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JEL Classification: D86, D82, D62, C78, C92

Keywords: Contracts, Externalities, Bargaining, communication, Laboratory experiments

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Contracting under Asymmetric Information and Externalities: An Experimental Study

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1 Introduction

Externalities are ubiquitous, in both the public and the private sector. For instance, a nation's climate policy can have an impact on other nations. A city's expenditures on infrastructure such as public schools and hospitals can benefit citizens in neighboring cities. A manufacturer's decision to invest in new production technologies may reduce the harm caused by pollution in a nearby community. When a country modernizes its defense capabilities, this may also improve the security of allied countries.

In a seminal article, Coase (1960) has pointed out that externalities need not lead to inefficiencies when transaction costs are sufficiently low, such that the involved parties can negotiate a suitable contract.[1] Specifically, suppose a decision-maker can implement a project (e.g., infrastructure investments, measures to reduce pollution, R&D activities, etc.) that is socially desirable, because the decision-maker's costs are smaller than the total benefits generated by the project. In some cases, it may be that the decision-maker's own benefit is larger than the cost of the project, so the project may be implemented even when no compensation payments are made. Yet, in other cases it may be that in the absence of a contract the decision-maker would not implement the project, because the decision-makers's own benefit is smaller than the cost of the project. Whether or not the project would be implemented without compensation may well be private information of the decision-maker. Thus, the question arises whether the transaction costs are sufficiently low such that the involved parties manage to agree on a contract specifying suitable transfer payments, making sure that the project will always be implemented.

Contract theory has identified asymmetric information as a major source of transaction costs.[2] In particular, starting with Myerson and Satterthwaite (1983) several impossibility theorems have been proven in the contract-theoretic literature. In this context, an impossibility theorem shows that under certain circumstances rational parties will not be able to voluntarily agree on a contract that specifies an ex post efficient outcome, *regardless* of the bargaining protocol that governs the negotiations. Yet, most impossibility results in the literature do not consider situations with externalities, where in the case of disagreement one of the parties can unilaterally make a decision that affects another party's payoff. An important exception is Klibanoff and Morduch (1995).[3] Somewhat surprisingly, they point out that the

[1] See the recent work by Medema (2020) for a comprehensive review of the literature on the Coase Theorem.

[2] For a textbook exposition of contract theory, see Bolton and Dewatripont (2005).

[3] See also Farrell (1987) for an early example of bargaining in the presence of externalities and private information, which shares some properties with Klibanoff and Morduch's (1995) more general analysis.

classical argument, according to which small externalities lead to small problems whereas large externalities give rise to large problems, can be violated. In particular, they show that it may be impossible to achieve ex post efficiency when the externality is relatively small, whereas ex post efficiency can be attained when the externality is sufficiently large. Intuitively, in the case of a small externality an affected party may not be willing to make a payment to the decision-maker in exchange for a specific decision if there is a good chance that the decision-maker will make the same decision even without getting a payment. In contrast, in the case of a large externality the affected party may be more inclined to contractually agree to a suitable payment in order to make sure that the decision-maker takes the efficient decision.

Reaching agreements to overcome externalities in the presence of asymmetric information can be of utmost importance for society, in particular with regard to health, safety, security, and environmental issues. Understanding if and how agreements ensuring ex post efficient outcomes can be reached is therefore crucial. In the present paper, we use a controlled laboratory experiment to study behavior in contract negotiations with externalities and private information.[4] In addition to studying a very simple and exogenously given bargaining game, we also explore unstructured negotiations in which individuals can freely communicate with each other.

Our experimental design follows Klibanoff and Morduch's (1995) basic setup. We consider two parties called player A and player B. Player A can either implement or not implement a project. Player A's net payoff v from implementing the project can be either positive or negative. While the distribution of v is commonly known, only player A knows the realization. When the project is implemented, then there is an externality of a commonly known size $w > 0$ on player B.[5] It is always ex post efficient to implement the project; i.e., the sum $v + w$ of player A's net payoff and the externality on player B is positive, even when player A's net payoff v is negative. The two parties can negotiate a contract, according to which player B makes a payment to player A and the project is implemented. If no agreement is reached, player A is free to decide whether or not to implement the project. Note that when the parties negotiate a contract, player B may be reluctant to make a payment to player A, because player A might implement the project even when no

[4]Since contract-theoretic models deal with private information, they are difficult to test in the field. If the researcher could observe the parties' information, then the information would not be private. Therefore, as has also been pointed out by Huck et al. (2011), in order to *directly* test contract-theoretic models, controlled laboratory experiments are particularly useful.

[5]Note that following Klibanoff and Morduch's (1995) leading example, we focus on the case of a positive externality. They have shown that the case of a negative externality can be treated analogously.

agreement is reached.

We use a 2x2 design, varying the bargaining procedure and the size of the externality. In two of our four treatments, we exogenously specify a simple bargaining protocol, namely an ultimatum game where player B can make a take-it-or-leave-it offer to player A. In the other two treatments, in order to impose as few restrictions as possible on the contract negotiations, we allow for unstructured bargaining with free-form communication. In each case, we are particularly interested in comparing the effects of a small externality to those of a large externality.

In the case of the ultimatum game, the theoretical prediction is that in the bad state (i.e., when player A's net payoff v is negative) the project will never be implemented if the size of the externality w is small, whereas it will always be implemented if the externality is large. In the good state (i.e., when player A's net payoff v is positive), the project will always be implemented, regardless of the size of the externality. The experimental results are broadly in line with the predictions. In the good state, the project is implemented in the overwhelming majority of the cases. In the bad state, implementation of the project is very rare when the externality is small. The most substantial deviation of our experimental findings from the theoretical predictions occurs in the bad state when the externality is large. While the project is implemented in a majority of the cases, the implementation frequency is substantially smaller than predicted. Mild inequity aversion of player A and mistakes by player B both contribute to this deviation. However, with regard to player B's behavior we observe some learning taking place over time.

In the case of free-form bargaining, theory again predicts that the project is always implemented in the good state, regardless of the externality. In the bad state, it is possible (but not necessary) that the parties always reach an agreement to implement the project when the externality is large. In contrast, when the externality is small, an impossibility result holds. No matter what bargaining protocol the parties choose, they will not be able to always implement the project in the bad state. Specifically, our parameters are chosen such that according to theory the project will not be implemented in more than 50% of the cases in the bad state. Indeed, the experimental results show that in the good state the project is implemented in the overwhelming majority of the cases, whereas in the bad state it is implemented in about half of the cases when the externality is small. When in the bad state the externality is large, the implementation frequency is substantially below the theoretically possible 100%, but significantly larger than in the case of the ultimatum game. The fact that the implementation frequency is much smaller than 100% when in the bad state the externality is large can be partially explained by low offers made by player B, in particular in the first rounds of the experiment. We observe some learning effects over time. The analysis of the free-form communication shows that in order to reach an agreement in the bad state it can help when player A explicitly points out that the state is bad, mentioning honesty and trust. In contrast, if player A discusses fairness issues this reduces the likelihood that the project will be implemented.

Overall, while our findings corroborate the relevance of the information constraints emphasized by contract theory, we also find that in the bad state ex post efficiency is not always attained in the case of a large externality, where it would be theoretically possible. The latter result is a cause for concern, since reaching an ex post efficient agreement is particularly important when the size of the externality is large.

Related literature. To the best of our knowledge, our paper presents the first experimental investigation of contracting under asymmetric information in the presence of externalities as theoretically studied by Klibanoff and Morduch (1995).

We explore behavior in a situation in which according to theory an impossibility result holds; i.e., ex post efficiency cannot always be achieved by voluntary negotiations, regardless of the bargaining protocol.[6] The most famous impossibility result was shown by Myerson and Satterthwaite (1983). They consider a buyer and a seller who can trade an indivisible object. Only the buyer knows his valuation and only the seller knows her cost. It turns out that if valuation and cost are continuous random variables which are independently distributed and their supports overlap (so it is ex ante uncertain whether or not trade is ex post efficient), then it is impossible to come up with a bargaining mechanism that always results in the ex post efficient trade decision.[7]

There is by now a large contract-theoretic literature on possibility and impossibility results following Myerson and Satterthwaite (1983), see e.g. Mailath and Postlewaite (1990), Makowski and Mezzetti (1994), Williams (1999), Schweizer (2006), and Segal and Whinston (2011, 2013). In this literature it is usually assumed that when no agreement between the parties is reached, there is no trade; i.e., the allocation is then given by a commonly known status quo.

In contrast, building on Klibanoff and Morduch (1995) we consider a setup where

[6]Note that it is remarkable that one can prove such a result without specifying a particular bargaining game, which is due to the *revelation principle.* Cf. Myerson (1982) for a general version of the revelation principle and see Fudenberg and Tirole (1991, chapter 7) for a textbook exposition.

[7]In Myerson and Satterthwaite's (1983) trading problem, ex post efficiency can always be achieved when there is only one-sided private information (e.g., let the informed party make a take-it-or-leave-it offer). Matsuo (1989) has shown that when types are binary, their impossibility result holds only in a special case. Moreover, in Myerson and Satterthwaite's (1983) problem ex post efficiency can also be attained when it is commonly known that it is always ex post efficient to trade the object (using a fixed-price mechanism where the price lies between the largest realization of the cost and the smallest realization of the valuation).

in the case of disagreement one of the parties can make a unilateral decision that has an external effect on the other party. The impossibility result in our setting is quite different from Myerson and Satterthwaite (1983). In particular, there is only one-sided private information and there are only two types. The simplicity of the setup makes it particularly suitable for an experimental investigation. Moreover, the impossibility result is stronger in the sense that it holds even though it is commonly known that it is always ex post efficient to implement the project.

While we are not aware of any experimental work exploring real human behavior in such a setting, there are some studies in the experimental literature that were motivated by Myerson and Satterthwaite's (1983) original impossibility theorem. In particular, McKelvey and Page (2000) compare bargaining under two-sided private information to bargaining under complete information. They allow for unstructured bargaining, but they rule out communication. In line with Myerson and Satterthwaite (1983), their results corroborate that there is more inefficiency in the case of private information. Valley et al. (2002) also study bargaining under two-sided private information, but they exogenously specify the bargaining protocol by using a double auction. They find that pre-play communication can increase the fraction of cases in which the ex post efficient decision is taken.[8]

There are also experimental studies that explore settings with one-sided private information without externalities, so that according to standard theory it would be possible to achieve ex post efficiency with suitable bargaining protocols. In particular, starting with Mitzkewitz and Nagel (1993) several authors have explored ultimatum games with asymmetric information, see e.g. Güth et al. (1996), Kagel et al. (1996), Güth and Huck (1997), Güth and Van Damme (1998), Huck (1999), and Harstad and Nagel (2004).[9] Note that in a standard ultimatum game the pie to be divided is destroyed when the responder rejects the proposer's offer, whereas in our setup after rejecting the proposer's offer the privately informed responder is free to unilaterally decide whether or not to implement the project.

Organization of the paper. The remainder of the paper is organized as follows. In the next section, we introduce the theoretical framework that provides the starting

[8] See also Casoria et al. (2020) for a recent survey of experimental studies investigating the effects of communication on behavior, in particular with regard to the mitigation of information problems in employer–employee relationships. Several experimental studies such as Harbring (2006) have found that free-form communication can facilitate coordination.

[9] Closely related to this literature are experiments that were motivated by contract-theoretic adverse selection models in which uninformed principals can make take-it-or-leave-it offers to privately informed agents; see e.g. Asparouhova (2006), Cabrales et al. (2011), Cabrales and Charness (2011), Hoppe and Schmitz (2013, 2015), and Mimra and Waibel (2018). Some authors such as Forsythe et al. (1991) and Camerer et al. (2019) have also studied unstructured bargaining in setups with one-sided private information without externalities. Charness and Dufwenberg (2011) show that communication can be helpful in partnerships with one-sided private information when the contractual terms are exogenously fixed.

point for our experimental study. We describe our experimental design in Section 3 and we derive predictions in Section 4. We present and analyze our experimental results in Section 5. Finally, concluding remarks follow in Section 6. Some technical details and further analyses of our data have been relegated to the Appendix and to the Supplementary Material.

2 The theoretical framework

2.1 The model

In this section, we present a stripped-down (binary) version of Klibanoff and Morduch's (1995) model.[10] There are two risk-neutral parties, player A (he) and player B (she). Player A has the right to make a decision $Q \in \{0, 1\}$. The decision $Q = 0$ means that we stick to the status quo, where both parties' payoffs are zero. The decision $Q = 1$ means that player A implements a project that has a direct externality on player B. Specifically, player A's valuation of the project is $v \in \{v_L, v_H\}$, where $v_L < 0 < v_H$, whereas player B's valuation of the project is $w > 0$.

Hence, when player B makes a transfer payment t to player A, then player A's payoff is

$$u_A(Q, t) = vQ + t$$

and player B's payoff is

$$u_B(Q, t) = wQ - t.$$

In a first-best world with symmetric information, according to the Coase Theorem the parties would agree on implementing the project whenever $v + w$ is positive. Yet, following Klibanoff and Morduch (1995) we are interested in the case in which player A has private information about his valuation v. In particular, v is a random variable with $\Pr\{v = v_H\} = p$, where $p \in (0, 1)$. Only player A knows the realization of v, whereas all other elements of the model (including the size of the externality w) are common knowledge.

The sequence of events is as follows. In the first stage, player A privately learns the realization of his valuation v. In the second stage, the two parties can bargain with each other. If the parties reach an agreement about a decision Q and a transfer payment t, then the agreement will be enforced and the game is over. If the parties do not reach an agreement, then the third stage is reached. In this case, player A can choose $Q \in \{0, 1\}$ unilaterally and no payment is made.

[10] Formally, our binary-type model is not a special case of Klibanoff and Morduch's (1995) setup. Yet, it captures the main insights and formalizes the same intuition as their continuous-type model. We think that the simplicity of the binary version of the model makes it particularly suitable for a laboratory study.

Note that when the third stage is reached, player A will implement the project if and only if $v = v_H$. Thus, when the externality is trivially small, $w < -v_L$, then player A's decision in the case of disagreement always corresponds to the first-best outcome. In what follows, we will focus on the interesting case in which player A will not always take the first-best decision already in the absence of an agreement.

Assumption 1. *Let* $w > -v_L$.

Specifically, Assumption 1 means that it is common knowledge that in a first-best world the project would always be implemented, regardless of the state of the world.

2.2 A simple ultimatum game

Before we look at general bargaining mechanisms, let us first study a simple ultimatum game. Specifically, suppose that in the second stage player B can offer a payment t that she will pay to player A when player A agrees to choose $Q = 1$. If player A accepts the take-it-or-leave-it offer, the decision $Q = 1$ and the payment t will be enforced. If player A rejects the offer, the third stage is reached. Player A can then freely choose $Q \in \{0, 1\}$ and no payment is made.

Recall that in the case of disagreement, in the third stage player A will set $Q = 1$ if and only if $v = v_H$. Therefore, if in the first stage player A has learned that $v = v_H$, then he will accept any offer $t \geq 0$ in the second stage. If player A has learned that $v = v_L$, then he will accept any offer $t \geq -v_L$.

Since player B does not know the realization of v, anticipating player A's reaction it is optimal for player B to propose $t = -v_L$ if $w + v_L \geq pw$, and $t = 0$ otherwise.

Therefore, the first-best solution will always be attained if the externality is sufficiently large, $w \geq -v_L/(1-p)$. Yet, if the externality is relatively small, $w < -v_L/(1-p)$, then the project will be implemented only in the good state of the world ($v = v_H$), but not in the bad state of the world ($v = v_L$). Thus, in the latter case the first-best outcome will not be achieved.

2.3 General analysis

The simple ultimatum game that we have studied in the previous section is just one example of a bargaining game that the parties could play in the second stage. There are countless ways to modify and extend the ultimatum game. For instance, when player A rejects player B's offer, he might have the possibility to make a counteroffer. It might also be the case that player A can make the first offer, and there could be many rounds with alternating offers. In general, bargaining games can have multiple equilibria, including equilibria in mixed strategies (see e.g. Muthoo, 1999).

In order to characterize what can be achieved by voluntary negotiations in general, we can invoke the revelation principle (cf. Myerson, 1982). According to the revelation principle, whatever the parties can achieve with any conceivable bargaining mechanism could also be achieved with a corresponding direct revelation mechanism. In such a mechanism, player A is directly asked about his valuation, and it is in player A's self-interest to tell the truth.[11]

In the general analysis we allow for randomization, so let $q \in [0,1]$ denote the probability that the decision $Q = 1$ is taken. In the present context, a direct revelation mechanism is given by a menu of contracts (q_H, t_H), (q_L, t_L), where (q_i, t_i) are the probability of implementing the project and the transfer payment when player A claims that $v = v_i$, where $i \in \{L, H\}$.

The incentive-compatibility constraints that ensure truth-telling by player A are

$$q_H v_H + t_H \geq q_L v_H + t_L, \qquad (IC_H)$$

$$q_L v_L + t_L \geq q_H v_L + t_H. \qquad (IC_L)$$

The constraint (IC_i) means that it is in the self-interest of type $i \in \{L, H\}$ of player A to pick the contract that is intended for him. The constraints that ensure voluntary participation are

$$q_H v_H + t_H \geq v_H, \qquad (PC_H^A)$$

$$q_L v_L + t_L \geq 0, \qquad (PC_L^A)$$

$$p(q_H w - t_H) + (1-p)(q_L w - t_L) \geq pw. \qquad (PC^B)$$

To see this, recall that if in the second stage no agreement is reached, then in the third stage player A will implement the project if and only if $v = v_H$. Hence, the constraint (PC_H^A) ensures that when type H of player A agrees to the mechanism, then he gets at least v_H, whereas the constraint (PC_L^A) ensures that type L gets at least zero. Recall that player B does not know the realization of v. Hence, the constraint (PC^B) ensures that player B's expected payoff when she participates in the mechanism is larger than her expected payoff when she does not participate.

Under Assumption 1, it is common knowledge that the project would always be implemented in a first-best world ($q_H^{FB} = q_L^{FB} = 1$). Under what circumstances can the first-best solution be attained in a second-best world with asymmetric information? Note that when $q_H = q_L = 1$, the incentive-compatibility constraints imply

[11] Note that direct revelation mechanisms are just a technical device that allows us to characterize what the parties can achieve without imposing any ad hoc restrictions on the class of feasible mechanisms. In particular, the revelation principle does not say that in practice the parties must use direct mechanisms to attain a specific outcome.

$t_H = t_L =: T$. Intuitively, when the project will be implemented regardless of player A's message, player A would always announce the state of the world that leads to a larger payment, so truth-telling requires that the payments are independent of the state. The participation constraint (PC_H^A) can then be rewritten as $T \geq 0$, whereas (PC_L^A) becomes $T \geq -v_L$, and (PC^B) now reads $T \leq (1-p)w$. A transfer payment T that satisfies these constraints exists if and only if $w \geq -v_L/(1-p)$. Therefore, the first-best solution can be attained whenever the externality is sufficiently large. Yet, if $w < -v_L/(1-p)$, then it is impossible to construct a direct revelation mechanism that achieves the first-best solution and in which the parties participate voluntarily. Hence, the revelation principle implies that in this case it is *impossible* to achieve the first-best solution with voluntary negotiations, no matter what bargaining mechanism one might come up with.

The following proposition summarizes our results and also characterizes what in general can best be achieved when $w < -v_L/(1-p)$ holds.

Proposition 1 *(i) In the case of a sufficiently large externality, i.e. if* $w \geq -\frac{1}{1-p}v_L$, *the first-best solution* ($q_H^{FB} = q_L^{FB} = 1$) *can be achieved.*

(ii) In the case of a relatively small externality, i.e. if $w < -\frac{1}{1-p}v_L$, *it is impossible to attain the first-best solution* ($q_H^{FB} = q_L^{FB} = 1$) *with voluntary negotiations. The maximum attainable expected total surplus is achieved by* $q_H = 1$, $q_L = \frac{pv_H}{pv_H - v_L - (1-p)w}$.

Proof. See the Appendix.

Hence, even though it is commonly known that in a first-best world the project would always be implemented, due to asymmetric information it is impossible for the parties to voluntarily agree on a mechanism which implements the project more frequently than stated in the proposition.

3 Experimental design

3.1 Procedure

Our experiment consists of four treatments. We have implemented a between-subject design with 80 participants in each treatment; i.e., in total 320 subjects participated in the experiment.[12] All subjects were students at the Karlsruhe Institute of Technology and enrolled in a variety of fields of study. No subject was allowed to participate

[12] Due to subjects that did not show up for a session, the number of subjects in each session is either 16 or 32. Three treatments encompass three sessions, while one treatment encompasses four sessions.

in more than one session. All interactions were anonymous; i.e., the subjects did not learn the identities of the subjects with whom they were matched.[13]

At the beginning of each session, all subjects received identical written instructions and they had to answer several comprehension questions.[14] Each subject was randomly assigned to a role and kept this role throughout the session. Half of the subjects in each treatment were in the role of player A, and the remaining half was assigned to the role of player B. Each session lasted between 60 to 90 minutes. We made use of the experimental currency unit ECU, with an exchange rate of 5 ECU to one euro. On average, a subject earned 17.26 euro in the whole experiment.

In order to give the subjects the opportunity to gain some experience, we used a perfect stranger matching protocol with eight rounds. In particular, each subject knew that it would interact only once with another subject.[15] This procedure leads to five independent matching groups (consisting of eight subjects in the role of player A and eight subjects in the role of player B) for each treatment.

After the main part of the experiment, we elicited various control variables. Specifically, we collected information on risk attitudes (Dohmen et al., 2009), social value orientation (Murphy et al., 2011), and reciprocity (Dohmen et al., 2009). Moreover, we implemented the subscale for the Honesty-Humility domain from the HEXACO personality inventory. The Honesty-Humility domain captures the facets fairness, sincerity, modesty, and greed avoidance (Ashton and Lee, 2009). We also collected demographic information from our subjects.[16]

3.2 Treatments

In each treatment, player A can implement a project. Player A has private information about his or her valuation v of the project, which can be either $v = v_H = 6$ or $v = v_L = -10$, with equal probability ($p = 1/2$). When the project is implemented, it has a commonly known externality w on player B.

We have used a 2x2 design, varying both the size of the externality and the bargaining procedure (cf. Table 1). Specifically, we compare the case of a small

[13] The computerized experiment was programmed and conducted with z-Tree (Fischbacher, 2007), and subjects were recruited using the software hroot (Bock et al., 2014).

[14] The instructions are provided in the Supplementary Material.

[15] While we could have implemented more rounds using a random matching protocol, note that in this case the players might have been able to recognize the player with whom they are matched from earlier interactions when free-form communication is possible. Therefore, studies in which free-form messages can be sent often employ a perfect stranger matching protocol (see e.g. Brandts et al., 2016; Fehr et al., 2019) or a one-shot design (e.g., Ellingsen and Johannesson, 2004; Charness and Dufwenberg, 2011).

[16] See Section S.1 of the Supplementary Material for more details on the control variables. In the ultimatum game treatments, we also conducted an additional round using the strategy method (Selten, 1967), which is discussed in Section S.2.1 of the Supplementary Material.

externality ($w = 14$) to the case of a large externality ($w = 24$). Moreover, we consider a simple ultimatum game (in which player B can make a take-it-or-leave-it offer to player A) as well as free-form bargaining (i.e., unstructured bargaining with free-form communication).

	Ultimatum game	Free-form bargaining
Small externality	*UG-14*	*FF-14*
Large externality	*UG-24*	*FF-24*

Table 1. The four treatments.

In the following, we describe our four treatments in more detail. At the beginning of each round, two subjects with different roles are matched in one group. Each round consists of up to three stages.

- *Ultimatum Game with Small Externality (Treatment UG-14):*

  In the first stage, the computer software randomly decides whether the state is "good" or "bad".[17] Both players know that the probability of each state is 50%. Player A is informed about whether the state is "good" or "bad", whereas player B is not informed about the state.

  In the second stage, player B can offer a payment X, where X can be any integer between 0 and 14. If player A accepts the offer, the payment is made and the project is implemented, so player A's payoff is X ECU + 6 ECU in the "good" state and X ECU − 10 ECU in the "bad" state, whereas player B's payoff is 14 ECU − X ECU. In this case, the round is over. If player A rejects the offer, no payment is made and the third stage is reached.

  In the third stage, player A can unilaterally decide whether or not to implement the project. If player A implements the project, player A's payoff is 6 ECU in the "good" state and −10 ECU in the "bad" state, whereas player B's payoff is 14 ECU. If player A does not implement the project, both players receive zero ECU.

- *Ultimatum Game with Large Externality (Treatment UG-24):*

  This treatment is identical to treatment UG-14, except that "14" is replaced by "24".

[17] Note that in the instructions we refer to the state of the world as a "situation", which sounds more natural in everyday language.

- *Free-Form Bargaining with Small Externality (Treatment FF-14):*

  The first stage is identical to the first stage in treatment UG-14.

  In the second stage, the players have three minutes in which they can freely bargain about a payment X to be made from player B to player A (where X can be any integer between 0 and 14). Specifically, the players can make binding offers with regard to X and they can freely communicate by sending each other chat messages.[18] Neither the number of offers nor the number of chat messages is limited. Each player can accept an offer made by the other player by clicking on an "accept" button. Moreover, each player can click on a button to break off the negotiations. In addition, players can also retract offers they have made as long as the offer has not been accepted. If the players reach an agreement (i.e., one of the players accepts an offer made by the other player), then the agreed-upon payment is made and the project is implemented, so player A's payoff is X ECU + 6 ECU in the "good" state and X ECU − 10 ECU in the "bad" state, whereas player B's payoff is 14 ECU − X ECU. Then the round is over. If the players do not reach an agreement (i.e., no player has clicked on the "accept" button within the three minutes or a player has clicked on the "break off" button), then no payment is made and the third stage is reached.

  The third stage is the same as in treatment UG-14.

- *Free-Form Bargaining with Large Externality (Treatment FF-24):*

  This treatment is identical to treatment FF-14, except that "14" is replaced by "24".

4 Predictions

Recall that in each treatment it is commonly known by the players that it is always ex post efficient to implement the project, regardless of the state of the world.[19] Our main interest is to find out how often the project will actually be implemented and to what extent the treatment variations have the theoretically predicted effects.

In the ultimatum game treatments, the theoretical predictions are very clear. As explained in Section 2.2, in the case of a small externality ($w = 14 < -v_L/(1 -$

[18] A text message could contain up to 280 characters. The subjects were not allowed to reveal their identity through the messages. Note that Galeotti et al. (2018) have recently allowed for free-form bargaining in a similar way (albeit in an experiment with complete information about the payoffs).

[19] Assumption 1 is satisfied, since $w > -v_L = 10$ holds in the treatments with the large externality ($w = 24$) as well as in the treatments with the small externality ($w = 14$).

$p) = 20$), player B offers a payment of zero. Hence, in the bad state player A rejects the offer and never implements the project. In the good state, the project will always be implemented (either player A accepts the offer, or player A rejects and implements the project in the third stage). In the case of a large externality ($w = 24 > -v_L/(1-p) = 20$), in equilibrium player B offers a payment of 10 which player A accepts, so the project is always implemented.[20]

In the free-form bargaining treatments, it is also the case that according to theory the project will always be implemented in the good state.[21] Without specifying the bargaining game, we cannot make point predictions regarding project implementation in the bad state. Yet, the analysis of Section 2.3 shows that in the case of a small externality ($w = 14$) an impossibility result holds; i.e., no matter what bargaining game the players play, it is impossible that the project will always be implemented in the bad state. Specifically, the probability that the project will be implemented cannot be larger than $\frac{pv_H}{pv_H - v_L - (1-p)w} = 50\%$. In contrast, in the case of a large externality ($w = 24$), it is possible (but not necessary) that the project will always be implemented in the bad state.

5 Results

5.1 Overview

We start with a short summary of our central results. Table 2 provides an overview of the main descriptive statistics.

First, we look at the prime variable of interest, the relative implementation frequency of the project. In all treatments, the project is implemented in more than 94% of the cases in the good state of the world, which is reasonably close to the theoretical prediction of 100%. In the bad state of the world, the project is implemented in only 9% of the cases in UG-14 and in 56% of the cases in FF-14. These results are not too far apart from the theoretical upper bounds of 0% and 50%, respectively. Overall, the findings are thus broadly in line with the theoretical predictions if the externality is small.

[20] Note that given an offer of 10, in the bad state player A is indifferent between accepting and rejecting. In Section 2.2 we have made the usual assumption that player A accepts in this case, since in theory arbitrarily small payments above $-v_L$ are feasible. In the experiment, payments must be integers. Thus, if player B expects player A to reject the offer 10, it is optimal for player B to offer 11.

[21] To see this, recall that even when no agreement is reached in the second stage, player A will implement the project in the third stage.

	UG-14	UG-24	FF-14	FF-24
Implementation frequency				
bad state	$\frac{15}{160}$ (9.38%)	$\frac{82}{160}$ (51.25%)	$\frac{89}{160}$ (55.63%)	$\frac{110}{160}$ (68.75%)
good state	$\frac{156}{160}$ (97.50%)	$\frac{158}{160}$ (98.75%)	$\frac{151}{160}$ (94.38%)	$\frac{155}{160}$ (96.88%)
Agreement frequency				
bad state	$\frac{15}{160}$ (9.38%)	$\frac{82}{160}$ (51.25%)	$\frac{89}{160}$ (55.63%)	$\frac{109}{160}$ (68.13%)
good state	$\frac{130}{160}$ (81.25%)	$\frac{149}{160}$ (93.13%)	$\frac{124}{160}$ (77.50%)	$\frac{135}{160}$ (84.38%)
Implem. frequ. in third stage				
bad state	$\frac{0}{145}$ (0%)	$\frac{0}{78}$ (0%)	$\frac{0}{71}$ (0%)	$\frac{1}{51}$ (1.96%)
good state	$\frac{26}{30}$ (86.67%)	$\frac{9}{11}$ (81.81%)	$\frac{27}{36}$ (75.00%)	$\frac{20}{25}$ (80.00%)
Mean payoff of player A				
bad state	−0.07	0.93	0.86	3.19
good state	8.44	16.02	11.31	15.72
Mean payoff of player B				
bad state	0.44	6.25	1.37	6.43
good state	11.06	13.61	7.57	13.34

Table 2. Descriptive statistics. All payoffs are in ECU. Note that the third-stage implementation frequencies directly follow from the implementation and agreement frequencies.

	UG-14 vs. UG-24	FF-14 vs. FF-24	UG-14 vs. FF-14	UG-24 vs. FF-24
Implem. frequ.				
bad state	0.008	0.143	0.008	0.032
good state	1.000	0.532	0.333	0.683
Agreem. frequ.				
bad state	0.008	0.143	0.008	0.040
good state	0.079	0.349	0.595	0.032
Payoff player A				
bad state	0.008	0.008	0.008	0.008
good state	0.008	0.008	0.008	0.841
Payoff player B				
bad state	0.008	0.008	0.016	0.548
good state	0.024	0.008	0.008	0.889

Table 3. p-values for pairwise comparisons between treatments (two-tailed Mann-Whitney U tests on matching group averages).

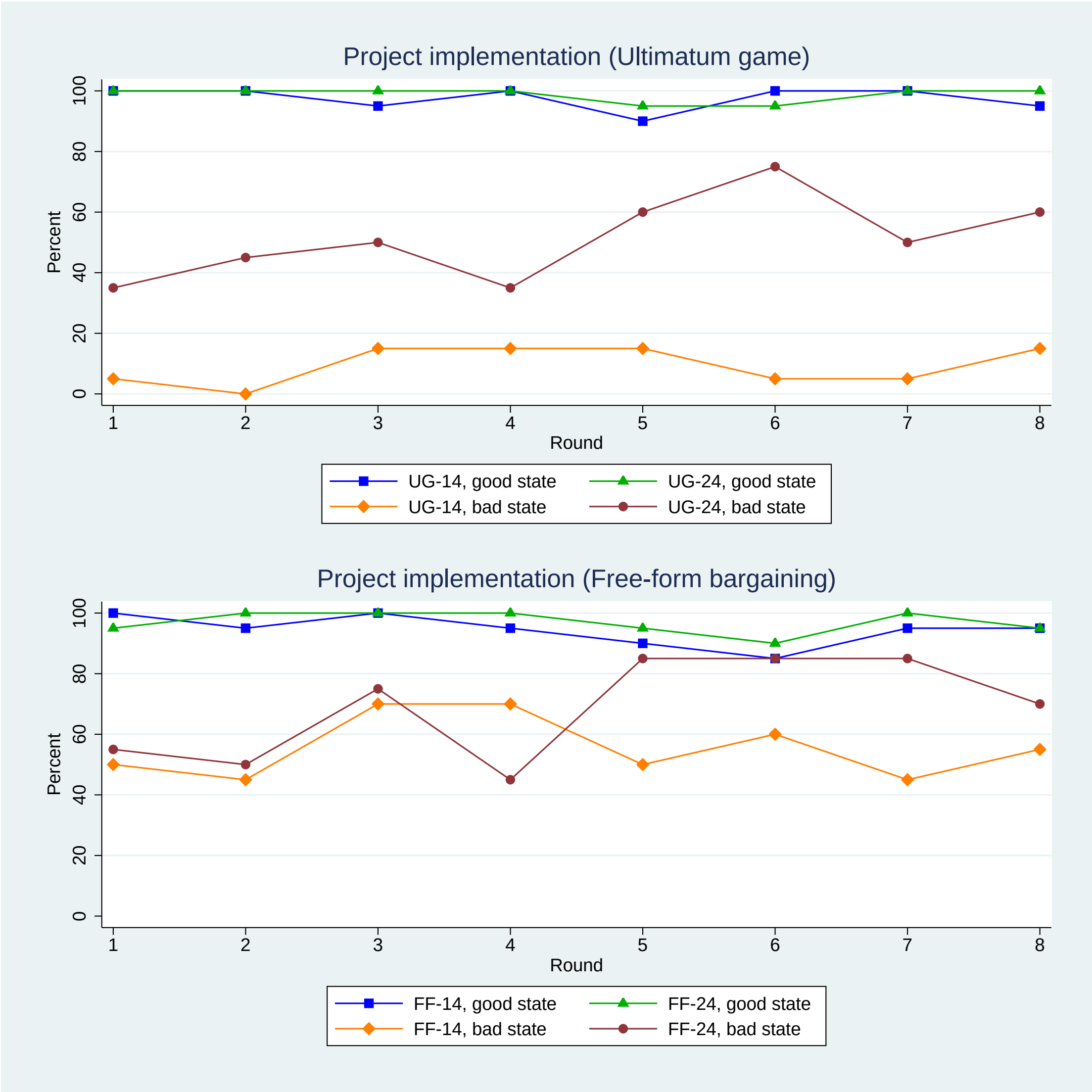

Figure 1. The relative frequencies with which the project was implemented in each treatment, conditional on whether the state was good or bad.

In contrast, the implementation frequency in the bad state is only 51% in UG-24, which is substantially below the theoretical prediction of 100% given the large externality. Also, in FF-24 the implementation frequency in the bad state is 69%, whereas up to 100% would be theoretically possible. Hence, when the externality is large then in the bad state there are unexploited gains from trade. According to theory these gains could be realized despite the presence of asymmetric information.

In order to investigate potential learning over time, we take a look at the implementation frequencies in all eight rounds depicted in Figure 1. In the second half of the experiment, the implementation frequencies in the bad state in UG-24 and FF-24 are larger than in the early rounds. Specifically, in rounds $5-8$ in the bad state the project is implemented in 61% of all cases in UG-24 and in 81% of all cases in FF-24. Indeed, in UG-24 and in FF-24 the implementation frequencies in the bad state in rounds $5-8$ are significantly different from those in rounds $1-4$ ($p = 0.063$, Wilcoxon signed-rank test).[22] Thus, over the rounds the subjects have learned to leave fewer gains from trade unrealized in the bad state when the externality is large. In contrast, the implementation frequencies in the good state of UG-24 and FF-24 (as well as the implementation frequencies in UG-14 and in FF-14, regardless of the state) do not differ significantly between rounds $1 - 4$ and rounds $5 - 8$.

As can be seen in Table 3, in the good state the implementation frequencies do not differ significantly when we vary the size of the externality or the bargaining procedure, which is in line with the theoretical predictions. Also as predicted, in the bad state the implementation frequencies differ significantly between UG-14 and UG-24 ($p = 0.008$). The implementation frequencies in the bad state do not differ significantly between FF-14 and FF-24 when we consider all eight rounds. Yet, when we consider only experienced subjects (rounds $5-8$), the implementation frequencies in the bad state differ significantly between FF-14 and FF-24 ($p = 0.024$). Moreover, regardless of whether the externality is small or large, free-form bargaining leads to significantly higher implementation frequencies in the bad state than the ultimatum game.

Finally, Table 2 also shows whether the project was implemented due to an agreement between the players in stage 2 or due to player A's unilateral decision in stage 3. If no second-stage agreement was reached in the bad state, then as predicted the project was never implemented in the third stage, except for only one case in FF-24. Moreover, when no second-stage agreement was reached in the good state, player A implemented the project in the third stage in at least 75% of the cases (whereas player A would always do so according to theory).

In the following sections, we take a closer look at the offers, the acceptance behavior, player A's third-stage implementation decisions, and the resulting payoffs. In particular, we want to shed further light on the experimental findings that deviate from the theoretical predictions.

5.2 Ultimatum game

5.2.1 Offers and reactions to the offers

Recall that according to the theoretical predictions, when the third stage is reached player A implements the project if and only if the state is good. In the second stage, player A accepts any offer (strictly) larger than 10 in the bad state, and any offer

[22] Throughout, all tests are two-tailed Mann-Whitney U tests on matching group averages unless reported otherwise. We use two-tailed Wilcoxon signed-rank tests on matching group averages if we test for differences within treatments.

(strictly) larger than 0 in the good state.[23] Note that player A has a relatively simple task in the ultimatum game, and player A's optimal behavior does not depend on the size of the externality. In contrast, player B's task is more difficult. Not knowing the state of the world and anticipating player A's behavior, according to theory it is optimal for player B to offer 0 in treatment UG-14 and 10 or 11 in treatment UG-24. Figure 2 shows what offers the subjects in the role of player B actually made and how the subjects in the role of player A reacted to these offers. We first take a closer look at player A's behavior (depicted in the lower part of Figure 2) and subsequently investigate player B's behavior (shown in the upper part of Figure 2).

Player A's behavior. Consider first player A's behavior in the bad state. As predicted, there is not a single case in which player A rejects player B's offer and subsequently implements the project in the third stage. Moreover, it is extremely rare that player A accepts an offer smaller than 10. This never happens in treatment UG-24 and in less than 3% of the cases (4/145) in treatment UG-14. If player B offers 10, we observe both rejections and acceptances by player A; the acceptance rate is 2/6 (33%) in UG-14 and 3/19 (16%) in UG-24. An offer of 11 or larger is always accepted in treatment UG-14. Thus, so far the behavior of subjects in the role of player A is very close to the theoretical predictions.

The most notable deviation is the fact that in treatment UG-24, an offer of 11 was rejected in 38% of the cases. We observe some learning, as rejections of the offer 11 dropped from 50% (13/26) in the first half of the experiment to only 31% (12/39) in the second half.[24] Apparently, some subjects in the role of player A disliked the extremely inequitable outcome when an offer of 11 is accepted in the bad state. In this case, player A's payoff is 1 and player B's payoff is 13. Some A-players prefer to punish player B for making this offer, which is reminiscent of responder behavior in standard ultimatum games. Yet, note that in the present context inequity aversion seems to be rather mild, as offers weakly larger than 12 were *always* accepted also in UG-24 (i.e., subjects in the role of player A found it acceptable to have a payoff of only 2, whereas player B's payoff is 12).[25]

[23] Player A is indifferent between accepting and rejecting when the offer is 10 in the bad state and 0 in the good state.

[24] To further investigate if the behavior is stable over time, we look at the behavior of subjects that have been exposed to an offer of 11 repeatedly. In sum, we have 65 cases with an offer of 11, but only 19 A-players received such an offer more than once. Four of them (10 cases) decided to reject the offer in all cases, whereas eight subjects (20 cases) always accept an offer of 11. Seven A-players switched over time and the two that received more than two offers decided to reject three out of the four offers.

[25] The finding that inequity aversion seems to play a less pronounced role compared to standard ultimatum games (as studied by Fehr and Schmidt, 1999) can be explained when player A's fairness views take into consideration that player B does not know the state of the world (cf. Cappelen et al., 2013).

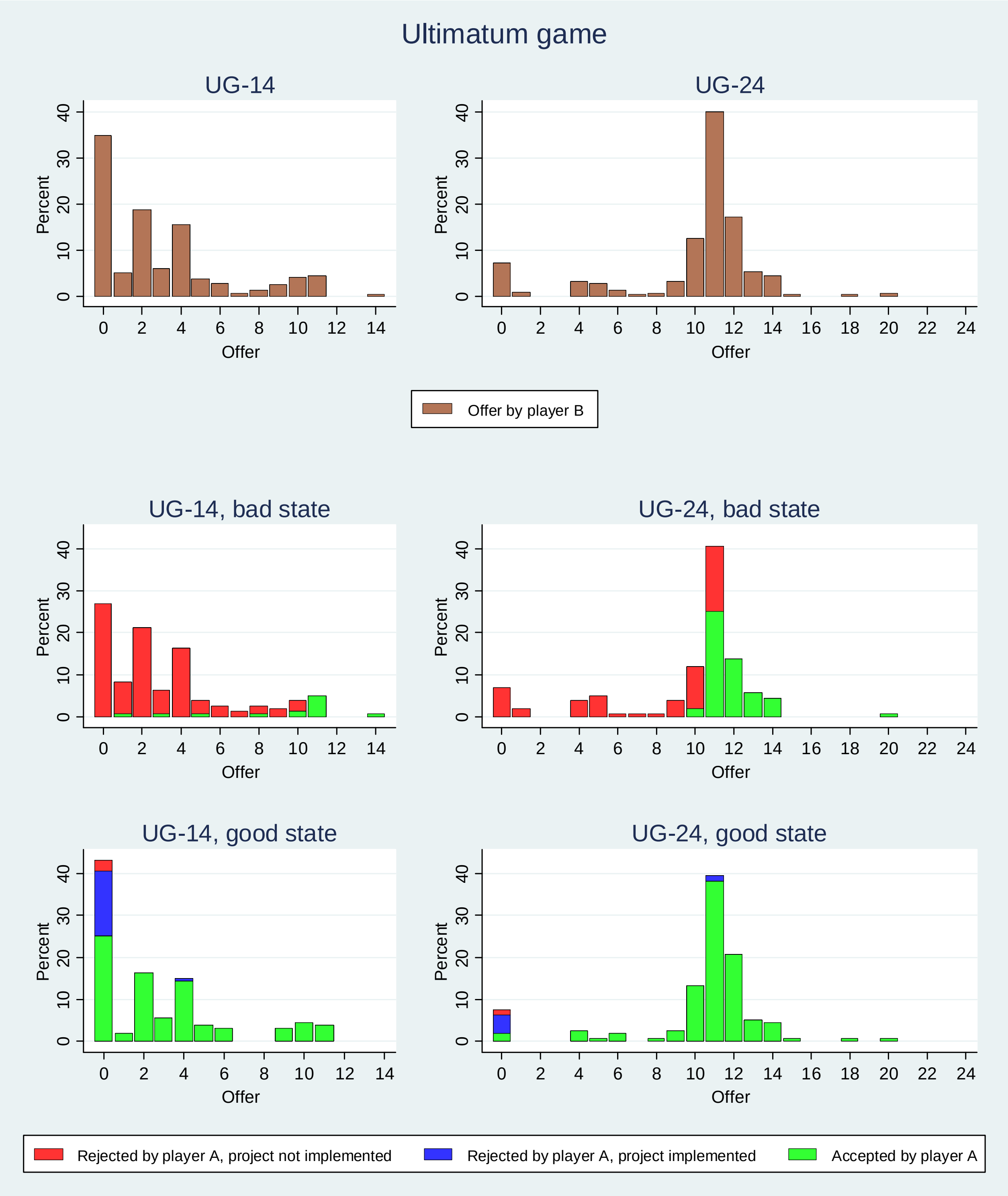

Figure 2. Ultimatum game. The distribution of the offers made by player B, and player A's reaction conditional on the state of the world.

Next, consider player A's behavior in the good state. As predicted, an offer strictly larger than 0 was almost always accepted.[26] When player B offered 0,

[26]This did not happen in only one out of 91 cases in UG-14 and in only two out of 148 cases in

rejections occurred frequently. However, by far most subjects in the role of player A subsequently implemented the project in the third stage (which leads to the same payoffs as accepting the offer 0). Specifically, there are only four cases in UG-14 and two cases in UG-24 in which the project was not implemented in the good state (which is in line with mild inequity aversion). Hence, with very few exceptions the behavior of the subjects in the role of player A in the good state is in line with the theoretical predictions.

Player B's behavior. Next we consider player B's behavior, which is shown in the upper part of Figure 2.[27] Given the fact that player B's task was more difficult, it is remarkable that the most frequent offers correspond to the theoretical predictions. Specifically, in treatment UG-14 the most frequently made offer is 0, which was made in 35% of the cases. Moreover, in treatment UG-24 the most frequently made offer is 11, which was made in 40% of the cases (and the offer 10, which can also be optimal according to theory, was made in 13% of the cases). The offers made in UG-14 and UG-24 are significantly different ($p = 0.008$), with a mean of 2.88 in UG-14 and 9.95 in UG-24.

In the treatment UG-14, only very few subjects in the role of player B aim at implementation of the project in the bad state. Specifically, less than 9% of the offers are weakly larger than 10. Thus, as predicted the overwhelming majority of subjects in the role of player B made offers that player A had to reject in the bad state in order to avoid making a loss. Given that the offer will be accepted in the good state only, both players have equal payoffs if the offer is 4 (so that in the good state each player's payoff is 10). This offer was made in 16% of the cases.[28]

In the treatment UG-24, by far most subjects in the role of player B seem to aim at implementation of the project in the bad state. Yet, 19% of the offers are strictly smaller than 10, so in theses cases player A would make a loss when implementing the project in the bad state. We observe some learning over time, because 23% of the offers are strictly smaller than 10 in rounds $1-4$, whereas this percentage drops to 16% in rounds $5-8$. Given that the project will be implemented in the good state only, both players have equal payoffs when the offer is 9. This offer was made in only 3% of the cases. Given that the project will always be implemented, both players have the same expected payoff when the offer is 13. This offer was made in

UG-24. Yet, in these cases player A still implemented the project in the third stage, so it seems to be likely that the rejections were just mistakes.

[27] Recall that player B does not know the state of the world, so any differences between the distributions of offers in the good state and the bad state (as depicted in the lower part of Figure 2) are merely by coincidence.

[28] Observe that the offers strictly larger than 4 and strictly smaller than 10 are most likely attributable to errors. In fact, while these offers are made in 16% of the cases in rounds $1-4$, they are made in only 6% of the cases in rounds $5-8$.

only 5% of the cases. Overall, the B-players do not seem to aim at equalizing the players' payoffs.

5.2.2 Regression analysis

In addition to the non-parametric analysis, we use random effects logit regression models with the decision to implement the project as the dependent variable to investigate the moderating effects of social preferences and demographic information. We focus our econometric analysis on the bad state because the variation of the dependent variable is too low in the good state.

The results for the ultimatum games are reported in Table A1 in the Appendix. Model 1 reports the results if we control only for the externality, replicating the non-parametric result that the implementation frequency is higher in UG-24 than in UG-14 in the bad state. We add controls for player B's offers as well as round and matching group in Model 2. A higher offer leads to a higher implementation frequency and the treatment dummy is no longer significant because offers vary between the treatments. Model 3 also includes controls for social value orientation (SVO) and attitudes towards risk. Interestingly, we find a weakly significant effect that players characterized as prosocial (based on SVO) are more likely to implement the project. This effect is driven by players in the UG-24 treatment and can also be found if we restrict the dataset to observations with offers above 9.[29] This finding indicates that some subjects prefer to punish and not implement the project based on their social value orientation. The remaining models in Table A1 contain controls for reciprocity measures and variables from the HEXACO personality inventory subdomain honesty-humility, which have no significant impact on the decision to implement the project.

We use random effects tobit regressions with the offer as the dependent variable to investigate the impact of social preferences, risk attitude, and learning over time on player B's behavior (see Table A2 in the Appendix). First, we observe that the effect of higher offers in UG-24 than in UG-14 is robust if we add various control variables. Second, we find that offers increase over time indicating learning effects. A further analysis reveals that this effect is driven by players in UG-24, whereas we do not find systematic patterns for the UG-14 treatment.[30] Third, social preferences and demographic controls have no systematic impact on the offer.

[29] See Table S2 in the Supplementary Material. The result is in line with previous research (cf. Karagonlar and Kuhlman, 2013), which has shown that subjects characterized as prosocial according to SVO are more willing to accept inequitable offers in standard ultimatum games.

[30] See Table S3 in the Supplementary Material. This finding is in support of our observation that B-players in UG-24 learn over time not to make offers that A-players must reject in the bad state in order to avoid making a loss.

5.2.3 Payoffs

Taken together, the players' behavior in treatment UG-14 reflects the theoretical considerations quite well. Note that according to theory, both players' payoffs are zero in the bad state, whereas player A gets 6 and player B gets 14 in the good state. The actual payoffs (cf. Table 2) are on average not too far away from these predictions. However, player B's offers are somewhat more generous, so in the good state player A's payoff is larger and player B's payoff is smaller than predicted. In treatment UG-24, the predicted offer is 10 or 11, so in the good state player A's payoff is 16 or 17, whereas player B's payoff is 14 or 13. The actual payoffs in the good state are remarkably close to these predictions. Yet, in the bad state theory predicts a payoff of 0 or 1 for player A and of 14 or 13 for player B. While player A's payoff is as predicted, player B's payoff is much smaller.

The latter observation reflects that in our ultimatum game treatments, the main deviation between theory and experimental results is the fact that the project is not implemented in almost half of the cases in the bad state in UG-24. As we have seen, this deviation can be attributed to two factors. First, 19% of the offers made by player B are so small that player A has to reject them in order to avoid a loss. Second, in the bad state the offer 10 (where according to theory player A is indifferent) is rejected in 84% of the cases, and the offer 11 is rejected in 38% of the cases. The fact that player B sometimes makes an offer smaller than 10 is most likely attributable to decision errors and we indeed observe fewer such offers over time. As pointed out above, the fact that player A sometimes rejects an offer of 11 can be attributed to (rather mild) inequity aversion. Both facts together lead to the smaller-than-predicted implementation frequency in the bad state of UG-24.

5.3 Free-form bargaining

5.3.1 Offers and reactions to the offers

We now take a closer look at the offers, the decisions whether or not to accept, and the third-stage implementation decisions in the free-form bargaining treatments. As there is no exogenously fixed bargaining protocol in these treatments, in what follows we particularly focus on the opening offers and the final offers.

We define an offer as *opening offer* if it is the first offer made. Table 4 reports the frequencies with which the opening offer was made by player A and by player B, as well as the means of these offers, conditional on the treatment and the state of the world. The upper parts of Figures 3 and 4 show the distributions of the opening offers.

We define an offer as *final offer* if it was either accepted or ultimately rejected by the other player. The latter case occurs when after receiving the offer the other player has broken off the negotiations (by clicking on the break-off button) or the other player has waited until the three-minutes bargaining stage was over (and no new offers were made).[31] The lower parts of Figures 3 and 4 show the distributions of the final offers as well as the reactions to these offers.

Note that the average number of offers is relatively small, varying between 1.85 and 2.89. This is not surprising, as the players could use the free-form chat communication to coordinate on an offer. In a few cases the players concluded in their chat that they cannot reach an agreement, so no offer was made at all (which happened in almost 8% of the cases in the bad state in FF-14). Overall, in 34% of the cases only one offer was made.

As can be seen in Table 4, in each treatment and in each state of the world, on average a final offer made by player A was smaller than an opening offer made by player A. Similarly, in each treatment and in each state, on average a final offer made by player B was larger than an opening offer made by player B. Hence, when a player made more than one offer, he or she typically made concessions by adjusting the offer to make it more attractive for the other player.[32]

	FF-14, bad	FF-14, good	FF-24, bad	FF-24, good
Opening offer made by A	$\frac{84}{160}$ (52.5%)	$\frac{86}{160}$ (53.8%)	$\frac{75}{160}$ (46.9%)	$\frac{99}{160}$ (61.9%)
Mean of opening offer made by A	11.89	9.52	16.59	14.12
Final offer made by A	$\frac{81}{160}$ (50.6%)	$\frac{68}{160}$ (42.5%)	$\frac{60}{160}$ (37.5%)	$\frac{58}{160}$ (36.3%)
Mean of final offer made by A	11.59	9.26	15.52	12.21
Opening offer made by B	$\frac{64}{160}$ (40.0%)	$\frac{73}{160}$ (45.6%)	$\frac{79}{160}$ (49.4%)	$\frac{57}{160}$ (35.6%)
Mean of opening offer made by B	7.45	5.36	10.73	9.32
Final offer made by B	$\frac{64}{160}$ (40.0%)	$\frac{90}{160}$ (56.3%)	$\frac{94}{160}$ (58.8%)	$\frac{98}{160}$ (61.3%)
Mean of final offer made by B	9.89	6.04	13.60	11.39
No offers made	$\frac{12}{160}$ (7.5%)	$\frac{1}{160}$ (0.6%)	$\frac{5}{160}$ (3.1%)	$\frac{4}{160}$ (2.5%)
Mean of number of offers made	1.85	1.85	2.89	2.38

Table 4. Offers in the free-form bargaining treatments.

Offers made by player B. We start with Figure 3, which depicts the distributions of the offers made by player B. In contrast to the ultimatum game treatments, player B's offers can now depend on the state of the world, because claims about the state can be made by player A in the free-form text messages.

[31] Note that in FF-14, the total number of final offers is slightly smaller than the total number of opening offers. The reason is that in four cases an offer was made that was subsequently withdrawn.

[32] See also Figure S3 in the Supplementary Material, which shows all offers made in the 3-minutes bargaining phase. In each state of each treatment, we see that the gap between player A's and player B's offers becomes smaller as time progresses.

Consider first player B's behavior in the treatment FF-14, where the externality is small. Recall that both players have the same payoffs if they agree on the payment 12 in the bad state and on the payment 4 in the good state.[33] Note that in the bad state, the most frequent opening offers by player B are 4 (made in 34% of the cases) and 12 (made in 22% of the cases). In the good state, the opening offer 4 is made in 56% of the cases, whereas the opening offer 12 is made in only 8% of the cases. Hence, we already see an impact of communication when the opening offer is made. Now compare these numbers to the final offers made by player B, which are depicted in the lower part of Figure 3. In the bad state, the two most frequent offers are now 12 (made in 38% of the cases) and 11 (made in 30% of the cases), whereas the offer 4 is made in only 6% of the cases. Thus, player A often seems to be successful during the negotiations in persuading player B that the state is bad.[34] In the good state, the most frequent offer is still 4, which is made in 41% of the cases.

Now consider player B's behavior in the treatment FF-24, where the externality is large. The offer 9 yields an equal split of the surplus if it is accepted in the good state, whereas the offer 17 yields an equal split of the surplus if it is accepted in the bad state. In the good state, 9 is indeed the most frequent opening offer (made in 18% of the cases) and the most frequent final offer (made in 22% of the cases). In the bad state, the opening offers are more evenly distributed, and the most frequent final offers are 12, 15, and 17 (made in 18%, 17%, and 17% of the cases, respectively). We observe some learning in the bad state, because 14% of the final offers are 10 or below in rounds $1-4$, whereas only 4% are 10 or below in rounds $5-8$.

Observe that the colors in the lower part of Figure 3 indicate how player A reacted when the final offer was made by player B. As predicted, when player A rejected player B's offer in the bad state, then player A never implemented the project in the third stage. With the exception of only one case, in the bad state all offers strictly smaller than 10 were rejected. Note that whereas in UG-24 offers weakly larger than 12 were always accepted, this is not the case in FF-24. While player B's ability to make a take-it-or-leave-it offer in the ultimatum game has put player B in a strong bargaining position, player A apparently feels entitled to a larger share of the pie in the case of free-form bargaining. Observe also that in the good state there are several cases in which player A rejects a strictly positive offer and nevertheless implements the project in the third stage (3 out of 4 cases in FF-14 and 6 out of 9 cases in FF-24). Apparently, the negotiations have enraged some players, but self-interest often prevailed in the end.

[33]When the project is implemented, player A's payoff $v + X$ is equal to player B's payoff $w - X$ if $X = (w - v)/2$.

[34]For a detailed analysis of the text messages, see Section 5.3.2 below.

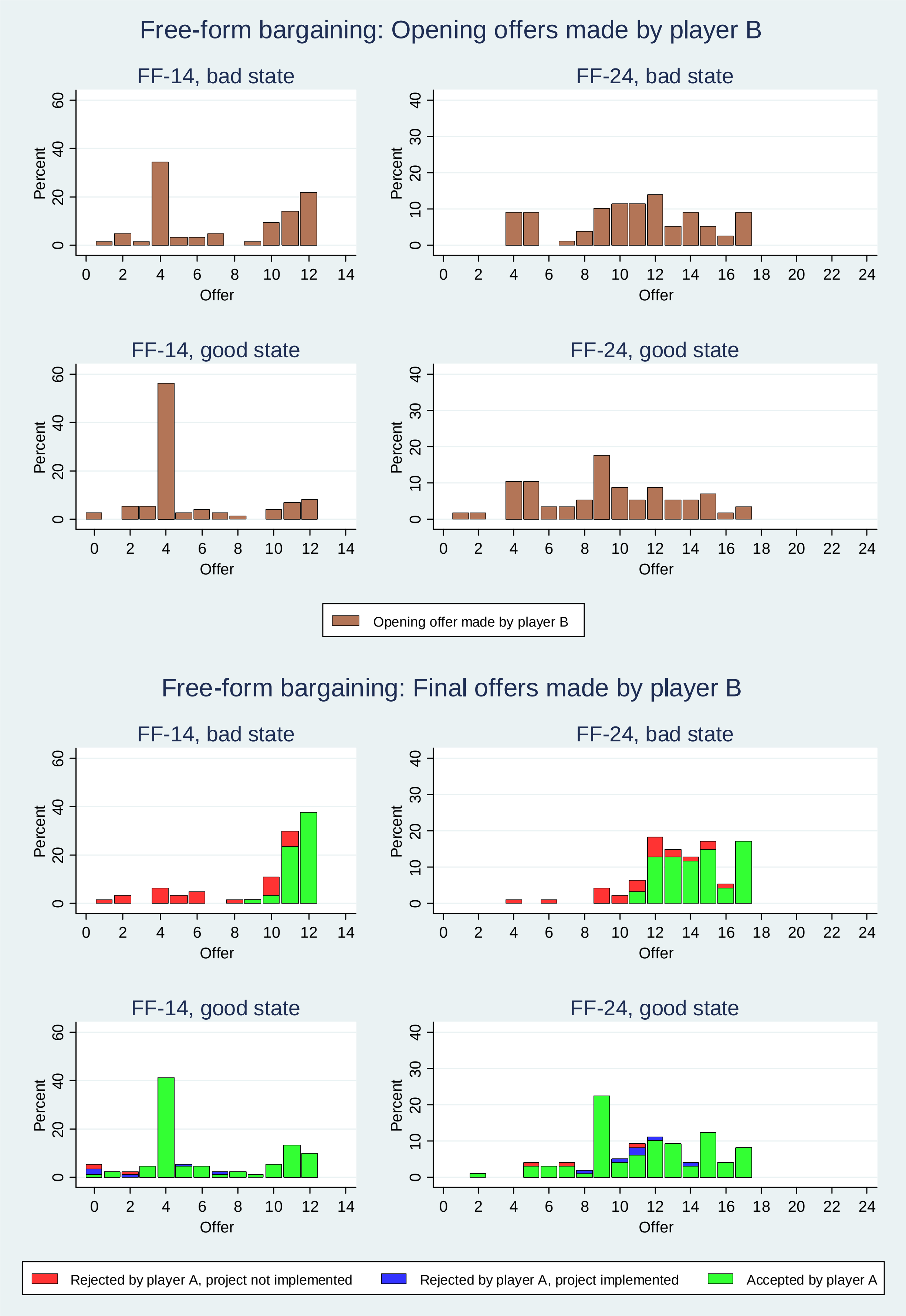

Figure 3. Free-form bargaining. Opening and final offers made by player B.

Offers made by player A. Figure 4 shows the distributions of offers made by player A. In the bad state of FF-14, player A makes the opening offer 12 in 83% of the cases, whereas player A makes some concessions in the final offers, where the offers 12 and 11 are made in 67% and 26% of the cases, respectively. It is remarkable that in the good state of FF-14, the most frequent opening offer is 12 (made in 49% of the cases). Thus, in the good state player A often tries to persuade player B that the state is bad.[35] When player A makes the final offer, then in the good state of FF-14 the offer 12 is still made in 37% of the cases, whereas the equal-split offer 4 is made in 22% of the cases.

In the bad state of treatment FF-24, player A's opening offer is 17 in 61% of the cases, whereas player A makes some concessions in the final offers (where the offer 17 is made in 32% of the cases). In the good state of FF-24, player A again often tries to convince player B that the state is bad, so the most frequent opening offer is 17 (made in 40% of the cases).[36] Yet, during the negotiations player A often gives in, so in the final offers the equal-split offer 9 is most frequently made (in 26% of the cases).

The colors in the lower part of Figure 4 indicate whether the final offer made by player A was accepted or rejected by player B, and in the latter case whether or not player A subsequently implemented the project in the third stage. When player B rejected player A's final offer in the bad state, then with only one exception player A never implemented the project in the third stage. Observe that in the bad state player B rejects the equal-split offers in a substantial fraction of the cases, so player B often does not trust player A's claim that they are in the bad state. In the good state, when player B rejects player A's final offer, then in most cases player A implements the project in the third stage.

5.3.2 Payoffs

Taken together, in the bad state of the world both parties benefit from the fact that with free-form bargaining the project is more often implemented than in the case of the ultimatum game (see the players' payoffs reported in Table 1). Yet, in the good state of the world player B's payoff is smaller in the case of free-form bargaining than in the corresponding ultimatum game, because player B was exogenously put in a stronger bargaining position in the ultimatum game. As we have seen, even when it is player B who makes the final offer in the case of free-form bargaining, the offers are on average larger than in the ultimatum game.

[35] Indeed, in the text messages that are analyzed in more detail below, 83% of the A-players making an opening offer of 12 in the good state of FF-14 lie and claim that the state is bad.

[36] In FF-24, 78% of the A-players making an opening offer of 17 in the good state lie and claim in the chat that the state is bad.

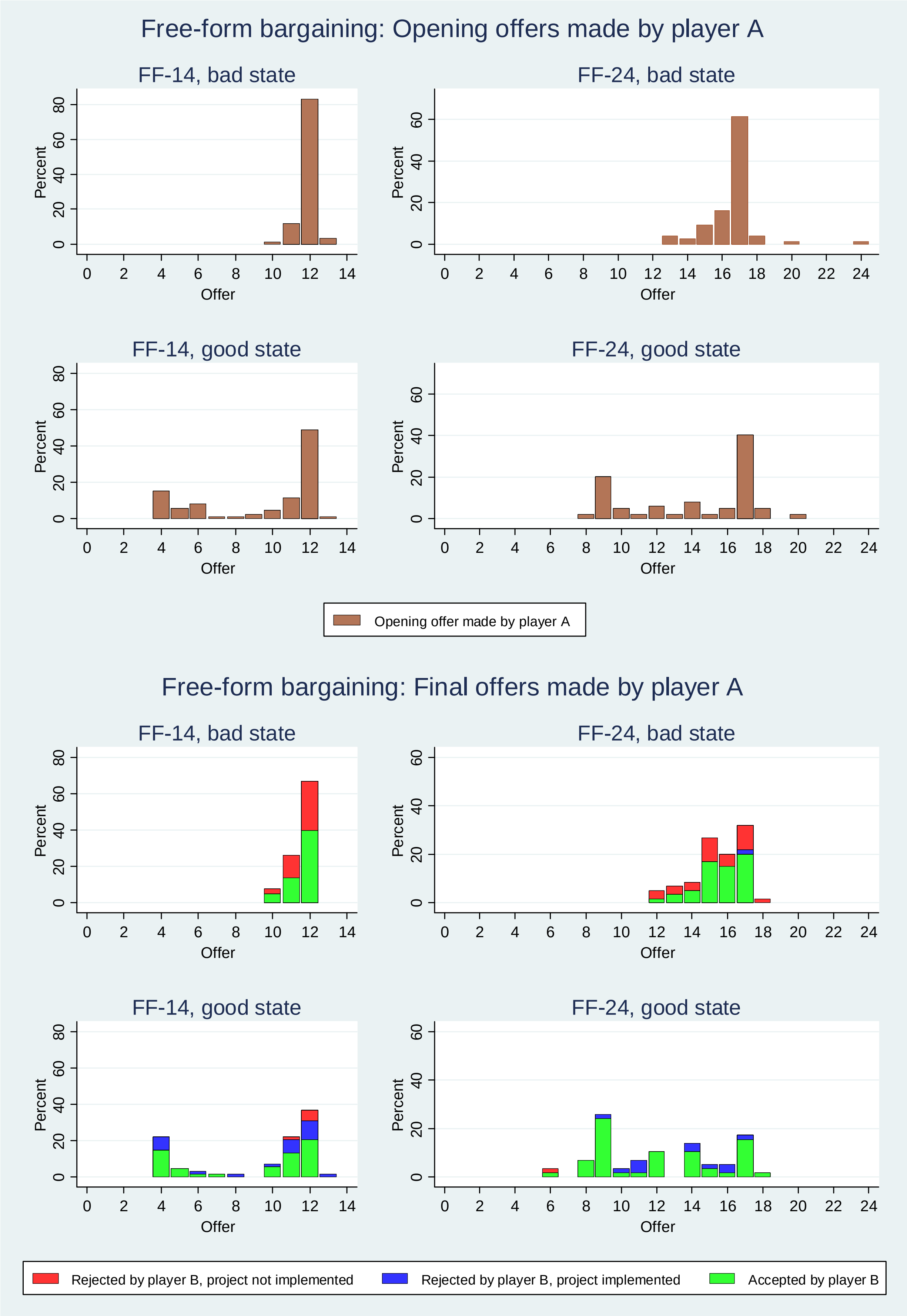

Figure 4. Free-form bargaining. Opening and final offers made by player A.

5.3.3 Analysis of the text messages

The text messages were categorized by two research assistants.[37] Both coders have read the experimental instructions and received short descriptions of the categories displayed in Table 5. The coders also had the opportunity to ask clarifying questions during the coding process. The results are shown in Table 6.

In FF-14, player A truthfully reveals the bad state in 89% of the cases. In the good state, player A reveals the true state in only 34% of the cases, whereas player A lies and claims that the state is bad in 44% of the cases. In FF-24, the bad state is truthfully revealed by the A-players in 84% of the cases. In the good state, the true state is revealed in only 23% of the cases, whereas in 50% of the cases the A-players claim that the state is bad. Thus, in the good state A-players often try to convince the B-player via the chat that the state is bad, which correspond to the high opening offers made by A-players. In FF-24, more B-players feel the need to explicitly ask about the state than in FF-14.[38]

During the negotiations, both players frequently make offers in the text messages or suggest how the total surplus should be divided. Player B suggests to split the revenue equally for a given state very rarely, with the exception of FF-14 assuming a good state (14% of the cases). In both treatments, player A suggests to split the revenue equally assuming a good state in less than 17% of the cases in which the state is actually good. In contrast, A-players demand an equal split assuming a bad state in around half of the cases if the true state is bad, but also in 26% of the cases in FF-14 and 21% of the cases in FF-24 if the state is actually good.

The chat analysis also reveals that A-players are more active in suggesting numerical offers via the text messages. Interestingly, A-players mention trust and honesty in around 40% of the cases in both treatments if the state is bad, but only in 19% of the cases in FF-14 and in 14% of the cases in FF-24 if the state is actually good. The lower share of honesty-related messages in the good state indicates some social costs of lying.

Moreover, B-players have concerns and say that they doubt that the state is bad when it is actually bad in 53% (resp., 58%) of the cases in FF-14 (resp., FF-24). In contrast, these percentages are only 36% in FF-14 and 33% in FF-24 if the state is good. However, given that B-players less often receive the information that the state is bad if it is actually good, the relative share of doubt is highest in the good state of treatment FF-14.

[37] The mean numbers of messages vary between 4.54 and 6.48, depending on the role of the player, the state, and the treatment. See Section S.3.2 of the Supplementary Material for a detailed analysis of the numbers of messages and words used by the players.

[38] We also observe that in the bad state B-players send more messages to A-players in FF-24 than in FF-14 (see the Supplementary Material).

The chat analysis further reveals that A-players mention fairness arguments more often than B-players. In contrast, B-players more often try to haggle and ask for a larger share of the surplus. Also, B-players more often mention bad experiences in previous rounds. We also observe that A-players tend to threaten to break off the negotiations more often than B-players.

Variable	**Description**
A_claim_good	A claims that situation is good
A_claim_bad	A claims that situation is bad
A_equalsplitgood	A suggests equal split for good situation (need not be true state)
A_equalsplitbad	A suggests equal split for bad situation (need not be true state)
A_division	A suggests a division
A_num_offer	A writes a numerical offer in the chat
A_accept	A accepts the offer
A_reject	A rejects the offer
A_trust_honesty	A mentions trust, honesty, or similar
A_fairness	A mentions fairness
A_haggle	A tries to haggle, mentions wanting a higher share, or reminds that without the project both players get zero payoff
A_loss	A claims he/she will make a loss with the current offer
A_bad_experience	A mentions bad experience in previous rounds
A_honor	A asks B to honor A's revelation that the situation is good by offering a larger share of the surplus to A
A_break_off	A mentions breaking off the negotiations
B_ask_state	B asks A about situation
B_equalsplitgood	B suggests equal split for good situation
B_equalsplitbad	B suggests equal split for bad situation
B_division	B suggests a division
B_num_offer	B writes a numerical offer in the chat
B_accept	B accepts the offer
B_reject	B rejects the offer
B_doubt	B doubts honesty of A, mentions honesty
B_fairness	B mentions fairness
B_haggle	B tries to haggle, mentions wanting a higher share, or reminds that without the project both players get zero payoff
B_bad_experience	B mentions bad experience in previous rounds
B_break_off	B mentions breaking off the negotiations

Table 5. Overview of the classification categories.

Variable	FF-14, bad	FF-14, good	FF-24, bad	FF-24, good
A_claim_good	0%	33.75%	0%	23.13%
A_claim_bad	88.75%	44.38%	83.13%	50%
A_equalsplitgood	0.63%	14.38%	0%	16.25%
A_equalsplitbad	56.25%	25.63%	47.50%	21.25%
A_division	74.38%	68.13%	76.25%	67.50%
A_num_offer	69.38%	63.13%	70.63%	61.25%
A_accept	6.25%	16.25%	8.75%	11.88%
A_reject	2.50%	0.63%	1.88%	0%
A_trust_honesty	40%	19.38%	40.63%	14.38%
A_fairness	15.63%	13.75%	22.50%	16.25%
A_haggle	0%	0.63%	1.25%	0%
A_loss	21.25%	9.38%	11.88%	6.25%
A_bad_experience	11.25%	10.63%	11.88%	6.25%
A_honor	0%	5.63%	0.63%	0%
A_break_off	23.75%	10.63%	16.88%	4.38%
B_ask_state	35.63%	43.75%	45%	51.88%
B_equalsplitgood	0%	14.38%	0%	0.63%
B_equalsplitbad	3.13%	4.38%	1.25%	1.88%
B_division	41.88%	46.88%	56.25%	44.38%
B_num_offer	41.25%	45%	53.75%	44.38%
B_accept	19.38%	18.75%	12.50%	20.00%
B_reject	1.88%	0.63%	3.75%	1.25%
B_doubt	53.13%	35.63%	57.50%	33.13%
B_fairness	6.88%	9.38%	5.00%	6.25%
B_haggle	22.50%	15.63%	36.25%	21.88%
B_bad_experience	28.75%	21.25%	34.38%	23.13%
B_break_off	4.38%	1.25%	0%	1.25%

Table 6. Classification of the text messages.

5.3.4 Regression analysis

As in the ultimatum game treatments, we run random effects logit regressions for the free-form bargaining treatments with the decision to implement the project using data from the bad state (see Table A3 in the Appendix). In Model 1, we control only for the externality and find a small effect that a higher externality leads to higher implementation rates. If we add controls for the number of offers by each player as well as controls for the last offer by both players if they submitted any, the results show that the externality has no significant impact on the implementation decision. Note that not all players submitted offers. Therefore, our dataset is restricted to the subsample of players making offers if we add these controls. We observe no strong learning effects in general over both treatments. The offers made by player A do not have a strong impact on the implementation decision. Yet, higher offers by player B increase the chance of implementation, whereas more frequent offers by player B decrease the chance. We do not find an impact of prosocial traits on the decision to implement, but players with higher scores on the honesty-humility domain are less likely to implement the project.

In Table A4, we also control for selected chat content. Again, we restrict the sample to observations in the bad state. The likelihood that the project is implemented increases if player A claims that the state is bad. The likelihood of implementation also increases if A-players use more arguments related to trust and honesty. In contrast, mentioning fairness more often is an indicator that the bargaining might not be successful. Also, a higher number of messages by A-players decreases the chance of project implementation. Our findings that higher scores on the honesty-humility scale and mentioning fairness more often decreases the chance of implementation whereas mentioning honesty and trust enhances the chance indicate that inequity aversion and fairness concerns influence the decision to implement the project in the bad state. If A-players feel the need to send more messages, this indicates that the bargaining process is more likely to fail. The chat content of player B has no significant impact on the outcome of the process.

We also execute random effects tobit regressions with the final offer of player B as the dependent variable. Note that not all B-players submitted a final offer, which restricts the dataset. Similar to the ultimatum game treatments, we control for social preferences and demographic characteristics, but also add information about the state and the number of offers by each player as controls (see Table A5). We observe that B-players submit higher final offers if the state is bad or if the externality is large, whereas the number of offers has no significant impact. A higher risk aversion triggers higher offers by player B, presumably because more risk-averse players want to increase the implementation likelihood by offering a higher share to A-players. In Table A6, we control for chat content and find that player A's claim that the state is bad increases the offer of player B, whereas the mentioning of fairness or honesty by player A has no such effect. In addition, the suggestion of player A to split the revenue equally in case of a bad state increases the offer. Interestingly, the offer also slightly increases if player B raises doubts about the honesty of player A, whereas a higher number of messages by player A leads to lower offers. It seems that outspoken concerns and doubts can be addressed during the bargaining process leading to higher offers, whereas more messages by A-players indicate lower offers by B-players. Thus, more messages by A-players harm the outcome of the negotiations in the bad state in two ways. First, more messages lead to lower offers by B-players, and we know from the results in Table A3 that lower offers decrease the chance of implementation. Second, more messages by A-players also decrease the likelihood of implementation directly, as can be seen in Table A4.

Finally, Table A7 shows random effects tobit regressions with the final offer of player A as the dependent variable. We observe that player A demands a higher payment if the state is bad or if the externality is large. In addition, a higher number of offers by player A reduces the final offer, indicating that often player A announces a high demand and later gives in. Social preferences and demographic characteristics do not play a major role. Regarding the content of the chat, we observe a similar pattern as for offers by player B (see Table A8). Announcing a bad state, demanding an equal split in the bad state, and doubts by player B increase the final offer, whereas other chat content has no significant impact.

6 Concluding remarks

Sixty years ago, Coase (1960) discussed how the problems caused by externalities can be solved through voluntary contracting between the involved parties. His lead example was building a fence when straying cattle may destroy crops on neighboring land. The topic of externalities has lost none of its relevance. A nation's measures to contain the outbreak of a virus may save other nations from a deadly pandemic. When in a city the hiring and training of police officers is improved, this may help to prevent violent riots and looting also in other cities. Yet, even when it is commonly known that it would be efficient to implement certain measures, in the presence of externalities decision-makers might be unable to reach an agreement due to asymmetric information. Thus, it is important to explore how subjects behave in contract negotiations when both externalities and private information come into play.

As a first step, we have conducted a controlled laboratory experiment. It turns out that the concerns that were first formalized by Klibanoff and Morduch (1995) are well-founded. When the size of the externality is relatively small, the parties reach an agreement in the bad state only slightly more often than theoretically predicted. In particular, allowing for unstructured bargaining with free-form communication, we were able to broadly corroborate the impossibility result proved by Klibanoff and Morduch (1995). When the size of the externality is large, then as expected the subjects reach an agreement in the bad state more often than when the externality is small. Yet, there is still a substantial fraction of cases in which the subjects do not reach an agreement, even when we allow for free-form bargaining. This finding is alarming, because in practice reaching an agreement is particularly important in the case of large externalities.

In future research, it would be very desirable to investigate to what extent our findings also hold true in the field. In a recent paper, Snowberg and Yariv (2020) have compared behaviors of university students and a representative sample of the U.S. population. They find that experiments utilizing undergraduate students allow generalizable inferences and are thus indeed a useful first step to generate insights about the behavioral effects of a public policy.[39] With regard to Myerson and Satterthwaite's (1983) original impossibility theorem, researchers have begun only very recently to do the second step and explore its relevance in the field (see Larsen, 2020).[40] So far, we are not aware of any attempts to explore contracting under asymmetric information in the presence of externalities using field data. We hope that our contribution helps to spur more research on this important topic.

[39] See also Fréchette (2015), who reports similar results when comparing experiments run on students and professionals.

[40] Larsen (2020) finds that real-world bargaining in a used-car market is indeed inefficient, but this inefficiency is not solely due to the information constraints highlighted in Myerson and Satterthwaite (1983). Our experimental results are in a similar spirit. While the information constraints highlighted by Klibanoff and Morduch (1995) are clearly relevant, we find also inefficiencies not predicted by their model.

Appendix

A.1 Proof of Proposition 1

Part (i) has already been shown in the analysis preceding Proposition 1. Now consider part (ii), where $-v_L < w < -v_L/(1-p)$ holds. In order to characterize the best attainable outcome, consider a (fictitious) benevolent mechanism designer who wants to maximize the expected total surplus. The designer must find a mechanism q_H, t_H, q_L, t_L that maximizes

$$pq_H(v_H + w) + (1-p)q_L(v_L + w)$$

subject to the constraints

$$\begin{aligned} q_H v_H + t_H &\geq q_L v_H + t_L, && (IC_H) \\ q_L v_L + t_L &\geq q_H v_L + t_H, && (IC_L) \\ q_H v_H + t_H &\geq v_H, && (PC_H^A) \\ q_L v_L + t_L &\geq 0, && (PC_L^A) \\ p(q_H w - t_H) + (1-p)(q_L w - t_L) &\geq pw. && (PC^B) \end{aligned}$$

Observe that the constraints (IC_L) and (IC_H) imply the monotonicity constraint $q_H \geq q_L$, because $v_H > v_L$ holds by assumption. We first solve a relaxed problem in which the constraints (IC_L) and (PC_H^A) are ignored. It will turn out that the solution to the relaxed problem satisfies the omitted constraints, so it is also the solution to the original problem.

Note that in the solution to the relaxed problem $q_H = 1$ must hold, since $v_H + w > 0$. Moreover, note that constraint (PC_L^A) must be binding in the solution (otherwise we could decrease t_L and thereby relax the remaining two constraints), so $t_L = -q_L v_L$. Constraint (IC_H) must also be binding, since otherwise we could decrease t_H and relax constraint (PC^B). Hence, $t_H = q_L(v_H - v_L) - v_H$. Since $v_L + w > 0$, we want to make q_L as large as possible, so also (PC^B) will be binding and hence

$$q_L = \frac{pv_H}{pv_H - v_L - (1-p)w}.$$

It is straightforward to check that the solution indeed satisfies the omitted constraints (IC_L) and (PC_H^A). □

A.2 Regressions

	(1)	(2)	(3)	(4)	(5)
UG-24	2.904***	−1.141	−1.338	−1.228	−1.172
	(0.507)	(0.971)	(0.942)	(0.969)	(0.950)
Offer		1.159***	1.189***	1.160***	1.156***
		(0.249)	(0.254)	(0.262)	(0.251)
Prosocial (SVO)			1.458*		
			(0.784)		
Risk attitude			−0.055	−0.126	
			(0.171)	(0.185)	
Pos. reciprocity				0.423	
				(0.482)	
Neg. reciprocity				0.332	
				(0.374)	
Honesty-Humility					0.667
					(0.636)
Female			−0.666	−0.953	−0.963
			(0.830)	(0.891)	(0.846)
Age			−0.001	0.008	−0.002
			(0.049)	(0.052)	(0.050)
Round		0.104	0.097	0.115	0.111
		(0.107)	(0.106)	(0.107)	(0.106)
Matching group		−0.0004	−0.0004	−0.0003	−0.0002
		(0.001)	(0.001)	(0.001)	(0.001)
Constant	−11.52***	−7.602**	−7.481**	−6.705*	−9.476*
	(1.899)	(3.306)	(3.533)	(3.632)	(4.050)
Observations	320	320	320	320	320
log likelihood	−154.207	−84.705	−81.920	−83.210	−83.686

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A1. Random-effects logit regression with the implementation decision as the dependent variable for the ultimatum game treatments in the bad state. Note that player B's offer can vary between 0 and 14 in UG-14 and between 0 and 24 in UG-24, so this variable has to be interpreted with caution.

	(1)	(2)	(3)	(4)
UG-24	8.308***	8.307***	8.169***	8.557***
	(0.818)	(0.820)	(0.821)	(0.820)
Prosocial (SVO)		1.019		
		(0.872)		
Risk attitude		−0.265	−0.263	
		(0.189)	(0.191)	
Pos. reciprocity			0.167	
			(0.406)	
Neg. reciprocity			0.045	
			(0.413)	
Honesty-Humility				1.134
				(0.727)
Female		0.223	0.164	0.237
		(0.913)	(0.926)	(0.884)
Age		−0.021	−0.029	−0.035
		(0.058)	(0.059)	(0.058)
Round	0.105**	0.105**	0.105**	0.105**
	(0.052)	(0.052)	(0.052)	(0.052)
Matching group	−0.001	−0.001	−0.001	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Constant	−22.96***	−20.67***	−20.30***	−26.86***
	(2.863)	(3.356)	(3.455)	(4.062)
Observations	640	640	640	640
# left censored obs.	135	135	135	135
log likelihood	−1414.880	−1412.960	−1413.554	−1413.442

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A2. Random-effects tobit regression with the offer of player B as the dependent variable for the ultimatum game treatments.

	(1)	(2)	(3)	(4)	(5)
FF-24	0.598**	−0.791	−1.008	−1.013	−0.624
	(0.274)	(1.246)	(1.247)	(1.253)	(1.206)
Offer player B		0.640***	0.652***	0.651***	0.650***
		(0.200)	(0.204)	(0.203)	(0.204)
Offer player A		−0.339	−0.321	−0.320	−0.361
		(0.276)	(0.276)	(0.282)	(0.268)
# offer player B		−0.556*	−0.568*	−0.567*	−0.578*
		(0.311)	(0.309)	(0.314)	(0.306)
# offer player A		−0.265	−0.301	−0.294	−0.302
		(0.450)	(0.445)	(0.442)	(0.449)
Prosocial (SVO)			−0.110		
			(0.730)		
Risk attitude			−0.188	−0.190	
			(0.172)	(0.173)	
Pos. reciprocity				−0.0350	
				(0.302)	
Neg. reciprocity				0.0105	
				(0.355)	
Honesty-Humility					−1.740**
					(0.743)
Female			−0.846	−0.867	−0.117
			(0.833)	(0.820)	(0.695)
Age			0.150	0.149	0.168*
			(0.0912)	(0.0907)	(0.0922)
Round		0.0328	0.0129	0.0135	0.0407
		(0.115)	(0.114)	(0.114)	(0.113)
Matching group		−0.000958	−0.00117	−0.00114	−0.00114
		(0.00114)	(0.00112)	(0.00112)	(0.00106)
Constant	−0.363	2.276	0.364	0.291	4.378
	(0.424)	(2.761)	(3.118)	(3.184)	(3.703)
Observations	320	179	179	179	179
log likelihood	208.43634	−84.602072	−81.835912	−81.835912	−78.253403

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A3. Random-effects logit regression with the implementation decision of player A as the dependent variable for the free-form bargaining treatments in the bad state. Note that not all players made offers, which reduces the number of observations. The offer can vary between 0 and 14 in FF-14 and between 0 and 24 in FF-24, so the offer variables have to be interpreted with caution.

	(1)	(2)	(3)	(4)	(5)
FF-24	−0.733	−0.930	−1.033	−1.258	−0.923
	(1.210)	(1.206)	(1.133)	(1.310)	(1.221)
Offer A	−0.483*	−0.394	−0.380	−0.414	−0.418
	(0.261)	(0.256)	(0.246)	(0.276)	(0.268)
Offer B	0.698***	0.666***	0.669***	0.760***	0.686***
	(0.188)	(0.184)	(0.170)	(0.215)	(0.194)
# message A	−0.343**	−0.300**	−0.347**	−0.299**	−0.313**
	(0.142)	(0.141)	(0.139)	(0.150)	(0.149)
# message B	−0.0565	−0.0452	−0.0518	−0.0131	−0.0198
	(0.0957)	(0.0959)	(0.0916)	(0.103)	(0.105)
A_claim_bad	1.905**				
	(0.866)				
A_equalsplitbad		0.185			
		(0.532)			
A_trust_honesty			1.262**		
			(0.613)		
A_fairness				−1.611*	
				(0.880)	
B_doubt					−0.295
					(0.698)
B_bad_experience					0.494
					(0.665)
Female	−0.362	−0.497	−0.553	−0.827	−0.489
	(0.757)	(0.763)	(0.716)	(0.880)	(0.795)
Age	0.125	0.131	0.122	0.137	0.133
	(0.0866)	(0.0890)	(0.0858)	(0.0998)	(0.0932)
Round	0.134	0.158	0.129	0.132	0.106
	(0.124)	(0.126)	(0.120)	(0.131)	(0.141)
Matching group	−0.00127	−0.00139	−0.00110	−0.00194	−0.00149
	(0.00113)	(0.00115)	(0.00108)	(0.00132)	(0.00122)
Constant	0.213	0.645	0.556	1.287	1.108
	(2.979)	(3.066)	(2.937)	(3.427)	(3.210)
Observations	179	179	179	179	179
log likelihood	−76.772	−79.443	−77.233	−77.311	−79.162

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A4. Random-effects logit regression with the implementation decision of player A as the dependent variable for the free-form bargaining treatments in the bad state. The demographic control variables are from player A.

	(1)	(2)	(3)	(4)	(5)
FF-24	4.720***	4.823***	4.965***	5.016***	4.921***
	(0.486)	(0.486)	(0.498)	(0.484)	(0.501)
Good state	−2.837***	−2.761***	−2.758***	−2.765***	−2.759***
	(0.329)	(0.335)	(0.335)	(0.335)	(0.335)
# offer player B		0.185	0.165	0.165	0.182
		(0.222)	(0.221)	(0.221)	(0.222)
# offer player A		−0.201	−0.189	−0.187	−0.202
		(0.195)	(0.195)	(0.195)	(0.195)
Prosocial (SVO)			−0.097		
			(0.496)		
Risk attitude			−0.200**	−0.194*	
			(0.010)	(0.100)	
Pos. reciprocity				0.115	
				(0.235)	
Neg. reciprocity				−0.007	
				(0.251)	
Honesty-Humility					0.334
					(0.431)
Female		0.488	0.298	0.332	0.436
		(0.491)	(0.485)	(0.492)	(0.494)
Age		0.074	0.071	0.066	0.070
		(0.062)	(0.060)	(0.061)	(0.062)
Round	−0.060	−0.058	−0.062	−0.063	−0.059
	(0.068)	(0.068)	(0.068)	(0.068)	(0.068)
Matching group	0.001	0.001	0.001	0.001	0.0007
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	4.262***	2.183	3.282*	3.211*	1.000
	(0.935)	(1.711)	(1.780)	(1.759)	(2.292)
Observations	346	346	346	346	346
# left censored obs.	5	5	5	5	5
log likelihood	−876.818	−874.214	−874.214	−874.214	−874.214

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A5. Random-effects tobit regression with the final offer of player *B* as the dependent variable for the free-form bargaining treatments. Note that not all players made offers, which reduces the number of observations. The demographic control variables are from player *B*.

	(1)	(2)	(3)	(4)	(5)
FF-24	4.385***	4.783***	4.779***	4.764***	4.773***
	(0.433)	(0.474)	(0.480)	(0.480)	(0.506)
Good state	−1.359***	−2.346***	−2.800***	−2.775***	−2.660***
	(0.330)	(0.357)	(0.347)	(0.339)	(0.341)
# offer A	−0.283	−0.232	−0.257	−0.256	−0.253
	(0.173)	(0.193)	(0.197)	(0.196)	(0.194)
# offer B	0.195	0.195	0.215	0.207	0.240
	(0.194)	(0.219)	(0.225)	(0.224)	(0.223)
# message A	−0.148**	−0.136**	−0.122*	−0.136**	−0.128*
	(0.0583)	(0.0650)	(0.0682)	(0.0678)	(0.0659)
# message B	0.0866	0.0859	0.0950	0.0946	0.0570
	(0.0592)	(0.0659)	(0.0669)	(0.0668)	(0.0701)
A_claim_bad	3.361***				
	(0.341)				
A_equalsplitbad		1.217***			
		(0.356)			
A_trust_honesty			−0.00157		
			(0.406)		
A_fairness				0.371	
				(0.417)	
B_doubt					0.765*
					(0.420)
B_bad_experience					0.0917
					(0.438)
Female	0.252	0.552	0.559	0.558	0.609
	(0.439)	(0.481)	(0.489)	(0.486)	(0.515)
Age	0.0368	0.0688	0.0748	0.0743	0.0707
	(0.0549)	(0.0600)	(0.0609)	(0.0607)	(0.0647)
Round	−0.0509	−0.0235	−0.0373	−0.0321	−0.0567
	(0.0636)	(0.0713)	(0.0725)	(0.0726)	(0.0761)
Matching group	0.000698	0.000466	0.000521	0.000583	0.000448
	(0.000677)	(0.000741)	(0.000751)	(0.000753)	(0.000797)
Constant	1.321	1.974	2.416	2.398	2.381
	(1.536)	(1.689)	(1.716)	(1.706)	(1.808)
Observations	346	346	346	346	346
# left censored obs.	5	5	5	5	5
log likelihood	−829.794	−866.959	−872.716	−872.320	−870.901

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A6. Random-effects tobit regression with the final offer of player B as the dependent variable for the free-form bargaining treatments. Note that not all player made offers which reduces the number of observations. The demographic control variables are from player B.

	(1)	(2)	(3)	(4)	(5)
FF-24	3.772***	3.931***	3.936***	3.917***	3.932***
	(0.417)	(0.424)	(0.420)	(0.424)	(0.424)
Good state	−2.762***	−2.863***	−2.884***	−2.875***	−2.868***
	(0.279)	(0.279)	(0.277)	(0.279)	(0.278)
# offer player B		−0.140	−0.149	−0.144	−0.147
		(0.164)	(0.162)	(0.164)	(0.163)
# offer player A		−0.423*	−0.428**	−0.420*	−0.420*
		(0.219)	(0.218)	(0.220)	(0.219)
Prosocial (SVO)			−0.861*		
			(0.461)		
Risk attitude			−0.046	−0.099	
			(0.104)	(0.106)	
Pos. reciprocity				0.097	
				(0.176)	
Neg. reciprocity				0.080	
				(0.245)	
Honesty-Humility					−0.358
					(0.400)
Female		−0.426	−0.391	−0.537	−0.383
		(0.468)	(0.496)	(0.493)	(0.469)
Age		−0.035	−0.030	−0.035	−0.032
		(0.050)	(0.049)	(0.050)	(0.050)
Round	0.042	0.050	0.048	0.051	0.050
	(0.058)	(0.057)	(0.057)	(0.057)	(0.057)
Matching group	−0.001	−0.001	−0.001	−0.006	−0.001
	(0.001)	(0.001)	(0.001)	(0.000681)	(0.001)
Constant	8.120***	9.504***	10.43***	10.07***	10.63***
	(0.785)	(1.405)	(1.564)	(1.585)	(1.882)
Observations	267	267	267	267	267
# left censored obs.	0	0	0	0	0
log likelihood	−601.783	−597.802	−595.728	−597.257	−597.399

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A7. Random-effects tobit regression with the final offer of player A as the dependent variable for the free-form bargaining treatments. Note that not all players made offers, which reduces the number of observations. The demographic control variables are from player A.

	(1)	(2)	(3)	(4)	(5)
FF-24	3.884***	4.034***	3.919***	3.890***	3.950***
	(0.369)	(0.376)	(0.427)	(0.425)	(0.422)
Good state	−2.208***	−2.603***	−2.897***	−2.892***	−2.775***
	(0.269)	(0.276)	(0.292)	(0.285)	(0.287)
# offer A	−0.356*	−0.495**	−0.453**	−0.463**	−0.525**
	(0.200)	(0.212)	(0.222)	(0.222)	(0.225)
# offer B	−0.0105	−0.0534	−0.144	−0.156	−0.116
	(0.151)	(0.160)	(0.166)	(0.166)	(0.166)
# message A	−0.120*	−0.0587	0.00225	−0.0186	−0.0299
	(0.0630)	(0.0654)	(0.0715)	(0.0691)	(0.0703)
# message B	0.0360	0.0413	0.0407	0.0405	0.0187
	(0.0543)	(0.0577)	(0.0604)	(0.0602)	(0.0612)
A_claim_bad	2.594***				
	(0.320)				
A_equalsplitbad		1.741***			
		(0.309)			
A_trust_honesty			−0.189		
			(0.342)		
A_fairness				0.560	
				(0.415)	
B_doubt					0.544*
					(0.305)
B_bad_experience					0.0458
					(0.349)
Female	−0.554	−0.369	−0.408	−0.406	−0.462
	(0.408)	(0.414)	(0.472)	(0.468)	(0.465)
Age	−0.0408	−0.0272	−0.0326	−0.0323	−0.0356
	(0.0430)	(0.0435)	(0.0499)	(0.0495)	(0.0491)
Round	0.0500	0.111*	0.0407	0.0434	0.0359
	(0.0537)	(0.0585)	(0.0594)	(0.0593)	(0.0613)
Matching group	−0.000478	−0.000294	−0.000663	−0.000592	−0.000646
	(0.000577)	(0.000587)	(0.000667)	(0.000664)	(0.000657)
Constant	7.782***	8.014***	9.419***	9.404***	9.474***
	(1.292)	(1.323)	(1.470)	(1.460)	(1.455)
Observations	267	267	267	267	267
# left censored obs.	0	0	0	0	0
log likelihood	−568.112	−582.460	−597.387	−596.630	−595.843

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A8. Random-effects tobit regression with the final offer of player *A* as the dependent variable for the free-form bargaining treatments. Note that not all player made offers which reduces the number of observations. The demographic control variables are from player *A*.

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Supplementary Material for "Contracting under Asymmetric Information and Externalities: An Experimental Study"

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S.1 Control variables

At the end of the experiment, we elicited various control variables which we describe in detail below. The subjects were informed up-front that after the main part of the experiment short additional parts and a survey would follow. The subjects received the instructions for each part at the beginning of the respective part and the payoffs were added up to the payoff of the main experiment.[1]

First, all subjects participated in an incentivized lottery. The subjects had to decide between a safe and a risky option. If they selected the safe option, they received a fixed amount of money for sure. If they opted for the risky option, they received 2.80 euro with a probability of 1/2 and zero otherwise. We divided the subjects into two groups: The fixed payment for the first group was 60 euro cent, whereas the fixed payment was 80 euro cent for the other group. Thus, the lottery yields to the same payoff structure B-players face in the UG-14 treatment if they decide between offering zero or offering 10 or 11 ECU. We do not further use the lottery results in our analysis, because 90% of the subjects selected the risky option.

In a next step, we implemented a measure of social value orientation (SVO) in our experiment (Murphy et al., 2011).[2] The concept of social value orientation offers insights into the extent to which people care about others. The SVO measure in our experiment consists of six dictator games. In each dictator game, all subjects decide simultaneously about the distribution of a payment between themselves and another matched subject. We made clear that the subjects would be matched with another subject with whom they had never interacted before. After all subjects made their decisions, the computer randomly determined one of the six games for payment. In addition, the computer also determined if the subject was in the active role of the decision maker or not. The results allow us to group subjects into SVO types based on their choices. Overall, we have a share of 65.3% prosocial and 34.4% individualistic subjects.[3] This distribution of types across subjects is in line with previous findings (see e.g. Balliet et al., 2009, or Murphy et al., 2011).

We also elicited the general willingness to take risks on a 11-point likert scale and implemented a short survey on positive and negative reciprocity (Dohmen et al., 2009). In addition, we asked all subjects to answer the subscale for the Honesty-Humility domain from the HEXACO personality inventory (Ashton and Lee, 2009). The HEXACO survey allows to assess six major dimensions of personality. We concentrate on the subscale Honesty-Humility, which contains the facets fairness,

[1] In the ultimatum game treatments, the control variables were elicited after the strategy-method round (see Section S.2.1 below) was completed.

[2] We implemented the SVO z-tree code by Crosetto et al. (2012) in our program. The dictator games played correspond to the primary items discussed in Murphy et al. (2011).

[3] In addition, there was one competitive subject.

sincerity, modesty, and greed avoidance. People scoring high on this scale are less likely to manipulate other people for personal gain and they are less likely to break rules than people with low scores. They are also less motivated by material gains and feel less self-important compared to people with low scores.

Furthermore, we asked subjects to give us demographic information such as sex and age. The subjects in the free-form bargaining sessions were also asked if they found the chat option helpful.

We use the demographic information as well as information on SVO, risk attitude, reciprocity, and scores on the Honesty-Humility subscale as controls in our econometric analysis. Not surprisingly, we observe correlations between SVO type and Honesty-Humility as well as reciprocity scores (see Table S1). We, therefore, implement these controls in separate econometric analyses to avoid confounding effects.

	Prosocial (SVO)	Honesty-Humility	Positive reciprocity	Negative reciprocity	Risk attitude
Prosocial (SVO)	–	0.227 (0.000)	0.040 (0.481)	−0.097 (0.085)	−0.020 (0.730)
Honesty-Humility	0.227 (0.000)	–	0.161 (0.004)	−0.321 (0.000)	−0.098 (0.079)
Positive reciprocity	0.040 (0.481)	0.161 (0.004)	–	0.001 (0.992)	0.045 (0.418)
Negative reciprocity	−0.097 (0.085)	−0.321 (0.000)	0.001 (0.992)	–	0.075 (0.184)
Risk attitude	−0.020 (0.730)	−0.098 (0.079)	0.045 (0.418)	0.075 (0.184)	–

Table S1. Pairwise correlation matrix for social preferences and risk attitudes over all treatments (p-values are given in parenthesis).

S.2 Ultimatum game

S.2.1 Strategy method

Procedure

In the ultimatum game treatments, after the final round of the main experiment the subjects were informed that an additional round would follow. In this additional round, we employed the strategy method (cf. Selten, 1967) to elicit beliefs of B-players and a response function of A-players. First, all B-players had to state their beliefs about the decision of A-players if the state was bad (resp., good) for all feasible offers ($0-14$ in UG-14 and $0-24$ in UG-24). Second, all B-players had to state their offer as in the previous rounds, without knowing the realized state. Third, all A-players learned about the realized state and had to record their decision for each feasible offer. Fourth, the payments were calculated by randomly matching the actual offer of player B with player A's corresponding response for the randomly drawn state. Note that the matched subjects were no longer perfect strangers and we have to interpret this data with caution.

Results

The results of the strategy-method round are broadly in line with the behavior in the main part of the experiment. Consider first player A's response in the bad state, which is depicted in the upper panels of Figure S1. In UG-14, only two players accept offers below 10, presumably by mistake. In UG-24, 50% of the A-players reject an offer of 11 and do not implement the project. The majority of these subjects also rejected such an offer in the previous eight rounds of the main experiment at least once. Interestingly, 35% of the A-players do not implement the project if the offer is 12, and one player even does not implement for offers up to 16 (thus accepting only offers that would lead to at least the same payoff for the A-player as for the B-player). Now consider the good state, which is shown in the lower panels of Figure S1. In UG-14, 60% of A-players reject an offer of zero but subsequently implement the project. A small minority rejects offers up to 5 but still implements the project, whereas only one A-player plans to reject and not implement if the offer is below 8. We observe a rather similar pattern for UG-24. If the offer is zero, 25% of the players reject the offer but implement the project, whereas 30% decide against the implementation. We also observe two players that do not implement the project if the offer is below 8.

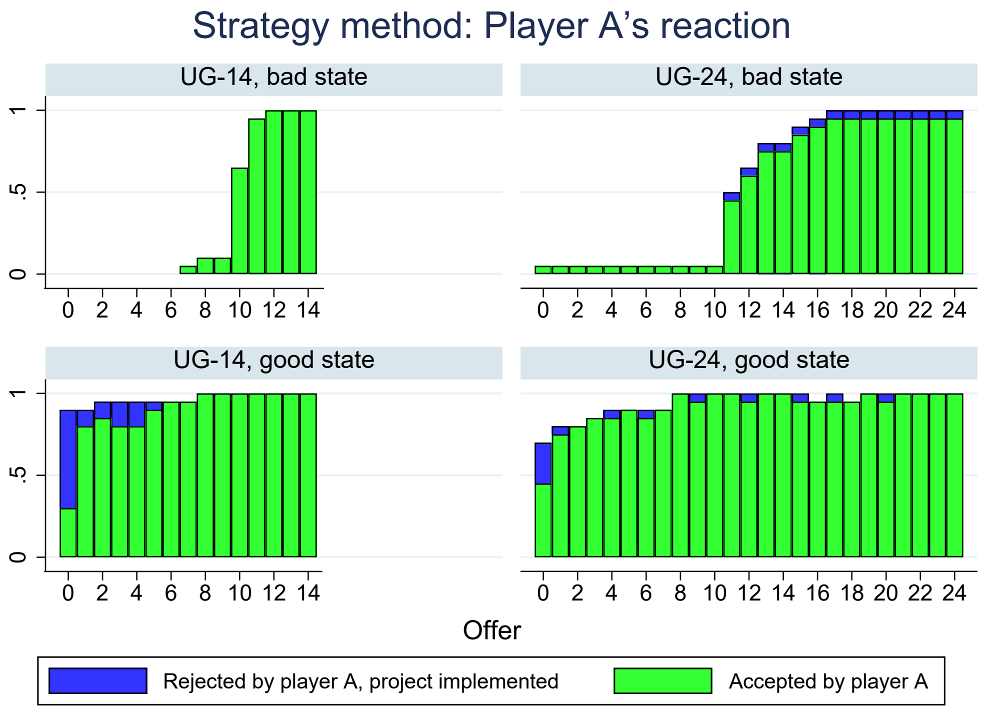

Figure S1. Reaction of player A, elicited in the strategy-method round. Note that the category "Rejected and project not implemented" is given by the space above each bar.

Next, we take a closer look at the stated beliefs of B-players, which are displayed in Figure S2. Consider UG-14 first. 90% of B-players expect A-players to decide against project implementation for offers strictly below 10 in the bad state, whereas 90% of the B-players assume acceptance of offers of 11 or above. Only one B-player believes that A-players will not implement the project regardless of the offer made if the state is good. The majority $(80-95\%)$ expects A-players to accept offers strictly larger than zero in the good state. Thus, the majority of B-players has formed beliefs about the behavior of A-players in both states in UG-14 which closely resemble the strategic responses of A-players.

Now consider UG-24. 98% of B-players believe that A-players will not implement the project in the bad state if the offer is strictly below 10, whereas 90% expect acceptance of offers strictly larger than 11. Given this belief it is somewhat surprising that the share of offers below 10 in the main experiment was rather large. However, recall that we elicited the beliefs after the eight rounds of the main experiment, so learning could have taken place. Indeed, only five B-players make an offer below 10 in the last round of the main experiment. 78% of the B-players expect A-players to accept an offer of 11 and only 13% expect the acceptance of an offer of 10 in the bad state, which may be due to the assumption that A-players exhibit inequity aversion. Almost all B-players expect acceptance of offers strictly larger than 10 if the state is good. Interestingly, the beliefs are rather mixed for offers below 10, especially between 1 and 5, which might be due to differing assumptions about player A's inequity concerns. Overall, the beliefs about player-A behavior are rather well adjusted, but the beliefs about behavior in the good state reveal some heterogeneity of B-players' expectations about A-players' behavior.

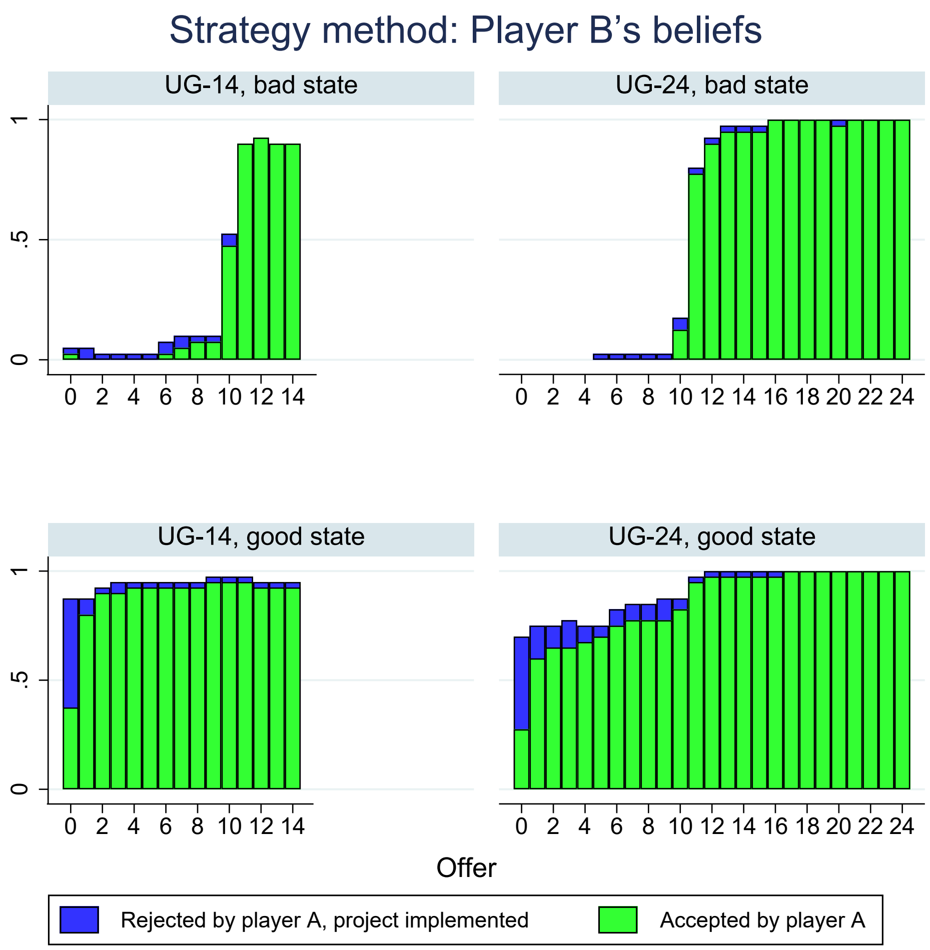

Figure S2. Beliefs of player B, elicited in the strategy-method round. Note that the category "Rejected and project not implemented" is given by the space above each bar.

S.2.2 Additional regressions

Tables S2 and S3 show additional regressions for the ultimatum game treatments. We split the dataset and execute the regressions for each ultimatum game separately to investigate the impact of social value orientation in each treatment condition. Furthermore, we restrict our dataset to offers above 9 in UG-24 in model (3) in Table S2.

	(1)	(2)	(3)
	UG-14	UG-24	UG-24, Offer > 9
Offer	0.719***	5.689***	5.666***
	(0.212)	(2.084)	(2.096)
Prosocial (SVO)	0.795	2.935*	2.928*
	(1.238)	(1.640)	(1.638)
Risk attitude	−0.255	0.035	0.035
	(0.241)	(0.402)	(0.402)
Female	1.217	−3.357	−3.346
	(1.435)	(2.094)	(2.093)
Age	0.022	0.007	0.007
	(0.158)	(0.076)	(0.076)
Round	0.188	0.110	0.110
	(0.228)	(0.196)	(0.196)
Matching group	−0.001	−0.001	−0.001
	(0.002)	(0.002)	(0.002)
Constant	−7.923	−61.872***	−61.630***
	(4.833)	(22.645)	(22.777)
Observations	160	160	123
log likelihood	−23.221	−40.655	−40.651

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table S2. Random-effects logit regression with the implementation decision of player A as the dependent variable in the bad state for UG-14 and UG-24. Model (1) contains data from UG-14 only and models (2) and (3) only use data from UG-24. In model (3) we further restrict the dataset to observations where player B made an offer strictly above 9 in UG-24.

	(1)	(2)	(3)	(4)
	UG-14	UG-24	UG-14	UG-24
Prosocial (SVO)			3.363**	−0.548
			(1.477)	(0.997)
Risk attitude			−0.019	−0.527**
			(0.296)	(0.230)
Female			0.404	−0.011
			(1.466)	(1.146)
Age			0.005	−0.023
			(0.231)	(0.050)
Round	−0.003	0.191***	−0.004	0.191***
	(0.084)	(0.066)	(0.084)	(0.066)
Matching group	−0.001	−0.002	−0.001	−0.002
	(0.002)	(0.001)	(0.002)	(0.001)
Constant	2.029*	10.40***	−0.620	14.11***
	(1.163)	(1.118)	(5.887)	(2.101)
Observations	320	320	320	320
# left censored obs.	112	23	112	23
log likelihood	−628.764	−781.256	−626.182	−778.064

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table S3. Random-effects tobit regression with the offer of player B as the dependent variable for UG-14 and UG-24. We restrict the dataset to observations from UG-14 in models (1) and (3) and to observations from UG-24 in models (2) and (4).

S.3 Free-form bargaining

S.3.1 Offers

Recall that in the free-form bargaining treatments, both players could make offers during the three minutes bargaining phase. Figure S3 shows all offers made during the bargaining phase. Observe that in each state of FF-14 and FF-24, the gap between the fitted values of the offers made by A-players and B-players shrinks over time.

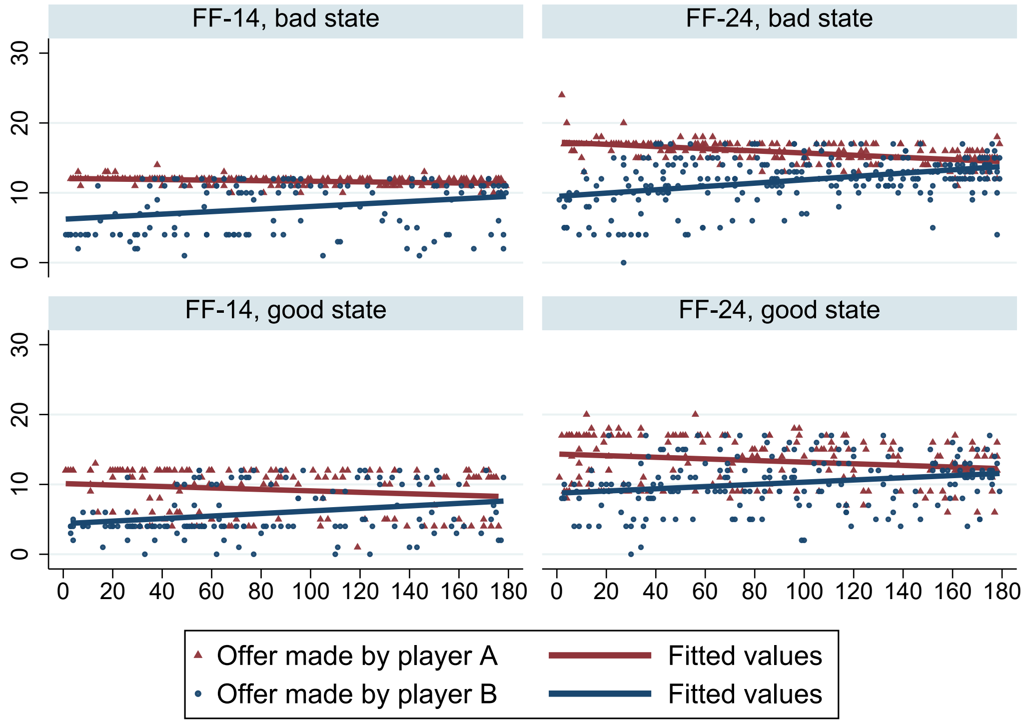

Figure S3. Offers made during the 180 seconds of the bargaining phase in the treatments FF-14 and FF-24, conditional on the state.

Figure S4 depicts the average opening and final offers over all eight rounds. Observe that in each state of FF-14 and FF-24, the average opening offer of player A is in every round larger than the average opening offer of player B. During the negotiations the players make concessions, so the average final offers of the players tend to be closer to each other.

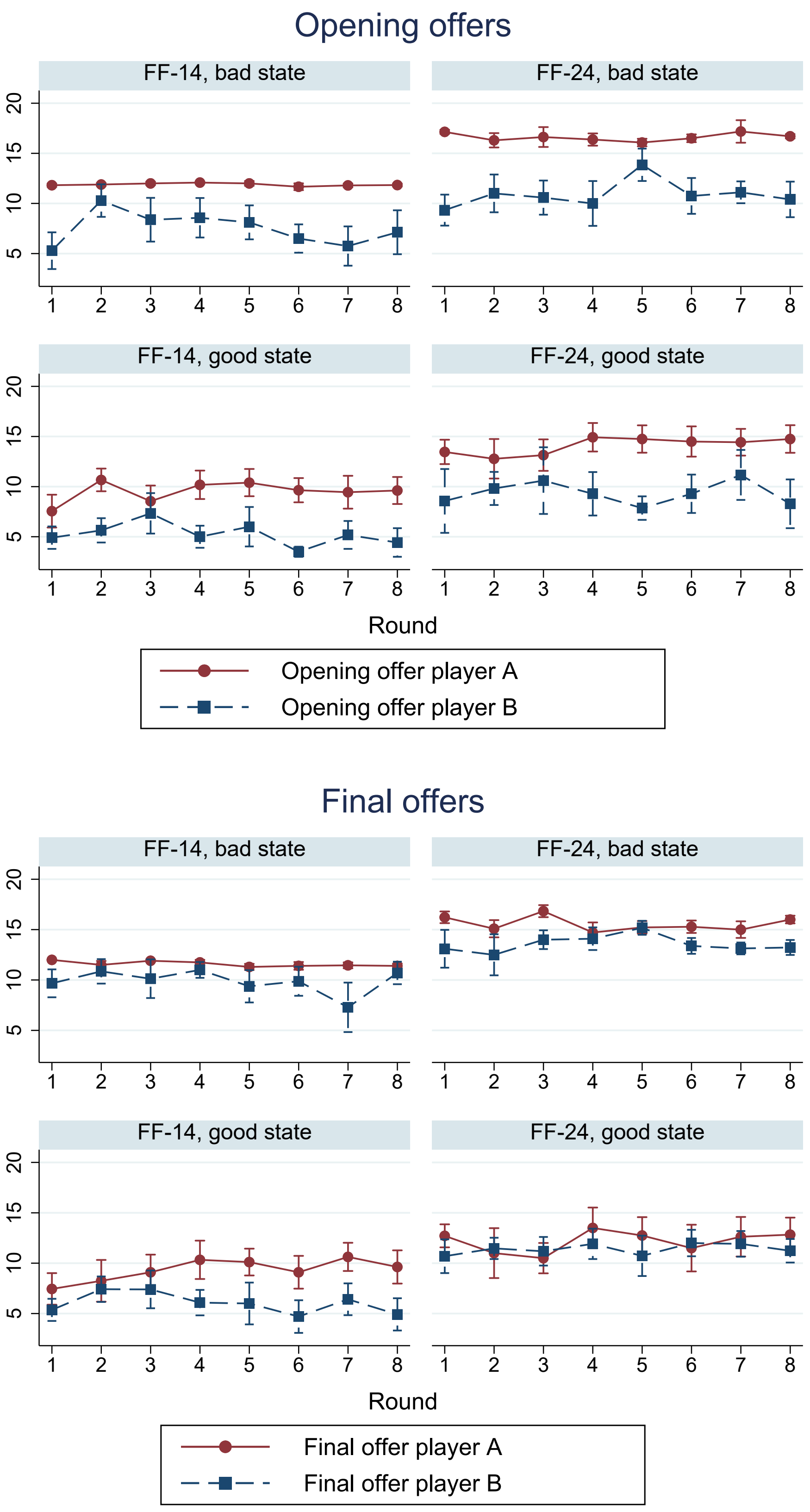

Figure S4. Average opening and final offers in the treatments FF-14 and FF-24, conditional on the state.

S.3.2 Text messages

Table S4 shows how many messages and how many words A-players and B-players used on average during the bargaining phase, conditional on the state of the world. Almost all groups exchanged at least some messages. First, one might have expected that A-players tend to send more messages and words than B-players, because only the A-players know the state of the world. Indeed, in FF-14 in both states the numbers of messages and words used by A-players are significantly larger than those used by B-players. However, the numbers of messages and words used in FF-24 by A-players and B-players is rather balanced and not significantly different. Second, one might also have expected A-players to use more words in the bad state trying to convince the B-players to make or accept a high offer. We observe that A-players indeed use significantly more words in bad situations than in good situations.

	FF-14		FF-24	
	bad	good	bad	good
Mean number of messages by A	6.13	5.29	6.48	4.81
Mean number of messages by B	4.86	4.54	6.06	4.79
p-value (A versus B)	0.063	0.063	0.438	1.000
Mean number of words by A	34.71	27.84	35.41	22.96
Mean number of words by B	23.01	21.71	31.78	21.98
p-value (A versus B)	0.063	0.063	0.188	0.813
No messages by A	0%	3%	3%	7%
No messages by B	2%	5%	4%	9%

Table S4. Descriptive statistics regarding the numbers of messages and words, and p-values for pairwise comparisons between player A and player B (two-tailed Wilcoxon signed-rank tests on matching group averages).

	FF-14	FF-24	FF-14 vs. FF-24	FF-14 vs. FF-24
	bad vs. good	bad vs. good	bad	good
Messages by A	0.063	0.125	0.841	0.183
Messages by B	0.500	0.188	0.056	0.421
Words by A	0.063	0.063	1.000	0.095
Words by B	0.813	0.125	0.016	1.000

Table S5. p-values for pairwise comparisons between states (two-tailed Wilcoxon signed-rank tests) and treatments (two-tailed Mann-Whitney U tests) on matching group averages.

As can be seen in Table S5, in the bad state the number of messages and words sent by B-players in FF-24 is significantly larger than in FF-14. Thus, B-players get more active in the bad state of FF-24, indicating that they feel more need to discuss the division of the surplus than in the FF-14 treatment. Indeed, we observe that B-players ask for the state in 45% of the cases in the bad state of FF-24, but only in 36% of the cases in FF-14. Also, the share of B-players complaining about past bad experiences and trying to haggle is higher if the externality is large.

Figure S5 depicts the average number of messages in the eight rounds. We observe a slight tendency to exchange more messages over time, especially in the good state of the world.

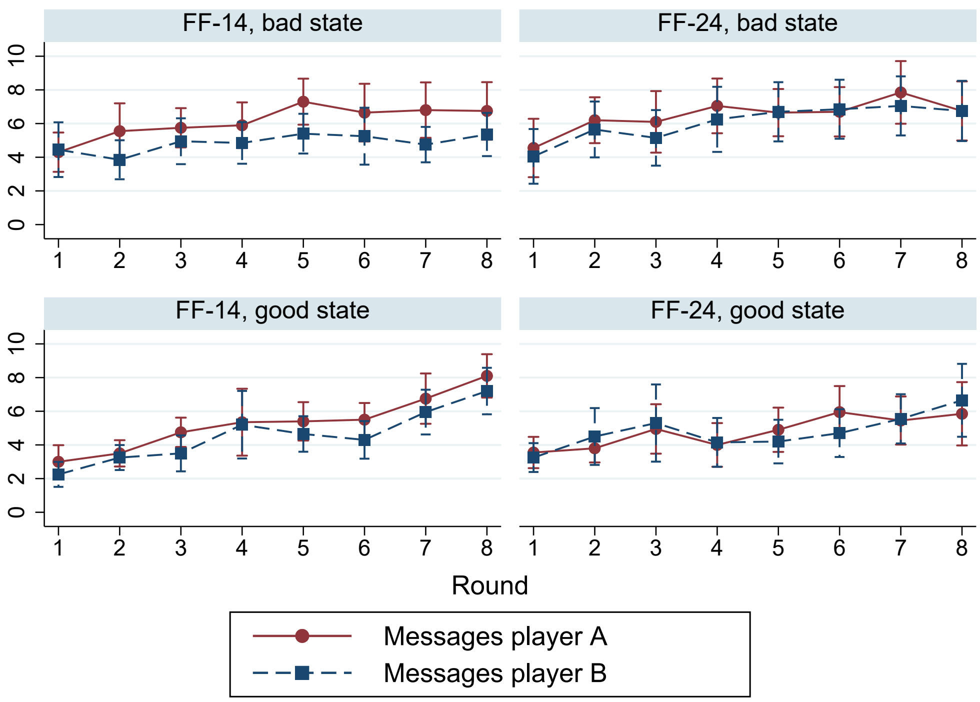

Figure S5. Average number of messages sent in the free-form bargaining treatments, conditional on the state.

S.4 Instructions

In this section, we provide English translations of the instructions for the treatments UG-14 and FF-14. The instructions for the treatments UG-24 and FF-24 are identical, except that "14" is replaced by "24" throughout.[4]

S.4.1 Ultimatum game (UG-14)

Welcome to the experiment!

This experiment consists of a main part with **8 rounds**, three additional short parts, and a questionnaire.

In the main part two participants interact with each other.

One participant is in the role of **Player A**, the other one in the role of **Player B**.

Your role is randomly drawn at the beginning of the experiment. You will be informed about your role at the beginning of the experiment.

You will **keep your role** (Player A or B) over all **8 rounds**.

In each round, one Player A will be matched with one Player B. You will be matched with a **different participant** in each round.

In the main part, we use a currency called ECU. At the end of the experiment, it will be converted in euro. **One euro** equals **5 ECU**.

General procedure

In each round, **Player A** can implement a **project**.

At the beginning of each round, the computer randomly **determines a situation** by a virtual coin flip. With a probability of 50% the current situation is "bad", with a probability of 50% the current situation is "good".

Only Player A learns if the situation drawn by the computer is "bad" or "good".

Player B does not receive any information about the drawn situation.

Depending on the situation (good or bad) the project results in different revenues for Player A if he decides to implement the project.

The revenue in case of a "good" situation is positive for Player A and amounts to 6 ECU, whereas in case of a "bad" situation it is negative and amounts to -10 ECU.

Regardless of the current situation, the project results in **a revenue of 14 ECU** for **Player B if Player A implements the project**. Thus, the current situation has

[4] The original instructions (in German) are available from the authors upon request.

no impact on the revenue of Player B. If Player A does not implement the project, both players receive 0 ECU.

Player A and Player B can **bargain with each other** over the implementation of the project. For this purpose they can agree that a transfer payment will be made between the players.

Bargaining process

Player B offers a payment of X ECU that he is willing to pay to Player A for implementing the project (where X must be an **integer** between 0 and 14).

Possibility 1: Player A accepts the offer

If Player A accepts the offer, the **project will be implemented**. The payoff of Player A in this round is **X ECU + 6 ECU** if the situation is "good", and it is **X ECU - 10 ECU** if the situation is "bad". The payoff of Player B in this round is **14 ECU - X ECU**.

Possibility 2: Player A rejects the offer

If Player A rejects the offer, no payment is made from Player B to Player A. Player A can then freely decide whether or not to implement the project:

• If Player A implements the project, his payoff in this round is **6 ECU** in a "good" situation and **-10 ECU** in a "bad" situation. The payoff of Player B in this round then is **14 ECU**.

• If Player A does not implement the project, both players receive a payoff of 0 ECU in this round.

Sequence of events in a round

Specifically, each round consists of up to three stages and proceeds as follows:

First stage: Player A learns if situation is "good" or "bad"

At the beginning of each round, the computer randomly determines the situation by a virtual coin flip. With a probability of 50% the current situation is "bad", with a probability of 50% the current situation is "good".

Only Player A learns if the situation drawn by the computer is "bad" or "good". Player B does not receive any information about the drawn situation.

Second stage: Bargaining

Player B offers a payment of X ECU to Player A (where X must be an integer between 0 to 14). In order to do this, Player B types his offer into the box "Offer to Player A".

Player A is informed about the offer of Player B and can accept the offer by clicking on the button “Accept Offer”. He can reject the offer by clicking on the button “Reject Offer”.

• If the players reach an agreement (which is the case if Player A accepts the proposed X from Player B by clicking on the button „Accept Offer“), the project is implemented. Player B pays X ECU to Player A and the round is over.

• If the players do not come to an agreement (which is the case if Player A clicks on the button “Reject Offer”), the third stage is reached.

Third stage: Decision of Player A if no agreement has been reached in the second stage

If no agreement has been reached in the second stage, no transfer payments will be made between the two players. Player A can then freely decide whether or not to implement the project.

Thus, the players' payoffs in a round are as follows:

	Payoff of Player A if situation is “good”	Payoff of Player A if situation is “bad”	Payoff of Player B
Agreement between Player A and Player B	**X ECU + 6 ECU**	**X ECU - 10 ECU**	**14 ECU - X ECU**
No agreement, Player A **implements** the project	**6 ECU**	**-10 ECU**	**14 ECU**
No agreement, Player A **does not** implement the project	**0 ECU**	**0 ECU**	**0 ECU**

Your payoff

At the end of the experiment you will receive the sum of your payoffs of all 8 rounds. Your profit is converted using the rate of 1 euro for 5 ECU and paid to you in cash. You may also receive additional payoffs from the other parts of the experiment.

Please note

Throughout the experiment, all communication is forbidden. Please open your cubicle door if you have a question and we will come to your cubicle. All decisions are anonymous, i.e. no participant learns the identity of another participant who has made a particular decision. You will receive your payoff privately, i.e. no participant learns the payoff of another participant.

Thank you very much for your participation and good luck!

S.4.2 Free-form bargaining (FF-14)

Welcome to the experiment!

This experiment consists of a main part with **8 rounds**, three additional short parts, and a questionnaire.

In the main part two participants interact with each other.

One participant is in the role of **Player A**, the other one in the role of **Player B**.

Your role is randomly drawn at the beginning of the experiment. You will be informed about your role at the beginning of the experiment.

You will **keep your role** (Player A or B) over all **8 rounds**.

In each round, one Player A will be matched with one Player B. You will be matched with a **different participant** in each round.

In the main part, we use a currency called ECU. At the end of the experiment, it will be converted in euro. **One euro** equals **5 ECU**.

General procedure

In each round, **Player A** can implement a **project**.

At the beginning of each round, the computer randomly **determines a situation** by a virtual coin flip. With a probability of 50% the current situation is "bad", with a probability of 50% the current situation is "good".

Only Player A learns if the situation drawn by the computer is "bad" or "good".

Player B does not receive any information about the drawn situation.

Depending on the situation (good or bad) the project results in different revenues for Player A if he decides to implement the project.

The revenue in case of a "good" situation is positive for Player A and amounts to 6 ECU, whereas in case of a "bad" situation it is negative and amounts to -10 ECU.

Regardless of the current situation, the project results in **a revenue of 14 ECU** for **Player B if Player A implements the project**. Thus, the current situation has no impact on the revenue of Player B. If Player A does not implement the project, both players receive 0 ECU.

Player A and Player B can **bargain with each other** over the implementation of the project. For this purpose they can agree that a transfer payment will be made between the players.

Bargaining Process

Player A and Player B can bargain about whether the project is implemented and a transfer payment is made from Player B to Player A. The players have **three**

minutes to bargain via chat. During the three minutes the players can agree on a payment of X ECU (where X must be an **integer** between 0 and 14). The players can send text messages to each other and they can make proposals regarding the payment of X ECU that Player B has to transfer to Player A.

Possibility 1: The players reach an agreement

If the players reach an agreement, the **project is implemented**. The payoff of Player A in this round is **X ECU + 6 ECU** if the situation is "good", and it is **X ECU - 10 ECU** if the situation is "bad". The payoff of Player B in this round is **14 ECU - X ECU**.

Possibility 2: The players do not reach an agreement

If the players do not reach an agreement, no payment is made from Player B to Player A. Player A can then freely decide whether or not to implement the project:

• If Player A implements the project, his payoff in this round is **6 ECU** in a "good" situation and **-10 ECU** in a "bad" situation. The payoff of Player B in this round then is **14 ECU**.

• If Player A does not implement the project, both players receive a payoff of 0 ECU in this round.

Sequence of events in a round

Specifically, each round consists of up to three stages and proceeds as follows:

First stage: Player A learns if situation is "good" or "bad"

At the beginning of each round, the computer randomly determines the situation by a virtual coin flip. With a probability of 50% the current situation is "bad", with a probability of 50% the current situation is "good".

Only Player A learns if the situation drawn by the computer is "bad" or "good". Player B does not receive any information about the drawn situation.

Second stage: Bargaining

The players have three minutes to bargain via chat. During the three minutes the players can agree on a payment of X ECU (where X must be an integer between 0 to 14). The players can send text messages to each other and they can make proposals regarding the payment of X ECU that Player B has to transfer to Player A. Each text message may contain up to 280 characters. The players can exchange as many messages as they like during the three minutes.

To submit a binding offer to another player, players type their offer in the intended box and click on "Send Offer". If a player wants to retract his offer, he leaves the box empty and clicks on "Send Offer". Each player observes the offer of the other player in a separate box. A player can accept an offer made by the other player by clicking on the button "Accept Offer". The players can submit as many offers to the other player as they like during the three minutes. If a player does not want to continue bargaining and wants to irrevocably break off the negotiations, he can click on the "Break Off" button.

• If the players reach an agreement (which is the case if one player accepts the proposed X from the other player by clicking on the button "Accept Offer"), the project is implemented. Player B pays X ECU to Player A and the round is over.

• If the players do not come to an agreement, the third stage is reached. This happens if

  • three minutes have passed and the players have not reached an agreement on a payment of X ECU, or

  • one player decides to break off the negotiations before the three minutes have passed.

Third stage: Decision of Player A if no agreement has been reached in the second stage

If no agreement has been reached in the second stage, no transfer payments will be made between the two players. Player A can then freely decide whether or not to implement the project.

Thus, the players' payoffs in a round are as follows:

	Payoff of Player A if situation is "good"	Payoff of Player A if situation is "bad"	Payoff of Player B
Agreement between Player A and Player B	**X ECU + 6 ECU**	**X ECU - 10 ECU**	**14 ECU - X ECU**
No agreement, Player A **implements** the project	**6 ECU**	**-10 ECU**	**14 ECU**
No agreement, Player A **does not** implement the project	**0 ECU**	**0 ECU**	**0 ECU**

Remark

It is forbidden to reveal information about your identity (i.e., name, seat number, clothing, and so on) in the text messages. If such messages are detected, this leads to **exclusion** from the experiment with a total payoff of 0 euro.

Your payoff

At the end of the experiment you will receive the sum of your payoffs of all 8 rounds. Your profit is converted using the rate of 1 euro for 5 ECU and paid to you in cash. You may also receive additional payoffs from the other parts of the experiment.

Please note

Throughout the experiment, all communication is forbidden, apart from communication via the experimental software. Please open your cubicle door if you have a question and we will come to your cubicle. All decisions are anonymous, i.e. no participant learns the identity of another participant who has made a particular decision. You will receive your payoff privately, i.e. no participant learns the payoff of another participant.

Thank you very much for your participation and good luck!

S.5 References

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