Can Contracts Solve the Hold-Up Problem? Experimental Evidence

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Abstract

In the contract-theoretic literature, there is a vital debate about whether contracts can mitigate the hold-up problem, in particular when renegotiation cannot be prevented. Ultimately, the question has to be answered empirically. As a first step, we have conducted a laboratory experiment with 1084 participants. We consider investments that directly benefit the non-investing party. While according to standard theory, contracting would be useless if renegotiation cannot be ruled out, we find that option contracts significantly improve investment incentives compared to a no-contract treatment. This finding can be explained by Hart and Moore's (2008) notion that contracts may serve as reference points.

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1 Introduction

How to induce trading partners to make relationship-specific investments is a central theme in the contract-theoretic literature. A party may have insufficient incentives to make non-contractible investments if it fears that it will be held up by its partner in the future. This hold-up problem is an important ingredient of the incomplete contracting approach, which has become a leading paradigm in institutional and organizational economics.[1] The possibility to solve the hold-up problem contractually has attracted broad interest and has been studied extensively in a vast theoretical literature initiated by Hart and Moore (1988). However, up to now there is scarce empirical evidence about the effectiveness of different contracts in inducing investment incentives. In this paper, we report about a large-scale laboratory experiment designed to explore the role of contracts in mitigating the hold-up problem.

We consider a buyer and a seller who can trade one unit of an indivisible good at some future date 2. It is always ex post efficient to trade. At date 1, the seller can make an observable but unverifiable investment that directly improves the buyer's value of the good; i.e., the investment is "cooperative" in the sense of Che and Hausch (1999). We investigate a cooperative investment, because in the theoretical literature it turned out that the difficulty to find a contractual solution to the hold-up problem is particularly severe in this case.[2]

Suppose first that the parties have not written any contract before the investment stage. Then they will negotiate at date 2 in order to realize the ex post gains from trade. According to contract-theoretic reasoning, in this case the seller may have insufficient incentives to invest because he fears that in the negotiation process he will lose a part of the returns created by his investment. Alternatively, the parties might consider to write a fixed-price contract at an initial date 0. But since this contract specifies that the buyer has to purchase the good from the seller for a fixed price at date 2, the seller

[1] See the seminal contributions by Grossman and Hart (1986) and Hart and Moore (1990), which build on the pioneering work by Coase (1937) and Williamson (1975, 1985). Cf. Hart (1995) for a comprehensive textbook exposition.

[2] Specifically, Maskin and Moore (1999) and Che and Hausch (1999) have shown that in the case of cooperative investments there exists no contractual solution at all to mitigate the hold-up problem if the parties cannot commit not to renegotiate. In contrast, Edlin and Reichelstein (1996) have shown that in the case of "selfish" investments (i.e., when the investment directly benefits the investor), the first-best investment can be induced by a suitable contract even if renegotiation cannot be ruled out.

has no investment incentives at all, because his revenue is independent of his investment. In contrast, the underinvestment problem can be solved if the parties write a simple option contract at date 0, provided that they can commit not to renegotiate the contract. The idea is that the option contract specifies a strike price such that the buyer will exercise the option only if the seller has chosen the first-best investment level. Anticipating the buyer's behavior, the seller will actually choose the first-best investment level, provided that the strike price at least covers his investment costs. However, if renegotiation cannot be ruled out, the buyer might prefer not to exercise the option, because he anticipates that the ex post inefficient no-trade decision will be reversed and that through renegotiations he will obtain a larger share of the gains from trade. The seller in turn anticipates the buyer's behavior and hence he has the same investment incentives as if there were no contract at all.

Our experimental study consists of two parts. In the first part, we study the investment behavior in the four scenarios just described (no contract, fixed-price contract, option contract, option contract with renegotiation) in four different treatments. For simplicity, in the experiment the seller can choose between only two investment levels, where high investment is first-best. To make the hold-up problem most severe, ex post negotiations are such that the buyer makes a take-it-or-leave-it price offer to the seller. Standard contract-theoretic arguments as outlined above imply that (1) the fixed-price contract cannot ameliorate the hold-up problem, (2) the non-renegotiable option contract solves the hold-up problem, and (3) the renegotiable option contract is less effective in mitigating the hold-up problem than the non-renegotiable option contract; in particular, (4) investment behavior given a renegotiable option contract is as in the no-contract benchmark. Our central goal is to find out whether these four predictions are borne out by the data.

We find support for predictions (1) to (3). Yet, we have to reject prediction (4): Compared to the no-contract benchmark, the fraction of high investments turns out to be significantly larger given a renegotiable option contract. This result can be explained neither by standard theory nor by social preference models in which subjects' utilities depend on other subjects' payoffs. This is because in the no-contract treatment and in the option contract with renegotiation treatment the attainable payoff allocations are the same.

We will then investigate whether Hart and Moore's (2008) novel idea that contracts can serve as reference points for trading relationships may shed light on the observed differences regarding the investment behavior in the option contract with renegotiation treatment and in the no-contract benchmark. Hart and Moore (2008) argue that an ex ante contract may shape the parties' feelings of entitlement with regard to ex post outcomes. A party that ex post does not get what it feels entitled to will be aggrieved and may be willing to punish its trading partner, even if this is costly and yields no material gain. For our option contract with renegotiation treatment, this may imply that a buyer might exercise the option (or make a renegotiation offer not too much below the strike price), because he fears that a seller who has chosen high investment feels entitled to the strike price, so that if the option was not exercised, the seller would be aggrieved and hence inclined to reject small offers.

In the second part of our experimental study, we report about additional treatments that we have designed in order to explore whether the observed differences in investment behavior between the option contract with renegotiation treatment and the no-contract treatment can be attributed to Hart and Moore's (2008) reference point theory. Specifically, we have conducted variants of the no-contract and the option contract with renegotiation treatments in which instead of making a take-it-or-leave-it offer, the buyer can dictate the trade price. In other words, the seller cannot engage in costly punishment by rejecting offers. Moreover, we have conducted further variants of the original no-contract and the option contract with renegotiation treatments in which the strategy method is used to elicitate the sellers' rejection behavior. A model in the spirit of Hart and Moore's (2008) reference point theory implies that (5) compared to the no-contract benchmark, an option contract has an effect only if the seller has a punishment opportunity and (6) sellers are more likely to reject small price offers when a renegotiable option contract has been signed than in the absence of a contract. We find strong support for prediction (5) and some support for prediction (6).

Our paper brings together two different strands of literature. First, our prime motivation stems from the ongoing and extensive debate in contract theory whether clever contractual arrangements such as option contracts can mitigate or even solve the hold-up problem. In particular, does contracting have any value if renegotiation cannot be prevented? Building on Maskin and Moore (1999), several authors have argued that renegotiation undermines the ability of any conceivable contract to create investment incentives (see e.g. Hart and Moore, 1999, Segal, 1999, Che and Hausch, 1999, and Segal and Whinston, 2002). In contrast, other authors such as Nöldeke and Schmidt (1995, 1998) and Lyon and Rasmusen (2004) are more optimistic about the possibility to solve the hold-up problem with suitable option contracts.[3] While the debate in the theoretical literature is focused on details of the renegotiation game (e.g., whether or not the option can still be exercised after a renegotiation offer has been turned down), our experiment suggests that writing option contracts can have a value even in a setting where the renegotiation process is such that according to standard theory option contracts would be useless.

Second, our paper provides further evidence in support of Hart and Moore's (2008) recent behavioral theory that contracts may serve as reference points.[4] They focus on the trade-off between rigid and flexible contracts in a setting with ex ante uncertainty about the state of nature. A rigid contract specifies a price at which trade will occur. While trade takes place in the good state only, the parties get what they expect, so there is no reason for aggrievement. A flexible contract determines a price range only, so that trade may take place also in the bad state of the world, but aggrievement and costly punishment may occur if a party gets less than it felt entitled to.[5] Fehr, Hart, and Zehnder (2010) find experimental evidence that largely confirms the novel theory. However, they consider neither non-contractible investments nor renegotiation, on which we focus in our experiment. In particular, to the best of our knowledge, there is not yet any experimental evidence that option contracts may serve as reference points and thereby help to mitigate the hold-up problem.

The remainder of the paper is organized as follows. Section 2 presents the first part of our experimental study, in which we investigate whether suitable contractual arrangements can mitigate the hold-up problem. In the second part of our study (Section 3), we explore whether our finding that option contracts can improve investment incentives even if renegotiation cannot be prevented might be explained by Hart and Moore's (2008) notion that contracts can serve

[3]See also Hart and Moore (1988), Chung (1991), Rogerson (1992), Hermalin and Katz (1993), Aghion, Dewatripont, and Rey (1994), Edlin and Reichelstein (1996), Bernheim and Whinston (1998), Maskin and Tirole (1999), Tirole (1999), Edlin and Hermalin (2000), MacLeod (2002), Schmitz (2002), Guriev (2003), Wickelgren (2006), Watson (2007), Evans (2008), Ohlendorf (2009), and Aghion et al. (2009) for further contributions to this vital debate.

[4]See also Hart and Moore (2007), Hart (2008, 2009), and Hart and Holmström (2010).

[5]Given a flexible contract, Hart and Moore (2008) assume that a party feels entitled to the best outcome allowed by the contract. Another plausible assumption (cf. Hart and Moore, 2008, p. 33) would be that a party's entitlement is based on his rational expectation of what he receives in equilibrium, along the lines of Koszegi and Rabin (2006). In a recent experiment, Abeler et al. (2009) find support for theories of expectation-based reference-dependent preferences.

as reference points. Concluding remarks follow in Section 4. Simple models capturing the behavioral ideas to which we refer in the paper are presented in Appendix A and Appendix B.

2 Can contracts solve the hold-up problem?

2.1 Experimental design

Motivated by the ongoing debate in contract theory, the main goal of our study is to experimentally investigate the question whether contracts can mitigate or even solve the hold-up problem. To shed light on this question, we have conducted four main treatments.[6] In each treatment, a seller and a buyer can trade one unit of an indivisible good. Before trade, the seller can make a relationship-specific investment $e \in \{e_l, e_h\}$, which is measured by its costs. In particular, the seller can invest either $e_l = 0€$ or $e_h = 8€$. Thereby, the seller influences the buyer's value from consumption of the good. Depending on the seller's investment decision, the buyer's value is either $v(e_l) = 10€$ or $v(e_h) = 22€$. Note that by assumption $v(e_h) - e_h > v(e_l) - e_l > 0$. Hence, the first-best outcome is achieved if high investment ($e = e_h$) is chosen and trade takes place.

No contract (NC^+) treatment. As a benchmark, suppose first that no contract can be written. There are up to four stages. In the first stage, the parties decide simultaneously whether or not to participate in the subsequent trade-relationship. If one or both parties do not participate, the experiment is over and each party makes zero profit. If both parties choose to participate, then in the second stage the seller makes the investment decision $e \in \{0€, 8€\}$. In the third stage, the buyer learns how much the seller has invested; i.e., the buyer learns his valuation $v(e)$. Then the buyer can make a take-it-or-leave-it offer to the seller; i.e., he offers a price p at which he is willing to buy the good (where p can be any integer between zero and the buyer's valuation).[7] In the

[6] The four treatments are variants of the four scenarios studied in the illustrative example in Section I of Che and Hausch (1999).

[7] In the contract-theoretic literature studying the hold-up problem, some authors have considered the more general case in which the seller (resp., buyer) can make a take-it-or-leave-it offer with some probability α (resp., $1 - \alpha$), see e.g. the appendix of Hart and Moore (1999). We have decided to let the seller's bargaining power α be equal to zero, since this makes the hold-up problem most severe (this assumption is also made in the main part of Hart and Moore, 1999).

fourth stage, the seller decides whether he wants to sell the good to the buyer at price p. If the seller accepts the offer, the seller's profit is $p - e$ and the buyer's profit is $v(e) - p$. If the seller rejects the offer, the seller's profit is $-e$ and the buyer makes zero profit.

Fixed-price contract (FP) treatment. There are up to two stages. In the first stage, the seller and the buyer can decide whether or not to accept the following contract: "Seller and buyer agree contractually, that the buyer will purchase the good at price $p = 15€$ in stage 2." If one or both parties do not accept the contract, the experiment is over and each party makes zero profit, while stage 2 follows if both parties accept the contract. In the second stage, the seller makes the investment decision $e \in \{0€, 8€\}$. The parties' profits then follow immediately from the contract and the seller's investment decision. Specifically, the seller's profit is $15€-e$ and the buyer's profit is $v(e) - 15€$.

Option contract (OC) treatment. There are up to three stages. In the first stage, the seller and the buyer can decide whether or not to accept the following contract: "The buyer has the option to buy the good at price $p = 15€$ in stage 3." If one or both parties do not accept the contract, the experiment is over and each party makes zero profit, while stage 2 follows if both parties accept the contract. In stage 2, the seller makes the investment decision $e \in \{0€, 8€\}$. In stage 3, the buyer learns how much the seller has invested and then he can decide whether or not to exercise the option. If the option is exercised, the seller's profit is $15€-e$ and the buyer's profit is $v(e) - 15€$. If the option is not exercised, the seller's profit is $-e$ and the buyer makes zero profit.

Option contract with renegotiation (OCR) treatment. There are up to five stages. The first three stages are as in the OC treatment, except that the consequences of not exercising the option in stage 3 are different now. If the buyer has not exercised the option, then stage 4 follows. In stage 4, the buyer can make a take-it-or-leave-it offer to the seller; i.e., he offers a price p at which he is willing to buy the good (where p can be any integer between zero and the buyer's valuation). In stage 5, the seller decides whether he agrees to trade the good at price p. If the seller accepts the offer, the seller's profit is $p - e$ and the buyer's profit is $v(e) - p$. If the seller rejects the offer, the seller's profit is $-e$ and the buyer makes zero profit.

Figure 1 shows the four game trees corresponding to the four main treatments.

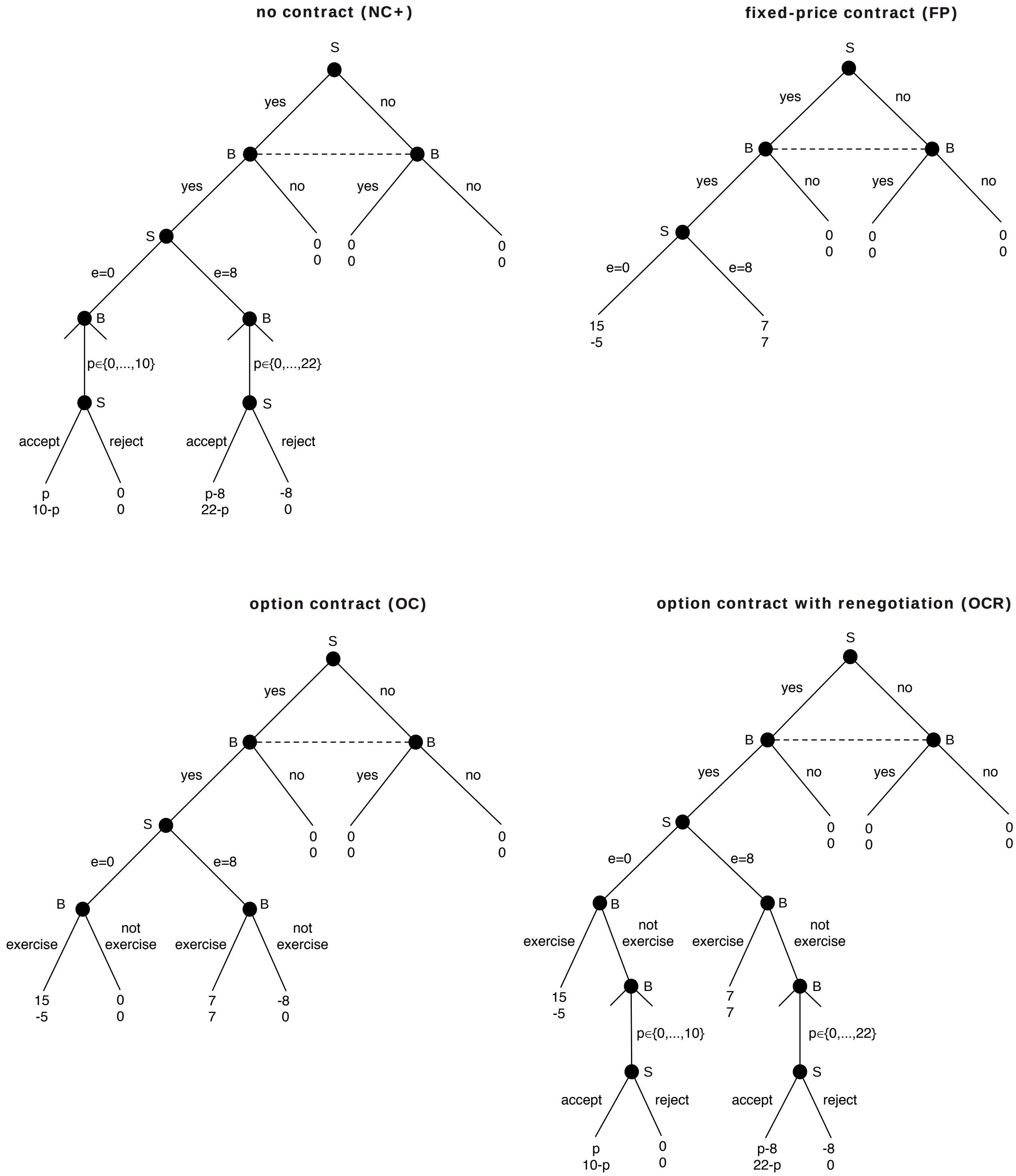

Figure 1. The game trees. In the payoff pairs at the end of each branch, the top (resp., bottom) payoff is the seller's (resp., buyer's).

Subjects, payments, and procedures. In total, 472 subjects participated in these four treatments. In addition, we conducted a fifth treatment (NC) with 124 subjects, which differed from the NC^+ treatment in only one respect: The subjects were not explicitly asked whether or not they wanted to participate; i.e., the first stage was skipped. Moreover, 488 subjects participated in four additional treatments which were motivated by the results of the main treatments and which will be described in Section 3.1. All 1084 subjects were students of the University of Cologne from a wide variety of fields of study. The computerized experiment was programmed and conducted with zTree (Fischbacher, 2007) and subjects were recruited using ORSEE (Greiner, 2004). A session lasted between 20 and 30 minutes. Subjects were paid on average 13.15€.[8]

In each session, half of the participants were randomly assigned to the role of sellers and the others to the role of buyers. Each seller was randomly matched with one buyer. No subject was allowed to participate in more than one session. In order to give subjects a monetary incentive to take their decisions seriously and to ensure a large number of independent observations, each session consisted of only one round; i.e., there were no repetitions and this was known to the subjects. All interactions were anonymous; i.e., no subject knew the identity of its trading partner. At the beginning of each session, written instructions were handed out to each subject.

2.2 Predictions

We now derive predictions on how the investment behavior should vary between the different treatments. If it is assumed that it is commonly known that all subjects are rational money-maximizers, the predictions are very clear.

No contract (NC^+). Under standard assumptions, the parties participate in the trade-relationship and after the investment stage, the seller will accept any offer weakly larger than zero, so that the buyer offers the seller a price $p = 0$€.[9] Anticipating the fact that the buyer will not compensate the seller for his investment, the seller chooses the low investment level $e_l = 0$€.

This means that in the absence of contractual safeguards, no high investments are made. In other words, a hold-up problem occurs, which raises the question whether the following contractual arrangements may be suitable to

[8] To ensure non-negative payoffs, in addition to the profit made in the experiment, all subjects were paid a participation fee of 8€.

[9] We make the usual contract-theoretic assumption that a party participates in case of indifference; otherwise the relationship might not be formed. Moreover, since in the experiment 1€ is the smallest monetary unit and the seller is indifferent between accepting and rejecting $p = 0$€, the buyer might also offer $p = 1$€. But still, the seller would never choose the high investment.

improve the sellers' investment incentives.

Fixed-price contract (FP). Under standard assumptions, if the fixed-price contract were signed, the seller would choose the low investment level e_l, since he would obtain the price $p = 15€$ regardless of his investment decision. But this implies that a buyer will never agree to such a contract, because $p = 15€ > v(e_l) = 10€$. Thus, compared to the no-contract setting, the fixed-price contract cannot enhance the seller's incentives to invest.[10]

Prediction 1. *The fixed-price contract cannot mitigate the hold-up problem; i.e., in the FP treatment we will not observe more high investments than in the NC^+ treatment.*

Option contract (OC). If the option contract with the strike price $p = 15€$ is signed, then the buyer will exercise the option if and only if $e = e_h$, because $v(e_l) < p < v(e_h)$. Anticipating the buyer's behavior, the seller invests e_h, because then his payoff is $15€ - 8€$, while it would be only $0€$ if he chose low investment (implying that the option would not be exercised). Since each party then gets a payoff of $7€$, both parties sign the contract. Hence, the first-best outcome can be achieved with an option contract.[11] However, this conclusion crucially relies on the assumption that the opportunity to trade is irretrievably forgone once the buyer has not exercised the option; i.e., the parties can commit not to renegotiate.

Prediction 2. *The option contract is an effective remedy for the hold-up problem; i.e., in the OC treatment we will observe more high investments than in the NC^+ and in the FP treatment.*

Option contract with renegotiation (OCR). If the buyer decides not to exercise the option, then an ex post inefficiency would occur. When renegotiation cannot be ruled out, the parties will renegotiate to overcome the ex post inefficiency; i.e., they will agree on trade by bargaining and thus split the surplus

[10] More generally, observe that if a fixed-price contract with price p was signed, the seller's profit is $p - e$. Hence, there exists no price p such that the seller has an incentive to invest. In the experiment, we have set $p = 15€$, since this price equalizes the parties' net payoffs given high investment, so it seems to be the price that gives the fixed-price contract the best chance to mitigate the hold-up problem when fairness concerns matter.

[11] More generally, any strike price p such that $\max\{e_h, v(e_l)\} \leq p \leq v(e_h)$ leads to the first-best outcome, because the buyer will exercise the option whenever the seller has chosen high investment and the seller is at least reimbursed for his investment costs e_h. In order to compare the effectiveness of the option contract with the fixed-price contract, we have again chosen $p = 15€$.

$v(e)$ as in the no-contract case. This implies that the buyer will never exercise the option, because in the renegotiations he can make a take-it-or-leave-it offer and thus extract the total surplus.[12] Hence, the seller has the same investment incentives as in the no-contract case. Moreover, the decision whether to sign the contract is strategically equivalent to the participation decision in the NC^+ treatment.

Prediction 3. *Contract renegotiation is harmful; i.e., in the OCR treatment we will observe fewer high investments than in the OC treatment.*

Prediction 4. *Renegotiation makes contracting redundant; i.e., in the OCR treatment we will observe the same fraction of high investments as in the NC^+ treatment.*

A central goal of our experimental study is to test whether these four predictions based on contract-theoretic reasoning are borne out by the data. In particular, will only a non-renegotiable option contract be able to effectively mitigate the hold-up problem?

In the light of previous experiments on hold-up problems (Hackett, 1993; Ellingsen and Johannesson, 2004a,b), we did not expect all subjects to choose low investment in the no-contract benchmark treatment, in contrast to standard theory. The occurrence of high investments can be explained by fairness concerns. Indeed, in Appendix A we present a simple model of social preferences based on Charness and Rabin (2002) that can explain that some sellers invest high even in the absence of a contract.[13] We did not make a specific pre-

[12] More generally, if the seller's bargaining power α (see footnote 7 above) is sufficiently small, then the buyer will not exercise the option. Specifically, this is the case if $v(e) - p < (1 - \alpha)v(e)$. Hence, the seller's date-1 profit is $\min\{p, \alpha v(e)\} - e$. Note that the best the parties can do is to agree on a price $p \geq \alpha v(e_h)$, so that the seller has the same investment incentives as in the no-contract case. See also Maskin and Moore (1999) and Che and Hausch (1999), who have proven even more general versions of the result that contracting may be useless when renegotiation cannot be ruled out.

[13] Fehr and Schmidt (1999) have developed another prominent model of social preferences. However, Ellingsen and Johannesson (2004a) have shown that the fraction of subjects exhibiting inequity aversion as modelled by Fehr and Schmidt (1999) must be rather large in order to explain high investments in the absence of contracts. Ewerhart (2006) shows that inequity aversion can solve the hold-up problem if the trade surplus is divided by alternating-offers bargaining with an infinite horizon when agents are sufficiently patient. Von Siemens (2009) investigates a model in which sellers have heterogeneous fairness preferences that are private information. Investments may then affect the buyer's beliefs about the seller's type and hence the buyer's bargaining behavior, which can generate strong incentives to invest.

diction regarding the fraction of high investments in the NC^+ treatment. The main purpose of the NC^+ treatment is to serve as a benchmark; i.e., we want to find out for our subject pool how large the fraction of high investments is in the absence of a contract, in order to then empirically assess whether suitable contractual arrangements can improve investment incentives over and above this benchmark.

Note that it is not the goal of the present paper to test a particular theory of social preferences. Indeed, while for plausible parameter constellations the model that we present in Appendix A is compatible with Predictions 1-4 as derived from standard theory, there are also circumstances under which this model would allow Predictions 1-3 not to hold.[14] It should be emphasized, however, that Prediction 4 is robust with regard to the introduction of social preferences; i.e., as long as the parties' utilities depend only on their own and possibly their trading partner's final payoffs, we should observe no difference between NC^+ and OCR.

2.3 Results

In this section we describe and analyze the results of the four main treatments. Figure 2 shows for each treatment how much has been invested and how often the trade-relationship was not established. In accordance with previous experimental findings, the observed investment levels in the NC^+ benchmark treatment show that not all sellers choose zero investment, but that there is a relevant share of sellers (41.5%) who prefer to invest high.[15] This finding may not be very surprising, given that there is abundant experimental evidence suggesting that the behavior of a substantial fraction of subjects in the lab

[14]For example, as shown in Appendix A, there are parameter constellations such that the social preferences model would predict that the fraction of high investments under a fixed-price contract is larger than given no contract. This may not be surprising taking into account that under a fixed-price contract, the strategic situation resembles a gift-exchange game, and it is known that given fairness concerns, in such games an agent may reward a principal for offering a large fixed wage by exerting high effort. See Akerlof (1982), Fehr, Kirchsteiger, and Riedl (1993, 1998), and Fehr and Schmidt (1999, section VI).

[15]Note that in the NC^+ treatment, the trade-relationship was always formed. In the additional fifth treatment in which we dropped the participation stage (NC), the share of high investments was 35.5%. While one might speculate that explicitly agreeing to participate in the trade-relationship creates a more cooperative atmosphere in which sellers feel more committed to contribute to the relationship by investing, the difference in investment behavior is actually not significant (p-value$= 0.414$, two-sided Fisher exact test).

can be explained by social preferences.

With regard to the FP treatment, we find that the contract was rejected in 28.1% of the cases. It is interesting to note that in all cases in which the contract was not accepted, it was always the buyer who rejected it, as predicted. Given that the fixed-price contract was accepted, 32.6% of the sellers chose the high investment level.

Furthermore, it is immediate to see that if renegotiation can be ruled out, an option contract is highly effective in inducing investment incentives. The contract was always accepted and there was high investment in 90.9% of the cases. In the OCR treatment, where renegotiation cannot be ruled out, the option contract was rejected in 6.2% of the cases. Conditional on acceptance of the contract, 71.7% of the sellers chose the high investment level.

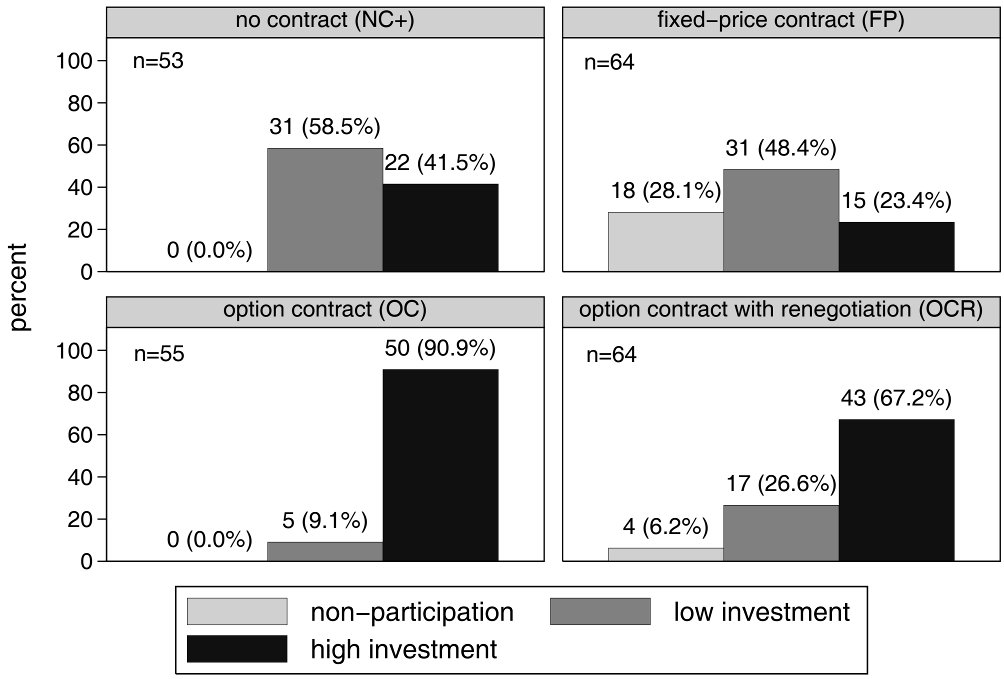

Figure 2. Non-participation and investment behavior (n denotes the number of seller-buyer pairs in each treatment).

Table 1 reports significance levels with regard to the differences in investment behavior between the treatments. Given that a fixed-price contract was signed, the investment levels in the NC$^+$ treatment and the FP treatment do not differ significantly. Yet, taking into consideration also the cases in which the fixed-price contract was rejected, the investment levels in the FP treatment are significantly lower. The fact that a fixed-price contract cannot improve investment incentives compared to the no-contract benchmark is in accordance with Prediction 1.

Compared to NC^+ (and hence also compared to FP), if renegotiation can be ruled out, then an option contract leads to an extreme improvement in investment incentives, which is highly significant. This result strongly supports Prediction 2. If it is possible to prevent renegotiation, then indeed an option contract is very effective in mitigating the underinvestment problem.

In the OCR treatment, the chosen investment levels are significantly lower than in the OC treatment, which is in line with Prediction 3. This finding provides empirical evidence for the standard contract-theoretic argument that subjects fear to be held-up when renegotiation is possible; i.e., there is a hold-up problem. On the other hand, even if renegotiation cannot be ruled out, it is highly significant that there is more investment if the parties have agreed on an option contract than if there is no contract at all. Hence, we can clearly reject Prediction 4.

	NC^+ vs. FP	NC^+ vs. OC	FP vs. OC	OC vs. OCR	FP vs. OCR	NC^+ vs. OCR
all observations	0.0463	< 0.0001	< 0.0001	0.0018	< 0.0001	0.0086
cond. on particip.	0.4090	< 0.0001	< 0.0001	0.0097	< 0.0001	0.0021

Table 1. Significance levels for pairwise comparisons of investment behavior between the treatments. The table reports the p-values according to two-sided Fisher exact tests. In the first row, all observations are taken into consideration, while in the second row, in the FP and OCR treatments only those seller-buyer pairs that accepted the contract are considered.

Figure 3 offers a closer look at the data. In particular, it illustrates how often ex post inefficiencies occurred and how the total surplus was split among buyers and sellers in the different treatments. In the four panels, the upper curve represents different combinations of the parties' profits from trading the good given high investment; i.e., different locations of the circles along this curve mark different splits of the total surplus of 14€. Similarly, the lower curve indicates different combinations of the profits from trade given low investment, such that the total surplus is 10€.

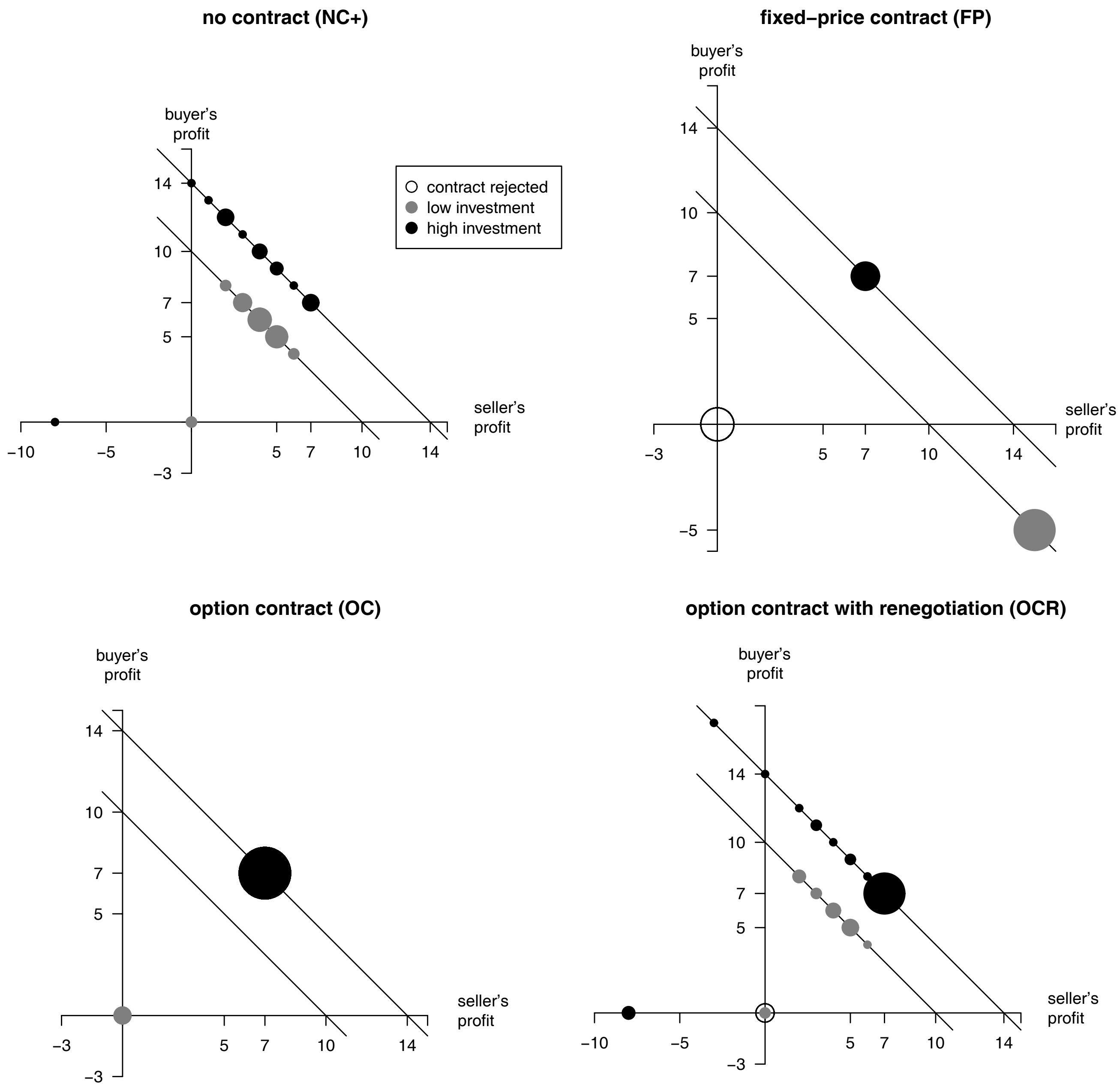

Figure 3. Profits of sellers and buyers in the four treatments. The size of the circles represents the number of observations.

Consider the NC^+ treatment. Observe that given high investment, one offer was rejected, while given low investment, two offers were rejected. The sellers' average profit was 3.55€ given high investment, while it was 3.84€ given low investment; however, the difference in sellers' profits is not statistically significant (p-value=0.9707, two-sided Mann-Whitney U test).

Next, consider the FP treatment. The circle in the origin represents the 28.1% of the cases in which the contract was rejected by the buyer. It is immediate to see that given the contract was signed, the majority of sellers (67.4%) chose low investment. As a result, the average profit of the buyers who accepted the contract was -1.09€, while they could make zero profit by simply rejecting the contract. The difference in the buyers' profits is statistically significant (p-value=0.0202, two-sided Mann-Whitney U test). Hence, rejecting the contract was the more profitable strategy for buyers.

In the OC treatment, in all of the 90.9% of the cases in which the high investment level was chosen the option was actually exercised. When the investment was low, the option was never exercised.

Finally, consider the OCR treatment. The contract was rejected in 6.2% of the cases, as indicated by the circle in the origin. When the contract was signed, three offers were rejected given high investment, while two offers were rejected given low investment. The seller's average profit in the OCR treatment was 5.07€ given high investment, but it was only 3.47€ given low investment. The difference in the sellers' profits is highly significant (p-value$<$0.0001, two-sided Mann-Whitney U test).

Comparing the panels that illustrate the NC^+ and OCR treatments, one sees immediately that even if renegotiation cannot be ruled out, the option contract strongly influences the split of the surplus given high investment. In the OCR panel, the by far biggest circle corresponds to the case in which the strike price was paid.

Hence, besides that sellers invest more in OCR than in NC^+, it is also striking that the buyers' behavior differs remarkably between these treatments. Given high investments, Figure 4 illustrates for the NC^+ and OCR treatments the distributions of prices at which buyers were willing to buy (i.e., the strike price if the option was exercised in OCR or otherwise the offer made to the seller). Obviously, the option contract influences the buyers' perception of how much the sellers are supposed to get. Indeed, given that the high investment level was chosen, 72.1% of the buyers exercised the option in the OCR treatment, while only 22.7% of the buyers offered a price of 15€ in the NC^+ treatment.

Furthermore, the average price at which trade occurred given high investment was 12.10€ in NC^+ and 14.05€ in OCR.[16] The difference in trade prices is highly significant (p-value=0.0001, two-sided Mann-Whitney U test).

[16]Note that in the additional NC treatment, the average price at which trade occurred given high investment was 12.64€. Compared to NC^+ the difference in trade prices is not statistically significant (p-value=0.3861, two-sided Mann-Whitney U test).

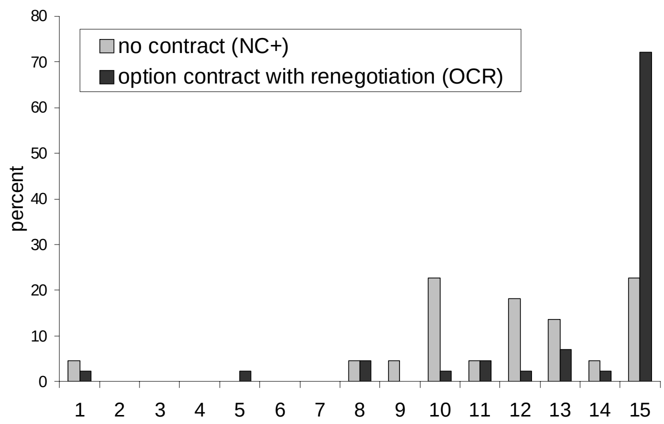

Figure 4. The prices at which buyers were willing to buy, given high investment. Implausible offers larger than 15€ did not occur. Note that in the NC$^+$ treatment, only 27.3% of the buyers offered 14€ or 15€, while in the OCR treatment the option was exercised by 72.1% of the buyers. The average price at which a buyer was willing to buy was 11.73€ in the NC$^+$ treatment and 13.58€ in the OCR treatment. The difference is statistically significant (p-value=0.0005, two-sided Mann-Whitney U test).

In the next section, we will discuss potential theoretical explanations for the observed differences between NC$^+$ and OCR. Specifically, we will hypothesize that Hart and Moore's (2008) novel idea that contracts can serve as reference points may shed light on the observed behavior. We will then report about additional treatments that we have carried out in order to test the implications of the theoretical analysis.

3 Contracts as reference points

3.1 Experimental design and predictions

Let us sum up the results of our four main treatments. The fact that there are high investments already in the no-contract benchmark treatment indicates that social preferences matter for a relevant share of subjects. Yet, the presence of fairness considerations does not invalidate contract-theoretic arguments against fixed-price contracts and in favor of non-renegotiable option contracts as solutions to the hold-up problem. Indeed, we have found strong evidence in support of Predictions 1 and 2. Moreover, in accordance with Prediction 3, the data corroborates the contract-theoretic insight that the impossibility to rule out renegotiation weakens the effectiveness of option contracts to mitigate the hold-up problem. However, we have also found that in the OCR treatment, sellers choose high investment more often than in the NC^+ treatment. This finding is in stark contrast to Prediction 4, according to which there should be no difference between OCR and NC^+.

Observe that in OCR and NC^+, the buyer has the same possibilities with regard to his price offer, except that in the OCR treatment he first has to decide not to exercise the option. Moreover, the only difference between exercising the option in the OCR treatment and offering a price $p = 15€$ in the NC^+ treatment is that a seller could reject the offer in the latter case; but regardless of the investment level, rejecting an offer of $p = 15€$ is extremely implausible (in fact, an offer of 15€ was never rejected). Hence, neither standard theory nor social preference theories can explain why subjects behave differently in the two treatments. In both treatments, a buyer should make the same price offer and, given a seller's expectation about the type of buyer (self-interested or fair-minded) he is going to meet, the seller should choose the same investment level.

However, the observed differences in behavior between OCR and NC^+ might be explained by Hart and Moore's (2008) recent idea that contracts can serve as reference points. Specifically, if the option contract is perceived as a reference point, then this may lead to more high investments in the OCR treatment. Given that the parties have mutually agreed on the contract, sellers might feel entitled to the strike price when they choose the high investment level. Buyers might then actually exercise the option (or make a price offer not too much below the strike price), because they fear that otherwise the seller would be aggrieved and reject the offer.[17]

In Appendix B, we extend the simple social preferences model of Appendix

[17]Note that rejecting the offer is a form of costly punishment and thus corresponds to a "shading" activity in Hart and Moore (2008). They point out (p. 33) that their assumptions regarding shading behavior are not derived from first principles, leaving the microfoundations of the behavioral black box to future research. We follow their shortcut but think that interdependent preferences (Levine, 1998; Gul and Pesendorfer, 2007) or intention-based reciprocity (Rabin, 1993; Dufwenberg and Kirchsteiger, 2004) might be promising approaches to explore the behavioral black box. In particular, Dufwenberg, Smith, and Van Essen (2009) have recently found experimental support for the role of negative reciprocity in mitigating the hold-up problem, provided that the investor holds the rights of control of his investment proceeds.

A by embedding Hart and Moore's (2008) idea that contracts can serve as reference points. The extended model can explain that compared to NC$^+$, in OCR the prices at which buyers are willing to trade are larger and more sellers choose high investment.[18] Moreover, the model allows us to make further predictions that can be tested by conducting additional treatments.

In particular, a renegotiable option contract can improve investment incentives only if the sellers can punish the buyers when they do not exercise the option. Hence, the contract cannot mitigate the hold-up problem when a seller has no opportunity to reject a price dictated by a buyer. An alternative theoretical explanation for the observed differences in behavior between OCR and NC$^+$ would be that buyers might feel that agreeing to the option contract is like a promise to pay a price of 15€, and they might be reluctant to break their promise even if sellers' acceptance behavior would not be influenced by the fact that the option contract has been signed.[19] To investigate whether we find support for the implications of the reference point hypothesis in the spirit of Hart and Moore (2008) or for the alternative explanation, we have conducted the following variants of the NC$^+$ and OCR treatments in which the buyers can dictate the terms of trade after the investment decision:

Dictatorial no-contract (DNC$^+$) treatment. There are up to three stages. The first two stages are as in the NC$^+$ treatment. In the third stage, the buyer learns his valuation $v(e)$ and then he unilaterally determines the price p at which trade of the good occurs (where p can be any integer between zero and the buyer's valuation). The seller's profit is $p - e$ and the buyer's profit is $v(e) - p$.

Option contract with dictatorial renegotiation (OCDR) treatment. There are up to four stages. The first three stages are as in the OCR treatment. If

[18] The model in Appendix B builds on Hart's (2009) argument that if a particular price has been contractually determined and a lower price is offered in renegotiations, then this triggers a stronger negative response than if the same low price is offered in a setting where no price was made salient from the outset.

[19] Note that Ellingsen and Johannesson (2004a,b) and Charness and Dufwenberg (2006, 2010) experimentally confirmed that free-form, personalized statements-of-intent can enhance cooperative behavior. Yet, Charness and Dufwenberg (2008) found that impersonal, bare messages (i.e., indicating whether or not to make a promise to play cooperatively) are ineffective. In our experiment, both parties only had to indicate whether or not they agree to the option contract, but there was no personal, free-form communication. Hence, we have isolated the effect of a mutually agreed-upon contract from the effect of personalized communication.

the buyer has not exercised the option, then in stage 4 the buyer unilaterally determines the price p at which trade of the good occurs (where p can be any integer between zero and the buyer's valuation). The seller's profit is $p-e$ and the buyer's profit is $v(e)-p$.

In Appendix B it is shown that the model in which the option contract serves as reference point leads to the following prediction.

Prediction 5. *(a) The trade prices and the fractions of high investments do not differ between the OCDR and DNC$^+$ treatments.*

(b) The prices at which buyers are willing to trade and the fraction of high investments are larger in OCR than in OCDR.

If we find support for Prediction 5, then this will speak against an explanation according to which buyers dislike promise breaking but instead is in line with a reference point effect in the spirit of Hart and Moore (2008). A further test of the reference point hypothesis would be to investigate whether compared to the no-contract treatment, sellers are more likely to reject low price offers in OCR when the option was not exercised. In order to find out whether the sellers' rejection behavior changes once an option contract has been signed, we have conducted two further variants of NC$^+$ and OCR in which we apply the strategy method to elicitate the sellers' rejection behavior:

No-contract strategy method (NC$^+$S) treatment. There are up to three stages. The first stage is as in the NC$^+$ treatment. If both parties choose to participate, then in the second stage the seller makes the investment decision $e \in \{0€, 8€\}$ and hereafter he decides for any possible price offer p (where p can be any integer between zero and the buyer's valuation) whether or not trade takes place if in stage 3 the buyer offers p. In the third stage, the buyer learns his valuation $v(e)$ and he chooses the price p. If in the second stage the seller had decided to trade at this price, the seller's profit is $p-e$ and the buyer's profit is $v(e)-p$. Otherwise, the seller's profit is $-e$ and the buyer makes zero profit.

Option contract with renegotiation strategy method (OCRS) treatment. There are up to four stages. The first stage is as in the OC treatment. If both parties agree to the contract, then in the second stage the seller makes the investment decision $e \in \{0€, 8€\}$ and hereafter he decides for any possible price offer p (where p can be any integer between zero and the buyer's valuation) whether or not trade takes place if the buyer does not exercise the option and offers p in stage 4. In stage 3, the buyer learns his valuation $v(e)$ and then he can decide whether or not to exercise the option. If the option is exercised, the seller's profit is 15€$-e$ and the buyer's profit is $v(e) - 15$€. If the option is not exercised, then stage 4 follows. In stage 4, the buyer chooses the price p. If in the second stage the seller had decided to trade at this price, the seller's profit is $p - e$ and the buyer's profit is $v(e) - p$. Otherwise, the seller's profit is $-e$ and the buyer makes zero profit.

In the model in Appendix B it is shown that when a share of the subjects has reference-dependent preferences, then the sellers' likeliness to reject a small price offer increases with the strength of the reference point effect. This observation leads us to make the following prediction.

Prediction 6. *Small price offers are more often rejected in OCRS than in NC$^+$S.*

3.2 Results

We now report and analyze the results of the four additional treatments that were designed to test whether the different behavior in NC$^+$ and OCR can be attributed to the notion that contracts may serve as reference points. Figure 5 shows for the two treatments in which the buyer can dictate a trade price how much has been invested and how often the trade-relationship was not formed.

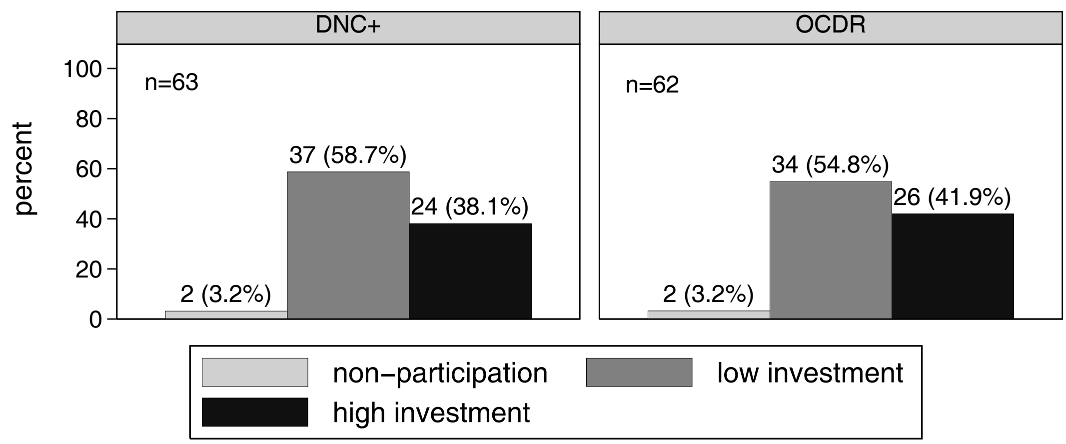

Figure 5. Non-participation and investment behavior (n denotes the number of seller-buyer pairs in each treatment).

In the first two rows of Table 2 we report the significance levels regarding the differences in investment behavior between treatments. Observe that the investment behavior does not differ significantly between our new benchmark treatment DNC^+ and our previous benchmark NC^+. However, Figure 5 illustrates that if the buyer can dictate the trade price, then a renegotiable option contract can no longer improve investment incentives. Indeed, Table 2 shows that the investment behavior does not differ significantly between DNC^+ and OCDR, which is in accordance with Prediction 5a. Moreover, in line with Prediction 5b, it turns out that the fraction of high investments is significantly larger in OCR, where the seller can reject the buyer's offer, than in OCDR, where costly punishment is not possible.

	DNC^+ vs. OCDR	DNC^+ vs. NC^+	OCDR vs. OCR
investm. (all observations)	0.7168	0.8490	0.0070
investm. (cond. on particip.)	0.7137	0.8499	0.0030
price at which willing to buy	0.3777	0.0030	< 0.0001

Table 2. Significance levels for comparisons of investment behavior and the prices at which buyers are willing to trade given high investment. In the first row, all observations are taken into consideration, while in the second row, only those seller-buyer pairs that agreed to participate are considered. In the first two rows, p-values are according to two-sided Fisher exact tests, and in the third row, p-values are according to two-sided Mann-Whitney U tests.

When the buyers have the possibility to dictate the trade price, then given high investment, the average price paid is 7.25€ in DNC^+ and 8.62€ in OCDR. As shown in Table 3, the difference between the trade prices in these two treatments is not significant, which is in line with Prediction 5a. Hence, mutually agreeing to the option contract which makes the price of 15€ salient does not directly affect the prices at which buyers want to trade. However, given that an option contract has been signed and high investment has been made, the prices at which buyers are willing to trade are significantly larger in OCR than in OCDR; i.e., they are larger when sellers can reject renegotiation offers, which is in accordance with Prediction 5b. In particular, in the OCDR treatment, the option was exercised by only 19.2% of the buyers, while in the OCR treatment, the option was exercised by 72.1% of the buyers. The difference is highly significant (p-value<0.0001, two-sided Fisher exact test).

Taken together, the fact that given high investment the buyers are willing to trade at larger prices in OCR than in NC^+ seems to be due to an indirect effect: The buyers fear that the renegotiable option contract changes the sellers' rejection behavior. Hence, an explanation of the different behavior in NC^+ and OCR solely based on promise-breaking aversion can be rejected, while we find support for the idea that buyers believe that sellers' feelings of entitlement are influenced by the contract.

Having established that the buyers fear that sellers are more prone to reject small offers in OCR than in NC^+, the question arises whether this fear is actually justified. To shed some light on this question, we have to resort to the strategy method, since in our main treatments small offers are rare so that we observe only a few rejections. Table 3 shows that the sellers' investment behavior as well as the buyers' behavior in NC^+S and OCRS are qualitatively similar to the corresponding main treatments. However, the differences between NC^+S and OCRS are less pronounced than the differences between NC^+ and OCR.

	NC^+S	OCRS
high investment	$\frac{24}{56} = 42.9\%$	$\frac{39}{63} = 61.9\%$
low investment	$\frac{32}{56} = 57.1\%$	$\frac{24}{63} = 38.1\%$
non-participation	0	$\frac{1}{63} = 1.6\%$
price at which willing to buy	12.79€	13.54€

Table 3. Investment behavior and non-participation in the strategy method treatments. Pairwise comparisons between the treatments yield p-values 0.0443 for high investments and 0.0418 for high investments conditional on participation (two-sided Fisher exact tests), and 0.2470 for the prices at which buyers were willing to buy (two-sided Mann-Whitney U test).

All sellers except for two in each of the treatments NC^+S and OCRS had increasing acceptance strategies; i.e., they indicated a minimum acceptable offer such that all smaller (resp., larger) offers were rejected (resp., accepted). When we analyze the sellers' rejection behavior, we take into account only the sellers with increasing acceptance strategies, since presumably the other sellers simply made mistakes.[20]

[20] One omitted seller decided to accept only offers weakly *smaller* than 15 (presumably, he confused rejection with acceptance), while the other three omitted sellers seem to have

Figure 6 shows for each possible price offer given high investment the fraction of sellers who were willing to accept the offer. It is striking that the acceptance frequencies in the OCRS treatment are smaller than in the NC$^+$S treatment for any given price offer except for the offer $p = 12€$ (in which case the acceptance frequency is 72.97% in OCRS and 72.73% in NC$^+$S).[21]

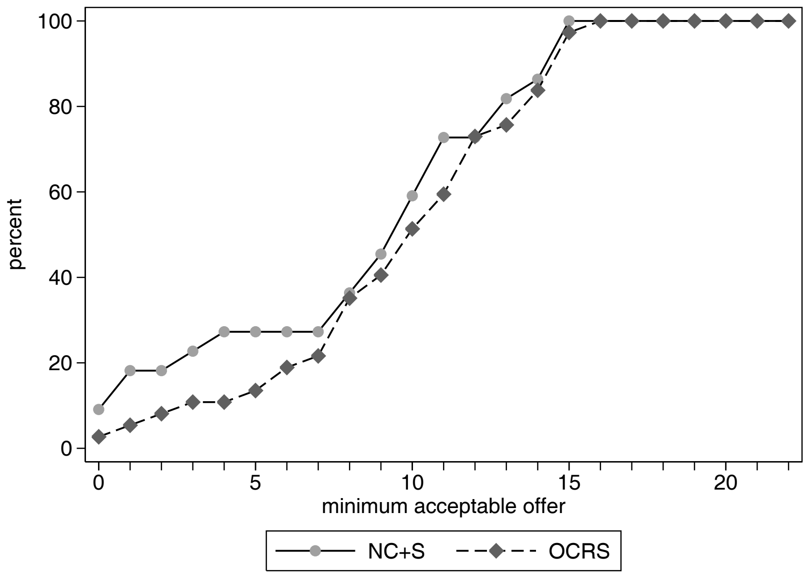

Figure 6. Acceptance frequencies per price offer given high investment.

In particular, the difference in the acceptance frequencies becomes apparent for price offers smaller than $p = 8€$. While the fact that small offers were more often rejected in OCRS than in NC$^+$S is in line with the reference point hypothesis, it should be noted that the difference is only marginally significant.[22] However, as already mentioned, when the strategy method is used, the treatment effects that we want to explain (i.e., the differences in the sellers'

forgotten to check one or two accept buttons for prices above their minimum acceptable offers. The results do not change qualitatively if we include these four sellers into the analysis.

[21] The average minimum acceptable price offer is 8.68€ in NC$^+$S and 9.92€ in OCRS. However, the difference in acceptance rates is not statistically significant when looking at the entire distributions.

[22] If we truncate the distributions and look at acceptances for offers strictly smaller than 8€ only, then the difference in the minimum acceptable offers is marginally significant (p-value=0.0586 according to a one-sided Mann-Whitney U test).

investment behavior and the buyers' behavior) are less pronounced.[23] Hence, we might expect that when using the strategy method, also the treatment effect with regard to the sellers' rejection behavior might not be as strong as in a setting where subjects have to accept or reject actual offers.[24]

To summarize, exploring the reasons for the observed differences between OCR and NC^+, we have found strong evidence for the conjecture that in OCR buyers exercise the option (or make relatively large offers otherwise), because they fear that sellers are more likely to engage in costly punishment by rejecting small offers in OCR than in NC^+. While a huge number of participants would be required to find out whether this fear is justified in the original setting, the strategy method provides some evidence that points in this direction.

4 Concluding remarks

The question whether or not suitable contracts can solve or at least mitigate the hold-up problem has been at the center of a long-lasting and controversial debate in the contract-theoretic literature. In this paper, we make a first step to address this important question in the laboratory. We consider a setting in which the seller's investment influences the buyer's valuation of the good. We find support for the contract-theoretic predictions that, compared to the no-contract benchmark, a fixed-price contract does not improve investment incentives, while a non-renegotiable option contract is very effective in inducing investments. Moreover, also as predicted, the impossibility to prevent renegotiation reduces the effectiveness of the option contract.

However, it turns out that a renegotiable option contract still significantly improves investment incentives compared to the no-contract benchmark. This finding is in contrast to standard contract theory and also cannot be explained by social preference theories according to which subjects' utilities can depend

[23] In particular, recall that with regard to the prices at which buyers are willing to buy given high investment, the difference between NC^+ and OCR is highly significant (p-value=0.0005, two-sided Mann-Whitney U test), while it is not significant between NC^+S and OCRS (p-value=0.2470, two-sided Mann-Whitney U test)

[24] Güth et al. (2001, p. 165) report that the strategy method, which economizes on subjects, may fail to find significant differences in behavioral patterns that are found in the natural design. See also Brandts and Charness (2009), who survey the literature that investigates whether the strategy method and the more natural direct response method lead to different behavior. They conclude that if some treatment effect is found using the strategy method, then it will also manifest using the direct method.

on other subjects' payoffs. Yet, we find support in favor of an explanation along the lines of Hart and Moore's (2008) idea the contracts can serve as reference points.

Note that in Hart and Moore (2008) for a contract to serve as a reference point it is important that the contract has been concluded in a competitive market. The importance of competition has been confirmed experimentally by Fehr, Hart, and Zehnder (2009). The explanation is that competition insulates a party from blame for the terms of the contract. Yet, in our experiment, the option contract is perceived as a reference point even though its terms have not been negotiated in a competitive market. The difference in findings may not be surprising, given the fact that as a simplification, in our experiment the initial contract is exogenous. The exogeneity of contracts may play the blame-insulation role that competition plays when contracts are endogenous.[25]

Moreover, the fact that given high investment the strike price allowed the parties to share the total surplus evenly, might have had a positive effect on the parties' willingness to accept the price as a reference point. It might be interesting to investigate whether ex ante competition may (further) increase the parties' readiness to accept the strike price as a reference point, in particular if the (exogenously given or endogenously determined) strike price were such that exercising the option would lead to an unequal split of the surplus. In future research, we plan to conduct experiments designed to address these questions and to explore the role of additionally allowing for lump-sum payments.[26] Furthermore, in future research we plan to experimentally assess the effectiveness of contracts for different renegotiation games and settings where investments directly affect the investing party.[27]

[25]Note also that in contrast to Fehr, Hart, and Zehnder's (2009) no-competition setting, in our experiment the parties were explicitly asked whether or not they wanted to sign the contract. The fact that they deliberately agreed to the option contract might have strengthened their perception of the strike price as the salient reference point.

[26]Note that if a suitable lump-sum payment is chosen, then also a strike price different from 15€ allows the parties to split the total surplus evenly when the seller chooses high investment and the buyer exercises the option.

[27]Segal (1999) and Hart and Moore (1999) have shown that in settings in which investments directly affect the investing party only, the impossibility to rule out renegotiation makes contracting useless if the environment is sufficiently complex. We plan to assess experimentally whether also in this setting contracts can become useful by serving as reference points.

Appendix A

Let us consider the following simple model in which a share μ of the subjects has social preferences, while the other subjects are self-interested. Let Π_i denote the material payoff of party $i \in \{B, S\}$. If a subject is self-interested, its utility is simply given by its material payoff. If party i has social preferences, then its utility function is

$$U_i(\Pi_i, \Pi_j) = \begin{cases} \rho\Pi_j + (1-\rho)\Pi_i & \text{if } \Pi_i \geq \Pi_j, \\ \sigma\Pi_j + (1-\sigma)\Pi_i & \text{if } \Pi_i < \Pi_j, \end{cases}$$

where $\sigma \in (0, 1/2)$ and $\rho \in (1/2, 1)$. Hence, if party i's material payoff is larger than party j's payoff, then party i places a relatively large weight ρ on party j's payoff. In contrast, if party i's material payoff is smaller than party j's payoff, then party i places only a relatively small weight σ on party j's payoff.

No contract. Suppose first that the seller has invested $e = 0$. Given an offer $p \in [0, 10]$, a self-interested seller always accepts the offer. A seller with social preferences accepts the buyer's offer whenever $U_S(p, 10-p) \geq U_S(0, 0)$, which is always the case since $\sigma > 0$ and $\rho < 1$.[28] Anticipating the seller's acceptance behavior, a self-interested buyer offers $p = 0$. A buyer with social preferences reasons in the following way. If he offers $p \leq 5$, then his utility is $U_B(10-p, p) = \rho p + (1-\rho)(10-p)$, which is increasing in p, such that the best the buyer can do is to offer $p = 5$. Then his utility is 5. If the buyer offered $p > 5$, his utility would be $U_B(10-p, p) = \sigma p + (1-\sigma)(10-p)$, which is decreasing in p, so the buyer is better off when he offers $p = 5$.

Suppose now that the seller has made the investment $e = 8$.[29] Being offered $p \in [0, 22]$, a self-interested seller always accepts. A seller with social preferences accepts the buyer's offer whenever $U_S(p-8, 22-p) \geq U_S(-8, 0)$, which always holds since $\sigma > 0$ and $\rho < 1$. Anticipating the seller's behavior, a self-interested buyer offers $p = 0$. Now consider a buyer with social preferences.

[28] Note that one could generalize the model by allowing σ to become negative. If $\sigma < 0$, a seller with social preferences rejects offers smaller than $v(e)\sigma/(2\sigma - 1)$. This implies that a self-interested buyer's offer depends on his belief about the seller's type, so that signaling considerations would lead to tedious case distinctions. We do not pursue this variant of the model, since it would only complicate the analysis while it would still be unable to explain any differences between NC^+ and OCR.

[29] We assume that the seller's material payoff that enters the utility functions of subjects with social preferences includes the investment costs. Experimental studies investigating hold-up problems have shown that investments are typically not perceived as sunk (Hackett, 1993; Ellingsen and Johannesson, 2004a,b).

If he offers $p \leq 15$, his utility is $U_B(22-p, p-8) = \rho(p-8) + (1-\rho)(22-p)$, which is increasing in p, such that the buyer's utility attains its maximum (which is 7) when he offers $p = 15$. If instead the buyer offered $p > 15$, his utility is $U_B(22-p, p-8) = \sigma(p-8) + (1-\sigma)(22-p)$, which is decreasing in p, so that the buyer is better off when he offers $p = 15$.

In the investment stage, a self-interested seller thus chooses $e = 8$ if $\mu 7 + (1-\mu)(-8) \geq \mu 5$. Hence, he chooses high investment whenever $\mu \geq \frac{4}{5}$. A seller with social preferences chooses $e = 8$ if $\mu 7 + (1-\mu)[\sigma 22 + (1-\sigma)(-8)] \geq \mu 5 + (1-\mu)\sigma 10$. Hence, he prefers high investment whenever $\mu \geq \frac{4-10\sigma}{5-10\sigma}$. It is a weakly dominant strategy for both parties to participate in the relationship, since then each party can ensure a non-negative utility.

Fixed-price contract. Given that the fixed-price contract has been signed, the seller knows that the good will definitely be sold at the price $p = 15$. Hence, a self-interested seller will always choose low investment ($e = 0$), since $15 - 0 > 15 - 8$. In contrast, a seller with social preferences will always choose high investment ($e = 8$). This is because $U_S(15-8, 22-15) \geq U_S(15, 10-15)$, or equivalently $7 \geq \rho(-5) + (1-\rho)15$, which is always strictly satisfied. Anticipating the seller's investment behavior, a self-interested buyer accepts the fixed-price contract if and only if $\mu(22-15) + (1-\mu)(10-15) \geq 0$, i.e. whenever $\mu \geq 5/12$, and he prefers not to accept the contract otherwise. A buyer with social preferences accepts the contract if and only if $\mu U_B(7,7) + (1-\mu)U_B(-5, 15) \geq U_B(0,0)$, or equivalently $\mu 7 + (1-\mu)[\sigma 15 + (1-\sigma)(-5)] \geq 0$, i.e. whenever $\mu \geq \frac{5-20\sigma}{12-20\sigma}$. In any case, the seller can only be (weakly) better off by signing the contract.

Option contract. Suppose that the option contract has been signed. Given high investment, a self-interested buyer will always exercise the option (since $22 - 15 > 0$), while given low investment, he will never exercise the option (since $10 - 15 < 0$). Now consider a buyer with social preferences. Given high investment, he will also always exercise the option, since $U_B(7,7) = 7 \geq U_B(0,-8) = -8\rho$. Given low investment, the buyer will not exercise the option if $U_B(10-15, 15) < U_B(0,0)$, or equivalently $\sigma 15 + (1-\sigma)(-5) < 0$, i.e. whenever $\sigma < 1/4$. Anticipating the buyer's behavior, the investment decision of a self-interested seller depends on σ. If $\sigma < 1/4$, the seller always invests high (since $15 - 8 > 0$), while if $\sigma \geq 1/4$, the self-interested seller invests high whenever $15 - 8 \geq \mu(15-0)$, or equivalently $\mu \leq 7/15$. A seller with social preferences will always choose the high investment, as it is easily verified that $U_S(7,7) \geq 0$ and $U_S(7,7) \geq \mu U_S(15,-5)$ always hold. It is a weakly dominant strategy for the parties to sign the option contract.

Option contract with renegotiation. If the option is not exercised, then the buyer's behavior regarding his offer and the seller's subsequent decision whether or not to accept the offer will be as in the NC^+ case (regardless of whether the subjects have standard preferences or social preferences). Moreover, the buyer's decision whether to exercise the option is strategically the same as the decision whether to offer $p = 15$ in the NC^+ case. This is because in the NC^+ case, an offer of $p = 15$ will never be rejected, so that the difference between OCR and NC^+ (the fact that the seller cannot prevent trade once the buyer has exercised the option) is irrelevant. Hence, the seller's investment behavior will also be as in the NC^+ case and it is a weakly dominant strategy for the parties to sign the option contract. To conclude, also if a share μ of the subjects has social preferences, the investment decisions in NC^+ and OCR do not differ.[30]

Observation A. (i) Given that a share μ of the subjects has social preferences, high investments can occur even in the no-contract benchmark. Yet, if μ is not too large, there remains a hold-up problem, i.e. not all subjects choose high investment.

(ii) Under plausible assumptions, Predictions 1, 2, and 3 are consistent with the model in which a share of subjects has social preferences. For instance, if $\mu = \sigma = 0.4$, then the predicted fractions of high investments are 0.4 in NC^+, 0.16 in FP, 1 in OC, and 0.4 in OCR; i.e., compared to the NC^+ benchmark, a fixed-price contract does not improve investment incentives, while an option contract does so only if it is non-renegotiable. However, there are also circumstances in which Predictions 1, 2, and 3 cannot be made.

(iii) Regardless of the parameters, the model always implies Prediction 4.

[30]Note that one could also consider a model in which the subjects are heterogeneous; i.e., different subjects have different social preference parameters σ and ρ. Yet, also in such a more general model a renegotiable option contract would not change the situation strategically compared to the NC^+ setting.

Appendix B

We will now extend the model of Appendix A to show that the behavior in OCR might change when option contracts serve as reference points.[31] Specifically, consider a model in which a share μ of the subjects has social preferences with utility functions $U_i(\Pi_i, \Pi_j)$ as in Appendix A. The other subjects are still self-interested, but now their preferences may be reference-dependent.[32] In particular, their utility functions are as follows. If an option contract with a strike price $p = 15$ has been signed, sellers who have chosen high investment feel entitled to the price 15. Hence, if the option is not exercised and the offered price p is smaller than the reference price of 15, then if this deviation is strong ($15 - p > \delta$), a seller who accepts the offer incurs a utility loss θ. The seller can avoid the utility loss only if he rejects the offer. Let $q \in \{0, 1\}$ denote the trade level; i.e., $q = 1$ if the option is exercised and q is given by the seller's acceptance decision otherwise. Then a seller's utility given high investment is

$$u_S(q, p, \delta, \theta) = \begin{cases} qp - 8 & \text{if } 15 - p \leq \delta, \\ q(p - \theta) - 8 & \text{if } 15 - p > \delta, \end{cases}$$

where $\delta > 0$ and $\theta > 0$. For simplicity, we assume that in the absence of a contract (NC^+), a self-interested seller's utility is given by his material payoff only. This assumption is in the spirit of Hart (2009), who argues that if a particular price has been contractually specified and a lower price is offered in renegotiations, then this leads to a stronger negative response than if the same low price is offered in a setting where no price was made salient from the outset.[33] Given low investment, it is reasonable to assume that in the OCR setting the strike price of 15 does not serve as reference point anymore, such

[31] Note that in the FP and OC settings, trade can occur only at a prespecified price, so there is no room for ex post aggrievement and costly punishment. Hence, the results in these settings do not change.

[32] It is not evident how to introduce reference-dependence in the spirit of Hart and Moore (2008) into the utility functions of the subjects with social preferences. In particular, does a seller still attach the same weight to the buyer's material payoff when the buyer has not exercised the option? One possibility would be to assume that offering less than what the seller feels entitled to in light of the contract is perceived as misbehavior in the sense of Charness and Rabin (2002), such that in the seller's utility function the weight that is put on the buyer's material payoff becomes smaller.

[33] The model could be generalized such that also in the NC^+ setting the self-interested sellers have reference-dependent utilities (in NC^+, no particular price is made salient, so any price between zero and the buyer's value might serve as a reference point; cf. Fehr,

that a self-interested seller's utility does not differ from the NC^+ setting. We assume that a self-interested buyer's utility is always given by his material payoff.[34]

Consider first a seller's decision whether or not to accept an offer p when in the preceding stage the option was not exercised. A seller with social preferences accepts any $p \geq 0$ (see Appendix A). Similarly, a self-interested seller who has chosen low investment accepts any offer $p \geq 0$. Given high investment, a self-interested seller's utility is reference-dependent, such that he accepts whenever $u_S(1, p, \delta, \theta) \geq u_S(0, p, \delta, \theta)$, or equivalently $p \geq p^T := \min\{15 - \delta, \theta\}$. Sellers may be heterogeneous with regard to δ (the critical deviation from the strike price that triggers aggrievement) and θ (the strength of aggrievement). This implies that different sellers may have different threshold prices p^T. We denote by $F(\cdot)$ the cumulative distribution function of the self-interested sellers' threshold prices.

In a perfect Bayesian equilibrium, when high investment was chosen, a buyer with social preferences prefers the price $p = 15$ (see Appendix A), so that he exercises the option, while a self-interested buyer makes an offer $p^* \in \arg\max(22 - p)[\hat{\mu} + (1 - \hat{\mu})\hat{F}(p)]$, where the buyer's beliefs $\hat{\mu}$ and $\hat{F}(\cdot)$ must follow from applying Bayes' rule whenever applicable. When low investment was chosen, a buyer with social preferences offers $p = 5$ (see Appendix A), while a self-interested buyer offers $p = 0$. A self-interested seller chooses the high investment whenever $\mu 7 + (1 - \mu)[q(p^* - \theta I_{15-p^*>\delta}) - 8] \geq \mu 5$ where $q = 1$ if $p^* \geq p^T$ and $q = 0$ otherwise, while a seller with social preferences chooses $e = 8$ whenever $\mu 7 + (1 - \mu)[\sigma(22 - p^*) + (1 - \sigma)(p^* - 8)] \geq \mu 5 + (1 - \mu)\sigma 10$.

For example, suppose again that $\mu = \sigma = 0.4$. If $\delta \in \{4, 7\}$ with equal probability and $\theta = 9$, then there exists a separating equilibrium in which sellers with social preferences and self-interested sellers with $\delta = 7$ choose high investment, while self-interested sellers with $\delta = 4$ choose low investment.[35]

Hart, and Zehnder, 2010). Our findings are robust as long as we assume that the impact of the reference point is sufficiently stronger when both parties have mutually agreed upon a contract fixing a particular price.

[34] This assumption is in line with Fehr, Hart, and Zehnder (2010). Alternatively, one could imagine that if an option contract has been signed, then the buyer might be aggrieved when the seller chooses low investment, so that he might offer a lower price. Note that this could only make high investments more attractive in the OCR setting compared to NC^+.

[35] In this example, the threshold prices of self-interested sellers with $\delta = 4$ (resp., $\delta = 7$) are $\min\{15-4, 9\} = 9$ (resp., $\min\{15-7, 9\} = 8$). Hence, $F(p) = \frac{1}{2}I_{\{p \geq 8\}} + \frac{1}{2}I_{\{p \geq 9\}}$, Bayes' rule implies $\hat{\mu} = 0.4/0.7$, $\hat{F}(p) = I_{\{p \geq 8\}}$, and $p^* = 8$.

Hence, in this case the fractions of high investment are 0.4 in NC^+ and 0.7 in OCR.

Observation B. (i) The stronger the reference point effect (i.e., the smaller the critical deviation δ and the larger the utility loss θ), the larger becomes the threshold price $p^T := \min\{15 - \delta, \theta\}$ below which renegotiation offers are rejected.

(ii) The average price at which a buyer is willing to trade given high investment is larger in the OCR setting $(15\mu+(1-\mu)p^*)$ than in the NC^+ benchmark (15μ).

(iii) The conditions for high investment are easier to satisfy in the OCR setting than in NC^+, since given low investment, there is no difference between NC^+ and OCR, but given high investment, on average the seller anticipates to receive a larger price.

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Supplementary Material

The following instructions were handed out to the participants in the NC^+ treatment:

<u>Experimental Instructions</u>

In this experiment there is always one seller who interacts with one buyer. You are randomly assigned either to the role of the seller or to the role of the buyer.

The experiment consists of only one single period.
The period consists of up to four stages.

Stage 1:
On the screen you can see whether you have been assigned to the role of the seller or to the role of the buyer.

Both the seller and the buyer can decide whether or not they want to participate in the trade relationship described in stages 2 to 4.

If one or both parties do not agree to participate, the experiment is over. Then each party makes a profit of 0 €.

If both parties agree to participate in the trade relationship, then stage 2 follows.

Stage 2:
The seller can make an investment decision. He can invest either 0 € or 8 € and thereby he can influence the buyer's valuation for a particular good which can be traded later.

If the seller has invested 0 €, then the buyer's valuation for the good is 10 €.
If the seller has invested 8 €, then the buyer's valuation for the good is 22 €.

Stage 3:
The buyer learns the seller's investment decision and so now he knows his valuation. Then the buyer can make an ultimate price offer p to the seller at which the buyer is willing to buy the good. (The price has to be an integer between zero and the buyer's valuation for the good.)

Stage 4:
The seller can decide whether he wants to sell the good to the buyer at the offered price p.

At the end of stage 4, the profits are as follows.

If the seller has invested 0 €:
- If the seller has accepted the offer:
  Seller's profit: p € - 0 € = p €
  Buyer's profit: 10 € - p €
- If the seller has not accepted the offer:
  Seller's profit: 0 €
  Buyer's profit: 0 €

If the seller has invested 8 €:
- If the seller has accepted the offer:
  Seller's profit: p € - 8 €
  Buyer's profit: 22 € - p €
- If the seller has not accepted the offer:
  Seller's profit: -8 €
  Buyer's profit: 0 €

The following instructions were handed out to the participants in the FP treatment:

<u>Experimental Instructions</u>

In this experiment there is always one seller who interacts with one buyer. You are randomly assigned either to the role of the seller or to the role of the buyer.

The experiment consists of only one single period.
The period consists of up to two stages.

Stage 1:
On the screen you can see whether you have been assigned to the role of the seller or to the role of the buyer.

Both the seller and the buyer can decide whether or not they agree to the following contract:

"Seller and buyer agree contractually, that the buyer purchases a particular good at the price of 15 € at the end of stage 2."

If one or both parties do not agree to the contract, the experiment is over. Then each party makes a profit of 0 €.

If both parties agree to the contract, then stage 2 follows.

Stage 2:
The seller can make an investment decision. He can invest either 0 € or 8 € and thereby he can influence the buyer's valuation for the good.

If the seller has invested 0 €, then the buyer's valuation for the good is 10 €.
If the seller has invested 8 €, then the buyer's valuation for the good is 22 €.

At the end of stage 2, the profits result from the signed contract and the investment decision.

If the seller has invested 0 €:
Seller's profit: 15 € - 0 € = 15 €
Buyer's profit: 10 € - 15 € = -5 €

If the seller has invested 8 €:
Seller's profit: 15 € - 8 € = 7 €
Buyer's profit: 22 € - 15 € = 7 €

The following instructions were handed out to the participants in the OC treatment:

<u>**Experimental Instructions**</u>

In this experiment there is always one seller who interacts with one buyer. You are randomly assigned either to the role of the seller or to the role of the buyer.

The experiment consists of only one single period.
The period consists of up to three stages.

Stage 1:
On the screen you can see whether you have been assigned to the role of the seller or to the role of the buyer.

Both the seller and the buyer can decide whether or not they agree to the following contract:

"The buyer has the option to purchase a particular good at the price of 15 € in stage 3."

If one or both parties do not agree to the contract, the experiment is over. Then each party makes a profit of 0 €.

If both parties agree to the contract, then stage 2 follows.

Stage 2:
The seller can make an investment decision. He can invest either 0 € or 8 € and thereby he can influence the buyer's valuation for the good.

If the seller has invested 0 €, then the buyer's valuation for the good is 10 €.
If the seller has invested 8 €, then the buyer's valuation for the good is 22 €.

Stage 3:
The buyer learns the seller's investment decision and so now he knows his valuation. Then the buyer can exercise the option.

At the end of stage 3, the profits are as follows.

If the seller has invested 0 €:

- If the buyer has exercised the option:
  Seller's profit: 15 € - 0 € = 15 €
  Buyer's profit: 10 € - 15 € = -5 €
- If the buyer has not exercised the option:
  Seller's profit: 0 €
  Buyer's profit: 0 €

If the seller has invested 8 €:

- If the buyer has exercised the option:
  Seller's profit: 15 € - 8 € = 7 €
  Buyer's profit: 22 € - 15 € = 7 €
- If the buyer has not exercised the option:
  Seller's profit: -8 €
  Buyer's profit: 0 €

The following instructions were handed out to the participants in the OCR treatment:

<u>**Experimental Instructions**</u>

In this experiment there is always one seller who interacts with one buyer. You are randomly assigned either to the role of the seller or to the role of the buyer.

The experiment consists of only one single period.
The period consists of up to five stages.

Stage 1:
On the screen you can see whether you have been assigned to the role of the seller or to the role of the buyer.

Both the seller and the buyer can decide whether or not they agree to the following contract:

"The buyer has the option to purchase a particular good at the price of 15 € in stage 3."

If one or both parties do not agree to the contract, the experiment is over. Then each party makes a profit of 0 €.

If both parties agree to the contract, then stage 2 follows.

Stage 2:
The seller can make an investment decision. He can invest either 0 € or 8 € and thereby he can influence the buyer's valuation for the good.

If the seller has invested 0 €, then the buyer's valuation for the good is 10 €.
If the seller has invested 8 €, then the buyer's valuation for the good is 22 €.

Stage 3:
The buyer learns the seller's investment decision and so now he knows his valuation. Then the buyer can exercise the option.

- If the buyer has exercised the option, the experiment is over and the profits are as follows:

  If the seller has invested 0 €:
  Seller's profit: 15 € - 0 € = 15 €
  Buyer's profit: 10 € - 15 € = -5 €

  If the seller has invested 8 €:
  Seller's profit: 15 € - 8 € = 7 €
  Buyer's profit: 22 € - 15 € = 7 €

- If the buyer has not exercised the option, then stage 4 follows.

Stage 4:
Now the buyer can make an ultimate price offer p to the seller at which the buyer is willing to buy the good. (The price has to be an integer between zero and the buyer's valuation for the good.)

Stage 5:
The seller can decide whether he wants to sell the good to the buyer at the offered price p.

At the end of stage 5, the profits are as follows.

If the seller has invested 0 €:

- If the seller has accepted the offer:
  Seller's profit: p € - 0 € = p €
  Buyer's profit: 10 € - p €
- If the seller has not accepted the offer:
  Seller's profit: 0 €
  Buyer's profit: 0 €

If the seller has invested 8 €:

- If the seller has accepted the offer:
  Seller's profit: p € - 8 €
  Buyer's profit: 22 € - p €
- If the seller has not accepted the offer:
  Seller's profit: -8 €
  Buyer's profit: 0 €

The following instructions were handed out to the participants in the NC treatment:

Experimental Instructions

In this experiment there is always one seller who interacts with one buyer. You are randomly assigned either to the role of the seller or to the role of the buyer.

The experiment consists of only one single period.
The period consists of three stages.

Stage 1:
On the screen you can see whether you have been assigned to the role of the seller or to the role of the buyer.

The seller can make an investment decision. He can invest either 0 € or 8 € and thereby he can influence the buyer's valuation for a particular good which can be traded later.

If the seller has invested 0 €, then the buyer's valuation for the good is 10 €.
If the seller has invested 8 €, then the buyer's valuation for the good is 22 €.

Stage 2:
The buyer learns the seller's investment decision and so now he knows his valuation. Then the buyer can make an ultimate price offer p to the seller at which the buyer is willing to buy the good. (The price has to be an integer between zero and the buyer's valuation for the good.)

Stage 3:
The seller can decide whether he wants to sell the good to the buyer at the offered price p.

At the end of stage 3, the profits are as follows.

If the seller has invested 0 €:

- If the seller has accepted the offer:
  Seller's profit: p € - 0 € = p €
  Buyer's profit: 10 € - p €
- If the seller has not accepted the offer:
  Seller's profit: 0 €
  Buyer's profit: 0 €

If the seller has invested 8 €:

- If the seller has accepted the offer:
  Seller's profit: p € - 8 €
  Buyer's profit: 22 € - p €
- If the seller has not accepted the offer:
  Seller's profit: -8 €
  Buyer's profit: 0 €

The following instructions were handed out to the participants in the DNC^{+} treatment:

<u>Experimental Instructions</u>

In this experiment there is always one seller who interacts with one buyer. You are randomly assigned either to the role of the seller or to the role of the buyer.

The experiment consists of only one single period.
The period consists of up to three stages.

Stage 1:
On the screen you can see whether you have been assigned to the role of the seller or to the role of the buyer.

Both the seller and the buyer can decide whether or not they want to participate in the trade relationship described in stages 2 and 3.

If one or both parties do not agree to participate, the experiment is over. Then each party makes a profit of 0 €.

If both parties agree to participate in the trade relationship, then stage 2 follows.

Stage 2:
The seller can make an investment decision. He can invest either 0 € or 8 € and thereby he can influence the buyer's valuation for a particular good which will be traded later.

If the seller has invested 0 €, then the buyer's valuation for the good is 10 €.
If the seller has invested 8 €, then the buyer's valuation for the good is 22 €.

Stage 3:
The buyer learns the seller's investment decision and so now he knows his valuation. Then the buyer can set a price p at which he buys the good; i.e., trade takes place at price p. (The price has to be an integer between zero and the buyer's valuation for the good.)

At the end of stage 3, the profits are as follows.

If the seller has invested 0 €:
Seller's profit: p € - 0 € = p €
Buyer's profit: 10 € - p €

If the seller has invested 8 €:
Seller's profit: p € - 8 €
Buyer's profit: 22 € - p €

The following instructions were handed out to the participants in the OCDR treatment:

Experimental Instructions

In this experiment there is always one seller who interacts with one buyer. You are randomly assigned either to the role of the seller or to the role of the buyer.

The experiment consists of only one single period.
The period consists of up to four stages.

Stage 1:
On the screen you can see whether you have been assigned to the role of the seller or to the role of the buyer.

Both the seller and the buyer can decide whether or not they agree to the following contract:

"The buyer has the option to purchase a particular good at the price of 15 € in stage 3."

If one or both parties do not agree to the contract, the experiment is over. Then each party makes a profit of 0 €.

If both parties agree to the contract, then stage 2 follows.

Stage 2:
The seller can make an investment decision. He can invest either 0 € or 8 € and thereby he can influence the buyer's valuation for the good.

If the seller has invested 0 €, then the buyer's valuation for the good is 10 €.
If the seller has invested 8 €, then the buyer's valuation for the good is 22 €.

Stage 3:
The buyer learns the seller's investment decision and so now he knows his valuation. Then the buyer can exercise the option.

- If the buyer has exercised the option, the experiment is over and the profits are as follows:

  If the seller has invested 0 €:
  Seller's profit: 15 € - 0 € = 15 €
  Buyer's profit: 10 € - 15 € = -5 €

  If the seller has invested 8 €:
  Seller's profit: 15 € - 8 € = 7 €
  Buyer's profit: 22 € - 15 € = 7 €

- If the buyer has not exercised the option, then stage 4 follows.

Stage 4:
Now the buyer can set a price p at which he buys the good; i.e., trade takes place at price p. (The price has to be an integer between zero and the buyer's valuation for the good.)

At the end of stage 4, the profits are as follows.

If the seller has invested 0 €:

Seller's profit: p € - 0 € = p €

Buyer's profit: 10 € - p €

If the seller has invested 8 €:

Seller's profit: p € - 8 €

Buyer's profit: 22 € - p €

The following instructions were handed out to the participants in the $NC^{+}S$ treatment:

<u>Experimental Instructions</u>

In this experiment there is always one seller who interacts with one buyer. You are randomly assigned either to the role of the seller or to the role of the buyer.

The experiment consists of only one single period.
The period consists of up to four stages.

Stage 1:
On the screen you can see whether you have been assigned to the role of the seller or to the role of the buyer.

Both the seller and the buyer can decide whether or not they want to participate in the trade relationship described in stages 2 to 4.

If one or both parties do not agree to participate, the experiment is over. Then each party makes a profit of 0 €.

If both parties agree to participate in the trade relationship, then stage 2 follows.

Stage 2:
The seller can make an investment decision. He can invest either 0 € or 8 € and thereby he can influence the buyer's valuation for a particular good which can be traded later.

If the seller has invested 0 €, then the buyer's valuation for the good is 10 €.
If the seller has invested 8 €, then the buyer's valuation for the good is 22 €.

The buyer learns the seller's investment decision and so now he knows his valuation.

Stage 3:
In the following stage 4, the buyer will offer a price p at which he would like to buy the good.

Already in the present stage 3, the seller indicates for all possible price offers whether or not the good is to be sold if this price will be offered.

The buyer does not learn the decisions that the seller makes here in stage 3; i.e., in stage 4 the buyer will make a price offer p without knowing whether for this offer the seller has already decided "I do not sell" or "I sell."

Stage 4:
The buyer chooses a price p at which he would like to buy the good. (The price has to be an integer between zero and the buyer's valuation for the good.)

The good is sold if for the now actually chosen price p the seller had indicated "I sell" in stage 3. Otherwise, the good is not sold.

At the end of stage 4, the profits are as follows.

If the seller has invested 0 €:

- If the good is sold:
  Seller’s profit: p € - 0 € = p €
  Buyer’s profit: 10 € - p €
- If the good is not sold:
  Seller’s profit: 0 €
  Buyer’s profit: 0 €

If the seller has invested 8 €:

- If the good is sold:
  Seller’s profit: p € - 8 €
  Buyer’s profit: 22 € - p €
- If the good is not sold:
  Seller’s profit: -8 €
  Buyer’s profit: 0 €

The following instructions were handed out to the participants in the OCRS treatment:

Experimental Instructions

In this experiment there is always one seller who interacts with one buyer. You are randomly assigned either to the role of the seller or to the role of the buyer.

The experiment consists of only one single period.
The period consists of up to five stages.

Stage 1:
On the screen you can see whether you have been assigned to the role of the seller or to the role of the buyer.

Both the seller and the buyer can decide whether or not they agree to the following contract:

"The buyer has the option to purchase a particular good at the price of 15 € in stage 4."

If one or both parties do not agree to the contract, the experiment is over. Then each party makes a profit of 0 €.

If both parties agree to the contract, then stage 2 follows.

Stage 2:
The seller can make an investment decision. He can invest either 0 € or 8 € and thereby he can influence the buyer's valuation for the good.

If the seller has invested 0 €, then the buyer's valuation for the good is 10 €.
If the seller has invested 8 €, then the buyer's valuation for the good is 22 €.

The buyer learns the seller's investment decision and so now he knows his valuation.

Stage 3:
Suppose that in the following stage 4 the buyer would not exercise the option to buy the good at the price of 15 €. In this case, in the following stage 5, the buyer will offer a price p at which he would like to buy the good instead.

Already in the present stage 3, the seller indicates for all possible price offers whether or not the good is to be sold if this price will be offered.

The buyer does not learn the decisions that the seller makes here in stage 3; i.e., if the buyer does not exercise the option, then in stage 5 he will make a price offer p without knowing whether for this offer the seller has already decided "I do not sell" or "I sell."

Stage 4:
The buyer can exercise the option.

- If the buyer has exercised the option, the experiment is over and the profits are as follows:

  If the seller has invested 0 €:
  Seller's profit: 15 € - 0 € = 15 €
  Buyer's profit: 10 € - 15 € = -5 €

If the seller has invested 8 €:
Seller's profit: 15 € - 8 € = 7 €
Buyer's profit: 22 € - 15 € = 7 €

- If the buyer has not exercised the option, then stage 5 follows.

Stage 5:
The buyer chooses a price p at which he would like to buy the good. (The price has to be an integer between zero and the buyer's valuation for the good.)

The good is sold if for the now actually chosen price p the seller had indicated "I sell" in stage 3. Otherwise, the good is not sold.

At the end of stage 5, the profits are as follows.

If the seller has invested 0 €:
- If the good is sold:
  Seller's profit: p € - 0 € = p €
  Buyer's profit: 10 € - p €
- If the good is not sold:
  Seller's profit: 0 €
  Buyer's profit: 0 €

If the seller has invested 8 €:
- If the good is sold:
  Seller's profit: p € - 8 €
  Buyer's profit: 22 € - p €
- If the good is not sold:
  Seller's profit: -8 €
  Buyer's profit: 0 €

Furthermore, at the end of each of the different experimental instructions, the following information was provided:

Your payoff:
In addition to the (possibly negative) profit realized in the experiment you get 8 € and the resulting amount is paid out to you in cash.

Please note:
During the whole experiment communication is not allowed. If you have a question, please raise your hand out of the cabin. All decisions are anonymous; i.e., no participant ever learns the identity of a person who has made a particular decision. The payment is conducted anonymously, too; i.e., no participant learns what the payoff of another participant is.