-cost types across treatments are shown whereas the lower half of the table shows the decisions of the low-cost types across treatments.





Notes: The figure shows the share with which a particular effort level is chosen across all decisions by cost-type and treatment. In the upper half of the figure the decisions of the high-cost types are shown whereas the lower half of the table shows the decisions of the low-cost types.

Figure A.4: Histogram of Effort Choices by Cost-type and Treatment.

## D.2 Further Analyses

### D.2.1 Coordination outcomes

We further analyze coordination outcomes by logistic regressions of the dummy *Coordination* that takes the value one if  $e_i = e_j$  and zero if  $e_i \neq e_j$ . Each period, two matched subjects generate one observation. Hence, we have 3840 observations when we utilize all 30 periods and 640 observations when we analyze the last five periods. Table A.5 reports the results. Coordination is significantly hampered if (1,1) is equality-dominant. In line with the results regarding effort choice, we do not find any direct effect of increased risk on the ability to coordinate. In contrast to the analysis of effort, the interaction between risk and equality dominance is also not significant. The period coefficient indicates that subjects learn to better coordinate over time.

Table A.5: Repeated-Interaction Coordination: Logistic Regressions

	All Periods		Last Five Periods	
Model	(I)	(II)	(III)	(IV)
Estimation	Logistic	Logistic	Logistic	Logistic
ED11	-2.003*** (0.416)	-1.476** (0.644)	-1.639** (0.649)	-1.264** (0.552)
High Risk	-0.314 (0.433)	-0.348 (0.782)	-0.020 (0.704)	-0.308 (0.700)
ED11 X High Risk	0.017 (0.579)	0.242 (0.904)	0.618 (0.929)	0.645 (0.966)
Period	0.052*** (0.005)	0.042*** (0.013)	-0.176* (0.091)	-0.120** (0.056)
Constant	2.304*** (0.324)	1.602*** (0.546)	8.058*** (2.626)	5.561*** (1.657)
Observations	3840	3840	640	640
Subject Pairs	128	128	128	128
Cohorts	32	32	32	32
Random Effects	Yes	No	Yes	No
Clustered S.E.	No	Yes	No	Yes
Pseudo R2	0.04	0.09	0.03	0.04

Notes: Logistic regressions. Dependent variable is coordination in percentages. Coordination is achieved if both players choose the same effort level. Data is collapsed for every two subjects that are partners in a given period. Models (I) and (II) are based on data from all periods. Models (IV) and (V) are based on data from the last five periods. *ED11* indicates that (1,1) is equality-dominant. *High Risk* indicates high risk. Standard errors in parentheses. If applicable, standard errors are clustered on the cohort level. Random effects are on subject pairs. \* < 0.10, \*\* < 0.05, \*\*\* < 0.01.

### D.2.2 Efficiency

Table A.6 presents the results of random-effects regression of efficiency on the treatment indicators confirming the non-parametric results. If (1,1) is equality-dominant, efficiency significantly drops by about 15% points while risk has no significant main effect. The interaction between equality dominance and risk is also significant and increases in magnitude for the last five periods. The effect of Period is significant but economically small.

Table A.6: Repeated-Interaction Efficiency: Random-Effects Regressions

	<b>All Periods</b>	<b>Last Five Periods</b>
Model	(I)	(II)
Estimation	GLS	GLS
ED11	-15.155*** (5.013)	-13.392** (5.637)
High Risk	-9.580 (6.741)	-9.706 (6.354)
ED11 X High Risk	-17.600* (10.555)	-20.439** (10.025)
Period	0.137* (0.080)	-0.956** (0.422)
Constant	94.783*** (2.030)	123.800*** (11.854)
Observations	3840	640
Subjects Pairs	128	128
Cohorts	32	32
R2	0.25	0.29

Notes: Reported are random-effects GLS regressions with random effect on subject. Dependent variable is efficiency in percentages. Efficiency is defined as the difference between the sum of actual payoffs and the minimum sum of payoffs divided by the difference between the maximum sum of payoffs and the minimum sum of payoffs. Model (I) is based on data from all periods. Model (II) is based on data from the last five periods. *ED11* indicates that (1,1) is equality-dominant. *High Risk* indicates high risk. Standard errors clustered on the cohort level in parentheses. \* < 0.10, \*\* < 0.05, \*\*\* < 0.01.