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**Communication,
Lending Relationships and Collateral**

Communication, Lending Relationships and Collateral

PROEFSCHRIFT

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Contents

1	Introduction	1
I	Communication in Public Good Games	9
2	Which Words Bond?	11
2.1	Introduction	11
2.2	Theoretical Framework	16
2.2.1	The Baseline Game	17
2.2.2	Actions	18
2.2.3	Words	18
2.3	Experimental Design and Hypotheses	25
2.3.1	Parametrization and Treatments	25
2.3.2	Hypotheses	26
2.3.3	Experimental Procedures	27
2.4	Results	28
2.4.1	Contributions by the informed player	28
2.4.2	Message use and information transmission	30
2.4.3	Contributions by the uninformed player	33
2.4.4	Payoffs and Efficiency	35
2.4.5	Discussion	37
2.5	Conclusion	40
2.6	Appendix A	43
2.7	Appendix B	45

3	Hiding an Inconvenient Truth	51
3.1	Introduction	51
3.2	Literature Overview	56
3.3	Theoretical Framework	59
3.3.1	The Actions Game	59
3.3.2	Allowing communication	60
3.3.3	Messages with literal meaning and lying costs	63
3.4	Hypotheses	65
3.5	Experimental Design	66
3.6	Results	68
3.6.1	The impact of communication on efficiency	68
3.6.2	The leader's communication	70
3.6.3	The follower's reactions	73
3.7	Conclusion	77
3.8	Appendix A	79
3.9	Appendix B	83
II	Moral Hazard in the Credit Market	89
4	The Threat of Expropriation	91
4.1	Introduction	91
4.2	Experimental design	95
4.2.1	Main treatment	95
4.2.2	Control Treatments	98
4.2.3	Procedures	99
4.3	Predictions	101
4.4	Results	105
4.4.1	Aggregate treatment effects	105
4.4.2	Loan offers	108
4.4.3	Repayment behavior	117
4.4.4	Profits	120
4.5	Conclusion	123
4.6	Appendix A	124
4.6.1	The Repeated Lending Game	124

A.2. Lending without expropriation	127
A.3. Lending with expropriation	128
A.4. Application to the experiment	130
4.7 Appendix B	132
4.8 Appendix C	142
5 The Incentive Effect of Collateral	145
5.1 Introduction	145
5.2 Related literature and survey evidence	150
5.3 Theoretical framework	152
5.3.1 Contracting under moral hazard	152
5.3.2 Risk neutrality	154
5.3.3 Risk aversion	156
5.4 Experimental design	157
5.4.1 Treatments and hypotheses	157
5.4.2 Procedures	158
5.5 Results	160
5.5.1 Credit supply and demand	160
5.5.2 Effort	162
5.5.3 Payoffs	166
5.6 A weak incentive effect of collateral: Why?	167
5.7 Conclusion	171
5.8 Appendix A	174
5.9 Appendix B	176
5.10 Appendix C	187
C.1. Pre-experimental games	187
C.2. Beliefs	188
Bibliography	190

Chapter 1

Introduction

This thesis consists of two parts. The first part “Communication in Public Good Games” contains two studies on communication, in situations where telling the (precise) truth conflicts with monetary incentives. The second part “Moral Hazard in the Credit Market” consists of two studies on moral hazard and contracts between principals and agents, with a focus on the credit market. The role of incentives such as reputation and relationship formation, on the one hand, and the effect of collateral, on the other, are studied.

The first part of the thesis is motivated by the fact that relatively little is known about the effect of communication in strategic environments. A standard assumption in the theoretical literature has been that individuals lie whenever it is in their monetary interest to do so. Yet a recent body of experimental literature suggests that some individuals seem to display an aversion to lying. In a variety of environments with asymmetric information, informed individuals sometimes exhibit some tendency to tell the truth although it is monetarily costly (e.g. Gneezy, 2005, Sanchez-Pages and Vorsatz, 2007 and Erat and Gneezy, 2009). At the same time, in a variety of strategic interactions where individuals can make promises about their future actions, several studies find that individuals sometimes keep their promises despite the monetary incentives to break them (e.g. Ellingsen and Johannesson, 2004, and Charness and Dufwenberg, 2006). This evidence has spurred a new set of theories that allow individuals to exhibit a disutility from lying (e.g. Demichelis and Weibull, 2009, and Kartik, 2009). In these theories the distinc-

tion between telling the truth and lying is vital, making the literal meaning of messages and, thus, the role of language centrally important. Given that little is known about the effect of different properties of natural language, a new set of questions has opened up, to which the first part of the thesis provides some answers. In particular, one open question is whether the disutility from lying is constant across languages. More precisely, does it matter for individuals whether lies are about private information or about their actions? Also, does it matter whether individuals have to be precise? Can vagueness be a substitute for lies?

In Chapter 2 we examine whether lying about private information is inherently different from lying about one's actions. We address this question in the context of a one-shot 2-player public good game, where one player is privately informed about the value of a contribution to the public good. This value can be low, high, or intermediate, the latter case giving rise to a prisoners' dilemma. We examine the effect of communication, by allowing the informed player to send a costless message to the uninformed player. The message can be about the value of the public good, in one case, or about the informed player's decision to contribute, in the other. The effect of costless communication is compared to two benchmark scenarios: to the absence of communication and to the case where the informed player moves first and, hence, signals with her contribution decision (actions).

Theoretically, actions lead to fully efficient contributions. In the unique Nash Equilibrium, the informed player contributes both when the value is intermediate and high and the uninformed player, upon observing a contribution, contributes as well. Interestingly, if the informed player can signal with costless messages, instead of actions, there exist 'influential' equilibria in which the uninformed player reacts to the information contained in messages and contributes when the value is intermediate and high, as he does in actions. However, since the informed player's contribution remains unobserved, messages allow the informed player to free-ride when the value is intermediate. Thus, if the informed player is not averse to lying, in an 'influential' equilibrium she free-rides when the value is intermediate, both when messages are about contributions and when they are about the value of the public good. In contrast to this prediction, our experimental results reveal

that free-riding depends on the language: the informed player free-rides less when she talks about her contribution than when she talks about the value of the public good. If the value is intermediate and the informed player talks about her contribution, she often sends the message ‘I contribute’ and contributes, although the contribution is not observed by the uninformed player. In contrast, when talking about the value of the public good, she often sends the message ‘the value is high’ but does not contribute. This represents a novel finding in the literature: it suggests that the aversion to lying may interact with the language available. At the same time, though contributions differ, we find that the same information is transmitted to the uninformed player, who therefore follows messages about contributions, messages about the value of the public good and the actions of the informed player to the same extent.

In Chapter 3 we study the interaction between lies, vagueness and efficiency, by examining the effect of verbal communication when the precise truth conflicts with efficiency. We ask: can verbal communication destroy efficiency? Or are lies and vagueness used to hide inconvenient truths? To address these questions, we add verbal communication to the sequential move 2-player public good game, in which the informed player signals with her contribution decision (actions), considered within Chapter 2. In particular, with communication, the informed player sends a message about the value of the public good, which, in combination with her contribution decision, is observed by the uninformed player. We consider two languages: a first language where messages about the value must be precise and a second language where messages can include multiple values of the public good or none (a blank message).

In the absence of communication, we know that the unique Nash Equilibrium is fully efficient, i.e. both players contribute when the value is intermediate and high. Interestingly, when communication is added and it must be precise, an important tension arises. Under standard assumptions of selfishness and rationality, in equilibrium the informed player must send the same message when the value is intermediate and high. Thus, it requires her to lie in at least one of the states. Otherwise, the uninformed player would know when the value is intermediate. This could discourage him from contributing

and in turn destroy the informed player's own incentive to contribute. In contrast, if communication can be vague, the informed player need no longer lie. She can send the same vague message, including the intermediate and high values, or a blank message, both when the return is intermediate and high. Experimentally, we find that, when communication must be precise, the informed player frequently lies, preserving efficiency by exaggerating the value of the public good when it is intermediate. At the same time, if the informed player can be vague, we show that she often turns to vague messages when the value is intermediate. This allows her to avoid a precise lie, but also implies that implicitly reveals all values. Interestingly, efficiency is preserved, since the uninformed player does not seem to realize that vague messages hide inconvenient truths.

In all, the findings in Part I provide us with several new insights about lying aversion and the role of language in games. First, in both Chapters, we find evidence suggesting that some individuals exhibit some aversion to lying, though this aversion does not appear very strong. In particular, when individuals talk about private information, and especially if they have to be precise, lying occurs frequently. Second, our finding that contribution behavior can be affected by the content of the messages available contributes to a growing literature that examines unstructured communication and relates the content of messages to behavior (e.g., Brandts and Cooper, 2007). We go one step back, by exogenously determining the content of messages, and show that even when individuals cannot choose the content of messages, content per se can interact in important ways with individual behavior.

The second part of the thesis shifts the focus to a different topic, that of moral hazard in principal-agent relationships in the credit market. Problems of moral hazard are abundant in the credit market. Among others, borrowers may strategically default or they may choose to put less effort and resources into their investment if their liability in case of bankruptcy is limited. Empirically, such problems seem to have severe consequences. In countries where institutions protecting creditor's rights are weaker ratios of credit to GDP are significantly lower (Djankov et al., 2007). This suggests that the functioning of credit markets may be significantly inhibited by weak creditor protection. Yet an important body of theoretical and experimental

literature suggests a solution to this problem: the use of relational contracts (e.g. Stiglitz and Weiss, 1983, Brown and Zehnder, 2007). When lenders and borrowers interact repeatedly, implicit agreements that punish a default with the discontinuation of future credit supply can effectively incentivize borrowers to repay and increase credit volume. Therefore, the question arises, why do institutions that protect creditor's rights still appear to have such empirical importance, if relational contracts can potentially solve the problem of enforcement?

Chapter 4 addresses this question by focusing on an important feature of credit markets, which has been previously disregarded: expropriation. After a loan has been extended, a borrower who strategically defaults may have the opportunity to expropriate the lender's funds, i.e. use them for future investment. In particular, if bankruptcy procedures are slow and courts cannot seize the assets of defaulting borrowers, or lenders and courts cannot prevent the tunneling of assets by borrowers (Johnson et al., 2000), a defaulting borrower may effectively have the opportunity to expropriate the lender's funds and use them for future investment. How does this threat of expropriation affect credit relationships? We answer this question by examining finitely-repeated experimental credit relationships in which repayment is not third-party enforceable, i.e. the borrower can default on her loans. In our main treatment the borrower can expropriate the lender's funds: a defaulting borrower can reinvest the loaned funds in future periods. In a control treatment the borrower cannot expropriate borrowed funds, i.e. if she defaults she cannot reinvest these funds in future periods. Therefore, after a default, the borrower still needs to receive a loan from the lender to be able to invest.

We present predictions regarding the characteristics of relationships, when expropriation is feasible and when it is not, under the assumption that there are two types of borrowers: selfish borrowers, who default whenever there is a monetary incentive to do so, and reciprocal borrowers, who never default as long as the repayment requested does not exceed a given threshold (in a similar vein as in Kreps et al, 1982). When expropriation is possible, two types of equilibria emerge. In the first type, labeled reputation equilibria, the lender offers a small loan in the first period of the relationship and gradually increases its size, conditional on borrower repayment. This motivates selfish

borrowers to repay, until the last periods of the relationship, but also leads to a relatively low investment volume, especially at the beginning of credit relationships. In the second type, labeled screening equilibria, the lender offers a large loan in the first period of the relationship. Selfish borrowers default and are thus screened out by lenders. Such equilibria yield many defaults in the first period of the relationship, but a high level of investment, as a selfish borrower can expropriate the lender's funds and invest them in future periods. In contrast, if expropriation is not possible, there is one type of equilibria only, reputation equilibria. In this case, the lender offers large loans from the first period of the relationship. If no expropriation is possible, the threat of cutting off future credit to a defaulting borrower is enough to motivate a selfish borrower to repay until the last periods of the relationship.

Experimentally, we find that potential expropriation decreases the overall volume of credit. As predicted under the reputation equilibria, the lender offers smaller loans in initial periods. Over time, loan sizes increase, if the borrower repays, exhibiting a rising profile, similar to what is often observed in small business lending (Ioannidou and Ongena, 2010) and in microfinance with the practice of 'progressive lending' (Armendariz and Morduch, 2006). At the same time, the borrower is more likely to default in earlier periods of the relationship when expropriation is possible, especially when she receives a large loan. Together these results suggest that credit relationships may be particularly difficult to establish in markets where the expropriation of funds is feasible. This finding, which is strongly relevant to credit markets in which lenders' rights are weak, also has important implications for sovereign lending, as well as for foreign direct investment in countries with weak investor protection.

Last, Chapter 5 examines a standard feature of credit contracts, collateral, and its role in reducing problems of moral hazard. While collateral is often used in small and medium business loans, relatively little is known about how it affects borrower behavior. A large body of theoretical literature poses two arguments for the use of collateral. A first motivation is its power in reducing problems of moral hazard, i.e. eliciting more effort from borrowers (e.g. Innes, 1990). A second motivation is its effect as a screening device between borrowers, who would like to finance projects of ex-ante unknown quality (e.g.

Bester, 1985). Both these theories suggest that collateral reduces defaults, through its incentive effect as well as through its selection effect. Surprisingly, several empirical studies find that collateral does not significantly reduce defaults (e.g. Jimenez and Saurina, 2004, Berger et al., 2011). Could it be that the incentive effect of collateral is weaker than expected? This chapter uses experimental tools to answer this question, isolating the incentive (moral hazard) effect of collateral and evaluating its strength.

Furthermore, we examine the relationship between collateral and credit volume. Having collateral can be a crucial determinant of access to credit. Lenders who cannot seize collateral from borrowers upon default are unlikely to offer any credit in one-shot interactions, but they are likely to offer credit if collateral becomes available. Surprisingly, however, recent studies that increase available collateral, by extending property titles for lands that were previously informally owned, reveal that the effect of collateral on credit volume tends to be weak (e.g. Field and Torero, 2006). We study a potential reason for this weak effect: the fact that borrowers may not be willing to take up credit, especially if a large collateral must be pledged and interest rates are high.

We present a new experimental design aimed at examining the incentive effects of collateral. In the experiment, a lender may choose to offer a loan and request collateral, while the borrower can choose whether to accept a loan offer and the effort he is willing to exert. Effort is a monetary cost, which increases the likelihood of success of the investment project. Across treatments, both the amount of available collateral and the interest payment are varied exogenously and independently.

The results reveal that the incentive effect of collateral depends on the interest rate. In environments where interest rates are low and thus the borrower can make large profits in case of success, collateral significantly increases effort. Interestingly, if interest rates are high, collateral no longer affects borrower effort. Across treatments, we find that borrowers do not provide more effort if collateral doubles. Within treatments, and for a given borrower, the effort when collateral is requested compared to when it is not does not significantly change either. The results suggest that loss aversion offsets the incentive effect of collateral when interest rates are high. Indeed,

a loss averse borrower does not have an incentive to increase her effort with collateral because of her fear of losses: if the investment fails, exerting more effort would imply larger losses as she loses the collateral pledged and any effort provided. On the other hand, the results also reveal that collateral increases credit supply. But, if interest rates are high, increases in collateral lead to a decrease in credit demand. These findings thus suggest that, collateral can have significant effects on moral hazard and credit volume, especially if interest rates are low. In credit markets with high interest rates, however, the effect of collateral on moral hazard and credit volume may actually be weaker than expected.

Overall, the findings in Part II provide further evidence of the importance of moral hazard in credit markets as well as the potential strengths and limitations of incentives in reducing moral hazard. Further, the results point out that the study of institutions in credit markets, such as the potential of expropriation or the use of collateral, which are of crucial importance but cannot be easily understood using field data, can benefit substantially from the use of experimental tools as a complementary source of data.

Part I

**Communication in Public Good
Games**

Chapter 2

Which Words Bond? Signaling in a Public Good Game¹

2.1 Introduction

Popular proverbs about words and actions are abundant. While some say 'an Englishman's word is his bond', others say that 'actions speak louder than words' (Knowles, 2006). Indeed words can be just cheap talk (Farrell and Rabin, 1996). But can words speak as loud as actions? Furthermore, does the effectiveness of words depend on what words are spoken? Our aim is to compare words and actions in a public good game with private information, and vary the set of words (i.e., the language) that can be used.

In public good games, the influence of actions, or more precisely, of it being common knowledge that some actions are observed, has been widely studied. Theoretically, Hermalin (1998) and Vesterlund (2003), show that, if informed players contribute first to a team project or charity, they can 'lead by example': their contribution can elicit the contribution of uninformed players and enhance efficiency. Experimentally, Potters et al. (2007) find support for these results². The role of being allowed to talk about the value of a contribution, or about the size of the own contribution, however, has

¹This chapter is based on Serra-Garcia, van Damme and Potters (2010).

²Several studies have investigated the effect of observing another player's contribution before deciding one's own (sequential moves) in complete information settings (e.g. Güth et al., 2007, Moxnes and van der Heijden, 2003). We consider a situation in which there is private information.

remained unexplored in contexts like these³. In this chapter, we examine the potential influence of words theoretically, and test the resulting hypotheses experimentally.

Our analysis proceeds in the context of a two-player one-shot public good game. The game is symmetric with respect to the players' contributions. The value of a contribution can be low, intermediate or high, each being equally likely. If the value is low, it is individually rational and (Pareto) efficient not to contribute. If it is intermediate, the game is a prisoners' dilemma: it is efficient to contribute, but each player has an incentive to free ride. Finally, if the value is high, contributing is both individually rational and efficient. The exact state of nature, however, is only known to one of the players. The parameters are set such that, in case no signaling is possible, the uninformed player will not contribute. On the other hand, if the uninformed player knows that the value is either intermediate or high, and considers both possibilities to be equally likely, he will contribute. If no signaling is possible, the informed player only contributes when the value is high and the uninformed player never contributes, hence, contributions are inefficiently low.

We compare two different kinds of signaling by the informed player: actions and words. In the first case, as in Potters et al. (2007), the informed player moves first and her contribution is revealed before the uninformed player makes his contribution decision. The informed player now has an incentive to contribute if (and only if) the value is high or intermediate. Her contribution then signals to the uninformed player that he should contribute as well. Consequently, the actions of the informed player are influential: they determine the uninformed player's contribution. As both players contribute unless the value is low, the game with signaling by actions produces a fully efficient outcome.

To study the effect of words, we allow for two different languages. The first language allows the informed player to talk about the value of a contribution. She can say 'the value is low', 'the value is intermediate', or 'the value is high'.

³The effect of communication in social dilemmas has been frequently studied, but in most cases, again assuming complete information (see Balliet, 2010, for a recent meta-analysis).

The second language allows her to talk about her contribution decision. The informed player can say 'I do not contribute' or 'I contribute'. In both of these cases, talk is cheap, that is, the messages do not directly influence the payoffs.

The traditional cheap talk literature has focused on two disjoint classes of games (Farrell and Rabin, 1996): sender-receiver games with incomplete information, in which only the uninformed player takes payoff-relevant actions, and complete information games, where pre-play communication is used to foster coordination or cooperation. In the first case, the informed player is allowed to talk about her type (the private information); in the second case, she can talk about the action she intends to take. In our public good game, there is private information and both players take payoff-relevant actions. We allow the informed player to either talk about the value of a contribution (her type), or about the action she intends to take. The existing literature has shown that each type of communication can be effective in the respective class of games, and has investigated under which circumstances such communication is most effective. The game we employ allows us to investigate the effectiveness of these types of communication within one framework.

From a standard theoretical perspective, the exact language is irrelevant: for any language that allows at least two different messages, there are two pure equilibrium outcomes⁴. In the first equilibrium, words are ignored - considered as just cheap talk - and contribution levels are as in the game without signaling. In the second equilibrium, the informed player sends the same message (say G) when the state is intermediate and when it is high, and a different message (say B) when the value is low. The uninformed player contributes only after having heard G, hence, words can as be influential as actions.

Note that, for the two languages considered in this paper, all messages have a natural (or focal) meaning: although messages need not be believed, they will always be understood. Our work, hence, is in the tradition of Farrell (1985, 1993), who was the first to argue that messages having a literal

⁴The baseline game and the game with signaling through actions each have a unique equilibrium, and this is in pure strategies; the game with words also has mixed strategy equilibria.

meaning may destabilize certain equilibrium outcomes⁵. We show that, in our context, only the influential equilibrium outcome, is neologism-proof (Farrell, 1993), hence, we focus on this outcome. For the uninformed player, we thus predict the same behavior under words as under actions. In contrast, words allow the informed player to free ride when the value is intermediate. In the equilibrium with actions, this player is forced to contribute when the value is intermediate, but, since her contribution cannot be observed by the receiver in the case of words, theory predicts that she will contribute less in that case.

Existing theory thus predicts that (1) words can be as influential as actions (the informed player communicates the same information about the value in both situations, to which the uninformed player responds in the same way); (2) the informed player will contribute less under words than under actions (as, under words, this player will free ride in the intermediate state); and (3) that it does not matter which words can be used. We test these hypotheses experimentally.

Our experiment reveals that words indeed can be as influential as actions. Informed players most frequently use the message 'the state is high' (resp. 'I contribute'), both when the state is intermediate and high, to which uninformed players react by contributing, as they do after observing a contribution of the informed player. Moreover, as predicted, when the state is intermediate, the rate of free riding by the informed player is much lower in case signaling is by actions (19% of the time) than in case signaling is by words (81% of the time, averaged across both languages). Still, in contrast to what theory predicts, it does matter what language is available. There are two key differences. First, while existing theory remains silent about which messages will be used, actual behavior displays important regularity: informed players strongly make use of the natural meaning of the words that are available. Secondly, and perhaps more striking, while free riding by the informed player is almost universal (94%) when talk is about the value, it falls significantly when she talks about her contribution (68%). In the specific case that the informed player says 'I contribute', she in fact contributes

⁵There is a separate literature that builds on the presumption that messages, whilst not having an inherent meaning, may acquire meaning through an evolutionary learning approach; see Blume et al. (2001) for a comparison of the two approaches.

41% of the time, revealing that for some players a word can be a bond.

We address both discrepancies in this paper. The first is rather easily dealt with by a theoretical extension of the ideas underlying Farrell's neologism-proofness concept: if uninformed players are likely to interpret messages according to their literal meaning, informed players will use messages according to their literal meaning, whenever this is a credible statement.

We suggest two, potentially complementary, explanations for the fact that the extent of free riding depends on the language that is available. Both explanations build on the idea that players dislike lying to some degree. The first explanation is in line with previous experimental studies, which find that lying depends on the associated consequences, that is, on the costs and benefits that follow from the lie (Gneezy, 2005, Hurkens and Kartik, 2009)⁶. In our game, not lying is less costly when talk is about the contribution than when talking about the value of contributing. When talking about the value, if the informed player reveals the intermediate state truthfully, the uninformed player no longer contributes, which decreases the informed player's payoff substantially. In contrast, in talking about her contribution, the informed player can avoid lying at a low cost by indeed contributing if she says 'I contribute'. In this case, the uninformed player still contributes and the informed player does not forgo as much monetary payoff.

The second explanation elaborates on a similar idea by arguing that there may be different types of lies, and that some lies may be perceived as being more costly than others. In this respect, we note that the message 'I contribute' is similar to a promise, as it refers to an action of the speaker. In contrast, the message 'the value is high' does not resemble a promise. The norm that promises should be kept may be stronger than the norm that one should not lie, and, therefore, players may be less likely to not contribute when they have announced a contribution. The similarity of the message 'I contribute' to 'I promise to contribute' could thus be a driving force behind the decrease in free-riding. In social dilemmas and trust games, with symmetric information, promises are often made and kept, especially when

⁶See Kartik et al. (2007) and Kartik (2009), among others, for models of sender-receiver games in which such costs of lying are allowed. Demichelis and Weibull (2008) follow a similar approach, assuming that players have a lexicographic preference, after payoffs, for choosing an action which is in line with the meaning of the message they send.

communication is free-form (Balliet, 2010, Charness and Dufwenberg, 2006, Ellingsen and Johannesson, 2004, Vanberg, 2008). Our experiment reveals a similar effect in a game of private information. It is noteworthy, however, and somewhat in contrast to these complete information studies, that we observe a relatively strong effect, even though we allow only a very restricted set of messages.

The contribution of our study, hence, is three-fold. First, we compare words and actions in a game with incomplete information and show that words can be as influential as actions. Previous studies comparing words and actions have only considered games of complete information (Bracht and Feltovich, 2009, Duffy and Feltovich, 2002 and 2006, and Wilson and Sell, 1997)⁷. Second, we slightly extend the reasoning underlying Farrell's neologism-proofness concept, show that it allows us to predict both messages and actions, and demonstrate that the prediction on which messages will be used is reasonably accurate. Third, we consider two different languages. In one case, the informed player can talk about her private information (value of contributing), in the second case she can talk about her actions. We show that the language that is available matters for the informed player's own contribution. To the best of our knowledge, especially this latter aspect has remained unexplored in the literature on private information games⁸.

The structure of the paper is as follows. In Section 2.2, we develop the theoretical framework, outlining the equilibria under actions and words. We then describe the experimental design in Section 2.3 and move to the results in Section 2.4. Section 2.5 concludes.

2.2 Theoretical Framework

We study a one-shot public good game with two players, one informed and one uninformed. The informed player has private information regarding the value of a contribution to the public good. There are three equally-probable

⁷Also Brandts and Cooper (2007) compare words to financial incentives used by a 'manager' in a weak-link coordination game. Çelen et al. (2009) compare advice to observation of other's actions in a social learning environment.

⁸Some previous studies have focused on the evolution of the strategic meaning of different sets of messages (Blume et al., 1998 and 2001, and Agranov and Schotter, 2009).

values of a contribution's value, also called the state, $s \in S = \{a, b, c\}$, where $a \leq 0, 0 < b < 1$ and $c > 1$.⁹ Both the informed and the uninformed player decide whether to contribute or not to the project, where $x_i = 1$ indicates a contribution and $x_i = 0$ none, with $i = \{I, U\}$. Whenever convenient, we will also denote the action of I by x and the action of U by y . The payoff function of the game is given by:

$$u_i = 1 - x_i + s(x_i + vx_j), \quad j \neq i, j = \{I, U\}$$

where $v > 0$. Throughout we assume that $a + b + c < 3$, $b + c > 2$, $a(1 - v) < 1$ and $b > 1/(1 + v)$. These parameter restrictions imply: (i) against the prior distribution, the uninformed player's best response is not to contribute; (ii) if the uninformed player knows that the state is either b or c , and considers these to be equally likely, his best response is to contribute; (iii) if $s = a$, the informed player has not contributing as his dominant action; and (iv) it is socially optimal to contribute when the state is b .

Within this context, the baseline game does not allow any information transfer. In addition, we consider various games that allow signaling by the informed player. Under 'Actions', the informed player can signal through her contribution decision. In the case of 'Words', she can send a message, either about the state, or about her contribution decision. We, hence, consider four different games. In the subsections below we describe the equilibria of these games. Technical proofs are presented in Appendix A.

2.2.1 The Baseline Game

Let us first consider the Nash Equilibrium (NE) of the game when the uninformed player receives no signal. The strategy of the informed player is denoted as $\sigma = (x_a, x_b, x_c)$, where x_s denotes the probability of contributing in state s . The strategy of the uninformed player is specified as τ , the probability that he contributes.

⁹This game is a general version of the game used in Potters et al. (2007). In their setting, $a = 0, b = 0.75, c = 1.5$ and $v = 1$. Our theoretical results are more general; in our experiment, we use the same values for a, b, c , but set $v = 2$. We choose $v = 2$ in order to increase the efficiency gains from contributing when $s = b$ and $s = c$.

Proposition 1 *The baseline game has a unique Nash Equilibrium, given by $(\sigma^*, \tau^*) = \{(0, 0, 1); 0\}$.*

In the unique NE of the game, only the informed player contributes, and then only if $s = c$. Since she cannot signal her private information to the uninformed player, the latter never contributes. However, if he would know that $s = c$, the uninformed player would prefer to contribute. Also, when $s = b$, neither player contributes while total payoffs would be maximized if both players did. Signaling the state with either words or actions can improve upon this outcome.

2.2.2 Actions

In the 'Actions' game, the informed player chooses her contribution x first; the uninformed player observes x and then chooses his contribution y . A strategy σ of the informed player is defined as above. Since the uninformed player can condition his decision on the observed choice of the other, his strategy space expands. A strategy τ of the uninformed player now is denoted as $\tau = (y_0, y_1)$, where y_z denotes the probability that the uninformed player contributes given $x = z$. The next Proposition states that, if the informed player can signal the value by revealing her contribution, both her contribution and that of the uninformed player increase. In particular, a contribution by the informed player is influential, as it leads to a contribution of the uninformed player as well.

Proposition 2 *The game with Actions has a unique Nash Equilibrium, $(\sigma^*, \tau^*) = \{(0, 1, 1); (0, 1)\}$.*

Note that signaling with the contribution decision ('leading by example') leads to a fully efficient NE. Players choose $x = y = 1$ when $s = b$ or $s = c$, while they choose $x = y = 0$ if $s = a$. This maximizes the sum of payoffs for each value of s .

2.2.3 Words

We introduce 'Words' by allowing the informed player to send a message m , from a given set of messages M , to the uninformed player. To allow that

some information can indeed be transmitted, we assume that M contains at least two elements. The informed player first selects m , which is observed by the uninformed player before he decides about y . The uninformed player does not, however, observe x . The payoff function remains the same, hence, communication is costless.

Since the informed player observes the realization of s before sending a message, she can condition both her message and her contribution on the state of nature. We denote the strategy of the informed player as $\sigma = (\sigma_a, \sigma_b, \sigma_c)$ where $\sigma_s = (m_s, x_s)$. m_s is a probability distribution over M , and x_s is the probability of contributing in state s . Similarly τ specifies, for each $m \in M$, the probability $y(m)$ that the uninformed player contributes after the message m . We write $M_s(\sigma)$ for the set of messages in M that occur with positive probability when the state is s and σ is played. Similarly $X_s(\sigma)$ denotes the set of contributions that the informed player makes with positive probability when the state is s and σ is played. Note that, since messages are costless, standard analysis leaves undetermined the messages that will be used, hence, there will always be multiple Nash equilibria. In Proposition 3, we, therefore, focus on the equilibrium outcomes: the contribution levels $x(s)$ and $y(s)$ in each state s .

There are two pure strategy equilibrium outcomes. In the equilibria of the first type, communication is uninformative, viewed as pure cheap talk, so that contribution levels are the same as in the baseline game. In the equilibria of the second type, the informed player's messages are influential, i.e. they induce the uninformed player to contribute when the state is b or c , but not when the state is a . In these equilibria, the informed player only contributes when $s = c$, hence, she free rides when $s = b$. We call these 'influential' equilibria.¹⁰

Proposition 3 *There are two pure strategy equilibrium outcomes in the game with Words, given by, respectively:*

¹⁰There are also equilibria in which the informed player randomizes over messages, but these still yield the same contribution levels. If $a=0$, then there are also other mixed strategy equilibria in which some messages are used in all states of nature by the informed player; see the proof (in Appendix A) for details. We will focus on the pure strategy equilibria.

- (1) $X(\sigma) = (X_a(\sigma), X_b(\sigma), X_c(\sigma)) = (0, 0, 1)$ and
 $\tau(m) = 0$ for all $m \in M_s(\sigma)$, where $s = \{a, b, c\}$
- (2) $X(\sigma) = (X_a(\sigma), X_b(\sigma), X_c(\sigma)) = (0, 0, 1)$ and
 $\tau(m) = 0$ for all $m \in M_a(\sigma)$, while $\tau(m) = 1$ for all $m \in M_b(\sigma) \cup M_c(\sigma)$

Introducing words can, hence, have two effects on contribution levels: a positive one, which increases the uninformed player's contribution levels, but not those of the informed player, or a null-effect, which leaves contribution levels as in the baseline case.

Words with a focal meaning: neologism-proof equilibrium

In this subsection, we show that only an influential equilibrium is neologism-proof, as defined in Farrell (1993). We also discuss why we consider this concept to be relevant in our context.

Thus far, we left the message space M to be an abstract set, and just assumed it to be large enough for partial separation. The existing game theoretic literature on 'cheap talk' can be divided into two classes. Most papers have assumed that messages do not have an a priori meaning, but that they may acquire a meaning through their use in equilibrium. Starting from Farrell (1985, 1993), there is a smaller literature that assumes that players share a common language, in which messages have a natural, focal meaning. In this setting, although messages do not need to be believed, they will be understood. The idea is that, in such a context, players cannot (or will not) fully neglect the meaning that a message has outside of the specific game under consideration. In his seminal papers, Farrell has shown that, under this assumption, some equilibria are no longer plausible, since they can be destabilized by reference to the focal meaning of the messages; formally they are not neologism-proof. In the experiments that we conducted, see the next section, we used messages that have a literal meaning; hence, our work is in this second tradition. We will show that only an influential equilibrium is neologism-proof¹¹.

¹¹Rabin (1990) has argued that Farrell's definition rules out too many equilibrium outcomes. For further discussion, see also Farrell and Rabin (1996). It can, however, be shown that, if $a < 0$, only the influential equilibrium satisfies Rabin's condition of Credible Message Rationalizability. If $a = 0$, player I is indifferent between all responses of player

Strictly speaking, however, there are two reasons why the neologism-proofness concept is not directly applicable to our context. First, our public goods game with ‘Words’ is not of the type that has been considered in the traditional cheap talk literature, as it is a game with private information in which both players take payoff-relevant actions. Nevertheless, the informed player, I , has a strictly dominant contribution level $x_I(s)$, in each state of nature s . If we assume that I will always choose this contribution, we are back in the standard setting, to which Farrell’s ideas can be applied¹². Second, and perhaps more important, the interpretation of Farrell’s concept relies on the players having a *rich* language at their disposal. In our experiments, we used a restricted language. We return to this aspect after having given the formal definition and having formulated the result.

For a subset T of S write $b_U(T)$ for the best response of player U , given the prior, but conditional on the state s being in T . Let $e = (\sigma, \tau)$ be an equilibrium and denote by $u_I^e(s)$ the equilibrium payoff of player I , given that the state is s . Farrell (1993) defines the set T to be self-signaling with respect to e if

$$T = \{s \in S : u_I(s, b_U(T)) > u_I^e(s)\}$$

and he defines the equilibrium e to be *neologism-proof* if there is no set of types T that is self-signaling with respect to it. The interpretation is as follows. Suppose e is the equilibrium under consideration, and suppose that player I says “the state belongs to the set T ”. If player U interprets the message literally, he will be inclined to choose $b_U(T)$. On the other hand, player U should not be credulous, but rather ask himself the question: when does player I have an incentive to use this message, assuming that it would be believed? If T is self-signaling, player I strictly benefits from using the message ‘the state is in T ’ exactly when this statement is true. When T is

U and also the uninfluential equilibrium satisfies CMR. If I would have social preferences and attach some positive weight to the utility of U , then I strictly prefers U to choose $y=0$ if $a=0$, and in this case again only the influential equilibrium is CMR. Details are available from the authors upon request.

¹²It is innocuous to make this assumption as also the best reply of the uninformed player only depends on the posterior distribution over the states and not on the contributions that player I makes.

self-signaling, there are good arguments to believe this message as the literal meaning of the message ‘the state is in T ’ is consistent with the incentives that the game provides. Consequently, if an equilibrium e is not neologism-proof, and the language that is available to the players is rich enough to allow a self-signaling set to identify itself, e can be upset by the corresponding self-signaling message. We have

Proposition 4 *Only an influential equilibrium is neologism-proof.*

The proof relies on the fact that the set $T = \{b, c\}$ is self-signaling. If the informed player uses the message "the state is b or c ", the uninformed player should thus believe her. Farrell (1993) assumes that players have a *rich* natural language at their disposal, so that this message is available. In our experiments, although we used messages with a natural meaning, we did *not* use a rich language. In particular, in none of the two games that we experimented with was the message “the state is b or c ” available. Nevertheless, in each of these games, there were messages (such as "the state is c " or "I contribute") available, that could naturally be interpreted like this. In other words, the self-signaling set $\{b, c\}$ might be able to signal through a different message than “the state is in $\{b, c\}$ ”. Furthermore, although the *interpretation* of Farrell’s concept relies on this richness assumption, the formal definition only refers to the mathematical structure of the game under consideration. For both of these reasons, we believe that the concept is relevant to our game.

It should be noted that, although the concept of neologism-proofness limits the number of equilibrium *outcomes* to one, it does not lead to restrictions on the messages that will be used. As already mentioned in the context of Proposition 3, there are multiple *equilibria*. For example, consider the case discussed in the Introduction, where there are (at least) the messages B (Bad) and G (Good). In this case, in one neologism-proof equilibrium, player I sends the message B when $s = b$, or $s = c$, to which player U responds with $y = 1$, while player I uses the message G when $s = a$, which is then followed by the response $y = 0$. In another equilibrium, player I sends the message G if $s = b$, or $s = c$, (with response $y = 1$), while the message is B if $s = a$ (with response $y = 0$). Formally, according to the logic of the concept, both

of these equilibria are neologism-proof. Nevertheless, the latter equilibrium seems more natural than the first. After all, in this latter equilibrium, player I communicates that the state is Bad exactly when this is the case, while she communicates that the state is G , when it is not bad. In other words, the latter equilibrium is closer to the truth than the former.

Talking about the state or talking about the contributions

To further develop the above idea, let us now focus on the two specific message sets that will be discussed in the remainder of this paper. In the first case, $M = M^s = \{a, b, c\}$, so that messages correspond to the state of nature¹³. In the second case, $M = M^x = \{x = 1, x = 0\}$, the messages correspond to the contribution decision of the informed player. To select among the equilibria, hence, to also pin down the messages that will be used, we make two assumptions, each of them corroborated by extensive experimental evidence. The first assumption is that players (or at least some of them) have at least a minimal aversion to lying. Several experiments (e.g. Gneezy, 2005, Sánchez-Pagés and Vorsatz, 2007, and Hurkens and Kartik, 2009) have shown that players dislike lying. As in Demichelis and Weibull (2009), we adopt a very minimal version of this idea, namely that, when the material payoffs are the same, players prefer not to lie¹⁴.

This assumption is sufficient to obtain a unique, focal, equilibrium in the case where messages are about the contribution of the informed player, $M^x = \{x = 1, x = 0\}$. In this case, there are two pure equilibria that produce the influential equilibrium outcome. In the first, I sends the message $x = 0$ when $s = a$ and the message $x = 1$ when $s = b, c$. In the second, messages are reversed: I says $x = 1$ when $s = a$ and says $x = 0$ when $s = b, c$. In the first equilibrium, I tells the truth when $s=a$ and c ; in the second, she always

¹³We chose this set of messages because it is precise and corresponds directly to the informed player's private information. In Serra-Garcia et al. (2011) we consider a richer set of messages allowing for two or more states to be stated in one message and a blank message. In that paper, the action of the informed player is observed by the uninformed player as well as the informed player's message. We find that players' contribution behavior is not significantly affected by the richer message space, but that informed players are often vague.

¹⁴We note that Farrell (1993, p. 519) also explicitly refers to players having a slight preference for telling the truth in order to justify his refinement of neologism-proofness.

lies. We consider the first equilibrium to be focal.

Now consider the case in which player I can talk about the state, but is required to provide full (precise) information, $M^s = \{a, b, c\}$. Table 2.1 describes the 6 message combinations that are possible in the various influential pure equilibria.

Equilibrium nr.	Message sent if state			# states lie
	a	b	c	
1	a	b	b	1
2	a	c	c	1
3	b	a	a	3
4	b	c	c	2
5	c	a	a	3
6	c	b	b	2

Table 2.1: Message use in influential equilibria and lies

An argument as above points in the direction of the first or the second equilibrium, but it does not discriminate between those. Nevertheless, we argue that only the second equilibrium is focal. The additional assumption leading to this conclusion is that a small but positive portion of uninformed players is naïve and interprets messages literally and naïvely. Such an assumption is also used in Crawford (2003), Kartik et al. (2007) and Ellingsen and Östling (2010). Experiments have indeed shown that some receivers are credulous and interpret messages literally and naïvely (e.g. Cai and Wang, 2006). Under this additional assumption, only the second equilibrium is focal. Since player I wants to induce U to contribute when the state is b or c , and U might interpret messages literally, I uses message c . He assumes that U will react to the unused message b by interpreting it literally and, hence, by not contributing. Note that the natural language reinforces the equilibrium. For this reason we call this equilibrium focal.

We have proved:

Proposition 5 *The games with words M^s and M^x each have a unique focal equilibrium. The focal equilibrium is influential. If player I talks about the state, she will reveal it when it is a , whilst she will say c when the state is b or c . Alternatively, when player I talks about her contribution, she will*

honestly reveal her contribution when the state is a or c , but she will lie and say that she contributes in state b . Player I only contributes when the state is c , and player U only does so after message c or after a message stating that I contributes.

2.3 Experimental Design and Hypotheses

2.3.1 Parametrization and Treatments

In the experiment, the payoff function of our game is the following, $u_i = 40[1 - x_i + s(x_i + vx_j)]$, where $s = \{0, 0.75, 1.5\}$ and $v = 2$. Subjects are asked to choose between A (equivalent to $x_i = 0$) and B (equivalent to $x_i = 1$) in each round. The payoffs of a player depend on her choice, the choice of the other player and the earnings table selected. The earnings table number (1, 2 or 3) corresponds to the value of s ($s = 0, 0.75$ or 1.5 , respectively). Payoffs (in points) are shown in Table 2.2 for each earnings table number. These tables were shown to subjects both in the instructions (see Appendix B) as well as on the computer screens.

	Earnings Table 1		Earnings Table 2		Earnings Table 3	
	Other person's choice		Other person's choice		Other person's choice	
	A	B	A	B	A	B
Your choice	A	40 40	A	40 100	A	40 160
	B	0 0	B	30 90	B	60 180

Table 2.2: Payoff Matrices

In all treatments, at the beginning of each round, the informed player, named first mover in the experiment, is informed about the earnings table selected, and next decides whether to contribute or not. In the Baseline, the uninformed player, named second mover, receives no information and is simply asked to make a decision. In Words and Actions, the uninformed player first receives the signal from the informed player and is then asked to make a decision. In Actions, the signal is the decision of the informed player (A or B). In Words, the informed player is explicitly asked to also select a message to send to the uninformed player. In Words(s), the three possible

messages are 'The earnings table selected by the computer is s ', where s is either 1, 2 or 3. In this game, the informed player thus talks about the state. In Words(x), two messages are possible: 'I choose A' or 'I choose B'. In this game, the informed player thus talks about (her) contributions. The roles of informed and uninformed player are randomly determined within each pair in each round. The information available in each treatment is detailed in Table 2.3 below.

	Informed player	Uninformed player
Baseline	Observes s	No information
Words(s)	Observes s	Observes $m \in M^s$
Words(x)	Observes s	Observes $m \in M^x$
Actions	Observes s	Observes x

Table 2.3: Experimental Design - Information Structure by Treatment

In each period, both players have a history table at the bottom of their screens, displaying the following information for each previous period: the earnings table selected, the role of the player, the own decision and that of the other player, including the message sent if applicable, and the earnings of both players. From this information, players could not identify the players with whom they had previously played.

2.3.2 Hypotheses

We take the results from Propositions 1 to 5 and summarize the equilibrium contributions of the different treatments in Table 2.4, below. The informed player never contributes when $s=0$, and always does when $s=1.5$. When $s=0.75$, she only does in Actions, that is, if her contribution is observed. The reactions of the uninformed player range from never contributing (as in Base) to imitating the informed player (in Actions).

Treatment	Choices ^a		
	$s=0$	$s=0.75$	$s=1.5$
Baseline	(0, 0)	(0, 0)	(1, 0)
Words	(0, 0)	(0, 1)	(1, 1)
Actions	(0, 0)	(1, 1)	(1, 1)

Note: ^a (x, y)

Table 2.4: Expected Choices

The hypotheses 1 and 3 are derived from the contribution behavior of both players as described in this table. Hypothesis 2 focuses on the communication between the players and is derived from Proposition 5. Relatedly, the efficiency¹⁵ (ξ) of each treatment can be ranked as follows: ξ_{Base} (61.3%) $\leq \xi_{Words(s) \text{ and } (x)}$ (91.9%) $< \xi_{Actions}$ = (100%). These inequalities lead to hypothesis 4¹⁶.

Hypothesis 1 (informed player contribution behavior): *when $s=0.75$, the informed player contributes:*

- (a) *more frequently under Actions than in Words(s) or in Words(x)*
- (b) *with equal frequency in Words(s) as in Words(x).*

Hypothesis 2 (message use and information transmission):

(a) *if $s=0$, the message 'the state is 0' is used in Words(s), whilst the message 'I do not contribute' is used in Words(x). If $s=0.75$ or $s=1.5$, the messages that are used are 'the state is 1.5' and 'I contribute', respectively.*

(b) *the same information is transmitted in Words(s), Words(x) and Actions.*

Hypothesis 3 (uninformed player contribution behavior): *the messages 'the state is 1.5' and 'I contribute', in Words(s) and Words(x), respectively, are as influential as a contribution is in Actions.*

Hypothesis 4 (efficiency):

- (a) *efficiency is highest under Actions.*
- (b) *efficiency under Words(s) is equal to that under Words(x).*

2.3.3 Experimental Procedures

Four matching groups (of 8 subjects each) participated in each treatment. Subjects were re-paired every period with another subject in their matching

¹⁵Efficiency is calculated throughout the paper as the sum of payoffs of the leader and the follower in each treatment, divided by the maximum sum of payoffs attainable.

¹⁶We do not formulate a hypothesis about payoffs since the treatment effects are expected to be small for the informed player's payoffs. We briefly discuss predicted and actual payoffs in Section 2.4.4.

group and roles were randomly assigned. To have enough learning possibilities for each earnings table (value of s), subjects played the game for 21 periods. Further, since there were 8 subjects in each matching group, each subject met the same person at most 3 times, without coinciding two consecutive periods in the same role. Overall, 84 pairings were obtained per matching group (4 pairs x 21 periods): 25 faced Earnings Table 1, 30 Earnings Table 2 and 29 Earnings Table 3¹⁷. The experiment was programmed and conducted with the software *z-Tree* (Fischbacher, 2007). It was conducted in CentERlab, at Tilburg University. Subjects received an invitation to participate in the experiment via e-mail. They could enrol online to the session of the experiment, which was most convenient for them, subject to availability of places. Subjects were paid their accumulated earnings in cash and in private at the end of the experiment. Average earnings were 12.20 Euro (sd: 2.46) and sessions lasted approximately 60 minutes.

2.4 Results

We report results from the second half of our experiment (periods 11 to 21). This is motivated by the fact that, in the first 10 periods, informed players exhibit strong learning for $s=0.75$. Our unit of observation will be each matching group in the experiment; we thus have 4 independent observations per treatment.

2.4.1 Contributions by the informed player

The informed player's contribution decision is determined by two main factors. The first one is the state, s , and the second one is the treatment. In Figure 2.1, we observe the average frequency with which informed players contribute by state and treatment.

The four leftmost columns of Figure 2.1 reveal that, when $s = 0$, the informed player contributes between 0 and 4% of the time. In contrast, when $s = 1.5$ (four rightmost columns), she contributes approximately 90%

¹⁷The matching schemes, roles and states of nature for each period and pair were randomly drawn before the experiment. This allowed us to have the same exact patterns across different matching groups.

of the time. In neither of these cases is there a significant difference across treatments (Kruskall-Wallis test, p -value=0.1718 and 0.8152, respectively).

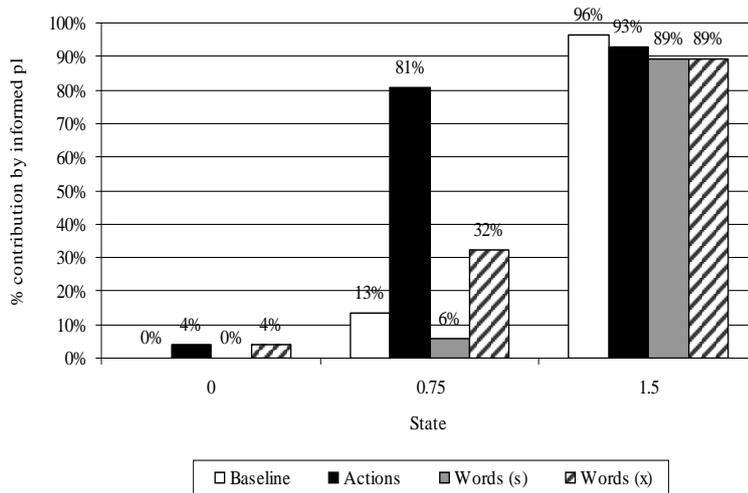


Figure 2.1: Contribution Frequency by Informed Player, by State and Treatment

Treatment differences become significant when $s = 0.75$. First, the informed player contributes significantly more often (81% of the time) in the Actions treatment, when her contribution is observed, than in any other treatment (Mann-Whitney (MW) test, p -value=0.0194 comparing Actions to Baseline, or Actions and Words(s); p -value=0.0202 comparing Actions and Words(x)).

The informed player's contribution is also affected by the words she can use. When the informed player talks about her contribution decision, her contribution frequency increases to 32%, compared to 6%, when she talks about the state (MW test, p -value=0.0421).

Result 1 (contributions of the informed player):

(a) When $s = 0.75$, the informed player's contribution is higher in Actions than in Words(s) and in Words(x). Thus, we do not reject Hypothesis 1 (a).

(b) *The contribution frequency of the informed player is also affected by the language that is available. The informed player contributes more often when sending messages about her contribution ($Words(x)$), than when she sends messages about the state ($Words(s)$). We, thus, reject Hypothesis 1 (b).*

In contrast to what standard theory predicts, it, hence, matters what the informed player can talk about. We will examine this result in more detail at the end of this section, after having studied the use of messages by the informed player, the information transmitted through these messages, and the reaction of the uninformed player.

2.4.2 Message use and information transmission

In Table 2.5, we display the informed player's message use in $Words(s)$ and $Words(x)$. The rows display the possible messages and the columns the frequencies with which they are used in the various states. For example, in treatment $Words(s)$, the message 'the state is 0' is used 71.1% of the time when $s = 0$.

Treatment	Message (m)	Message use ^a		
		$s=0$	$s=0.75$	$s=1.5$
$Words(s)$	'The state is 0'	71.1%	8.8%	1.8%
	'The state is 0.75'	11.6%	16.2%	3.6%
	'The state is 1.5'	17.3%	75.0%	94.7%
$Words(x)$	<i>a)</i>			
	<i>Matching groups 13,15 and 16</i>			
	'I do not contribute'	94.9%	23.5%	9.5%
	'I contribute'	5.1%	76.5%	90.5%
<i>b)</i>	<i>Matching group 14</i>			
	'I do not contribute'	61.5%	17.6%	28.6%
	'I contribute'	38.5%	82.4%	71.4%

Note: ^a Number of times m is sent over total number of times that s is drawn

Table 2.5: Message use in $Words(s)$ and $Words(x)$, by treatment and state

Let us first focus on the $Words(s)$ treatment. When $s = 0$, informed players most frequently use the message 'the state is 0' (71.1%). Instead

when $s = 0.75$ or $s = 1.5$, the informed player most frequently uses the message 'the state is 1.5' (75% and 94.7%, respectively). The frequency with which this message is used in these states is not significantly different (Wilcoxon signed-rank (WSR) test, p-value=0.1441). Note that, when $s = 0$ or $s = 1.5$, the informed player most frequently tells the truth, but that, when $s = 0.75$, lies are very frequent. In any case, the natural meaning of the words plays a role.

Let us now turn to Words(x). In this treatment, we observe differences in message use across matching groups. Three matching groups (the groups 13, 15 and 16), use messages as expected in the focal equilibrium, while one matching group (group 14) does not. In this matching group, when $s = 0$, the message 'I contribute' is sent much more frequently than in any other matching group (38.5%, versus 0% in matching group 13, or 7.7% in groups 15 and 16). Furthermore, in this group 14, the message 'I contribute' also is used more often when $s = 0.75$ than when $s = 1.5$. We find that this difference in message use in matching group 14 has important consequences in terms of the information transmitted by the informed player. In the tables that follow, we therefore report separate statistics for this group¹⁸.

In matching groups 13, 15 and 16, when $s = 0$, the informed player most frequently says 'I do not contribute' (94.9%). When $s = 0.75$ or $s = 1.5$, she most frequently sends the message 'I contribute' (76.5% and 90.5%). Again, the frequency with which she sends this message does not differ significantly between these two states (WSR test, p-value= 0.2850). We also here see that the natural meaning of the message plays a role.

To consider the information transmitted in Actions, Words(s) and Words(x), we now take the behavior of the informed player during periods 11 to 21 and calculate (using Bayes' rule) the posterior probability that the state is s , given the signal received. Table 2.6 displays the results. The rows represent the different signals (distinguished also by matching group in the case of Words(x)), while the final three columns give the posterior probability of each state.

¹⁸In treatment Words(s) we find no substantial differences across matching groups and, therefore, report averages across all matching groups throughout.

Treatment	Signal	Probability that		
		$s=0$	$s=0.75$	$s=1.5$
Actions	Informed player's decision			
	$x=0$	0.75	0.18	0.06
	$x=1$	0.02	0.5	0.48
Words(s)	Message about the state			
	'The state is 0'	0.85	0.13	0.02
	'The state is 0.75'	0.18	0.54	0.28
	'The state is 1.5'	0.07	0.44	0.48
Words(x)	Message about the contribution			
	a) <i>Matching groups 13,15 and 16</i>			
	'I do not contribute'	0.70	0.23	0.07
	'I contribute'	0.03	0.49	0.48
	b) <i>Matching group 14</i>			
	'I do not contribute'	0.53	0.20	0.27
	'I contribute'	0.17	0.48	0.35

Table 2.6: Posterior probability of each state conditional on signal by informed player

In Actions, after a contribution ($x = 1$), the probability that $s = 0.75$ is 0.5, while the probability that $s = 1.5$ is 0.48. Instead, if the informed player does not contribute, the probability that $s = 0$ is 0.75.

In Words(s), after the message 'the state is 1.5' the probability that $s = 0.75$ is 0.44. This probability is not significantly different from the corresponding probability, 0.5, after a contribution in Actions (MW test, p-value=0.1489). The probability that $s = 1.5$ is 0.48, which again is not significantly different from that after a contribution in Actions (MW test, p-value=1.000). This message therefore did not transmit significantly different information than a contribution decision of the informed player, in Actions. Furthermore, the probability that $s = 0$ after the message 'the state is 0' (0.85) is not significantly different from that (0.75) after no contribution by the informed player in Actions (MW test, p-value=0.2482).

In the treatment Words(x), for matching groups 13, 15 and 16, after a message 'I contribute', the probability that $s = 0.75$ is 0.49, and that of $s = 1.5$ is 0.48. These are not significantly different to those after a contribution in the Actions treatment (MW test, p-value=0.5637 for state 0.75 and 0.4678 for state 1.5). Furthermore, again excluding matching group 14, the probability that $s = 0$ after the message 'I do not contribute' (0.70,)

is not significantly different from that (0.75) after no contribution in Actions (MW test, p-value 0.1102). Instead, for matching group 14, the probability that $s = 1.5$, after the message 'I contribute' is 0.35.

Result 2 (message use and information transmission):

(a) *In Words(s), the message 'the state is 0' is most frequently used when $s=0$, while the message 'the state is 1.5' is most frequently used when $s=0.75$ or 1.5. In Words(x), 'I do not contribute' is most frequently used when $s=0$, and 'I contribute' is used most often when $s=0.75$ or 1.5 (especially in matching groups 13, 15 and 16). We therefore do not reject Hypothesis 2a.*

(b) *Compared to a contribution decision in Actions, the message 'the state is 1.5' in Words(s), or the message 'I contribute' in Words(x) (except in one matching group) does not convey significantly different information. Compared to no contribution in Actions, the messages 'the state is 0' and 'I do not contribute' also do not convey significantly different information. Thus, we do not reject Hypothesis 2b.*

2.4.3 Contributions by the uninformed player

The uninformed player reacts to the information transmitted by the informed player. In Table 2.7, rows again display the different possible signals. Column (1) gives the average contribution frequency of the uninformed player. Columns (2) and (3) give the expected payoff in points from not contributing, or contributing, calculated using the posterior probabilities displayed in Table 2.6, as well as (for Words(s) and Words(x)), the frequency with which the informed player contributes conditional on each message sent. The last column of Table 2.7, (4), displays the empirical best reply, based on the expected payoff calculation. The choice with the highest expected payoff is then displayed for each signal.

In the baseline treatment, the first row in Table 2.7, the uninformed player receives no signal but contributes 39.2% of the time. This is an unexpectedly high level of contributions, since the empirical best reply is not to contribute. This contribution rate is, however, similar to that in Ellingsen and Johannesson (2004), who find that 35% of sellers invest when there is

no communication, despite the prediction of no investment. One possible explanation in our game is that individuals try to 'guess' when the state will be high and that they fall prey of the 'gambler's fallacy' (Kahneman and Tversky, 1974). For example, the likelihood of a contribution decreases in the period after the state was 1.5, despite the fact that players are informed that in every period the state is 0, 0.75 or 1.5 with equal probability. Another possible explanation is that social preferences play a role. After all, with an expected value of s of 0.75 it is socially efficient to contribute.

Treatment	Signal	(1) Uninformed Player's Contribution Frequency	(2) Expected Payoffs $\pi(y=0)$	(3) $\pi(y=1)$	(4) Empirical best reply
Baseline	-	39.2%	81.22	71.22	$y=0$
Actions	$x=0$	4.4%	40.00	9.27	$y=0$
	$x=1$	88.0%	127.77	131.65	$y=1$
Words(s)	'The state is 0'	2.3%	43.67	8.60	$y=0$
	'The state is 0.75'	42.0%	71.67	64.69	$y=0$
	'The state is 1.5'	69.7%	93.30	95.51	$y=1$
Words(x) a)	<i>Matching groups 13,15,16</i>				
	'I do not contribute'	7.6%	53.40	24.67	$y=0$
	'I contribute'	62.3%	109.69	113.35	$y=1$
b)	<i>Matching group 14</i>				
	'I do not contribute'	13.3%	52.00	34.00	$y=0$
	'I contribute'	13.8%	71.03	66.21	$y=0$

Table 2.7: Uninformed player's contribution frequency, expected payoffs and best reply, by treatment

In the treatments where signals are received, the uninformed player responds optimally to signals in most cases. In Actions, after observing a contribution by the informed player, the uninformed player contributes 88% of the time. This is the choice that yields the highest expected payoff ($131.65 > 127.77$), and thus it is also the empirical best reply. In Words(s), after a message 'the state is 1.5', the uninformed player contributes 69.7% of the time, which again is also his best reply.

In Words(x) and for matching groups 13, 15 and 16, the uninformed player contributes 62.3% of the time after message 'I contribute', which is also his

best reply. Interestingly, for matching group 14, the uninformed player rarely contributes after a message 'I contribute' (only 13.8%). This is his empirical best reply, as can be seen by comparing 71.03 to 66.21. This is mainly driven by the informed player's use of message 'I contribute' when the state is 0 in 38.5% of the cases (as shown in Table 2.5).

Uninformed player contributions in Actions are very similar to those in the treatments Words(s) and Words(x). If we compare the reaction to a contribution of the informed player in Actions to the reaction to the message 'the state is 1.5', we find that these are not significantly different (MW test, p-value=0.1489). If we compare that reaction to a contribution (88%) to the reaction to the message 'I contribute' (62.3%), we find that the difference is only marginally significant (MW test, p-value=0.0771). Finally, comparing the reaction to the message 'the state is 1.5' to the message 'I contribute', we find no significant differences (MW test, p-value=0.7237). This leads to Result 3.

Result 3 (contributions of the uninformed player): *The uninformed player frequently contributes (more than 60% of the time) after observing the contribution of the informed player, or after hearing the message 'the state is 1.5', or after the message 'I contribute'. Furthermore, the reaction to 'the state is 1.5' is not significantly different from the reaction after observing a contribution, while the reaction to the message 'I contribute' is only marginally different from that after observing a contribution (except for one matching group). Thus, the messages 'the state is 1.5' and 'I contribute' are as influential as actions, and we do not reject Hypothesis 3.*

2.4.4 Payoffs and Efficiency

In Table 2.8 below we display average payoffs and efficiency by treatment. We also display the predicted average payoffs and efficiency in equilibrium.

Table 2.8 reveals that the informed player does remarkably well in the baseline treatment, compared to the theoretical prediction. This is due to the fact that the uninformed player contributes more frequently than predicted. In contrast, under Actions, Words(s) and (x), the informed player

does worse as predicted, while the uninformed player's payoff comes close to the theoretical prediction in most cases. Interestingly, the uninformed player's payoff is significantly higher in matching groups 13, 15 and 16 in Words(x) compared to Words(s), while the informed player's payoff suffers a slight (non-significant) decrease (MW test, p-value=0.0339 and 0.4795, respectively). These changes reveal that the decrease in free-riding by the informed player in Words(x) has important effects, particularly for the uninformed player.

Taking both the informed and uninformed player's payoff, we can calculate efficiency. Table 2.8 shows that efficiency is highest in Actions (89.1%), and that it is significantly higher there than in Words(s) and Words(x), where it is 76.1% and 78.6% respectively (MW test, comparing Actions and Words(s), p-value=0.0209, comparing Actions and Words(x) in matching groups 13, 15 and 16, p-value=0.0497). Thus, we find that, as predicted, Actions leads to the most efficient outcome. If we compare efficiency between Words(s) and Words(x), we do not find a significant difference (MW test, p-value=0.4795).

Treatment	Informed player's average payoff		Uninformed player's average payoff		Efficiency	
	Observed	Predicted	Observed	Predicted	Observed	Predicted
Baseline	73.24 (1.97)	46.36	78.01 (2.25)	78.18	72.8% (0.02)	61.0%
Actions	89.72 (2.74)	103.86	95.40 (3.30)	103.86	89.1% (0.02)	100.0%
Words(s)	83.30 (11.93)	107.73	74.83 (4.20)	80.68	76.1% (0.06)	91.9%
Words(x)						
a) <i>Matching groups 13,15,16</i>	76.06 (14.45)	107.73	87.12 (3.29)	80.68	78.6% (0.05)	91.9%
b) <i>Matching group 14</i>	51.36	107.73	63.18	80.68	55.1%	91.9%

Note: standard deviations in parentheses.

Table 2.8: Average Payoffs and Efficiency, by treatment

Result 4 (efficiency):

(a) *Efficiency is highest under Actions, as predicted. We therefore do not reject Hypothesis 4 (a).*

(b) Efficiency is not significantly different in $Words(s)$ and $Words(x)$.

We therefore do not reject Hypothesis 4 (b).

2.4.5 Discussion: messages and contributions by the informed player

All in all, the theoretical predictions from Section 2.2 organize the data very well. As we, however, have seen at the beginning of this section, hypothesis 1 (b) is rejected: when the informed player talks about her contribution, she contributes more often than when she talks about the value of a contribution. Our objective here is to discuss this result in somewhat greater detail.

We display in Table 2.9, in the rows labeled Contribution Freq, the contribution frequencies by the informed player, conditional on the state and the message that she sends. For completeness, this table also displays, in the rows labeled Message Freq, the frequency with which each message is used. This latter information was already been displayed in Table 2.5.

Treatment	Message (m)		State			
			$s=0$	$s=0.75$	$s=1.5$	
Words(s)	'The state is 0'	Contribution Freq ^a .	0.0%	16.7%	100.0%	
		Message Freq ^b .	71.1%	8.8%	1.8%	
	'The state is 0.75'	Contribution Freq.	0.0%	6.7%	50.0%	
		Message Freq.	11.6%	16.2%	3.6%	
	'The state is 1.5'	Contribution Freq.	0.0%	4.1%	90.7%	
		Message Freq.	17.3%	75.0%	94.7%	
Words(x)	a) <i>Matching groups 13,15 and 16</i>	'I do not contribute'	Contribution Freq.	2.8%	23.3%	100.0%
			Message Freq.	94.9%	23.5%	9.5%
	'I contribute'	Contribution Freq.	50.0%	41.2%	100.0%	
		Message Freq.	5.1%	76.5%	90.5%	
	b) <i>Matching group 14</i>	'I do not contribute'	Contribution Freq.	0.0%	33.3%	25.0%
			Message Freq.	61.5%	17.6%	28.6%
		'I contribute'	Contribution Freq.	0.0%	7.1%	70.0%
			Message Freq.	38.5%	82.4%	71.4%

Note:^a Number of times the informed player contributes and sends m over total number of times m is sent, by state;^b Number of times m is sent over total number of times that s is drawn.

Table 2.9: Contribution frequency by the informed player, conditional on the message sent, and message use

Let us focus on the case $s = 0.75$ and the focal equilibrium. In Words(s), the informed player sends the message 'the state is 1.5' in 75% of the cases, and, in such case, she very rarely contributes (only in 4.1% of the cases), as shown in bold. In particular, the informed player lies frequently. Let us contrast this with the behavior in the matching groups 13, 15 and 16 in the Words(x) treatment. First of all, when $s = 0.75$, the informed player frequently states that she contributes (76.5%). However, conditional on sending the message 'I contribute', she indeed contributes in 41.2% of the cases. Hence, when $s=0.75$, the informed player contributes more often conditional on saying 'I contribute' as compared to when saying 'the state is 1.5' (MW test, p-value=0.0745). In contrast, conditional on sending the message 'I do not contribute' or 'the state is 0', contributions are not significantly different (MW test, p-value=0.6374).

This difference in behavior across messages 'I contribute' and 'the state is 1.5' is not driven by differences in the informativeness of the messages, as we saw in section 2.4.2, or in the reactions of the uninformed player, as we saw in section 2.4.3.

We suggest two explanations for this result, both relying on the idea that players may dislike lying. Existing research has shown that often individuals indeed have an aversion to lying about private information (e.g., Gneezy, 2005) or about intended actions (e.g., Ellingsen and Johannesson, 2004), and that the extent of lying may depend on the costs and benefits involved.

Let us first assume that players dislike lying as such. Formally, assume that the informed player's utility not only depends on her own material payoff but that she also suffers a disutility of c , when sending a message which is not true. Kartik (2009) follows this approach, which we simplify greatly here¹⁹. We will argue that it is less costly to avoid lying when the informed player talks about her contribution than when she talks about the state. Again, suppose $s=0.75$ and that we are in the focal equilibrium. When words are about the state and the informed player says 'the state is 1.5', her utility is $u_I(x=0, \text{'the state is 1.5'}, y=1)=100-c$. In contrast, if she deviates and tells the truth about the state, she can expect the uninformed player not

¹⁹A similar approach is used in Kartik et al. (2007), Chen et al. (2008) and Chen (2009).

to contribute, hence, her utility will only be 40. Consequently, a lie brings considerable benefits. Only when the cost of lying is high, if $c \geq 60$, will the informed player say 'the state is 0.75'.

Now consider the situation in which the informed player talks about her contribution. As in the previous case, if she says 'I contribute' but does not, her utility is $100-c$. If, instead, she says 'I do not contribute', her payoff drops to 40. However, in contrast to the previous case, the informed player can protect herself against this drop in payoff by saying 'I contribute' and choosing to indeed contribute. In this case, her payoff drops to 90, but she avoids the lie. For players that dislike lying somewhat, but not too much ($10 < c < 60$), this combination is the preferred one. In other words, players who dislike lying somewhat, but not too much, will choose to contribute in state $s=0.75$ and announce to do so, while they will choose to report ' $s=1.5$ ' in that state and to not contribute. Note that, if the informed player talks about the state, there is no cheap way to avoid the lie: even if she would contribute, she would still lie. This may explain why the level of free-riding depends on the language available.

The second explanation is based on the assumption that the informed player may have a taste for keeping her word. Ellingsen and Johannesson (2004) and Miettinen (2008) proposed models in which players suffer a disutility if they do not act as they announced or promised to do, and Vanberg (2008) provided evidence that people have a preference for keeping promises per se²⁰. Now, in our game, there are no explicit promises, but saying 'I contribute' is somewhat similar to making a promise, while, in contrast, saying 'the state is 1.5' clearly is not. If individuals dislike breaking promises, they might be willing to forgo monetary payoffs in order to avoid breaking a promise, but not when talking about the state. To a certain extent, this explanation thus relies on the assumption that lying about intentions is perceived as being more costly than lying about a more neutral aspect, such as

²⁰Interestingly, existing studies on games with complete information show mixed results when communication about intentions is restricted, as in our case, to pre-formulated messages. Such restricted communication does not increase cooperation or trust in some studies (e.g. Bochet et al., 2006, and Charness and Dufwenberg, 2010), while it does in others (e.g. Duffy and Feltovich, 2002). See Balliet (2010) for meta-analysis, as well as the reviews by Bicchieri and Lev-On (2007) and Koukoulis et al. (2009), and the references therein.

the state of nature.

The reader might wonder whether also guilt aversion (Batigalli and Dufwenberg, 2007) could not explain the difference in behavior across the two languages. According to this theory, an individual suffers a disutility when she lets another player down. In order to avoid this disutility or guilt, an individual might act according to what he believes others expect him to do (see Charness and Dufwenberg, 2006, Vanberg, 2008, and Ellingsen et al., 2009, for experimental tests of this theory, with the latter two papers arguing that guilt aversion may be less prominent than previously thought). Thus, if the informed player makes a promise and others expect her to keep it, she might keep it to avoid guilt. This theory, however, does not predict a priori that messages 'I contribute' and 'the state is 1.5' generate different beliefs regarding what the uninformed player expects, while also the realized equilibrium payoff is the same in both cases (and equal to 30 in case of earnings table 2), so that the extent of letting the other down also is the same. It follows that guilt aversion does not imply a different behavior of the informed player across languages.

2.5 Conclusion

In the context of a two-player, one-shot, public good game in which only one player is informed about the value of a contribution, we have compared signaling by words and actions. Using actions, the informed player reveals her contribution decision to the uninformed before the latter decides on his contribution. Using words, the informed player sends (cheap talk) messages, either about the value or about her contribution decision, before the other player decides on his contribution. We compare these signaling devices using also a baseline game in which no signaling is available.

From a theoretical perspective, by using actions, fully efficient contribution levels can be achieved. In the experiment, we find that contribution levels are indeed most efficient using this kind of signal. This result is in line with that of Potters et al. (2007).

According to standard theory, whether messages are about the value of a contribution, or about the contribution, is irrelevant. By allowing cheap

talk, two Nash equilibrium outcomes become possible, but only one of these is neologism-proof. In this equilibrium, by using the appropriate words, the informed player can elicit the uninformed player's contribution. Consequently, words can be as influential as actions. However, 'cheap talk' has a 'dark side': it allows the informed player to free-ride on the contribution of the uninformed one.

Our experiment shows that words can indeed be as influential as actions. In most matching groups, messages are informative, as much as contribution decisions. And uninformed players react to the messages 'the state is 1.5' or 'I contribute' in a similar way as to a contribution decision. Broadly, the messages used in the experiment are also in line with what (our slight refinement of) neologism-proofness predicts.

In sharp contrast to the standard theoretical prediction, however, we find that it matters whether messages are about the value of the contribution to the public good, or about the contribution of the informed player. Informed players contribute more often when saying 'I contribute', than when saying 'the value is 1.5'. Two possible explanations for this 'anomaly' were advanced in this paper: aversion to lying (coupled with the fact that it is less costly to avoid lies about contribution levels) and an intrinsic desire to keep one's word.

It is not straightforward to come up with a design that could separate the two explanations. The key is to find messages that affect whether the decision to contribute or not would turn the focal meaning of the message into a lie, while not involving an explicit promise. An admittedly somewhat contrived example would be a treatment with the following two messages: "if you contribute your payoff will be the same as my payoff" and "if you do not contribute your payoff will be the same as my payoff". In equilibrium, the informed player could send the latter message when the state is low, and the former message when the state is intermediate or high. In both the intermediate and the high state, the informed player can only prevent the message "if you contribute your payoff will be the same as my payoff" from being a lie by contributing herself since this message will induce the uninformed player to contribute. At the same time, the message is not an explicit promise about the informed player's action. So, a treatment with these two messages would

separate the cost of lying argument from the argument that people want to keep their promises.

Irrespective of the outcomes of such a treatment, though, the present paper shows that it is interesting and important to pay attention to the focal meaning of messages. This meaning affects the non-material, psychological costs of different combinations of messages and actions.

2.6 Appendix A: Proofs

Proposition 1 *The baseline game has a unique Nash Equilibrium, given by $(\sigma^*, \tau^*) = \{(0, 0, 1); 0\}$.*

Proof. Since $\frac{a+b+c}{3} < 1$, it is a strictly dominant strategy for U to choose $x_U = 0$. Since $a, b < 1$, $x_I = 0$ is a strictly dominant action for I , when $s = a$ or $s = b$. On the contrary, since $c > 1$, when $s = c$, it is a strictly dominant strategy for I to choose $x_I = 1$.

Proposition 2 *The game with Actions has a unique Nash Equilibrium, $(\sigma^*, \tau^*) = \{(0, 1, 1); (0, 1)\}$.*

Proof.- We will prove the stronger result that strategy profile X^* is the only one that survives iterated elimination of strictly dominated strategies.

Since $a \leq 0$ I has $x_I^* = 0$ as a strictly dominant action for $s = a$. From $a + b + c < 3$, it follows that U will respond to $x_I = 0$ by not contributing either: seeing $x_I = 0$ makes him less optimistic that the state is intermediate or good. This in turn implies that I has $x_{Is} = 1$ as her dominant action when $s = c$. Since $b + c > 2$, this in turn implies that U will contribute after a contribution of I . Having established that, for U , only $\tau^* = (0, 1)$ survives the elimination of dominated strategies, it easily follows that $x_{Ib} = 1$, hence, that $\sigma^* = (0, 1, 1)$ is the unique surviving strategy for I

Proposition 3 *There are two pure strategy equilibrium outcomes in the game with Words, given by, respectively:*

- (1) $X(\sigma) = (X_a(\sigma), X_b(\sigma), X_c(\sigma)) = (0, 0, 1)$ and
 $\tau(m) = 0$ for all $m \in M_s(\sigma)$, where $s = \{a, b, c\}$
- (2) $X(\sigma) = (X_a(\sigma), X_b(\sigma), X_c(\sigma)) = (0, 0, 1)$ and
 $\tau(m) = 0$ for all $m \in M_a(\sigma)$, while $\tau(m) = 1$ for all $m \in M_b(\sigma) \cup M_c(\sigma)$

Proof. First of all, note that player i strictly prefers player j ($j \neq i$) to contribute when $s > 0$, while she strictly prefers the other not to contribute when $s < 0$. Write D_i for the difference in (expected) payoff for player i between contributing ($x_i=1$)

and not ($x_i=0$). It is easily seen that $D_i = E(s) - 1$. It immediately follows that the informed player will not contribute when $s=a,b$ and will contribute when $s=c$.

For now, assume $a < 0$. If player U follows a constant strategy ($y(m) = y^*$ for all $m \in M$), then equilibrium requires $y^* = 0$, as there is at least one message where $y^* = 0$ is a best response. There can be many equilibria of this type, and there are at least $|M|$ pure equilibria of this type, one for each $m \in M$. All these equilibria are uninformative; talk is considered pure cheap talk.

Next, assume that player U 's strategy is not constant. Let \bar{m} be a message with the highest probability that player U contributes, while \underline{m} denotes one with the lowest. If these messages are unique, then types b and c will choose \bar{m} , while type a will choose \underline{m} . Equilibrium requires that $y(\bar{m}) = 1$ and $y(\underline{m}) = 0$, and this is indeed an equilibrium. We see that there are multiple pure semi-separating equilibria, but that these all yield the same outcome. Of course, \bar{m} and \underline{m} need not be unique. Non-uniqueness of \underline{m} does not create specific problems. Suppose \bar{m} is not unique. As type a will not choose any such \bar{m} , there must exist at least one \bar{m} where player U attaches beliefs of at least $\frac{1}{2}$ to facing type c and, hence chooses $y(\bar{m}) = 1$. In the equilibrium, only such \bar{m} will be chosen by both b and c . These types can differ a bit in their strategies, but not too much. This still generates the same pure semi-separating outcome. Consequently, if $a < 0$, there are only two equilibrium outcomes: one in which player U never contributes, and another one in which he contributes for sure after some messages, there is no contribution after other messages, and there is randomization after a third set of messages. In this second equilibrium, types b and c randomize among messages in the first set, a randomizes among messages in the second set, and messages in the third set appear with zero probability.

Let us finally consider $a = 0$. It will be clear from the above argument that, if we restrict ourselves to pure strategies, (only) the two equilibrium outcomes exist that were identified above. If $a = 0$, however, type a is indifferent between what U does, hence, he could randomize between \bar{m} and \underline{m} . If he randomizes, the result can be such that $D_U = E(s|m) = 0$, so that U can randomize as well. This then gives rise to various mixed equilibria. We do not specify further details here, as these can be filled in by the reader.

2.7 Appendix B: Instructions

The text in [], indicates treatment variations, while the text in { } was not included in the written instructions but read aloud by the experimenter.

{Experimenter announces: "We're now ready to begin the experiment. Thank you all for coming. You should all have a set of instructions. I am going to begin by reading through the instructions aloud"}

Instructions

Introduction

This is an experiment about decision making. You are not allowed to talk to the other participants during the experiment. If, at any stage, you have any questions raise your hand and a monitor will come to where you are sitting to answer them.

The experiment will consist of twenty-one rounds. In each round you will be randomly paired with another participant. At the end of the experiment you will be paid in private and in cash, based upon your accumulated earnings from all twenty-one rounds. Your earnings will be converted into EUR according to the following rate: 100 points = 0.70 EUR.

Choices and earnings

In each round you have to choose between two options, A and B. The other person in your pair also has to choose between option A and option B.

Your earnings and the earnings of the other person in your pair will depend on your choice, the choice of the other person and the earnings table selected randomly by the computer.

One of three possible earnings tables is randomly selected by the computer at the beginning of each round, and may vary from round to round. In any round the earnings table is equally likely to be earnings table 1, earnings table 2 or earnings table 3. This earnings table is the same for you and the person with whom you are paired in a round. The earnings table may be different for different pairs of participants.

For each earnings table, your earnings are displayed below. These earnings depend on your choice and that of the other person in your pair. If

you want to know your earnings for a particular earnings table and a choice made by you and the other person in your pair, first move to that particular earnings table. Then, select your choice and that of the other person. Your earnings are stated in points. From these tables you can also calculate the earnings of the other person in your pair, by switching the terms ‘your choice’ and ‘other person’s choice’.

{Experimenter announces: In the next page you see three tables. Your earnings are displayed depending on the earnings table selected by the computer, your choice and the choice of the other person}.

If the earnings table is 1,

Earnings Table 1			
Other person’s choice			
		A	B
Your choice	A	40	40
	B	0	0

If the earnings table is 2,

Earnings Table 2			
Other person’s choice			
		A	B
Your choice	A	40	100
	B	30	90

If the earnings table is 3,

Earnings Table 3			
Other person’s choice			
		A	B
Your choice	A	40	160
	B	60	180

Procedure and information

At the beginning of each round you will be randomly paired with another participant. This will be done in such a way that you will not be paired with the same person two rounds in a row. Nor will you be paired with the same person more than three times throughout the experiment. You will never

know the identity of the other person in your pair, nor will that person know your identity.

In each round, one participant in each pair is randomly chosen to be the first mover and the other the second mover. At the beginning of each round you will be informed about your role (first mover or second mover) in the pair for that round.

The first mover will be informed about the exact earnings table selected by the computer (earnings table 1, earnings table 2 or earnings table 3) before making his or her choice, but the second mover will not be informed about the earnings table before making his or her choice.

[Words(s) and (x): In each round, the first mover will choose a message he or she wishes to send to the second mover. first movers may choose among the following messages:]

[Words(s):

- “The earnings table selected by the computer is 1”
- “The earnings table selected by the computer is 2”
- “The earnings table selected by the computer is 3”.

Please note that it is costless for the first mover to send a message.]

[Words(x):

- “I choose A”
- “I choose B”.]

Please note that it is costless for the first mover to send a message.]

[Baseline and Actions: In each round,] [Words(s) and (x): Also,] the first mover will enter a choice (A or B). [Baseline: Then,] the second mover will enter a choice (A or B). [Actions, Words(s) and (x): Before making his or her choice the second mover will be informed about the first mover’s [Words(s) and (x): message but not choice.] [Actions: choice.]]

When all the second movers have made their choices, the result of the round will be shown on your screen. The screen will list the earnings table that was selected by the computer, [Words(s) and (x): the message that was sent by the first mover,] the choices made by you and the other person in your pair, the amounts earned by you and the other person in your pair, and your accumulated earnings until that round.

Quiz

To make sure everyone understands how earnings are calculated, we are going to ask you to complete a short quiz. Once everyone has completed the quiz correctly we will continue with the instructions. If you finish the quiz early, please be patient. For each question you have to calculate earnings in a round for you and the other person in your pair.

{Experimenter announces: "Now please answer the questions in the quiz by filling in the blanks. In five minutes I'll check each person's answers. If you have a question at any time, just raise your hand."}

Complete the following table

[Baseline and Actions

Earnings table selected by the computer	Your choice	Other person's choice	Your earnings	Earnings of the other person in your pair
2	B	B	—	—
1	B	B	—	—
3	A	B	—	—
1	A	B	—	—
3	A	A	—	—
3	B	A	—	—

[Words(s): Earnings table selected by the computer	Message sent by first mover 'The earnings table selected by the computer is:	Your choice	Other person's choice	Your earnings	Earnings of the other person in your pair
2	1'	B	B	—	—
1	1'	B	B	—	—
3	3'	A	B	—	—
1	2'	A	B	—	—
3	3'	A	A	—	—
3	1'	B	A	—	—

Earnings table selected by the computer	Message sent by first mover 'I choose	Your choice	Other person's choice	Your earnings	Earnings of the other person in your pair
2	A	B	B	—	—
1	B	B	B	—	—
3	A	A	B	—	—
1	B	A	B	—	—
3	A	A	A	—	—
3	A	B	A	—	—

{When all subjects have completed quiz correctly, experimenter announces:
"Everyone has completed the quiz so I'll continue with the instructions at the top of the fourth page where it says "summary"."} }

Summary

Before we start the experiment let us summarize the rules. The sequence of each round is as follows:

1. Two participants are randomly paired; one is randomly chosen to be the first mover and the other the second mover.
2. The earnings table is selected by the computer: the earnings table is equally likely to be earnings table 1, earnings table 2 or earnings table 3.
3. The first mover is informed about the earnings table selected by the computer.
4. [Words(s) and (x): The first mover choose which message he or she wishes to send to the second mover]
5. The first mover chooses between A and B.
6. The second mover [Actions, Words(s) and (x): is informed about the first mover's [Words(s) and (x): message] [Actions: choice], but not the earnings table, and] chooses between A and B.
7. Both the first mover and the second mover are informed about the results of the round.

After round 21 the experiment ends and each participant is paid his or her accumulated earnings, in private and in cash. Recall that accumulated earnings will be converted to EUR according to the following rate: 100 points = 0.70 EUR.

{Experimenter announces: "We will now start the experiment. At various times you will have to wait for others to make their decisions. When that happens please be patient. On the top right corner of your screen you will see a time display labeled "remaining time (sec)". This time display is not binding, you may take as much time as you need to reach your decision. If you have a question at any time, just raise your hand."}

Chapter 3

Hiding an Inconvenient Truth: Lies and Vagueness¹

The effective manager, in organizational terms, develops strategies to keep workers at their tasks (...) these managerial strategies included: lying to workers about opportunities for advancement, deceiving overburdened workers at their tasks (...)

Jackall (1980, p.158)

The rule of thumb here [in the communication between bosses and subordinates] seems to be that the more troublesome a problem, the more desiccate and vague the public language describing it should be.

Jackall (1988, p.136)

"No comment" is a comment.

Georg Carlin (comedian)

3.1 Introduction

A standard assumption in economic models is that players opportunistically misreport their private information when it is in their (material) interest to

¹This chapter is based on Serra-Garcia, van Damme and Potters (2011).

do so. Recent experimental studies, which are briefly reviewed below, have, however, shown that many individuals have some aversion to lying. In the present paper we examine how lying aversion interacts with the language that is available for communication. We compare, theoretically and experimentally, a setting in which only precise (single-valued) messages about the state of the world are allowed to one in which messages are allowed to be vague (set-valued).

We hypothesize that, all else equal, people prefer to be vague but truthful over being precise but untruthful. In case messages must be precise, inconvenient information can only be concealed by means of a lie. Whether senders will use such lies will depend on the strength of lying aversion. In case vague messages are available, these can be used to cover up inconvenient information, whilst lying is still avoided. To make this work, in equilibrium, the same vague messages must then be used when the information is convenient. Otherwise, the receiver can infer that vagueness means bad news and act accordingly.

Lies and vagueness are particularly important in the game we study because they can be efficiency-enhancing and even Pareto improving *ex ante* relative to truthtelling. This contrasts with most studies on lying aversion, which examine lies that, when believed, hurt others. In our game, when messages must be precise, a strong aversion to lying may hurt both the sender's and the receiver's material payoffs. Will this be sufficient to induce the sender to lie? If vague messages are available, will they be used to prevent lying? If so, will they be used consistently, that is, both when information is convenient and when it is inconvenient? Can senders resist the temptation to communicate convenient information precisely?

We address these questions in the context of a 2-player public good game with asymmetric information. In particular, we use the Actions game of Chapter 2, in which the informed player (labeled leader in what follows) contributes first. The uninformed player (follower) observes the leader's contribution, makes inferences about the value, and then decides on his contribution. The public good has three equally likely values: low, intermediate or high. If the value is low, it is individually rational and (Pareto) efficient not to contribute. In contrast, if the value is high, contributing is both individu-

ally rational and efficient. In the intermediate case, the game is a prisoners' dilemma: it is Pareto efficient to contribute, but each player has an incentive to free ride. The parameters are such that, given his prior beliefs, the follower's best action is not to contribute. However, if the follower knows that the value is equally likely to be intermediate or high, contributing becomes his best response. If the leader can only communicate through her actions ("leading by example", as in Hermalin (1998) and Vesterlund (2003)), then she will contribute if and only if the value is intermediate or high, since the follower will then imitate her contribution. Thus, the game with Actions has a unique Nash equilibrium (both players contribute if and only if the value is intermediate or high), and this is efficient. Potters et al. (2007) have shown that behavior in the laboratory conforms to this equilibrium, hence, a high efficiency level is obtained.

We introduce communication in this game by allowing the leader to send, alongside her contribution decision, a message about the value of the public good. In the case of precise communication (PC), three messages are available: 'the value is low', 'the value is intermediate' and 'the value is high'. In the treatment with vague communication (VC), we allow the leader to mention any combination of states, or to say nothing. Hence, in total eight messages are then available. In this case, precise messages are still available, but the leader can also say things like 'the value is intermediate or high' or 'the value is low, intermediate or high', or not say anything (send a blank message). We term a message vague if it is not available in PC.² Note that all these messages have a literal meaning. Throughout, we maintain the assumption that these literal meanings are understood and can be assumed to be understood. We say that a message is a lie whenever it is a statement which is not true.³ Consequently, in PC, a message is a lie when the value

²In the literature, vagueness has been defined in different ways. The Stanford Encyclopedia of Philosophy defines a term to be vague if there exist statements using this term that resist all attempts to settle whether it is true or false. According to this definition, the statement "this boy is small" can be vague. Strictly speaking, the statement "my type is in S" is not vague. What we call vague messages in this paper are set-valued messages. We compare point-valued communication to set-valued communication. Other papers define vagueness as noise in the communication process (Blume and Board, 2009). We will turn to the differences in the next section.

³Although this may appear to be a rather trivial definition, in the philosophical literat-

stated in the message is different from the actual one. A vague message is truthful if it contains the actual value or is blank; otherwise it is a lie.

Under the standard assumptions (of self-interested and rational players), the game in which communication is required to be precise does not have an equilibrium in which the leader always tells the truth and the outcome is efficient. If the leader were to reveal truthfully that the game is a prisoners' dilemma, the follower would free ride and then it is best for the leader to not contribute either. When the value is intermediate, there are thus three possibilities in PC: (i) lying about the value (saying it is high) and contributing, (ii) revealing the true value, anticipating the free riding of the follower and best responding to that, and (iii) revealing the true value, but nevertheless contributing and hoping that the follower will reciprocate. The last strategy seems rather risky; the second is costly in terms of payoffs and efficiency, while the first involves lying. All three options have their drawbacks: which one will be chosen?

Previous evidence leaves the answer to this question open. On the one hand, anecdotal evidence suggests that lying is common; compare our opening quote for the case of managers communicating to their workers. Similarly, Gneezy (2005) finds that individuals are willing to lie and that more individuals lie if the costs the lie inflicts on the receiver decrease. On the other hand, Erat and Gneezy (2009) find that several individuals (at least 39%) avoid Pareto white lies, despite their efficiency-enhancing nature.⁴

The dilemma about what to do in the intermediate state is somewhat less pronounced in the VC treatment. Here the leader does not need to lie to achieve the efficient outcome. If the value is intermediate, she can simply use a blank message, or say 'the value is intermediate or high'. An important

ure there is quite some discussion about the appropriate definition of a lie, in particular on whether the intention to deceive is a necessary condition for a statement to be a lie (e.g. Bok, 1978). We do not have to enter into this discussion; our game is simple enough so that we can abstract from false statements made by mistake. Other studies in economics, with a focus on deception, rather than lying, highlight that by telling the truth one may also be deceiving others, see e.g. Sutter (2009).

⁴Erat and Gneezy (2009) define White Lies as lies that increase the receiver's payoff. They further distinguish between Pareto White Lies, which increase both the sender and the receiver's payoffs, and Altruistic White Lies, which increase the receiver's payoffs but decrease the sender's. As our game shows, the classification of a statement along these lines can depend upon the point in time at which the statement is evaluated.

condition for this to work is that the same message be then used also when the value is high; otherwise a rational and selfish follower will infer that the value is intermediate and not contribute in this case. However, if the leader has an aversion towards making vague statements, or if she naively communicates the state when it is high, a problem remains. Therefore, it is relevant to investigate whether there are differences in communication patterns and contribution decisions between PC and VC.

Our experiment reveals that, in PC, the leader frequently lies when the value is intermediate, by saying that it is high. In contrast, low or high values are revealed truthfully. In most cases, the leader contributes for intermediate and high values, and the follower reacts by mimicking the leader. Consequently, in PC, contributions are not significantly lower, as compared to the benchmark treatment without communication (NC), and efficiency is preserved.

When the language is richer, as in VC, the frequency of lies in the intermediate state drops significantly; the leader instead often uses vague messages, such as a blank message, or by saying ‘the value is intermediate or high’. Interestingly, these vague messages are used much less often when the value is high; in this case, most often the true state is simply revealed. In VC, we, hence, observe overcommunication (i.e., the leader’s messages lead to a finer partition of states than in equilibrium), a phenomenon that earlier has been observed in Forsythe et al. (1999), Blume et al. (2001) and Cai and Wang (2006). The follower does not seem to realize that he should not trust vague messages; he neglects them, or interprets them literally, and contributes. Accordingly, contribution levels of both the leader and the follower remain at the same levels as without communication, and thus efficiency does not vary in this treatment either.

The communication pattern observed is thus consistent with players displaying some aversion to lying, although the “psychological cost” of lying does not seem to be too high. Furthermore, vague messages are risky since good information is revealed precisely. It is only as a consequence of the fact that the follower does not seem to realize such overcommunication in the good state that using vague messages is effective in the VC treatment.

Our results are in line with the anecdotal evidence reported by Jackall

(1980, 1988), cited in the opening quotes, that effective managers resort to lying to motivate their workers when this is required. It is also in line with the suggestion that vague language will be used when the situation is somewhat "troublesome". It also points out an important consideration for studying communication in laboratory experiments. Using vague messages can be a way to costlessly avoid lying, and this might naturally be preferred by participants. A caveat is that this strategy only works if the uninformed side is somewhat naïve: as parties with good information tend to reveal their information, vagueness is often a veil to cover an inconvenient truth.

The remainder of the paper is organized as follows. Section 3.2 briefly relates our study to the literature. In Section 3.3, we outline the (stable) equilibria of the games without and with communication, where in the latter case we distinguish between the pure cheap talk case and the case where lying is associated with costs. In Section 3.4, we list the hypotheses that follow from the theory. In Section 3.5, we describe the experimental design and the procedures. The experimental results are presented in Section 3.6. Section 3.7 concludes. All proofs are included in Appendix A.

3.2 Literature Overview

In the literature, two approaches have been taken to study cheap talk communication of private information or of intended actions. The first approach starts by assuming that messages have no a priori meaning and focuses on the evolution of their strategic meaning over time (among others, Blume, 1998). In this approach, the meaning of messages is thus endogenous to the game and derived from their use in equilibrium. Starting with Farrell (1985, 1993), there is a second approach that focuses on messages with an established, literal meaning. Blume et al. (2001) compare these two approaches in sender-receiver games with partial common interest, showing that, with a priori meaning, communication is more likely to arise and does so more quickly. Our work is in the second tradition. The messages that are considered in this paper have a natural (or focal) meaning, and, although messages need not be believed, they will always be understood. Within this second approach, one can also meaningfully talk about lying; in effect, when the sender is averse to

lying, this transforms the game from one with costless signaling to one with costly signaling.

Kartik et al. (2007) and Kartik (2009) present models of strategic communication with lying costs and show that such costs may lead to “language inflation”, whereby in equilibrium the literal meaning of messages is higher than the true state. We incorporate lying costs along the same lines and observe a similar effect. Closely related papers are Chen et al. (2008), who present a refinement to select among cheap talk equilibria, with one of the motivations behind being related to lying costs, and Chen (2009) where a model with honesty and receiver naïvete is developed. Demichelis and Weibull (2008) theoretically show, in a certain class of complete information coordination games, that lexicographically small lying cost may lead to the selection of the Pareto dominant Nash equilibrium.

Recently, several experimental studies have examined individuals’ decision to lie in different games; among others, see Gneezy (2005), Sanchez-Pages and Vorsatz (2007), Fischbacher and Heusi (2008), Hurkens and Kartik (2009), and Lundquist et al. (2009). In these studies, the emphasis is on lying with the intention to deceive: subjects are presented with the choice of lying and increasing their payoff at the expense of others, or telling the truth and forgoing some monetary payoff. A frequent finding is a non-zero portion of individuals who are telling the truth, despite its monetary costs.

In our paper, we concentrate on lies which are (ex ante) Pareto-improving, that is, they can increase both the sender’s as well as the receiver’s payoff. Considering this ex-ante perspective, such lies could also be called Pareto White Lies, as is done in Erat and Gneezy (2009). However, from an ex-post perspective, if the leader contributes when the state is intermediate, lying is not beneficial for the follower, as he would earn a higher payoff if he would not contribute. The study by Erat and Gneezy (2009) does not display this difference between the ex-ante and the ex-post situation, because in their game the uninformed player has no information at all on the payoff consequences, whilst ours is a standard incomplete information game. Also, in their paper they only allow for precise messages. Therefore, the fact that, in natural language, vague messages offer a costless way to avoid lying or telling the precise truth has remained unexamined in previous experimental

studies on lying aversion.

We assume messages have a literal meaning and, therefore, their interpretation with respect to the set of values of the public good is clear. In this context, we say a message is vague if it contains several values or none. Hence, we identify vagueness with 'set-valuedness'. Vagueness has been used and defined in a different way in Lipman (2009), Blume and Board (2009) and Agranov and Schotter (2009). Lipman (2009) discusses several definitions of vagueness and why it cannot be optimal under standard assumptions, and concludes arguing that a model of bounded rationality is necessary. Blume and Board (2009) formalize vagueness as noise in the communication process (see also Blume et al., 2007). They find that vagueness can be efficiency-enhancing, as the noise mitigates the conflict between the sender and receiver. In our paper, vagueness can be efficiency-enhancing, since it allows a leader with a strong lying aversion to avoid lying and nevertheless elicit the follower's contribution. Agranov and Schotter (2009), on the other hand, define vagueness as lack of meaning (e.g., the words "x is high"), and compare it to ambiguity, which is defined as lack of a unique interpretation (e.g., the message "x is between 0 and 2"). They find experimentally that vague messages and ambiguous messages perform similarly, as long as the number of vague words available is small. If many vague words become available, efficiency decreases.

In addition to the aforementioned papers by Blume et al. (2001) and Agranov and Schotter (2009), several experimental studies have compared the effect of different message sets (languages), but none has compared precise to vague communication. Forsythe et al. (1999) study the impact of restricting communication to include the true state of nature, compared to unrestricted cheap talk. They find that efficiency increases when senders are forced to reveal the true state. Blume et al. (1998) increase the message space from two to three messages. They find that, when the interests of senders and receivers conflict, this leads to a slight increase in pooling equilibria and, thus, less information is transmitted.⁵ Sanchez-Pages and Vorsatz

⁵Some experimental studies of sender receiver games allow senders to send vague messages, containing more than one state of nature (Dickhaut et al., 1995, and Cai and Wang, 2006). Their focus is however on how much information is transmitted as interests of senders and receivers diverge.

(2009) allow the sender to remain silent, but at a cost, and do not distinguish between telling the truth and telling the precise truth, as we do in our paper.

Finally, in the previous Chapter, we compare talking about actions, e.g. "I contribute", to speaking about private information, "the value is x ". There, we consider the same public good setting, but where talk occurs only if moves are simultaneous. In that case, in the intermediate state, the informed player has an incentive to talk the other into contributing without contributing herself. We find that the leader does so when talk is about her private information, but that she significantly increases her contribution when she is forced to talk about that.

3.3 Theoretical Framework

3.3.1 The Actions Game

As in Chapter 2, in our public good game G , there are two players, the leader and the follower. At the beginning of the game, Nature moves by picking the state of nature s from the set $S = \{a, b, c\}$, where $a \leq 0$, $0 < b < 1$, $c > 1$, and all values are equally likely. The payoff function of player i is

$$u_i = 1 - x_i + s(x_i + vx_j) \quad i \in \{1, 2\}, j = 3 - i$$

where $v > 0$ measures the positive externality imposed by player j on player i . We assume again that $b + c > 2$, $a + b + c < 3$, $a(1 - v) < 1$ and $b(1 + v) > 1$.

If the state $s = a$ is common knowledge, it is both individually rational and socially optimal not to contribute. In fact, both players not contributing is the unique Pareto efficient outcome in that case. Instead, when $s = c$, it is a dominant strategy to contribute and both players contributing is the unique Pareto efficient outcome. Since $\frac{1}{1+v} < b < 1$, the intermediate state b corresponds to a prisoners' dilemma: it is individually rational not to contribute, but it is socially optimal to do so.

However, we consider a situation where s is not common knowledge: *only* the leader is informed about the value of s . We focus on the Actions game, where the leader chooses $x_1 \in \{0, 1\}$ first. The follower observes x_1 and

chooses $x_2 \in \{0, 1\}$. The condition $b + c > 2$ implies that, if the follower knows that the state is either b or c , both with 50% probability, then he will choose $x_2 = 1$. The condition $a(1 - v) < 1$ guarantees that the leader has not contributing as a dominant action if $s = a$. This implies that the Actions game is dominance solvable, hence, has a unique Nash equilibrium. We write a strategy of the leader as $\sigma = (\sigma_a, \sigma_b, \sigma_c)$, where σ_s denotes the probability of contributing in state s . A strategy of the follower will be specified as $\tau = (\tau_0, \tau_1)$ where τ_z denotes the probability that the follower contributes given that $x_1 = z$.

Proposition 1 *The Actions game has a unique Nash Equilibrium, (σ^*, τ^*) with $\sigma^* = (0, 1, 1)$ and $\tau^* = (0, 1)$. This equilibrium is efficient, that is, the sum of the players' payoffs is maximized for all $s \in S$.*

Given full efficiency without communication, we next ask what will be the effect of adding verbal communication to the Actions game. What communication strategies would the leader use if talk about the state of nature is costless? What will the equilibria be? We address these questions theoretically in the following subsections.

3.3.2 Allowing communication

We now add one-way communication from the leader to the follower. After the leader is informed about s , she sends the follower a message, $m \in M$, where M contains at least two messages. At the same time, she chooses x_1 . The follower observes m and x_1 and chooses x_2 . The payoff function of each player remains as above, hence, the additional communication is costless ('cheap talk'). We write $G(M)$ for the resulting game. We first consider the pure cheap talk case with a general message set M , and then move to the language sets in the case of PC and VC, together with lying costs. We will show that, in the general case, although allowing communication leads to additional and inefficient Nash equilibria, only the efficient equilibrium from Proposition 1 is stable.

As a result of the messages being costless, game $G(M)$ allows multiple equilibria. Part of this multiplicity is 'inessential' (payoff irrelevant) and only

concerns the messages. For example, one equilibrium has players contributing according to the strategy pair (σ^*, τ^*) from Proposition 1, but the leader announcing m' for any $s \in S$ whereas another equilibrium has the same contributions, with the leader always announcing a different message m'' . Clearly, such multiplicity is not very interesting. However, there are also other, quite different, equilibria, with inefficient contribution levels, and such equilibria are even sequential. For example, suppose that the leader chooses $(m', 0)$ in state $s = a$, and chooses $(m'', 0)$ if $s = b, c$. Also, suppose that the follower responds to $(m'', 0)$ with $x_2 = 1$ and to all other combinations of messages and actions with $x_2 = 0$. Further, the follower stubbornly believes that any action of the leader different from $(m', 0)$ or $(m'', 0)$ signals that the state is $s = a$, while after $(m', 0)$ and $(m'', 0)$ his beliefs satisfy Bayes' rule. Given this behavior of the follower, the best response of the leader is to follow the strategy as indicated, and we have obtained a Nash (even Sequential) Equilibrium in which only the follower contributes, and then only when the state is intermediate or high: the efficiency of this equilibrium is substantially lower than that of the Nash Equilibrium from Proposition 1.

The inefficient Sequential Equilibrium from the previous paragraph does not survive the Intuitive Criterion (Cho and Kreps, 1987). Suppose the leader deviates from her equilibrium strategy and chooses $(m'', 1)$. Then, under the Intuitive Criterion, the follower must infer that the state is $s = c$, since only in this state can the deviation possibly yield the leader a payoff higher than in the current equilibrium. But, given such beliefs, it is a best response for the follower to choose $x_2 = 1$ after the deviation, upsetting the equilibrium.

Although the intuitive criterion suffices to eliminate this specific inefficient equilibrium, we need to apply a refinement which is a little stronger to eliminate the multiplicity in contributions in general.⁶ Formally, we rely on the 'equilibrium dominance' criterion, which is implied by stability as in Kohlberg and Mertens (1986). We show that all stable equilibria of the cheap

⁶Equilibria exist in which the leader randomizes between different messages when $s = a$, including also the message, say m'' , used when $s = \{b, c\}$. In neither state does the leader contribute. The randomization is such that the follower is indifferent between contributing or not after m'' . In such an equilibrium, the leader also has an incentive to deviate to contributing when $s = b$. The intuitive criterion is not powerful enough to eliminate mixed equilibria of this type.

talk game $G(M)$ lead to the same contribution levels as those obtained in Proposition 1.

To state this result formally, we introduce some notation. Let σ denote a strategy of the leader in the game $G(M)$ with communication language M and let τ be a strategy of the follower. Then $\sigma = (\sigma_a, \sigma_b, \sigma_c)$ where $\sigma_s : M \times \{0, 1\} \rightarrow [0, 1]$, and $\sigma_s(m, x_1)$ denotes the probability that a message-contribution pair is chosen by the leader in state s . If the strategy is pure, that is, does not involve any randomization, we simplify notation by writing $\sigma_s = (m, x_1)$. Similarly τ specifies the probability $\tau(m, x_1)$ that the follower will contribute for any message-contribution pair (m, x_1) that the leader may choose. We write $M_s(\sigma)$ for the set of messages in M that occur with positive probability when the state is s and σ is played. Similarly $X_s(\sigma)$ denotes the probability that the leader contributes when the state is s and σ is played. Finally, $E(s \mid m, x_1; \sigma)$ denotes the expected value of s given (m, x_1) and strategy σ .

Proposition 2 *In any stable equilibrium of the game $G(M)$ we have:*

- (1) $(X_a(\sigma), X_b(\sigma), X_c(\sigma)) = (0, 1, 1)$
- (2) $E(s \mid m, 1; \sigma) \geq 1$ for all $m \in M_b(\sigma) \cup M_c(\sigma)$
- (3) $\tau(m, 0) = 0$ for all $m \in M_a(\sigma)$, while $\tau(m, 1) = 1$ for all $m \in M_b(\sigma) \cup M_c(\sigma)$

Condition (1) states that, in a stable equilibrium, the leader contributes unless $s = a$. Condition (2) states that for any message that is sent with positive probability when $s = b$ or $s = c$, the follower's conditional expected value of s is at least 1. This condition is necessary and sufficient for the best reply of the follower to be to contribute. Condition (2) is satisfied if types b and c of the leader follow the same strategy ($\sigma_b = \sigma_c$), with this being different from the strategy of type a ($\sigma_a \neq \sigma_b$); more generally, it requires that σ_b and σ_c are not too different. Condition (3) states that the follower mimics the contributions of the leader.

Proposition 2 implies that, with communication, and irrespective of the language that is available, the (stable) equilibrium *contributions* are the same as in the equilibrium without communication. Note, however, that, if speaking is costless, equilibrium does not determine the *messages* that will be

used: as long as the messages used in states b and c are sent with a similar frequency, a stable equilibrium results. By using messages with a literal meaning, and assuming that players are averse to lying, we can, to a great extent, eliminate this indeterminacy. In fact, when messages have to be precise, the indeterminacy is eliminated. We turn to this in the next subsection.

3.3.3 Messages with literal meaning and lying costs

We now focus on the case where messages have a literal meaning. We allow the leader to talk about the state and consider two different languages. In the first, the leader is forced to communicate precisely: she has to communicate a state, hence, messages correspond to states. We refer to this game as $G(PC)$. The messages available are $M_{PC} = \{a, b, c\}$. In the second case, $G(VC)$, also vague communication is allowed: the leader communicates a set of states. This means, $M_{VC} = \{a, b, c, 'a \text{ or } b', 'a \text{ or } c', 'b \text{ or } c', 'a, b \text{ or } c', 'blank'\}$. The second language is richer than the first; all messages that are available in the first case are also available in the second.

In both cases, the leader can lie if she wants, but we assume that she has an aversion to do that: if in state s the message m is a lie, then the leader incurs a disutility of ε ; for the rest the payoffs remain as specified at the beginning of Section 3.3.1. We refer to the resulting games as $G_\varepsilon(PC)$ and $G_\varepsilon(VC)$. Note that our assumption implies that the leader does not value being precise, hence, she does not mind using vague messages. At the end of this subsection, we will argue that, if the leader would prefer to be precise, vague messages would lose their attraction; we would essentially be back in the game with precise communication.

Proposition 3 *In any stable equilibrium of the game $G_\varepsilon(PC)$ with precise communication and positive cost of lying, we have:*

- If $\varepsilon < b(1 + v) - 1$: $\sigma_a = (a, 0)$, $\sigma_b = \sigma_c = (c, 1)$, and

$$\tau(a, 0) = 0, \tau(c, 1) = 1;$$
- If $\varepsilon > b(1 + v) - 1$: $\sigma_a = (a, 0)$, $\sigma_b = (b, 0)$, $\sigma_c = (c, 1)$, and

$$\tau(a, 0) = \tau(b, 0) = 0, \tau(c, 1) = 1$$

Proposition 3 shows that, if lying costs are small, the contribution levels

remain as in the game without verbal communication. The leader contributes if and only if the state is b or c , and the follower mimics the leader's contribution. Furthermore, the assumption of lying costs leads to a precise prediction about which messages will be used: the leader lies when $s = b$ by saying that it is c , and is truthful in the states a and c . However, if lying costs are larger, the leader truthfully reveals each state, so that neither player contributes in state b , with a drop in efficiency as its consequence.

Note that, in any stable equilibrium of $G_\varepsilon(PC)$, the leader always obtains his best possible payoff, both when the state is a as when it is c . In contrast, if $s = b$, the leader can improve: if ε is small, she incurs lying costs, while for large ε the contributions are not at the efficient level. These negative aspects can be avoided when vague messages can be used, as in the game $G_\varepsilon(VC)$. We have:

Proposition 4 *The game $G_\varepsilon(VC)$ with vague communication and positive cost of lying has multiple stable equilibria. First of all, any stable equilibrium of the game $G_\varepsilon(PC)$ remains stable in $G_\varepsilon(VC)$. Next to that, there are stable equilibria in which the leader, while being truthful, uses a vague message when $s = b, c$, hence:*

- $\sigma_a = (m_a, 0)$ where m_a is a message that is truthful when $s = a$, and $\tau(m_a, 0) = 0$
- $\sigma_b = \sigma_c = (m, 1)$ where m is a vague message that is truthful both when $s = b$ and $s = c$, and $\tau(m, 1) = 1$

Note that, when $s = a$ or $s = c$, both players are indifferent about which of the equilibria from Proposition 4 is played. In contrast, when $s = b$, the leader strictly prefers an equilibrium with vague communication. Consequently, from the ex ante point of view, the leader prefers vague communication. When lying costs are small, this preference is not very strong, but the larger these costs are, the more the leader prefers to communicate vaguely. Furthermore, for large lying costs, also the follower strictly prefers an equilibrium with vague communication. On the basis of these attractive payoff properties, we predict players to coordinate on such an equilibrium (see Hypothesis 3 in the next section).

To conclude this Section, let us briefly discuss the case where the leader does not just dislike lying, but where she also dislikes being vague. If we assume that vagueness is disliked equally much as lying (hence, vague messages are associated with the same cost of ε), then we are essentially back to the context of Proposition 3. A slight adaptation of the proof of that Proposition shows that when $s = a$ or $s = c$ the leader will be precise and truthful, hence, this modified game, $G'_\varepsilon(VC)$, has a unique stable equilibrium outcome, which is as in Proposition 3.

3.4 Hypotheses

If lying costs are absent, as in the standard game theoretic approach, or sufficiently small, we obtain the result that the stable equilibria of the game with (precise or vague) communication lead to the same contribution levels and, hence, efficiency, as the game without communication (Propositions 1-4). This forms our main hypothesis.

Hypothesis 1: *The addition of communication has no effect on contributions, payoffs and efficiency.*

Taking into account the literal meaning of messages, and assuming small lying costs, we can also hypothesize which messages will be used by the leader in each state. If communication must be precise ($G_\varepsilon(PC)$), and lying costs are small, the leader will send message a when $s = a$, while she will send message c when the state is b or c . This leads to Hypothesis 2.

Hypothesis 2: *When communication must be precise, the leader reveals states a and c truthfully and precisely. But, she lies when the state is b , by saying that it is c .*

However, if lying costs are large, Hypothesis 2 does not hold. In consequence, Hypothesis 1 would also be rejected. In particular, from Proposition 3, we know that, if lying costs are large, the leader prefers to reveal that the state is b and to not contribute in that state. This, in turn, implies that, if $s = b$, the follower does not contribute either, and that efficiency falls.

In contrast, when communication can be vague (as in $G_\varepsilon(VC)$), the leader prefers sending vague and truthful messages, such as the state is 'b or c', 'a, b, or c', or 'blank', when the state is b or c . This leads to Hypothesis 3.

Hypothesis 3: *When communication can be vague, the leader sends a truthful message in state a . When the state is b or c , the leader uses the same vague and truthful message.*

Lastly, the follower, who is assumed to be rational and self-interested, reacts optimally to the information revealed by the leader. Therefore, in the PC treatment, he contributes after observing a contribution of the leader accompanied by message c . In treatment VC, he contributes after observing a contribution of the leader accompanied by a message that is truthful when the state is c . This leads to Hypothesis 4.

Hypothesis 4: *The follower's contribution decision is optimal given the information revealed by the leader's contribution and message, if available. Consequently,*

- (i) In NC, the follower imitates the leader;*
- (ii) In PC, he contributes after observing a contribution of the leader together with message c ;*
- (iii) In VC, he contributes after observing a contribution of the leader together with a message that is truthful in state c .*

3.5 Experimental Design and Procedures

As in Chapter 2, the payoff function of our game was given by $u_i = 40[1 - x_i + s(x_i + vx_j)]$, where $i = \{1, 2\}$, $j = 3 - i$, $s = \{0, 0.75, 1.5\}$ and $v = 2$. Payoffs (in points) are shown below again for each s . These tables were shown to subjects both in the instructions (see Appendix B) as well as on the computer screens.

In each round, the leader was informed about s first and then could make her choice, A or B, on the same screen. If the treatment allowed communication, the leader, at the same time, was asked to select a message from a list of possible messages. The follower was informed about the leader's

choice (and message, when relevant) and was asked to choose between A or B. The roles of leader and follower were randomly determined within each pair in each round.

		$s = 0$		$s = 0.75$		$s = 1.5$	
		Other person's choice		Other person's choice		Other person's choice	
		A	B	A	B	A	B
Your choice	A	40	40	40	100	40	160
	B	0	0	30	90	60	180

Table 3.1: Payoff matrices

We ran three treatments. The No communication (NC) treatment, serves as a baseline.⁷ Under Precise Communication (PC), only precise messages regarding s could be chosen, corresponding to language M_{PC} . With Vague Communication (VC), vague messages were available, corresponding to language M_{VC} .

For each of the three treatments we had two sessions with 16 subjects each. Since we had two independent matching groups of 8 subjects in each session, we obtained 4 independent observations per treatment. Subjects were re-paired every period with another subject in their matching group and roles were randomly assigned. To have enough learning possibilities for each earnings table, subjects played the game for 21 periods. Since there were 8 subjects in each matching group, each subject met the same person 3 times. We ensured that the same pair did not meet twice in a row. Overall, 84 pairings were obtained per matching group (4 pairs x 21 periods): 25 faced Earnings Table 1, 30 Earnings Table 2 and 29 Earnings Table 3.⁸ The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007). Players were paid their accumulated earnings in cash and in private at the end of the experiment.

The experiment was conducted in CentERlab at Tilburg University during the second week of April, 2008. It lasted between 50 and 80 minutes and

⁷The data in this treatment are the same as in the treatment 'Actions' in Chapter 2. Treatments PC and VC add communication to 'Actions' and thus are novel evidence.

⁸The matching schemes, roles and states of nature for each period and pair were randomly drawn before the experiment. This allowed us to have the same patterns across different matching groups.

subjects earned 13.55 EUR on average. Most of the subjects were students in Economics (40%) and Business (40%).

3.6 Results

In this section, we report the experimental results. We first analyze the impact of communication on efficiency, and on the contributions of the leader and the follower. Then, we turn to the leader's use of messages and the follower's reactions to these. Throughout we take into account all periods of the experiment. Unless explicitly specified otherwise, the results do not change when taking the first half, or the second half of the experiment. The unit of observation is taken to be each matching group in the experiment.

3.6.1 The impact of communication on efficiency

Efficiency, defined as the sum of leaders' and followers' payoffs, divided by the maximum sum of payoffs attainable, is displayed in Table 3.2. Columns (1) to (3) display efficiency by state, while column (4) displays overall efficiency.

Treatment	Efficiency ^a			Overall (4)
	s=0 (1)	s=0.75 (2)	s=1.5 (3)	
NC	91.0%	80.1%	90.3%	87.3%
	(6.2)	(6.3)	(2.3)	(2.4)
PC	94.0%	75.7%	89.3%	85.7%
	(3.7)	(3.7)	(10.8)	(6.4)
VC	92.5%	81.5%	89.6%	87.5%
	(4.4)	(9.1)	(13.9)	(10.1)
Mann-Whitney tests, p-values				
NC vs PC	0.4678	0.3094	0.7702	0.7728
NC vs VC	0.6592	0.8845	0.2454	0.5637

Note:^a Efficiency = $\frac{\text{sum of follower and leader payoff}}{\text{maximum sum of payoffs}}$;

Standard deviations in parentheses.

Table 3.2: Efficiency by state s and treatment

The table shows that the addition of communication has no effect on efficiency. Overall efficiency is around 85% in all treatments, with little

variation. At the bottom of each column, we display Mann-Whitney tests, comparing efficiency in NC and PC, and in NC and VC, respectively. There are no significant differences across treatments. Efficiency is lowest when $s = 0.75$ and communication is precise (75.7%).

Examining contributions in somewhat more detail, we see that communication did not alter significantly the contribution of either leader or follower. Hence, also individual payoffs do not differ. Figure 3.1 displays average contributions of the leader and the follower per state and treatment, and shows that these do not change significantly across treatments.

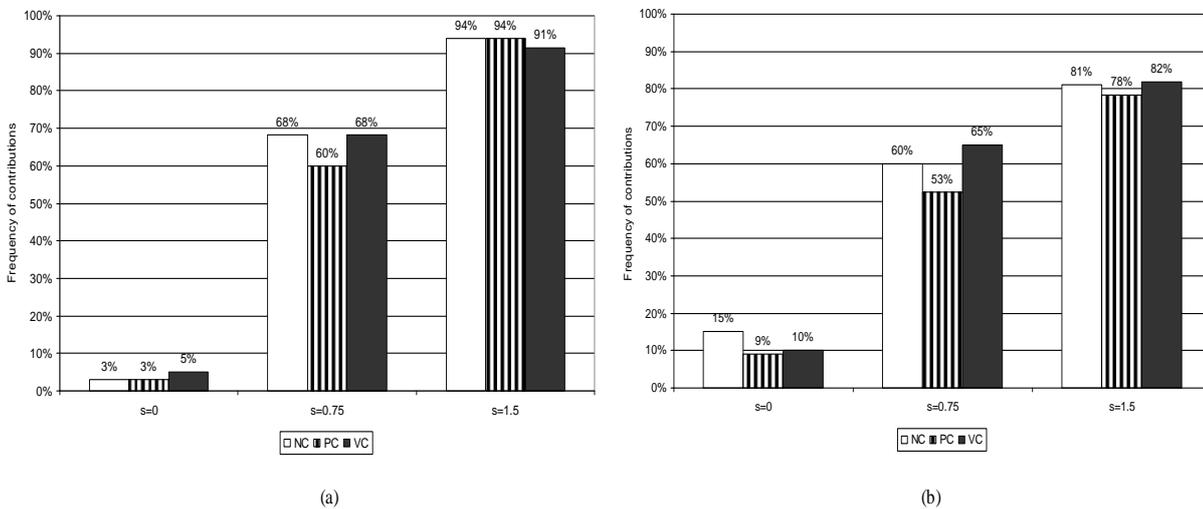


Figure 3.1: Average contributions of leaders (Figure 3.1a) and followers (Figure 3.1b) per state s and treatment

When $s=0$ (the three leftmost bars in Figures 3.1a and 3.1b), average contributions are close to 0%, while, when $s=1.5$ (the three rightmost bars), they are above 90% for player 1 and around 80% for player 2. When $s=0.75$, the average contribution lies between 50% and 70%, with that in PC being lowest for both players. Contributions in NC are similar to those observed in Potters et al. (2007). For $s=0.75$, if we compare the leader's contributions in NC (68%) with those in PC (60%), the Mann-Whitney test yields a p-value of 0.3065. The leader's contribution frequency in VC is 68%, which is not significantly different to that in NC either (MW test, p-value of 0.6612). Similarly, comparing the follower's contributions in NC vs. PC yields a p-

value of 0.4624 and NC vs. VC yields a p-value of 0.7702.⁹ Consequently, we do not reject Hypothesis 1, as summarized in Result 1.

Result 1: *The addition of communication, whether restricted to be precise or not, does not significantly affect contributions of either player, payoffs or efficiency. Therefore, we do not reject Hypothesis 1.*

3.6.2 The leader's communication

Table 3.3 displays the frequencies with which a message is sent (in %), depending on state s and the leader's contribution decision. The upper panel displays the results for the precise communication (PC) treatment, while the bottom panel gives the data for the vague communication (VC) treatment.

Under PC, in state 0, the leader is most frequently truthful and does not contribute (82%). In state 1.5, the leader is also frequently truthful, but with contribution (86.2%). In contrast, when the state is intermediate ($s = 0.75$), the leader lies in more than 70% of the cases. The truthful message, '0.75', is used in only 28.3% of the cases; in 13.3% it is paired with no contribution, and in 15% with a contribution. When $s = 0.75$, most frequently, the leader sends message '1.5' and contributes (43.3%).¹⁰ In each state the modal response is in line with hypothesis 2, and therefore in line with the stable equilibrium outcome with no or small lying costs.

⁹If we compare treatments PC and VC, the Mann-Whitney test yields a p-value of 0.6631 for the difference in the leader's contributions and 0.1059 for that in the follower's contributions.

¹⁰Interestingly, when $s=0.75$, in 20% of the cases the leader sends message '1.5' and does not contribute. This may be driven by the leader's desire to induce the follower to contribute without doing so herself. However, the follower seldom contributes after receiving message '1.5' without a contribution of the leader, as will be shown below. Over time, the leader seems to learn, since the frequency with which message '1.5' and no contribution is observed drops to 11.8% in the second half of the experiment, compared to 30.8% in the first half.

Treatment	State	Contribution	Message					other vague messages	Total
			'0'	'0.75'	'1.5'	'0.75 or 1.5'	'blank'		
PC	s=0	$x_1=0$	82.0%	6.0%	9.0%				97.0%
		$x_1=1$	0.0%	1.0%	2.0%				3.0%
	s=0.75	$x_1=0$	6.7%	13.3%	20.0%				40.0%
		$x_1=1$	1.7%	15.0%	43.3%				60.0%
	s=1.5	$x_1=0$	0.9%	0.9%	4.3%				6.0%
		$x_1=1$	0.9%	6.9%	86.2%				94.0%
VC	s=0	$x_1=0$	61.0%	3.0%	2.0%	5.0%	17.0%	7.0%	95.0%
		$x_1=1$	0.0%	0.0%	1.0%	3.0%	0.0%	1.0%	5.0%
	s=0.75	$x_1=0$	2.5%	4.2%	9.2%	3.3%	7.5%	5.0%	31.7%
		$x_1=1$	1.7%	24.2%	18.3%	8.3%	10.8%	5.0%	68.3%
	s=1.5	$x_1=0$	0.9%	0.0%	1.7%	3.4%	0.9%	1.7%	8.6%
		$x_1=1$	0.9%	1.7%	75.9%	1.7%	7.8%	3.4%	91.4%

Table 3.3: Frequency with which each combination of contribution and message decision is observed, by state and treatment

Although message '1.5' together with $x_1 = 1$ is observed more frequently in state 1.5 than in state 0.75, the difference is only marginally significant with a Wilcoxon signed ranks test (WSR-test, p-value=0.068) if we take all periods of the experiment into account, and it becomes insignificant in the second half, after period 10 (WSR-test, p-value=0.144). Consequently, with experience, the leader lies and contributes more often.

Result 2: *In the PC treatment, the leader lies in more than 70% of the cases when the state is 0.75, most often by saying it is 1.5. She reveals the state truthfully when it is 0 and 1.5. Therefore, we do not reject Hypothesis 2.*

In the VC treatment, when $s = 0.75$ vague messages are used frequently. Messages '0.75 or 1.5' and 'blank' are used in 11.7% (3.3%+8.3%) and 18.3% (7.5%+10.8%) of the cases, respectively. The leader contributes and sends message '1.5' only 18.3% of the time, a frequency which is significantly lower than in treatment PC, 43.3% (Mann-Whitney (MW) test, p=0.020). This is consistent with leaders having moderate lying costs.

However, equilibrium requires that the leader chooses the same contribution and message when $s = 1.5$ as when $s = 0.75$. In fact, given that the

leader contributes, the frequency with which message '1.5' is used in state 0.75 (18.3%) is significantly lower than the frequency of that message in state 1.5, 75.9% (WSR-test, p-value=0.068). This result does not change in the second half of the experiment. This is the first indication that Hypothesis 3 is not supported. It suggests that, in the VC treatment, leaders are overcommunicating, a phenomenon earlier observed in Forsythe et al. (1999), Blume et al. (2001) and Cai and Wang (2006).

To investigate in more detail whether such overcommunication is taking place, we now analyze the information revealed by the leader's messages. Below, we focus on the cases in which the leader contributes and we compare the probability that the state is 0, 0.75 and 1.5 across the different available messages. This posterior probability is displayed in Table 3.4. It is calculated by taking the message use of all leaders in each state and by using Bayes' Rule. We also display the expected payoff difference from contributing compared to not contributing, from the follower's perspective, i.e. $E(\pi(x_2 = 1) - \pi(x_2 = 0)|m, x_1 = 1)$. This payoff difference is simply equal to $E(s|x_1 = 1, m) - 1$, that is, the conditional expected value of the state, minus 1. If this difference is positive, $E(s|1, m) - 1 > 0$, the follower's best response is to contribute; otherwise, not contributing is optimal.

Treatment	Message (m)	Prob($s=0 x_1=1,m$)	Prob($s=0.75 x_1=1,m$)	Prob($s=1.5 x_1=1,m$)	$E(s 1, m) - 1$
NC	-	0.02	0.42	0.56	0.16
PC	'0'	0.00	0.75	0.25	-0.06
	'0.75'	0.02	0.77	0.22	-0.10
	'1.5'	0.01	0.34	0.64	0.22
VC	'0'	0.00	0.50	0.50	0.13
	'0.75'	0.00	0.88	0.13	-0.16
	'1.5'	0.01	0.20	0.79	0.33
	'0.75 or 1.5'	0.54	0.39	0.07	-0.60
	'blank'	0.00	0.63	0.37	0.02

Table 3.4: Probabilities that the state s is 0, 0.75 and 1.5 conditional on each message given that the leader contributed

Without verbal communication, in treatment NC, a contribution by the leader reveals that the probability that the state is 0.75 (0.42) is relatively close to that of the state being 1.5 (0.56). Also, $E(s|1, m) - 1 = 0.16 > 0$. Thus, the follower has an incentive to contribute.

In treatment PC, we see that sending message '1.5' and contributing leads to a similar result: the conditional probability that the state is 1.5 is 0.64, which is enough to incentivize the follower to contribute as well. In contrast, if the leader sends message '0' or '0.75' and contributes, the follower has no incentive to contribute ($E(s|1, m) - 1$ is -0.06 and -0.10, respectively).

In treatment VC, we see that a precise message, '0.75' or '1.5', is essentially revealing the corresponding state.¹¹ Consequently, the follower has no incentive to contribute when the message sent is '0.75'. After a vague message (message '0.75 or 1.5' or a blank message), there is a much higher probability that the state is 0.75 than that the state is 1.5. In particular, after message '0.75 or 1.5' the probability that the state is high is only 0.07, and the best response is not to contribute.¹² Thus, when vague messages are used, in particular the message 'the value is 0.75 or 1.5', the leader is essentially saying that the state is not good, and that the best response is not to contribute; the leader is overcommunicating.

Result 3: *In the VC treatment, when $s = 0.75$, the leader lies significantly less than in PC. Instead, she frequently uses vague messages, such as 'the value is 0.75 or 1.5', or 'blank'. As the leader reveals the good value ($s = 1.5$) precisely in more than 75% of the cases, this leads to overcommunication. Therefore, we reject Hypothesis 3.*

3.6.3 The follower's reactions

In the absence of communication (treatment NC), the follower matches the leader's contribution. He contributes when the leader does (in 84.5% of the cases), and he does not if the leader does not contribute (88% of the cases). Consequently, we do not reject Hypothesis 4(i).

¹¹Note that, if the leader sends message 0 and contributes, $E(s) - 1$ is positive, 0.13. This result is driven by the fact that this message is sent rarely and only in two of the four matching groups.

¹²The probability that $s=0$ is high (0.54) after message '0.75 or 1.5' because it is rarely used in some matching groups. In particular, in two of the four matching groups this message is only used once and only in state 0. In another matching group, it is used 6 times only when $s=0.75$, and in the final matching group it is used once when $s=0$, four times when $s=0.75$ and twice when $s=1.5$.

We examine the follower's reactions to messages and contributions of the leader in PC and VC in Table 3.5 below. This table displays the reaction of the follower (fraction of $x_2=1$) to each message of the leader, conditional on her contribution decision. As in Table 3.3, the upper panel presents results for treatment PC and the bottom one for treatment VC.

We first consider the follower's reaction to messages in Treatment PC. In this treatment, the follower reacts to both the contribution and the message of the leader. Given that the leader contributes, in 83.9% of the cases, the follower responds to message '1.5' with a contribution. In contrast, if the leader sends message '0.75', but still contributes, the follower often free-rides on the leader's contribution. He contributes in 32.5% of the cases, significantly less than when the message is '1.5' (WSR-test, p-value=0.068)¹³. Thus, the follower reacts optimally to these messages, contributing only after 1.5 as it is only in this case it is optimal. These reactions are in line with Hypothesis 4(ii).

Treatment			Leader's message ^a				
			'0'	'0.75'	'1.5'	'0.75 or 1.5'	'blank'
PC	If $x_1 = 1$	Percentage of $x_2 = 1$	0.0%	32.5%	83.9%		
		Frequency ^b	0.9%	8.0%	45.8%		
	If $x_1 = 0$	Percentage of $x_2 = 1$	4.5%	11.7%	33.5%		
		Frequency	27.1 %	6.8%	11.3%		
VC	If $x_1 = 1$	Percentage of $x_2 = 1$	75.0%	74.2%	86.9%	70.8%	79.2%
		Frequency	0.9%	9.2%	33.0%	4.5%	6.5%
	If $x_1 = 0$	Percentage of $x_2 = 1$	1.0%	38.9%	41.0%	7.4%	26.7%
		Frequency	19.3%	2.4%	4.5%	3.9%	8.0%

^a In Table 3.5 we report the follower's reaction to vague messages which were used in more than 5% of the cases in at least one treatment.

^b Frequency (in %) refers to the number of times a combination of message m and x_1 was observed over the total number of times the public good game was played within a treatment.

Table 3.5: Follower's contributions for a given message and contribution of the leader

When vague messages are allowed, if the leader contributes, the follower no longer reacts differently to the message sent by the leader. Given $x_1 = 1$,

¹³The difference in contributions of the follower between messages 0.75 or 1.5, conditional on the leader contributing, is significant at the 10% level when taking all periods together, as reported, and taking periods 11 to 21 (WSR-test, p=0.068). But it is not significant from periods 1 to 10 (WSR-test, p=0.353).

the contribution rate of the follower after message '0.75' is of 0.742, while it is 0.869 after message '1.5'. The difference is not significant (WSR-test, $p=0.465$). Similar response rates are observed for vague messages (0.75 or 1.5) and for blank messages, and differences are insignificant. In this treatment, after a contribution of the leader, the follower is not behaving optimally. As we saw in the previous section, the leader often overcommunicates. She sends vague messages when $s = 0.75$, but reveals the state precisely when $s = 1.5$. Thus, the follower has no incentive to contribute after message '0.75' or message '0.75 or 1.5', based on the information conveyed by these messages. Nevertheless, he still frequently does contribute. This is against Hypothesis 4(iii), but is in line with Blume et al. (2001), who find that receivers do not fully take advantage of the sender's overcommunication.

The reactions of the follower are confirmed when regressing the follower's contribution on the leader's contribution and messages. In Table 3.6, the regression results are presented. We first note that a contribution by the leader always increases the probability of the follower's contribution significantly, as we see from the significant coefficients of x_1 in the first row. The reaction to messages varies across treatments. In column (1) for the PC treatment, we observe that both messages '0' and '0.75' have a significant negative effect on the follower's probability to contribute, compared to message '1.5' (the omitted message). In contrast, considering the VC treatment, in column (2), we find that message '0.75' and vague messages have no significant effect on follower's contributions, compared to message '1.5'. This confirms the conclusions drawn from Table 3.5, that the follower does not react differently to the messages '1.5', '0.75' or to vague messages in the VC treatment. These results are summarized in Result 4.

Result 4: *In the NC and PC treatments, the follower most often optimally reacts to the information conveyed by the contribution and, in PC, messages of the leader, and we do not reject Hypotheses 4(i) and (ii). In contrast, in the VC treatment, the follower often does not react optimally. He contributes with equal frequency after messages '1.5', '0.75', '0.75 or 1.5' and blank, although message '0.75' and vague messages are indirectly revealing that the state is 0.75. Therefore, we reject Hypothesis 4(iii).*

Table 3.6: Follower reactions to the leader's contribution and messages

Probit regression results. The follower's contribution x_2 is the dependent variable; x_1 is the contribution of the leader; $m=0$ is a dummy variable which is 1 if the message is 'the value is 0', similarly for $m=0.75$; vague messages include 'the value is 0.75 or 1.5' and blank; other vague messages are excluded; the omitted message is thus 'the value is 1.5'. Several individual characteristics are included as controls: age, gender, field and level of studies, nationality and previous experience in experiments. These are not reported here for brevity. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors in brackets.

	(1) PC	(2) VC
	x_2	x_2
x_1	1.354*** [0.191]	1.609*** [0.394]
$m=0$	-1.647*** [0.302]	-1.529*** [0.073]
$m=0.75$	-0.888*** [0.239]	-0.297 [0.414]
vague message		-0.242 [0.167]
Period	0.009 [0.014]	-0.021*** [0.006]
Constant	-1.10 [1.161]	-1.194 [1.808]
Observations	336	319
Log-likelihood	-126.9	-121.5
Pseudo - R2	0.455	0.445

In the VC treatment, the leader is not hurt by her overcommunication. Since the follower does not react to the information contained in vague messages or in the message '0.75', the leader's overcommunication is not 'punished'. An interesting question is why the follower does not react to the leader's overcommunication in VC. It could be driven by the fact the follower has less experience with messages in the VC treatment, where more messages are available compared to the PC treatment. However, the follower has slightly more experience with message '0.75' in the VC treatment, where its frequency is 9.2%, than in the PC treatment, where its frequency is 8%. Alternatively, one might conjecture that the follower is reciprocal towards a leader who contributes, despite her overcommunication. However, reciprocity is not consistent with the fact that the follower often 'punishes' the leader in PC, by not contributing after receiving message '0.75' and observing a contribution of the leader. It may be that the follower just pays less attention to messages in this treatment, where more messages are available.

3.7 Conclusion

The assumption of positive but moderate lying cost organizes the data from our experiment reasonably well. When communication must be precise, the leader lies frequently to avoid revealing the state and to prevent the ensuing free riding behavior. With only precise language available, the follower is attentive to both the messages that the leader uses and the leader's actions and he generally responds optimally.

The situation is different when vague messages are available as well. Equilibrium requires that the leader uses the same message when the value is high as when it is intermediate. Empirically, the leader's communication behavior is different: she reports the state precisely when it is high, but communicates vaguely when it is intermediate. Hence, there is overcommunication. Although this could clearly hurt the leader, as well as efficiency, the leader is saved by the fact that, with the richer language, the follower pays less attention to the messages, or finds them more difficult to interpret; in any case, when vague messages are available, the follower predominantly reads to what the leader does, not to what she says. As a result, contribution levels,

payoffs and efficiency are not much different in the case when communication is possible, as compared to when it is not, and material payoffs do not depend much on the language that is available for communicating.

Some of the management literature recommends that managers use lies or vague language to motivate workers to work hard and invest. Lying conflicts with general ethics, and being vague would seem to be self-destructing over time, if workers accumulate additional information. Our experiment shows that ethics are not very strong, and that learning may take considerable time. In such circumstances, such behavior may indeed be meaningful and beneficial.

Finally, recall the quote at the beginning of this paper: "'no comment' is a comment". The phrase 'no comment' is typically used to conceal an inconvenient truth. Such concealment should not be effective when convenient truths are revealed precisely and truthfully. Then 'no comment' is a comment indeed. The most frequently used vague message in our experiment is 'blank', which may be seen as the equivalent of 'no comment'. Somewhat surprisingly, followers do not seem to pick up the fact that it is usually only used when the truth is inconvenient indeed. Hence, in the experiment, it is an effective message to hide private information. Perhaps this may explain why it still such a popular expression among public figures. As Winston Churchill was once quoted saying: "'No comment' is a splendid expression. I am using it again and again" (Muller, 1999, p.20).

3.8 Appendix A: Proofs

Proposition 1

The baseline game has a unique Nash Equilibrium, (σ^*, τ^*) with $\sigma^* = (0, 1, 1)$ and $\tau^* = (0, 1)$. This equilibrium is efficient, that is, the sum of the players' payoffs is maximized for all $s \in S$.

Proof. - As in Chapter 2, Proposition 2 - We will prove the stronger result that strategy profile (σ^*, τ^*) is the only one that survives iterated elimination of strictly dominated strategies.

Since $a(1 - v) < 1$ the leader has $x_1 = 0$ as a strictly dominant action for $s = a$: the worst payoff resulting from not contributing is $1 + av$, while choosing $x_1 = 1$ yields at most a . The condition $a + b + c < 3$ then implies that the follower will respond to $x_1 = 0$ by not contributing either: seeing $x_1 = 0$ makes him less optimistic that the state is intermediate or high. Since $c > 1$, this implies that the leader has $x_1 = 1$ as her dominant action when $s = c$. Since $b + c > 2$, this in turn implies that the follower will contribute after a contribution of the leader. Having established that, for the follower, only $\tau^* = (0, 1)$ survives the elimination of dominated strategies, it easily follows that $\sigma_b = 1$, hence, that $\sigma^* = (0, 1, 1)$ is the unique surviving strategy for the leader.

Proposition 2

In any stable equilibrium of the game $G(M)$ we have:

- (1) $(X_a(\sigma), X_b(\sigma), X_c(\sigma)) = (0, 1, 1)$
- (2) $E(s \mid m, 1; \sigma) \geq 1$ for all $m \in M_b(\sigma) \cup M_c(\sigma)$
- (3) $\tau(m, 0) = 0$ for all $m \in M_a(\sigma)$, while $\tau(m, 1) = 1$ for all $m \in M_b(\sigma) \cup M_c(\sigma)$

Proof. First of all, we note that, since $a(1 - v) < 1$, any action with $x_1 = 1$ is strictly dominated for $s = a$. Consequently, type $s = a$ of the leader will not contribute. In the remainder of the proof, we can thus focus on the types b and c .

The second important observation is that, with respect to these types b and c , a single crossing condition is satisfied. Formally, denote by p the probability that the follower will contribute in response to some $(m, 0)$ and let q be the probability

that he contributes in response to some $(m', 1)$. Then a simple calculation shows that, if type b of the leader weakly prefers $(m', 1)$ to $(m, 0)$, then any type c strictly prefers $(m', 1)$ to $(m, 0)$.

From this it follows that, in equilibrium, type $s = c$ of the leader cannot randomize her contribution. Assume she would. Then she would be indifferent between some $(m, 0)$ and some $(m', 1)$. But this implies that type $s = b$ would strictly prefer $(m, 0)$ to $(m', 1)$. Consequently, when seeing $(m', 1)$, the best response of the follower would be to contribute with probability 1, contradicting the indifference for type $s = c$ that was assumed.

Next, assume that there is an equilibrium in which type $s = c$ does not contribute. The single crossing property implies that also type $s = b$ does not contribute. Let $m^* \in M$ be a message such that type c chooses $(m^*, 0)$ with positive probability in equilibrium and write p^* for the probability that the follower contributes after $(m^*, 0)$. Obviously, type c will only choose messages for which p^* is maximal, and a similar remark holds for type b . It follows that the equilibrium utility of type s ($s = b, c$) is given by $u_s^* = 1 + svp^*$, and that in order for type s not to deviate to some action $(m, 1)$, we must have

$$u_s^* = 1 + svp^* \geq s(1 + vq) \quad (*)$$

where q is the probability that the follower contributes after $(m, 1)$. The single crossing condition implies that, in (*), only the constraint for type $s = c$ is binding. Consequently, the equilibrium can be stable (in the sense of Kohlberg and Mertens, 1986), only if it survives if the follower interprets the message-action pair $(m, 1)$ as coming from type c and then plays a best response. Given this interpretation, the best response, however, is $q = 1$, and this violates (*) for $s = c$. This shows that an equilibrium in which $s = c$ does not contribute is not stable; hence, in any stable equilibrium, we must have $X_c(\sigma) = 1$.

Finally, let m be a message used by $s = c$ in equilibrium. Then $\tau(m, 1)$ must be constant over all such messages m . In fact, $\tau(m, 1) = 1$ for all such m , since $(m, 1)$ is strictly dominated for type $s = a$. If type b chooses not to contribute, her payoff is 1, as in that case the follower will infer that the state is a or b . On the other hand, if $s = b$ chooses $(m, 1)$, then her payoff will be $b(1 + v)$. It follows that type $s = b$ will mimic type $s = c$. This established the proof of (1). The conditions (2) and (3) simply follow since, in any equilibrium, the follower must play a best response against all actions of the leader that occur with positive

probability.

Proposition 3

In any stable equilibrium of the game $G_\varepsilon(PC)$ with precise communication and positive cost of lying, we have:

- If $\varepsilon < b(1+v) - 1$: $\sigma_a=(a,0)$, $\sigma_b=\sigma_c=(c,1)$, and $\tau(a,0) = 0$, $\tau(c,1) = 1$

- If $\varepsilon > b(1+v) - 1$: $\sigma_a=(a,0)$, $\sigma_b=(b,0)$, $\sigma_c=(c,1)$, and $\tau(a,0) = \tau(b,0) = 0$, $\tau(c,1) = 1$

Proof. Since $a(1-v) < 1$ and lying costs are strictly positive, $(a, 0)$ is a strictly dominant strategy for type a . Consequently, in any Nash equilibrium, we will have $\sigma_a=(a,0)$. As in Proposition 2, we can therefore focus on the types b and c .

Let us first focus on type c . We first show that, in any stable equilibrium, type c must choose $(c,1)$ with positive probability. Assume not, then it follows that also type b chooses $(c,1)$ with zero probability. (If b would choose $(c,1)$ with positive probability, the follower would respond to $(c,1)$ with $x_2=0$, yielding type b the payoff $b - \varepsilon$, which is less than the payoff 1 that type b can at least guarantee by choosing $(b,0)$.) Consequently, consider an equilibrium in which $(c,1)$ is not chosen at all in equilibrium. An argument as in the proof of Proposition 2 shows that c is more likely to deviate to $(c,1)$ than b is, hence, that the follower should respond with $\tau(c,1)=1$, upsetting the equilibrium. We have, therefore, shown that $\sigma_c(c,1)>0$ in any stable equilibrium.

Note that if the follower responds with $\tau(c,1)=1$, then type c will not choose any other action, and the proof is complete, at least for type c . So assume $\tau(c,1) < 1$. Given $\sigma_c(c,1) > 0$, this choice of the follower can only be optimal if $\sigma_c(c,1) < 1$. Assume $m \neq c$ is such that $\sigma_c(m,1) > 0$. Then c must be indifferent between the two messages, hence, because of the lying cost $\tau(m,1) > \tau(c,1)$. But then type b strictly prefers $(m,1)$ to $(c,1)$, so that $\sigma_b(c,1) = 0$, hence, $\tau(c,1) = 1$, a contradiction. A similar argument leads to a contradiction in case some $(m,0)$ would be chosen with positive probability by type c . This establishes that $\sigma_c(c,1) = 1$, which, in turn, leads to the conclusion that $\tau(c,1) = 1$.

Now, consider type b . The only possibility for this type to elicit a contribution from the follower is by choosing $(c,1)$. This will yield payoff $b(1+v) - \varepsilon$. Alternatively, by choosing $(b,0)$, the guaranteed payoff is 1. It follows that b will choose

$(c, 1)$ if $b(1+v)^{-\varepsilon} > 1$, and will choose $(b, 0)$ if the reverse inequality is satisfied.

Given that we have uniquely determined the strategy of the leader, it easily follows that the follower's strategy must be as written in Proposition 3. Hence, in any stable equilibrium, the leader and the follower contribute when the state is c , and, when lying costs are small, also if the state is b .

Proposition 4

The game $G_\varepsilon(VC)$ with vague communication and positive cost of lying has multiple stable equilibria. First of all, any stable equilibrium of the game $G_\varepsilon(PC)$ remains stable in $G_\varepsilon(VC)$. Next to that, there are stable equilibria in which the leader, while being truthful, uses a vague message when $s = b, c$, hence:

- $\sigma_a = (m_a, 0)$ where m_a is a message that is truthful when $s = a$, and $\tau(m_a, 0) = 0$

- $\sigma_b = \sigma_c = (m, 1)$ where m is a vague message that is truthful both when $s = b$ and $s = c$, and $\tau(m, 1) = 1$

Proof. That a stable equilibrium outcome of the game $G_\varepsilon(PC)$ remains stable in the extended game $G_\varepsilon(VC)$ (formally: that such an outcome cannot be upset by applying the equilibrium dominance criterion) follows from the fact that both type a and type c obtain their highest possible payoff in such an equilibrium; unexpected messages of the leader should, therefore, be attributed to type b , however, type b clearly has no incentive to deviate from the equilibrium either.

The strategy pairs described in Proposition 4 in which vague messages are used are clearly Nash equilibria: each player best responds to the other. As also in these equilibria both type a and type c obtain their best possible payoff, a similar argument as above implies that also such equilibria cannot be upset by applying the equilibrium dominance criterion.

3.9 Appendix B: Instructions

The text in [], indicates treatment variations, while the text in { } was not included in the written instructions but read aloud by the experimenter.

{Experimenter announces: "We're now ready to begin the experiment. Thank you all for coming. You should all have a set of instructions. I am going to begin by reading through the instructions aloud"}

Instructions

Introduction

This is an experiment about decision making. You are not allowed to talk to the other participants during the experiment. If, at any stage, you have any questions raise your hand and a monitor will come to where you are sitting to answer them.

The experiment will consist of twenty-one rounds. In each round you will be randomly paired with another participant. At the end of the experiment you will be paid in private and in cash, based upon your accumulated earnings from all twenty-one rounds. Your earnings will be converted into EUR according to the following rate: 100 points = 0.70 EUR.

Choices and earnings

In each round you have to choose between two options, A and B. The other person in your pair also has to choose between option A and option B.

Your earnings and the earnings of the other person in your pair will depend on your choice, the choice of the other person and the earnings table selected randomly by the computer.

One of three possible earnings tables is randomly selected by the computer at the beginning of each round, and may vary from round to round. In any round the earnings table is equally likely to be earnings table 1, earnings table 2 or earnings table 3. This earnings table is the same for you and the person with whom you are paired in a round. The earnings table may be different for different pairs of participants.

For each earnings table, your earnings are displayed below. These earnings depend on your choice and that of the other person in your pair. If

you want to know your earnings for a particular earnings table and a choice made by you and the other person in your pair, first move to that particular earnings table. Then, select your choice and that of the other person. Your earnings are stated in points. From these tables you can also calculate the earnings of the other person in your pair, by switching the terms ‘your choice’ and ‘other person’s choice’.

{Experimenter announces: In the next page you see three tables. Your earnings are displayed depending on the earnings table selected by the computer, your choice and the choice of the other person}.

If the earnings table is 1,

Earnings Table 1

Other person’s choice

		A	B
Your choice	A	40	40
	B	0	0

If the earnings table is 2,

Earnings Table 2

Other person’s choice

		A	B
Your choice	A	40	100
	B	30	90

If the earnings table is 3,

Earnings Table 3

Other person’s choice

		A	B
Your choice	A	40	160
	B	60	180

Procedure and information

At the beginning of each round you will be randomly paired with another participant. This will be done in such a way that you will not be paired with the same person two rounds in a row. Nor will you be paired with the same person more than three times throughout the experiment. You will never

know the identity of the other person in your pair, nor will that person know your identity.

In each round, one participant in each pair is randomly chosen to be the first mover and the other the second mover. At the beginning of each round you will be informed about your role (first mover or second mover) in the pair for that round.

The first mover will be informed about the exact earnings table selected by the computer (earnings table 1, earnings table 2 or earnings table 3) before making his or her choice, but the second mover will not be informed about the earnings table before making his or her choice.

[PC and VC: In each round, the first mover will choose a message he or she wishes to send to the second mover. first movers may choose among the following messages:]

[PC:

- “The earnings table selected by the computer is 1”
- “The earnings table selected by the computer is 2”
- “The earnings table selected by the computer is 3”.

Please note that it is costless for the first mover to send a message.]

[VC:

- “The earnings table selected by the computer is 1”
- “The earnings table selected by the computer is 2”
- “The earnings table selected by the computer is 3”
- “The earnings table selected by the computer is 1 or 2”
- “The earnings table selected by the computer is 1 or 3”
- “The earnings table selected by the computer is 2 or 3”
- “The earnings table selected by the computer is 1, 2 or 3”
- “The earnings table selected by the computer is – (blank)”.

Please note that it is costless for the first mover to send a message.]

[NC: In each round,] [PC and VC: Also,] the first mover will enter a choice (A or B). Then, the second mover will enter a choice (A or B). Before making his or her choice the second mover will be informed about the first mover’s [PC and VC: message and] choice.

When all the second movers have made their choices, the result of the round will be shown on your screen. The screen will list the earnings table

that was selected by the computer, [PC and VC: the message that was sent by the first mover,] the choices made by you and the other person in your pair, the amounts earned by you and the other person in your pair, and your accumulated earnings until that round.

Quiz

To make sure everyone understands how earnings are calculated, we are going to ask you to complete a short quiz. Once everyone has completed the quiz correctly we will continue with the instructions. If you finish the quiz early, please be patient. For each question you have to calculate earnings in a round for you and the other person in your pair.

{Experimenter announces: "Now please answer the questions in the quiz by filling in the blanks. In five minutes I'll check each person's answers. If you have a question at any time, just raise your hand."}

Complete the following table

[NC:Earnings table selected by the computer	Your choice	Other person's choice	Your earnings	Earnings of the other person in your pair
2	B	B	—	—
1	B	B	—	—
3	A	B	—	—
1	A	B	—	—
3	A	A	—	—
3	B	A	—	—]

[PC: Earnings table selected by the computer	Message sent by first mover 'The earnings table selected by the computer is:	Your choice	Other person's choice	Your earnings	Earnings of the other person in your pair
2	1'	B	B	—	—
1	1'	B	B	—	—
3	3'	A	B	—	—
1	2'	A	B	—	—
3	3'	A	A	—	—
3	1'	B	A	—	—]

Earnings table selected by the computer	Message sent by first mover 'The earnings table selected by the computer is:	Your choice	Other person's choice	Your earnings	Earnings of the other person in your pair
2	1 or 2'	B	B	—	—
1	-(blank)'	B	B	—	—
3	2 or 3'	A	B	—	—
1	2'	A	B	—	—
3	1,2 or 3'	A	A	—	—
3	3'	B	A	—	—

{When all subjects have completed quiz correctly, experimenter announces:
"Everyone has completed the quiz so I'll continue with the instructions at the top of the fourth page where it says "summary"."}

Summary

Before we start the experiment let us summarize the rules. The sequence of each round is as follows:

1. Two participants are randomly paired; one is randomly chosen to be the first mover and the other the second mover.
2. The earnings table is selected by the computer: the earnings table is equally likely to be earnings table 1, earnings table 2 or earnings table 3.
3. The first mover is informed about the earnings table selected by the computer.
4. [PC and VC: The first mover choose which message he or she wishes to send to the second mover]
5. The first mover chooses between A and B.
6. The second mover is informed about the first mover's [PC and VC: message and] choice, but not the earnings table, and chooses between A and B.
7. Both the first mover and the second mover are informed about the results of the round.

After round 21 the experiment ends and each participant is paid his or her accumulated earnings, in private and in cash. Recall that accumulated earnings will be converted to EUR according to the following rate: 100 points = 0.70 EUR.

{Experimenter announces: "We will now start the experiment. At various times you will have to wait for others to make their decisions. When that happens please be patient. On the top right corner of your screen you will see a time display labeled "remaining time (sec)". This time display is not binding, you may take as much time as you need to reach your decision. If you have a question at any time, just raise your hand."}

Part II

**Moral Hazard in the Credit
Market**

Chapter 4

Relational Contracting under the Threat of Expropriation - Experimental Evidence¹

4.1 Introduction

When explicit contracts are costly to write and enforce relational contracts can mitigate opportunistic behavior in principal agent relationships. Existing theoretical research suggests that relational contracts may be particularly important in labor and credit markets, preventing workers from shirking (Bull, 1987) and borrowers from defaulting on their loans (Stiglitz and Weiss, 1983). Experimental evidence confirms that relational contracts do emerge in competitive labor and credit markets and reduce moral hazard by workers and borrowers (Brown et al., 2004; Brown and Zehnder, 2007; Fehr and Zehnder, 2009).

Existing experimental studies of relational contracting examine repeated principal-agent games which have one key feature in common: In each period the agent must trade with a principal in order to earn a surplus. This implies that the principal can discipline the agent by threatening to terminate the relationship should he or she behave opportunistically. This feature of existing experimental studies is unnatural in many environments. For example, in the context of bank-credit slow bankruptcy procedures and/or the inability

¹This chapter is based on Brown and Serra-Garcia (2010).

of courts to immediately seize the assets of defaulting borrowers imply that a borrower may be able to expropriate borrowed funds from the lender and reinvest them. Likewise, if lenders and courts cannot prevent the tunneling of loaned funds to other investments (Johnson et al., 2000) the borrower may be able to expropriate borrowed funds. Thus, in countries with weak creditor protection and debt enforcement defaulting borrowers may continue their economic activity without the support of a lender. Cross-country data on debt enforcement and creditor protection suggests indeed that expropriation of funds by borrowers is perfectly feasible, particularly in emerging and developing economies².

Expropriation is also a major concern in sovereign lending and foreign direct investment (FDI). In the context of sovereign debt the borrower country can choose to default on the loan, and it may be impossible for the lender to recover any funds, due to the limitations of international law (Bulow and Rogoff, 1989). In the context of FDI, weak investor protection implies that the host-country partner may expropriate the investor's assets and continue production (e.g., Thomas and Worrall, 1994).³

In this paper we examine how potential expropriation of funds affects relational contracting. We concentrate on credit relationships and investigate how the credit volume, interest rate and loan repayment are affected by potential expropriation. We implement a credit market experiment in which a lender and a borrower interact for 7 periods. In each period the principal decides how much to lend to the borrower and which repayment to request. If the borrower receives a loan he earns a deterministic investment return.

²The 2010 Doing Business Indicators of the World Bank (www.doingbusiness.org) show that the time required by a lender to recover a secured debt through a bankruptcy procedure ranges from 1.7 years on average in OECD countries to 3.4 years in Sub-Saharan Africa and 4.5 years in South Asia. The recovery rate (cents on the dollar) for the lender varies hereby from 68.6 in OECD countries to 17 in Sub-Saharan Africa and 20 in South Asia. Looking at a broader set of regulations and institutions which protect creditors, the Legal Rights Index elicited by Doing Business (on a scale of 0-10) varies from 6.8 in OECD countries to 4.6 in Sub-Saharan Africa and 5.3 in South Asia. Evidence by Djankov et al. (2007, 2008) shows that these indicators of debt enforcement and creditor protection are correlated with access to credit and economic performance across countries.

³Expropriation is not only a characteristic of credit and investment relationships. In many labor relationships, such as in consultancy or law firms, expropriation of know-how or clients by employees is parallel to expropriation of funds by borrowers. A solution used in this context is the non-compete clause (Kräkel and Sliwka, 2006).

The borrower then decides whether to make the repayment requested by the principal. In our main treatment, a lender who defaults on a loan can expropriate these funds from the lender, i.e. he can use them to invest in future periods. We compare this main treatment to an otherwise identical control treatment in which, upon default, the agent cannot use the borrowed funds for future investment.

We expect potential expropriation to have two main effects on lender-borrower relationships in our experiment: First, we expect to see less relational contracts in which borrowers are motivated to repay loans and more relationships in which borrowers default, and thus are screened out, in initial periods. Second, when relational contracts emerge under expropriation we expect them to display lower credit volumes in initial periods. Only by "starting small" and increasing loan sizes over time can a lender motivate a borrower to repay when expropriation is feasible.

Our experimental results confirm these predictions: Aggregate lending is lower when expropriation is feasible than when it is not, leading to lower investment and efficiency. In particular, loans offered in the initial period of a relationship are substantially lower with expropriation than without. When borrowers can expropriate the lender's funds, they default more often in early periods of a relationship, especially when they receive a large loan.

Our study contributes to the theoretical literature studying the increase in stakes over time in credit and investment relationships. Expropriation provides a rationale for the observation of the gradual building up of credit relationships in microfinance (Morduch, 1999, Armendariz and Morduch, 2006), in small-business lending, (Ioannidou and Ongena, 2010) and in FDI relationships (Rauch and Watson, 2003). Several reasons have been suggested for the progressive increase in stakes within principal-agent games. Some are based on the existence of asymmetric information about players' types, i.e. whether they are myopic or patient (Ghosh and Ray, 1996 and 2001), high or low ability (Rauch and Watson, 2003) or have a preference for cooperation or not (Sobel, 1985)⁴. Others are based on the optimality for the principal to increase stakes towards the end of the relationship, such that he

⁴This has also been studied in prisoner's dilemmas (see Watson, 1999 and 2002, Andreoni and Samuelson, 2006).

can extract a greater surplus in the beginning (e.g. Thomas and Worrall, 1994, and Ray, 2002).

Our paper also contributes to the extensive literature on relational contracting in labor (e.g. Bull, 1987, MacLeod and Malcolmson, 1998) and credit relationships (e.g. Boot and Thakor, 1994, Boot, 2000). Experimental evidence both in labor and credit environments has shown that relationships can be sustained and lead to more efficient outcomes than one-shot interactions (see e.g. Fehr et al., 2009 for an overview). To our knowledge, all existing experimental investigations of relational contracting ignore potential expropriation by the agent: If the agent defaults or shirks in one period, the funds he earns from doing so cannot be stored for future periods, but must be immediately consumed. This implies that if the agent wants to earn income in future periods he has to trade with a principal. This of course increases the prospects for successful relational contracts as principals have a strong disciplining device: the threat of discontinuation of a relationship.

Our lending game is closely related to the trust game introduced by Berg et al. (1995). One-shot and repeated trust games have been studied intensively in the experimental literature (for a review see, e.g., Camerer 2003). They have also been adapted to lending relationships, for the study of experimental credit markets (Brown and Zehnder, 2007). Experiments on repeated trust games have followed two different approaches. Some studies (starting with Camerer and Weigelt, 1988, many experiments have followed this tradition⁵) examine dichotomous decisions by the first-mover (trust or not trust) and second mover (honor or not honor). Other studies allow the first-mover to choose how much to send to the second-mover from an initial endowment, while the second-mover decides how much to send back (Cochard et al., 2004, King-Casas et al., 2005 and Bornhorst et al., 2010). As in Brown and Zehnder (2007) we combine these approaches: Lenders can choose how much to lend to the borrower, while the borrower chooses whether to repay or not.

The rest of the paper is organized as follows. Section 4.2 describes the

⁵See Neral and Ochs (1992), Anderhub et al. (2002), Brandts and Figueras (2003), Engle-Warnick and Slonim (2004, 2006a, 2006b), Rigdon et al (2007) and Duffy et al. (2009).

experimental design. In Section 4.3, we outline the predictions, and report the experimental results in Section 4.4. Section 4.5 concludes.

4.2 Experimental design

Table 1 provides an overview of our three experimental treatments.

Treatment	Conditions	Matching groups & relations
Expropriation (E Treatment)	7 period game, borrower can expropriate loan principal	7 matching groups = 63 lender-borrower relations
No Expropriation (NE Treatment)	7 period game, borrower cannot expropriate loan principal	8 matching groups = 72 lender-borrower relations
One-Shot (1S Treatment)	1 period game borrower cannot expropriate loan principal	6 matching groups = 54 lender-borrower relations

Table 4.1. Treatments and subjects

4.2.1 Main treatment

In a single round of our main treatment, the **Expropriation treatment (E treatment)**, one lender and one borrower are paired for 7 periods. We choose a finite horizon instead of an infinite horizon for several reasons. Theoretically, under both horizons, the effect of expropriation on credit volume and repayment behavior is expected to be qualitatively similar. It leads to a decrease in credit volume and makes repayment less likely. Experimentally, the fixed number of periods implies that all sessions are of the same length. Therefore, differences in learning are ruled out. Also, the finite number of periods implies that we can observe individual variation in reputation concerns. While these concerns are constant in an infinite horizon, they are strong at the beginning and very weak at the end with a finite horizon⁶.

In each period $t = \{1, \dots, 7\}$ the borrower has an investment opportunity: he can invest the amount $I_t \in \{0, 1, 2, 3, \dots, 10\}$, which yields a gross return

⁶We choose 7 periods rather than 2 or 3, to be able to clearly separate the initial ‘starting small’ in loan sizes from the potential end-game effect, i.e. a reduction of loan sizes in the last periods of the game due to the fact that the game is close to an end.

of $3I_t$, with certainty⁷. We hold the investment opportunity of the borrower constant over time in order to examine credit rationing over the course of a relationship⁸.

The investment amount of the borrower in each period $I_t = C_t + S_t$ is equal to his capital C_t and the loan size S_t he receives from the lender. In period 1 the borrower starts off with zero capital $C_1 = 0$. The loan available to the borrower in each period $t = \{1, \dots, 7\}$ and the capital of the borrower in periods $t = \{2, \dots, 7\}$ are determined by the subsequent decisions of the lender and borrower. The decision structure in each period is as follows:

- **Loan offer:** The lender receives an endowment of 10 units at the beginning of each period. As the borrower can invest at most 10 units per period, the lender can offer a loan size of $S_t \in [0, 10 - C_t]$ to the borrower. The lender also chooses her requested repayment R_t . The requested repayment cannot exceed the income generated by the loan: $R_t \in [0, 3S_t]$. When the lender has determined her offer (S_t, R_t) , the offer is shown to the borrower.
- **Loan acceptance:** If the lender chooses an offer with a strictly positive loan $S_t > 0$, the borrower must decide whether to accept ($A_t = 1$) or reject the offer ($A_t = 0$).
- **Repayment decision:** If the borrower accepts a loan offer (S_t, R_t) , he then decides whether to make the repayment requested by the lender ($D_t = 0$) or default ($D_t = 1$). Partial repayments are not possible⁹.

⁷For an experimental analysis of credit relationships with stochastic investment returns see Fehr and Zehnder (2009).

⁸If, for example, we observe that a lenders offers a small loan in period 1 and she increases it over time, we know that the borrower was credit constrained in period 1. By contrast, when field studies observe rising loan schedules over time (e.g. Ioannidou and Ongena, 2010) they typically cannot distinguish whether this is due to increasing investment opportunities of the borrower over time or a relaxation of credit constraints. Kirschenmann (2010) examines credit constraints over the course of microfinance relationships by contrasting the desired loan size and granted loan size as reported in credit file data of a Bulgarian bank. However, her identification of credit constraints is based on the assumption that borrowers report their true financing needs.

⁹In reality some borrowers obviously become delinquent without fully defaulting. However, due to the deterministic nature of investment earnings in our design we exclude partial repayments, as in Brown and Zehnder (2007).

As mentioned above, the borrower starts off with zero capital. However, if the borrower receives a loan he can expropriate the lender's funds and keep these funds for future investment. We assume that borrowers who default in period t automatically have the loan principal S_t added to their capital for all subsequent periods. We further assume that borrowers cannot liquidate their capital (and consume the proceeds) before the final period¹⁰. The capital of a borrower in periods $t = \{2, \dots, 7\}$ thus equals the sum of the loaned funds which he did not repay: $C_t = \sum_{k=1}^{t-1} D_k S_k$.

We implement a symmetric "reservation" income of 10 points per period for the lender and the borrower. This design choice was made so that asymmetric reservation payoffs would not affect the decisions of lenders to offer credit.

The income of the lender in each period is equal to her reservation payoff plus her net income from lending ($R_t - S_t$) if she lends.

$$\pi_t = \begin{cases} 10 & \text{if no loan } (S_t = 0, A_t = 0) \\ 10 - S_t + R_t & \text{if loan repaid } (S_t > 0, A_t = 1, D_t = 0) \\ 10 - S_t & \text{if loan default } (S_t > 0, A_t = 1, D_t = 1) \end{cases}$$

The income of the borrower is equal to his reservation payoff plus his gross investment income $3(C_t + S_t)$ minus any repayment he makes to the lender (R_t) and minus the capital which he is forced to keep for the following period $C_{t+1} = C_t + D_t S_t$. As mentioned above, borrowers cannot liquidate their capital before the final period. In periods $t = \{1, \dots, 6\}$ this amount is thus deducted from their gross income and transferred as capital to the following period.

$$u_t = \begin{cases} 10 + 3C_t - C_t & \text{if no loan } (S_t = 0, A_t = 0) \\ 10 + 3(C_t + S_t) - R_t - C_t & \text{if loan repaid } (S_t > 0, A_t = 1, D_t = 0) \\ 10 + 3(C_t + S_t) - (C_t + S_t) & \text{if loan default } (S_t > 0, A_t = 1, D_t = 1) \end{cases}$$

¹⁰The fact that we force borrowers to reinvest funds that they expropriate, rather than allowing them to decide whether to consume or reinvest them seems restrictive. We made this design choice for two reasons. First, we wanted to simplify the game as much as possible by abstracting from consumption / saving decisions. Second, reinvestment of loaned funds is the optimal strategy of a borrower who has defaulted: in a reputation equilibrium, any borrower who defaults on a loan will not receive future loans and so it is in his best interest to reinvest the funds he has available.

We assume that at the end of period 7 the borrower can liquidate all of his capital and consume it. We make this assumption to ensure that repayment behavior in the final period of our main treatment has the same payoff implications as in our control treatments (described below) where loan defaults are feasible but the expropriation of loan principal is not.

$$u_7 = \begin{cases} 10 + 3C_t & \text{if no loan } (S_t = 0, A_t = 0) \\ 10 + 3(C_t + S_t) - R_t & \text{if loan repaid } (S_t > 0, A_t = 1, D_t = 0) \\ 10 + 3(C_t + S_t) & \text{if loan default } (S_t > 0, A_t = 1, D_t = 1) \end{cases}$$

At the end of each period the lender is informed about the borrower's repayment decision. Each player gets to know his own and his partner's payoffs for this period and both players are informed about the borrower's capital for the following period.

4.2.2 Control Treatments

We contrast our main treatment with a control treatment in which expropriation is not feasible, the **No Expropriation treatment (NE treatment)**. In this treatment the decision structure, information conditions and parameters are identical to the E treatment. The only difference between the two treatments is the determination of the borrower's capital. In the NE treatment we impose that the borrower cannot expropriate loaned funds and reinvest them. Thus, $C_t = 0$ in each period.

Note that in both the E treatment and the NE treatment borrowers can default on their loans. The difference between the two treatments lies in what a borrower can do with the funds when he defaults. In the NE treatment the borrower must "consume" all of these funds and cannot reinvest any part of them. This treatment represents a legal environment in which loan default is possible, but the borrower can only evade repaying a loan if he liquidates his investment and consumes all the proceeds. In the E treatment, by contrast, the borrower is not forced to liquidate his investment if he defaults on a loan. The borrower continues using the loaned funds for investment purposes without having to surrender either his assets or his future profits from these assets to the creditor. The E treatment thus represents a legal environment

in which creditor protection and debt enforcement are weaker than in the NE treatment.

In both treatments, we abstract from the possibility of saving from net investment earnings. We concentrate on the problem of weak investor protection and, thus, do not allow borrowers to ‘legally’ save money for investment, from the profits earned in each period.

Our second control treatment is the One Shot Treatment (1S Treatment). Here the lending game lasts for 1 period only and borrowers have zero capital. This treatment serves as a benchmark for lending activity, when multi-period relationships are not feasible.

4.2.3 Procedures

At the beginning of each session participants are randomly assigned to the role of either a borrower or a lender. These roles are fixed for the whole session. Each player forms part of a matching group, composed of 3 lenders and 3 borrowers. Each player plays three rounds of our lending game: each lender (borrower) repeats the lending game with three different borrowers (lenders) in her/his matching group. As a consequence we observe 9 lender-borrower relationships for each matching group.

In the E and NE treatments, the lender and the borrower have an overview of the history of play in previous periods for the current round. As mentioned above, each round lasts 7 periods. For each past period in the current round they can see the loan size and requested repayment of the lender, whether it was accepted by the borrower and whether the borrower repaid. As a new round started lenders and borrowers were newly matched, and the history of play was erased.

In total 126 students participated in our experiment. In the E treatment there were 7 matching groups of 6 players each, in the NE treatment 8 matching groups, and in the 1S treatment 6 matching groups. As displayed by Table 4.1 this implies that we observe 63 lender-borrower relationships in the E treatment, 72 relationships in the NE treatment and 54 relationships in the 1S treatment.

Each participant could only participate in one session, so that each sub-

ject experienced only one of the treatments. All participants were students at Tilburg University. The experiment was programmed and conducted with the experimental software z-Tree (Fischbacher, 2007).

Behavior in our lending game might be affected by individual characteristics. First, as shown by Schaechter (2007), individual risk preferences do affect decisions in trust-games. Second, the level of strategic reasoning, i.e. the anticipation of what other subjects in the matching group might do, can affect behavior significantly (Nagel, 1995). Third, social preferences, i.e. reciprocal motives and fairness preferences of the borrower, as well as the anticipation of these preferences, i.e. trust by the lender, should affect behavior in our experiment (see Camerer, 2003 for a detailed discussion)¹¹. Before the lending game started, the participants took part in three short pre-experimental games aimed at measuring their levels of risk aversion, strategic reasoning, trust and trustworthiness. Appendix C describes these pre-experimental games in detail and provides summary statistics for their outcomes in the E and NE treatments. We show there that there are no significant differences in behavior in these games between the two treatments. The instructions for these games are available from the authors upon request.

Throughout the pre-experimental games subjects received no feedback. They were not informed about other subjects' decisions or their own payoffs until the end of the experiment. Subjects were informed about this at the beginning of the experiment. They also knew that the decisions in each pre-experimental game had no effect on the lending game.

After the three pre-experimental games and before starting our lending experiment, each subject had to read a detailed set of instructions. The instructions can be found in Appendix B. The experimental instructions were framed in a credit market language¹². After reading the instructions parti-

¹¹Roe and Wu (2009) show that the behavior of players in a repeated gift-exchange game is related to their behavior in one-shot social preference games

¹²The reason why we chose a context-specific and not a neutral framing was that the experiment was relatively complex. In complex experiments a completely neutral language bears the danger that subjects create their own (potentially misleading) interpretation of the decision environment. Thus, the context specific framing gives us control over what our participants have in mind. In our view, this not only reduces noise but also increases the external validity of the experiment. See also Brown and Zehnder (2007) for a discussion

participants had to pass a test with control questions. The lending game did not start until all subjects had correctly answered all control questions.

Sessions in which the NE or E treatment was played lasted approximately 120 minutes. Sessions in which the 1S treatment was played lasted on average 60 minutes. Subjects received a show-up fee of 5 Euros and 1 additional Euro for every 25 points earned during the experiment. They received an additional sum of 3 Euro at the end of the sessions in which the 1S treatment was played. This was done to avoid very low earnings for subjects in this treatment. On average subjects earned 10 euro per 60 minutes of participation.

4.3 Predictions

Under the assumption of common knowledge of rationality and selfishness of all market participants, the predictions for each of our three treatments are straightforward. Since repayments are not enforceable, a borrower's best response is to never repay a loan in a one period game. Lenders, anticipating this behavior, will never offer credit in the 1S treatment. As our E and NE treatments last for a finite number of periods, a simple backward induction argument ensures that this equilibrium is played in each period of these treatments as well.

A broad body of experimental evidence suggests, however, that not all people will simply maximize monetary payoffs in our experiment. Social preferences based on reciprocity (Dufwenberg and Kirchsteiger, 2004) or distributional concerns (Fehr and Schmidt, 1999) can induce borrowers in our experiment to repay loans even in the 1S treatment. Evidence from similar one-period trust games or investment games (Berg et al., 1995) suggests that a substantial share of second movers, i.e. borrowers in our context, do exhibit such social preferences.

We examine our three treatments under the assumption that some (non-distinguishable) borrowers are conditionally reciprocal: they are willing to meet their repayment obligations in a one-shot situation, as long as the repayment requested by the lender does not exceed a threshold value. We

of this issue.

assume that this threshold $\bar{R}_t = \bar{r}S_t$ can be characterized by the maximum (gross) interest rate \bar{r} that a social borrower is willing to pay. We assume that the remaining borrowers are selfish in the sense that they never repay loans in a one-shot situation. In accordance with previous experimental evidence, we assume that the share of social borrowers is positive but not large. Therefore, it is not profitable for risk-neutral lenders to lend in a one-shot game. Based on these assumptions, we provide an analytical examination of the E and NE treatments in Appendix A. In the following we outline the qualitative predictions per treatment resulting from that analysis and use these to establish hypotheses for our main treatment effects.

Our assumption on the share of social borrowers implies that, in a one-shot game, lenders will not be willing to lend, since only social borrowers repay loans. Therefore, we predict that lending will collapse in our 1S treatment.

Since borrower types are a priori indistinguishable, the E and NE treatments can be characterized as finitely repeated games of incomplete information. Theory suggests that such games have multiple equilibria (Kreps et al., 1982). We distinguish between two types of equilibria and, within each type, concentrate on the profit-maximizing equilibria for the lender, as he makes loan offers (as in Thomas and Worrall, 1994). In the first type of equilibria, *reputation equilibria*, selfish borrowers imitate the behavior of social borrowers during the first periods but separate by defaulting towards the end of the game. In the second type of equilibria, *screening equilibria*, selfish borrowers are screened out by the lender in the first period, and from period 2 onwards the lender only lends to (now identified) social borrowers.

In the NE treatment the profit-maximizing reputation equilibrium for the lender has the lender extend loans of maximum size 10 in periods 1 to 6 and a smaller loan in period 7. Loan offers in periods $t = \{2, \dots, 7\}$ are contingent on the borrower repaying all past loans. Therefore, a selfish borrower has an incentive to imitate the social one by repaying in periods 1 through 5 with certainty. In period 6 the selfish borrower is indifferent between repaying and defaulting, as the loan size in period 7 falls, and repays with positive but smaller than one probability. This allows the lender to learn about the borrower's type in period 6 and lend profitably in period 7. Thus, in the NE

treatment the profit-maximizing reputation equilibrium for the lender has maximum lending in periods 1 through 6 and full repayment in periods 1 through 5.

No screening equilibrium exists in the NE treatment. If such equilibrium would exist, selfish borrowers would default with certainty in the first period of the game. After their default, the lender would offer maximum loans of 10 to the borrowers who did not default, i.e. social borrowers. However, given that the lender offers maximum loans in subsequent periods, a selfish borrower has no incentive to default in the first period.

In the E treatment, the potential to expropriate and reinvest loaned funds increases the borrower's incentive to default. Still, reputation equilibria exist in this treatment. However, these equilibria must be characterized by "starting small" loan profiles: to meet the borrower's incentive constraint, the lender must start with non-maximum loans and increase the loan size offered to the borrower, if he or she repays. The intuition for this result is simple: if the lender offers the maximum loan of 10 in period 1, a selfish borrower could default and reinvest these funds in all future periods without paying interest. The selfish borrower only stands to gain from repaying initial loans if future loans are higher. Thus, the lender earns most profits by offering an increasing loan profile, with the maximum possible starting loan size.

In contrast to the NE treatment, a screening equilibrium does exist in the E treatment. If the lender offers a large enough loan in the first period, a selfish borrower prefers to default straight away. For example, a selfish borrower will never repay a maximum loan of 10, with desired repayment of $10\bar{r}$, while a social borrower will repay such a loan.

Whether the reputation or a screening equilibrium yields higher profits for the lender in the E treatment depends on the parameters of the game: the gross return on investment (3 in our experiment) the share of social borrowers, and the threshold interest rate of social borrowers \bar{r} . In Appendix A, we show that if $\bar{r}=2$ the lender earns a higher profit in the reputation equilibrium than in a screening equilibrium.¹³

¹³The assumption that $\bar{r}=2$ implies that social borrowers demand at least half the surplus from a loan contract. As we show in section 4.4, this assumption is supported by

Comparing our predictions for the E and NE treatments, we expect lower levels of credit volume in the E than in the NE treatment. There are two reasons for this. First, reputation equilibria in the E treatment should be characterized by “starting small”, and thus by lower initial loan sizes than in the NE treatment. Second, in the E treatment screening equilibria which imply no lending to selfish borrowers in periods 2 through 7 exist, in contrast to the NE treatment. The repayment rate in the E treatment should be lower in initial periods but higher in subsequent periods, than in the NE treatment, if some relationships in the E treatment are characterized by screening. Aggregate investment may be either higher or lower in the E than in the NE treatment. If both treatments are characterized by reputation equilibria we expect higher investment in the NE than in the E treatment due to lower lending volumes in the E treatment. However, a screening equilibrium in the E treatment characterized by the maximum loan of 10 in period 1 implies full efficiency due to expropriation and reinvestment by selfish borrowers.

Hypothesis 1 (E treatment vs. NE treatment): *credit volume in the E treatment is lower than in the NE treatment. The repayment rate in the E treatment should be lower in initial periods and higher in later periods, compared to the NE treatment. Aggregate investment may be either higher or lower in the E treatment due to the potential for fully efficient screening equilibria.*

The predictions for our E treatment and the 1S treatment suggest that we should see a higher credit and investment volume in the former. Moreover, if reputation equilibria emerge in the E treatment, the aggregate repayment rate should be higher in that treatment.

Hypothesis 2 (E treatment vs. 1S treatment): *credit volume, repayment rate and investment volume in the E treatment is higher than in the 1S treatment.*

observed behavior in our experiment. We find that the 2 is the most common interest rate demanded in all three of our treatments.

4.4 Results

We report our results in two steps: Section 4.4.1 provides an overview of our aggregate treatment effects by comparing the outcomes from the E, NE and 1S treatments. This sets the stage for a detailed comparison of loan offers, borrower repayment and profits in the E and NE treatments.

4.4.1 Aggregate treatment effects

Table 4.2 presents mean statistics by treatment for lenders' offers and borrowers' repayment behavior, as well as the resulting level of investment and payoffs. Our matching process implies that each lender (borrower) played the lending game with three different borrowers (lenders). Panel A of Table 4.2 reports summary statistics based on the observed outcome in all three rounds. Panel B reports results for 3rd round behavior only. In both panels the significance of treatment effects between the E and NE, as well as between the E and 1S treatments are measured by p-values of two-sided Mann-Whitney tests which use the means per matching group as independent observations.

Comparing the **E treatment and the NE treatment** we find that the *Credit volume*, defined as the average loan size per period, is significantly lower in the E treatment compared to the NE treatment, as predicted in Hypothesis 1. If we consider all three rounds (Panel A) the average credit volume per period is 3.17 in the E treatment, compared to 5.67 in the NE treatment ($p=.01$). A similar result is obtained if we consider only the third round (Panel B). The *Interest rate* offered by lenders, defined as the desired repayment divided by the loan size, is close to 2 in both treatments, which implies that most lenders offered an equal split of the surplus. After learning, in round 3, the interest rate is not significantly different between the E and NE treatments ($p=.42$).

Turning to borrower behavior, Table 4.2 shows that the large majority of loan offers are accepted. We also find a high *Repayment* rate in both the E and NE treatments. Considering all three rounds, the repayment rate is 65% in the E treatment and 79% in the NE treatment. The difference between the two treatments is significant ($p=.05$). If we consider the last round, this difference disappears with repayment rates at 70% and 83%, respectively

($p=.15$).

Considering all three rounds, we find a similar level of *Investment* in the E (5.45) and the NE treatment (5.54). However, by round 3, investment falls substantially in the E treatment and is significantly lower than in the NE treatment ($p=.03$). *Lender profits* differ significantly between the E and NE treatments. In the E treatment lenders just break even and earn significantly less than in the NE treatment (10.8 vs. 13.3, $p<.01$). Conversely, *Borrower profits* are higher in the E than in the NE treatment although this difference is not statistically significant (20.1 vs. 17.8, $p=.13$).

Result 1: *The possibility of expropriation leads to a lower credit volume in the E treatment compared to the NE treatment. Aggregate repayment rates however do not differ. These two facts lead to lower investment, and thus efficiency, in the E treatment compared to the NE treatment.*

Comparing the **E treatment and the 1S treatment** we find a significantly higher rate of loan repayment by borrowers (64% vs. 10%, $p<.01$). This does not however translate into higher credit volumes. Contrary to our hypothesis 2, we find no significant difference in credit volume between the E and 1S treatment (3.17 vs. 3.81, $p=.39$). These results are robust to learning effects across rounds, as shown in Panel B of Table 4.2. A look at lender profits in the 1S treatment reveals why we observe a similar level of lending in the E and 1S treatments: lenders are over-optimistic in the 1S treatment. In this treatment they earn less than their outside option on average (7 vs. the outside option of 10) as the low repayment rate implies that those lenders who do extend credit make substantial losses. Such behavior is likely to disappear and loans to fall to 0 with more repetitions (as observed in Brown and Zehnder, 2007).

Result 2: *The repayment rate of borrowers is significantly higher in the E treatment than in the 1S treatment. However, credit volumes are similar in the two treatments due to over-optimistic lending behavior of lenders.*

Table 4.2. Summary Statistics by Treatment

The table reports means for each variable by treatment, at the matching group level. It also reports the Mann-Whitney test p-values comparing outcomes across treatments. Credit volume is the size of the loan offered by the lender and has a minimum value of 0 and a maximum value of 10. Interest is the gross interest rate calculated as desired repayment / loan size for all loan offers exceeding 0. By design Interest lies between 0 and 3. Acceptance is a dummy variable which is 1 if loan size > 0 and the offer was accepted and 0 if loan size > 0 and the offer was declined. Repayment is a dummy variable which is 1 if a loan was accepted and the desired repayment was made, and 0 if a loan was accepted and the desired repayment was not made. Investment volume is defined as the accepted loan size plus the accumulated capital of the borrower. Lender profit and Borrower profit are the per-period payoffs of the lender / borrower.

Panel A. All rounds					
	Mean			Mann-Whitney test (p-values)	
	E	NE	1S	E vs. NE	E vs. 1S
Credit volume	3.17	5.67	3.81	0.01	0.39
Interest	2.13	1.99	1.96	0.05	0.20
Acceptance	88%	96%	95%	0.04	0.14
Repayment	64%	79%	10%	0.05	0.00
Investment volume	5.45	5.54	3.61	0.91	0.02
Lender profit	10.83	13.26	7.02	0.01	0.00
Borrower profit	20.06	17.82	20.20	0.13	0.89

Panel B. Round 3					
	Mean			Mann-Whitney test (p-values)	
	E	NE	1S	E vs. NE	E vs. 1S
Credit volume	2.40	5.87	2.28	0.00	0.83
Interest	2.09	2.00	1.55	0.42	0.03
Acceptance	92%	99%	100%	0.09	0.04
Repayment	70%	83%	0%	0.15	0.00
Investment volume	4.41	5.78	2.28	0.03	0.00
Lender profit	11.09	14.14	7.72	0.01	0.00
Borrower profit	17.73	17.42	16.83	0.42	0.57

Having described the aggregate effects of expropriation on credit volume, repayment and efficiency in this value we now turn to investigating how these effects come about. In values 4.4.2 and 4.4.3 we provide a detailed comparison of lender and borrower behavior over the course of their relationships in the E treatment to the NE treatment. In value 4.4.4 we examine how differences in lender and borrower behavior impact on their respective profits.

4.4.2 Loan offers

Figure 4.1A displays the distribution of loan offers in the first period of relationships in the E and NE treatments. The figure reveals that large loans are less frequent in the initial period in the E compared to the NE treatment. In the NE treatment more than 35% of lenders chose the maximum loan size of 10, and 60% offer loan sizes of 6 and above. By contrast, in the E treatment only 19% of lenders offer a loan of 10 in period 1 and only 30% of loans offered are 6 and above. Figure 4.1B shows that the distribution of interest rates is similar in the E and NE treatments: In both treatments the surplus sharing gross interest rate of 2 is most common.

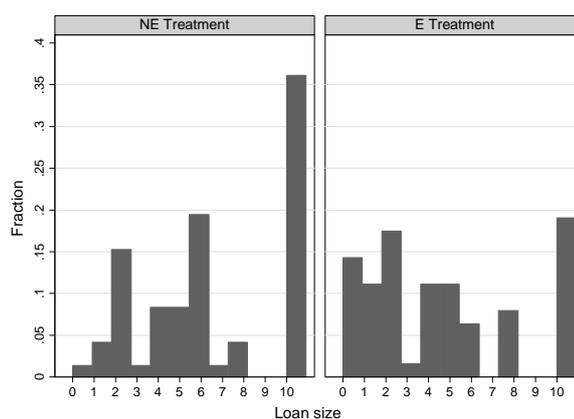


Figure 4.1A: Loan size

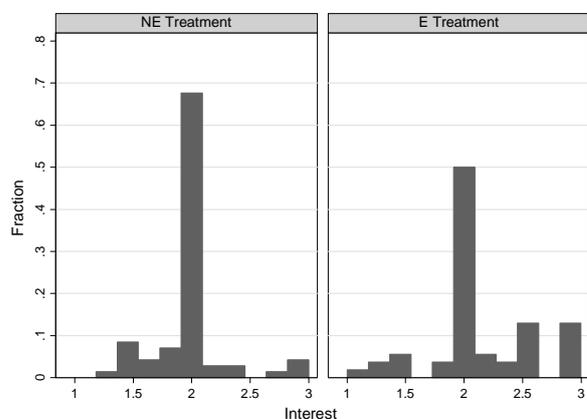


Figure 4.1B: Interest

Figure 4.1. Period 1 loan offers in the NE and E Treatments

Table 4.3 reports the results of OLS regressions relating first-period loan offers to the treatment (E or NE), round of the experiment (round 1, 2 or 3) and characteristics of the lender. Period 1 loans are significantly smaller in the E than NE treatment in round 2 and 3 of the experiment, but not in round 1 (see column 3). Table 4.3 also confirms that there is no difference in first-period interest rates between the two treatments (columns 4-6).

The variation in period 1 loan offers across lenders seems to be strongly related to individual risk attitudes. In Table 4.3 we control for three measures of lender characteristics using data from the pre-experimental games discussed in value 4.2.3. We find that lenders with higher indicators of risk aversion offer smaller period 1 loans. This finding confirms field evidence by Schaechter (2007) suggesting that first-mover behavior in trust-games is significantly related to individual risk attitudes. We find no relation between loan offers in period 1 and our measures of strategic reasoning or trust.

Result 3: *In the E treatment lenders offer smaller loans in the initial period of relationships compared to the NE treatment, while interest rates are similar in both treatments.*

Table 4.3. Determinants of first-period loan offers

The table reports OLS estimates for the dependent variables Loan size (columns 1-3) and Interest (columns 4-6), using observations from the first period of each relationship only. Round 2 and Round 3 are dummy variables which are 1 only for observations from the corresponding round, while E Treatment is a dummy variable which is 1 for all observations from the E treatment and zero for those from the NE treatment. The variables Risk aversion, Strategic reasoning and Trust are lender-specific measures elicited from pre-experiment games. Standard errors are reported in brackets and are corrected for clustering at the matching group level. *, **, *** indicate significance at the 10%, 5%, and 1% level respectively.

Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)
	E	Loan size NE	E and NE	E	Interest NE	E and NE
Round 2	-0.905 [0.556]	1.125*** [0.284]	1.125*** [0.274]	0.098 [0.117]	0.032 [0.064]	0.027 [0.065]
Round 3	-1.952*** [0.425]	1.042 [0.575]	1.042* [0.554]	-0.068 [0.176]	0.052 [0.067]	0.048 [0.068]
E Treatment			-0.51 [0.746]			0.158 [0.140]
E * Round 2			-2.030*** [0.594]			0.059 [0.134]
E * Round 3			-2.994*** [0.685]			-0.1 [0.174]
Risk aversion	-0.440* [0.187]	-0.632** [0.208]	-0.575*** [0.111]	-0.021 [0.034]	0.030* [0.013]	0.014 [0.021]
Strategic Reasoning	-0.015 [0.057]	-0.039 [0.038]	-0.026 [0.042]	-0.003 [0.005]	0.003 [0.004]	-0.001 [0.003]
Trust	0.33 [0.285]	0.057 [0.140]	0.154 [0.128]	-0.029 [0.025]	0.028* [0.012]	0.012 [0.013]
Constant	7.165 [6.001]	12.082*** [2.852]	10.224** [3.437]	2.630*** [0.384]	1.422*** [0.300]	1.892*** [0.307]
Method	OLS	OLS	OLS	OLS	OLS	OLS
Lender effects	no	no	no	no	no	no
Observations	63	72	135	63	72	135
Number of Lenders	21	24	45	21	24	45
R2	0.26	0.13	0.24	0.07	0.17	0.07

Figure 4.2 displays how relationships develop over time in the E and NE treatment. We classify each lender-borrower relationship into one of three types at the end of each period: relationships in which no loan has been extended (No loan), relationships in which a loan has been extended in at least one period and no default has occurred (No default), and relationships in which at least one loan has been extended and the borrower has defaulted at least once (Default). Figure 4.2 shows that in the E treatment more relationships are characterized by default in earlier stages of the relationship than the NE treatment. By period 3 less than 40% of relationships are without default in the E treatment, while almost 70% are in the NE treatment ($p=.01$). After period 5 more relationships feature defaults in the NE treatment. These patterns support our prediction that relationships are less likely to be characterized by reputation building and more likely to involve screening in the E treatment.

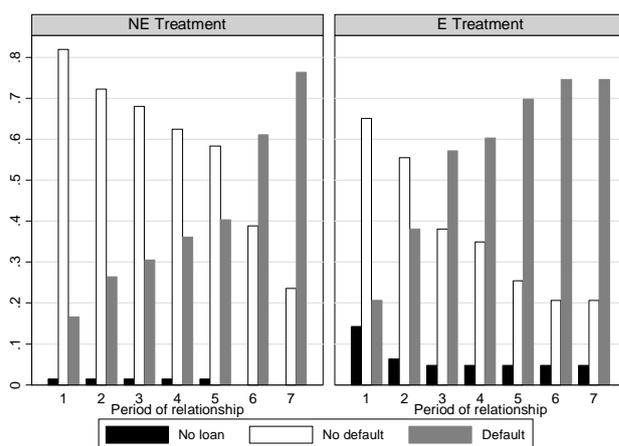


Figure 4.2. Lender -borrower relationships

Lenders react strongly to repayment behavior in our experiment. Table 4.4 examines loan sizes and interest rates offered by lenders over the course of relationships. Loan sizes offered by lenders in both treatments are significantly higher if there was no default by the borrower in previous periods (columns 1-2). As revealed by the negative coefficient of $E * No\ default$, in column 3, lenders reward borrowers less strongly for repayments in the E than in the NE treatment. Interest rates are not significantly affected by repayment behavior in either treatment (columns 4-5).

Table 4.4. Loan offers in periods 2-7

The table reports panel estimates for *Loan size* (columns 1-3) and *Interest rate* (columns 4-6) offered to borrowers in periods 2 through 7. *No default* is a dummy for those borrowers which received at least one loan and never defaulted in prior periods. *Round 2* and *Round 3* are dummy variables which are 1 only for observations from the corresponding round, while *E Treatment* is a dummy variable which is 1 for all observations from the E treatment and zero for those from the NE treatment. All regressions include random effects per lender and time fixed effects which are not reported for brevity. Standard errors are reported in brackets and are corrected for clustering at the matching group level. *, **, *** indicate significance at the 10%, 5%, and 1% level respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Loan size			Interest		
Treatment	E	NE	E and NE	E	NE	E and NE
No default	3.416*** [0.282]	5.144*** [0.312]	5.161*** [0.279]	0.081 [0.069]	0.021 [0.038]	0.018 [0.047]
Round 2	-1.786*** [0.314]	-1.212*** [0.322]	-1.215*** [0.292]	-0.062 [0.071]	-0.006 [0.033]	-0.007 [0.041]
Round 3	-1.869*** [0.286]	-1.157*** [0.327]	-1.161*** [0.296]	-0.128* [0.066]	-0.018 [0.033]	-0.022 [0.041]
E Treatment			-0.362 [0.616]			0.135 [0.095]
E * No default			-1.758*** [0.419]			0.088 [0.069]
E * Round 2			-0.576 [0.475]			-0.061 [0.069]
E * Round 3			-0.705 [0.453]			-0.109* [0.066]
Constant	2.934*** [0.495]	2.866*** [0.547]	3.056*** [0.468]	2.178*** [0.101]	2.015*** [0.057]	2.021*** [0.072]
Method	OLS	OLS	OLS	OLS	OLS	OLS
Lender random effects	yes	yes	yes	yes	yes	yes
Time fixed effects	yes	yes	yes	yes	yes	yes
Observations	306	432	738	193	307	500
Number of Lenders	21	24	45	21	24	45
R2 - overall	0.44	0.46	0.50	0.02	0.01	0.05

Figure 4.3 and Table 4.5 examine the time structure of the loan size in relationships without previous default in more detail. Figure 4.3A displays the mean loan size over the course of a relationship for those relationships with no prior default. In the NE treatment, the mean loan size to non-defaulting borrowers increases strongly over time; from 6.3 in period 1 to 8.8 in period 5. This result is in contrast to the profit-maximizing equilibrium for the lender in the NE treatment, a flat profile of loans of size 10, but is in line with previous experimental research (Anderhub et al., 2002; Cochard et al., 2004; King-Casas et al., 2005 and Bonhorst et al., 2009). These studies show that in repeated trust games first-movers do increase the stakes over time, and that this can be explained by learning (Anderhub et al., 2002)¹⁴. By contrast, the loan size remains almost constant over time in the E treatment. Here the mean loan size to non-defaulting borrowers increases from 4.4 in period 1 to 5.4 in period 2. After this, however, the mean loan size hovers between 4.9 and 5.5 until period 6 before falling to 2 in the final period.

The constant loan sizes over time in the E treatment are surprising. After all, in this treatment the lender can only motivate (selfish) borrowers to repay by increasing loan sizes over time. Analyzing loan offers in more detail we find that the flat pattern of mean loan size in the E treatment over time is driven by some lenders who stop lending, although the borrower did not default. In Figure 4.3B we therefore examine the mean loan size in "fully active" relationships only, i.e. relationships in which lenders always offered a strictly positive loan between periods 1 and 5. Considering these relationships only, we find a significant increase in the mean loan size for both the NE and the E treatment. In particular in the E treatment the loan size increases from 4.4 in period 1 to 8.4 in period 6.

¹⁴In our experiment loan sizes increase substantially during the first periods of the first round of the NE treatment (from 5.6 in period 1 to 9.8 in period 6), but the loan profile becomes flatter in the third round (starts at 6.7 and peaks in period 5 at 8.8). Such a change over time is not observed in the E treatment.

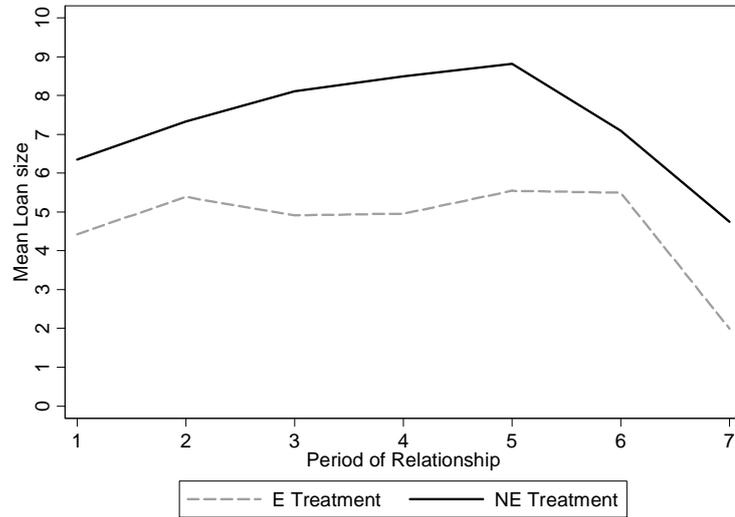
Figure 4.3. Relationships without default

Figure 4.3A. Loan size in relationships without default

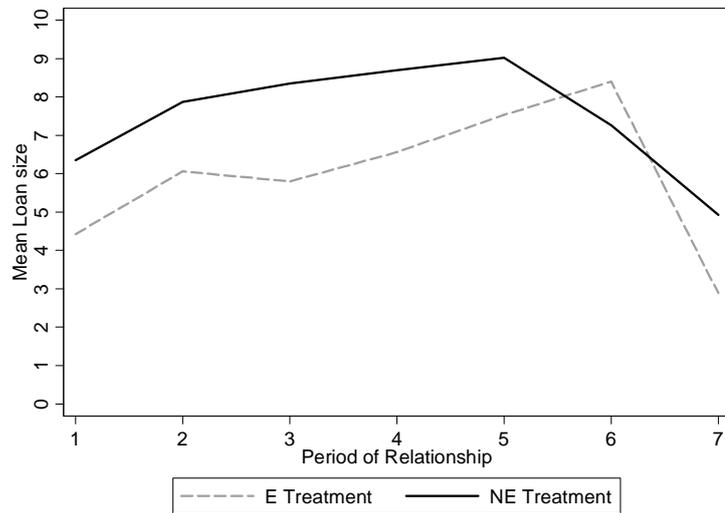


Figure 4.3B. Loan size in "fully active" relationships without default

Table 4.5 provides a multivariate analysis of loans in relationships without previous default. We relate the loan size offered by lenders to the period of the relationship and the round of the experiment. To account for non-linear time trends of loan offers we include the period of the relationship as well as its squared value in the model. We start by pooling the data across all lenders, columns (1-3). We then account for heterogeneity in loan offers across lenders with lender random effects in columns (4-6). Our results in columns (1-3) confirm the time pattern of loan sizes presented in Figure 4.3A. We find that the coefficient of Period is only significantly positive in the NE treatment, but not in the E treatment. Controlling for heterogeneity of behavior across lenders in columns (1-4) we confirm the pattern presented in Figure 4.3B. We find a significant positive coefficient of Period and a negative coefficient of its squared value for both treatments. These results suggest that, once we control for the (significant) heterogeneity in behavior across lenders, loan sizes in no-default relationships increase over time, but at a declining growth rate, in both treatments.

In unreported regressions we replace the lender random effects in columns (4) and (5) of Table 4.5 with our measures of risk aversion, strategic reasoning, and trust from our pre-experimental games. Confirming our results from Table 4.4 we find that in both treatments risk averse lenders offer lower loans to borrowers, even when they have never defaulted in the past. We also find that the lenders' level of trust is strongly correlated with loan offers to non-defaulting borrowers in the E treatment, but not in the NE treatment. Lenders' level of strategic reasoning is not correlated with loan offers to non-defaulting borrowers in either treatment.

Result 4: *In the E and NE treatments, lenders increase loan sizes to borrowers who repaid all prior loans, but do not alter interest rates.*

Table 4.5. Loan size and interest rates in relationships without default

This table reports panel estimates for Loan size, using pooled OLS (columns 1-3) and random effects per lender (columns 4-6) in relationships without any previous default. Period and Period2 are variables denoting the period of the relationship and its squared value, respectively. E treatment is a dummy variable which is 1 for all observations from the E treatment and zero for those from the NE treatment. Round 2 and Round 3 are dummy variables which are 1 only for observations from the corresponding round. Standard errors are reported in brackets and are corrected for clustering at the matching group level. *, **, *** indicate significance at the 10%, 5%, and 1% level respectively.

Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)
	Loan size (pooled OLS)			Loan size (random effects)		
Treatment	E	NE	E and NE	E	NE	E and NE
Period	1.032	3.328***	3.328***	2.382***	3.133***	3.128***
	[0.982]	[0.684]	[0.701]	[0.684]	[0.520]	[0.512]
Period ²	-0.155	-0.416***	-0.416***	-0.295***	-0.413***	-0.413***
	[0.114]	[0.078]	[0.080]	[0.079]	[0.059]	[0.058]
Round 2	-3.264***	-1.603***	-1.603***	-1.213**	-0.816**	-0.797**
	[0.671]	[0.482]	[0.494]	[0.518]	[0.402]	[0.396]
Round 3	-2.680***	-1.067**	-1.067**	-1.015**	-0.713*	-0.707*
	[0.651]	[0.468]	[0.479]	[0.504]	[0.375]	[0.370]
E Treatment			2.571			-1.111
			[2.322]			[1.826]
E * Period			-2.296*			-0.809
			[1.175]			[0.875]
E * Period ²			0.261*			0.125
			[0.135]			[0.100]
E * Round 2			-1.661**			-0.529
			[0.811]			[0.666]
E * Round 3			-1.612**			-0.408
			[0.787]			[0.638]
Constant	5.648***	3.077**	3.077**	1.957	3.240***	3.245***
	[1.930]	[1.368]	[1.401]	[1.428]	[1.097]	[1.088]
Method	OLS	OLS	OLS	OLS	OLS	OLS
Lender random effects	No	No	No	Yes	Yes	Yes
Observations	151	275	426	151	275	426
Number of Lenders	-	-	-	20	24	44
Adj. R2 (overall for random effects)	0.166	0.135	0.250	0.126	0.133	0.235

4.4.3 Repayment behavior

Figure 4.4 displays the repayment behavior of borrowers in the E and NE treatment. Figure 4.4A displays repayment behavior in period 1 depending on the loan size offered to borrowers. The figure shows that in the E treatment, the repayment rate in period 1 is higher for loans of sizes 1-5, than for loans of 6-9 and loans of size 10. By contrast, in the NE treatment the repayment rate is equally high for small and large loans. This finding supports our hypothesis 1, which suggests that the possibility of expropriation gives borrowers stronger incentives to default on large loans at the beginning of a relationship.

Figure 4.4B displays repayment rates by period in the E and NE treatments. The repayment rate in the NE treatment exceeds 80% in the initial periods and then falls substantially in periods 6 and 7. As in Brown and Zehnder (2007) this pattern suggests the presence of strong reputation incentives. Selfish borrowers imitate social ones during the first periods and start defaulting in periods 6 and 7, as the game comes close to an end. By contrast, in the E treatment we find no time trend in the repayment rate. Comparing the E to the NE treatment we find a lower repayment rate in initial periods but a higher repayment rate in the final periods of relationships. This finding supports our hypothesis that the E treatment may be characterized by more screening and less reputation building than the NE treatment.

Table 4.6 presents the results of a regression analysis of individual borrower repayment behavior in the E and NE treatments. The results in the table suggest that in both treatments the probability of a borrower repaying a loan is hardly related to the loan size but negatively related to the interest rate. Confirming the pattern observed in Figure 4.4 the table reports a stronger time trend on loan repayment in the NE than in the E treatment.

In unreported regressions we replace borrower random effects in columns (1) and (2) of Table 4.6 with the measures of risk aversion, strategic reasoning and trustworthiness from our pre-experimental games. Interestingly we find that repayment behavior in the E and NE treatments are unrelated to risk aversion and trustworthiness. We find that repayment rates are positively

related to strategic reasoning in the NE but not in the E treatment.

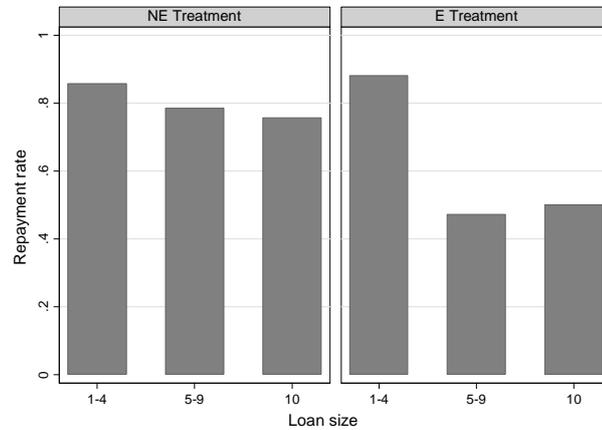


Figure 4.4A. Repayment by loan size in period 1

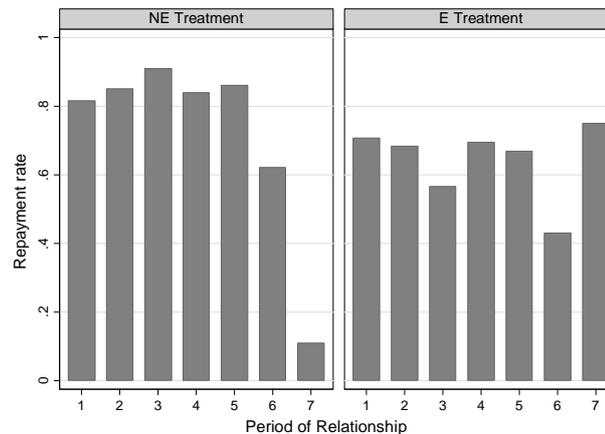


Figure 4.4B. Repayment by period

Figure 4.4. Repayment of loans

Result 5: *In the E treatment the repayment rate in initial periods is lower than in the NE treatment, but the fall in the repayment rate towards the end of the game is also more moderate. This suggests that there is more screening out of selfish borrowers and less reputation based relational contracts in the E compared the NE treatment.*

Table 4.6. Determinants of repayment

The table reports panel estimates for the dependent variable *Repayment* which is 1 if the borrower made the desired repayment after accepting a loan offer and 0 if the borrower did not make the desired repayment. *Loan size* and *Interest* are size of the loan and the gross interest rate offered by the lender. *Period* is the period of the relation. *Round 2* and *Round 3* are dummy variables which are 1 in the corresponding round, while *E Treatment* is a dummy variable which is 1 for observations in the E treatment and zero in the NE treatment. Columns (1-3) report probit estimates, (4) reports OLS estimates. Standard errors are reported in brackets. *, **, *** indicate significance at the 10%, 5%, and 1% level respectively.

	(1)	(2)	(3)	(4)
Treatment	E	NE	E and NE	E and NE
Loan size	-0.037 [0.039]	0.034 [0.036]	0.001 [0.025]	0.013* [0.008]
Interest	-0.870*** [0.273]	-1.516*** [0.412]	-1.130*** [0.223]	-0.342*** [0.079]
Period	-0.131** [0.062]	-0.296*** [0.052]	-0.216*** [0.038]	-0.065*** [0.011]
Round 2	-0.165 [0.270]	0.244 [0.212]	0.102 [0.163]	0.064 [0.051]
Round 3	0.24 [0.253]	0.455** [0.215]	0.368** [0.162]	0.091* [0.049]
E Treatment			-0.483* [0.286]	-0.281 [0.247]
E * Loan size				-0.018 [0.012]
E* Interest				0.094 [0.103]
E* Period				0.036* [0.018]
E * Round 2				-0.108 [0.086]
E * Round 3				-0.032 [0.081]
Constant	2.744*** [0.719]	4.531*** [1.034]	3.763*** [0.598]	1.527*** [0.185]
Method	Probit	Probit	Probit	OLS
Borrower random effects	yes	yes	yes	yes
Observations	216	365	581	581
Number of Borrowers	21	24	45	45
R2 overall				0.12

4.4.4 Profits

Our results above show that lenders in the E treatment are less likely to offer high first-period loans than in the NE. Lenders in both treatments increase their loan sizes when the borrower has repaid previous his loans. In this value we examine how these lending strategies pursued in the E and NE treatments affected lender and borrower profits.

Figure 4.5 displays the average profit of lenders per period over the course of each relationship with a borrower. We classify each lender-borrower relationship into one of three profiles: (i) Relationships in which the lender offers the maximum loan size in the first period (which we label "Start big"); (ii) relationships in which the lender offers a first-period loan of less than 10, but then raises his loan offer between period 1 and period 5 (which we label "Start small and increase"); and (iii) "Other" relations. According to this classification there are 12 "Start big" relations, 19 "Start small and increase" relations and 32 "Other" relations in the E treatment. In the NE treatment there are 26 "Start big" relations, 23 "Start small and increase" relations and 23 "Other" relations.

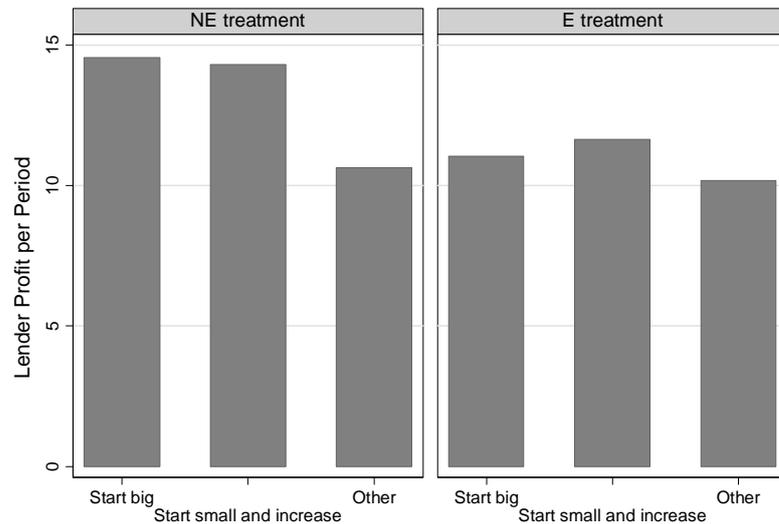


Figure 4.5. Initial loan offers and lender profits

The figure shows that in the NE treatment the strategies of "Start big" and "Start small and increase" are most profitable, yielding significantly higher profits than "Other" relations (Wilcoxon signed ranks test, $p=.03$ in both cases). By contrast, in the E treatment "Start small and increase" only yields slightly higher profits than "Other" ($p=.13$) and "Start big" ($p=.83$).

The regression analysis presented in Table 4.7 confirms that lenders in the E treatment were not better off if they pursued a strategy of "Start big" or "Start small and increase", compared to "Other" strategies. The OLS estimates presented in column (1) suggests that average lender profits in the E treatment were similar for all three relationship types. By contrast, the estimates in column (2) suggest that lenders in the NE treatment earned roughly 40% less from "Other" than from "Start big" or "Start small and increase". These results suggest that the observed lending strategies in the E and NE treatments were rational from the point of view of the lender.

Columns (4-6) of Table 4.7 examine how borrowers' payoffs are affected by the lending strategy of the lender. The results reported show that in both treatments borrowers earned more if lenders pursued a strategy of "Start big" or "Start small and increase". Not surprisingly, borrowers in the E treatment benefit more than those in the NE treatment from "Start big" as they more often default on large first-period loans.

Result 6: *The different lending strategies observed in the E and NE treatments are rational from a lender's perspective: in the E treatment lenders do not earn higher profits from "Starting small" compared to offering high first-period loans or pursuing other strategies. By contrast lenders, in the NE treatment earn substantially higher profits when they offer high initial loans or "Start small" and then increase their loan size.*

Table 4.7. Lender and borrower profits

The table reports OLS estimates for the dependent variables *Lender profits* (columns 1-3) and *Borrower profits* (columns 4-6), which are calculated as the average profit over the 7 periods for a relationship. *Start big* is a dummy variable which is one for all relations in which the lender offers a first-period loan of 10, and zero otherwise. *Start small & increase* is a dummy variable which is one for all relations in which the lender offers a higher loan in period 3 than in period 1, and zero otherwise. *Round 2* and *Round 3* are dummy variables which are 1 only for observations from the corresponding round, while *E Treatment* is a dummy variable which is 1 for all observations from the E treatment and zero for those from the NE treatment. Standard errors are reported in brackets and are corrected for clustering at the matching group level. *, **, *** indicate significance at the 10%, 5%, and 1% level respectively.

Dependent variable	(1)	(2)	(3)	(4)	(5)	(6)
	Lender profits			Borrower profits		
Treatment	E	NE	E and NE	E	NE	E and NE
Start big	1.192 [1.140]	4.182*** [0.456]	4.296*** [0.427]	8.807*** [1.378]	5.164*** [0.694]	5.275*** [0.701]
Start small & increase	0.811 [0.463]	3.971*** [0.458]	3.814*** [0.347]	3.525** [1.147]	3.706*** [1.026]	3.735*** [0.979]
Round 2	-1.474** [0.502]	0.794 [0.966]	-0.297 [0.621]	-1.535 [1.041]	-1.536 [1.018]	-1.543** [0.696]
Round 3	-0.279 [0.422]	1.277 [0.909]	0.527 [0.545]	-3.429** [1.044]	-1.965* [1.013]	-2.647*** [0.733]
E Treatment			-0.113 [0.590]			2.595* [1.413]
E * Start big			-3.084** [1.155]			3.671** [1.447]
E * Start small & increase			-3.069*** [0.640]			-0.271 [1.462]
Constant	10.945*** [0.535]	9.791*** [0.798]	10.413*** [0.527]	18.975*** [1.302]	15.934*** [1.311]	16.114*** [1.091]
Method	OLS	OLS	OLS	OLS	OLS	OLS
Lender random effects	no	no	no	no	no	no
Borrower random effects	no	no	no	no	no	no
Observations	72	63	135	72	63	135
R2	0.09	0.37	0.35	0.34	0.34	0.36

4.5 Conclusion

In countries with weak creditor rights and debt enforcement relational contracting in the credit market may be hampered by the potential expropriation of funds by borrowers. We examine the impact of potential expropriation on lender-borrower relationships in an experimental credit market.

Our results suggest that potential expropriation reduces the number of relational contracts in which moral hazard is mitigated through reputation incentives. Instead, potential expropriation increases the number of relationships in which moral hazard is reduced by screening out selfish agents. When relational contracts do emerge under expropriation they are characterized by smaller credit volumes and thus less efficient than without expropriation.

Our findings provide strong support to the conjecture that observed patterns of investment in microfinance and FDI relationships may be driven by concerns over borrower default. In particular, the small initial investment sizes, observed in such relationships (Armendariz and Morduch, 2006; Rauch and Watson, 2003) may be driven by the fear that borrowers or host-country partners may expropriate funds.

Our findings also provide support to the hypothesis that sovereign lending is adversely affected by the lack of legal recourse (Bulow and Rogoff, 1989). Our results suggest that in a lending environment where the borrower can expropriate the lender's funds, as is the case in sovereign lending, borrowers will face credit constraints.

4.6 Appendix A. Predictions for the E and NE treatments

A.1. The Repeated Lending Game

A lender and a borrower interact for $T = 7$ periods. In every period, the schedule of events is the following:

1. The lender has an endowment of 10 in every period t . The borrower has a capital of C_t , where $C_1 = 0$.
2. The lender makes an offer (S_t, R_t) to the borrower. Whereby $S_t \in [0, 10 - C_t]$ and $R_t \in [1, v]S_t$, where $v > 1$.
3. The borrower chooses to accept ($A_t = 1$) or reject ($A_t = 0$) the offer.
4. If the offer is accepted the borrower earns an investment income of $I_t = v \cdot (S_t + C_t)$ and chooses whether to repay ($D_t = 0$) or default ($D_t = 1$)

We examine behavior in this game under two different conditions. First, in what we call the lending game without expropriation (or no-expropriation case), the capital of the borrower is $C_t = 0$ in all periods. Second, in the lending game with expropriation, where we have that the borrower's capital for $t > 1$ is:

$$C_t = \sum_{k=1}^{t-1} S_k D_k$$

The monetary payoff for the lender Π_t is 10 if he decides not to give a loan or if his loan offer is not accepted. If he gives out a loan, his offer specifies a loan size S_t and a repayment of $R_t = i_t S_t$, where $i_t \in [1, v]$. If the borrower accepts the offer ($A_t = 1$), he receives S_t and chooses whether to repay or not. Thus the lender's payoff Π_t in period t is:

$$\Pi_t = 10 - A_t S_t (1 - i_t (1 - D_t))$$

In turn, the borrower's income stems from two sources. He has a fixed income from other self-financed projects or income from other activities of

10. Additionally, he earns an investment income, which depends on whether he accepts a loan offer and the loan size offered S_t , as well as his own capital. If the borrower decides to repay, $R_t = i_t S_t$ is transferred to the lender. If he defaults, he accumulates capital for the next period, C_{t+1} , if in the lending game with expropriation. The borrower's payoff U_t in period t is:

$$U_t = 10 + v \cdot (A_t S_t + C_t) - A_t R_t (1 - D_t) - C_{t+1}$$

There are two borrower types, social (H for 'high') and selfish (L for 'low'), not observable to the lender. An L type repays a loan if it maximizes his monetary payoffs. An L type borrower will thus never repay a loan in period T . Assuming that lenders offer contracts (S_t, i_t) only to a borrower who repays in all prior periods, the incentive constraint of an L type borrower in the game without expropriation for periods $k = t \dots T - 1$ is:

$$[\mathbf{IC}_L, \text{No expropriation}] \sum_{k=t+1}^{T-1} (v - i_k) S_k + v S_T \geq v S_t$$

In the game with expropriation the incentive constraint for the L type borrower is

$$[\mathbf{IC}_L, \text{Expropriation}] \sum_{k=t}^{T-1} (v - i_k) S_k + v S_T \geq \sum_{k=t}^{T-1} (v - 1) S_t + v S_t$$

Note that in both incentive constraints, the monetary payoff of the borrower is positive. His participation constraint is therefore satisfied and has an incentive to accept any loan offer.

The H type borrower repays any loan he has accepted. However, the H type also cares about relative payoffs, which makes him yield negative utility if the gross interest rate is above a threshold $\bar{r} \in (1, v)$. The participation constraint of the H type can thus be written as

$$[\mathbf{PC}_H] i_t \leq \bar{r}$$

The lender's prior about the borrower being of type H is $\bar{p} \in (0, 1)$, i.e. \bar{p} is the ex-ante probability that the borrower is of type H . For any period $t > 1$ the lender updates his belief p_t on the borrower's type using Bayes' Rule. If selfish borrowers repay in period $t-1$ with a probability $\gamma_{t-1} \in [0, 1]$, then the lenders updated belief is given by $p_t = \frac{p_{t-1}}{p_{t-1} + \gamma_{t-1}(1-p_{t-1})}$.

Assuming that the participation constraint of H borrowers is met in all periods ($i_t \leq \bar{r}$) and that L type borrowers repay with a repayment probability $\gamma_1, \dots, \gamma_T$, whereby $\gamma_T = 0$, the participation constraint of the lender can be defined as

$$[\mathbf{PC\ Lender}_t] \sum_{k=t}^T S_k ((p_k + \gamma_k(1 - p_k)) i_k - 1) \geq 0, \text{ whereby } i_k \leq \bar{r}$$

Since $\gamma_T = 0$, for lenders to lend in the final periods we must have $p_T \bar{r} - 1 \geq 0$.

In what follows we will describe the equilibria of the repeated lending game, both with and without expropriation. The equilibrium concept used throughout is that of Perfect Bayesian Equilibrium (PBE). We will consider two types of equilibria: **reputation** and **screening** equilibria. Reputation equilibria are defined as those equilibria in which the L borrower repays loans at least in period 1. He thus builds a reputation, by imitating the H borrower for at least one period. Screening equilibria are defined as those in which the L type borrower defaults with certainty in period 1. Therefore, for the rest of the game L borrowers have been screened out and H types are identified. Whenever these equilibria exist, there exist a plethora of them. As is conventional in the literature (e.g. Thomas and Worrall, 1994), we concentrate on the equilibrium which is profit-maximizing for the lender, as he is the player making offers and the borrower only has the option of accepting them or not.

We make the following assumptions regarding the ex-ante probability \bar{p} that the borrower is of type H . Assumption 1 implies that the proportion of H type borrowers does not make it profitable to extend a loan in a one-shot situation:

$$\text{Assumption 1: } \bar{p} < \frac{1}{\bar{r}}$$

Assumption 2 implies that the proportion of H type borrowers is high enough to make a reputation equilibrium feasible in the repeated game with T periods feasible:

$$\text{Assumption 2: } \bar{p} \geq \frac{1}{\bar{r}T}$$

A.2. Lending without expropriation

Given our assumptions about \bar{p} , the profit-maximizing reputation equilibrium for the lender has maximum loan sizes in all non-final periods, and a smaller loan in the final period. Borrowers pool in periods 1 through 5, during which L borrowers always repay. In period 6 L borrowers default with positive probability and in period 7 they default always.

Proposition A1: *In the lending game without expropriation the profit-maximizing reputation equilibrium for the lender is characterized by offers $(S_t, i_t) = (10, \bar{r})$ if $t \leq 6$ and $(S_7, i_7) = (10\frac{\bar{p}}{v}, I)$. The H type borrower accepts and repays in all periods. The L type borrower accepts in all periods, repays with $\gamma_t = 1$ in periods $t \leq 5$, with $\gamma_6 = \frac{\bar{p}}{(1-\bar{p})}(\bar{r} - 1)$ and $\gamma_7 = 0$.*

Proof: We first consider whether the IC of the L type borrower is satisfied in periods 1 to 6. Then, we check whether the PC of the H type borrower is satisfied. Finally, whether the lender's PC is satisfied and whether the equilibrium is profit-maximizing.

- L type borrower repayment: Condition [IC_{L, No expropriation}] holds with inequality in all periods $t < 6$. In period 6 it holds with equality, so we know that the L type borrower is indifferent between repaying and not. Thus, $\gamma_1 = \dots = \gamma_5 = 1$ and $\gamma_6 = \frac{\bar{p}}{(1-\bar{p})}(\bar{r} - 1)$ is a best response behavior.
- H type borrower accepts and repays as $i_t = \bar{r}$ for all t .
- Lender contracts: Condition [PC Lender_T] is met with equality if he offers $(S_7, i_7) = (10\frac{\bar{p}}{v}, \bar{r})$ as $p_T = \frac{\bar{p}}{\bar{p} + \gamma_6(1-\bar{p})} = \frac{1}{\bar{r}}$. The lender's profits from lending in period 6 are $S_{T-1}((\bar{p} + \gamma_6(1-\bar{p}))i_{T-1} - 1)$ which are positive for $(S_6, i_6) = (10, \bar{r})$, as $\bar{p} > \frac{1}{\bar{r}^2}$ (Assumption 2). Since $\gamma_t = 1$ in all periods $t \leq 5$ the lender's participation constraint is met.
- This equilibrium is profit-maximizing for the lender for three reasons: (i) $i_t = \bar{r}$, therefore the H type borrower repays, and the lender extracts the maximum surplus; (ii) since $\frac{\partial \pi_t}{\partial S_t} > 0$, conditional on repayment, offering maximum loan sizes (of 10) until period 6 is profit-maximizing;

(iii) Since $\gamma_t = 1$ until period 5, he obtains maximum profits until this period and screening starts in the last period possible, 6.

In the game without expropriation, a **separating equilibrium**, in which L borrowers default with certainty in period 1, does not exist. In such an equilibrium the lender will offer maximum credit at the interest rate I for all periods 2 through 7 to borrowers who repay in period 1. Given this prospective loan schedule L borrowers would not default in period 1.

Proposition A2: *In the lending game without expropriation no fully separating equilibrium ($\gamma_1 = 0$) exists.*

Proof: In a fully separating equilibrium the lender will set the maximum possible interest rate and loan size $(S_t, i_t) = (10, \bar{r})$ in all periods $t > 1$. The incentive constraint of L borrowers is then $\sum_{t=2}^6 (v - \bar{r}) 10 + v 10 \geq i_1 S_1$. Given that the interest rate in period 1 cannot exceed \bar{r} it is impossible for the lender to offer a contract which does not meet $[\text{IC}_L, \text{No expropriation}]$.

Finally, note that the equilibrium described in Proposition A1 is 'second-best', as the loan sizes are maximal until period 6, but must fall in period 7 to meet the L borrower's IC.

A.3. Lending with expropriation

Given the above parameters a **reputation equilibrium** exists in the expropriation game. In contrast to the non-expropriation treatments loans are of a smaller size in period 1 and increase over time, with maximum credit only in the final period. Repayment behavior is identical to the reputation equilibrium under non-expropriation: borrowers pool in periods 1 through 5, with L borrowers repaying always. In period 6 L borrowers default partly and in period 7 they default always.

Proposition A3: *In the game with expropriation the profit-maximizing reputation equilibrium for the lender is characterized by offers $(S_7, i_7) = (10, \bar{r})$ and for all periods $t < 7$: $i_t = \bar{r}$, $S_t = \frac{(v-I)}{((7-t)(v-1)+\bar{r})} \sum_{k=t+1}^6 S_k + \frac{v}{((7-t)(v-1)+\bar{r})} 10$. The H type borrower accepts and repays in all periods. The L type borrower*

accepts in all periods, repays with certainty in periods 1-5, with probability $\gamma_6 = \frac{\bar{p}}{(1-\bar{p})}(v-1)$ and $\gamma_7 = 0$.

Proof:

- *L* type borrower repayment: The incentive constraint $[\text{IC}_{L,\text{Expropriation}}]$ holds with equality in all periods $t \leq 6$. As a result $\gamma_6 = \frac{\bar{p}}{(1-\bar{p})}(\bar{r}-1)$ and $\gamma_t = 1$ if $t < 6$ is a best response behavior.
- *H* type borrower accepts and repays as $i_t = \bar{r}$ for all t .
- Lender contracts: Proposition A1 shows that the participation constraint of the lender is met in all periods. The same holds under expropriation, as the repayment behavior of the *L* type borrowers is identical.
- By the same reasons as in Proposition A1, the interest rate and the repayment behavior are profit-maximizing for the lender. To incentivize the *L* type borrower to repay until period 6 loan sizes have to be increasing, as follows from $\text{IC}_{L,\text{Expropriation}}$. Therefore, to reach maximum profits the lender starts by choosing the maximum loan size of 10 in the last period, 7. In the previous periods, the loan size is chosen such that the borrower's IC is satisfied with equality.

Under expropriation a **separating equilibrium** exists in which *L* borrowers default with certainty in period 1.

Proposition A4: *In the lending game with expropriation a fully separating equilibrium ($\gamma_1 = 0$) exists. The profit-maximizing screening equilibrium for the lender has offers $(S_1, i_1) = \left(10 \frac{6v-5}{6(v-1)+I}, \bar{r}\right); (S_2, i_2) \dots (S_7, i_7) = (10, \bar{r})$.*

Proof: In a screening equilibrium, which maximizes the lender's profits, the lender will set the maximum interest rate ($i_t = \bar{r}$) and loan size ($S_t = 10$) in each period $t > 1$. In period 1 the lender offers the maximum interest rate and lowest loan size such that the borrower does not prefer to default in period 2. This implies that $6(v-1)S_1 + vS_1 > (v-i_1)S_1 + 5(v-1)10 + v10$. This implies that $i_1 = \bar{r}$ and $S_1 = 10 \frac{6v-5}{6(v-1)+\bar{r}}$.

Note that the screening equilibrium is more efficient than the reputation equilibrium. This is due to the fact that loan sizes are larger in period 1 under the screening equilibrium and L type borrowers default and reinvest these large loans until period 7. Therefore, investment levels are higher than under the reputation equilibrium. However, full efficiency is not reached, because this would require an initial loan size of 10, which is not profit-maximizing for the lender, who can screen by giving out a loan of $S_1 = 10 \frac{6v-5}{6(v-1)+\bar{r}} < 10$.

Whether the lender earns a higher profit under the reputation equilibrium or the separating equilibrium depends on the schedule of loan sizes in the reputation equilibrium, as well as the share of H type borrowers. In the next subvalue, we use the parameters in place in our experiment, to generate the predicted loan sizes and compare profits.

A.4. Application to the experiment

In our experiment we have that $v = 3$. We assume that H type borrowers are fair-minded and will repay only if they receive at least half of the gains from trade in any period, i.e. $\bar{r} = 2$. This gross interest rate also coincides with that observed in the experiment. Assuming $\bar{r} = 2$, our assumptions 1 and 2 on the share of H borrowers hold if $\frac{1}{2} > \bar{p} > (\frac{1}{2})^7$.

This implies from assumption 2 that a reputation equilibrium would be possible even in a 2 period repeated game. These parameters also imply the following schedule of loan sizes.

Period	No-expropriation	Expropriation
1	10	4.19
2	10	4.51
3	10	4.92
4	10	5.47
5	10	6.25
6	10	7.5
7	6.666667	10

Table A: Predicted loan sizes over time

The profits from the reputation equilibrium are $(4.19+4.51+4.92+5.47+6.25)(\bar{r}-1) + 7.5(\bar{p} + (1-\bar{p})\gamma_6)\bar{r} - 7.5 = 25.34 + 7.5(\bar{p}\bar{r}^2 - 1) = 25.34 + 7.5*$

$4\bar{p} - 7.5 = 17.84 + 30\bar{p}$. In contrast, the profits from the screening equilibrium are $9.29(\bar{r}\bar{p} - 1) + 60\bar{p}(\bar{r} - 1) = 9.29(2\bar{p} - 1) + 60\bar{p} = 78.58\bar{p} - 9.29$. The lender prefers the screening equilibrium only if $78.58\bar{p} - 9.29 > 17.84 + 30\bar{p}$. This is not the case for any $\bar{p} < 27.13/48.58 = 0.56$. If $\bar{p} < 1/\bar{r} = 1/2$, as in assumption 1, the lender does not prefer the screening equilibrium.

4.7 Appendix B: Instructions

The instructions displayed below are for all treatments. Parts of the text which are specific to a treatment are presented in brackets and the corresponding treatment is mentioned. We use the following code for treatments: NA no accumulation; A accumulation, and 1S for one-shot.

Experiment 4

Instructions for Lenders

For simplicity, throughout these instructions we refer to the lender in the masculine form, i.e. “he”, and the borrower in the feminine form, i.e. “she”.

Overview of the experiment

a) For this experiment you have been grouped together with 5 other participants. In this group there are 3 lenders and 3 borrowers. You will be a lender for the entire duration of the experiment.

b) The experiment consists of 3 rounds: in each round you will be matched with a different borrower. You will not be matched with the same borrower twice. You will not be informed about the identity of the other participants at any point.

c) Each round consists of [NA, A: 7 periods][1S:1 period]. You will interact with the same borrower for [NA, A: 7 periods][1S:1 period] only.

d) In each period you have an endowment which you can use to offer credit to the borrower. If you offer credit you can ask for a repayment from the borrower. If you make a credit offer, the borrower decides whether to accept this offer. If the borrower accepts your credit offer, she decides whether to make the repayment desired by you.

e) The points you earn in each period depend on the amount of credit you offer in each period, your desired repayment, whether the borrower accepts the offer, and whether the borrower makes your desired repayment.

f) All points that you earn during the course of the experiment will be exchanged into euro at the end of the experiment. The exchange rate will be:

25 points = 1 euro

g) This is the final experiment. Your earnings from this experiment will be paid out together with your earnings from the previous 3 experiments after this experiment is completed.

Experimental Procedures

There are 3 lenders and 3 borrowers in this experiment. You are a lender for the entire duration of the experiment. The experiment lasts for 3 rounds, and in each round you will be matched with a different borrower. Each round consists of [NA, A: 7 periods][1S:1 period], so that you interact with the same borrower for [NA, A: 7 periods][1S:1 period]. In the following we describe in detail how you and the borrower make decisions in each period. Attached to these instructions are screen shots of each screen on which either you or the borrower will be required to enter a decision.

1. Investment

In each period of this experiment the borrower has an investment opportunity. The amount the borrower invests is determined [A: by her capital and] by the credit amount the borrower receives from you. The borrower's investment amount cannot exceed 10 points in any period.

[A:

In period 1 the borrower's capital is 0. Her capital in periods 2-7 depends on her and your decisions in periods 1-6. How the borrower's capital in period 2-7 is determined is explained in value 4.

]

value 2 describes in detail how the borrower's credit amount in each period is determined.

In each period the investment income of the borrower is three times her investment amount.

$$\begin{aligned} \text{Investment amount} &= [\text{A: Capital} +] \text{ Credit amount} \leq 10 \\ \text{Investment income} &= 3 \times \text{Investment amount} \end{aligned}$$

2. Credit offers

In each period you have an endowment of 10 points. With this endowment you can make a credit offer to the borrower. For this purpose, the “credit offer” screen (screen shot attached to these instructions) will be shown to you at beginning of each period.

At the top of the screen you can see which round of the experiment you are in, what your identification number is, and the identification number of the borrower you are matched with for this round. All lenders and borrowers keep their identification number for the whole duration of the experiment. This allows you to check that within each round of 7 periods you are always matched with the same borrower, and that in each new round you are matched with a new borrower. At the top of the screen you also see which period you are in, and the remaining time left to make your credit offer (in seconds). In each period you have 30 seconds to make your credit offer.

To make a credit offer you first choose the credit amount. As the borrower has a maximum investment amount of 10 [A: which also includes her capital], the maximum credit amount you can offer in any period is 10 [A: – the borrower’s capital].

You then choose your desired repayment. The desired repayment may not exceed three times the credit amount.

$$\begin{aligned} 0 &\leq \text{Credit amount} \leq 10 \text{ [A: – Capital]} \\ 0 &\leq \text{Desired repayment} \leq 3 \times \text{Credit amount} \end{aligned}$$

You do not have to make a credit offer to the borrower in any period. If you do not want to make a credit offer you can enter a credit amount of 0 and a desired repayment of 0.

[A:

If the borrower’s capital equals the maximum investment amount of 10, then you cannot make a credit offer in this period. In this case the credit offer screen will inform you that no credit offer can be made.]

After you have determined your credit offer by entering a credit amount and desired repayment you must click on the "enter" button to finalize this offer. As long as you have not clicked on "enter" you may revise your offer.

[NA, A: On the left hand side of the “Credit offer” screen you can see the history of your interaction for all completed periods in this round. The history displays the following items for each period: [A: the borrower’s capital,] your credit amount offered, your desired repayment and whether the desired repayment was made (yes/no).]

3. Accepting the credit offer and making the desired repayment.

If you make a credit offer, the borrower will see the details of this offer on the “Credit acceptance” screen (screen shot attached). The borrower can then decide whether to accept the credit offer or not.

If the borrower accepts a credit offer she then chooses her Actual repayment. The borrower’s actual repayment can either be your desired repayment or 0. The borrower decides whether to make the desired repayment by choosing “yes” or “no” on the “Repayment decision” screen (screen shot attached).

$$\text{Actual repayment} = \text{Desired repayment or } 0$$

[A:

4. The borrower’s capital

In period 1 the borrower’s capital is 0.

The borrower’s capital for periods 2, 3, 4, 5, 6, or 7 depends on her credit amount and her actual repayment in the previous periods.

- If the borrower did not accept a credit offer in the previous period, her capital is equal to that in the previous period.
- If the borrower accepted a credit in the previous period and made the desired repayment to the lender, her capital is equal to that in the previous period.
- If the borrower accepted a credit in the previous period and did not make the desired repayment to the lender, her capital is equal to that in the previous period plus the credit amount in the previous period.

Capital for periods 2, 3, 4, 5, 6 or 7=	= Capital in previous period if no credit offer is accepted in the previous period.
	=Capital in previous period if a credit offer is accepted and the desired repayment is made in the previous period
	=Capital in previous period + Credit Amount in previous period if a credit offer is accepted and the desired repayment is not made in the previous period

]

5. Income calculation

If you did not make a credit offer or your offer was not accepted by the borrower your income equals your endowment of 10 points in this period. If you did make a credit offer and it was accepted by the borrower your income depends on the amount of credit you offered and the actual repayment of your borrower.

$$\text{Your Income} = 10 - \text{Credit amount} + \text{Actual repayment}$$

In each period the borrower has a certain income of 10 points. As mentioned in value 1 the borrower earns an additional investment income which is three-times the size of her investment amount. The borrower's income in each period equals her 10 points plus her investment income minus her actual repayment [A: and minus the borrower's capital for the next period. As period 7 is the final period the borrower's income in this period equals her 10 points plus her investment income minus her actual repayment.]

$$\text{Income of the Borrower} = 10 + \text{Investment income} - \text{Actual repayment [A:} - \text{Capital for next period]}$$

You will be informed about your income [A:;][NA, 1S: and] the income of the borrower [A: and the borrower's capital] on the "Income" screen (screen shot attached).

After you have studied the income screen, you can record this information on your documentation sheet. You can then proceed to the next period or next round.

Experiment 4 Instructions for Borrowers

For simplicity, throughout these instructions we refer to the lender in the masculine form, i.e. “he”, and the borrower in the feminine form, i.e. “she”.

Overview of the experiment

h) For this experiment you have been grouped together with 5 other participants. In this group there are 3 lenders and 3 borrowers. You will be a borrower for the entire duration of the experiment.

i) The experiment consists of 3 rounds: in each round you will be matched with a different lender. You will not be matched with the same lender twice. You will not be informed about the identity of the other participants at any point.

j) Each round consists of [NA, A: 7 periods][1S:1 period]. You will interact with the same lender for [NA, A: 7 periods][1S:1 period] only.

k) In each period the lender has an endowment which he can use to offer credit to you. If the lender offers credit he can ask for a repayment from you. If the lender offers credit, you decide whether to accept this credit offer. If you accept the credit offer, you decide whether to make the repayment desired by the lender.

l) The points you earn in each period depend the amount of credit offered by the lender, his desired repayment, whether you accept the lender’s credit offer, and whether you make the desired repayment to him.

m) All points that you earn during the course of the experiment will be exchanged into euro at the end of the experiment. The exchange rate will be:

$$25 \text{ points} = 1 \text{ euro}$$

n) This is the final experiment. Your earnings from this experiment will be paid out together with your earnings from the previous 3 experiments after this experiment is completed.

Experimental Procedures

There are 3 lenders and 3 borrowers in this experiment. You are a borrower for the entire duration of the experiment. The experiment lasts for 3 rounds, and in each round you will be matched with a different lender. Each round consists of [NA, A: 7 periods][1S:1 period], so that you interact with the same lender for [NA, A: 7 periods][1S:1 period]. In the following we describe in detail how you and the lender make decisions in each period. Attached to these instructions are screen shots of each screen on which either you or the lender will be required to enter a decision.

1. Investment

In each period of this experiment you have an investment opportunity. The amount you invest is determined [A: by your capital and] by the credit amount you receive from the lender. Your investment amount cannot exceed 10 points in any period.

[A:

In period 1 your capital is 0. Your capital in periods 2-7 depends on your and the lender's decisions in periods 1-6. How your capital in period 2-7 is determined is explained below in value 4.]

value 2 describes in detail how your credit amount in each period is determined.

In each period your investment income is three times your investment amount.

$$\text{Investment amount} = [\text{A: Capital} +] \text{Credit amount} \leq 10$$

$$\text{Investment income} = 3 \times \text{Investment amount}$$

2. Credit offers

In each period the lender has an endowment of 10 points. With this endowment the lender can make a credit offer to you. For this purpose, the "credit offer" screen (screen shot attached to these instructions) will be shown to the lender at beginning of each period.

To make a credit offer the lender first chooses the credit amount. As you have a maximum investment amount of 10 [A: which also includes your capital], the maximum credit amount the lender can offer in any period is 10 [A: – capital].

The lender then chooses his desired repayment. The desired repayment may not exceed three times the credit amount.

$$\begin{aligned} 0 &\leq \text{Credit amount} \leq 10[\text{A:} - \text{Capital}] \\ 0 &\leq \text{Desired repayment} \leq 3 \times \text{Credit amount} \end{aligned}$$

The lender does not have to make a credit offer to you in any period. If the lender does not want to make a credit offer he can enter a credit amount of 0 and a desired repayment of 0.

[A:

If your capital equals your maximum investment amount of 10, then the lender cannot make a credit offer to you.]

3. Accepting credit offers and choosing the actual repayment

If the lender makes a credit offer to you, you will see the details of this offer on the “Credit acceptance” screen (screen shot attached).

At the top of the screen you can see which round of the experiment you are in, what your identification number is, and the identification number of the lender you are matched with for this round. All lenders and borrowers keep their identification number for the whole duration of the experiment. This allows you to check that within each round of 7 periods you are always matched with the same lender, and that in each new round you are matched with a new lender. At the top of the screen you also see which period you are in, and the remaining time left to make your decision (in seconds). In each period you have 30 seconds to accept a credit offer.

On the right hand side of the screen you see the credit offer made by the lender. You can decide to accept a credit offer or not by clicking on the yes or no button on the right hand side of this screen. After you have made your decision you must click on the "enter" button to finalize this decision. As long as you have not clicked on "enter" you may revise your decision.

If you decide to accept the credit offer you then choose your Actual repayment. Your Actual repayment is either equal to the desired repayment of the lender or 0. You decide whether to make the desired repayment by choosing “yes” or “no” on the “Repayment decision” screen (screen shot attached).

$$\text{Actual repayment} = \text{Desired repayment or } 0$$

[NA, A: On the left hand side of the “Credit acceptance” screen and “Repayment decision” screen you can see the history of your interaction for all completed periods in this round. The history displays the following items for each period: [A: your capital,] the credit amount offered, the desired repayment and whether the desired repayment was made (yes/no).]

[A:

4. Your capital

In period 1 your capital is 0.

Your capital for periods 2, 3, 4, 5, 6 or 7 depends on your credit amount and your actual repayment in the previous periods.

- If you did not accept a credit offer in the previous period, your capital is equal to that in the previous period.
- If you accepted a credit in the previous period and made the desired repayment to the lender, your capital is equal to that in the previous period.
- If you accepted a credit in the previous period and did not make the desired repayment to the lender, your capital is equal to that in the previous period plus the credit amount in the previous period.

	= Capital in previous period if you did not accepted a credit offer in the previous period.
Capital for periods 2, 3, 4, 5, 6 or 7=	=Capital in previous period if you accepted a credit offer and made the desired repayment in the previous period
	=Capital in previous period + Credit Amount in previous period if you accepted a credit offer and did not make the desired repayment in the previous period

]

5. Income calculation

If the lender did not make a credit offer or you did not accept the lender’s offer, the lender’s income equals his endowment of 10. If the lender did make

a credit offer and it was accepted by you, the lender's income depends on the amount of credit offered and your actual repayment.

$$\text{Income of Lender} = 10 - \text{Credit amount} + \text{Actual repayment}$$

In each period you earn a certain income of 10 points. As mentioned in value 1 you earn an additional investment income which is three-times the size of your investment amount. Your income in each period equals your 10 points plus your investment income minus your actual repayment [A: and minus your capital for the next period. As period 7 is the final period your income in this period equals your 10 points plus your investment income minus your actual repayment.]

$$\begin{aligned} &\text{Your Income} = \\ &10 + \text{Investment income} - \text{Actual repayment [A: -Capital for} \\ &\quad \text{next period]} \end{aligned}$$

You will be informed about your income[A:, your capital] and the income of the lender on the "Income" screen (screen shot attached).

After you have studied the income screen, you can record this information on your documentation sheet. You can then proceed to the next period or next round.

4.8 Appendix C. Behavior in Pre-experiment Games

Table C summarizes the behavior of our subjects in the three pre-experiment games described in section 4.2.3. The table shows that there is no significant difference in pre-experiment game behavior between the E and NE treatments.

Treatment	E					NE					T-test E vs. NE Pr(T > t)
	Obs	Mean	Std.	Min	Max	Obs	Mean	Std.	Min	Max	
Risk aversion	42	5.9	2	0	11	48	6.1	1.5	3	10	0.54
Strategic Reasoning	42	71.7	16.1	20	97	48	71.8	12.1	40	94	0.98
Trust	42	5.8	3.2	0	10	48	5.1	3.6	0	10	0.32
Trustworthiness	42	19.5	13.6	0	46	48	18.6	13.1	0	44	0.76

Table C. Behavior in pre-experiment games in the E and NE treatments

The first game was a risk preference elicitation task (following Dohmen et al., 2010). In this task, each player made eleven decisions, each of which had two options, A and B. Option A was a lottery with two outcomes, 0 and 100 points. The probability that the second outcome would be drawn was one half in each decision. Option B was a certain amount, which ranged from 0 points (in decision number 1) to 100 points (in decision number 11) and incremented by 10 points as the decision number increased. The indicator Risk aversion in Table C reports the number of times a subject chose option B in this game.

The second game was a one-shot guessing game (Nagel 1995). Each participant was randomly matched with 5 other participants. Each participant had to choose a number between 0 and 100. The participant whose choice was closest to $2/3$ of the average choice would be the winner of a prize of 150 points. The indicator Strategic Reasoning in Table C is the choice made by subjects in this guessing game.

The third game was identical to the lending game of our 1S treatment, but played in the strategy method. First, subjects were asked to make decisions in the role of borrower. They were shown a table in which each column displayed a loan size in steps of 2 (2, 4, 6, 8 and 10), while each row displayed

a requested repayment in steps of 2 (2, 4, ..., 30). They were asked whether they would make the desired repayment, in each cell of the table for which the desired repayment was smaller or equal to three times the loan size. The subject then moved onto a different screen in which he was asked to make his decisions as a lender, i.e. to make a loan offer and request a repayment, both in steps of 2. The indicator Trust in Table C is the loan offer a subject chose to make as a lender in this game. The indicator Trustworthiness in Table C is the number of times a subject chose to repay as a borrower in this game.

Chapter 5

The Incentive Effect of Collateral

5.1 Introduction

This paper examines the effect of collateral on moral hazard and credit volume. Collateral is widely used in practice for financial contracting. More than 80% of small-business loans issued in the U.S. (Berger, Espinosa-Vega, Frame and Miller, 2010) and more than 75% of small- and medium-business loans issued in over 100 countries, mainly developing economies (Chavis, Klapper and Love, 2010), are collateralized. Since the use of collateral is costly (among others, it requires valuing and monitoring the assets pledged as collateral), a large, mainly theoretical literature has studied potential motivations for the use of collateral.

A main theoretical motivation is that collateral reduces moral hazard. Models of lending under moral hazard predict that pledging collateral induces borrowers to increase effort. Fear of losing the pledged asset increases borrowers' incentives to exert effort, i.e. take costly actions that increase the likelihood of repayment (e.g., Innes, 1990, and Boot, Thakor and Udell, 1991). Since collateral increases effort and thus the expected profits from lending, it may be a key determinant of a borrower's access to credit. This implies that regulations determining the type of collateral that may be pledged or how property may be registered (de Soto, 2001) are especially important. Borrowers who lack adequate collateral may lack access to credit.

Despite the potential role of collateral in reducing problems of moral hazard, the empirical evidence is scarce. One problem is that collateral may also be used as a screening device. Investment projects of borrowers vary in quality, which is often unknown to lenders. If collateral is used in an environment with asymmetric information (e.g., Bester 1985 and 1987), borrowers with a high quality project, i.e. a higher probability of success for any effort choice, are more likely to choose collateralized loans, accompanied by a lower interest rate. This, however, implies that collateral leads to a lower probability of default, both because of its incentive effect and because of screening. Since both the quality of projects and the actions of borrowers are unobservable, these effects cannot be easily isolated empirically. This paper isolates the incentive effect of collateral experimentally, by using a controlled laboratory environment in which all projects are of the same quality and examining borrower reactions to exogenous variations in collateral.

In contrast to the above-mentioned theoretical predictions, recent studies actually find that collateralized loans often have a higher probability of default (Jimenez and Saurina, 2004, Berger, Frame and Ioannidou, 2010). Since lenders tend to request collateral from observably worse borrowers, this indicates that the effect of selection on observables is substantially larger than the potential incentive effect of collateral. It is unclear, however, how strong the incentive effect is. Could it be actually weaker than theoretically predicted? Several factors could potentially weaken the incentive effect. A first factor is risk aversion. Risk averse borrowers face a tradeoff between the incentive effect of collateral and their desire for insurance, making an increase in effort less attractive (Holmstrom, 1979). Also, collateral shifts losses towards borrowers and puts lenders in a secure position. If borrowers strongly dislike losses or consider pledging collateral puts them in a disadvantaged position relative to the lender, they may not exhibit the traditional incentive effect of collateral either.

The existing empirical evidence on the effect of collateral on credit access is also scarce and unexpectedly weak. Recent studies examine exogenous changes to property titles to evaluate the impact of a title, which makes an asset pledgeable as collateral, on credit access. Galiani and Schargrodsky (2010) do not find a significant increase in credit access after titles have been

extended in their Argentinean sample, while Field and Torero (2006) find that in Peru access to credit from public sector banks increases but that from private sector banks does not. It is unclear why credit access does not always increase. It may be that other enforcement problems remain and that lenders fear not being able to seize assets upon default. Or it may be that interest rates are too high and thus, though credit may be given, it is not demanded. Surveys conducted by the World Bank, described below, indeed show that in many developing economies firms often do not demand credit though in need of it, due to high interest rates. Therefore, the effect of collateral on credit volume may strongly depend on the interest rate.

This study provides experimental evidence which answers three main questions: Does collateral decrease problems of moral hazard? Does collateral affect credit supply, demand, and ultimately credit volume? Do these effects depend on an important loan characteristic, the interest rate?

The experimental design is based on the framework provided by a standard model of lending under moral hazard (Innes, 1990). The main insights are captured in a one period lending game. Theoretical predictions are derived assuming borrowers are risk neutral, as is standard in the literature, and also extended to the case of risk-averse borrowers, which is shown to be relevant experimentally. The setup of the game is as follows. Each lender is matched with a borrower and decides whether or not to offer a loan. If he offers a loan, he can request collateral. If the borrower accepts the loan offer, she decides on her effort. Effort refers to all costly actions that increase the probability of project success. It is not contractible and not observable to the lender and thus the source of moral hazard.¹

The effect of collateral is examined by varying the amount of collateral that can be pledged across treatments. Collateral may cover 50% of the loan amount or it may cover 100% of the loan amount, a commonly observed case. To identify the effect of collateral, the interest rate is determined exogenously. In particular, at each level of collateral, a low and high interest is considered. Further, a benchmark treatment is added, in which borrowers do not have

¹Since the main goal of the paper is to identify the effect of collateral on the borrower's effort, or more generally on her ex-post actions in relation to the investment project. A different source of moral hazard, strategic default, and other enforcement problems are ruled out by design.

any collateral, to examine the effect of collateral availability.

For a given interest rate, an increase in collateral is expected to increase the effort provided by borrowers. The strength of this increase depends on risk aversion. Borrowers who are more risk averse are expected to exhibit weaker increases in effort. Nevertheless, whatever the size of the incentive effect, this is expected to be the same both at low and high interest rates. On the other hand, an increase in collateral is expected to increase credit supply. In particular, lenders are expected to supply credit when collateral can be pledged. Interestingly, the effect of collateral on credit demand is ambiguous. If borrowers are risk neutral, they are expected to always demand credit. However, if borrowers are risk averse, an increase in collateral when interest rates are high may lead to a decrease in credit demand.

The first and most important experimental result is that the incentive effect of collateral is not independent of the interest rate as hypothesized. At low interest rates, an increase in collateral significantly increases effort. At high interest rates, it does not. Remarkably, the incentive effect of collateral is weak when interest rates are high. The second main finding is that credit supply increases with collateral. Importantly, increases in collateral also lead to a decrease in credit demand if interest rates are high. This decrease in demand is empirically related to borrowers' risk aversion. If interest rates are high, an increase in collateral decreases the credit demand of risk-averse borrowers.

The experimental evidence therefore provides one unexpected and remarkable result: the effect of collateral on effort is strong when interest rates are low, but weak when these are high. This result cannot be explained by risk aversion, but may be driven by borrowers' aversion to losses or by fairness concerns. When collateral is large, a failure to repay the loan implies that the borrower loses the asset pledged as collateral and faces the costs for the effort provided. Consequently, loss averse borrowers may not increase effort with collateral increases, if interest rates are high. Alternatively, borrowers may consider a loan with high interest and collateral 'unfair'. Such loan gives a large profit to the lender, while leaving the borrower with little profit. By providing a small effort, borrowers decrease the lender's payoff advantage. To understand whether loss aversion or fairness concerns are driving borrow-

ers' effort decisions, an additional treatment is added to the experiment. In this treatment a tax on the lender's profits is introduced. The tax decreases fairness concerns, while keeping concerns about losses constant. The results reveal that the borrower's effort remains small. This indicates that borrowers' reactions to collateral increases are not likely to be driven by fairness concerns, but seem to be driven by loss aversion. Further, subject's explanations of effort choices and the actual distribution of effort choices is also in line with loss aversion.

These findings have two main implications. First, the incentive effect of collateral may be weak when interest rates are high. If borrowers are concerned about losses, pledging collateral may not significantly decrease the incentive problems associated with lending. Monitoring activities by banks may therefore be especially important in achieving an increase in borrower effort. Second, the experimental evidence reveals that the effect of collateral on credit volume may also be weak in credit markets where interest rates are high. If interest rates are high, increases in collateral may not translate in an increase in credit volume, because borrowers are not willing to accept loan offers. This may explain why the provision of property titles does not always result in an increase in credit volume, as observed by Galiani and Schargrodsky (2010) and Field and Torero (2006). In addition, this result is also in line with survey evidence which indicates that borrowers in need for credit may not demand it, if interest rates are high. Therefore, institutional reforms, such as reforms of property rights systems, that aim at extending the availability and use of collateral potentially need to be accompanied with sufficient competition in the credit market, which lowers interest rates and makes loan offers more attractive for borrowers.

The rest of the paper is organized as follows. In the next section, a brief overview of the related literature and survey evidence is given. Then, the theoretical framework and results are described. In Section 5.4, the experimental design is outlined and in Section 5.5 the experimental results are presented. Section 5.6 presents additional results, which complement those of Section 5.5, and Section 7.5 provides a conclusion.

5.2 Related literature and survey evidence

The use of collateral and its effect on loan performance have been widely theoretically studied. Several studies focus on the ex-ante effect of collateral. In the presence of asymmetric information about the borrower quality, collateral has an ex-ante effect on the pool of borrowers (e.g., Stiglitz and Weiss, 1981, Bester, 1985 and 1987). Other studies focus on the ex-post effect of collateral. Collateral provides incentives for borrowers to act as lenders desire, providing a large effort, as observed by, among others, Innes (1990), Aghion and Bolton (1997), Holmstrom and Tirole (1997) and Mookherjee and Ray (2002).² Collateral may also affect strategic default by borrowers (e.g., Banerjee and Newman, 1993) and their reports on the investment's performance when verifying the state is costly for the lender (e.g., Townsend, 1979). Some studies allow for both roles of collateral, ex-ante and ex-post (Chan and Thakor, 1987, Boot, Thakor and Udell, 1991).

Guided by existing theories, several studies examine the determinants and consequences of collateral empirically, with the objective of distinguishing between these theories (Berger and Udell, 1990, Jiménez and Saurina, 2004, Jiménez, Salas and Saurina, 2006; Berger, Espinosa-Vega, Frame and Miller, 2010, Berger, Frame and Ioannidou, 2010).³ A problem is that the ex-ante and ex-post effects are difficult to separate because the borrower's quality and actions are both unobserved by the lender. Since they both affect the probability of default, one cannot directly identify the effect of collateral on moral hazard for two projects of the same quality. In this paper, I provide, to the best of my knowledge, the first direct evidence on the ex-post effect of collateral on moral hazard.⁴ In a related paper, Capra, Comeig and

²These effects may vary when the lending relationship is repeated because reputation concerns serve as an incentive to provide effort (Boot and Thakor, 1994).

³Other studies consider the more general link between institutions, finance, and development, by examining how differences in creditor rights across countries affect the use of collateral (Liberti and Mian, 2010).

⁴The only closely related study is Andreoni (2005). He studies experimentally the effect of implementing a satisfaction-guaranteed policy, by which principals can recover their payment if the agent fails to perform as they wish. This differs from the setup here, where borrowers provide effort that determines the probability of project success. The lender can therefore receive the requested collateral only if the project fails, and he receives the interest if the project succeeds.

Fernandez (2009) conduct an experiment on screening in the credit market, as hypothesized by Bester (1985 and 1987). They find evidence of ex-ante moral hazard, i.e. borrowers increasing the risk of their projects and at the same time choosing contracts featuring lower collateral requirements. In this paper, I focus on the ex-post effects of collateral and, thus, on borrower behavior given different collateral conditions⁵.

The incentive effect of collateral implies that collateral may be key for credit access. Credit access in turn has important consequences for growth and development (Levine, 2005). De Soto (2001) therefore argues that the right institutions, especially, property rights systems should be in place (see Woodruff, 2001, for a review of de Soto's book). Among other features, property titles allow individuals to pledge collateral (Besley and Ghatak, 2009b) and thus should be easy to obtain. Besley and Ghatak (2009a) have studied the theoretical implications of De Soto's argument, while Galiani and Schargrodsky (2010) and Field and Torero (2006) use natural experiments to test it. Earlier papers have surveyed titled and untitled farmers (Carter and Olinto, 2003 and Feder, Onchan, Chalamwong and Hongladarom, 1988). This paper complements the existing papers providing experimental evidence on the effect of collateral on credit access.

Existing studies on credit markets in developing economies have mainly focused on the supply side: how institutions can help increase credit supply and thus relax credit constraints. Recent survey evidence points out that the demand side should be given a prominent role as well. The Enterprise Surveys conducted by the World Bank (www.enterprisesurveys.org) reveal that many firms do not demand credit though in need for it (see also Brown, Ongena, Popov and Yesin, 2011, for the case of Eastern Europe). The survey, conducted in 96 countries, mainly developing economies, between 2006 and 2010 contains information regarding the access to credit and credit needs of over 42,000 firms. A majority of firms (62.8%) report the need for credit. Remarkably, only 35.7% actually demand it. The reason for not demanding credit that is mentioned most frequently is that interest rates are not

⁵Both papers contribute to a growing body of research that uses experimental methodologies to increase our understanding of the microeconomics of banking (e.g., Brown and Zehnder, 2007 and 2010, and Fehr and Zehnder, 2009).

favorable. Therefore, in this paper the role of credit demand and its potential interaction with interest rates is studied carefully. Importantly, the type of loans considered in the paper is common among the firms surveyed. Over 74% of loans or lines of credit are collateralized and the most frequent percentage of collateral relative to the loan amount is 100%.

5.3 Theoretical framework

5.3.1 Contracting under moral hazard

The lending game is based on Innes (1990). To bring out most clearly the effect of collateral on borrower behavior and credit volume, effort is simplified to a finite set with five elements and two potential project outcomes are possible, success or failure. More precisely, the borrower has an investment project, which yields 300 points in case of success, while it yields 0 points in case of failure. Effort, $e = \{1, 2, 3, 4, 5\}$, is the main determinant of success. Exerting more effort, e.g. spending more time and resources, increases the probability of success linearly ($p(e) = \frac{e}{6}$). However, this effort is costly, $g(e) = 4e^2$, and the borrower requires a loan of 100 points to start the project and cover these expenses.

Effort is neither contractible nor observable by the lender. Thus, after extending a loan, the lender cannot influence the borrower's effort. Nevertheless, she anticipates that, if the borrower does not bear any costs of project failure, his effort will be small. To incentivize the borrower to increase his effort, the lender may request the borrower to pledge his assets as collateral. The borrower has an endowment of 100, which are assets that are very costly for him to liquidate (e.g. the piece of land on which he lives). But, a portion C of these assets, where $0 \leq C \leq 100$, may be pledgeable as collateral. We assume that the value of collateral, C , is the same for the borrower and the lender, and no transaction costs or loss in collateral value ensue from default. Our interest is in the effect of increases in collateral, C , on borrower behavior. To identify this effect we vary C exogenously across treatments.⁶

⁶Changes in C may reflect changes in the property rights system, which extend property

The contracting process is structured as follows. The lender decides first whether or not to offer a loan, $\{offer, no\ offer\}$. If she chooses to *offer* and collateral is available, the lender can choose to request *collateral* or *no collateral*. To simplify notation, if the lender chooses *no collateral*, C is set to 0. If *collateral* is chosen, C is set to the amount of collateral available. By design, the lender does not decide on the repayment, R , which is varied exogenously across treatments. This allows the identification of the impact of collateral on effort, for a given level of repayment, avoiding the endogeneity in the joint effect of collateral and repayment.

If the lender offers a loan, the borrower decides whether to *accept* or *reject* it. If she accepts, the borrower decides on effort. The relationship between effort, the probability of success and effort costs is displayed in Table 5.1.

Effort (e)	1	2	3	4	5
Probability of success	1/6	2/6	3/6	4/6	5/6
Costs	4	16	36	64	100

Table 5.1: Effort, probability of success, and costs

If the lender decides not to offer a loan or the borrower rejects an offer, no loan is extended. Then, the lender and borrower keep their initial endowments, of 150 and 100 respectively. If a loan is offered and accepted, two outcomes are possible. First, if the project succeeds, the lender is paid back repayment R , which includes the loan principal of 100 and an interest payment. Thus, no strategic default is allowed. Second, the project may fail, in which case the lender receives the requested collateral, C , instead of repayment. This leads to the following payoffs for the lender:

$$\pi_L = \begin{cases} 150 & \text{if no loan is offered or accepted} \\ 50 + R & \text{if project succeeds} \\ 50 + C & \text{if project fails} \end{cases}$$

The payoffs for the borrower are:

titles on the borrower's endowment, or changes in regulation, which increase the type of assets that are pledgeable.

$$\pi_B = \begin{cases} 100 & \text{if no loan is offered or accepted} \\ 500 - R - 4e^2 & \text{if project succeeds} \\ 200 - C - 4e^2 & \text{if project fails}^7 \end{cases}$$

In this environment, how are borrower effort and credit volume expected to vary with increases in collateral? We first examine the effect of collateral under the standard assumption that borrowers are risk neutral and then that of risk aversion.

5.3.2 Risk neutrality

We start by assuming that borrowers are risk neutral and their utility from income is linear. A borrower who accepts a loan offer has expected utility,

$$E(\pi_B) = \frac{e}{6}(500 - R) + (1 - \frac{e}{6})(200 - C) - 4e^2$$

Her optimal effort, which is also the incentive compatibility constraint (IC), is

$$e^* = \frac{1}{48}(300 - R + C) \quad (\text{IC})$$

The IC clearly depicts the incentive effect of collateral: an increase in C , increases e^* , i.e. $\frac{\partial e^*}{\partial C} > 0$. Importantly, it also reveals that the incentive effect is independent of the repayment, $\frac{\partial^2 e^*}{\partial C \partial R} = 0$. Additionally, the IC also reveals that an increase in repayment decreases effort, $\frac{\partial e^*}{\partial R} < 0$. Furthermore, the borrower is willing to accept a loan offer provided

$$\frac{e}{6}(400 - R) + (1 - \frac{e}{6})(100 - C) - 4e^2 \geq 0 \quad (\text{PC})$$

To determine the repayment level, we use the lender's optimal contract as a benchmark. The level of collateral and repayment that maximize the lender's profits are determined by maximizing the lender's expected profits, i.e.

$$\max_{C,R} \frac{e}{6}R + (1 - \frac{e}{6})C - 100$$

subject to the borrower's incentive compatibility constraint (IC), the bor-

⁷Note that, even if the project fails and $C = 100$, the borrower never makes a net loss. This avoids any problem in implementing net losses experimentally.

rower's participation constraint (PC) and the lender's own participation constraint. Requesting collateral is always optimal for the lender because the first derivative with respect to C is always positive. The optimal interest rate, for values of collateral between 0 and 100, is

$$R^* = 150 + C$$

The intuition behind the optimal interest rate is as follows. When the amount of collateral is low, the incentive effect of collateral is also low. The borrower must pay a low interest to have an incentive to provide a large effort. As the amount of collateral comes closer to 100, a low interest becomes unnecessary. The larger amount of collateral provides the borrower with sufficient incentive to exert effort. Thus, the lender can charge a higher interest rate and still elicit a large effort (see also Besley and Ghatak, 2009a). Given the relationship between R^* and C , we will assume in what follows that $150 \leq R \leq 250$.

If $R^* = 150 + C$, the lender's participation constraint is satisfied if $C \geq 100 - 25 \cdot \frac{25}{8} = 21\frac{7}{8}$. Thus, for any $C \geq 21\frac{7}{8}$, it is optimal for the lender to *offer*. For the borrower, it is optimal to *accept* in all cases, because her PC, which can now be rewritten as $\frac{25^2}{16} + 100 - C$, has been taken into account and thus is satisfied. These results yield Proposition 1. The proof is presented in Appendix A.

Proposition 1: *If the lender and the borrower are risk neutral, an increase in collateral from 0 to 100% of the loan amount (1) reduces the problem of moral hazard: effort increases, and (2) increases credit supply, but it does not affect credit demand, and therefore it increases credit volume. These effects do not vary across different interest rate levels.*

Proposition 1 highlights two main effects of collateral. Pledging more collateral increases the effort provided by the borrower and thus the probability of repayment. This effect, together with the fact that lending becomes more secure for lenders, makes lending profitable. Credit supply increases and since credit demand remains profitable, collateral leads to an increase in credit volume.

5.3.3 Risk aversion

We allow for risk aversion of the borrower by assuming that the borrower's utility takes the form $u = x^\alpha$ and $0 < \alpha < 1$. The expected utility from accepting a loan can then be formulated as follows:

$$E(u_B) = \frac{e}{6} \cdot (500 - R)^\alpha + \left(1 - \frac{e}{6}\right) \cdot (200 - C)^\alpha - 4e^2$$

where effort costs are assumed to be separable.⁸ The borrower's optimal effort is then

$$e^* = \frac{(500 - R)^\alpha - (200 - C)^\alpha}{48} \quad (\text{IC}_{RA})$$

Risk aversion decreases the borrower's optimal effort, compared to risk neutrality. This follows from the fact that a risk averse borrower weighs the incentive effect of collateral with her desire for insurance (as in Holmstrom, 1979). In addition, risk aversion also makes the reaction to collateral increases weaker, i.e. $\frac{\partial e^*}{\partial C}$ is smaller under risk aversion than under risk neutrality. However, since repayment only affects utility in case of project success, even if the borrower is risk averse, the effect of collateral on effort is still independent of the repayment, $\frac{\partial^2 e^*}{\partial C \partial R} = 0$.⁹ The effects of risk aversion are summarized in Proposition 2. The proof is presented in Appendix A.

Proposition 2: *If the borrower is risk averse, an increase in collateral from 0 to 100% of the loan amount reduces the problem of moral hazard: effort increases. As in the case of risk neutrality, this effect is independent of the interest rate. In comparison to risk neutrality, the optimal effort of risk averse borrowers is lower and their reaction to collateral requests weaker. Additionally, the effect of collateral on credit demand may interact with the interest rate: credit demand is more likely to fall with collateral increases at high interest rates.*

Interestingly, risk aversion leads to an interaction between the effect of collateral on credit demand and repayment. If the interest rate on a loan is

⁸Assuming separability simplifies the analysis and is in line with previous literature.

⁹This result follows from the assumption that effort is separable. Should effort costs not be separable, the sign of $\frac{\partial^2 e^*}{\partial C \partial R}$ depends on the parameter values chosen. Numerical calculations show that $\frac{\partial^2 e^*}{\partial C \partial R} > 0$ for the parameter values considered in the experiment.

high and a large amount of collateral must be pledged, a risk averse borrower may prefer to reject a loan offer and have the certainty that she will keep her endowment of 100.

5.4 Experimental design

5.4.1 Treatments and hypotheses

The experiment consists of four main treatments and one benchmark treatment. The four main treatments allow for a 2x2 design, where the amount of collateral and the level of interest are varied separately¹⁰. Two levels of collateral are considered, 50% and 100% of the loan amount. Also, two levels of interest payment are considered, low and high. A low interest corresponds to a repayment of 200, while a high interest corresponds to a repayment of 250.

A benchmark treatment is added to evaluate the impact of collateral availability. In this treatment, labeled No Collateral, collateral is 0. Offering a loan is not profitable and thus credit supply is expected to be zero. The repayment level is set to $R=200$. The exact level of repayment does not affect the predictions, because it is not profitable to offer loans.

When collateral becomes available, credit supply is expected to increase, since offering credit and requesting collateral is optimal at collateral levels of 50 and 100, for both high and low interest. At the same time, if borrowers are risk neutral, credit demand does not vary. This leads to our first hypothesis:

Hypothesis 1: *When collateral increases from $C=0$ to $C=50$ and $C=100$, credit volume increases. Credit supply increases, while credit demand does not vary, in both Low and High Interest treatments.*

Hypothesis 1 may not be satisfied if borrowers are risk averse. In that case, the effect of collateral availability on credit volume is expected to depend on the interest rate. At high interest rates, an increase in collateral

¹⁰Since repayment is the sum of loan principal and interest payment and the loan principal does not vary across treatments, an increase in repayment is equivalent to an increase in the interest. Therefore, these treatments are labeled high interest and low interest.

may decrease credit demand. Thus, credit volume may fall with increases in collateral.

Table 5.2 displays the four treatments and predicted effort. To derive exact predictions, borrower risk-neutrality is assumed. As Table 5.2 reveals, effort increases from 3 to 4 if collateral increases from 50 to 100 and the interest is low. The same increase, from 2 to 3, is expected if the interest is high. If borrowers are assumed to be risk averse, the qualitative predictions regarding effort do not vary. The same change in effort is expected when collateral changes, in the low- and high-interest treatments. The exact effort level in each treatment may however be lower.

		Interest	
		Low ($R=200$)	High ($R=250$)
Collateral	$C=50$	$e^* = 3$	$e^* = 2$
	$C=100$	$e^* = 4$	$e^* = 3$

Table 5.2: Experimental treatments and predictions

The effort level is therefore hypothesized to increase with collateral, at both high and low interest.

Hypothesis 2: *If collateral increases, effort increases. Both if borrowers are risk neutral or risk averse, the same increase is observed in Low and High Interest treatments.*

5.4.2 Procedures

The experiment was conducted in CentERlab at Tilburg University. In total 156 students participated in the experiment: 28 in the treatment with $C=100$ and high interest, and 32 in each other treatment. Subjects participated in only one treatment and were invited via e-mail to participate. The experiment was conducted using z-Tree (Fischbacher, 2007).

Subjects started the lending game by reading a printed copy of the instructions (see Appendix B). After all subjects had read the instructions, they were asked to fill in a quiz that was then checked by the experimenter.

The labeling of the game was neutral. Each subject was assigned the role of player 1 or player 2, lender or borrower respectively, from the start. Player 1 could offer 100 points to player 2 and, in the treatments with available collateral, player 1 could request collateral. To simplify the borrower's task in the experiment and to ensure the effect of effort on the probability of success was clear, the borrower's task in the investment project consisted in buying red balls. At the start, there were 6 black balls in the project. Player 2 could choose how many red balls to buy (1, 2, 3, 4, or 5) and each red ball replaced a black ball. Black and red balls represented project failure and success, respectively. Therefore, subjects could easily understand that by buying more balls, they were increasing the chances of project success. Buying red balls was costly for the borrower. The borrower was clearly informed about these costs (in the instructions and computer screens).

The game was played once. This prevented wealth effects, which may influence borrowers' perception of collateral pledging over time and thus incentives. It also prevented group reputation effects from influencing lenders' and borrowers' decisions. To elicit borrowers' decisions the strategy method was used. That is, each borrower decided to accept or reject a loan offer and chose her effort before knowing the lender's offer. This method provides a within-subject measure of the effect of collateral requests, i.e., borrower decisions are observed both when the lender requests collateral and when he does not. After the effort decision, the decisions of the lender and borrower were combined (within each pair) and the computer made a random draw from the distribution, determined by the effort choice of the borrower.

Each session started with three pre-experimental games: a risk-preference elicitation task (which is a variation of Holt and Laury, 2002), a p -beauty contest game with $p=\frac{2}{3}$ (Nagel, 1995) and a trust game (Berg, Dickhaut and McCabe, 1995). These games, which were played without any feedback, yield measures related to risk preferences, rationality, and social concerns. These can then be used as controls on behavior in the lending game.¹¹ After the lending game, subjects' beliefs about others' behavior were elicited. Subjects were rewarded monetarily, depending on the distance between their belief and the actual average behavior of others.

¹¹Appendix C.1 presents a detailed description of these games and summary statistics.

At the end of the experiment, they were informed about the outcome of each pre-experimental game, the lending game, and the accuracy of their beliefs.¹² Subjects were then paid their earnings in private and in cash. Average total earnings were 10.5 EUR. Of these, the largest portion was earned in the lending game, 6.6 EUR. The experiment lasted 45 to 60 minutes.

5.5 Results

We start by reporting the results regarding the effect of collateral on credit volume. Thereafter, we turn to the effect of collateral on effort.

5.5.1 Credit supply and demand

Figure 5.1 displays the credit supply and credit demand per treatment. The dark line displays credit supply, the percentage of lenders who offer credit, while the dashed line displays credit demand, the percentages of borrowers that accept a loan offer.

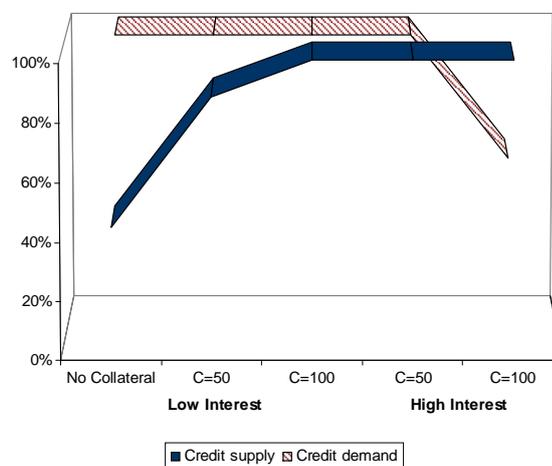


Figure 5.1: Credit demand and supply by treatment

In the benchmark treatment, No Collateral, 44% of lenders offer credit. Credit supply increases to 88% if $C=50$ and the interest is low, and to 100%

¹²Beliefs were close to actual behavior of other players. A detailed summary of beliefs compared to actual behavior is provided in Appendix C.2.

in all other treatments. When supplying credit, a majority of lenders request collateral. If the interest is low, 93% of lenders request collateral in $C=50$ and 94% in $C=100$. If the interest is high, all lenders request collateral.

Credit demand is high, 100%, in the treatments with Low Interest, and that with $C = 50$ and high interest. However, in the treatment with $C = 100$ and high interest, demand for credit is only 57%. This drop in credit demand with increases in collateral implies that Hypothesis 1 is rejected and leads to Result 1.

Result 1: *Increases in collateral lead to an increase in credit supply. At the same time, at high interest rates, an increase in collateral decreases credit demand.*

Therefore, we observe the predicted increase in credit supply with increases in collateral. Interestingly, in the treatment without collateral, offering a loan is not profitable, but many lenders do so. This seems to be driven by lenders' trust of borrowers. The Spearman rank correlation coefficient between *Trust* and *offer* in No Collateral is positive and significant, 0.4789 (p-value=0.06), and *Trust* is the only individual characteristic that is significantly correlated to credit offers. This relation between trust and credit supply in the absence of collateral is consistent with the relation between trust and credit volume observed in high risk markets, such as venture capital markets (Bottazzi, Da Rin and Hellman, 2010).

Further, we observe that at high interest rates demand decreases with collateral. As studied above, this may be caused by risk aversion. The data reveal that risk-averse borrowers may be slightly more likely to reject credit offers, although the relationship is not significant (Fisher's exact test, p-value=0.24). A caveat is that in this treatment the share of risk averse borrowers is higher than in the others: 57% of the borrowers are risk averse while in other treatments the share of risk-averse borrowers is at most 31%. The results from an additional treatment, in which collateral and interest rates remain high, but the lender's income is taxed (more details in the next section), address this potential concern. The additional data, with a sample of borrowers who are less risk averse, confirms the relationship between risk aversion and credit demand and its statistical significance (Fisher's exact

test, $p\text{-value}=0.07$).¹³

5.5.2 Effort

Figure 5.2 displays the average effort by treatment. Each column represents the average effort per treatment. A rhombus is added in each case, representing the predicted effort in case of risk neutrality.

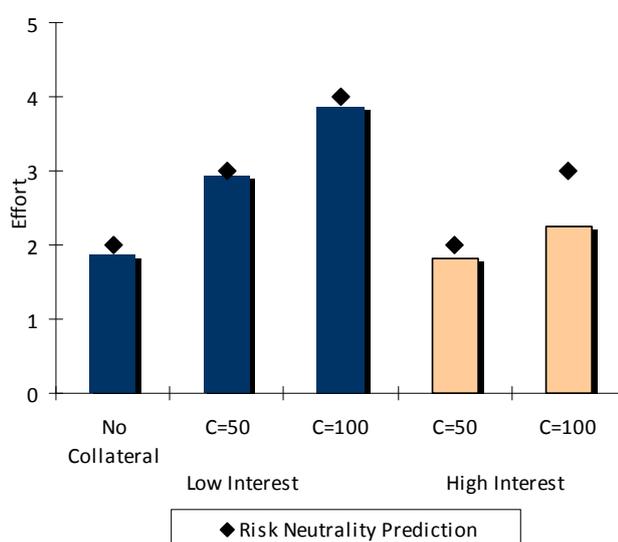


Figure 5.2: Effort by treatment

In the benchmark treatment, No Collateral, the effort is 1.9. In treatments with low interest, an increase in collateral changes effort significantly. The effort is 2.8 when collateral is 50 and it increases to 3.9 when collateral is 100 (Mann-Whitney (MW) test, $p\text{-value}<.01$).

Interestingly, if the interest is high, an increase in collateral does not yield a significant change in effort. Effort, 2.3 compared to 1.8, is not significantly different (MW test, $p\text{-value}=0.19$). Furthermore, when the interest is high and $C=100$, effort deviates significantly from the risk neutral prediction. The average effort is 2.3, whereas we would expect it to be 3 (t-test, $p\text{-value}=0.04$). Since in this treatment lenders always request collateral, the low effort cannot

¹³This relationship persists in regressions controlling for other individual characteristics. The results are available from the author.

stem from the lack of collateral requests. It is rather borrowers who are not strongly responding to the incentives of collateral. Comparing within-subject effort choices for the case where the lender requests collateral and the case that he does not yields similar results. Table 5.3 presents the average effort in each case, for all treatments in which collateral is available.

Collateral		Low Interest	High Interest
$C=50$	Effort if no collateral requested	2.2 (1.0)	1.2 (0.5)
	Effort if collateral requested	2.9 (0.8)	1.8 (0.7)
	<i>WSR-test (p-value)</i>	<i><.01</i>	<i><.01</i>
$C=100$	Effort if no collateral requested	2.6 (1.1)	1.3 (0.6)
	Effort if collateral requested	3.9 (1.1)	2.3 (0.9)
	<i>WSR-test (p-value)</i>	<i>0.01</i>	<i>0.07</i>

Note: Standard deviations in parenthesis. WSR-test is the nonparametric Wilcoxon signed-ranks test.

Table 5.3: Effort response to a request to pledge collateral

If $C=50$, effort when collateral is requested is significantly different to that when it is not, both with low and high interest. This is revealed by the p-value of the WSR-test, which is less than .01 in both cases. The same result is obtained when $C=100$ and the interest is low. In contrast, the effect of a collateral request is weaker when the interest and collateral are high. In that case, effort displays a small change, from 1.3 to 2.3, which is marginally significant, p-value=0.07.

A regression analysis of effort decisions is shown in Table 5.4, which reports OLS estimation results for the determinants of effort.¹⁴ These results are presented for the case where the interest is low (columns 1 and 2), where it is high (columns 3 and 4), and the combination of the two (columns 5 and 6). The effect of a collateral request and of the different treatment variations are considered first. Individual characteristics are added subsequently.

¹⁴Results remain the same if an ordered logit regression is used.

Table 5.4: Determinants of effort

This table reports OLS regression estimates for effort, the dependent variable. The variable *Collateral Request* takes value 1 if the lender chooses to request collateral. *Collateral Request***C=100* takes value 1 if the lender requests collateral and *C=100*. *High interest* takes value 1 when *R=250*. *Collateral Request***C=100***High Int.* is the interaction term between *Collateral Request*, *C=100* and *High Interest*. *Risk aversion*, *Strategic Reasoning*, *Trust* and *Trustworthiness* are measures from the pre-experimental games. *Risk aversion***High Int.* is the interaction term between risk aversion and High Interest.*** p<0.01, ** p<0.05, * p<0.1; Clustered standard errors at the subject level in brackets.

	(1)	(2)	(3)	(4)	(5)	(6)
	Low Interest		High Interest		All	
Collateral Request	0.531**	0.639***	0.579***	0.575***	0.555***	0.567***
	[0.230]	[0.219]	[0.177]	[0.175]	[0.144]	[0.142]
Collateral Request* <i>C=100</i>	0.938**	0.723*	0.438	0.447	0.922**	0.827**
	[0.357]	[0.367]	[0.346]	[0.310]	[0.353]	[0.362]
High Interest					-1.157***	-1.144***
					[0.193]	[0.217]
Collateral Request* <i>C=100</i> *High Int.					-0.468	-0.340
					[0.475]	[0.468]
Risk aversion		-0.389		-0.173		-0.347
		[0.301]		[0.205]		[0.311]
Risk aversion*High Interest						0.116
						[0.381]
Strategic Reasoning		-0.004		0.008		0.006
		[0.010]		[0.005]		[0.005]
Trust		-0.056		0.008		-0.025
		[0.040]		[0.022]		[0.025]
Trustworthiness		0.035		-0.009		0.013
		[0.041]		[0.025]		[0.026]
Constant	2.406***	2.884***	1.233***	0.723*	2.398***	2.086***
	[0.193]	[0.784]	[0.106]	[0.391]	[0.178]	[0.444]
Observations	64	64	54	54	118	118
Number of subjects	32	32	30	30	62	62
R-squared	0.258	0.295	0.274	0.317	0.491	0.506

When the interest payment is low, requesting more collateral, 100 instead of 50, increases the effort level significantly. This can be seen from the positive and significant coefficient of the variable *Collateral Request***C=100* in columns 1 and 2. However, if the interest payment is high, this effect is no longer observed (columns 3 and 4). Increasing collateral does not increase effort, as already revealed by Figure 5.2. When the two levels of interest payment are combined (columns 5 and 6), we observe that the coefficient of *Collateral Request***C=100* is significantly positive, but the sum of this coefficient and that of *Collateral Request***C=100***High Interest* is not significantly different from 0 (F-test, p-value=0.14). This confirms that collateral increases lead to an increase in effort when the interest is low but not when it is high. Individual characteristics, including risk aversion and its interaction with the interest level, do not significantly affect effort decisions. This evidence leads to the rejection of Hypothesis 2, yielding Result 2.

Result 2: *The incentive effect of collateral depends on the interest rate charged. If the interest is low, an increase in collateral leads to a significant increase in effort. However, if the interest is high, an increase in collateral does not significantly affect effort.*

It is surprising and unclear why the incentive effect of collateral depends on the interest rate. As we have seen in the theoretical framework, both under risk neutrality and risk aversion, the effect of collateral is not expected to vary with the interest rate. Two potential explanations can be given. First, if the project fails, borrowers not only lose their collateral but also the effort put into the project. When the payoff from project success is low (due to the high interest), if borrowers are loss averse, a way to reduce losses is to put a low effort into the project. Second, borrowers may perceive a high payoff obtained by the lender as unfair. When the interest is high, the lender's payoff advantage is largest. Borrowers may decrease this advantage by decreasing their effort. These two explanations are detailed in the next section, which presents the results from an additional treatment aimed at distinguishing between them.

5.5.3 Payoffs

The incentive effects of collateral have consequences for lender, borrower and total payoffs. More collateral increases the lender's payoff, although it does not always increase the borrower's payoff. Table 5.5 below gives the expected payoffs, using the decisions of players and calculating the expected payoff based on the probability of success. The realized payoffs are basically the same for most of the treatments, where the average of the draws corresponds to the expectation, except for the treatment with low interest and $C=50$, where the draws were unexpectedly lucky.

Starting with the lender, his payoff is lowest when no collateral is available. In this treatment 44% of lenders offer a loan, but doing so is unprofitable, since borrowers provide a low effort.

Collateral		Low Interest	High interest
No Collateral	Lender	133.3	
	Borrower	150.0	-
	<i>Total</i>	<i>283.4</i>	
$C=50$	Lender	165.1	157.8
	Borrower	177.0	168.1
	<i>Total</i>	<i>342.1</i>	<i>325.9</i>
$C=100$	Lender	214.6	182.1
	Borrower	164.2	119.0
	<i>Total</i>	<i>378.8</i>	<i>301.1</i>

Table 5.5: Lender, borrower, and total payoffs by treatment

The lender's payoff increases with collateral, both in treatments with high and low interest. Interestingly, the lender's payoff is largest in the treatment where $C=100$ and the interest is low, and not when it is high (the difference in profits is significant, MW-test p-value=0.01), despite the fact that when $C=100$, a high interest is ex-ante optimal.

The borrower's payoff is largest when $C=50$ and the interest is low. This is because in this treatment the borrower gains access to credit without having to pledge a large collateral or pay a high interest. For the opposite reason, the borrower's payoff is lowest when $C=100$ and the interest is high.

The sum of the two payoffs, labeled *Total* in Table 5.5, is highest when collateral is 100 but the interest is low. In this treatment effort is highest, leading to the highest payoffs, which are significantly higher than in other treatments. A regression analysis yields the same results. The estimation results are available from the author.

Result 3: *The lender's payoff increases with increases in collateral. The borrower's payoff, however, increases when collateral increases from 0 to 50, but decreases when it increases from 50 to 100.*

5.6 A weak incentive effect of collateral: Why?

The experiment reveals that the effect of collateral on moral hazard depends on the interest rate. This section discusses two potential explanations and examines the results from an additional treatment to clarify which is dominant.

As mentioned before, borrowers' loss aversion or fairness concerns could affect the impact of collateral on moral hazard. Suppose borrowers are loss averse (Kahneman and Tversky, 1979). Utility is then experienced by borrowers in terms of changes with respect to a reference point x . Thus, the borrower's utility depends on the difference between her final payoff π_B and this reference point,

$$U(x) = \begin{cases} \pi_B - x & \text{if } \pi_B - x \geq 0 \\ \lambda(\pi_B - x) & \text{if } \pi_B - x < 0 \end{cases}$$

where $\lambda > 1$ (often assumed to be $\lambda \approx 2$)^{15,16}. In the lending game a natural reference point is the borrower's initial endowment, 100 points. In the No Collateral treatment and the treatments with $C=50$, at most 50 points are pledged and effort supply is at most 3. Thus, the loss domain (where $\pi_B - x < 0$) is not entered. In contrast, in treatments where $C=100$, borrowers enter the loss domain. If the project fails, borrowers transfer their

¹⁵See Booij and van der Kuilen (2009) for population estimates of the value of λ .

¹⁶We abstract from probability biases and diminishing sensitivity in the specification of utility, for simplicity.

complete initial endowment of 100 points to the lender. Since they must provide an effort of at least one, their effort costs are perceived as losses.

Importantly, the effect of loss aversion differs across the treatments with low and high interest. If the interest low, the optimal effort for a loss averse borrower increases with λ , and if $\lambda > 1.8$, it is 5 (the maximum effort). Intuitively, when the interest is low, the rents from success are large, and therefore the borrower has an incentive to exert a high effort to obtain those payoffs and avoid losing her capital. In contrast, with high interest, the rents from success are small and the borrower is less motivated to make the project succeed and more motivated to reduce the losses from failure. The optimal effort actually falls with λ . More precisely, compared to expected-payoff maximizing effort of 3, now $e^* = 2$ for $1.8 \leq \lambda < 3$, and $e^* = 1$ for $3 \leq \lambda < 7$ (for $\lambda > 7$, a very unrealistic case, borrowers prefer to reject credit offers).

Alternatively, suppose the borrower has fairness concerns. A simple way to model these is using the inequity aversion model of Fehr and Schmidt (1999). In this model, the utility of the borrower over each pair of final payoffs is $U(\pi_B, \pi_L) = \pi_B - \alpha_B \max\{0, \pi_L - \pi_B\} - \beta_B \max\{0, \pi_B - \pi_L\}$, where $\alpha_B \geq \beta_B$ and $0 \leq \beta_B < 1$.¹⁷ Lower levels of α_B are needed for the borrower to be willing to lower her effort supply when collateral is 100 and the interest is high, compared to when the interest is low. In particular, when the interest is high, $\alpha_B \geq 0.25$ suffices for the borrower to prefer an effort below 3 (the own-payoff maximizing effort). Thus, fairness concerns could explain the low effort under high interest and collateral.

A potential concern when comparing low- and high-interest treatments, when $C=100$, is that acceptance varies across treatments, because fewer bor-

¹⁷Note that inequity aversion is a model that generates spiteful behavior when a player is at a payoff disadvantage. Such spiteful behavior may also be generated by different models, such as Levine (1998). In his model there are altruistic, selfish, and spiteful types, which are unidentifiable ex-ante. A player's utility depends on others' types in the following way: $U_i = u_i + \frac{\alpha_i + \lambda a_j}{1 + \lambda} u_j$, where u_i is the payoff of players i , $-1 < a_i \leq 1$ the coefficient of altruism of player i , and λ the weight player i assigns to player j 's type. Note that in our experiment most lenders offer loans and request collateral and thus their behavior is consistent with that of a pooling equilibrium (all types choosing the same action). As a consequence, the borrower's perception of a_j is most likely equal to the population average, \bar{a} . Therefore, we are left with a parameter that is very similar to that of inequity aversion and can be simplified to $\alpha_i(a_i, \lambda, \bar{a})$.

rowers demand credit when $C=100$ and the interest is high. This could lead to differences in the risk aversion of borrowers who accept a loan. Nevertheless, selection works against lower effort. Suppose risk-averse borrowers reject offers when $C=100$ and the interest is high, while they accept offers when $C=100$ and the interest is low. Then the pool of borrowers who demand credit is likely to be less risk averse when the interest rate is high. Thus, when $C=100$ and interest rates are high, we would not expect a lower effort.

An additional treatment, labeled the Tax treatment, allows us to distinguish between loss aversion and fairness concerns. This treatment is identical to that with $C=100$ and high interest, but with a tax of 75 points on the lender's profits if the project succeeds. This tax decreases the difference between lender and borrower payoffs and therefore strongly reduces the role of fairness. In fact, it makes the payoff difference close to that in the treatment with $C=100$ and low interest, where effort is close to the prediction.

Effort in the Tax treatment is presented in Figure 5.3. Interestingly, it is not significantly different to effort if $C=50$ or $C=100$, without a tax (MW-test, p-value=0.52 and 0.61, respectively).

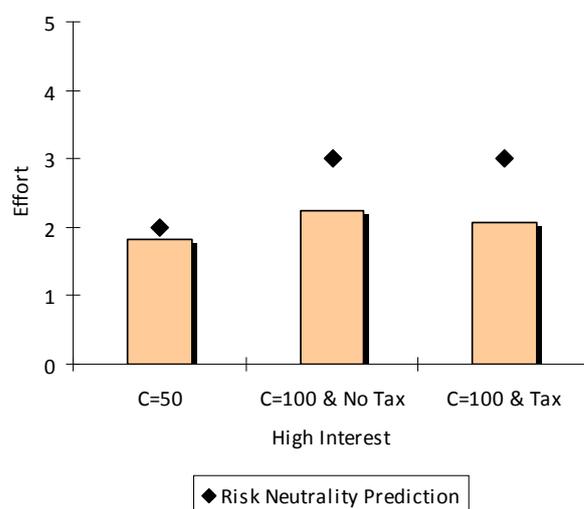


Figure 5.3: Effort in the Tax treatment

Further, in the Tax treatment a collateral request does not significantly

affect effort. Table 5.6 presents effort if collateral is not requested and if it is in the treatments with $C=100$ and high interest, with and without the tax. In the Tax treatment effort is on average 1.7 if no collateral is requested, while it is 2.1 if collateral is requested. This difference is insignificant (WSR test, p -value=0.15). This indicates that the effort when $C=100$ and the interest is high is not likely to be driven by fairness concerns. Instead, it suggests that loss aversion drives effort decisions.

	$C=100$, High Interest	
	No tax	Tax
Effort if no collateral requested	1.3 (0.6)	1.7 (1.0)
Effort if collateral requested	2.3 (0.9)	2.1 (1.0)
<i>WSR-test (p-value)</i>	<i>0.07</i>	<i>0.15</i>

Note: Standard deviations in parenthesis. WSR-test is the nonparametric Wilcoxon signed-ranks test.

Table 5.6: The effect of collateral requests, with and without a tax

A further piece of evidence supporting the role of loss aversion is the distribution of effort choices within the two treatments with $C = 100$. Figure 5.4 displays the frequency with which each effort level was chosen by borrowers. If the interest is high, a majority of the borrowers ($32+27=59\%$) choose an effort lower than 3 (either 1 or 2), despite the fact that 3 is the expected payoff maximizing effort. These low effort choices are in line with borrowers exhibiting loss aversion. Importantly, if we consider the treatment with Low Interest, we observe that a substantial portion of borrowers (31%) choose an effort of 5, despite the fact that 4 is the expected payoff maximizing effort. Again, exerting such a high effort at low interest rates is in line with loss aversion.

Interestingly, not only are effort decisions in line with loss aversion, but also borrowers' explanations for their effort choices in post-experimental questionnaires point to the role of loss aversion. As one of the subjects mentioned, "[I chose effort] 2, you can gain a lot if u win and the possibility to win is higher than 1, and if you lose, you cannot lose that much." Another

subject mentioned "[I chose effort] two, because if [the project succeeds], (...), i can get a much higher payoff; [if the project fails], i will get 84 point, which is not much lower than 100". This leads to Result 4.

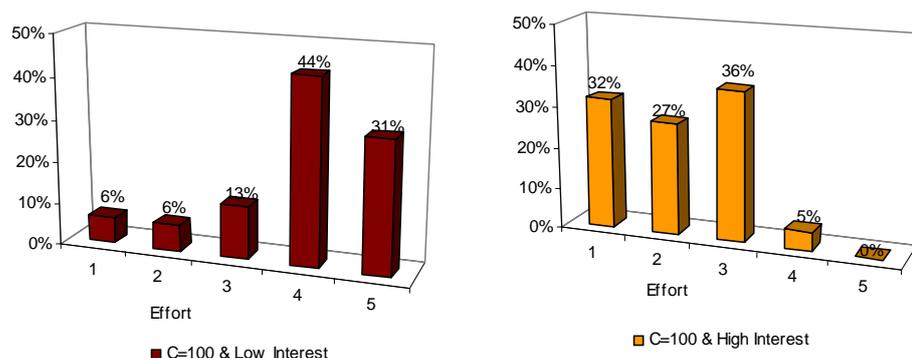


Figure 5.4: Effort distribution in treatments with $C=100$

Result 4: *The interaction between the effect of collateral on moral hazard and the interest rate seems to be driven by loss aversion. After the introduction of a tax that reduces fairness concerns when $C=100$ and the interest is high, borrower effort remains low, as in the absence of a tax.*

Finally, let us note one could consider designing an additional treatment which mitigates the effect of loss aversion, by increasing the borrower's pay-offs such that the loss domain is not entered. This unfortunately would also affect the borrower's participation constraint and would hamper treatment comparisons due to the potential differences in participation.

5.7 Conclusion

Understanding the role of collateral in credit markets is important. Collateral is widely used in financial contracting and can have important consequences for growth and the persistence of income inequality. Several theoretical models have studied the role of collateral. Many have pointed out the effect of collateral in reducing moral hazard and the implications this has for credit

supply. However, empirical evidence for the effect of collateral on moral hazard is scarce. This paper contributes to the literature by providing the first experimental evidence regarding the effect of collateral on moral hazard and credit volume.

A major contribution of the paper is to identify the direct effect of collateral on borrower effort. The main finding is that, in contrast to the theoretical predictions, the effect of collateral on effort depends on the interest rate. In markets with low interest rates, increases in collateral have a strong effect on effort. In contrast, in markets with high interest rates, the effect of collateral increases is weak. When collateral and the interest rate are high, borrowers provide an unexpectedly low effort. The results from an additional treatment suggest that this effect is caused by borrowers' loss aversion. In taking up a loan with high collateral, borrowers face the risk of losing their initial wealth and paying effort costs as well. When the interest rate is high, loss averse borrowers prefer providing a low effort.

A second important contribution of the paper is to identify the effect of collateral on credit supply and demand. As many theoretical studies have pointed out, increases in collateral make lending more profitable because they reduce the problem of moral hazard. Thus, credit supply should increase with collateral availability. The experimental results confirm this prediction. The results also show that credit demand may depend on collateral requirements. Theoretically, if borrowers are risk averse, increases in collateral availability may decrease credit demand, especially if the interest rate is high. The experimental results reveal that risk aversion has such an effect on credit demand.

The results have important implications. They indicate that, in credit markets with low interest rates, the incentive effect of collateral is likely to significantly reduce loan defaults. In these markets, collateral is also likely to strongly increase credit volume. In contrast, in credit markets with high interest rates the effect of collateral may be much weaker. Collateral may not reduce loan defaults significantly. This indicates that monitoring by banks may be especially important in these markets. Also, it is shown that high interest rates and collateral could decrease credit demand. Such result contributes to the existing survey evidence, indicating that high interest rates

reduce credit demand, by pointing out a reason for why credit demand is low: borrowers may be averse to the risks involved in debt contracts.

Importantly, the experimental results provide an explanation for why property titling need not increase credit volume: if interest rates are high, borrowers may not be willing to demand credit, even if it becomes available to them. This implies that institutional reforms, which increase the types of collateral that may be pledged in debt contracts or ease the registration of property, may not be sufficient. To make these reforms work, competitive credit markets, featuring low interest rates, may be necessary.

5.8 Appendix A: Proofs

Proposition 1. *If the lender and the borrower are risk neutral, an increase in collateral from 0 to 100% of the loan amount has two main effects: (1) it reduces the problem of moral hazard: effort increases; (2) it increases credit supply, but it does not affect credit demand, and therefore it increases credit volume. These effects do not vary across different interest rate levels.*

Proof. If the borrower is risk averse, increases in collateral decrease the problem of moral hazard, independently of the interest rate. However, at high interest rates, increases in collateral may decrease credit demand: $e^* = \frac{1}{48}(300 - R + C)$, $\frac{\partial e}{\partial C} > 0$, and $\frac{\partial^2 e}{\partial C \partial R} = 0$. The second effect of collateral follows from the fact that, given $R^* = 150 + C$, the lender's participation constraint is satisfied if $C \geq 21\frac{7}{8}$, and the borrower's participation is satisfied for all $0 \leq C \leq 100$. ■

Proposition 2. *If the borrower is risk averse, an increase in collateral from 0 to 100% of the loan amount reduces the problem of moral hazard: effort increases. As in the case of risk neutrality, this effect is independent of the interest rate. In comparison to risk neutrality, the optimal effort of risk averse borrowers is lower and their reaction to collateral requests weaker. Additionally, the effect of collateral on credit demand may interact with the interest rate: credit demand is more likely to fall with collateral increases at high interest rates.*

Proof. Assume that $E(u_B) = \frac{\epsilon}{6} \cdot (500 - R)^\alpha + (1 - \frac{\epsilon}{6}) \cdot (200 - C)^\alpha - 4e^2$. The optimal effort is the

$$e^* = \frac{(500 - R)^\alpha - (200 - C)^\alpha}{48} \quad (5.1)$$

First, note that the optimal effort decreases with risk aversion, i.e. $\frac{\partial e^*}{\partial \alpha} > 0$. This follows from the fact that,

$$\frac{\partial e^*}{\partial \alpha} = \frac{(500 - R)^\alpha \ln(500 - R) - (200 - C)^\alpha \ln(200 - C)}{48} > 0$$

Also, note that the effect of collateral on effort is positive but weaker than under risk aversion, since $0 < \alpha < 1$ and thus

$$\frac{\partial e^*}{\partial C} = \frac{\alpha(200 - C)^{\alpha-1}}{48} < \frac{1}{48}$$

But, as in the case of risk neutrality, we have that the effect of collateral on effort does not depend on the interest rate, i.e. $\frac{\partial^2 e^*}{\partial C \partial R} = 0$.

Additionally, the borrower's participation constraint is

$$\frac{e}{6} \cdot (500 - R)^\alpha + \left(1 - \frac{e}{6}\right) \cdot (200 - C)^\alpha - 4e^2 \geq 100^\alpha$$

Taking the difference we have that $\frac{e}{6} \cdot (500 - R)^\alpha + \left(1 - \frac{e}{6}\right) \cdot (200 - C)^\alpha - 4e^2 - 100^\alpha$ increases with α . In particular, $\frac{\partial U}{\partial \alpha}(e^*) = \frac{\partial}{\partial \alpha} \left[(200 - C)^\alpha + \frac{[(500 - R)^\alpha - (200 - C)^\alpha]^2}{48 \cdot 12} - 100^\alpha \right]$,

$$\frac{\partial U}{\partial \alpha}(e^*) = (200 - C)^\alpha \ln(200 - C) - 100^\alpha \ln(100) + \frac{[(500 - R)^\alpha - (200 - C)^\alpha][(500 - R)^\alpha \ln(500 - R) - (200 - C)^\alpha \ln(200 - C)]}{48 \cdot 6} > 0$$

since $0 \leq C \leq 100$. Since more risk averse borrowers feature a lower α , it follows that their expected utility is lower than in the case of risk neutrality. Keeping R constant, an increase in C , which decreases expected utility, is more likely to violate the borrower's participation constraint when α is lower, i.e. when the borrower is more risk averse. ■

5.9 Appendix B: Instructions

Instructions are presented for the treatment where collateral is 100 and repayment is 200. The instructions for other treatments are identical, except for the changes in collateral and repayment corresponding to each treatment.

Instructions

This experiment will consist of 1 period only. In this experiment you will be randomly paired with another participant. Each participant is randomly assigned to be player 1 or player 2. You have been randomly assigned to be:

Player 1 or 2

You will keep this role throughout the experiment. You will not know the identity of the other player nor will the other player know your identity at any point. You will be paid your total earnings in cash and in private at the end of experiment 5. The exchange rate from points to EUR is the following:

$$25 \text{ Points} = 1 \text{ EUR}$$

Overview of decisions

At the beginning of the experiment, player 1 is endowed with 150 points. Player 2 is endowed with 100 points. Player 1 can offer 100 points to player 2 to start a project. Player 2 cannot use his or her endowment for that purpose. If player 1 offers 100 points to player 2, he/she can request a guarantee of 100 points from player 2. Player 2 can accept an offer from player 1.

If player 2 accepts an offer, player 2 makes a decision with regard to a project. In this project, player 2 can use the 100 points he/she gets from player 1 to buy red balls. Player 2 can buy 1, 2, 3, 4 or 5 red balls. At the start, there are 6 black balls in the project. Each red ball bought by player 2 replaces one black ball. Buying red balls is costly. The exact costs will be shown in the next section.

After player 2 has decided how many red balls to buy, a ball is randomly drawn out of the project by the computer. If the ball is red, the project yields

300 points. Player 1 receives 200 points and player 2 receives 100 points. If the ball is black, the project yields 0 points. If player 1 requested a guarantee of 100 points and the ball is black, he/she receives 100 points from player 2.

Instructions for player 1

Offering points

At the beginning of the experiment, you are endowed with 150 points. Player 2 is endowed with 100 points. You can offer 100 points to player 2 to start a project. Player 2 cannot use his or her endowment for that purpose. If you offer 100 points to player 2, you can request a guarantee of 100 points from player 2.

In the screenshots attached at the end of the instructions you find an image of the decision screens you will see during the experiment. These screens are titled ‘Offer screen’.

Accepting offers and buying red balls

Player 2 decides whether to accept an offer from you. If player 2 accepts, he/she can use the 100 points received from you to buy red balls for a project. The more red balls are bought, the less black balls there are in the project, as displayed in Table 1. Therefore, the more red balls are bought, the higher is the probability that a red ball is randomly drawn out of the project.

Number of red balls bought	1	2	3	4	5
The project contains:					
Number of red balls	1	2	3	4	5
Number of black balls	5	4	3	2	1
Probability that red ball is drawn	1/6 or 16.7%	2/6 or 33.3%	3/6 or 50%	4/6 or 66.7%	5/6 or 83.3%

Table 1: The project’s red and black balls

Buying red balls is costly for player 2. The exact costs are detailed in Table 2.

Number of red balls bought	1	2	3	4	5
Cost	4	16	36	64	100

Table 2: Cost of buying red balls

Player 2 will be asked to decide whether he/she accepts your offer and how many red balls to buy for two cases: if you request no guarantee and if you request a guarantee of 100 points.

At the end of experiment 5, player 2 will be informed about your offer and whether you requested a guarantee of 100 points. You will be informed about whether player 2 accepted this offer and the color of the ball drawn from the project. You will not be informed about the number of balls bought by player 2.

In the screenshots attached at the end of the instructions you find an image of the decision screens player 2 will see during the experiment. These screens are titled ‘Accept screen’ and ‘Project screen’.

Payoffs

Your payoff depends on whether you offer 100 points, whether you request a guarantee of 100 points, whether player 2 accepts the offer, the number of red balls bought by player 2 and the color of the ball that is thereafter drawn from the project.

If you do not offer 100 points or player 2 does not accept the offer, payoffs are equal to the initial endowments:

$$\text{Your payoff} = 150$$

$$\text{Player 2's payoff} = 100$$

If you offer 100 points and player 2 accepts this offer, the payoffs depend on whether the ball drawn from the project is red or black. If the ball drawn is red, your payoff is equal your endowment, 150 points, minus 100 points offered to player 2, plus the return you receive from the project, 200 points. Player 2's payoff is his/her endowment, 100 points, plus 100 points received from you, plus the return he/she receives from the project, 100 points, and minus the costs of buying red balls.

$$\text{Your payoff} = 150 - 100 + 200 = 250$$

$$\text{Player 2's payoff} = 100 + 100 + 100 - \text{Costs}$$

If the ball drawn is black, your payoff is equal to your endowment, 150 points, minus 100 points offered to player 2, plus the guarantee requested

by you. If you did not request a guarantee, the guarantee requested is 0. If you requested a guarantee, the guarantee requested is 100 points. Player 2's payoff is his/her endowment, 100 points, plus 100 points received from you, minus the costs of buying red balls minus the guarantee requested by you.

$$\text{Your payoff} = 150 - 100 + \text{Guarantee requested}$$

$$\text{Player 2's payoff} = 100 + 100 - \text{Costs} - \text{Guarantee requested}$$

Below we display your payoffs and player 2's payoffs if you offer 100 points and player 2 accepts this offer. In each table, first you find the probability that a red ball is drawn. In the first table you find your payoffs and that of player 2 if no guarantee is requested by you. In the second table you find your payoffs and that of player 2 if a guarantee of 100 points is requested by you.

If no guarantee is requested by you:

Number of red balls bought					
Probability that a red ball is drawn	1/6	2/6	3/6	4/6	5/6
	or 16.7%	or 33.3%	or 50%	or 66.7%	or 83.3%
	Your payoff				
If a red ball is drawn:	250	250	250	250	250
If a black ball is drawn:	50	50	50	50	50
Expected payoff	83.3	116.7	150.0	183.3	216.7
	Player 2's payoff				
If a red ball is drawn:	296	284	264	236	200
If a black ball is drawn:	196	184	164	136	100
Expected payoff	212.7	217.3	214.0	202.7	183.3

If a guarantee of 100 points is requested by you:

Number of red balls bought					
Probability that a red ball is drawn	1/6	2/6	3/6	4/6	5/6
	or 16.7%	or 33.3%	or 50%	or 66.7%	or 83.3%
	Your payoff				
If a red ball is drawn:	250	250	250	250	250
If a black ball is drawn:	150	150	150	150	150
Expected payoff	166.7	183.3	200.0	216.7	233.3
	Player 2's payoff				
If a red ball is drawn:	296	284	264	236	200
If a black ball is drawn:	96	84	64	36	0
Expected payoff	129.3	150.7	164.0	169.3	166.7

Beside each computer terminal, you can find a calculator. You may use it to do any further calculations.

Before the experiment starts, we would like to ask you some questions about the experiment. Please fill in your answer. If you have finished filling in the questions, please raise your hand and an experimenter will come to where you are seated. If you have any questions, please raise your hand.

Questions

Question 1

You do not offer 100 points. What is your payoff and that of player 2?

Your payoff = _ _ _ _ _

Payoff of player 2 = _ _ _ _ _

Question 2

You offer 100 points and request a guarantee of 100 points. Player 2 does not accept this offer. What is your payoff and that of player 2?

Your payoff = _ _ _ _ _

Payoff of player 2 = _ _ _ _ _

Question 3

You make an offer of 100 points. Player 2 accepts this offer. Please fill in the table below.

If you do not request a guarantee of 100 points:

	Your payoff	Player 2's payoff	Probability that red ball is drawn
If number of red balls bought is:			
1 If red ball is drawn			
If black ball is drawn			
3 If red ball is drawn			
If black ball is drawn			
5 If red ball is drawn			
If black ball is drawn			

If you request a guarantee of 100 points:

	Your payoff	Player 2's payoff	Probability that red ball is drawn
If number of red balls bought is:			
1	If red ball is drawn		
	If black ball is drawn		
3	If red ball is drawn		
	If black ball is drawn		
5	If red ball is drawn		
	If black ball is drawn		

Summary

Before we start, let us briefly summarize the experiment.

1. Player 1 decides whether to offer 100 points to player 2 for a project. If he/she offers 100 points, he/she can request a guarantee of 100 points.
2. Player 2 decides whether to accept this offer.
3. Player 2 decides how many red balls to buy.
4. A ball is randomly drawn from the project.
5. Payoffs are calculated and shown on the screens after Experiment 5.

Instructions for player 2

Offering points

At the beginning of the experiment, player 1 is endowed with 150 points. You are endowed with 100 points. Player 1 can offer 100 points to you to start a project. You cannot use your endowment for that purpose. If player 1 offers 100 points to you, player 1 can request a guarantee of 100 points from you.

In the screenshots attached at the end of the instructions you find an image of the decision screens player 1 will see during the experiment. These screens are titled 'Offer screen'.

Accepting offers and buying red balls

You decide whether to accept an offer from player 1. If you accept, you can use the 100 points received from player 1 to buy red balls for a project.

The more red balls are bought, the less black balls there are in the project, as displayed in Table 1. Therefore, the more red balls are bought, the higher is the probability that a red ball is randomly drawn out of the project.

Number of red balls bought	1	2	3	4	5
The project contains:					
Number of red balls	1	2	3	4	5
Number of black balls	5	4	3	2	1
Probability that red ball is drawn	1/6 or 16.7%	2/6 or 33.3%	3/6 or 50%	4/6 or 66.7%	5/6 or 83.3%

Table 1: The project's red and black balls

Buying red balls is costly for player 2. The exact costs are detailed in Table 2.

Number of red balls bought	1	2	3	4	5
Cost	4	16	36	64	100

Table 2: Cost of buying red balls

You will be asked to decide whether you accept player 1's offer and how many red balls to buy for two cases: if player 1 requests no guarantee and if player 1 requests a guarantee of 100 points.

At the end of experiment 5, you will be informed about player 1's offer and whether player 1 requested a guarantee of 100 points. Player 1 will be informed about whether you accepted this offer and the color of the ball drawn from the project. Player 1 will not be informed about the number of balls bought by you.

In the screenshots attached at the end of the instructions you find an image of the decision screens you will see during the experiment. These screens are titled 'Accept screen' and 'Project screen'.

Payoffs

Your payoff depends on whether player 1 offers 100 points, whether player 1 requests a guarantee of 100 points, whether you accept the offer, the number of red balls bought by you and the color of the ball that is thereafter drawn from the project.

If player 1 does not offer 100 points or you do not accept the offer, payoffs are equal to the initial endowments:

$$\text{Your payoff} = 100$$

$$\text{Player 1's payoff} = 150$$

If player 1 offers 100 points and you accept this offer, the payoffs depend on whether the ball drawn from the project is red or black. If the ball drawn is red, your payoff is your endowment, 100 points, plus 100 points received from player 1, plus the return you receive from the project, 100 points, and minus the costs of buying red balls. Player 1's payoff is equal his/her endowment, 150 points, minus 100 points offered to you, plus the return player 1 receives from the project, 200 points.

$$\text{Your payoff} = 100 + 100 + 100 - \text{Costs}$$

$$\text{Player 1's payoff} = 150 - 100 + 200 = 250$$

If the ball drawn is black, your payoff is your endowment, 100 points, plus the 100 points received from player 1, minus the costs of buying red balls minus the guarantee requested by player 1. Player 1's payoff is equal to player 1's endowment, 150 points, minus 100 points offered to you, plus the guarantee requested by player 1. If player 1 did not request a guarantee, the guarantee requested is 0. If player 1 requested a guarantee, the guarantee requested is 100 points.

$$\text{Your payoff} = 100 + 100 - \text{Costs} - \text{Guarantee requested}$$

$$\text{Player 1's payoff} = 150 - 100 + \text{Guarantee requested}$$

Below we display your payoffs and player 1's payoffs if player 1 offers 100 points and you accept this offer. In each table, first you find the probability that a red ball is drawn. In the first table you find your payoffs and that of player 1 if no guarantee is requested by player 1. In the second table you find your payoffs and that of player 2 if a guarantee of 100 points is requested by player 1.

If no guarantee is requested by player 1:

Number of red balls bought					
Probability that a red ball is drawn	1/6 or 16.7%	2/6 or 33.3%	3/6 or 50%	4/6 or 66.7%	5/6 or 83.3%
	Your payoff				
If a red ball is drawn:	296	284	264	236	200
If a black ball is drawn:	196	184	164	136	100
Expected payoff	212.7	217.3	214.0	202.7	183.3
	Player 1's payoff				
If a red ball is drawn:	250	250	250	250	250
If a black ball is drawn:	50	50	50	50	50
Expected payoff	83.3	116.7	150.0	183.3	216.7

If a guarantee of 100 points is requested by player 1:

Number of red balls bought					
Probability that a red ball is drawn	1/6 or 16.7%	2/6 or 33.3%	3/6 or 50%	4/6 or 66.7%	5/6 or 83.3%
	Your payoff				
If a red ball is drawn:	296	284	264	236	200
If a black ball is drawn:	96	84	64	36	0
Expected payoff	129.3	150.7	164.0	169.3	166.7
	Player 1's payoff				
If a red ball is drawn:	250	250	250	250	250
If a black ball is drawn:	150	150	150	150	150
Expected payoff	166.7	183.3	200.0	216.7	233.3

Beside each computer terminal, you can find a calculator. You may use it to do any further calculations.

Before the experiment starts, we would like to ask you some questions about the experiment. Please fill in your answer. If you have finished filling in the questions, please raise your hand and an experimenter will come to where you are seated. If you have any questions, please raise your hand.

Questions

Question 1

Player 1 does not offer 100 points. What is your payoff and that of player 1?

Your payoff = _ _ _ _ _

Payoff of player 1 = _ _ _ _ _

Question 2

Player 1 offers 100 points and requests a guarantee of 100 points. You do not accept this offer. What is your payoff and that of player 1?

Your payoff = _ _ _ _ _

Payoff of player 1 = _ _ _ _ _

Question 3

Player 1 makes an offer of 100 points. You accept this offer. Please fill in the table below.

If player 1 does not request a guarantee of 100 points:

	Your payoff	Player 1's payoff	Probability that red ball is drawn
If number of red balls bought is:			
1	If red ball is drawn		
	If black ball is drawn		
3	If red ball is drawn		
	If black ball is drawn		
5	If red ball is drawn		
	If black ball is drawn		

If player 1 requests a guarantee of 100 points:

	Your payoff	Player 1's payoff	Probability that red ball is drawn
If number of red balls bought is:			
1	If red ball is drawn		
	If black ball is drawn		
3	If red ball is drawn		
	If black ball is drawn		
5	If red ball is drawn		
	If black ball is drawn		

Summary

Before we start, let us briefly summarize the experiment.

1. Player 1 decides whether to offer 100 points to player 2 for a project. If he/she offers 100 points, he/she can request a guarantee of 100 points.

2. Player 2 decides whether to accept this offer.
3. Player 2 decides how many red balls to buy.
4. A ball is randomly drawn from the project.
5. Payoffs are calculated and shown on the screens after Experiment 5.

5.10 Appendix C: Additional Experimental Data

C.1. Pre-experimental games

The first pre-experimental game was a risk-preference elicitation task. Risk preferences were elicited to have a measure of each subject's risk aversion, because choosing effort is a risky choice. The elicitation is similar to that in Heinemann, Nagel and Oeckenfels (2009). Each subject is asked to make eleven choices between a secure payment and a lottery. While the lottery payout remains constant, 25 points in expectation, the secure payment increases from 0 to 50 in steps of 5. As the secure payment increases, the subjects are expected to switch from the lottery to the secure payment. If a subject switches to the secure payment when it is 20 or less, he is classified as risk averse. If he switches when it is 25, he is classified as risk neutral, and he is risk seeking for the remaining cases. The variable *Risk Aversion* is thus a dummy variable that takes value one if the subject is risk averse.¹⁸

After the risk-elicitation task, subjects played the p -beauty contest game with $p = \frac{2}{3}$ in groups of four. In this game each player chooses a number between 0 and 100. The winner is the subject whose guess is closest to $\frac{2}{3}$ of the average guess (Nagel, 1995). I measure *Strategic Reasoning* as the difference between 100 and the subject's guess. Since the winner is the player who is closest to $\frac{2}{3}$ of the average, there is a constant unraveling to lower guesses (until the Nash Equilibrium guess of 0). Thus, a larger difference between 100 and the guess proxies higher levels of strategic reasoning.

Then the subjects played a trust game (Berg, Dickhaut and McCabe, 1995). In this game two players, A and B, start with 10 points each. Player A can decide how many points (in integers) to send to player B. The points sent are multiplied by 3 by the experimenter and player B can freely choose how many to send back to A. For this game, the strategy-method was used and thus each player played the role of A, deciding how many points to send, and that of B, deciding for each possible amount sent by A how many points

¹⁸Multiple switches are rare: Only 7.8% of the subjects switch multiple times. These subjects are included in the data analysis below. The results remain the same if they are excluded.

to send back. Because player B has an incentive to send 0 points back to player A, the average number of points sent back by B is used as a proxy for *Trustworthiness*. The number of points sent by player A is a measure of *Trust*.

Table C.1 below presents summary statistics for the variables measured in the pre-experimental games. While *Trust* and *Trustworthiness* are not significantly different across treatments, *Risk Aversion* and *Strategic Reasoning* vary across treatments. For this reason, these variables are included as controls in the analysis of the results.

	No Collateral	Low Interest		High Interest			Kruskal-Wallis Test (p-value)
		$C=50$	$C=100$	$C=50$	$C=100$	$C=100$	
				+No Tax	+Tax		
Risk Aversion	0.28 (0.46)	0.31 (0.47)	0.16 (0.37)	0.22 (0.42)	0.57 (0.50)	0.25 (0.43)	0.11
Strategic Reasoning	65.03 (20.55)	74.28 (13.11)	77.72 (7.95)	66.72 (19.16)	74.61 (9.60)	62.84 (19.01)	<0.01
Trust	3.84 (3.62)	4.50 (3.76)	3.75 (3.69)	4.81 (3.88)	3.57 (3.58)	4.56 (3.86)	0.66
Trustworthiness	0.70 (0.70)	0.78 (0.83)	0.94 (0.86)	0.71 (0.71)	0.43 (0.49)	0.76 (0.77)	0.35

Note: Standard deviations in parentheses.

Table C.1: Individual characteristics by treatment

C.2. Beliefs

During the belief elicitation task, lenders reported their beliefs about the probability of acceptance of borrowers (on average across the borrowers in the session) and about their effort choice (conditional on acceptance). Borrowers on the other hand reported their beliefs about the probability of receiving an offer and being asked for collateral.

Table C.2 gives the beliefs reported by players and also the actual behavior (as seen in previous subsections). Panel A shows the beliefs of borrowers about the probability that lenders make offers and request collateral. If No Collateral is requested, borrowers believe that 53% of the lenders offer a loan, which is close to 44%, the actual offer ratio. In the other treatments,

borrowers tend to underestimate the proportion of lenders who offer a loan, although their guesses are above 72% in all cases. With respect to collateral requests, borrowers' beliefs are even closer to actual behavior.

		No Collateral	Low Interest		High Interest		
			$C=50$	$C=100$	$C=50$	$C=100$	$C=100$
						+No Tax	+Tax
Panel A: Borrower Beliefs							
Belief	Offer	0.53	0.73	0.91	0.72	0.86	0.85
	Collateral Request	-	0.92	0.91	0.93	0.89	0.90
Actual	Offer	0.44	0.88	1.00	1.00	1.00	1.00
	Collateral Request	-	0.93	1.00	0.94	1.00	1.00
Panel B: Lender Beliefs							
Acceptance							
Belief	If no collateral requested	0.94	0.90	0.99	0.92	0.88	0.98
	If collateral requested		0.91	0.76	0.84	0.59	0.47
Actual	If no collateral requested	1.00	1.00	1.00	1.00	1.00	1.00
	If collateral requested	-	1.00	1.00	1.00	0.57	0.87
Effort							
Belief	If no collateral requested	2.88	2.53	2.63	1.94	2.22	2.22
	If collateral requested	-	2.81	3.25	2.61	2.51	2.62
Actual	If no collateral requested	2.25	2.19	2.63	1.19	1.29	1.69
	If collateral requested	-	2.94	3.88	1.81	2.25	2.07

Note: this table reports beliefs and actual behavior by treatment. Panel A displays borrower beliefs and actual lender behavior. Panel B displays lender beliefs and actual borrower behavior.

Table C.2: Beliefs about other players' behavior

In Panel B lenders' beliefs about acceptance decisions, if collateral is requested and if it is not, are displayed. The beliefs of lenders are close to actual borrower behavior. Noticeably, lenders anticipate that a lower portion of borrowers accept their offers if collateral is high and no tax is levied on lenders. They guess that 59% of borrowers accept their offers and while actually 57% do. When a tax is levied, lenders expect fewer borrowers to accept their offer than actually do.

The lower part of Panel B gives lender beliefs about effort. Beliefs about effort when no collateral is requested are slightly higher than actual effort. However, this case is rarely observed. Beliefs about effort when collateral is requested are closer to actual effort and follow the observed treatment effects.

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