Asymmetry, Heterogeneity and Endogeneity in Principal Agent Relations

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Introduction

The principal agent model as introduced by Coase (1937) and first theoretically analyzed by Jensen and Meckling (1976) is widely used to describe conflicts between the owner of a firm and its workers. Among others, two problems which occur in principal agent relations are shirking and incomplete contracts. Shirking may occur if the principal cannot perfectly observe and control the efforts of the agent. Incomplete contracts are not enforceable. In reality almost all contracts are incomplete. The conflicting principal agent relations shine in a new light since models of social preferences have been introduced in economic theory. Among others, the theories of Fehr and Schmidt (1999) and Dufwenberg and Kirchsteiger (2004) provide manageable tools to model typical economic situations in a more realistic way. These theories of fairness and reciprocity explain the behavior in principal agent relations better than the standard theory which relies on the assumptions of egoistic and rational individuals. They can explain the functioning of contracts which are not enforceable by postulating positive reciprocation of individuals to kindness of other individuals. This leads to principal agent relations which can be understood as a kind of gift exchange. The investment game introduced by Berg et al. (1995) provides a framework to model such incomplete contracts within economic experiments. The first player has to make a risky move, entrusting a certain monetary investment to another player. The second player can either keep this money which is tripled on its way to his/her, or reciprocate to the gift by sending some of the money back to the first player. In contrast to standard theories reciprocity can explain why individuals send non-zero amounts to another one even though there is no opportunity to enforce a backtransfer.

This thesis contributes to both above mentioned problems within principal agent relations. Two Chapters address a particular question of incomplete contracts, namely the question if endogenous leadership in the sense of a voluntary input increases efficiency in an environment where the contract is not enforceable, represented by a variation of the above described investment game. Another Chapter addresses the question if the principal can reduce shirking in team production with the help of contract design. All research hypotheses within this thesis are derived from models which assume that individuals act as if they had social preferences. The thesis comprises four Chapters; each of them is a working paper and is self-contained.

Chapter 1 is joint work with Manfred Königstein and Balázs Rozsnyói.[1] It introduces an experimental game which is a variation of the investment game introduced by Berg et al. (1995) where the principal can choose the sequence of the game. This is referred to as endogenous leadership. If the principal decides to move first efficiency raises substantially in form of high investments and high backtransfers.

Chapter 2 is also joint work with Manfred Königstein and Balázs Rozsnyói.[2] It investigates an experimental game which is a variation of the game presented in Chapter 1. Now inequality in endowments is introduced within the modified investment game. In this setting inequality aversion and reciprocity predict different outcomes of the game. While inequality aversion predicts no transfer of the agent, reciprocity predicts transfers of both principal and agent. This might be the more realistic situation for principal agent relations. There are no efficiency gains of endogenous leadership to be found anymore, while a strong trust and reciprocity mechanism is still observed within the data. This indicates that inequality concerns play an important role in principal agent relations but positive reciprocation to kind acts still exists even though payoff equalizing preferences predict no reciprocity.

Chapter 3 is joint work with Manfred Königstein, Gabriele Lünser and Balázs Rozsnyói.[3] It addresses the problem which arises when organizing work in groups is more efficient for some workers but also risky for the principal since team production may create shirking incentives. An experimental game for a principal agent model where one principal faces 16 agents is introduced. Eight agents are high productive workers and the other eight agents are low productive workers in group tasks. The principal proposes contracts for an individual task and a group task in every period. Agents self-select themselves into tasks and provide effort either in the individual or in the group task. The group task is modeled as a public good. Thus teams are paid equally according to the team output regardless of the effort of one particular agent. Effort in the group task increases with the offered wage. Thus a reciprocity mechanism can be observed again. High productive agents are more likely to choose group task and provide higher efforts. But the sorting mechanism is far from being efficient. Thus, a substantial proportion of shirkers is still entering the group task.

While Chapters 1, 2 and 3 address particular experimental games, Chapter 4 addresses a framework to estimate parameters of utility functions which are assumed to generate the

[1] All authors contributed equally.
[2] All authors contributed equally.
[3] All authors contributed equally.

observed data of experiments. While analyzing data from decisions of individuals the question arises which structural model to use in order to estimate parameters. The most common procedure in experimental economics is to estimate a linear model. This seems sensible since linear approximations are often useful and easy to handle. However, they consequently ignore both the structure of the data (which are often discrete in experimental economics) and the data generating process, namely the individual considerations which lead to the observed behavior. An alternative way to estimate parameters from decisions of individuals is to use the framework of the logit equilibrium model introduced by McKelvey and Palfrey (1995, 1998). The logit equilibrium model is a flexible framework for estimating parameters of arbitrary utility functions. Further, it is compatible with the familiar logit model which arises from a random utility model for discrete choice. Thus it seems to overcome both shortcomings of the linear models. Chapter 4 presents a logit equilibrium model for a three stage two player ultimatum game with advance production. In a first stage both players simultaneously decide upon their effort to a joint production. On the second stage one player proposes a split of the joint return and on the third stage the other player either accepts or rejects the proposed split. The game is analyzed within the framework of a logit error model and parameters of the utility function proposed by Fehr and Schmidt (1999) as well as of a standard utility function with egoistic payoff maximizing preferences are estimated with maximum likelihood methods. The estimated results suggests that the Fehr and Schmidt (1999) utility model explains the data better than standard theory.

1. Voluntary Leadership in an Experimental Trust Game

1.1 Introduction

The trust game introduced by Berg et al. (1995) represents a basic two person conflict in which players may choose cooperative moves sequentially to achieve a mutually beneficial outcome. The first mover (trustor) chooses an investment which induces a return that accrues to the second mover (trustee). The second mover then can backtransfer money to the first mover but may also decide to keep the return for himself/herself. The first mover cannot use a court to enforce a payback of the initial investment or a part of the surplus in addition to investment. He/she may, however, trust that the second mover will reciprocate the given "gift".

Without trust there will be no surplus in this game. But if there is trust, and if higher investment leads to higher backtransfer, we refer to this as the "Trust-And-Reciprocity" mechanism.[4] Such a positive correlation between investment and backtransfer has been shown in many experimental studies including the seminal study by Berg et al. (1995). It is also documented in a recent meta-analysis by Johnson and Mislin (2011). From a pure rationalistic viewpoint this result is surprising: An egoistic and rational second mover should not backtransfer any money, and therefore the first mover should not invest in the first place. But the result is not surprising from everyday experience, which tells us that sequential gift exchange is common in social interaction. Despite this everyday experience it is interesting to study the forces that strengthen or weaken the Trust-And-Reciprocity mechanism. Camerer (2003) describes how several structural and individual factors, like e.g. stake size and nationality, influence behavior in trust games. Johnson and Mislin (2011)[5] investigate cultural differences in trust games. In addition to empirical studies, theoretical models have been developed that might explain Trust-And-Reciprocity within a wider rationality framework (see e.g. the social preference models of Dufwenberg and Kirchsteiger (2004) and Falk and Fischbacher (2006)).

Our study contributes to the research on trust games by investigating the influence of voluntary leadership. Voluntary leadership means that one of the two players can decide

[4] Reciprocity in experimental labour markets is reported e.g. in Gächter and Fehr (2002).

[5] Furthermore see the related studies on gift exchange experiments by Charness and Rabin (2002), Falk et al. (1999), Fehr et al. (1997), Fehr et al. (1993, 1998) as well as Gächter and Falk (2001).

whether to be first mover or second mover in the trust game. In natural relationships it is quite usual that the sequencing of moves is not predetermined. The mere fact that one player takes the "burden of the first move" in such a situation (we call this an "endogenous trust game") could make a difference compared to a situation, where the order of moves is predetermined. In an endogenous trust game the order of moves may be open in the sense that either player may volunteer to make the first move. But one may also think of situations where one player has the right to determine the order of moves. In a hierarchical relationship, like the principal-agent relationship of an employer and a worker, it might be the employer's choice whether to make the first move himself/herself or whether to pass this to the employee. E.g., the employer may decide to pay the employee ex-ante or ex-post. Payment ex-ante is risky, requires trust, and may induce reciprocity from the employee. Payment ex-post is safe, but may not be as beneficial for the principal if the agent no longer reciprocates by giving back more than what is necessary to get the job done. [6]

We present a lab experiment on an endogenous trust game in which one player (the principal) may decide to leave the investment choice to the agent or to take the investment decision himself/herself. In the latter case we refer to this as "voluntary leadership". The game differs from the trust game of Berg et al. (1995) with respect to the second mover's choice of backtransfer. In our game the second mover may choose an amount between zero and 10 and the amount is tripled and paid to the first mover. Accordingly, the game is symmetric in the sense that first mover and second mover face the same choice sets whereas choice sets are asymmetric in the trust game of Berg et al. (1995). We chose this variant of trust game since we are interested in the influence of voluntary leadership in an otherwise symmetric situation.

We find that voluntary leadership increases investment and increases backtransfer of the second mover compared to the alternative sequencing in which the agent is investor. Furthermore investment and backtransfer are higher under voluntary leadership than in the control treatment with exogenously determined sequencing. Lastly, we show that risk preference and inequality aversion as modeled formally by Fehr and Schmidt (1999) influence behavior in the endogenous trust game. The observed effect sizes are economically substantial.

In Section 1.2 we summarize the related literature. In Section 1.3 we describe our experimental game and provide a theoretical analysis. In addition to a benchmark theoretical

[6] We thank an anonymous referee for suggesting this illustrative example.

solution based on standard preferences we analyze the game assuming inequality aversion and risk preferences. The analyses lead to a set of empirical hypotheses. Section 1.4 describes experimental procedures, and Section 1.5 provides data analyses and empirical results. Section 1.6 concludes.

1.2 Related Literature

To our knowledge this is the first study on endogenous sequencing in trust games. Gächter and Renner (2005), Güth et al. (2007), Kumru and Vesterlund (2010) are related studies which consider a leader's choice in public good experiments. They report increased contributions and efficiency gains compared to simultaneous public good games due to high first mover contribution. In these studies leadership is not voluntary but predetermined by the experimenter.

There are only a few studies on endogenous leadership in the experimental literature[7]. Closest to our design are the studies of Arbak and Villeval (2013) and Rivas and Sutter (2011). Arbak and Villeval (2013) investigate a public good experiment with endogenous leadership. On the first stage one group member can contribute voluntarily while other group members contribute simultaneously after observing the contribution of the leader. A substantial number of subjects (about one out of four) are willing to act as leader. These first movers contribute significantly more to the public good compared to the contributions in simultaneous public good games. As a result second movers' contributions are rising. First movers earn less than second movers but voluntary leadership induces efficiency gains. Rivas and Sutter (2011) study several forms of leadership in public good games and compare exogenously enforced leadership and endogenous (voluntary) leadership. They also find higher contributions to the public good under endogenous leadership.

Our study contributes to both the literature on trust games – by making the sequencing of decisions a player's choice – and the literature on leadership in public good games – by reducing the number of players on which the success of the leader hinges. In our game the leader's payoff hinges on the decision of a single player, the second mover. Compared to a public good game the leader might find this more risky. Furthermore, the trust signal implied

[7] Fonseca et al. (2006a, 2006b) and Huck et al. (2002) study duopoly games with endogenous timing. Firms can choose their quantities in one of two periods. Potters et al. (2005) study a public good game with endogenous sequencing when some donors do not know the value of the public good. Nosenzo and Sefton (2011) study a public good game with endogenous move structure. Players can choose their contribution in one of two periods. Furthermore players receive different returns from the public good.

by voluntary leadership might have a different value in a two player trust game than in a public good game.

1.3 Experimental Game and Theoretical Predictions

1.3.1 The Trust Game with Endogenous Leadership and Symmetric Endowments

Consider a principal-agent game between two players, player *P* (principal) and player *A* (agent), which are both initially endowed with 10 money units. The game comprises three stages:

Stage 1: *P* decides upon the sequencing of moves in the trust game that follows in stages 2 and 3. *P* has two options, sequence "*P-First*" or sequence "*A-First*", with the meaning that in case of *P-First* (see stages 2.a and 3.a) the trust game is played with *P* being investor (first mover) and *A* being trustee (second mover) and vice versa in case of *A-First* (see stages 2.b and 3.b).

If *P-First*:

Stage 2.a: *P* decides upon investment $x_p \in \{0,1,...,10\}$; then *A* receives the amount $3x_p$.

Stage 3.a: *A* decides upon backtransfer $y_a \in \{0,1,...,10\}$; then *P* receives the amount $3y_a$.

If *A-First*:

Stage 2.b: *A* decides upon investment $x_a \in \{0,1,...,10\}$; then *P* receives the amount $3x_a$.

Stage 3.b: *P* decides upon backtransfer $y_p \in \{0,1,...,10\}$; then *A* receives the amount $3y_p$.

Payoffs are determined as follows:

$$\pi_p = 10 - x_p + 3y_a \text{ and } \pi_a = 10 - y_a + 3x_p$$

(if *P-First*)

or

$$\pi_p = 10 - y_p + 3x_a \text{ and } \pi_a = 10 - x_a + 3y_p$$

(if *A-First*)

This concludes the description of the game. If *P* chooses *P-First* we refer to this as the principal's choice of "voluntary leadership". The game theoretic solution with egoistic and rational players – i.e. our benchmark solution – is straightforward. In stage 3 the trustee has no incentive to backtransfer money, therefore the backtransfer will be zero. Consequently, it does not pay to invest in the first place, so investment will be zero. Anticipating this outcome player *P* is indifferent with respect to the sequencing of moves. Thus, the game theoretic solution with rational, payoff-maximizing players predicts that each player keeps the 10 money units, foregoing a potential efficient payoff of 30 for each if investment and backtransfer were maximal.

Stages 2 and 3 are similar to the trust game of Berg et al. (1995). In our game investments and backtransfers are tripled whereas in Berg et al. (1995) only investments were tripled. Furthermore, in our case the strategy space for backtransfers is fixed – the numbers zero to 10 – whereas in Berg et al. (1995) it is endogenous – from zero up to three times the investment. Thus, our trust game is symmetric whereas the game by Berg et al. (1995) is asymmetric. We chose this design since we wanted to investigate the influence of voluntary leadership in an otherwise symmetric game. Our design allows the second mover to return money even if the first mover's investment is zero. We actually find that some participants do so.

We know from many experiments on these games that contrary to the benchmark solution players do cooperate: Players trust in the second mover (the trustee) by choosing positive investment levels, and trustees reciprocate by choosing positive backtransfers. If investment and backtransfer are positively correlated we interpret this to be a Trust-And-Reciprocity mechanism.

Our experiment is designed to investigate whether the Trust-And-Reciprocity mechanism is influenced by voluntary leadership – i.e. a player's choice of the first mover position in the trust game. We expect the following influences:

> **Hypothesis 1.1:** If the principal chooses to be leader (voluntary leadership), then investment (**Hyp. 1.1.A**) and backtransfer (**Hyp. 1.1.B**) are higher than if the principal forces the agent to be first mover in the trust game.

Our main research hypothesis is motivated as follows: In our trust game being first mover is a more risky position than being second mover. Thus, if *P* chooses to be leader, he/she exposes himself/herself to higher risk. Therefore we consider this to be a strong signal of trust in addition to the subsequent choice of investment. Player *A* reciprocates *P*'s trust by higher backtransfer – i.e. we predict higher backtransfer controlling for investment. To control for investment one may consider e.g. the backtransfer rate (backtransfer divided by investment) or backtransfer minus investment. If *P* anticipates a higher backtransfer rate due to voluntary leadership, incentives for investment are higher and consequently we predict higher investment. These arguments are intuitive but they are inconsistent with the benchmark solution of the game. In the next Section we rely on more formal considerations of social preferences and risk aversion to motivate our hypotheses.

1.3.2 Social Preferences and Risk Preferences

Fehr and Schmidt (1999, henceforth FS) proposed a model of inequality averse players that can be applied to analyze our experimental game. It can explain cooperation in trust games which is an empirical regularity that has been reported in many studies. Therefore the FS model is more suitable than the standard model of egoistic and rational individuals. The FS model also provides a formal framework for arguing about individual player characteristics. Individual characteristics are potentially important in our empirical analyses, since they might moderate our main hypothesis (**Hyp. 1.1**). According to FS an inequality averse player maximizes the following utility function (we refer to this as FS-preferences):

$$U_j = \pi_j - \alpha_j \frac{1}{n-1}\sum_{i \neq j} \max\{\pi_i - \pi_j, 0\} - \beta_j \frac{1}{n-1}\max\sum_{i \neq j} \{\pi_j - \pi_i, 0\}$$

with restrictions $0 \leq \beta_j < 1$ and $\alpha_j \geq \beta_j$. The variables π_j and π_i represent monetary payoffs of players *j* and *i* while the parameter α_j (β_j) represents the degree of aversion against unfavorable (favorable) inequality. In Appendix A we provide a theoretical analysis of the trust game with endogenous leadership assuming FS-preferences and common knowledge of preference parameters. The following proposition can be shown to hold:

> **Proposition 1.1:** If the trustee (second mover in the trust game) is sufficiently inequality averse $\beta_j \geq 1/4$ there exists a subgame perfect equilibrium (SPE) with maximal investment and maximal backtransfer and with player *P* choosing sequence *P-First* (voluntary leadership).

Intuitively, since the trustee can always avoid unfavorable inequality, the backtransfer depends only on preference parameter β_j. Depending on β_j the trustee will either reciprocate positive investment $x_i > 0$ by choosing $y_j = x_i$ or will choose $y_j = 0$. Then, if

$y_j = x_i$ is anticipated by the investor (player *i*), maximal investment x_i is rational even for egoistic players ($\alpha_i = \beta_i = 0$). If the principal knows that the agent is sufficiently inequality averse he/she may choose to be investor. Alternatively, there also exists an SPE with maximal investment, maximal backtransfer and the sequence *A-First*. Furthermore, the benchmark solution (zero investment, zero backtransfer, any sequence) is also a SPE if inequality aversion is sufficiently low. Thus, under complete information we can establish cooperative equilibria and voluntary leadership.

If the preference parameters are not commonly known as it is the case in an experiment, investment is risky. The investor does not know the trustee's parameter β_j and cannot be sure about the backtransfer. If $x_i = 10$ is chosen, the expected utility of a risk neutral investor is

$$E(U_i) = prob(\bar{\beta})30 + (1 - prob(\bar{\beta}))(-\alpha_i 40)$$

with $prob(\bar{\beta})$ representing the investors subjective belief about the trustee being sufficiently inequality averse to choose $y_j = 10$. Since $E(U_i)$ is increasing in $prob(\bar{\beta})$ and decreasing in α_i investment is more likely if the investor is more optimistic about the trustee being inequality averse, and investment is less likely if the investor is more averse against unfavorable inequality. Consequently, the principal's willingness to take voluntary leadership should also increase in $prob(\bar{\beta})$ and decrease in α_i.

In addition one may wonder about the investor's attitude toward risk. If investment is zero, backtransfer will be zero as well, so the investor will keep the endowment of 10 for sure. With positive investment the payoff will be either larger or smaller than 10. Therefore a larger degree of risk aversion reduces incentives to invest and the principal's willingness to take voluntary leadership. With respect to the backtransfer one may argue that risk aversion does not matter, since the trustee is sure about the consequences of his/her choice. However, if the trustee acknowledges that the investor had to bear more financial risk, an inequality averse player may consider it fair to compensate the investor for taking the risk (see **Hypothesis 1.1**). Note that in this paragraph we argue only partially along the FS model, since the FS model does not incorporate risk aversion. Furthermore in our experiment we do not expect equilibrium behavior to occur necessarily. However, we find it instructive to derive qualitative predictions for investment and backtransfer based on FS-preferences and concern for risk. Furthermore individual player characteristics may influence observable behavior and therefore should be controlled for in the assessment of **Hypothesis 1.1**. Therefore we summarize our theoretical arguments in the following empirical hypotheses:

> **Hypothesis 1.2**: Investment is smaller if the investor is more risk averse (**Hyp. 1.2.A**), he/she exhibits a stronger aversion against unfavorable inequality (**Hyp. 1.2.B**), and if he/she has a lower subjective belief of an inequality averse trustee (**Hyp. 1.2.C**).

> **Hypothesis 1.3:** Backtransfer is increasing in the trustee's degree of favorable inequality aversion.

1.3.3 Control Treatment: Trust Game with Exogenous Leadership

To investigate the influence of voluntary leadership (**Hypothesis 1.1**) we run experimental sessions on the trust game with endogenous leadership and compare behavior under both sequences (*P-First* versus *A-First*). As explained above we interpret the choice of voluntary leadership as a signal of trust that leads to stronger reciprocation (higher backtransfer rate) than if the principal does not take leadership (and thus assigns the agent to be first mover in the trust game). A subtle question arising here is whether it is the choice of voluntary leadership that is perceived as a signal of trust or whether it is the refusal of voluntary leadership that is perceived as a signal of distrust or non-cooperative attitude. In the latter case an agent who is mandated to make the first move might choose low investment leading to low backtransfer. To discriminate the possibility of such a distrust-effect from the proposed trust-effect we ran a control treatment on a trust game with exogenous leadership. It is equivalent to the stages 2.a and 3.a of the trust game with endogenous leadership as described above (again with an endowment of 10 and payoff functions as above). The trust-effect should increase investment and backtransfer compared to the control treatment, while the distrust-effect should lower investment and backtransfer compared to the control treatment.

1.4 Experimental Procedures

The experiment was run in the experimental economics lab at the University of Erfurt. It comprised 10 sessions with groups of 20 participants each, and it was computerized using the software z-Tree (see Fischbacher 2007). The participants were students from different fields (social sciences and humanities) and recruited via Orsee (Greiner 2004). Each participant played only a single game, so the experiment was truly one-shot. Players received written instructions, were randomly paired and interacted anonymously (instructions are provided in Appendix B). The trust game with endogenous leadership was applied in eight sessions, and the control treatment (exogenous leadership) was applied in two sessions. We ran more sessions on the endogenous treatment to collect enough observations on voluntary leadership. Namely, we anticipated correctly that voluntary leadership is more often refused rather than chosen.

After playing the trust game the participants played the lottery game of Holt and Laury (2002) to determine their degree of risk aversion and played the distribution game of Danneberg et al. (2007) to determine their FS-preference parameters α_i and β_i. The collection of both, the degree of risk aversion and the FS-parameters, were incentivized. We will use these measures to test **Hypotheses 1.2.A, 1.2.B** and **1.3**. Details on these procedures are provided in the Appendix B. We also collected a measure of an individual's trust in other persons or society as a whole as it is collected by the World Value Survey (2005).[8] This measure may serve as a proxy for an investor's subjective belief of a reciprocal choice of the trustee and will serve to test **Hypothesis 1.2.C**. The participants also filled in the 16-PA-personality questionnaire of Brandstätter (1988) and provided some socio-demographic characteristics (age, gender, etc.) to allow for additional individual control measures. Thus, all in all we have a number of incentivized and non-incentivized measures. The experimental procedures are summarized in

Table 1.1. Sessions took about 50 minutes, subjects were paid anonymously, and average earnings were about 10 EUR.[9]

Table 1.1: Overview of Experimental Procedures

Treatment	Sequence of Games	Observations
Endogenous Leadership	1. Trust Game with Endogenous Leadership	8 Sessions
	2. Holt/Laury Game, Danneberg et. al. Game	80 Pairs
	3. Trust Question, 16-PA and Socio-Demographic Questionnaire	160 Participants
Exogenous Leadership	1. Trust Game With Exogenous Leadership	2 Sessions
	2. Holt/Laury Game, Danneberg et. al. Game	20 Pairs
	3. Trust Question, 16-PA and Socio-Demographic Questionnaire	40 Participants

8 The question is: Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people? Participants may answer "yes" or "no".

9 An average earning for a student job at the time of the experiment was about eight euro per hour.

1.5 Empirical Results

1.5.1 Descriptive Statistics and Simple Analyses

Table 1.2 and Table 1.3 provide summary statistics of experimental decisions. Accordingly, in the trust game with endogenous leadership most principals decide for the sequencing *A-First*. However, 16 out of 80 principals (20%) choose voluntary leadership (*P-First*).

Table 1.2: Summary Statistics (Means)

Treatment		Investment x	Backtransfer y	Backtransfer Rate y/x	# Obs.
Endogenous Leadership	*P-First* (Vol. Leadership)	9.13 (1.50)	8.06 (2.70)	0.89 (0.26)	16
	A-First	6.83 (3.09)	5.19 (3.09)	0.88 (0.64)	64
Exogenous Leadership		5.40 (2.76)	4.10 (3.09)	0.94 (0.86)	20

Notes: Table 1.2 includes means and standard deviations of investment, backtransfer and backtransfer rate by treatment.

Table 1.3: Summary Statistics (Medians)

Treatment		Investment x	Backtransfer y	Backtransfer Rate y/x	# Obs.
Endogenous Leadership	*P-First* (Vol. Leadership)	10.0 (2.0)	9.0 (3.0)	1.00 (0.17)	16
	A-First	7.5 (5.75)	5.0 (4.75)	1.00 (0.50)	64
Exogenous Leadership		5.0 (5.0)	3.0 (4.0)	0.67 (0.57)	20

Notes: Table 1.3 includes medians and interquartile range of investment, backtransfer and backtransfer rate by treatment.

Investment and backtransfer is higher in *P-First* than in *A-First* giving a first indication of support for **Hypothesis 1.1**. Means of investment and backtransfer are higher in the two endogenous leadership conditions than under exogenous leadership. Variances are relatively large, so we also look at medians. Table 1.3 confirms that median investments and median backtransfers are higher under endogenous leadership than exogenous leadership. According to pairwise Mann-Whitney U tests in Table 1.4 the differences in investment are highly statistically significant for the comparison of *P-First* versus *A-First* and *P-First* versus

Exogenous Leadership. Differences between *A-First* and *Exogenous Leadership* are only significant at a 10% level.

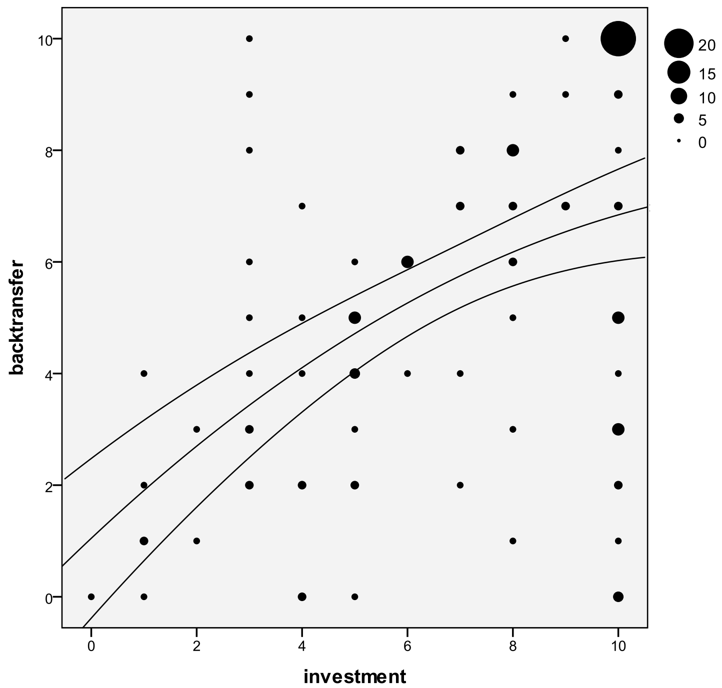
Table 1.4: Pairwise Mann-Whitney U Tests of Investment by Treatments

P-First versus *A-First*	p = 0.005, N = 80
P-First versus *Exogenous Leadership*	p < 0.001, N = 36
A-First versus *Exogenous Leadership*	p = 0.057, N = 84

Notes: P-values are calculated for two-tailed tests.

Figure 1.1 is a scatterplot of backtransfer against investment. It illustrates the joint distribution of backtransfers and investments, and it clearly indicates a positive correlation. Different dot sizes represent clustering of observations. The reference lines represent a quadratic regression of backtransfer on investment with a 95%-confidence band. Obviously, agents behave reciprocally, responding larger backtransfer for larger investment. The Spearman rank correlation coefficient between backtransfer and investment is positive and highly statistically significant ($\rho = 0.449$, $p < 0.001$, N = 100) giving robust support for the Trust-And-Reciprocity mechanism.

Figure 1.1: Scatterplot of Backtransfer over Investment



Notes: Different dot sizes represent clustering of observations. Quadratic regression line and 95%-confidence band included as well as reference lines for “backtransfer equal to investment” and “backtransfer sufficient to compensate investment”.

1.5.2 Regression Analyses of Investment

To investigate our hypotheses further we apply regression analyses controlling for the influence of social preferences, risk attitudes, personality characteristics, and other factors. Since Figure 1.1 also shows relatively large dispersion and that there is some clustering at the upper bound of the decision interval, we don't rely on OLS-regressions but apply Median regressions and Tobit regressions analyses. Table 1.5 shows the results of different model specifications for regressions of investment. Table 1.6 shows analogous analyses of the backtransfer.

Table 1.5: Regression Results of Regressions on Investment

Dependent Variable: *Investment*, Base Category is *P-First Exogenous*				
	Model 1-Median Regression		Model 2-Tobit Regression	
Variable	Coefficient	P-Value (Two-Tailed)	Coefficient	P-Value (Two-Tailed)
A-First Endogenous	1.223 (0.802)	0.131	0.925 (0.932)	0.323
P-First Endogenous	3.513 (1.039)	0.001	5.785 (1.391)	< 0.001
Alpha	-1.097 (0.466)	0.021	-1.276 (0.545)	0.021
Alpha Missing	-1.487 (0.851)	0.084	-1.776 (0.966)	0.069
Risk Aversion	-1.600 (0.669)	0.019	-2.239 (0.798)	0.006
Risk Missing	-2.291 (1.209)	0.061	-2.957 (1.488)	0.050
Male	1.513 (0.687)	0.030	2.495 (0.842)	0.004
Constant	7.264 (0.860)	< 0.001	7.734 (1.002)	< 0.001
Number of Observations	100		100	
Pseudo R^2	0.292		0.105	

Notes: Table 1.5 includes regression results for investment as dependent variable. Columns 2 and 3 contain coefficients and two-tailed p-values of the Median regression. Columns 4 and 5 contain coefficients and two-tailed p-values of the Tobit regression. Standard errors are included in parentheses.

Model (1) in Table 1.5 reports the result of a Median regression of investment. Overall the model fits well showing a pseudo R^2 of 0.292. *P-First* and *A-First* are 0-1-dummies for the two endogenous leadership conditions. Both coefficients are positive confirming higher investment compared to the reference category (exogenous leadership). But only the coefficient of *P-First* is significantly different from zero. Testing the effect of *P-First* against *A-First* shows also a significant difference ($p = 0.012$) supporting **Hypothesis 1.1.A**.

In line with **Hypotheses 1.2.A** and **1.2.B** investment decreases in *Risk Aversion* and unfavorable inequality aversion (*Alpha*).[10] Both effects are statistically significant. The variables *Alpha-Missing* and *Risk Missing* are nuisance variables coded as 1 (and otherwise 0) if a participant did not provide a consistent measure of α (21 out of 100 cases) or a missing measure of risk aversion (eight observations). We included these variables in order not to confuse effects of the variables of interest (*Alpha* and *Risk Aversion*). Male participants (dummy variable *Male*) invest more than female. The reported model was received as the final model after eliminating insignificant regressors from a larger model that contained the trust measure of the world value survey and the five 16-PA factors.

Model (2) is a Tobit regression using the same variables as model (1) and assuming a lower bound of zero and an upper bound of 10 for the dependent variable. It might be considered as a natural alternative for model specification, but it is less robust against outliers. The Tobit model qualitatively confirms model (1). All estimated coefficients show the same sign, but significance values differ. While the Median regression model seems more adequate in our view, we will use the Tobit model later on for computing mean effect sizes.

1.5.3 Regression Analyses of Backtransfer

Model (3) in Table 1.6 is a Median regression of backtransfer. The model fits well overall (pseudo $R^2 = 0.240$). As we predicted backtransfer is increasing in *investment*. This effect is highly significant ($p < 0.001$). Furthermore, backtransfer is higher under voluntary leadership (*P-First*) than under exogenous leadership (the reference category). Testing the coefficient of *P-First* against the coefficient of *A-First* shows also a highly significant difference ($p = 0.074$). These estimation results clearly support our main hypothesis (**Hyp. 1.1.B**).

Counter to **Hypothesis 1.3** the trustee's degree of favorable inequality aversion (*Beta*) has no significant effect even though the direction of influence is as predicted by the FS model.[11] The reported model was received as the final model after eliminating insignificant regressors from

[10] The variable *Risk Aversion* contains the Holt/Laury measure and a value of zero if the Holt/Laury measure is missing. Similarly, the variable *Alpha* contains the Danneberg et al. measure and a value of zero in case of an inconsistent Danneberg et al. measure.

[11] The variable *Beta* contains the Danneberg et al. measure and a value of zero in case of an inconsistent Danneberg et al. measure. *Beta_Missing* is a dummy variable representing observations with inconsistent measures of β .

a larger model that contained gender, the trust measure of the world value survey and the five 16-PA factors in addition to the variables in the final model. Though the effect of *Beta* is insignificant we decided to report this model since *Beta* is a key variable in our analysis of the FS model.[12]

Table 1.6: Regression Results of Regressions on Backtransfer

Dependent Variable: *Backtransfer*, Base Category is *P-First Exogenous*				
	Model 3 – Median Regression		Model 4 – Tobit Regression	
Variable	Coefficient	P-Value (Two-Tailed)	Coefficient	P-Value (Two-Tailed)
Investment	0.667 (0.092)	< 0.001	0.564 (0.132)	< 0.001
A-First Endogenous	1.333 (0.687)	0.055	0.287 (0.969)	0.767
P-First Endogenous	2.667 (0.930)	0.005	2.826 (1.343)	0.038
Beta	1.212 (1.027)	0.241	2.064 (1.456)	0.160
Beta_Missing	0.036 (0.676)	0.957	0.693 (0.996)	0.488
Constant	-0.370 (0.788)	0.640	0.600 (1.128)	0.596
Number of Observations	100		100	
Pseudo R^2	0.240		0.070	

Notes: Table 1.6 includes regression results for backtransfer as dependent variable. Columns 2 and 3 contain coefficients and two-tailed p-values of the Median regression. Columns 4 and 5 contain coefficients and two-tailed p-values of the Tobit regression. Standard errors are included in parentheses.

Model (4) shows a Tobit regression with upper bounds zero and 10 and using the same set of predictor variables. All effects show the same signs as in the Median regression, but significance results differ. Again, while the Tobit regression is less robust we rely on it for computing effect sizes.

1.6 Discussion and Conclusions

Voluntary leadership (*P-First Endogenous*) leads to higher investment in our trust game experiment compared to both *A-First Endogenous* and the treatment with exogenous

[12] If we estimate in an alternative model specification (not reported) the effect of *Beta* for large levels of *Beta* (the upper quartile level) we find a significant effect.

sequencing. The influence is shown as highly statistically significant in a Median regression analysis. Computing mean effect sizes we find that the predicted investment is 9.61 under voluntary leadership (*P-First*) compared to 7.39 under *A-First* and 6.69 in the reference category *P-First Exogenous*.[13] Thus, the effect of voluntary leadership on investment is not only statistically significant but also economically substantial (**Hyp. 1.1A**). We also find support for the second part of our main hypothesis: Backtransfer is higher under voluntary leadership than when the agent is forced to make the first move (**Hyp. 1.1.B**). Mean effect sizes predicted by the Tobit regression model are 7.24 for *P-First Endogenous* and respectively 5.21 for *A-First Endogenous* and 4.97 for *Exogenous Leadership*.[14] Again, voluntary leadership has an economically substantial effect.

We reproduce the finding of a positive correlation of investment and backtransfer that has been observed in other versions of trust games (see e.g. the meta-study of Johnson and Mislin 2011). This effect, the Trust-And-Reciprocity mechanism, is highly statistically significant.[15] Voluntary leadership adds to this finding. Since we control for investment in the regression analysis, we find the influence of voluntary leadership on top of the correlation between investment and backtransfer.

As predicted, investment decreases in risk aversion and unfavorable inequality aversion (**Hyp. 1.2.A** and **1.2.B**). It is larger for male than female. Eckel and Wilson (2004) and Houser et al. (2010) relied on the Holt/Laury measure of risk aversion in studying trust games as well. Both studies report only a weak influence of risk attitudes. Thus, we add to this literature by evidence in support of a correlation between investment and risk attitudes.[16] Counter to **Hypothesis 1.3** backtransfer does not correlate significantly with favorable inequality aversion (*Beta*) even though the effect points into the predicted direction (higher *Beta* leads to

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[13] We use the Tobit regression model to compute predicted values. *Alpha*, *Risk Aversion* and *Male* are set to mean values. *Alpha Missing* and *Risk Missing* are set to zero. The computations respect the truncation at zero and 10. If we compute effect sizes based on the linear index of the Tobit model (not reported), effect sizes are even larger.

[14] These are predicted values computed conditional on an investment level fixed at 7, a mean value of *Beta* and for *Beta Missing* = 0.

[15] Pillutla et al. (2003) report that the relationship between investment and backtransfer in the standard trust game (see Berg et al.) is nonlinear with backtransfer being relatively larger for maximal investment rather than intermediate investment levels. In our case here Figure 1.1 suggests, however, that backtransfer is concave in investment. Adding squared investment as regressor in model (3) (not reported) results in a negative but insignificant coefficient.

[16] Supporting evidence is also provided by Kosfeld et al. (2005). They show in a neuroeconomic study on a trust game variant that oxytocin increases the willingness to bear social risks. Bohnet and Zeckhauser (2004) investigate whether playing a binary-choice trust game is equivalent to taking a risky bet and show that the trust game is perceived as more risky.

higher backtransfer). These findings show that individual characteristics of players modify behavior in our trust game.

Analyzing the game under FS-preferences proved useful in deriving empirical predictions, e.g. by allowing for positive investments and backtransfers. In principle, it allows to consider individual characteristics of players via individual preference parameters. And, one might consider extending the model to allow for inequality aversion, risk aversion and incomplete information with respect to the other player's preferences at the same time. In this case one could possibly derive voluntary leadership formally as a trust signal, if this decision provides information about the unknown player type. However, to our knowledge this has not been done so far, and it would be beyond the scope of our study.[17].

While we were mainly interested in investment and backtransfer conditional on the choice of voluntary leadership one might also be interested in that choice itself. So one might ask: What drives the choice of voluntary leadership? – An answer to this question would also be relevant to understand the choices of investment and backtransfer. For instance, if the decision to lead implies self-selection on risk types, this would explain higher investment under voluntary leadership. We can use our data on individual characteristics to investigate whether the choice of voluntary leadership is correlated with certain player types. To do this we ran Logit regression (not reported) with the choice of *P-First Endogenous* (versus *A-First Endogenous*) as dependent variable and regressors *Risk Aversion*, *Alpha*, *Beta*, gender, the trust measure of the world value survey and the five 16-PA factors. However, none of these variables showed a significant influence.

Thus, our data do not explain the choice to lead. But we offer some thoughts on the psychology the decision to lead. We think informally of voluntary leadership as a signal of trust, like in the standard version of the Berg et al. (1995) game, where the choice of investment by the first mover is interpreted as "trust choice". If the principal decides to lead and to take the investment choice himself/herself this induces stronger reciprocation by the second mover. This psychological interpretation (of voluntary leadership as a trust signal) is speculative, since one may offer other explanations. For example, the principal may decide to lead in order to avoid a negative signal (if forcing the agent to lead is seen as signaling a non-cooperative attitude). This explanation, however, can be ruled out on the basis of our data,

[17] In addition there are other models of social preferences that might offer additional insight e.g. the intention-based models of Dufwenberg and Kirchsteiger (2004), and Falk and Fischbacher (2006) or the outcome-based model of Bolton and Ockenfels (2000).

since investment is not significantly lower under *A-First Endogenous* than under *Exogenous Leadership*. Rather, investment under *A-First Endogenous* is insignificantly larger than under exogenous sequencing.

Yet another alternative reason for the principal to take the lead may be that he/she expects the agent to be more risk-averse. To investigate this possibility one may run further experiments in the future in which one collects data on the principal's expectations regarding the agent's choice of backtransfer.

Interestingly, backtransfer (conditional on investment) is higher under both conditions, *P-First Endogenous* and *A-First Endogenous* than under *Exogenous Leadership*. In the former case it is the agent who chooses backtransfer, and the agent might want to compensate the principal for putting himself/herself at risk. In the latter case (*A-First Endogenous*) it is the principal who chooses backtransfer, and he/she might want to compensate the agent for having been put at risk by himself/herself. Psychologically, these are different reasons for increased backtransfers. So there is room for more experiments on endogenous trust games in the future.

2. Endogenous Leadership in an Experiment on the Investment Game with Heterogeneous Agents

2.1 Introduction

The trust game introduced by Berg et al. (1995) is widely used to model principal agent relations in experimental economics. The game consists of two players one of them called trustor and the other one called trustee. In the first stage the trustor decides which part of his/her endowment he/she wants to transfer to the trustee. On its way to the trustee the invested amount is multiplied by a factor larger than one (typically three). In stage two the trustee can send an arbitrary amount of what he/she wants to give back to the trustor. Meanwhile the rational selfish trustor will choose to send nothing back to the trustee and rather keeps the whole endowment for him/her. He/she prefers to maximize the joint payoff and will invest the full endowment. However the trustor is at the risk of being exploited by the trustee.

The endogenous trust game introduced by Kleine et al. (2013) is a modification of the trust game by Berg et al. (1995) with respect to two aspects. Firstly, not only the investment but also the backtransfer is tripled. Secondly, one of the players decides about the sequence of the game. Kleine et al. (2013) refer to this as endogenous leadership. They find substantial efficiency gains if one player endogenously decides to move first. In order to disentangle the fairness motives inequality aversion and positive reciprocity we want to modify this game by introducing inequality in endowments. This was done before in a similar way by Xiao and Bicchieri (2010). They introduce inequality in endowments in a trust game where the sequence is predetermined exogenously. We want to check if the strengthened trust reciprocity mechanism which is reported in Kleine et al. (2013) also holds if the players are asymmetrically endowed.

We think that inequality in endowments is a natural assumption for principal agent relations in practice. It is hard to believe that in real life principals and agents are equally endowed. In a more realistic setting the principal should be better off than the agent. Thus, Xiao and Bicchieri's (2010) as well as our design models real principal agent relations better than the standard trust game as proposed by Berg et al. (1995).

The paper proceeds as follows. In Section 2.2 we review the related literature. Section 2.3 presents the model of the game and derives our research hypothesis. After that in Section 2.4 we describe the experimental procedures. Section 2.5 presents and analyzes the data. In Section 2.6 we summarize and discuss the results, respectively.

2.2 Related Literature

To the best of our knowledge this is the first study on endogenous sequencing in trust games with asymmetric endowed players. The related literature can be divided in two strands, one on trust games with asymmetric endowments and one on endogenous leadership.

As mentioned above Xiao and Bicchieri (2010) introduced a variation of the trust game where players are endowed asymmetrically. They use a mechanism to introduce inequality in endowments which is very similar to ours. In their game the sequence is given exogenously, and the trustor's endowment is set to ensure that both players are paid equally, if the investor sends the maximal amount to the trustee. Xiao and Bicchieri (2010) restricted the strategies of both players. The investor could decide between zero or 10 and the trustee can respond either zero or any multiples of five. They find a decline in positive reciprocity when reciprocation increases inequality in payoffs.

Endogenous leadership in experimental economics has been studied by Arbak and Villeval (2013) as well as by Rivas and Sutter (2011). They keep their focus on endogenous leadership in public good games. Both studies found positive effects of endogenous leadership. Kleine et al. (2013) introduced a modified trust game with endogenous leadership. The main results of the studies are that a considerable number of players decide to move first, the endogenous leaders invest amounts near to the upper bound of the strategy space, endogenous leadership is rewarded with comparable high back transfers and the decision to move first endogenously strongly increases efficiency.

Our new trust game with endogenous leadership wants to check if the introduction of inequality in endowments reduces the positive effects of endogenous leadership found by Kleine et al. (2013).

2.3 Experimental Game and Theoretical Predictions

2.3.1 The Trust Game with Endogenous Leadership

The game has exactly the same structure as the game of Kleine et al. (2013). For that reason the following description is taken from there:

"Consider a principal-agent game between two players, player *P* (principal) and player *A* (agent), which are both initially endowed with 10 money units. The game comprises three stages:

Stage 1: *P* decides upon the sequencing of moves in the trust game that follows in stages 2 and 3. *P* has two options, sequence "*P-First*" or sequence "*A-First*", with the meaning that in case of *P-First* (see stages 2.a and 3.a) the trust game is played with *P* being investor (first mover) and *A* being trustee (second mover) and vice versa in case of *A-First* (see stages 2.b and 3.b).

If *P-First*:

Stage 2.a: *P* decides upon investment $x_p \in \{0,1,...,10\}$; then *A* receives the amount $3x_p$.

Stage 3.a: *A* decides upon backtransfer $y_a \in \{0,1,...,10\}$; then *P* receives the amount $3y_a$.

If *A-First*:

Stage 2.b: *A* decides upon investment $x_a \in \{0,1,...,10\}$; then *P* receives the amount $3x_a$.

Stage 3.b: *P* decides upon backtransfer $y_p \in \{0,1,...,10\}$; then *A* receives the amount $3y_p$."

However the payoff function is different. Payoffs are determined as follows:

$$\pi_p = 50 - x_p + 3y_a \text{ and } \pi_a = 10 - y_a + 3x_p$$

(if *P-First*)

or

$$\pi_p = 50 - y_p + 3x_a \text{ and } \pi_a = 10 - x_a + 3y_p$$

(if *A-First*)

This concludes the description of the game.

While both players are endowed with 10 experimental currency units (ECU) in Kleine et al. (2013), we endow player *P* (the trustor) with 50 ECU and the trustee (player *A*) only with 10 ECU. Thereby we introduce a conflict between different fairness motives, namely inequality aversion and reciprocity. Both players can transfer an amount between zero and 10 ECU. If player *P* transfers the maximum possible amount of 10 ECU both players' payoffs will be equal. Thus, player *A* has no incentive to transfer any amount back since this would decrease utility of inequality averse players as brought forward by Fehr & Schmidt (1999). If one player decides to invest a positive amount in standard trust games both inequality aversion and positive reciprocity predict positive backtransfer. Now, in our game with unequal endowments, the inequality aversion of player *A* would predict a transfer of zero, but at the same time positive reciprocity explains a positive transfer of player *A*. Furthermore we are interested in the strength of the signal which came from endogenous leadership. Kleine et al. (2013) already show that endogenous leadership causes high investments as well as high backtransfers. We want to check whether this holds under the condition of inequality in endowments.

To test the effects of reciprocity and inequality aversion we controlled the game described above with several other treatments. First we ran sessions where the sequence of moves was given exogenously. For that reason the control treatment only consists out of two stages (2.a, 3.a), where *P* invests and *A* transfers back. We want to refer to this treatment as *P-First Exogenous*. This treatment allows us to observe the effect of voluntary leadership, if we compare it with the situation *P-First-Endogenous*, because in both situations the better endowed player *P* invests first. Furthermore we hold all parameters, payoff multiplicators and instructions constant to the game of Kleine et al. (2013). Therefore we are able to compare our new results with the results of endogenous leadership with symmetric endowed players. This enables us to observe the effects of inequality in endowments.

2.3.2 Research Hypotheses

It is straightforward to show that the game theoretic solution with egoistic preferences predicts zero investment and zero backtransfer in trust games. This holds because at the second stage the trustee has no incentive to transfer back anything. Since the investor anticipates that he/she has also no incentive to invest positive amounts. As a result we can say that both players will hold on to their initial endowments and choose the inefficient solution.

On the other hand, models of social preferences predict investments and backtransfers that are different from zero. Among the proposed theoretical models of social preferences we will first rely on the inequality aversion model of Fehr and Schmidt (1999, henceforth FS).[18] The FS model for two players *i* and *j* is given by the following utility function:

$$U_j = \pi_j - \alpha_j \max\{\pi_i - \pi_j, 0\} - \beta_j \max\{\pi_j - \pi_i, 0\}$$

with restrictions $0 \leq \beta_j < 1$ and $\alpha_j \geq \beta_j$. The variables π_j and π_i represent monetary payoffs of players j and i while the parameter α_j (β_j) represents the degree of aversion against unfavorable (favorable) inequality. Appendix A contains the proofs of the following two propositions that we derive from the FS model.

> **Proposition 2.1**: Regardless of the degree of inequality aversion of player *A* and the sequence chosen by *P* player *A*'s transfer is zero.

It is easy to show that this does not depend on the inequality aversion of player *A*, if he or she transfers positive amounts. *A* positive transfer of player *A* always increases inequality since it increases the payoff of *P* and simultaneously decreases the payoff of player *A*. Thus, it has to decrease *A*'s utility according to the FS model. This holds for both possible sequences, because the transfer decision of player *P* is independent from the amount transferred by player A, even if player *A* has to move first which is shown by the following Proposition.

> **Proposition 2.2**: If player *P* (the better endowed player) is sufficiently inequality averse ($\beta_p > 1/4$) the subgame perfect equilibrium (SPE) is a full transfer of player *P*. Player *A*'s transfer is zero and player *P* is indifferent about the sequence.

The FS model predicts two possible outcomes of the game, one with equal payoffs and one with unequal payoffs amounting to the respective endowments of the player *A* and *P*. Consequently the FS model predicts zero transfer of player *A* and depending on his or her inequality aversion zero or full transfer of player *P*.

[18] See e.g. the intention-based models of Dufwenberg and Kirchsteiger (2004), and Falk and Fischbacher (2006) or the outcome-based models of Bolton and Ockenfels (2000) and Fehr and Schmidt (1999).

While the FS model makes point predictions, the predictions of the intention based theories of reciprocity[19] are more differentiated. The theory of reciprocity by Dufwenberg and Kirchsteiger (2004, henceforth DK) suggests the following utility function for player k:[20]

$$U_k(f) = \pi_k(f) + \rho_{kl}\sigma_k\sigma_l$$

Where *f* is a particular end node of the game, $\pi_k(f)$ is the payoff of player *k* in this particular end node *f* and ρ_{kl} is an individual parameter of player *k,* which represents the degree of reciprocity of player *k* to player *l*. If player *k* does not reciprocate it is zero and the utility of the end node is simply the payoff. Otherwise the utility is enlarged by the second term of the right hand side of the equation. This is the product of two terms: the reciprocity term of player *k*, σ_k, and the kindness term of player *l*, σ_l. The kindness term is the difference of the actual payoff and the so called equitable payoff. The equitable payoff π_k^e is simply the mean of the highest possible payoff π_k^h and the lowest possible payoff π_k^l of player *k*. It is given by

$$\pi_k^e = \frac{\pi_k^h + \pi_k^l}{2}.$$

The kindness term σ_l measures player *k*'s experienced kindness resulting from player *j*'s move and is given by

$$\sigma_l = \pi_k - \pi_k^e.$$

The reciprocation term σ_k measures the kindness of player *k* to player *l* and is defined symmetrically to the perceived kindness of player *k*.

In our game the kindness term is positive if the first mover invests more than three money units to the second mover.[21] The following proposition can be shown to hold and the proof is attached to Appendix A.

> **Proposition 2.3**: If one of the players invests an amount $x_l > 3$, then the backtransfer of the other player is also positive if $\rho_k > \frac{\Delta\pi_k}{\sigma_k\sigma_l}$.[22]

[19] Three popular models are proposed by Rabin (1993), Dufwenberg and Kirchsteiger (2004) and Falk and Fischbacher (2006).

[20] We now call both player *k* and *l* to distinct between the other notations. This is necessary because in the terms of the DK model both players are symmetric since their asymmetric endowment has no impact for the predictions in this model. Thus, we use the notation $k \in (A, P), l \in (A, P) \wedge k \neq l$.

[21] See Appendix A.

This means that there is a threshold parameter ρ_k such that every reciprocal player backtransfers positive amounts if the investment is large enough to produce a positive kindness term. Furthermore there is a negative correlation between the threshold of ρ_k and the investment x_l. The necessary threshold ρ_k is decreasing when the investment x_l increases. Thus, the larger the investment is, the higher is the probability of a positive backtransfer. This holds for both players, also the worse endowed player *A*, since the DK model doesn't account for initial payoff differences. This result is interesting because it contrasts the prediction of the FS model. Hence, it is able to predict both positive investment of player *P* and positive backtransfer of player *A*.

The two other regarding preference models discussed above predict different outcomes for our game. We think that the predictions of both models hold in some sense and that the observed outcome will be somewhere in between both predictions. Furthermore, if we take the result of Kleine et al. (2013) as a stylized fact, we expect that there might be an additional effect of voluntary leadership, i.e. we expect a higher backtransfer of player *A* if player *P* decides to move first voluntary. This cannot be explained by one of the models but seems to be natural in the sense that the risky choice to invest first can be interpreted as an additional signal of trust which is rewarded with strengthened reciprocal behavior of the second mover.

Based on the above theoretical reasoning, we formulate the following empirical hypotheses:

Hypothesis 2.1: Transfer of player *P* (either investment or backtransfer depending on the sequence) is larger than transfer of player *A*.

Hypothesis 2.2: If player *P* endogenously decides to move first the backtransfer of player *A* is higher than under exogenous treatment.

Hypothesis 2.3: Compared to the symmetric treatment of Kleine et al. (2013) investment and backtransfer of player *P* increases and investment and backtransfer of player *A* decreases.

[22] $\Delta\pi_k$ is the difference between the actual maximal payoff of player k at the node of her decision and the payoff he/she gets if he/she reciprocates with a positive backtransfer. This means that $\Delta\pi_k$ increases with σ_k.

2.4 Experimental Procedures

We used the same experimental procedures as in Kleine et al. (2013), but asked the first movers additionally about their belief about what the backtransfer of the other player might be. The experiments were conducted in the experimental economics lab at the University of Erfurt. It was computerized using the software z-Tree (see Fischbacher 2007). The subjects were recruited using the software Orsee (Greiner 2004). We ran 12 sessions with 246 participants, which were students from different fields (social sciences and humanities). Each subject participated in only one game, thus the experiment was truly one-shot. Players received written instructions, were randomly paired and interacted anonymously (instructions are attached in Appendix B). The trust game with endogenous leadership was applied in nine sessions with 192 participants. The control treatment (*P-First-Exogenous*) was applied in three sessions with 54 participants. Since some invited participants did not show up, the number of participants in each session was not equal. Consequently, we had to run more sessions on the endogenous treatment to collect enough observations on voluntary leadership.

After receiving and reading the written instructions the participants were matched randomly and played the investment game. In the endogenous treatment one player decided on the sequence. Then the investment decision was made by the first mover. After that we elicited the beliefs of the first mover about the amount sent back by the trustee. We incentivized this question with the *Quadratic Scoring Rule*[23]. We asked them to estimate the probability of every possible backtransfer. Thus, we obtained a probability distribution of every investor's belief about his or her expected backtransfer. After that the second mover was informed about the first mover's investment and decided upon the backtransfer. Finally both players were informed about their payoffs.

After the trust game was played we elicited risk aversion and FS-preference parameters α_j and β_j by letting the participants play the lottery game introduced by Holt and Laury (2002) as well as the distribution game by Danneberg et al. (2007). Both games were incentivized. We use these measures to control our treatment effects for possible exogenously determined effects. Details on these procedures are provided in the Appendix B. We also collected the trust measure provided by the World Value Survey (2005)[24]. The participants additionally

[23] The Quadratic Scoring Rule was introduced by Brier (1950). The article of Offerman et al. (1996) popularized the method among experimental economists.

[24] The question is: Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people? Participants may answer "yes" or "no".

filled in the 16-PA-personality questionnaire of Brandstätter (1988) and provided some socio-demographic characteristics, like: age, gender, experience in economic experiments and so on. This gives us the opportunity to control additionally for individual measures. All in all we have a number of incentivized and non-incentivized measures. The experimental procedures are summarized in Table 2.1. Each session took about 45 minutes, subjects were paid anonymously, and average earnings were about 18 EUR.[25]

Table 2.1: Overview of Experimental Procedures

Treatment	Sequence of Games	Observations
Endogenous Leadership	1. Trust Game with Endogenous Leadership	9 Sessions
	2. Holt/Laury Game, Danneberg et. al. Game	96 Pairs
	3. Trust Question, 16-PA and Socio-Demographic Questionnaire	192 Participants
Exogenous Leadership	1. Trust Game With Exogenous Leadership	3 Sessions
	2. Holt/Laury Game, Danneberg et. al. Game	27 Pairs
	3. Trust Question, 16-PA and Socio-Demographic Questionnaire	54 Participants

2.5 Empirical Results

2.5.1 Descriptive Statistics and Simple Analyses

Table 2.2 and Table 2.3 provide summary statistics of investment and backtransfer decisions and summarize the beliefs of investors about backtransfer of trustees and the actual backtransfer rate – 39 out of 96 (about 40.6 %) principals decided to move first.

Table 2.2: Summary Statistics (Means)

Treatment		Investment x	Belief b	Backtransfer y	Backtransfer Rate y/x	# Obs.
Endogenous Leadership	*P-First Endogenous*	6.85 (3.03)	5.06 (1.90)	4.95 (3.49)	0.83 (0.73)	39
	A-First	4.95 (3.30)	4.53 (2.08)	5.39 (3.42)	1.40 (1.16)	57
Exogenous Leadership		6.70 (2.74)	4.59 (1.72)	4.19 (2.84)	0.66 (0.39)	27

Notes: Table 2.2 includes means and standard deviations of investment, backtransfer and backtransfer rate by treatment.

[25] An average earning for a student job at the time of the experiment was about eight euro per hour.

According to the summary statistics in Table 2.2 there is no substantial difference between investment in *P-First-Endogenous* and *P-First-Exogenous*. Investment in *A-First* is smaller than under both conditions where the principal took the first move. The results do not change if medians are used (see Table 2.3).

Table 2.3: Summary Statistics (Medians)

Treatment		Investment x	Belief b	Backtransfer y	Backtransfer Rate y/x	# Obs.
Endogenous Leadership	*P-First Endogenous*	7 (5)	4.63 (1.31)	5 (6)	0.8 (0.5)	39
	A-First	5 (6)	4.78 (2.88)	5 (6)	1 (0.5)	57
Exogenous Leadership		7 (5)	5 (2.01)	4 (6)	0.67 (0.57)	27

Notes: Table 2.3 includes medians and interquartile range of investment, backtransfer and backtransfer rate by treatment.

Somewhat sharper is the difference in backtransfers and backtransfer rate between *P-First-Endogenous* and *P-First-Exogenous*. The median of backtransfer in *P-First-Endogenous* is one point higher. The backtransfer rate is approximately 1.26 times of the one in *P-First-Exogenous*. There is a distinct difference between backtransfer and backtransfer rate in *A-First,* and the treatments where the principal invests indicate support for **Hypothesis 2.2**.

The pairwise Mann-Whitney U tests shown in Table 2.4 all in all confirm the impression of the summary statistics. There is a highly significant difference in investment between *P-First-Endogenous* and *A-First*, a weaker significant difference between *P-First-Exogenous* and *A-First*, but no significant difference between *P-First-Endogenous* and *P-First-exogenous*. Differences in backtransfers between *P-First-Exogenous* and *P-First-Endogenous* are not significant. The backtransfer rate in *A-First* differs significantly from *P-First-Exogenous* and *P-First-Endogenous*. Thus, a first look at the data suggests no significant effects of endogenous leadership but a strong effect of the asymmetric endowment on investment and backtransfer.

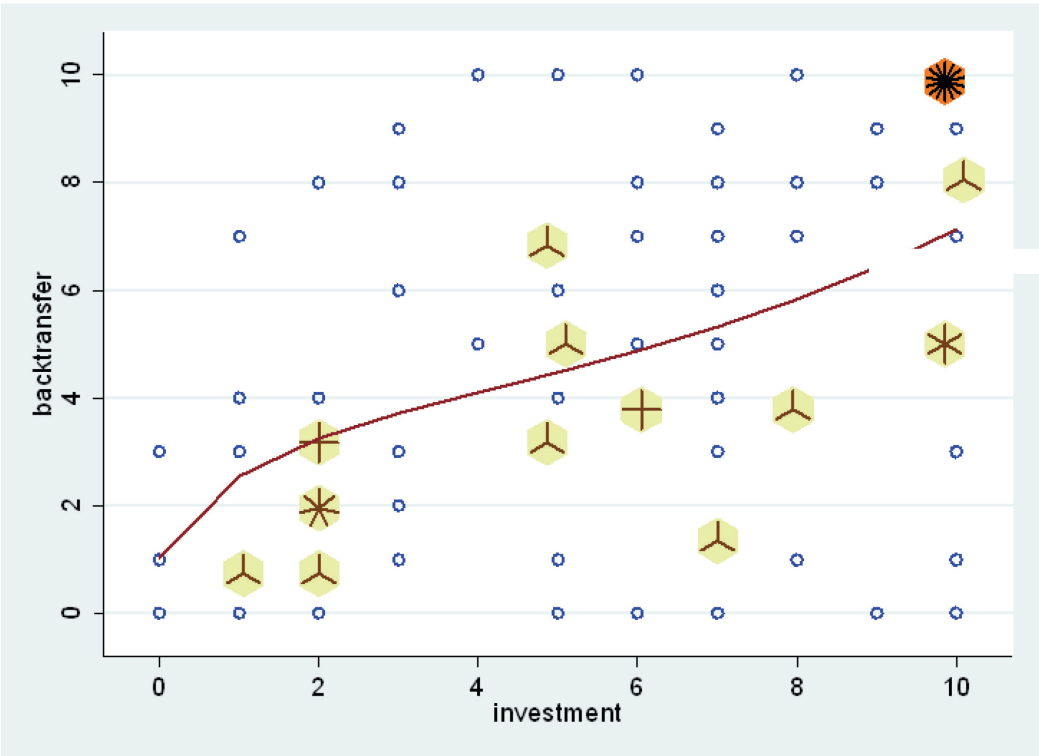
Table 2.4: Mann-Whitney U Test of Treatment Differences

Investment	
P-First-Endogenous versus *P-First-Exogenous*	p = 0.795, N = 66
P-First-Endogenous versus *A-First-Endogenous*	p = 0.006, N = 96
P-First-Exogenous versus *A-First-Endogenous*	p = 0.019, N = 84
Backtransfer	
P-First-Endogenous versus *P-First-Exogenous*	p = 0.390, N = 66
P-First-Endogenous versus *A-First-Endogenous*	p = 0.536, N = 96
P-First-Exogenous versus *A-First-Endogenous*	p = 0.139, N = 84
Backtransfer rate	
P-First-Endogenous versus *P-First-Exogenous*	p = 0.487, N = 66
P-First-Endogenous versus *A-First-Endogenous*	p < 0.001 , N = 96
P-First-Exogenous versus *A-First-Endogenous*	p < 0.001 , N = 84

Notes: P-values are calculated for two-tailed test.

The joint distribution of backtransfers and investments displayed in Figure 2.1 clearly indicates a positive correlation between investment and backtransfer.

Figure 2.1: Sunflowerplot of Backtransfer over Investment



Notes: Small dots represent one observation. In larger dots (called flowers) one line (called petal) is one observation. The curve is fitted with polynomial regression.

The petals represent clustering of observations and the polynomial regression fit is represented by the red curve. Spearman rank correlation coefficient between backtransfer and investment is positive and statistical significant (ρ = 0.477, $p < 0.001$, N = 123), which supports a strong trust and reciprocity mechanism.

2.5.2 Regression Analyses of Investment

We use regression analyses in order to test the robustness of our treatment differences. Thereby we are able to control the influence of other variables, namely: beliefs, social preferences, risk attitudes and personal characteristics. The conditional distribution of backtransfer on investment (shown in Figure 2.1) indicates clustering of observations on the upper bound and some outliers. Therefore we do not use OLS-regressions. We decided to use the more robust Median regression due to the outlier problem and the Tobit regression due to the clustering of observations on the upper bound.

Table 2.5 reports the results of different model specifications for regressions of investment on some potentially explanatory variables. There are no statistical relevant explanatory variables for investment beneath the 0-1-dummy variable for the treatment *A-First* and the variable belief, which is the average over expected backtransfer of the investor.[26]

The Median regression in Table 2.5 fits well (pseudo R^2 = 0.338). The base category of both regressions is *P-First-exogenous.* Both models in Table 2.5, the Median und the Tobit regression, show that there is a high significant positive effect of belief on investment. The higher the expected backtransfer, the higher is the investment or vice versa. Furthermore there is no significant effect of endogenous leadership. The 0-1 coded treatment dummy for *P-First-endogenous* remains insignificant. Principals who decide to invest instead of passing the first move to the agent do not invest more than principals who have to move first exogenously. But in line with the summary statistics and the nonparametric tests, agents who have to move first invest less than principals, which is shown by the negative high significant coefficient of the treatment dummy *A-First*. All excluded variables, like psychological measures and socioeconomic variables, have no significant effects on the investment decision.

[26] To find the best model we also apply Bayesian Model Averaging (BMA) techniques. This seems unavoidable because we have a set of 18 potentially explanatory variables, and we don’t rely on backward exclusion. Since this could produce multicollinearity problems. We use the R algorithm from Feldkircher and Zeugner (2009) to apply a model selection mechanism based on BMA. Even if the algorithm is performed for an OLS model and without modeling prior information it confirms the results of simple correlation analysis of the variables, i.e. pair wise regression fit, graphs of investment and other potential explanatory variables which are not reported.

Even risk aversion has – contrary to Kleine et al. (2013) – no significant effect and is therefore also excluded from the regression.

Table 2.5: Regression Results of Regression on Investment

Dependent Variable: *Investment*, Base Category is *P-First-Exogenous*				
	Median Regression		Tobit Regression	
Variable	Coefficient	P-Value (Two-Tailed)	Coefficient	P-Value (Two Tailed)
Belief (Average)	1.165 (0.125)	<0.001	1.461 (0.154)	<0.001
P-First-Endogenous	-0.663 (0.695)	0.342	-0.264 (0.752)	0.726
A-First	-1.712 (0.653)	0.010	-1.999 (0.690)	0.004
Constant	1.430 (0.795)	0.075	0.579 (0.878)	0.511
N	123		123	
Pseudo R^2	0.338		0.150	

Notes: Table 2.5 includes regression results for investment as dependent variable. Columns 2 and 3 contain coefficients and two-tailed p-values of the Median regression. Column 4 and 5 contain coefficients and two-tailed p-values of the of Tobit regression. Standard errors are included in parenthesis.

2.5.3 Regression Analyses of Backtransfer

Table 2.6 summarizes the regression analysis of backtransfer.[27] Again we use Median and Tobit regressions. The Median regression fits well overall (pseudo $R^2 = 0.326$). The base category is *P-First-Exogenous*. As expected, investment enters the regression with a high statistically significant positive coefficient. Consequently, this indicates that the trust-reciprocity-mechanism works well even in an environment with asymmetric endowed players. All other variables are 0-1 coded dummies. Again, as indicated by nonparametric analysis, there is no effect of *P-First-Endogenous*. The dummy variable for *A-First* is significant and comparable high. This means that player *P*, who decides to delegate the first move, reciprocates stronger to investment decisions of player *A*. Remember that player *P*'s endowment is five times higher than the endowment of players *A*. The variable *Experimental Experience*, which is coded as 1, if the person participated in any other experiment before, is significant and negative. For that reason somewhat experienced subjects show a lower backtransfer than others.

[27] Again we pretest the model structure by employing a BMA algorithm. Table 2.6 includes the specification of the regression as suggested by the BMA algorithm.

Table 2.6: Regression Results of Regressions on Backtransfer

Dependent Variable: *Backtransfer*, Base Category is *P-First-Exogenous*				
	Median Regression		Tobit Regression	
Variable	Coefficient	P-Value (Two-Tailed)	Coefficient	P-Value (Two-Tailed)
Investment	0.652 (0.060)	<0.001	0.724 (0.101)	<0.001
P-First-Endogenous	0.000 (0.565)	1.000	0.124 (0.841)	0.883
A-First	1.304 (0.548)	0.019	1.939 (0.822)	0.020
Alpha-Missing	-2.087 (0.655)	0.002	-1.797 (1.197)	0.136
Alpha-High	1.130 0.456)	0.015	1.279 (0.693)	0.068
Beta-Missing	0.783 (0.641)	0.225	1.533 (0.982)	0.121
Beta-High	1.478 (0.437)	0.001	1.791 (0.684)	0.010
Experimental Experience	-1.609 (0.408)	<0.001	-1.703 (0.611)	0.006
Constant	0.696 (0.690)	0.316	-0.260 (1.051)	0.805
N	123		123	
Pseudo R^2	0.326		0.106	

Notes: Table 2.6 includes regression results for backtransfer as dependent variable. Columns 2 and 3 contain coefficients and two-tailed p-values of the Median regression. Column 4 and 5 contain coefficients and two-tailed p-values of the of Tobit regression. Standard errors are included in parenthesis.

Notice that the inequality aversion parameters will have different effects in the sub treatments. On the one hand unfavorable inequality aversion measured by *Alpha* will affect the backtransfer decision of player *A* negatively. On the other hand favorable inequality aversion measured by *Beta* will affect player P's backtransfer decision in treatment *A-First* as well as his/her investment decision in the *P-First* treatments positively. However, the expected difference in effects between sub treatments is not supported by our regression. The variable *Beta-High* enters with a significant and positive coefficient[28], i.e. more inequality averse players should provide higher backtransfers. *Alpha-High* is also statistically significant but

[28] *Beta-High* is coded 1 if the favorable inequality aversion parameter exceeds the median which is about 0.25.

positive.[29] This contradicts the theoretical expectation about the effects of inequality aversion parameters. *Beta-Missing* and *Alpha-Missing* are nuisance variables for the participants who had intransitive preferences with respect to the elicitation of the inequality aversion parameters. *Alpha-Missing* is statistically significant and has the coefficient with the highest amount.[30] The Tobit specifications show almost the same effects. All in all our regressions supports **Hypothesis 2.1**. The weaker player *A* reveals less amounts of transfer in both sequences. And the regression analysis rejects **Hypothesis 2.2**. There seems to be no effect of endogenous leadership.

2.5.4 Comparison with the Symmetric Treatment

To complete our analysis we compare our results of the asymmetric treatment with the results of the symmetric treatment of Kleine et al. (2013). Remember that the design of this experiment is identical. The only difference is that both, *P* and *A*, are endowed symmetrically with an endowment of 10 ECU. For this analysis we do not rely on regression analysis because of the complex interpretation of the treatment dummies.[31] Therefore we use robust nonparametric tests. The investment decisions are compared with Mann-Whitney U tests. The results together with the data averages are presented in Table 2.7.

The difference between the *P-First-Exogenous* treatments is that player *P* in the asymmetric treatment is endowed with 50 ECU and with 10 ECU in the symmetric treatment. The difference between the means is not significant on a five percent level. Thus, better endowed players who have to invest first only invest marginally more than symmetrically endowed players. The differences between the *P-First-Endogenous* treatments are that in the symmetric treatment both players are endowed equally with 10 ECU, and in the asymmetric treatment player *P* is endowed with 50 ECU. Here the Mann-Whitney U test rejects the hypothesis that both means are equal ($p = 0.008$). This indicates that in the asymmetric treatment the better endowed players *P*, who decides to move first, invest substantial smaller amounts than they do in the symmetric treatment. The differences between the *A-First-Endogenous* treatments are as follows: in the asymmetric treatment player *A* faces a counterpart that is endowed with 50 ECU; while in the symmetric treatment *A-First-Endogenous*, *A* and his/her counterpart are

[29] *Alpha-High* is coded as 1 if the unfavorable inequality aversion parameter exceeds the mean which is about 0.45.

[30] We have 18 participants where *Alpha* is missing. Therefore we introduced coefficient *Alpha-Missing* that is necessary to avoid the exclusion of the 18 observations in the regression analysis.

[31] Note that we had to include 5 treatment dummies into one regression with on base category. This produces a very complex and circumbendibus interpretation of the particular treatment dummies.

equally endowed with 10 ECU. In both treatments *A* has to move first as a consequence of player *P*'s decision. The test rejects the hypothesis that both means of investment are equal (p = 0.002). Players *A* in the symmetric treatments invest substantially more than worse endowed players *A* in the asymmetric treatment.

Table 2.7: Average Investment and Mann-Whitney U Tests

Investment	P-First-Exogenous	P-First-Endogenous	A-First-Endogenous
Symmetric Treatment	5.40	9.13	6.83
	(20)	(16)	(64)
Asymmetric Treatment	6.70	6.85	4.95
	(27)	(39)	(57)
P-Value	0.0987	0.0079	0.0020

Note: Table 2.7 contains averages of investment decisions for all sub treatments within the symmetric and asymmetric treatment. The numbers of observations are included in parenthesis. P-value is for the two-tailed Mann-Whitney U test for differences between the averages in a sub treatment (columns) and between symmetric and asymmetric treatment (rows).

Since investment and backtransfer are positive correlated, one has to account for differences in investment in order to analyze differences in backtransfer decisions. Therefore we use relative backtransfers to compare both treatments.[32] The results of the Mann-Whitney U tests and the means of relative backtransfers are reported in Table 2.8.

Table 2.8: Average Relative Backtransfer and Mann-Whitney U Tests

Relative Backtransfer	P-First-Exogenous	P-First-Endogenous	A-First-Endogenous
Symmetric Treatment	0.94	0.89	0.88
	(20)	(16)	(63)
Asymmetric Treatment	0.66	0.81	1.37
	(27)	(39)	(54)
P-Value	0.4889	0.0823	0.0007

Note: Table 2.8 contains averages of relative backtransfer for all sub treatments within the symmetric and asymmetric treatment. The numbers of observations are included in parenthesis. P-value is for two-tailed Mann-Whitney U test for differences between the averages in a sub treatment (columns) and between symmetric and asymmetric treatment (rows).

Since the worse endowed players *A* in the asymmetric treatment have almost the same backtransfer rate as in the symmetric treatment[33], the difference between symmetric and

[32] This is problematic in cases where the investment is zero. We exclude these eight cases from our analysis. Notice that even this measure is problematic since it has boundary problems in the sense that full investment of 10 money units could only be replied by a relative backtransfer of one while lower investments could be replied with a relative backtransfer which exceeds one.

[33] The backtransfer rate is identical with respect to the medians. Both medians are about 0.66.

asymmetric treatment for *P-First-Exogenous* is not significant. The relative backtransfer in the *P-First-Exogenous* treatment is weakly significantly higher in the symmetric treatment, i.e. equally endowed players *A* send relatively more back than players *A* who have less than their counterpart. The difference in the relative backtransfer of players *P* in the *A-First-Endogenous* treatment is highly significant, i.e. the better endowed players *P* show a significantly higher relative backtranfer than equally endowed players *P*.

2.6 Discussion and Conclusions

We find that in all treatments investment and backtransfer is strongly positively correlated, i.e. the participants show social preferences. In line with **Hypothesis 2.1** we observe that worse endowed players *A* transfer less than better endowed players *P* which supports the FS model of inequality aversion. On the other hand, we observe high variance in the transfers of both players which contradicts the sharp predictions of the FS model – which are either no or full transfer by player *P* and no transfer by player *A* – and favors on the other hand the DK model of reciprocity.

It seems that a mixture of both models may describe the data best. The FS model predicts that players *P* – being better off – transfer more than players *A* in order to reduce advantageous inequality while players *A* – being worse – transfer less, i.e. nothing, in order to reduce disadvantageous inequality. However, we observe that players *A* invest positive amounts. This observation cannot be explained by the FS model but might be explained by positive reciprocity. If players *A* decide, according to a DK utility function, their utility can increase with positive backtransfer. And even if *A* is a first mover, his/her expected utility might increase with positive investment if he/she beliefs that player *P* reciprocates to his/her kindness in form of positive investment with high backtransfers.

Furthermore, our results contradict the hypothesis that voluntary leadership increases reciprocity if the players are endowed asymmetrically. Thus we cannot find evidence for our **Hypothesis 2.2**. However, this might be explained by the following reasoning. It seems that in the case of asymmetric endowed players the decision of the better endowed player to move first is not seen as a kind act. If this holds there is no reason left that predicts stronger reciprocity in *P-First-Endogenous* compared to *P-First Exogenous*. However, it could be that the decision of the better endowed player to move first is interpreted as a kind of a norm, meaning that the richer player should decide to move first. Evidence for this interpretation is provided by the fact that the number of players, who decide to move first, is twice as high in the asymmetric game compared to the symmetric game of Kleine et al. (2013). Furthermore if the norm "rich-moves-first" applies, then differently motivated players *P*, i.e. efficiency oriented and not efficiency oriented players *P*, should decide to move first. In Kleine et al. (2013) all voluntary leaders invest high amounts while in the asymmetric game that we investigate here they do not. In *P-First-Endogenous* the average investment is about 9.13 ECU in the symmetric treatment while it is about 6.85 ECU in the asymmetric treatment. There is much variance in the amount of investment even under the condition *P-First-Endogenous*. While Kleine et al. (2013) observed self-selection in the sense of efficiency orientated players *P* deciding to move first, this is not the case for the asymmetric game. Thus endogenous leadership in an environment with asymmetric endowed players does not increase efficiency if the better endowed player can act as the voluntary leader. Therefore it might be of interest to run two additional treatments, one where *A* has to move first exogenously and another where *A* can decide about the sequence. In line with our findings these new treatments would produce high efficiency gains if *A* decides to move first and invest high amounts.

Our results differ from the ones of Xiao and Bicchieri (2010) who find a substantial decrease in positive reciprocity caused by inequality in endowments. In contrast, we find no significant differences in the backtransfer rate between sub treatment *P-First-Endogenous* with symmetric endowments and sub treatment *P-First-Endogenous* with asymmetric endowments. However, better endowed players *P* undertake substantially less investment than players *P* who have the same endowment as players *A*. Furthermore, our design allows for more variance in the investment decision since we let the investor choose between 11 different investment levels while Xiao and Bicchieri (2008) faced their subject with a binary choice between an investment of either zero or 10. Another difference and a potential explanation for the different results is that in our experiment not only investment but also backtransfer is tripled, i.e. reciprocation increases efficiency. Therefore it may be of interest to investigate whether this has an effect or not. A trust game with standard parameters and asymmetric endowments might answer these open questions.

3. Heterogeneous Agents, Incentives and Group Performance

3.1 Introduction

Organizing work in teams may be beneficial for organizations since teams can be more productive than individuals. But teams might suffer from shirking incentives if work effort cannot be fully controlled.[34] The employer (principal) might wonder whether effort in teams (agents) can be increased by monetary incentives. Furthermore, if there is self-selection – i.e. agents can choose whether to work in a team or individually – the principal might wonder whether this leads the "right" agents to join teams, i.e. agents that have high team productivity and are cooperative; or whether it invites the "wrong" agents, i.e. agents that have low team productivity and/or are egoistic. There exists mixed evidence on sorting in the literature. Hamilton et al. (2003) analyze heterogeneous workers' productivity and their sorting in individual or group piece rate payment schemes in the garment industry. They find that productivity of agents is improved if work is organized in teams. Contrary, Bäker and Pull (2010) show that self-selection in teams is appealing for low productive agents.

These questions are addressed in our experimental study. In our principal-agent game there is one principal and 16 agents. The agents can choose either a group task (*GT*) or an individual task (*IT*) or no task (exit option). The group task has the structure of a public good game between four agents, so there are incentives to shirk by not providing effort in *GT*. The group return is split between the four team members and the principal according to a linear pay contract (*GT*-contract) that has been offered by the principal before the agents' choices of task. Alternatively, if agents choose *IT* they subsequently choose a productive effort resulting in an individual return which is split according to the *IT*-contract. The latter contract, as the *GT*-contract, is linear, comprising a fixed wage and a return share.

This game has been studied before in Königstein and Lünser (2011) for a homogenous population of agents as well as a heterogeneous population of agents. Under heterogeneity the agents differ with respect to their productivity in *GT*. We implement a new variant of the game by introducing observability of productivity types. Before the team members make their choice of effort in *GT* they are informed about all team members' productivities. This

[34] A theoretical analysis of shirking can be found in the classical work of Alchian and Demsetz (1972). Experimental evidence for shirking in team are inter alia documented by Meidinger et al. (2003) and Nalbantian, and Schotter (1997).

treatment, which differs from Königstein and Lünser (2011) where types were unknown to team members, allows the agents to discriminate their effort with respect to the teams' productivity. As a consequence it might lead to stronger separation of player types between tasks.

We use the social preference model of Fehr and Schmidt (1999) as a workhorse to provide theoretical predictions regarding the influence of contracts and productivity on task selection and effort in *GT*. The standard preference model of neoclassical economics is of no help here. It predicts zero effort in *GT* and no choice of *GT* at all, but these predictions are rejected right away by tons of data on public good experiments. Cooperation in public good games is predicted by several models of social preferences. We rely on the Fehr-Schmidt model for reasons of tractability. Comparing this model with other social preference models is not within the scope of our study.

Other studies on sorting into teams and team incentive and social preferences are e.g. Teyssier (2007, 2008) and Vyrastekova et al. (2012). Teyssier (2007) theoretically investigates optimal group incentives for inequality averse agents. She shows that multiple payment schemes can be optimal if agents are inequity averse since these agents may prefer and perform better in teams. Teyssier (2008) investigates competition incentive schemes versus revenue sharing in teams. She reports that inequality averse agents prefer revenue sharing and perform better under that condition. Vyrastekova et al. (2012) investigates relations between trust, team sorting and team performance. She observes that agents who trust relatively more than others select group task more often and perform comparably better in teams.

Our main hypotheses are, first, that the principal can positively influence effort in *GT* by offering higher return shares. Second, we predict that effort increase in team productivity. And finally, we predict that self-selection into *GT* depends on productivity and can be positively influenced by the terms of the *GT*-contract. Overall, the compound hypothesis of social preferences and rational play results in structural variables (monetary incentives and productivity) having strategic value which they don't have under standard neoclassical preferences.

The paper continues as follows: In Section 3.2 we describe the experimental game in detail. Theoretical analyses and empirical hypotheses are provided Section 3.3. Then we report experimental procedures in Section 3.4 and empirical results in Section 3.5. The final Section 3.6 summarizes findings and has concluding remarks.

3.2 Experimental Game

The experimental game is almost the same as proposed by Königstein and Lünser (2011).[35] Consider a principal-agent-game with one principal (manager) and 16 agents (indexed below by j = (1, 2, ..., 16)). Work of agents can be organized either in individual tasks (*IT*) or in group tasks (*GT*). Productivities of agents differ between tasks and agents. Half of the agents are high productive the others low productive. The proportion of high and low productive agents is common knowledge while actual productivity is privately known. High productive agents have a productivity of 7.5 in *GT*. Low productive agents have a productivity of 2.5 in *GT*. We also refer to these players as high types or low types. In *IT* both types of players have the same productivity of three. Thus low productive agents are relatively high productive in *IT* and high productive agents are relatively high productive in *GT*.

The principal offers two linear pay contracts, one for *IT* and one for *GT*. The agents can choose one of these contracts or reject both. Effort in *IT* results in an observable, individual return. In *GT* workers are organized in groups of four. The effort choices of the four team members determine the joint return (group return). Prior to effort choices in *GT* the workers are informed about all team members' productivities.[36] The game is played over 10 periods. In each period the principal offers new pay contracts, each agent selects a task and chooses effort. The stages of the game are now described in detail.

Stage 1: The principal offers linear pay contracts for *IT* $w^{IT} = (f^{IT}, s^{IT})$ and *GT* $w^{GT} = (f^{GT}, s^{GT})$. Each contract comprises a fixed wage f^{IT}, f^{GT} and a return share s^{IT}, s^{GT}. Fixed wages and return shares are restricted as follows:

$$s^{IT}, s^{GT} \in \{0\%, 10\%, ..., 100\%\} \text{ and } f^{IT}, f^{GT} \in \{-15, -14, ..., +15\}$$

Stage 2: Each agent may choose one of the tasks (*IT* or *GT*) which means that he or she accepts the terms of the contract. If the agent neither accept w^{IT} nor w^{GT} he or she decides for the exit option where he or she earns nothing in this period. If w^{IT} is accepted, the agent works individually and will be paid according to w^{IT}. Accepting w^{GT} doesn't ensure that an agent will work in a group. Since agents are matched in teams of four, accepting w^{GT} is a

[35] Thus the description of the game is taken from there and is almost identical.

[36] This differs from Königstein and Lünser (2011) where the game is the same but productivity of team members are not observable.

preliminary decision. Those agents who cannot be matched are asked for an alternative (final) choice of either *IT* or the exit option.

Stage 3a: Agents *j* who decided for *IT* choose individual work effort $e_j \in \{0,1,...,10\}$. Work effort is associated with the cost function $c(e_j) = 2e_j$. The individual return in *IT* is determined by $r_j^{IT} = 3e_j$.

Stage 3b: Agents *j* who decided for *GT* are informed about the productivities of their group members. Then they choose individual work effort $e_j \in \{0,1,...,10\}$. Work effort is associated with the cost function $c(e_j) = 2e_j$. The joint return in *GT* of group *k* is determined by

$$r_k^{GT} = \sum_{l=1}^{4} q_l e_l ,$$

r_k^{GT} is a weighted sum of efforts of all group members with weights $q_j \in \{2.5, 7.5\}\ \forall\, j = 1, 2, \ldots, 16$ given by the individual productivity parameters. Individual productivity q_j is determined at the beginning of the game, is privately known and stays constant throughout all 10 periods. Payoffs of agents are determined as follows:

In *IT*:

$$\Pi_j^{IT} = f^{IT} + s^{IT} r_j^{IT} - c(e_j) \tag{1}$$

In *GT*:

$$\Pi_j^{GT} = f^{GT} + s^{GT} \frac{1}{4} r_k^{GT} - c(e_j) \tag{2}$$

for all members *j* of team *k*. If the exit option is chosen *j*'s payoff is zero. The principal's payoff is determined as follows. He or she has to pay fixed wages to all agents in *IT* and *GT* and collects residual returns. Thus the principal earns

$$\Pi_P = \sum_{j \in IT} \left((1 - s^{IT}) r_j^{IT} - f^{IT} \right) + \sum_{k \in GT} \left((1 - s^{GT}) r_k^{GT} - 4 f^{GT} \right) \tag{3}$$

with $j \in IT$ representing an agent who has chosen *IT* and with $k \in GT$ representing a group of four agents who have chosen *GT*.

All subjects were informed that roles of players are randomly chosen and that roles as well as types of productivity are fixed for all ten periods. Furthermore all subjects know that they were playing a repeated game with a single principal facing 16 agents and that groups in *GT* were formed randomly in each period. The disclosure of productivities of team members was such that agents could not identify each other by player number or otherwise. Thus, they could not track each other's productivity or past choices.

3.3 Theoretical Analysis and Behavioral Hypotheses

We describe in an intuitive manner theoretical solutions to the game from the perspective of efficiency as well as individual rationality conditional on egoistic or social preferences. A more detailed analysis can be found in Königstein and Lünser (2011).

The efficient solution of the game mandates low type agents to choose *IT* and provide maximal effort and high type agents to choose *GT* and provide maximal effort. To see this notice that marginal productivities are higher than marginal cost at all effort levels, that the low type agent is more productive in *IT* than in *GT* and that this is vice versa for the high type agent. These choices maximize the joint payoff of the principal and all agents together and this payoff could be distributed evenly or unevenly by an appropriate choice of the contract. However, this collectively optimal outcome cannot be reached under individual rationality if players have egoistic preferences. Namely, as in any public good game it is not rational to contribute positive effort in *GT*. Therefore, effort in *GT* will be zero no matter how strong monetary incentives s^{GT} are, and the principal should not offer a positive fixed wage f^{GT}. The best that the principal may do is to induce all agents to choose *IT* and provide maximal effort. This can be reached by a contract that satisfies $s^{IT} \geq 2/3$ (incentive compatibility constraint) and $f^{IT} \geq 20 - 30 \cdot s^{IT}$ (participation constraint).

This solution, which follows from the standard assumption of economics of egoistic and rational players, will not be able to explain the empirical data. *IT* is instructive to view it as a benchmark case, but it has been shown in many public good experiments that participants cooperate, indeed. And we find cooperation as well (see below). Therefore, to have any chance of matching theory and data one needs a more complex theoretical model. Social preference models offer an alternative that is able to explain cooperation in public good games. Assuming social preferences of the type introduced by Fehr and Schmidt (1999, henceforth FS), Königstein and Lünser (2011) show that there exist subgame perfect equilibria in which agents choose *GT* and positive effort if agents are sufficiently inequality averse: E.g. if all agents are inequality averse the existence conditions for this solution are

$$\beta_j \geq 1 - \frac{5}{16} s^{GT} \text{ for low types and } \beta_j \geq 1 - \frac{15}{16} s^{GT} \text{ for high types.}$$

These conditions show that cooperation is reached more easily among highly productive types, if players are inequality averse and if monetary incentives are stronger. Thus, contrary to the benchmark solution with egoistic preferences the solution with FS-preferences predicts that the principal's design of the *GT*-contract has strategic value: Team production may vary with incentives. Specifically, our empirical hypotheses are as follows:

> **Hypothesis 3.1.A**: In *GT* a higher return share s^{GT} offered by the principal induces higher effort.
>
> **Hypothesis 3.1.B**: In *GT* effort of high productive types is larger than that of low productive types.
>
> **Hypothesis 3.1.C**: Effort in *GT* is positively correlated with the degree of inequality aversion.

The influence of the second payoff variable, the fixed wage, is less clear. On the one hand changes in f^{GT} leave payoff differences between team members unaffected for all effort choices. Therefore f^{GT} should have no influence on effort in *GT*. On the other hand, the solution proposed by Königstein and Lünser (2011) assumes that considerations of equality are taken only with respect to other team members but not with respect to the principal. If however, the participants in the experiment consider the principal's payoff as well, they might respond higher fixed wages by reciprocally choosing higher effort. An additional complication is that fixed wage and return share should be correlated negatively. This is predicted theoretically via the participation constraint and it will in fact hold empirically. For these reasons we do not propose a clear influence of f^{GT} of effort in *GT*.

Since **Hypothesis 3.1** proposes positive effort in *GT* this should affect the choice of task as well. The agent's choice of task is not necessarily *IT* as predicted for egoistic players but it may be *GT*. Specifically, it depends on expected earnings under both tasks and thus it depends on fixed wage, return share and productivity type.

Hypothesis 3.2.A: *GT* is chosen more likely the higher the offered *GT*-payment is and the lower the offered *IT*-payment is. Offered payments depend on both, fixed wages and return shares.

Hypothesis 3.2.B: *GT* is chosen more likely by high productive types than by low productive types.

Hypothesis 3.2.C: The probability of choosing *GT* is positively correlated with the degree of inequality aversion.

Hypotheses 3.1.A, **3.1.B**, **3.2.A** and **3.2.B** were also investigated in Königstein and Lünser (2011). They did not study **3.1.C** and **3.2.C** since they did not take measures of inequality aversion. Furthermore, a novel feature of our design is that the team members observe each other's productivity type before choosing effort. This allows agents to discriminate their effort choice with respect to the average productivity of the team. Consequently, under observable types it will be more difficult for low productive types to successfully join teams than under non-observable types. Therefore we predict a stronger, and thus more efficient, separation of types in our experiment than under non-observable types as in Königstein and Lünser (2011).

Hypothesis 3.3: Separation of productivity types is stronger here than in Königstein and Lünser (2011) in the sense that of all agents who choose GT the proportion of low types vs. high types is smaller here than in Königstein and Lünser (2011).

Hypotheses 3.1 to **3.3** are our main behavioral hypotheses. It should be mentioned that our experiment is not intended to test and propose the FS-preference model against other social preference models. Cooperation in public good games is also predicted by other social preference models. Showing which one is more successful is not within the scope of our study. We rather rely on the FS model as a workhorse. The mere fact that social preferences can generate cooperation (if preference parameters are chosen appropriately) is an important step forward compared to standard neoclassical preferences. Namely, the influence of structural variables like monetary incentives may change with changes in preferences and it makes little sense to assume preferences that are immediately refuted by the data as it is the case with standard neoclassical preferences.

3.4 Experimental Procedures

The experiment was conducted at the experimental economics lab at the University of Erfurt. It was computerized by using the software z-Tree (Fischbacher 2007) and all participants are recruited via Orsee (Greiner 2004). In total 153 students of various disciplines participated in the experiment. Each student participated only in one session. In the laboratory participants were separated by cabins. They received written instructions and examples to ensure that they had understood the rules of the game.

Participants were randomly and anonymously assigned to one of the roles. Roles were labeled "participant A" for the principal, "participant B" for agents with low productivity and "participant C" for agents with high productivity. The game was played according to the rules described above. At the end of each period the period payoffs were calculated by the computer program and displayed on the screen. Agents were informed about their own payoff and group return of their own team. The principal was informed about task selection as well as all return resulting from *IT* and *GT*. Payoffs were shown in points and the exchange rate of EUR and points was commonly known. The exchange rate was one euro per 100 points for the principal and one euro per 10 points for agents. Show-up fees were 0.5 euro for the principal and five euro for agents. [37]

After the participants had played the game we ran additional experiments and used questionnaires to collect additional data on individual characteristics. We elicit social preferences as proposed by Danneberg et al. (2007) and risk preferences as proposed by Holt and Laury (2002). Both elicitation mechanisms were incentivized. Screenshots of the procedure as well as the instructions of the game are attached to Appendix B. Finally, the participants had to fill out the 16-PA personality questionnaire of Brandstätter (1988) and answer some questions on socio-demographics (gender, age, etc.).

Sessions took about one hour and 45 minutes. Average earnings where about 15 euro. Decisions were taken privately and payments were made such that subjects did not see each other's payments.

[37] The experimental procedures of the principal agent game are almost the same as in Königstein and Lünser (2011). Thus the description is partially taken from there.

3.5 Empirical Results

3.5.1 Descriptive Statistics

Table 3.1 presents an overview of the collected experimental data.

Table 3.1: Overview of Experimental Data

Number of Periods		10	
Number of Principal Choices	Contract Design	90	
Number of Agent Choices	Task Choice, Effort	1440	
Contract Design (Mean, Std. Dev.)	*Return Share GT*	63.6%	(27.3)
	Fixed Wage GT	-0.8	(7.8)
	Return Share IT	69.3%	(22.1)
	Fixed Wage IT	-2.5	(7.1)
Choice of Task (Freq.)	*Group Task (GT)*	928	
	Individual Task (IT)	370	
	None (Exit Option)	142	
Effort (Mean, Std. Dev.)	*Group Task (GT)*	4.511	(3.084)
	Individual Task (IT)	5.831	(3.410)

We ran nine sessions. Since the game had 10 periods, we collected a total of 90 principal decisions and 1440 agent decisions. The majority of agents decided for the group task rather than the individual task or none. Effort in *GT* is positive and is on average about 4.5. Contract design is such that the four contract variables are correlated.

Table 3.2 shows Spearman rank correlation coefficients. Specifically, return share and fixed wage in *GT* as well as return share and fixed wage in *IT* are negatively and highly significantly correlated. This should be expected from a theoretical viewpoint. It has to be taken into account later since it may lead to multicollinearity in regression analyses. Return shares of the two tasks and both fixed wages are positively but not significantly correlated.

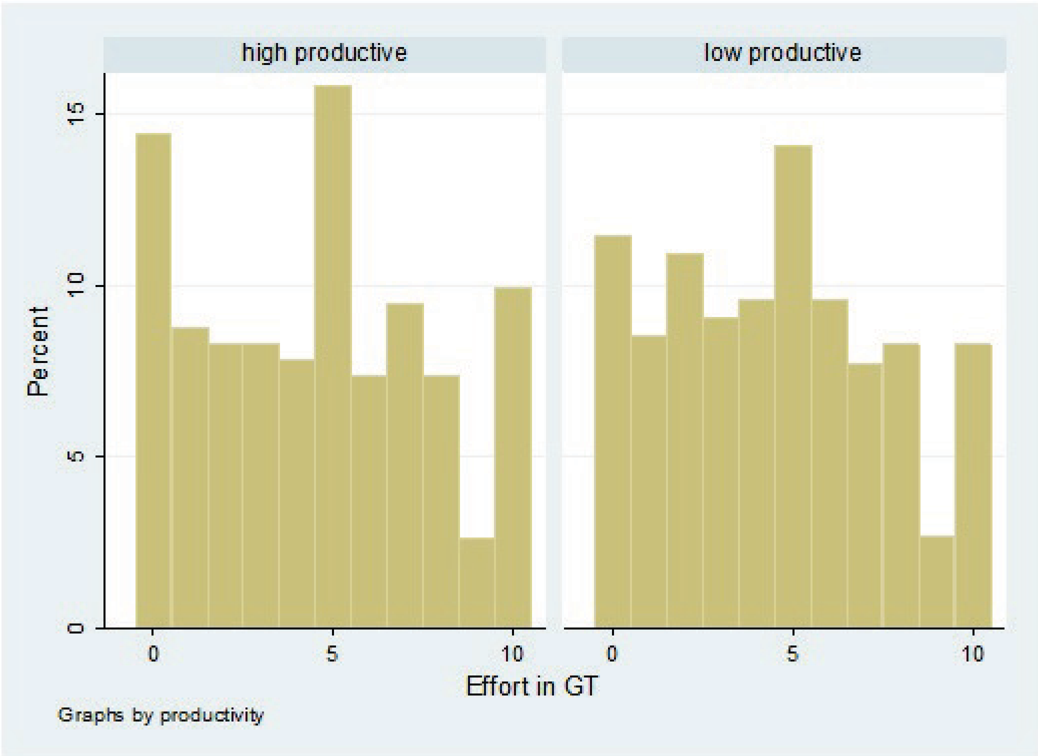
Table 3.2: Correlations of Contract Variables

Correlation	Spearman's Rho	P-Value
Return Share GT ~ Fixed Wage GT	-0.534	< 0.001
Return Share IT ~ Fixed Wage IT	-0.483	< 0.001
Return Share GT ~ Return Share IT	0.139	0.192
Fixed Wage GT ~ Fixed Wage IT	0.167	0.116
		N = 90

3.5.2 Effort in *GT*

We now look at effort in *GT*. As expected a substantial fraction of the participants choose *GT* and provide positive effort in teams. Figure 3.1 shows frequency distributions separately for high productive types and low productive types. Figure 3.2 shows frequency distributions separately for teams of different levels of average productivity. While it seems that effort increases in average team productivity (see Figure 3.2), a difference between high and low types can hardly be detected (see Figure 3.1).

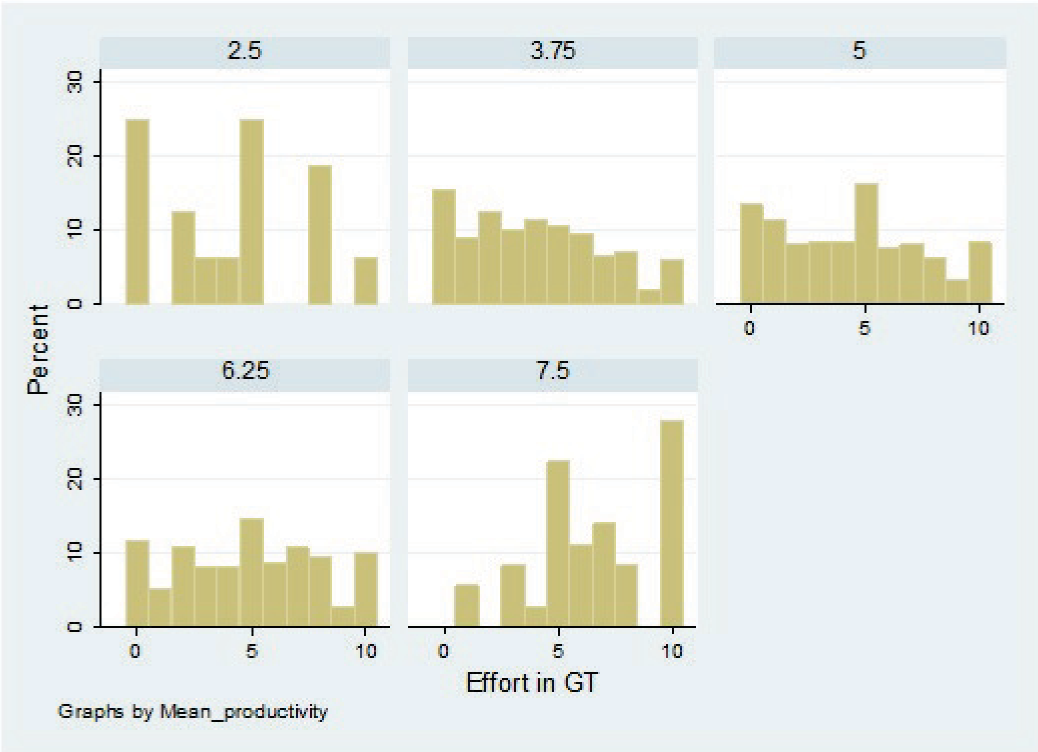
Figure 3.1: Effort in *GT* by Agent's Productivity Type



To gain a more accurate view we have to control for other influencing factors. This is done in a regression analysis reported in Table 3.3. It is a Tobit regression analysis on effort choice in *GT* as dependent variable with lower bound zero and upper bound 10. The influence of return share, fixed wage and productivity was estimated separately for symmetric teams – i.e. all four team members have the same productivity – and asymmetric teams. In asymmetric teams the variables return share, fixed wage, team productivity and a dummy for asymmetric teams (the reference category are symmetric and highly productive teams) are highly statistically significant.[38]

Result 3.1.A and 3.1.B: The influences of return share and productivity clearly support **Hypotheses 3.1.A** and **3.1.B**.

Figure 3.2: Effort in *GT* by Average Productivity of Teams



For symmetric teams neither the return share nor the fixed wage have a significant influence. But this hardly weakens **Results 3.1.A** and **3.1.B** for two reasons: First, insignificance does not mean that the results are wrong but just that they don't hold for all subgroups. Second, symmetric teams comprise only a small fraction (6.5%) of all teams. We will look at the influence of incentives in symmetric teams in more detail below. Symmetric teams of low productivity provide significantly lower effort than symmetric teams of high productivity (see *dummy low team productivity*). Furthermore there is a decrease in provision of effort over time (see the influence of *period*).

[38] To account for repeated measurement the standard errors where determined by assuming clustering on individuals. Since the choice of effort in *GT* is made conditional on the choice of task there might be a selection bias in effort choices. To check this possibility we estimated an alternative specification following the Heckman procedure Heckman (1979). We found the selection effect to be insignificant.

To illustrate the results we estimated a revised version of model 1 eliminating the insignificant regressors return share and fixed wage for symmetric teams (see Table C 1 in Appendix C). Relying on this regression model Figure 3.3 shows predicted values of effort in GT for different levels of the return share and for different teams. Accordingly, symmetric teams with high average productivity of 7.5 provide higher effort than all other teams and do so independent of the offered return share. Average effort is about seven. This is different for asymmetric teams. These teams have an average productivity of 3.75, five or 6.25, and effort responds strongly to changes in return share s^{GT}; at low return share levels effort is close to minimal; at high return share levels effort is about six. The predicted effort lines are ordered according to productivity which illustrates that effort is positively correlated with average productivity of the team. Finally, the predicted effort line is flat for symmetric teams of low productivity (productivity = 2.5). At high return share levels ($s^{GT} > 0.6$) predicted effort in these teams is lowest of all teams. However, at low levels of return share is larger than effort in teams that are asymmetric but have higher average productivity. Symmetry seems to stimulate higher effort.

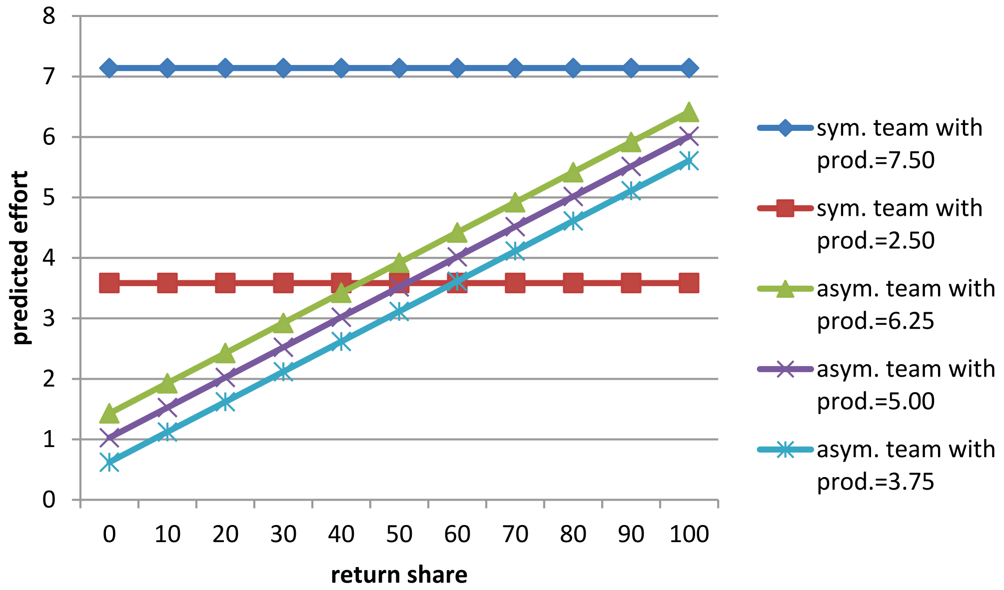
Table 3.3: Tobit Regression Analysis of Effort Choice in *GT*

Variable		Coefficient	Robust Std. Error	P-Value
Asymmetric Team	*Return Share*	0.050	0.008	< 0.001
	Fixed Wage	0.071	0.028	0.012
	Team Productivity	0.323	0.141	0.023
	Dummy Asym. Team	-8.932	3.328	0.007
Symmetric Team	*Return Share*	-0.015	0.043	0.478
	Fixed Wage	0.079	0.112	0.729
	Dummy Low Team Productivity	-3.495	1.201	0.004
Period		-0.266	0.056	< 0.001
Constant		9.720	3.220	0.003
Model Statistics: N = 800; P-Value < 0.001; Pseudo R^2 = 0.0324; Dependent Variable: Effort in *GT*				

Overall it seems that in high productive and symmetric teams effort is close to the upper bound so there is little scope for monetary incentives to further increase cooperation. This may explain why the return share has no significant influence in these teams. In symmetric and low productive teams effort does not respond positively to return share variations either. In such teams average individual productivity is 2.5 while individual marginal cost is two. Thus, the team as a whole can benefit from higher production only at very high return shares ($s^{GT} > 0.8$).

Contrary to **Hypothesis 3.1.C** inequality aversion as measured by the Danneberg et al. experiment had no significant influence on effort in *GT*. We tried several regression specifications (not reported here) but never found significance for effort in *GT*. We see two possible reasons for this. First, effort in *GT* is taken conditional on self-selection into *GT*. It may be that only the selection of *GT* is positively influenced by inequality aversion (which will turn out below) but not the effort in *GT* conditional on that choice. Secondly, the Danneberg et al. experiment might be a weak empirical measure of FS-preferences. There is some indication of this possibility due to the large fractions of players for which either the α-measure or the β-measure is missing (36 of 144 agent = 25%).

Figure 3.3: Predicted Value Plot for Regression Model 1



Notes: Figure 3.3 displays predicted values of effort in *GT* for teams according to average team productivity dependent on return share. The calculation of the predicted value based on the regression model in Table C 1 in Appendix C.

3.5.3 Choice of Task

According to the game rules the agents may choose one out of three tasks, *GT* or *IT* or none of these (exit option). The frequencies of choices are shown in Table 3.4.[39] Accordingly agents of high productivity type choose *GT* more frequently than low productivity types.

[39] These are frequencies of initial task choices. Final choices differed somewhat since agents in *GT* had to be matched in teams of four participants. Specifically, the number of final choices of *GT* was 800.

Table 3.4: Frequency of Task Choices

Agent's Choice	Group Task	Individual Task	Exit Option	Total
Low Productive Agents	441	205	74	720
High Productive Agents	487	165	68	720
Total	928	370	142	1440

To investigate the influence of contract design and productivity on task choice we ran a multinomial logit regression reported in Table 3.5.

Table 3.5: Multinomial Logistic Regression Results of Task Choices

	GT versus IT		
Variable	Coefficient	Std. Error	P-Value
Share in GT	0.036	0.004	< 0.001
Fix in GT	0.133	0.016	< 0.001
Share in IT	-0.032	0.005	< 0.001
Fix in IT	-0.177	0.019	< 0.001
HT	0.476	0.166	0.004
Alpha-High	0.499	0.191	0.009
Alpha-Missing	0.268	0.234	0.252
Beta-High	0.284	0.175	0.104
Beta-Missing	-0.359	0.285	0.207
Period	0.237	0.096	0.014
Period^2	-0.016	0.008	0.052
Constant	-0.506	0.550	0.358
	Exit Option versus IT		
Variable	Coefficient	Std. Error	P-Value
Share in GT	-0.002	0.006	0.695
Fix in GT	-0.094	0.021	< 0.001
Share in IT	-0.021	0.008	0.008
Fix in IT	-0.260	0.031	< 0.001
HT	0.404	0.334	0.226
Alpha-High	0.801	0.403	0.047
Alpha-Missing	-0.097	0.625	0.877
Beta-High	0.335	0.336	0.318
Beta-Missing	-1.377	0.586	0.019
Period	0.382	0.232	0.101
Period^2	-0.019	0.017	0.283
Constant	-2.959	1.023	0.004
Model Statistics: N = 1440; P-Value < 0.001; Pseudo R^2 = 0.2462			

The upper panel shows estimation results for the choice of *GT* versus the reference category *IT*. The lower panel shows estimation results for the choice of the exit option versus *IT*. We are mainly interested in the choice of *GT* versus *IT* therefore we focus on the upper panel. With respect to the influence of return shares and fixed wages we find that each of the four estimated coefficients shows the predicted sign and is highly statistically significant.[40]

[40] Standard errors are adjusted for clustering on individuals.

Result 3.2.A: In line with **Hypothesis 3.2.A** the probability of choosing GT increases in the payment offered by the GT-contract (s^{GT}, f^{GT}) and decreases in the payment offered by the IT-contract (s^{IT}, f^{IT}).

Result 3.2.B: High productive types choose GT more likely than low productive types.

The latter is indicated by the positive and significant coefficient of dummy high productivity. Table 3.5 furthermore reports positive influences of the FS-preference parameters α and β. A joint test for $\alpha = \beta = 0$ shows that the coefficients are jointly statistically significant ($p = 0.016$).

We collect this finding as

Result 3.2.C: GT is chosen more likely by individuals that are more inequality averse.

Finally we find that the probability of choosing *GT* increases over time and does so at a decreasing rate (see variables *period* and *period*^{2}).

A subtle question with respect to the influence of productivity is whether productivity simply shifts the probability of choosing *GT* upward or whether high types respond in a different manner on return share or fixed wage than low types. Table C 2 in the Appendix C reports a refined regression model that allows for interaction effects of the dummy high productivity and the four payment variables. While three of the four interaction terms are significant the main effect of dummy high productivity becomes insignificant. We consider this result as non-conclusive.

As a final step in the empirical analysis we want to assess **Hypothesis 3.3**. Table 3.6 shows predicted values (according to the regression model of Table 3.5) for the fraction of low types and high types under observable productivity for two different levels of s^{GT}.

Table 3.6: Separation of Productivity Types

	Observable Productivity		Non-observable Productivity (Königstein/Lünser)	
	$s^{GT} = 0.5$	$s^{GT} = 0.8$	$s^{GT} = 0.5$	$s^{GT} = 0.8$
Low Productive Agents	46.1%	48.3%	48.4%	49.3%
High Productive Agents	53.9%	51.7%	51.6%	50.7%

All variables of the regression model except s^{GT} and dummy high production were set to mean values. For comparison Table 3.6 also shows the respective predictions under non-observable productivity as reported in Königstein and Lünser (2011). In line with **Hypothesis 3.3** there is stronger separation of types when types are observable; the fraction of low productivity types entering *GT* is smaller than with non-observable productivity. But the separation is far from being efficient. Efficiency calls for a percentage of high types in *GT* of 100%. The self-selection of participants into tasks has led to an allocation of types that is only somewhat more efficient than a random allocation of types which would lead to an expected fraction of 50%.

3.6 Discussion and Conclusions

In our experiment we find that effort in *GT* increases in the return share offered by the principal (**Result 3.1.A**). The terms of the linear *GT*-contract also influence the choice of task (**Result 3.2.A**). Thus, monetary incentives have strategic value for self-selection into teams and for the degree of team cooperation even if the group task has the structure of a public good game. This is counter to the standard neoclassical prediction but it can be rationalized assuming FS-preferences.

Team cooperation increases in the team's average productivity (**Result 3.1.B**). The participants anticipate this in their task choice which leads high productivity types to choose *GT* more likely than low productivity types (**Result 3.2.B**). But the separation of types is far from complete: Theoretically, the efficient allocation of types requires all high types to choose *GT* and all low types to choose *IT*. But in fact, for $s^{GT} = 0.5$ the empirically predicted proportion of high types is just 53.9%. Thus, self-selection leads to a very inefficient allocation of types to tasks. This result is moderated by observability (**Result 3.3**). If the team members are informed about types prior to effort choices, the separation of types is stronger than under unobservable types as reported by Königstein and Lünser (2011).

However, there is a large gap for possible efficiency gains and one might speculate why the allocation of types is so inefficient. Again this question should be discussed within a framework of social preferences. The regression model for the choice of task showed that the FS-preference parameters have positive and significant influence on the probability of choosing *GT* (**Result 3.2.C**). This suggests that there are low productive but inequality averse agents who enter teams in order to prevent inequality. In addition there might be a fraction of egoistic types that enter teams in order to shirk.[41] But the fraction of egoists must be small because otherwise cooperation in teams would cease rather fast.

Counter to what should be expected the FS-preference parameter did not prove significant within the *GT*-effort-regression. Thus, it may be that only the choice of task is correlated with inequality aversion but not the effort choice which is conditional the task choice. Another possibility we mentioned is that the empirical measure of FS-preference parameters is weak and should be improved.

We found some indication that at low levels of incentives symmetric teams of low types show higher levels of cooperation than asymmetric teams of higher average productivity. It seems that symmetry helps to establish cooperation. But since only a small fraction of our observations are on symmetric groups, this effect should be seen as preliminary.

In concluding we emphasize that the compound model of FS-preferences and rationality was successful in producing theoretical predictions that are well supported by the data. Of course, other models of social preferences might have been used instead. But to discriminate between such models was not our issue here. Rather we studied the influence of team incentives and productivity within a social preference framework to allow for predictions that are not to be rejected right away, which is the case if one follows the standard assumption of egoistic preferences.

[41] This is in line with the findings of Bäker and Pull (2010), Teyssier (2008) and Vyrastekova et al. (2012).

4. Quantal Response Equilibrium for an Ultimatum Game with Advance Investment

4.1 Introduction

The quantal response equilibrium (QRE) introduced by McKelvey and Palfrey (1995, 1998) provides a flexible framework for estimating structural models of behavior in experiments. It allows the researcher to estimate parameters of arbitrary utility functions. The QRE can be viewed as an expansion of the Nash Equilibrium concept: it captures both; fully rational behavior as predicted by the latter and completely randomized behavior as well as all intermediate forms. Thus in the QRE one player chooses the stochastic best reply to another players' stochastic best reply. The imperfectness of choices can be interpreted as either decision errors or the influence of omitted variables within the postulated model.

In this Chapter I will present a QRE model for a simple three stage ultimatum game. The first stage comprises simultaneous effort decisions of two players which determine their contribution to a joint production function. During the second stage one predetermined player proposes how to split the joint production output and at the third stage the other player either accepts or rejects the offer.

In Section 4.2 I review the related literature. In Section 4.3 I describe the game and the transformation of the original game parameters first and then I formulate the QRE model. In Section 4.4 I present the results of the maximum likelihood estimation and I conclude with Section 4.5.

4.2 Related Literature

To the best of my knowledge this is the first study to apply the QRE model to a three stage game which comprises both simultaneous and sequential decisions. The related literature can be classified into two threads, one on the theoretical background of the QRE model and one on its application to games.

The pioneering work behind the QRE model was done by Luce (1959), Marschak (1960), Luce and Suppes (1965) and McFadden and Richter (1970). Luce (1959) introduced a choice axiom which implies the Independence of Irrelevant Alternatives Assumption (IRRA) and thus, building upon the IRAA, shows that the multinomial logit model can be derived as the appropriately specified model. Marshak (1960) introduces the random utility model which incorporates a random shock to the utility of every alternative. Marshak and Suppes (1965) and McFadden and Richter (1970) show that the Luce (1959) model is consistent with the random utility model if the random disturbances follow an Extreme Value Type I distribution. Later on McFadden (1974) introduces his conditional logit model which is widely known as the multinomial logit model. A brief history of the development of the logit model can be found in Kenneth E. Trains textbook on discrete choice methods (see Train 2003) and a more detailed history in McFadden's Nobel lecture (see McFadden 2001). In the 1990s McKelvey and Palfrey (1995, 1996, and 1998) use QRE models for game theoretic applications and propose a particular parametric class of QRE, the logit equilibrium.

McKelvey and Palfrey (1995) are the first to estimate parameters logit equilibrium models for decisions in games. Offerman et al. (1998) estimate parameters of a logit equilibrium model for a public good game. Hereafter the logit equilibrium is extensively used to describe behavior in games which cannot be explained by standard theory and the Nash Equilibrium concept including, inter alia, matching pennies games (Goeree et al. 2003), auction like games (Anderson et al. 2002), the volunteer's dilemma (Goeree et al. 2005), the traveller's dilemma (Capra et al. 1999) and simple lotteries (Laury and Holt 2002). Goeree and Holt (2000) estimate parameters of the Fehr and Schmidt (1999) utility function in a sequential three stage ultimatum bargaining game. Another study which draws on the Fehr and Schmidt (1999) utility function and the logit equilibrium is Goeree et al. (2005). They estimate a Fehr Schmidt utility function in a simultaneous experiment on the volunteers' dilemma. Yi (2005) and Kohler (2008) analyze the ultimatum game with a logit equilibrium model. Kohler (2008) estimates parameters of the utility function proposed by Bolton and Ockenfels (2000) with data from an ultimatum game conducted in Zimbabwe.

4.3 The Model

4.3.1 The Ultimatum Game with Advance Production

I consider a two player ultimatum game with advance production.[42] Both players were randomly assigned to their roles. The game comprises three stages:

In stage one both players *i* and *j* decide simultaneously about the effort

$$e^{(l)} \in \{0, 1, 2, \dots, 30\} \text{ with } l \in \{i, j\}$$

they are willing contribute to a joint production.

These efforts are associated with costs given by cost function

$$c(e^{(l)}) = \begin{cases} 0 & \text{if } e^{(l)}=0 \\ 15 + 12.5\, e^{(l)} - 1.73 {e^{(l)}}^2 + 0.015 {e^{(l)}}^3 & \text{otherwise.} \end{cases}$$

The outcome of the production is given by production function

$$r\left(e^{(i)}, e^{(j)}\right) = 22\, e^{(i)} + 44\, e^{(j)}.$$

Since the marginal productivity of player *j* is two times the marginal productivity of player *i*, it is evident that player *j* is more productive than player *i*.

In stage two player *i* is informed about the output of the joint production and decides upon how to split the common good by choosing an offer

$$o^{(i)} \in \left\{0, \dots, r\left(e^{(i)}, e^{(j)}\right)\right\}.$$

In stage three player *j* is informed about the output of the joint production and offer $o^{(i)}$. Then he/she can either accept or reject the offer which is indicated by function

$$\delta^{(j)}(o^{(i)}) = \begin{cases} 0 \text{ if rejection of } o^{(i)} \\ 1 \text{ if acceptance of } o^{(i)} \end{cases}.$$

If offer $o^{(i)}$ is rejected by player *j* the common good is not distributed among the players while they still have to bear their costs.

[42] The game is founded and implemented by Königstein and Tietz and published in Königstein (2000).

The payoff functions for the two players are given by

$$\pi^{(i)} = \delta^{(j)}\big(o^{(i)}\big)\big(r\big(e^{(i)}, e^{(j)}\big) - o^{(i)}\big) - c\big(e^{(i)}\big);$$
$$\pi^{(j)} = \delta^{(j)}\big(o^{(i)}\big)\, o^{(i)} - c\big(e^{(j)}\big).$$

It is straightforward to show that the efficient solution of the game is $e^{(i)} = 12$ and $e^{(j)} = 16$ which results in a return of $r(12, 16) = 968$ associated with costs of $c(12) = 115$ for player i and $c(16) = 243$ for player j. Backward induction yields the subgame perfect equilibrium of the game with

$$e^{(i)} = 12,\ e^{(j)} = 0,\ o^{(i)} = 1 \text{ and } \delta^{(j)}(o^{(i)}) = 1.$$

For further details see Königstein (2000). The dataset I use below stems from an implementation of this game by Königstein and Tietz in 1993 and 1994 in Frankfurt am Main. For a detailed description of the game and on how it was conducted see Königstein (2000).

4.3.2 Modifications of the Initial Game

For estimation purposes some parameters of the initial game introduced by Königstein (2000) have to be modified in order to avoid numerical problems while calculating the likelihood function. Effort decisions are still the same but censored at $e^{(l)} > 18$, thus

$$e^{(l)} \in \{0, 1, 2, \dots, 18\}.$$

I censor the effort decisions to avoid estimating a model for decisions which results in a division of costs. Remember that effort decisions above 12 for player i and above 16 for player j are too high in the sense of not payoff maximizing. Furthermore the effort decisions are classified. The first class contains only zero effort, the second class contains one and two and so forth until the last class which contains 17 and 18. Thus for the estimation I only use 10 classes of effort decisions

$$e^{(l)} \in \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$$

which are associated with cost

$$c(e^{(l)}) \in \{0, 15, 22, 26, 30, 39, 53, 76, 111, 161\}.$$

These costs are class midpoints of the original costs. The OLS estimate of the cost function for these values is given by

$$\mathrm{c}(e^{(l)}) = \begin{cases} 0 & \text{if } \mathrm{e}^{(l)}=0 \\ 3.31 + 15.37\,\mathrm{e}^{(l)} - 4.03\,{\mathrm{e}^{(l)}}^2 + 0.47\,{\mathrm{e}^{(l)}}^3 & \text{otherwise.} \end{cases}$$

The return function remains unaltered and is given by

$$r\left(e^{(i)}, e^{(j)}\right) = 22e^{(i)} + 44e^{(j)}.$$

These changes let the efficient solution of the game fall into another class of effort decisions. The efficient solution is now $e^{(i)} = 6$ and $e^{(j)} = 8$. This implies that the game theoretic solution is also changed and predicts zero effort of player j, $e^{(i)} = 6$, offer $o^{(i)} = 1$ and its acceptance by player j. All offers are also downscaled such that they have the same proportion to the return as they had before downscaling.[43] Furthermore all efforts, costs, returns and offers are multiplied by 0.1 to avoid numerical problems with the likelihood maximizing procedure within the software package R.

4.3.3 The Specification of the Logit Equilibrium

The logit equilibrium consists of a set of choice probability distributions for every single decision of the game. All of them have to be correctly anticipated by all players, i.e. players have consistent beliefs. In the ultimatum game with advance production every stage has its particular choice probabilities. In stage three these are the probabilities of acceptance of any possible offer conditional on every possible history of the game. The probability of offer $o^{(i)}$ being accepted by player j is given by

$$p^{(j)}(\delta^{(j)}(o^{(i)}) = 1|(e^{(i)}, e^{(j)})).$$

Stage two is described by the probability distribution of offers conditional on every possible combination of efforts. The probability of offer $o^{(i)}$ being made by player i is given by

$$p^{(i)}(o^{(i)}\,|(e^{(i)}, e^{(j)})).$$

43 I'm aware of the problem that downscaling produces distorted probabilities in the formula of the logit equilibrium. But this seems unimportant since I want to show an estimation procedure for this kind of game and do not want to make prediction of the behavior in the initial game.

Stage one is described by the probability distributions of all possible efforts of both players. The probability of player i choosing effort $e^{(i)}$ is given by

$$p^{(i)}(e^{(i)})$$

and the probability of player j is choosing effort $e^{(j)}$ is given by

$$p^{(j)}(e^{(j)}).$$

Since the whole history of the game is known, the acceptance probabilities of stage three can be computed easily. The probability of accepting offer $o^{(i)}$ is given by

$$p^{(j)}(\delta^{(j)}(o^{(i)}) = 1|(e^{(i)}, e^{(j)})) = \frac{\exp(\lambda^{(3)}U^{(j)}(o^{(i)}))}{\exp(\lambda^{(3)}U^{(j)}(o^{(i)}))+\exp(\lambda^{(3)}U^{(j)}(-c(\mathrm{e}^{(j)}))}.$$

Where $U^{(j)}(o^{(i)})$ is the utility of player j if he/she accepts a particular offer $o^{(i)}$, $U^{(j)}(-c(\mathrm{e}^{(j)}))$ is the utility of the costs of player j if the offer is rejected and $\lambda^{(3)}$ is the unknown precision parameter which has to be estimated.[44] The probability of rejecting an offer is simply

$$p^{(j)}\left(\delta^{(j)}\left(o^{(i)}\right) = 0\ |(e^{(i)}, e^{(j)})\right) = 1 - p^{(j)}\left(\delta^{(j)}\left(o^{(i)}\right) = 1|(e^{(i)}, e^{(j)})\right).$$

On stage two player i has to anticipate these acceptance probabilities to calculate expected utilities for all possible offers conditional on a given history. The expected utility of any offer $o^{(i)}$ is given by

$$EU\left(o^{(i)}\right) = p^{(j)}\left(\delta^{(j)}\left(o^{(i)}\right) = 1|(e^{(i)}, e^{(j)})\right)U\left(o^{(i)}\right) + p^{(j)}\left(\delta^{(j)}\left(o^{(i)}\right) = 0|(e^{(i)}, e^{(j)})\right)U\left(-c(e_i)\right).$$

According to these expected utilities the probability of offer $o^{(i)}$ to be chosen is given by

$$p(o^{(i)}) = \frac{\exp(\lambda^{(2)}EU(o^{(i)}))}{\sum_{o^{(i)}=0}^{r(e^{(i)},e^{(j)})}\exp(\lambda^{(2)}o^{(i)})}.$$

Here $EU\left(o^{(i)}\right)$ is the above described expected utility of a particular offer and $\lambda^{(2)}$ is the precision parameter of the proposer in stage two of the game.

[44] The parameter λ can be interpreted as the inverse of the standard deviation of the underlying decision generating process, the random utility model.

In stage one both players have to anticipate the probabilities of the following stages and form expected utilities for every possible effort combination. First they have to form an expected value of the expected utilities of offers $EU^{(l)}\left(\bar{o}\middle|(e^{(i)},e^{(j)})\right)$. These are weighted averages of expected utilities of offers of the proposer $EU^{(i)}\left(o^{(i)}\right)$ and the responder $EU^{(j)}\left(o^{(i)}\right)$, weighted with the probabilities of offers for every possible combination of efforts for $l \in \{i,j\}$ and are given by

$$EU^{(l)}\left(\bar{o}\middle|(e^{(i)},e^{(j)})\right) = \sum_{o^{(i)}=0}^{r(e^{(i)},e^{(j)})} p\left(o^{(i)}\right)EU^{(l)}\left(o^{(i)}\right).$$

Together with the correct anticipation of the effort probabilities of the other player they can now form expected utilities of particular efforts. Thus player i's expected utility of a particular effort is

$$EU^{(i)}(e^{(i)}) = \sum_{e^{(j)}=0}^{9} p\left(e^{(j)}\right)EU^{(i)}\left(\bar{o}\middle|(e^{(i)},e^{(j)})\right),$$

while player j's is

$$EU^{(j)}(e^{(j)}) = \sum_{e^{(i)}=0}^{9} p\left(e^{(i)}\right)EU^{(j)}\left(\bar{o}\middle|(e^{(i)},e^{(j)})\right).$$

In consequence the probabilities for particular efforts can be derived as

$$p^{(i)}\left(e^{(i)}\right) = \frac{\exp(\lambda EU^{(i)}(e^{(i)}))}{\sum_{e^{(i)}=0}^{9}\exp(\lambda^{(1)}EU^{(i)}(e^{(i)})};$$

$$p^{(j)}\left(e^{(j)}\right) = \frac{\exp(\lambda^{(1)}EU^{(j)}(e^{(j)}))}{\sum_{e^{(j)}=0}^{9}\exp(\lambda^{(1)}EU^{(j)}(e^{(j)})}.$$

These probabilities form the vectors of choice probabilities on stage one $\boldsymbol{p}^{(i)}\left(e^{(i)}\right)$ and $\boldsymbol{p}^{(j)}\left(e^{(j)}\right)$ respectively. In equilibrium both players have to anticipate the probabilities of the other player. This means that player i has to calculate this expected utilities with the correctly anticipated vector $\boldsymbol{p}^{(i)}\left(e^{(i)}\right)$ and player j with the correctly anticipated $\boldsymbol{p}^{(j)}\left(e^{(j)}\right)$.

Altogether on stage two player i has to anticipate the acceptance probabilities of player j on stage three. With these probabilities player i forms offer probabilities which have to be anticipated by both players on stage one. Together with the correct anticipation of the other player's effort probabilities this forms the logit equilibrium as stated by McKelvey and Palfrey (1995, 1996, 1998).

4.3.4 The Utility Functions

For the estimation I consider two different utility functions, each embedded in a logit equilibrium framework. The first specification is the standard utility function of egoistic players. In this case utility is equal to payoff and the utility function is given by

$$U\left(\pi^{(l)}\right) = \pi^{(l)}.$$

The second specification uses the model of Fehr and Schmidt (1999, henceforth FS) which is widely used to model other regarding preferences. In the FS model the utility of a player depends on his/her own payoff and the other player's payoff. For two players *f* and *g* it can be described by the utility function

$$U^{(f)}\left(\pi^{(f)}, \pi^{(g)}\right) = \pi^{(f)} - \alpha^{(f)} \max\left(0, \pi^{(g)} - \pi^{(f)}\right) - \beta^{(f)} \max(0, \pi^{(f)} - \pi^{(g)}),$$

with restrictions $\alpha^{(f)} \geq 0, \beta^{(f)} \geq 0$ and $\alpha^{(f)} \geq \beta^{(f)}$. As can be seen, the utility of player *f* depends on his/her own payoff $\pi^{(f)}$ and the payoff difference between the players weighted with parameters $\alpha^{(f)}$ and $\beta^{(f)}$. Depending on the characterizing parameters $\alpha^{(f)}$and $\beta^{(f)}$ player *f*'s utility is reduced by favored or unfavored inequality between both players' payoffs.

4.3.5 The Likelihood Function

To estimate the parameters of the utility function and the precision parameter λ one has to use maximum likelihood methods. The likelihood function is the product of all probabilities of all players on all stages. The link function is the above described logit error probability function which is the probability function of the underlying Extreme Value Type I cumulative distribution function. Thus the log likelihood function for all observed pairs of players $t \in \{1, \dots, n\}$ becomes

$$\log L = \sum_{t=1}^{n} \begin{matrix} \log\left(p^{(i)}(e_t^{(i)})\right) + \log\left(p^{(j)}(e_t^{(j)})\right) + \log\left(p^{(i)}(o_t^{(i)})\right) + \\ \delta_t^{(j)} \cdot \log\left(p^{(j)}(\delta_t^{(j)} = 1)\right) + (1 - \delta_t^{(j)}) \cdot \log\left(p^{(j)}(\delta_t^{(j)} = 0)\right) \end{matrix}.$$

The log likelihood function can be evaluated with standard maximum likelihood methods. It is important to notice that the maximization process is restricted in the sense that only equilibrium choice probabilities enter the maximum likelihood estimation procedure.

4.4 Estimation Results

The calculation of the logit equilibrium and the maximization of the likelihood function are carried out with the statistical software R. The dataset contains 232 observations which are transformed in the way described above. Summary statistics of the modified data are presented in Table 4.1.

Table 4.1: Summary Statistics

	$e^{(i)}$	$e^{(i)}$	$r(e^{(i)}e^{(i)})$	$o^{(i)}$	$o^{(i)}/r(e^{(i)}e^{(i)})$	$\delta^{(j)}(o^{(i)})$
Mean	6.26	6.59	427.77	199.71	0.45	0.86
S. Dev.	1.25	2.29	103.32	90.66	0.17	0.35

Notes: Table 4.1 includes the efforts of player i and j (in columns 2 and 3), the return of the joint production (column 4), the offer of player i (column 5), the relative offer (column 6) and the acceptance decision of player j (column 7).

Table 4.2 shows the results of the estimation of the two above described utility functions.

Table 4.2: Results of the Maximum Likelihood Estimations

	$\lambda^{(1)}$	$\lambda^{(2)}$	$\lambda^{(3)}$	α	β	logL	AIC	BIC
M1	0.000	0.061	0.117	-	-	-2617	5240	5251
	(0.013)	(0.016)	(0.013)					
M2	0.125	2.000	0.000	0.000	0.881	-1616	3241	3258
	(0.027)	(0.097)	(0.014)	(0.027)	(0.009)			

Notes: Table 4.2 presents the results of the maximum likelihood estimation for the models *M1* and *M2*. Standard errors are given in parenthesis.[45] It includes further the value of the log likelihood function (logL), the Akaike- (AIC) and the Schwarz Bayes- (BIC) information criteria.[46]

M1 is the model with egoistic preferences. To account for different levels of information in the different stages of the game I estimate different precision parameters for all stages. *M2* is the model with social preferences. Here I estimate the precision parameters $\lambda^{(s)}$ for each

[45] The standard errors in *M2* are approximated, since instead of the fisher information matrix the nearest positive definite matrix is used. This was necessary because a negative definite fisher information matrix was produced by the estimation. The approximation is proposed by e.g. Gill and King (2004) and Wothke (1993).

[46] The R code and the data used to estimate the free parameters of model *M2* are attached in Appendix D.

stage $s \in \{1,2,3\}$ along with the inequality aversion parameters $\alpha = \alpha^{(i)} = \alpha^{(j)}$ and $\beta = \beta^{(i)} = \beta^{(j)}$.[47]

The values of AIC and BIC clearly indicate a better fit of *M2* compared to *M1*. Thus the FS model is better able to explain the data. Nevertheless some estimates of the parameters seem to be implausible which will be investigated in more detail below.

The values of the precision parameters in *M1* indicate substantial deviations from payoff maximizing behavior. All three values of λ^s are close to zero indicating random behaviour of the players. It is plausible that $\lambda^{(1)} < \lambda^{(2)} < \lambda^{(3)}$ since the uncertainty is higher in stage 1 in comparison to stage 2 and higher in stage 2 in comparison to stage 3.

In *M2* the parameters $\lambda^{(1)}$ and $\lambda^{(3)}$ indicate noisy behavior in stages 1 and 3. On the other hand the value of $\lambda^{(2)}$ indicates behavior of player i in stage 2 that is close to utility maximization. The estimated α parameter is zero which implies no unflavored inequality aversion for both players. This is in line with their effort decisions but implausible in general. The value for β is very high. This is plausible and in line with the observed data because high values for β imply high effort decisions and payoff equating offer decisions. It is, however, not satisfying that three out of five parameters lie on their bounds.

The fit of model *M2* is shown in Figure 4.1 and Figure 4.2.[48] Due to the complexity of the game on stage two and three I only present the effort decisions from stage one. The figures show the estimated effort probabilities for players i and j respectively and the true relative frequencies of effort decisions. The model fits fairly well but underestimates the modus of the effort decisions of player i and j. This is not surprising since some of the parameters lie on their bounds. The estimation shows that the FS Model is not the appropriate model for the game structure.

[47] Note that the estimation requires parameter restrictions. I use the restrictions $\alpha \geq 0$ and $0 \leq \beta \leq 1$, the usual restrictions of the FS Model. The restriction $\alpha \geq \beta$ is not used. Furthermore I restrict the precision parameters to $0 \leq \lambda^{(s)} \leq 2$. The restriction is necessary to avoid numerical problems in the likelihood estimation procedure. Typically the precision parameter is restricted to $0 \leq \lambda^{(s)}$ only.

[48] Notice that for the calculation of the QRE probabilities the each parameter λ_i is multiplied by 10 to reverse the downscaling.

Figure 4.1: QRE Prediction and Relative Frequencies of the Effort Decision of Player *i*

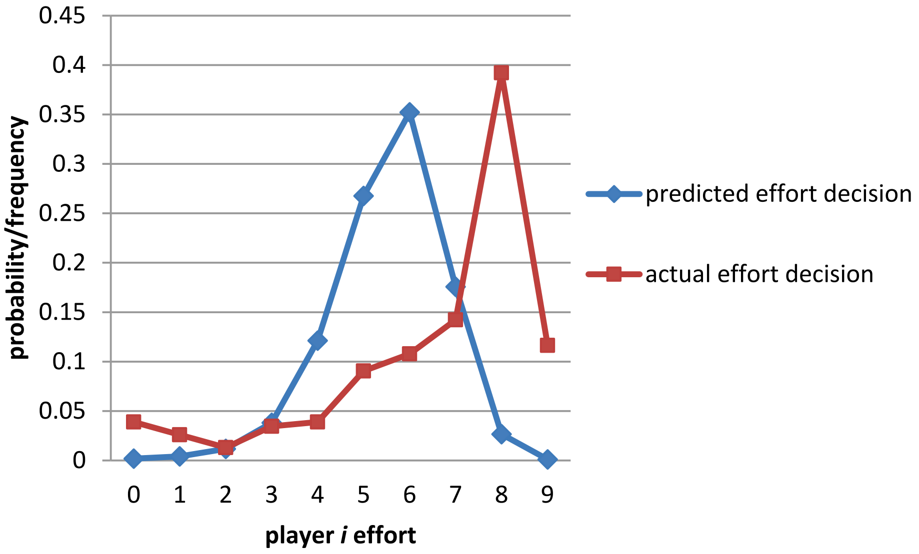
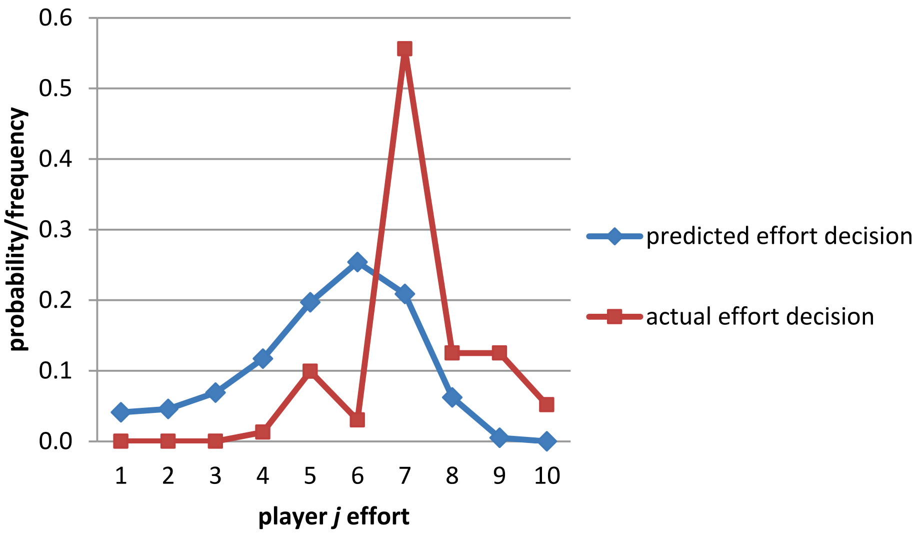


Figure 4.2: QRE Prediction and Relative Frequencies of the Effort Decision of Player *j*



4.5 Discussion and Conclusions

I present a logit error model for a three stage ultimatum game with advance production and estimate both a FS utility function and a standard egoistic payoff maximizing utility function. The results of the maximum likelihood estimation clearly indicate that the FS Model specification is preferable to the egoistic preferences specification. But the parameter estimates also indicate the limitation of the FS Model to this particular experiment. Without restricting the parameters the estimation procedure would produce negatives values for the unfavored inequality aversion parameter α (not reported). This is not in line with the assumptions of the FS Model because it would imply a utility gain from being paid worse than the other player. However this might be exactly the case in that experiment. Remember that player i is only half as productive as player j. Thus under several fairness conditions player i might wish to give player j two thirds of the joint production and keep only one third for himself/herself. Further on the necessity of numerous downscaling of the variables shows that the estimation of an logit equilibrium model is very sensitive to numerical problems as well as the estimation with complex "handmade" likelihood functions.

A next step may be to check the validity of other utility functions within this experiment. It seems necessary to consider utility functions which incorporate the above mentioned fairness considerations that unequal payoffs are utility maximizing in the light of asymmetric productivities of both players.

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Appendix A: Proofs

Proposition 1.1: If the trustee (second mover in the trust game) is sufficiently inequality averse $\beta_j \geq 1/4$ there exists a subgame perfect equilibrium (SPE) with maximal investment and maximal backtransfer and with player *P* choosing sequence *P-First* (voluntary leadership).

Proof: Suppose that players` social preferences are described by the following utility function (Fehr and Schmidt, 1999):

$$U_j = \pi_j - \alpha_j \frac{1}{n-1} \sum_{i \neq j} \max\{\pi_i - \pi_j, 0\} - \beta_j \frac{1}{n-1} \max \sum_{i \neq j} \{\pi_j - \pi_i, 0\}$$

with restrictions $0 \leq \beta_j < 1$ and $\alpha_j \geq \beta_j$. Furthermore, we assume that the preference parameters are common knowledge. It is easy to see that utility is decreasing in π_i if $\pi_j < \pi_i$. Hence, in a SPE backtransfer will never exceed investment, and the trustee`s utility function can be reduced to $U_2 = \pi_2 - \beta_2(\pi_2 - \pi_1)$ with index 1 (2) referring to first (second) mover. Given the monetary payoff functions as described by the game rules (see above) and for $x_1 \geq y_2$ the trustees's utility is

$$\begin{aligned} U_2 &= 10 + 3x_1 - y_2 - \beta_2((10 + 3x_1 - y_2) - (10 - x_1 + 3y_2)) \\ &= 10 + 3x_1 - y_2 - \beta_2(4x_i - 4y_2) \end{aligned}.$$

Since this is a linear function, the trustee maximizes his/her utility at a corner solution. Hence, he/she either reciprocates by choosing $y_2 = x_1$ which implies $U_2 = 10 + 2x_1$, or he/she chooses $y_2 = 0$ which implies $U_2 = 10 + 3x_1 - 4x_1\beta_2$. Establishing $y_2 = x_1$ as equilibrium choice requires $10 + 2x_1 \geq 10 + 3x_1 - 4x_1\beta_2$ which is sitequivalent to $\beta_2 \geq 1/4$.

Given the trustee's equilibrium choice $y_2 = x_1$ the utility of the investor (first mover) is simply $U_2 = 10 + 2x_1$. Since this is increasing in x_1, the investor's optimal choice is $x_1 = 10$. This concludes that maximal investment and maximal backtransfer are SPE-choices.

Regarding the choice of the sequence, player *P* is indifferent if $\beta_A \geq 1/4$ and $\beta_P \geq 1/4$. Player *P* strictly prefers *P-First* if $\beta_A \geq 1/4$ and $\beta_P \leq 1/4$.

q.e.d.

Let e be the minimum endowment of 10 money units. Thus player P is endowed with $5e$ and player A with e respectively.

Proposition 2.1: Regardless of the degree of inequality aversion of player A and the sequence chosen by P player A's transfer is zero.

Proof: The utility of player A is:

$$U(A) = e + 3x - y - \alpha(4e - x + 3y) = 3x - y + e(1 - 4\alpha) - \alpha 3y$$

Now it's easy to see that this utility decreases with $y > 0$ regardless of all other variables.

q.e.d.

Proposition 2.2: If player P (the better endowed player) is sufficiently inequality averse ($\beta_p > 1/4$) the subgame perfect equilibrium (SPE) is a full transfer of player P. Player A's transfer is zero and player P is indifferent about the sequence.

Proof:[49] Player P's utility according to the FS Model (Fehr and Schmidt, 1999) is:

$$U(P) = 5e + 3y - x - \beta(4e - x - 3x + 3y + y)$$

As we argue in **Proposition 2.1** the amount sent by player A y is zero thus the utility becomes

$$U(P) = 5e - x - \beta(4e - 3x - x) = 5e - \beta 4e - x + \beta 4x.$$

Now it's easy to see that this utility increases in x if:

$$\beta > 1/4.$$

q.e.d.

[49] For a more formal proof of this proposition see the proof of **Proposition 1.1**.

Proposition 2.3: If one of the players invests an amount $x_l > 3$, then the backtransfer of the other player is also positive if $\rho_k > \frac{\Delta\pi_k}{\sigma_k \sigma_l}$.

Proof: The first part of **Proposition 2.3** states that in our experiment an investment of three money units is necessary to produce a positive kindness term. This is easy to show. Remember that the kindness of player *l* is measured as:

$$\sigma_l = \pi_k - \pi_k^e$$

This means that the actual possible payoff of player k has to exceed the so called equitable payoff π_k^e. The equitable payoff is calculated as the mean of the maximum and the minimum possible payoffs for player *k*:

$$\pi_k^e = \frac{\pi_k^h + \pi_k^l}{2}$$

Now consider either player *A* or player *P* of our experiment. The difference between both players is their initial endowment. Call E_k the non transferable endowment of both players (for $k \in \{A, P\}$). Remember that player *A* has no such endowment thus $E_A = 0$ and for player *P* it is $E_P = 40$. Additional both players are endowed with the transferable amount $e = 10$ for both players. The minimum payoff of any player is

$$\pi_k^l = e + 0 * 3 - e + E_k = E_k$$

This payoff results from an investment of zero and full backtransfer. The maximum payoff of any player is

$$\pi_k^h = e + e * 3 + E_k$$

This payoff results from full investment and backtransfer of zero. The equitable payoff becomes

$$\pi_k^e = E_k + 2e$$

which is 20 for player *A* and 40 for player *P*. The kindness term is positive if the actual possible payoff resulting from the investment decision of the other player exceeds the equitable payoff. The condition is

$$\pi_k > \pi_k^e$$

Substituting the expression for π_k^e yields

$$E_k + e + 3x > E_k + 2e$$

The left hand side of the equation expresses the actual possible payoff of player k if he/she keeps the whole money. Thus it is the sum of the transferable und non transferable endowment and the investment x multiplied by 3. This inequality holds if

$$x > \frac{e}{3}$$

Since $e = 10$ and only integers are allowed this is equivalent to $x > 3$.

Consider now the utility function of the DK model (Dufwenberg and Kirschsteiger, 2004):

$$U_k = \pi_k + \rho_{kl}\sigma_k\sigma_l$$

If player l invests an amount greater than three money units player k compares her utility from reciprocating in form of a backtranfer and not reciprocating. If player k doesn't reciprocate her utility is simply the payoff:

$$U_k^0 = \pi_k^0$$

Player k reciprocates with positive backtransfer if:

$$U_k > U_k^0$$

Substituting both utility functions yields:

$$\pi_k + \rho_{kl}\sigma_k\sigma_l > \pi_k^0$$

Now it's easy to see that the utility to reciprocate is larger than to choose backtransfer of zero since

$$\rho_k > \frac{\pi_k^0 - \pi_k}{\sigma_k\sigma_l} = \frac{\Delta\pi_k}{\sigma_k\sigma_l}.$$

q.e.d.

Appendix B: Instructions

Set of Experiments I (see Chapter 1)

The set of experiments I consists of one main experiment M.1 and three side experiments S.1, S.2 and S.3. All instructions are translated from German.

Experiment M.1

General Instructions

You are participating in various decision experiments. At the end you will be paid according to your performance. Thus, it is important that you understand the following instructions. First, you receive and read the instructions for experiment one. Instructions for other experiments will be provided on the computer screen.

Within the experiments you can earn money depending on your decisions. Earnings will be added to your account while losses will be subtracted. In the end of the experiment your earnings will be paid in cash. Earnings are denoted by points. The conversion into euro will be announced in each experiment.

Please note that during the experiments communication is not allowed. If you have any question, please raise your arm. All decisions are taken anonymously. No other participant will get to know your name or monetary payoff.

Good luck!

Exogenous Treatment of Experiment M.1

The participants will be divided into groups with two persons in each group. They are called player A and B. Players are randomly assigned to their groups and types. Your type of player is displayed on screen. Points are converted into euros according to the following rule:

<u>10 points = 3 euro</u>

1) Each participant receives an endowment.
    a. <u>Participant A receives 10 points</u>
    b. <u>B receives 10 points</u>
2) Participant B transfers an amount x ($0 \leq x \leq 10$) to participant A.
3) Participant A gains 3x, i.e. participant A receives three times the amount transferred by B.
4) Participant A transfers an amount y ($0 \leq y \leq 10$) to participant B.
5) Participant B gains 3y, i.e. participant B receives three times the transferred amount.
6) The experiment is done.

Endogenous Treatment of Experiment M.1

The participants will be divided into groups with two persons in each group. They are called player A and B. Players are randomly assigned to their groups and types. Your type of player is displayed on screen. Points are converted into euros according to the following rule:

<u>10 points = 3 euro</u>

1) Each participant receives an endowment.
    a. <u>Participant A receives 10 points</u>
    b. <u>Participant B receives 10 points</u>
2) Participant B decides about the sequence of choices. There are two possible sequences. B-A or A-B. If B-A is chosen, the experiment continues as described in 3a) to 7a). If A-B is chosen, the experiment continues as described in 3b) to 7b).

<u>Sequence B-A</u>

3a) Participant B transfers an amount x ($0 \leq x \leq 10$) to participant A.

4a) Participant A gains 3x, i.e. participant A receives three times the amount transferred by B.

5a) Participant A transfers an amount y ($0 \leq y \leq 10$) to participant B.

6a) Participant B gains 3y, i.e. participant B receives three times the transferred amount.

7a) The experiment is done.

<u>Sequence A-B</u>

3b) Participant A transfers an amount x ($0 \leq x \leq 10$) to participant B.

4b) Participant B gains 3x, i.e. participant B receives three times the amount transferred by participant A

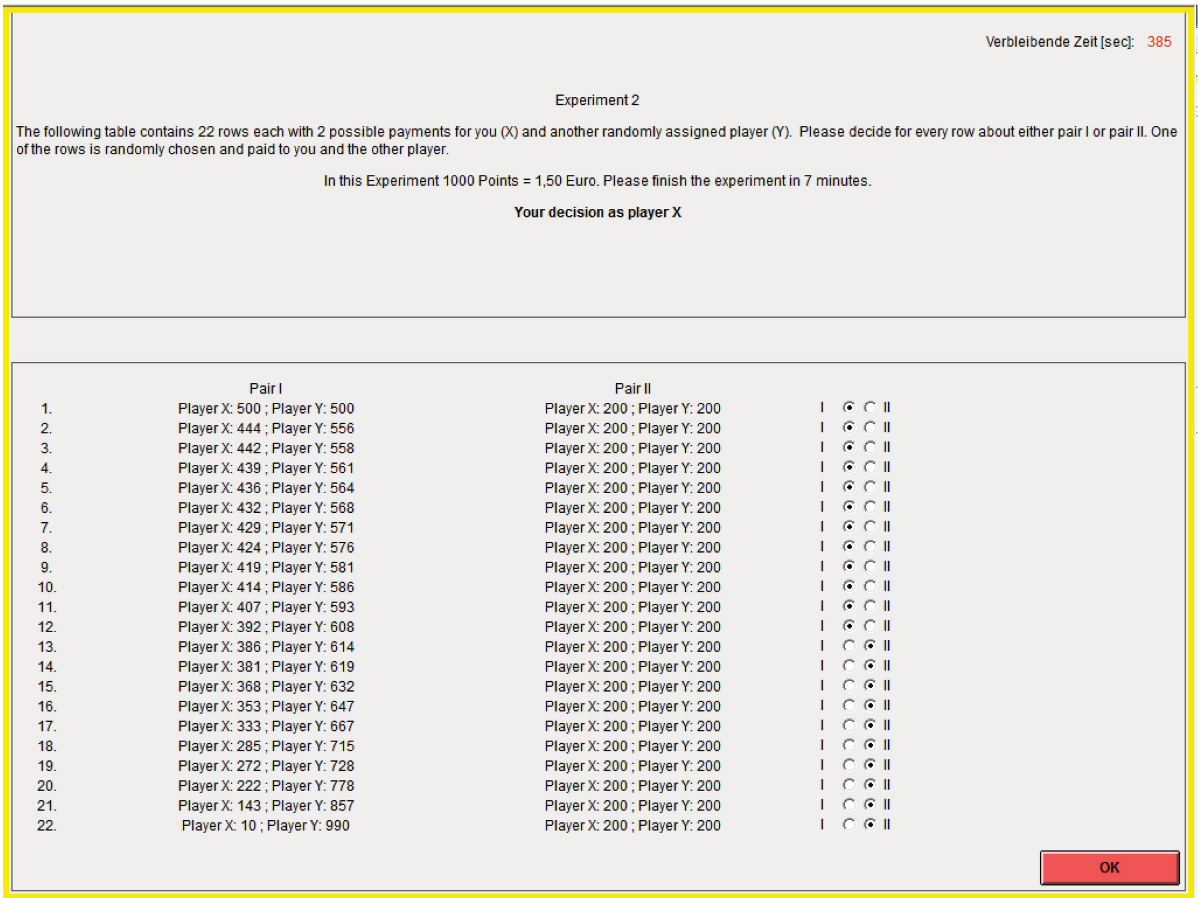
5b) Participant B transfers an amount y ($0 \leq y \leq 10$) to participant A.

6b) Participant A gains 3y, i.e. participant A receives three times the amount transferred by participant B.

7b) The experiment is done.

Side Experiment S.1

Figure B 1: Z-Tree Screenshot of Elicitation of Unfavored Inequality Aversion



Verbleibende Zeit [sec]: 385

Experiment 2

The following table contains 22 rows each with 2 possible payments for you (X) and another randomly assigned player (Y). Please decide for every row about either pair I or pair II. One of the rows is randomly chosen and paid to you and the other player.

In this Experiment 1000 Points = 1,50 Euro. Please finish the experiment in 7 minutes.

Your decision as player X

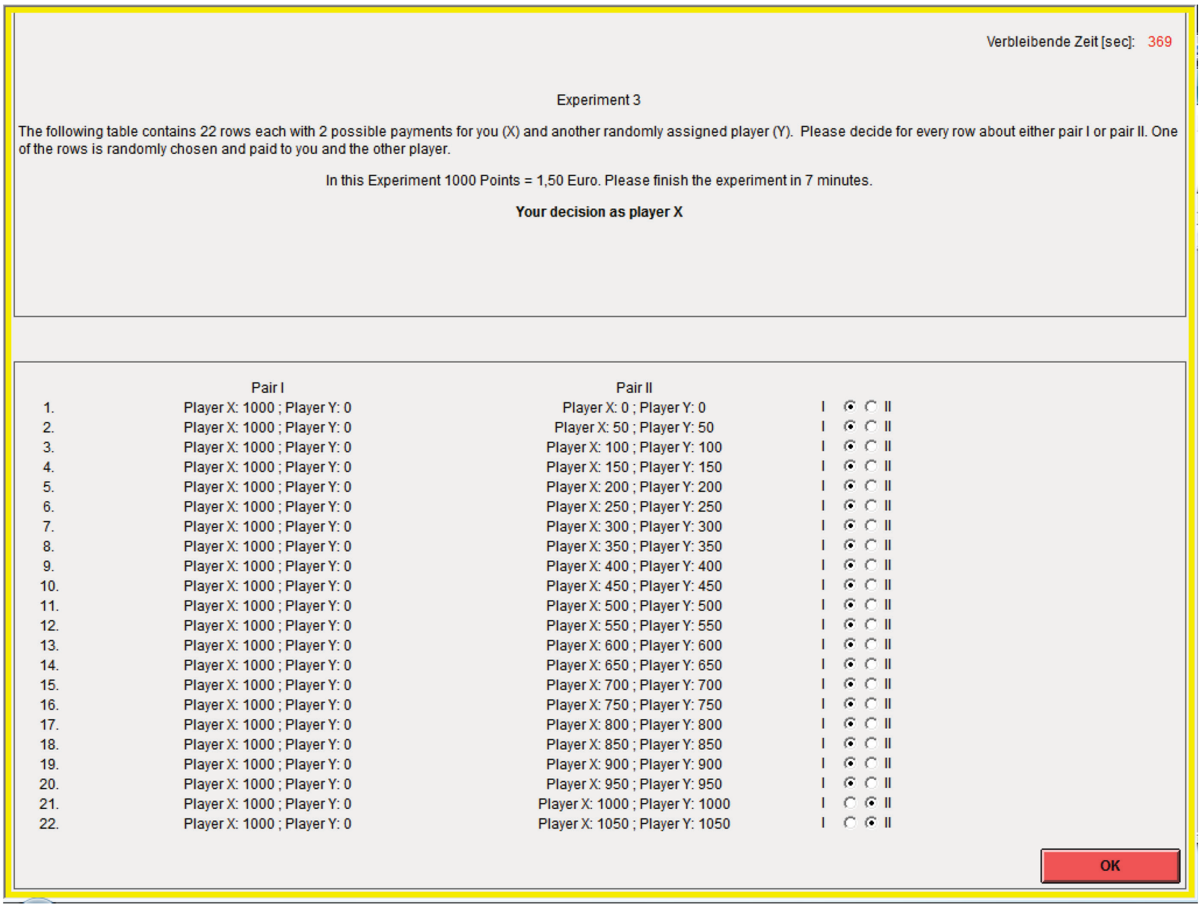
	Pair I	Pair II	
1.	Player X: 500 ; Player Y: 500	Player X: 200 ; Player Y: 200	I ◉ ○ II
2.	Player X: 444 ; Player Y: 556	Player X: 200 ; Player Y: 200	I ◉ ○ II
3.	Player X: 442 ; Player Y: 558	Player X: 200 ; Player Y: 200	I ◉ ○ II
4.	Player X: 439 ; Player Y: 561	Player X: 200 ; Player Y: 200	I ◉ ○ II
5.	Player X: 436 ; Player Y: 564	Player X: 200 ; Player Y: 200	I ◉ ○ II
6.	Player X: 432 ; Player Y: 568	Player X: 200 ; Player Y: 200	I ◉ ○ II
7.	Player X: 429 ; Player Y: 571	Player X: 200 ; Player Y: 200	I ◉ ○ II
8.	Player X: 424 ; Player Y: 576	Player X: 200 ; Player Y: 200	I ◉ ○ II
9.	Player X: 419 ; Player Y: 581	Player X: 200 ; Player Y: 200	I ◉ ○ II
10.	Player X: 414 ; Player Y: 586	Player X: 200 ; Player Y: 200	I ◉ ○ II
11.	Player X: 407 ; Player Y: 593	Player X: 200 ; Player Y: 200	I ◉ ○ II
12.	Player X: 392 ; Player Y: 608	Player X: 200 ; Player Y: 200	I ◉ ○ II
13.	Player X: 386 ; Player Y: 614	Player X: 200 ; Player Y: 200	I ○ ◉ II
14.	Player X: 381 ; Player Y: 619	Player X: 200 ; Player Y: 200	I ○ ◉ II
15.	Player X: 368 ; Player Y: 632	Player X: 200 ; Player Y: 200	I ○ ◉ II
16.	Player X: 353 ; Player Y: 647	Player X: 200 ; Player Y: 200	I ○ ◉ II
17.	Player X: 333 ; Player Y: 667	Player X: 200 ; Player Y: 200	I ○ ◉ II
18.	Player X: 285 ; Player Y: 715	Player X: 200 ; Player Y: 200	I ○ ◉ II
19.	Player X: 272 ; Player Y: 728	Player X: 200 ; Player Y: 200	I ○ ◉ II
20.	Player X: 222 ; Player Y: 778	Player X: 200 ; Player Y: 200	I ○ ◉ II
21.	Player X: 143 ; Player Y: 857	Player X: 200 ; Player Y: 200	I ○ ◉ II
22.	Player X: 10 ; Player Y: 990	Player X: 200 ; Player Y: 200	I ○ ◉ II

OK

Notes: Players have to decide upon one of each column in every row. The procedure is as proposed by Danneberg et al. 2007.

Side Experiment S.2

Figure B 2: Z-Tree Screenshot of Elicitation of Favored Inequality Aversion



Verbleibende Zeit [sec]: 369

Experiment 3

The following table contains 22 rows each with 2 possible payments for you (X) and another randomly assigned player (Y). Please decide for every row about either pair I or pair II. One of the rows is randomly chosen and paid to you and the other player.

In this Experiment 1000 Points = 1,50 Euro. Please finish the experiment in 7 minutes.

Your decision as player X

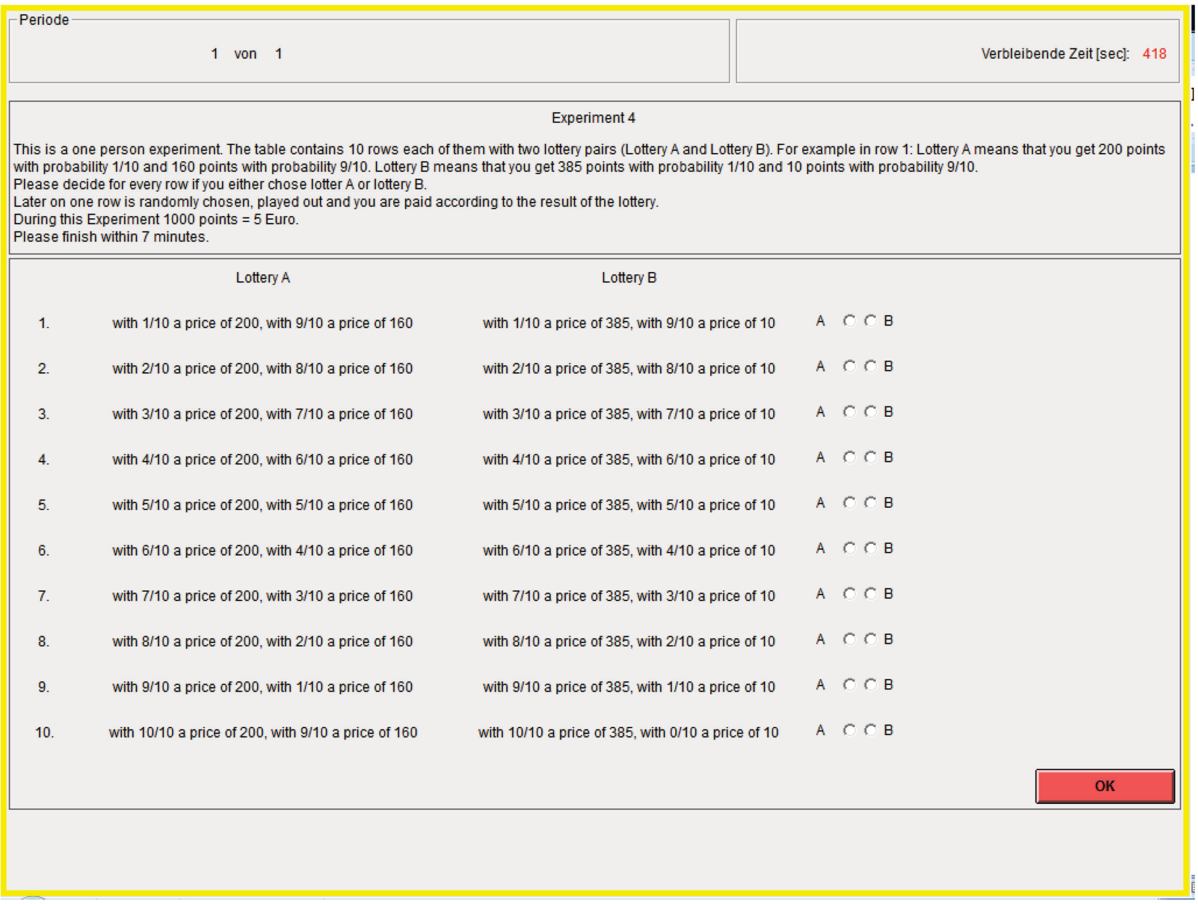
	Pair I	Pair II	
1.	Player X: 1000 ; Player Y: 0	Player X: 0 ; Player Y: 0	I ◉ ○ II
2.	Player X: 1000 ; Player Y: 0	Player X: 50 ; Player Y: 50	I ◉ ○ II
3.	Player X: 1000 ; Player Y: 0	Player X: 100 ; Player Y: 100	I ◉ ○ II
4.	Player X: 1000 ; Player Y: 0	Player X: 150 ; Player Y: 150	I ◉ ○ II
5.	Player X: 1000 ; Player Y: 0	Player X: 200 ; Player Y: 200	I ◉ ○ II
6.	Player X: 1000 ; Player Y: 0	Player X: 250 ; Player Y: 250	I ◉ ○ II
7.	Player X: 1000 ; Player Y: 0	Player X: 300 ; Player Y: 300	I ◉ ○ II
8.	Player X: 1000 ; Player Y: 0	Player X: 350 ; Player Y: 350	I ◉ ○ II
9.	Player X: 1000 ; Player Y: 0	Player X: 400 ; Player Y: 400	I ◉ ○ II
10.	Player X: 1000 ; Player Y: 0	Player X: 450 ; Player Y: 450	I ◉ ○ II
11.	Player X: 1000 ; Player Y: 0	Player X: 500 ; Player Y: 500	I ◉ ○ II
12.	Player X: 1000 ; Player Y: 0	Player X: 550 ; Player Y: 550	I ◉ ○ II
13.	Player X: 1000 ; Player Y: 0	Player X: 600 ; Player Y: 600	I ◉ ○ II
14.	Player X: 1000 ; Player Y: 0	Player X: 650 ; Player Y: 650	I ◉ ○ II
15.	Player X: 1000 ; Player Y: 0	Player X: 700 ; Player Y: 700	I ◉ ○ II
16.	Player X: 1000 ; Player Y: 0	Player X: 750 ; Player Y: 750	I ◉ ○ II
17.	Player X: 1000 ; Player Y: 0	Player X: 800 ; Player Y: 800	I ◉ ○ II
18.	Player X: 1000 ; Player Y: 0	Player X: 850 ; Player Y: 850	I ◉ ○ II
19.	Player X: 1000 ; Player Y: 0	Player X: 900 ; Player Y: 900	I ◉ ○ II
20.	Player X: 1000 ; Player Y: 0	Player X: 950 ; Player Y: 950	I ◉ ○ II
21.	Player X: 1000 ; Player Y: 0	Player X: 1000 ; Player Y: 1000	I ○ ◉ II
22.	Player X: 1000 ; Player Y: 0	Player X: 1050 ; Player Y: 1050	I ○ ◉ II

OK

Notes: Players have to decide upon one of each column in every row. The procedure is as proposed by Danneberg et al. 2007.

Side Experiment S.3

Figure B 3: Z-Tree Screenshot of Elicitation of Risk Preferences



Notes: Players have to decide upon one of two lotteries in every row. The procedure is as proposed by Holt and Laury (2002).

Set of Experiments II (see Chapter 2)

The set of experiments II consists of one main experiment M.2 (see below) and three side experiments S.1, S.2 and S.3 (see above). All instructions are translated from German.

Experiment M.2

You are participating in various decision experiments. At the end you will be paid according to your performance. Thus, it is important that you understand the following instructions. First, you receive and read the instructions for experiment one. Instructions for other experiments will be provided on the computer screen.

Within the experiments you can earn money depending on your decisions. Earnings will be added to your account while losses will be subtracted. In the end of the experiment your earnings will be paid in cash. Earnings are denoted by points. The conversion into euro will be announced in each experiment.

Please note that during the experiments communication is not allowed. If you have any question, please raise your arm. All decisions are taken anonymously. No other participant will get to know your name or monetary payoff.

Good luck!

Exogenous Treatment of Experiment M.2

The participants will be divided into groups with two persons in each group. They are called player A and B. Players are randomly assigned to their groups and types. Your type of player is displayed on screen. Points are converted into euros according to the following rule:

10 points = 3 euro

3) Each participant receives an endowment.
    a. Participant A receives 10 points
    b. B receives 50 points
4) Participant B transfers an amount x ($0 \leq x \leq 10$) to participant A.
5) Participant A gains 3x, i.e. participant A receives three times the amount transferred by B.
6) Participant A transfers an amount y ($0 \leq y \leq 10$) to participant B.
7) Participant B gains 3y, i.e. participant B receives three times the transferred amount.
8) The experiment is done.

Endogenous Treatment Experiment M.2

The participants will be divided into groups with two persons in each group. They are called player A and B. Players are randomly assigned to their groups and types. Your type of player is displayed on screen. Points are converted into euros according to the following rule:

10 points = 3 euro

1) Each participant receives an endowment.
    a. Participant A receives 10 points
    b. Participant B receives 50 points
2) Participant B decides about the sequence of choices. There are two possible sequences. B-A or A-B. If B-A is chosen, the experiment continues as described in 3a) to 7a). If A-B is chosen, the experiment continues as described in 3b) to 7b).

Sequence B-A

3a) Participant B transfers an amount x ($0 \leq x \leq 10$) to participant A.

4a) Participant A gains 3x, i.e. participant A receives three times the amount transferred by B.

5a) Participant A transfers an amount y ($0 \leq y \leq 10$) to participant B.

6a) Participant B gains 3y, i.e. participant B receives three times the transferred amount.

7a) The experiment is done.

Sequence A-B

3b) Participant A transfers an amount x ($0 \leq x \leq 10$) to participant B.

4b) Participant B gains 3x, i.e. participant B receives three times the amount transferred by participant A

5b) Participant B transfers an amount y ($0 \leq y \leq 10$) to participant A.

6b) Participant A gains 3y, i.e. participant A receives three times the amount transferred by participant B.

7b) The experiment is done.

Set of Experiments III (see Chapter 3)

The set of experiments II consists of one main experiment M.3 (see below) and three side experiments S.1, S.2 and S.3 (see above). All instructions are translated from German.

Experiment M.3

You are participating in two decision experiments. At the end you will be paid according to your performance. Therefore it is important, that you understand the following instructions.

-*Roll Assignment*

17 participants are taking part in the decision experiment 1. Each participant has one of three roles. One participant is of the type A (**player A**), eight participants are of the type B (**player B**) and eight participants are of the type C (**player C**). Your type is randomly determined at the beginning of the experiment and is displayed to you on your screen. Your type remains constant throughout the experiment and is shown on the top of the screen to remind you of your role assignment.

-*Payoff*

The experiment consists of several periods. During the experiment payoffs are measured in points and displayed on your account. At the beginning each participant's account has an amount of 50 points. Profits are added to your account and losses are subtracted from your account. In the case of a negative account balance you continue to participate in the experiment. Due to profits you can again obtain a positive account balance. At the end your payoffs are converted into euro and paid to you in cash. If your account balance is negative at the end, you receive a payoff of 0 euro for experiment 1. The following rules apply to the conversion of points into euros:

- For player B and C: 10 points = 1 euro
- For player A: 100 points = 1 euro

-*Other Details*

Please note that during the experiment **communication is not allowed**. If you have any questions, please raise your hand out of the cubicle. All decisions are made anonymously. No other participant will experience your name and your monetary payoff.

Best of luck!

Experiment 1 consists of **10 periods** and **17 players**: one player of type A, eight players of type B and eight players of type C.

Procedures for each period:

1. Player A proposes a payment scheme for an individual project (**Project I**) and a payment scheme for a group project (**Project II**) which are announced to all players B and C. Payment scheme I determines the payoff for project I and consists of a *return share I* (percentage of the individual return) and a *fixed wage I*. Payment scheme II determines the payoff for project II and consists of a *return share II* (percentage of the group return) and a *fixed wage II*.

2. Each player B or C decides whether he or she accepts payment scheme I, payment scheme II or neither of them.

3.a. **Participation in Project I**

Given a player B or C accepts the payment scheme I, he or she participates in project I (**individual project**) and chooses an investment level (0, 1, …, 10) with the corresponding investment costs (investment cost = 2* investment level). The chosen investment level determines the individual return (individual return = 3* investment level).

Thus the following payoffs results:

period payoff player B (C) =	**individual return** * ***return share I*** **+ *fixed wage I*** **− investment costs**

period payoff player A =	**individual return * (100% - *return share I*) – *fixed wage I***

This means: Player B (C) receives the agreed *return share I* of the individual return plus the *fixed wage I* minus the own investment costs. Player A receives the remaining return share of the individual return minus the *fixed wage I*.

Displayed information to the players: Player B (C) is informed about individual return and own payoff for the particular period. Player A is informed about the number of players in individual projects. Additionally, he or she is informed about the sum of all individual returns and the sum of the payoffs from individual projects.

3.b. **Participation in Project II**

Given that several players B or C accepted the payment scheme II, groups of 4 members are formed out of the players who want to participate in project II (**group project**). Group members can be of different types. The group composition is random. Redundant participants can't participate in a group project. They are informed and can decide, whether to alternatively accept payment scheme I or not. If so, see point 3.a. If not, see point 3.c.

Each of the four members of a group choose an investment level (0, 1, …, 10) with the corresponding investment costs (investment cost = 2 x investment level) without the knowledge of the other group members decisions. You will be informed about types of your group members (type B or type C) before choosing investment level. The chosen individual investment level determines the individual return contribution for each group member.

Individual return contribution of participant B = 2.5 * investment level
Individual return contribution of participant C = 7.5 * investment level
The sum of the four individual return contributions is the group return.
Thus the following payoff results:

period payoff player B (C) =	**group return * (*return share II*)/4** **+ *fixed wage II*** **− investment costs**

period payoff player A =	**group return * (100% - *return share II*)** **–4 * *fixed wage II***

This means: Each group member receives one fourth of the agreed share of the group return (*return share II*) plus the *fixed wage II* minus the own investment costs. Participant A receives the remaining share of the group return minus the four fixed wages.

Displayed information to the players: Player B (C) is informed about the group return and own period payoff. Participant A is informed about the number of participants in group projects, the sum of all group returns and the sum of payoffs from group projects.

3.c. **No participation on a project**

Given a player B (C) has neither accepted payment scheme I nor payment scheme II, he or she participates in no investment project in this period and receives the payoff 0.

Rules for the payment scheme:

- The return share can equal 0%, 10%, …, or 100%.
  Return shares I and II can be different.
- The fixed wage can equal -15, -14, …, 0, 1, … or 15.
  Fixed wages I and II can also be different.

Within the given limitations return share and fixed wages can be arbitrary chosen. A positive fixed wage means a payment of player A to the respective player B (C). A negative fixed wage means a payment of a player B (C) to player A.

End of a period and further periods

After the investment decisions payoffs are calculated. The period ends. Your period payoff and your account balance are displayed to you. The next period starts according to the same rules.

Appendix C: Regression Tables

Table C 1: Results of Tobit Regression on Dependent Variable Effort in *GT*

Variable	Coefficient	Robust Std. Error	P-Value
*Asymmetric Team * TpFix-GT*	0.323	0.141	0.023
*Asymmetric Team * Share GT*	0.050	0.008	< 0.001
*Asymmetric Team * Average Team Productivity*	0.071	0.028	0.012
Asymmetric Team	-7.779	1.167	< 0.001
Low Team Productivity	-3.555	1.210	0.012
Period	-0.262	0.057	< 0.001
Constant	8.530	0.659	< 0.001

Notes: Base category is symmetric team with productivity 7.5. The model statistics are N = 800 with p-value < 0.001 and pseudo $R^2 = 0.032$.

Table C 2: Results of Multinomial Logistic Regression on Tasks Selection

	GT versus *IT*		
Variable	Coefficient	Robust Std. Error	P-Value
Share in GT	0.030	0.005	< 0.001
Fix in GT	0.112	0.019	< 0.001
Share in IT	-0.025	0.006	< 0.001
Fix in IT	-0.148	0.022	< 0.001
*Share in GT * HT*	0.014	0.008	0.073
*Fix in GT * HT*	0.051	0.032	0.119
*Share in IT * HT*	-0.018	0.009	0.046
*Fix in IT * HT*	-0.070	0.039	0.077
HT	0.804	0.785	0.306
Alpha-High	0.504	0.193	0.009
Alpha-Missing	0.269	0.233	0.247
Beta-High	0.287	0.176	0.102
Beta-Missing	-0.364	0.284	0.200
Period	0.237	0.097	0.014
$Period^2$	-0.016	0.008	0.052
Constant	-0.630	0.647	0.330
	Exit Option versus *IT*		
Variable	Coefficient	Std. Error	P-Value
Share in GT	0.005	0.008	0.547
Fix in GT	-0.085	0.027	0.002
Share in IT	-0.024	0.011	0.028
Fix in IT	-0.245	0.040	< 0.001
*Share in GT * HT*	-0.014	0.011	0.175
*Fix in GT * HT*	-0.022	0.040	0.587
*Share in IT * HT*	0.004	0.016	0.790
*Fix in IT * HT*	-0.042	0.061	0.494
HT	0.662	1.137	0.561
Alpha-High	0.856	0.400	0.032
Alpha-Missing	-0.132	0.590	0.824
Beta-High	0.386	0.350	0.270
Beta-Missing	-1.376	0.599	0.022
Period	0.380	0.231	0.100
$Period^2$	-0.018	0.017	0.284
Constant	-3.119	1.099	0.005

Notes: The model statistics are N = 1440, p-value < 0.001, pseudo R^2 = 0.2523.

Appendix D: Code and Data

R Code

```
###########QRE for an Ultimatum Game with Advance Production############


########################################
### load libraries “stats” and “lmf” #####
########################################

library (stats)
library (lmf)

########################################
###          functions               ###
########################################

fun <- function(eu, euop, vv)
{
    ret <- 0

    for(i in 1 : max_deep)
    {
        if (euop[ip,ir,io]!=-Inf)
        {
            ret <- ret + exp(vv*eu[i])
        }
    }

    return (ret)
}

fune <- function(ww, eu)
{
    ret <- 0

    for(i in 1 : length(eu))
    {
        ret <- ret + exp(ww*eu[i])
    }

    return (ret)
}

funl <- function(f, epopdeep, maxrpodeep, maxprodeep)
{
    ret <- 0

    for (i in 1: max_deep)
    {
        if(epopdeep[i] != -Inf)
        {
            ret <- ret + exp(f[2]*(epopdeep[i]-f[4]*maxrpodeep[i]-
f[5]*maxprodeep[i]))
        }
    }

    return(ret)
```

```
}

funpeAll <- function(f, own, otherown, ownother)
{
    ret <- 0

    for (i in 1: grenze)
    {
        ret <- ret + exp(f[1]* (own[i]-f[4]*otherown[i]-f[5]*ownother[i]))
    }

    return (ret)
}

fillMatrix <- function(sourcematrix)
{
    ret <- array(0,c(grenze*grenze,max_deep))

    for(ie in 1: grenze)
    {
        for(ir in 1: grenze)
        {
            ret[(ie-1)*grenze+ir,] <- sourcematrix[ie,ir,]
        }
    }

    return (ret)
}

calcEffortProposer <- function(accept, payoff, cost)
{
    effort <- array(0,c(grenze,grenze,max_deep))

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            for(io in 1 : max_deep)
            {
                if (payoff[ip,ir,io] != -Inf & accept[ip,ir,io] != -Inf)
                {
                    effort[ip,ir,io]<-
accept[ip,ir,io]*payoff[ip,ir,io]+(1-accept[ip,ir,io])*-cost[ip]
                }
                else
                {
                    effort[ip,ir,io]<- -Inf
                }
            }
        }
    }

    return (effort)
}

calcEffortResponder <- function(accept, payoff, cost)
{
    effort <- array(0,c(grenze,grenze,max_deep))

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
```

```
        {
            for(io in 1 : max_deep)
            {
                if (payoff[ip,ir,io] != -Inf & accept[ip,ir,io] != -Inf)
                {
                    effort[ip,ir,io]<-
accept[ip,ir,io]*payoff[ip,ir,io]+(1-accept[ip,ir,io])*-cost[ir]
                }
                else
                {
                    effort[ip,ir,io]<- -Inf
                }
            }
        }
    }

    return (effort)
}

calcUtilityAccept <- function(payoffOwn, payoffOther, a, b)
{
    utility <- array(0,c(grenze,grenze,max_deep))

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            for(io in 1 : max_deep)
            {
                if (payoffOwn[ip,ir,io] != -Inf & payoffOther[ip,ir,io] !=
-Inf)
                {
                    utility[ip,ir,io]<- payoffOwn[ip,ir,io]-
a*max(0,payoffOther[ip,ir,io]-payoffOwn[ip,ir,io])-
b*max(0,payoffOwn[ip,ir,io]-payoffOther[ip,ir,io])
                }
                else
                {
                    utility[ip,ir,io]<- -Inf
                }
            }
        }
    }

    return (utility)
}

calcUtilityDenyProposer <- function(payoffOwn, payoffOther, costOwn,
costOther, a, b)
{
    utility <- array(0,c(grenze,grenze,max_deep))

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            for(io in 1 : max_deep)
            {
                if (payoffOwn[ip,ir,io] != -Inf & payoffOther[ip,ir,io] !=
-Inf)
                {
```

```
                    utility[ip,ir,io]<- -costOwn[ip]-a*max(0,-
costOther[ir]+costOwn[ip])-b*max(0,-costOwn[ip]+costOther[ir])
                }
                else
                {
                    utility[ip,ir,io]<- -Inf
                }
            }
        }
    }

    return (utility)
}

calcUtilityDenyResponder <- function(payoffOwn, payoffOther, costOwn,
costOther, a, b)
{
    utility <- array(0,c(grenze,grenze,max_deep))

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            for(io in 1 : max_deep)
            {
                if (payoffOwn[ip,ir,io] != -Inf & payoffOther[ip,ir,io] !=
-Inf)
                {
                    utility[ip,ir,io]<- -costOwn[ir]-a*max(0,-
costOther[ip]+costOwn[ir])-b*max(0,-costOwn[ir]+costOther[ip])
                }
                else
                {
                    utility[ip,ir,io]<- -Inf
                }
            }
        }
    }

    return (utility)
}

calcAcceptProb <- function (ura, urd, uu)
{
    accept <- array(0,c(grenze,grenze,max_deep))

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            for(io in 1 : max_deep)
            {
                if (ura[ip,ir,io] != -Inf & urd[ip,ir,io] != -Inf)
                {
                    accept[ip,ir,io]<-
exp(uu*(ura[ip,ir,io]))/(exp(uu*(ura[ip,ir,io]))+exp(uu*(urd[ip,ir,io])))
                }
                else
                {
                    accept[ip,ir,io]<- -Inf
                }
            }
```

```
        }
    }

    return (accept)
}

calcMaxPayoffEffort <- function(payoff1, payoff2)
{
    maxPayoff<- seq(0,0,length=grenze)

    for(ip in 1 : grenze)
    {
        maxPayoff[ip]<- max(0,payoff1[ip]-payoff2[ip])
    }

    return(maxPayoff)
}

calcMaxOffer <- function(effort1, effort2)
{
    maxOffer <- array(0,c(grenze,grenze,max_deep))

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            for(io in 1 : max_deep)
            {
                if (effort1[ip,ir,io] != -Inf & effort2[ip,ir,io] != -Inf)
                {
                    maxOffer[ip,ir,io]<- max(0,effort1[ip,ir,io] -
effort2[ip,ir,io])
                }
                else
                {
                    maxOffer[ip,ir,io]<- -Inf
                }
            }
        }
    }

    return (maxOffer)
}

calcExpectedPayoff <- function(exOffer, probOffer)
{
    expectedPayoff <- array(0,c(grenze,grenze))

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            payoff <- 0

            for(io in 1 : max_deep)
            {
                if (exOffer[ip,ir,io] != -Inf & probOffer[ip,ir,io] != -
Inf)
                {
                    payoff <- payoff + exOffer[ip,ir,io] *
probOffer[ip,ir,io]
                }
```

```
            }

            expectedPayoff[ip,ir] <- payoff
        }
    }

    return (expectedPayoff)
}

calcExpUtility <- function(utilityAccept, utilityDeny, accept)
{
    expectedUtility<- array(0,c(grenze,grenze,max_deep))

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            for(io in 1 : max_deep)
            {
                if (utilityAccept[ip,ir,io] != -Inf & utilityDeny[ip,ir,io]
!= -Inf & accept[ip,ir,io] != -Inf)
                {
                    expectedUtility[ip,ir,io]<-
accept[ip,ir,io]*utilityAccept[ip,ir,io]+(1-
accept[ip,ir,io])*utilityDeny[ip,ir,io]
                }
                else
                {
                    expectedUtility[ip,ir,io]<- -Inf
                }
            }
        }
    }

    return (expectedUtility)
}

calcProbOffer <- function(lambdaProb, expectedUtility)
{
    probOffer<- array(0,c(grenze,grenze,max_deep))

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            for(io in 1 : max_deep)
            {
                if (expectedUtility[ip,ir,io] != -Inf)
                {
                    probOffer[ip,ir,io]<-
exp(lambdaProb*expectedUtility[ip,ir,io])/fun(expectedUtility[ip,ir,],
expectedUtility, lambdaProb)
                }
                else
                {
                    probOffer[ip,ir,io]<- -Inf
                }
            }
        }
    }

    return (probOffer)
```

```
}

calcExpPayoffVectorProposer <- function(expPayoff, pp)
{
    expPayoffVector<- seq(0,0,length=grenze)

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            expPayoffVector[ip]<- expPayoffVector[ip] + expPayoff[ip,ir] * 
pp[ir]
        }
    }

    return (expPayoffVector)
}

calcExpPayoffVectorProposerResponder <- function(expPayoff, pp)
{
    expPayoffVector<- seq(0,0,length=grenze)

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            expPayoffVector[ir]<- expPayoffVector[ir] + expPayoff[ip,ir] * 
pp[ir]
        }
    }

    return (expPayoffVector)
}

calcExpPayoffVectorResponder <- function(expPayoff, qq)
{
    expPayoffVector<- seq(0,0,length=grenze)

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            expPayoffVector[ir]<- expPayoffVector[ir] + expPayoff[ip,ir] * 
qq[ip]
        }
    }

    return (expPayoffVector)
}

calcExpPayoffVectorResponderProposer <- function(expPayoff, qq)
{
    expPayoffVector<- seq(0,0,length=grenze)

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            expPayoffVector[ip]<- expPayoffVector[ip] + expPayoff[ip,ir] * 
qq[ip]
        }
    }
```

```
    return (expPayoffVector)
}

calcExpectedEffortProposer <- function(expUtility, p)
{
    expEffort <- seq(0,0,length=grenze)

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            expEffort[ip]<- expEffort[ip] + expUtility[ip,ir] * p[ir]
        }
    }

    return (expEffort)
}

calcExpectedEffortResponder <- function(expUtility, q)
{
    expEffort <- seq(0,0,length=grenze)

    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            expEffort[ir]<- expEffort[ir] + expUtility[ip,ir] * q[ip]
        }
    }

    return (expEffort)
}

############# likelihood function###############################

### f[1] = lambda for both players on stage 1    (effort decision)
### f[2] = lambda proposer on stage 2            (offer decision)
### f[3] = lambda responder on stage 3           (acceptance decision)
### f[4] = alpha
### f[5] = beta

#################################################################

log.lik <- function(f)
{
   logl<-
    -1*sum(
         d*((f[3]*(x-cres-f[4]*max(0,y-cprop-x+cres)-f[5]*max(0,x-cres-
y+cprop)))
          -log(exp(f[3]*(x-cres-f[4]*max(0,y-cprop-x+cres)-f[5]*max(0,x-
cres-y+cprop)))+exp(f[3]*(-cres-f[4]*max(0,-cprop+cres)-f[5]*max(0,-
cres+cprop)))))
         +
         (1-d)*((f[3]*(-cres-f[4]*max(0,-cprop+cres)-f[5]*max(0,-
cres+cprop)))
          -log(exp(f[3]*(x-cres-f[4]*max(0,y-cprop-x+cres)-f[5]*max(0,x-
cres-y+cprop)))+exp(f[3]*(-cres-f[4]*max(0,-cprop+cres)-f[5]*max(0,-
cres+cprop)))))
         +
         f[2]*(epop[ind[,c(1,2,3)]]-f[4]*maxrpo[ind[,c(1,2,3)]]-
f[5]*maxpro[ind[,c(1,2,3)]])
```

```
           -
log(funl(f,epopdeep[ind[,4],],maxrpodeep[ind[,4],],maxprodeep[ind[,4],]))
         +
         f[1]* (epepi[ind[,1]]-f[4]*maxrpep[ind[,1]]-f[5]*maxprep[ind[,1]])
          -log(funpeAll(f, epepi, maxrpep, maxprep))
         +
         f[1]* (eperi[ind[,2]]-f[4]*maxprer[ind[,2]]-f[5]*maxrper[ind[,2]])
           -log(funpeAll(f, eperi, maxprer,maxrper))
     )
}

########################################
###            constants             ###
########################################

grenze <- 10
max_deep<- 22*9+44*9+1 ###maximal elements in three dimensional arrays
third dimension

########################################
###       load and assign data       ###
########################################

A<-read.table(file="C:\\ultimatum.csv",sep=",",header=T)

x<-A$x ######################### offer
y<-A$y ######################### demand
eprop<-A$effortprop #############effort proposer
eresp<-A$effortresp ###############effort responder
d<-A$d ######################### accept decision
cres<-A$cres ##################### responders cost
cprop<-A$cprop ################# proposers cost
iprop<-A$iprop ################# proposers index
iresp<-A$iresp ################# responders index
ix<-A$ix ####################### offer index
index<-A$index ################# index of reduced matrices

########################################
###         starting values          ###
########################################

xx<-1
yy<-1
uu<-1
vv<-0.1
ww<-0.1

########################################
###           variables              ###
########################################

ep<-c(0:9) ####effort proposer
ep<-ep*0.1
er<-c(0:9) ####effort responder
er<-er*0.1
cp<-c(0,15,22,26,30,39,53,76,111,161) ####costs for proposer
cp<-cp*0.1
cr<-cp ####costs for responder


################## calculates the returns depending on all possible
efforts ep and er
```

```
return_matrix <- array(0,c(grenze,grenze))

for(ip in 1 : grenze)
{
    for(ir in 1 : grenze)
    {
       return_matrix[ip,ir] <- 22*ep[ip]+44*er[ir]
    }
}

#################### calculates all possible offers for all returns

offer_matrix <- array(-Inf,c(grenze,grenze,max_deep))

for(io in 1 : max_deep)
{
    for(ip in 1 : grenze)
    {
        for(ir in 1 : grenze)
        {
            if((io-1)*0.1 <= 22*ep[ip]+44*er[ir])
            {
                offer_matrix[ip,ir,io] <- (io -1)*0.1
            }
        }
    }
}

#################### calculates payments for proposer and responder under
acceptance condition

payp<- array(0,c(grenze,grenze,max_deep))
payr<- array(0,c(grenze,grenze,max_deep))

for(ip in 1 : grenze)
{
    for(ir in 1 : grenze)
    {
        for(io in 1 : max_deep)
        {
            if (offer_matrix[ip,ir,io] != -Inf)
            {
                payp[ip,ir,io]<-return_matrix[ip,ir]-
offer_matrix[ip,ir,io]-cr[ip]
            }
            else
            {
                payp[ip,ir,io]<- -Inf
            }

            if (offer_matrix[ip,ir,io] != -Inf)
            {
                payr[ip,ir,io]<-offer_matrix[ip,ir,io]-cr[ir]
            }
            else
            {
                payr[ip,ir,io]<- -Inf
            }
        }
    }
}
```

```
#### indices

ind<-cbind(iprop,iresp,ix,index)

###############################################
############ loop ############################
###############################################

# loop counter - used to use starting values in initial loop
round <- 0

repeat{

    # only first time use starting values
    if(round != 0)
    {
        xx<-out$par[4]
        yy<-out$par[5]
        uu<-out$par[3]*10
        vv<-out$par[2]*10
        ww<-out$par[1]*10
    }

    round <- round + 1

    #################### calculates utilities for both players under accept
and deny condition

    upa <- calcUtilityAccept(payp, payr, xx, yy)
    ura <- calcUtilityAccept(payr, payp, xx, yy)
    upd <- calcUtilityDenyProposer(payp, payr, cp, cr, xx, yy)
    urd <- calcUtilityDenyResponder(payp, payr, cr, cp, xx, yy)

    ########################################  stage 3

    #################### calculates accept probabilities of responder

    acc <- calcAcceptProb(ura, urd, uu)

    #################### expected payoff of any offer

    epop <- calcEffortProposer(acc, payp, cp)  # calculates expected
payoffs of offers for proposers
    epor <- calcEffortResponder(acc, payr, cr) # calculates expected
payoffs of offers for responder

    #################### max of zero and expected payoff differences of any
offers

    maxpro <- calcMaxOffer(epop, epor) # proposer  - responder
    maxrpo <- calcMaxOffer(epor, epop) # responder - proposer

    ########################################  stage 2

    euop <- calcExpUtility(upa, upd, acc) # calculates expected utilities
of offers for proposers
    poff <- calcProbOffer(vv, euop)       # calculates probabilities of
offers

    #################### expected payoffs for any efforts matrices
```

```
    epep <- calcExpectedPayoff(epop, poff) # expected payoff of effort for
proposer matrix
    eper <- calcExpectedPayoff(epor, poff) # expected payoff of effort for
responder matrix

    ########################################  stage 1

    euep <- calcExpectedPayoff(euop, poff) # expected utility of effort for
proposer matrix
    euor <- calcExpUtility(ura, urd, acc)  # expected utility of offer for
responder
    euer <- calcExpectedPayoff(euor, poff) # expected utility of effort for
responder matrix

    #################### probabilities of effort for both players

    ######## starting values of effort probabilities, equally distributed

    p<-seq(1/grenze, 1/grenze, length=grenze)
    q<-seq(1/grenze, 1/grenze, length=grenze)

    ######## definition of qre probability vectors for effort

    pp<-seq(0, 0, length=grenze)
    qq<-seq(0, 0, length=grenze)

    ######## numerator of qre probability, sums up
    ######## loop until mutual convergence

    repeat{

        ######## expected effort of other player

        euepi<- calcExpectedEffortProposer(euep, p)
        eueri<- calcExpectedEffortResponder(euer, q)

        ######### qre response effort probabilies conditional on other
players probabilities

        for(i in 1 : grenze)
        {
            qq[i]<-exp(ww*(euepi[i]))/fune(ww, euepi)

            pp[i]<-exp(ww*(eueri[i]))/fune(ww, eueri)
        }

        i<-abs(p-pp)
        j<-abs(q-qq)
        k<-j+i
        l<-sum(k)
        p<-pp
        q<-qq

        if(l<0.0000000001)
        {
            break
        }
    }

    ########################################  expected payoff of effort
vectors
```

```
    ######### expected payoff of proposer vector

    epepi  <- calcExpPayoffVectorProposer(epep, pp)          ### expected
payoff of proposer vector for proposers effort decision
    eperpi <- calcExpPayoffVectorResponderProposer(epep, qq) ### expected
payoff of proposer vector for responders effort decision

    ######### expected payoff of responder vector

    eperi  <- calcExpPayoffVectorResponder(eper, qq)         ### expected
payoff of responder vector for responders effort decision
    epepri <- calcExpPayoffVectorProposerResponder(eper, pp) ### expected
payoff of responder vector for proposers effort decision

    #######################################  max expected payoff
differences for effort decisions

    ######### expected payoff differences in proposers decision

    maxprep <- calcMaxPayoffEffort(epepi, epepri)
    maxrpep <- calcMaxPayoffEffort(epepri, epepi)

    ######### expected payoff differences in responders decision

    maxprer <- calcMaxPayoffEffort(eperpi, eperi)
    maxrper <- calcMaxPayoffEffort(eperi, eperpi)

    #######################################  likelihood estimation

    ######### elements to be substituted into the likelihood function

    epopdeep   <- fillMatrix(epop)
    maxprodeep <- fillMatrix(maxpro)
    maxrpodeep <- fillMatrix(maxrpo)

    ######### optim calculation

    out <- optim(c(ww/10,vv/10,uu/10,xx,yy), log.lik, method="L-BFGS-B",
hessian=T, lower = c(0,0,0,0,0), upper = c(2,2,2,2,1))



    uuu<-out$par[3]*10
    vvv<-out$par[2]*10
    www<-out$par[1]*10
    xxx<-out$par[4]
    yyy<-out$par[5]

    if(abs(uuu-uu)<0.001 & abs(vvv-vv)<0.001 & abs(www-ww)<0.001 & abs(xxx-
xx)<0.001 & abs(yyy-yy)<0.001)
    {
        break
    }
}

#============ result =======================
print (out)

OI<-solve(out$hessian)
se<-sqrt(diag(OI))
se
```

```
print (pp)
print (qq)

A<-nearPD(OI, corr = FALSE, keepDiag = FALSE, do2eigen = TRUE, doSym =
FALSE)
se<-sqrt(diag(A))
se
```

Data

Please save data under the name “ultimatum.csv” in main directory C.

```
effortprop,effortresp,return,x,y,d,cprop,cresp,iprop,iresp,ix,index
0.6,0.4,30.8,9.8,21,1,5.3,3,7,5,99,54
0.6,0.8,48.4,24.2,24.2,1,5.3,11.1,7,9,243,58
0.5,0.9,50.6,20.6,30,1,3.9,16.1,6,10,207,49
0.8,0.6,44,16.5,27.5,1,11.1,5.3,9,7,166,76
0.6,0.8,48.4,11.7,36.7,1,5.3,11.1,7,9,118,58
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0.6,0.8,48.4,25.9,22.5,1,5.3,11.1,7,9,260,58
0.6,0.9,52.8,32.3,20.5,1,5.3,16.1,7,10,324,59
0.5,0.8,46.2,23.2,23,1,3.9,11.1,6,9,233,48
0.6,0.8,48.4,15.9,32.5,1,5.3,11.1,7,9,160,58
0.6,0.7,44,21.4,22.6,1,5.3,7.6,7,8,215,57
0.6,0.8,48.4,27,21.4,1,5.3,11.1,7,9,271,58
0.4,0.9,48.4,28.4,20,1,3,16.1,5,10,285,39
0.6,0.8,48.4,15,33.4,0,5.3,11.1,7,9,151,58
0.6,0,13.2,1.7,11.5,0,5.3,0,7,1,18,50
0.6,0.7,44,22.6,21.4,1,5.3,7.6,7,8,227,57
0.6,0.7,44,14,30,0,5.3,7.6,7,8,141,57
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