An experimental comparison of reliance levels under alternative breach remedies[1]

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Abstract

Breach remedies serve an important role in protecting relationship-specific investments. The theoretical literature predicts that some commonly used types of breach remedies may protect too well, in the sense that they induce overinvestment. The driving forces behind this result are the complete insurance against potential separation that breach remedies may provide, and the possibility to prevent breach by increasing the damage payment due through the investment made. The question remains whether these two motives, and thus the derived overinvestment result, indeed show up in practice. In this paper we report on an experiment designed to address this issue.

Three breach remedies are studied: (i) liquidated damages, (ii) expectation damages and (iii) reliance damages. In line with theoretical predictions we find that overinvestment does not occur under liquidated damages. In case of expectation damages the full insurance motive indeed appears to be operative, but due to fairness considerations it leads to (slightly) less overinvestment than predicted. Reciprocal behavior reduces the working of the breach prevention motive to overinvest predicted for the reliance damages case. Overall, overinvestment indeed occurs, but is somewhat less severe than theory predicts.

JEL codes: K12, J41, C91.

1 Introduction

The value of a contract lies in the commitment it provides. Contracts create commitment through the implicit or explicit specification of what happens if a party fails to perform. Typically a defaulting party has to pay the other party damages. The rules specifying how the amount of damages should be calculated are usually referred to as breach remedies. The following four breach remedies are commonly used in practice and received considerable attention in the theoretical literature (cf. Chapter 7 in Cooter and Ulen 1997, Edlin 1997):

- specific performance: unilateral breach of contract is not possible. An agent is required to adhere to the contract if the other party asks him to do so;
- liquidated damages: the breacher has to pay a fixed amount – specified in the initial contract – to the victim of breach;
- expectation damages: the breacher has to compensate the victim such that the latter is equally well off as had trade occurred according to the original contract;
- reliance damages: the breacher compensates the victim such that the latter is equally well off as before the trade agreement had been signed (i.e. as if there had been no contract).

Liquidated damages are always privately stipulated and have to be incorporated explicitly into the initial contract. The other three remedies are, in various situations and circumstances, incorporated in the common law as being the default remedy.

Through their provision of commitment, breach remedies play an important role in protecting (non-contractable) relationship-specific investments.[1] (Such investments that are profitable only in the event of contract performance are usually referred to as reliance expenditures.) Without contractual commitment, under-investment may occur because of holdup (cf. Williamson 1985). Breach remedies can be used to overcome this holdup problem, because they effectively protect the investor against appropriation of the return on the investment by the trading partner.

[1]Another role breach remedies may have is that they can serve as a barrrier to entry. That is, they can be used to inefficiently exclude or appropriate rents from alternative trading partners (cf. Aghion and Bolton 1987, Chung 1992, Spier and Whinston 1995, Burguet et al. (1999)). In this paper we do not consider this entry barrier role, as we assume that alternative trading partners always behave competitively.

The theoretical literature reveals that, when we focus on so-called selfish investments, breach remedies generally lead to too much protection.[2] [3] Irrespective of whether renegotiation of the initial contract is possible (Shavell 1980) or not (Rogerson 1984), breach remedies typically induce overinvestment. There are generally two motives to overinvest in the presence of breach remedies. First, under specific performance, expectation damages and reliance damages, the breach remedy effectively insures the investor completely against potential separation. When separation is efficient in some possible contingencies, the investor is then over-insured from a social point of view. She will not accurately take account of the fact that the investment is not always socially profitable, and she will therefore overinvest. The second motive to overinvest is only operative under the reliance damages rule. Because the investor is in that case better off when the parties trade according to the contract than when they separate, she may have an incentive to reduce the probability of separation by investing more. Higher investments lead to a larger damage payment in case of a breach, making breach less attractive for the other party.

This paper reports about an experiment designed to test the above predictions concerning overinvestment under the various breach remedies. Outside the laboratory such tests of the theory are more difficult or even impossible to obtain because of unavailability of data and difficulties to control other, possible intervening, factors (the ceteris paribus condition).[4] In the experiment we consider the remedies of liquidated damages, expectation damages and reliance damages.[5] It is investigated whether the two motives to overinvest indeed show up in practice when theory predicts them to be operative. The

[2]Selfish investments are investments that directly benefit the investor, i.e. the buyer's investment increases her valuation of the traded good, while the seller's investment lowers his production costs. Che and Chung (1999) consider the case of cooperative investments in which the investment directly benefits the other party. For instance, the seller makes an investment that directly increases the buyer's valuation. Che and Chung show that there typically will be underinvestment in that case, even in the presence of penalties for breach.

[3]Under certain ingeniously designed contracts breach remedies do not necessarily induce overinvestment. In particular, Edlin and Reichelstein (1996) show that an initial contract that specifies a suitably chosen intermediate amount of trade together with a breach remedy secures efficient investments. In practice, however, such elaborate contracts may not be used. Moreover, they may also be unvailable because they require the contract to be "divisible". In this paper we focus on the discrete framework in which contracts are "entire" ($q \in \{0, 1\}$). The particular contracts considered by Edlin and Reichelstein (1996) are briefly discussed in the final section of this paper.

[4]Experiments are very suitable to test the predictions of well articulated formal theories in a controlled environment that allows these observations to be unambiguously interpreted in relation to the theory (Roth 1985). If the experimental design complies with all the conditions set by the theory, the results of the experiment should confirm the predictions of the theory, if this theory is sound.

[5]We do not study the specific performance breach remedy experimentally, since in that case breach is not possible. The experiment would then reduce to a single agent decision (investment) problem under certainty, lacking any strategic interaction.

focus is on the case where renegotiation of the initial contract is not possible (as in Shavell 1980, and in Chung 1992). It should be noted that theoretically holdup does not occur when renegotiation is not possible. Yet the two overinvestment motives are also predicted to be at work in the no-renegotiation case. To keep the experimental design as simple and clear-cut as possible we have chosen to study the overinvestment motives in a setting that does not allow for renegotiation.

The remainder of this paper is organized as follows. Section 2 describes the basic setup of the three stage game studied experimentally and derives the equilibrium predictions for each of the three breach remedies. Section 3 describes the experimental design and formulates the hypotheses that are put to the test. Hypotheses are based on game theoretical predictions and on notions of fairness and reciprocity. The experimental results are discussed in Section 4. The final section summarizes our main findings and provides some suggestions for future research.

2 The model

2.1 Basic setup of the model

We focus on a bilateral trade relationship in which one party invests and the other party has an alternative trading opportunity outside this relationship. We refer to the two parties involved as buyer and seller respectively. Both parties are assumed to be risk-neutral. For ease of exposition we assume that it is the (female) buyer who makes the investment, and that it is the (male) seller who has the alternative trading opportunity.[6] Trade between the buyer and the seller is restricted to one unit. The seller's production costs are assumed to be fixed and are normalized at zero. When the buyer and the seller trade, gross surplus equals $R(I) = V + v \cdot I$. Here $I \in [0, v]$ denotes the investment made by the buyer. This investment is completely relation-specific and also non-contractable, so holdup may occur. Parameter $V > 0$ represents the buyer's basic valuation when trading with the seller, and v (with $v > 0$) is the constant increment in the buyer's valuation with

[6]This assumption is without loss of generality. We could as well assume that the seller makes the investment and the buyer has the outside trading opportunity (cf. Rogerson 1984, Shavell 1980). A real world example that fits the setup used in the main text concerns a relationship between an employer and a worker, in which the employer invests in firm specific human capital and the worker has the opportunity to work for another (outside) employer at a fixed wage (cf. MacLeod and Malcomson 1993, Malcomson 1997).

Rather than the exact role of the investor (either buyer or seller), the important assumption in our setup is that the investor has no outside opportunity. The investor therefore never has an incentive to breach the original contract.

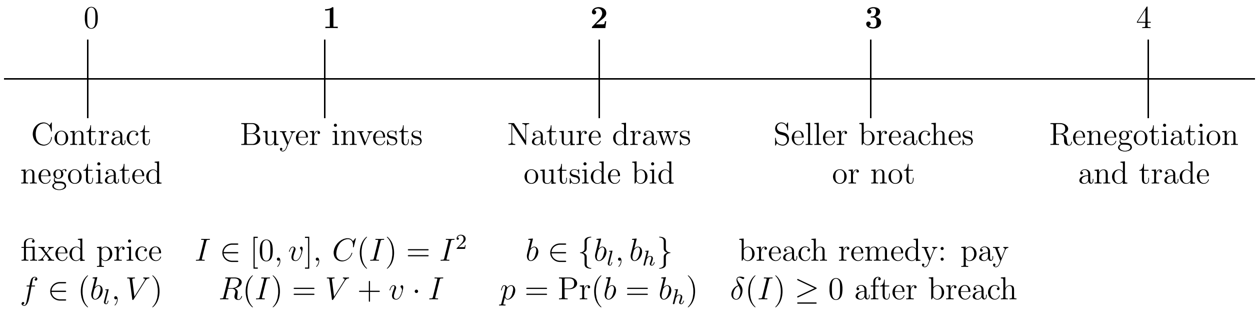


Figure 1: Timing of events in the standard holdup game

each unit of investment. The costs of investment equal $C(I) = I^2$.

Besides trading with the buyer, the seller may also trade his single unit outside the relationship at a fixed price. This outside bid b does not depend on the investment made by the buyer, reflecting the assumption that the investment is completely relation-specific. But, it is unknown at the time the buyer decides on her investment. In our simple setup the outside bid can either be low ($b = b_l$) or high ($b = b_h$; where $b_l < b_h$). The probability that the latter case applies equals $p \equiv \Pr(b = b_h)$. We assume that the outside bid is always competitive, such that b also represents the outside buyer's valuation of the seller's product. As noted, the buyer does not have an alternative opportunity. The timing of events is now as in Figure 1 (cf. Che and Chung 1999).

The standard holdup game starts with the buyer and the seller negotiating and signing a contract that governs their future relationship. This initial contract specifies that the seller receives a fixed payment f in case they trade according to the original contract. After the initial contract has been signed, the buyer chooses the level of relationship-specific investment. Then the uncertainty about the outside bid of the seller is resolved and this bid becomes known to both players. Knowing the price he can get from the alternative buyer, the seller decides whether to breach the original contract or not. In case of breach he has to pay damages of $\delta(I)$ to the buyer. This payment schedule may be agreed upon by both parties and incorporated into the initial contract (privately stipulated damages), or may be the default remedy that applies when no such schedule is stipulated in the original contract. In the last stage the buyer and the seller may renegotiate the outcome that pertains after the seller's breach decision. For instance, they may mutually agree on lowering the damage payment $\delta(I)$ in order to induce an efficient separation. After these renegotiations the final trade decision agreed upon determines the payoffs the players obtain.

In this paper we consider a condensed form of the standard holdup game. We omit stage 0 in which the buyer and the seller negotiate the initial pre-investment contract. We simply assume that such an initial contract specifying f already exists. Moreover, we do not allow for renegotiation after the seller's breach decision (cf. Shavell 1980). The three-stage game that results consists of the buyer's investment decision in stage 1, nature's outside bid draw in stage 2, and the seller's breach decision at stage 3. In Figure 1 these three stages are bold faced.

In the absence of renegotiation there is no holdup problem. Hence breach remedies are not needed to solve this non-existing problem. Still, the simplifying assumption that renegotiation is not possible is justified, because it does not affect the essential characteristics of the various breach remedies. Although the setup cannot provide us with direct evidence that breach remedies may indeed be used to solve an empirically observed holdup problem, it does provide us with an empirical test of whether the motives to overinvest under the different breach remedies (cf. the Introduction) indeed show up in the laboratory. Theoretically these motives to overinvest are present, irrespective of whether renegotiation is possible or not. We have chosen to study the case without renegotiation because that gives the simplest experimental design.

As already noted, we also do not explicitly consider the contract negotiation stage. This is in line with most of the theoretical literature, where it is typically assumed that the buyer and seller simply pick a fixed price f such as to maximize their joint surplus, yielding an *optimal* contract. The focus is then typically on the comparison of different damage rules under the assumption of such optimal contracts. Distributional considerations are simply assumed away in these papers by allowing the possibility of up-front transfers at the contracting stage. Here we make the (implicit) assumption that side-payments at the contracting stage are excluded.[7] As a result, distributional considerations follow directly from the final payoffs the buyer and seller obtain at the end of the game. The exclusion of side-payments is reflected in our assumption that $b_l < f < V$, and in the assumption that the largest possible investment level equals the buyers marginal increment in her valuation v (cf. Figure 1). Both the buyer and the seller then necessarily obtain a payoff from performing the contract that exceeds the payoff they at least obtain in the absence

[7]This assumption seems reasonable because we do not explicitly consider the contracting stage. By ruling out side-payments we also exclude so-called Cadillac contracts that specify a very large contracted amount of trade – that always exceeds the efficient amount – at a price at which the investor (here the buyer) always loses from trade. The investor will therefore always breach the contract. Large up-front payments in these type of contracts are needed to make up for the buyer's loss of sure breach, such that she willing to sign the initial Cadillac contract (cf. Edlin 1996).

of a contract; $V + v \cdot I - f - I^2 > 0$ for all $I \in [0, v]$ and $f > b_l$.[8]

The standard breach remedies studied in this paper now all imply a different damage schedule $\delta(I)$.

- Liquidated damages (LI): $\delta_{LI}(I) \equiv \delta_{LI} \geq 0$. A *fixed* amount, specified in the initial contract, has to be paid by the seller in case of a breach;

- Expectation damages (EX): $\delta_{EX}(I) \equiv V + v \cdot I - f$. The seller compensates the buyer such that the latter is equally well off as under contract performance. That is, the seller pays the buyer her *expectancy*, i.e. the expected gross gains from trade;

- Reliance damages (RE): $\delta_{RE}(I) = I^2$. The seller compensates the buyer such that she is equally well off as before the trade agreement had been signed. That is, the seller pays back the buyer's *investment costs*.

The focus in the theoretical literature is on whether the various breach remedies induce efficient breaches – that is, the buyer and the seller trade only when trade is efficient ex post, i.e. when $V + v \cdot I > b$ – and whether they encourage efficient levels of investment. The socially efficient level of investment I^* follows from maximizing expected net social surplus $S(I)$. Due to the assumption that $b_l < V$, trade between the buyer and the seller is always efficient when the outside bid turns out to be low, irrespective of the level of investment chosen. Given this assumption, I^* follows from:

$$\max_I \; S(I) = (1-p)(V + v \cdot I) + p \cdot max\{V + v \cdot I, b_h\} - I^2$$

The solution to the above maximization problem is given by $I^* = \frac{1}{2}v$ when $b_h \leq V + \frac{1}{4}(2-p)v^2$, and $I^* = \frac{1}{2}(1-p)v$ when $b_h \geq V + \frac{1}{4}(2-p)v^2$ (see Appendix A1). In the first case where b_h is rather low it holds that for the efficient level of investment trade between the buyer and the seller is always efficient, i.e. for both $b = b_l$ and $b = b_h$. In the second case where b_h is rather high it holds for I^* that separation, and thus breach, is efficient when $b = b_h$. Note that only in the latter case an investor who wants to choose the efficient level has to take into account that this investment pays off only when $b = b_l$. We take this latter case as being both the more plausible and the more interesting

[8] The assumption that $V + v \cdot I - f - I^2 > 0$ for all I is also made by Rogerson (1984, equation (25) on p. 48). In fact, one might argue that this constraint need not hold for all investment levels, but only for at least the equilibrium level of investment. When side payments are allowed for, the contract may in principle be such that $V + v \cdot I - f - I^2 < 0$ for all I. The assumption that the largest possible investment level equals the marginal increment rate also ensures that all investment levels do not lead to an immediate social loss on the investment; i.e. $V + v \cdot I - I^2 \geq V$ for all $I \in [0, v]$.

one. Assumption 1 below is therefore made throughout the paper, together with the assumptions reflected in Figure 1 above:

Assumption 1. $b_h > V + \frac{1}{4}(2-p)v^2$

Under assumption 1 it holds for the efficient level of investment that trade is efficient when $b = b_l$, and that separation is efficient in case $b = b_h$. We then have that $I^* = \frac{1}{2}(1-p)v$ and that $S(I^*) = (1-p)V + p \cdot b_h + \frac{1}{4}(1-p)^2 v^2$. Both I^* and $S(I^*)$ can be used as normative benchmarks to assess the performance of the various breach remedies.

2.2 Equilibrium breach behavior

In this and the following subsection we solve for the equilibria of the three stage game described in Figure 1 above. The equilibrium concept employed is subgame perfect Nash equilibrium. We first determine equilibrium breach behavior under each of the three breach remedies distinguished. In the next subsection we determine the corresponding equilibrium levels of investment.

The breach decision of the seller is a simple dichotomous choice. When he does not breach he obtains the fixed payment f. In case of breach he sells his single unit to the outside buyer at a price b, but also has to pay the original buyer $\delta(I)$ in damages. The seller thus chooses to breach iff $b \geq f + \delta(I)$.[9] [10] Following Shavell (1980), we let $B(\delta(I)) = \{b | b \geq f + \delta(I)\} \subseteq \{b_l, b_h\}$ denote the breach set, i.e. the set of outside bid values for which the seller prefers to breach rather than to perform the contract. Due to our assumption that $b_l < f < V$ we actually have $B(\delta(I)) \subseteq \{b_h\}$. Clearly, the breach set depends on the specification of $\delta(I)$.

By simply substituting the various formulae for $\delta(I)$ the breach set under the different breach remedies can be obtained. It immediately follows that for a *given* level of investment we have in our setup that

$$\emptyset = B_{LI}(\delta_{LI} > b_h - f) \subseteq B_{EX}(I) = B^*(I) \subseteq B_{RE}(I) \subseteq B_{LI}(\delta_{LI} < b_h - f) = \{b_h\}$$

Here $B_{LI}(\delta_{LI} > b_h - f)$ $[B_{LI}(\delta_{LI} < b_h - f)]$ is used to denote the breach set under

[9]In the spirit of Che and Chung (1999, pp. 91-92), $f + \delta(I)$ can be defined as the net trade price, or alternatively, as the true opportunity benefits of selling to the buyer. When the seller trades with the incumbent buyer rather than with the outside buyer, he receives a payment of f and saves on damage payments $\delta(I)$.

[10]As in Spier and Whinston (1995, Remark on page 185) we resolve any indifference in favor of selling to the outside buyer. This tie-breaking assumption is inessential for our results.

liquidated damages for the case where $\delta_{LI} > b_h - f$ [$\delta_{LI} < b_h - f$]. Note that the breach set under liquidated damages is independent of the level of investment chosen. $B^*(I)$ denotes the set of outside bid values for which breach is socially efficient. We thus in general observe that under high liquidated damages ($\delta_{LI} > b_h - f$) too few breaches occur from a social point of view. For instance, when $b = b_h$ and $b_h > V + v \cdot I$ the buyer and the seller inefficiently stick together; breach is then efficient. High liquidated damages $\delta_{LI} > b_h - f$ make breach prohibitively costly, such that they effectively correspond with the specific performance rule under which unilateral breach is not possible. Contrarily, under reliance damages and low liquidated damages ($\delta_{LI} < b_h - f$) the seller generally breaches (weakly) too often. The expectation damages rule is the only one that induces efficient separations for any given level of investment chosen.

An important observation is that $B_{EX}(I) = B^*(I) \subseteq B_{RE}(I)$ holds for a *given* level of investment. That is, only for a given level of investment the seller is more inclined to breach under reliance damages than under expectation damages. But, as the equilibrium investment level under reliance damages (weakly) exceeds the one under expectation damages (cf. Shavell, 1980), and the breach sets are weakly decreasing in I, it may occur that *in equilibrium* breach occurs less often under reliance damages. The analysis in the next subsection reveals that this may indeed occur in our setup.

2.3 Equilibrium investment behavior

Anticipating the breach decision of the seller, the buyer chooses the investment level that maximizes her expected payoffs. Table 1 summarizes the predicted investment levels under the various breach remedies. A formal derivation is relegated to Appendix A2.

The theoretical literature typically compares the different damage rules only under the assumption of *optimal* contracts. This implies that at the contracting stage the buyer and the seller always pick a value of f that maximizes their joint surplus. (This value need not be unique.) For instance, under both liquidated damages and reliance damages an optimal contract requires f (and δ_{LI}) to be such that always the first case in Table 1 applies. The Pareto rankings derived are then based on these optimal contracts. For these type of contracts, Table 1 confirms the Pareto ranking as derived by Shavell (1980, Proposition 5): RE≤EX<LI. In the sequel we do not a priori restrict our attention to optimal contracts, and also take non-optimal contracts into account.

From Table 1 it follows that, in the absence of renegotiation, breach remedies typically lead to overinvestment in relation-specific capital (cf. Shavell 1980). Only low liquidated damages ($\delta_{LI} < b_h - f$) induce efficient investments. In our simple setup the optimal

Table 1: Equilibrium predictions

Breach remedy	$\delta(I)$	Case	Equilibrium investment	Breach set	Breach set at I_{eq}
LI	δ_{LI}	$f + \delta_{LI} < b_h$	$\frac{1}{2}(1-p)v$	$\{b_h\}$	$\{b_h\}$
		$f + \delta_{LI} > b_h$	$\frac{1}{2}v$	$\emptyset$	$\emptyset$
EX	$V + v \cdot I - f$		$\frac{1}{2}v$	$b \geq V + v \cdot I$	$\{b_h\}$
RE	I^2	$(1-p)(V + \frac{1}{4}v^2 - f)$ $> V + v\sqrt{b_h - f} - b_h$	$\frac{1}{2}v$	$b \geq f + I^2$	$\{b_h\}$
		$(1-p)(V + \frac{1}{4}v^2 - f)$ $< V + v\sqrt{b_h - f} - b_h$	$\sqrt{b_h - f}$	$b \geq f + I^2$	$\emptyset$
Efficient			$\frac{1}{2}(1-p)v$	$b \geq V + v \cdot I$	$\{b_h\}$

Remark. For both LI and RE the first case applies for optimal contracts.

private liquidated damage schedule is not unique, as any $\delta_{LI} < b_h - f$ will work. This range contains both the case of *no-damages* and the case of *efficient expectation damages* as special cases. In the former the seller can simply breach without paying any penalties ($\delta_{LI} \equiv 0$) and the initial contract provides no enforcement at all. In the latter case the fixed amount δ_{LI} is set equal to the expectation damages *given* the efficient level of investment; i.e. $\delta_{LI} = \delta_{EX}(I^*) = V + \frac{1}{2}(1-p)v^2 - f$. Efficient expectation damages in general constitute the optimal private damage schedule in a variety of settings (cf. Spier and Whinston 1995).

In the other cases overinvestment is induced by two motives. The first one – the *full insurance* motive – follows from the fact that the buyer is completely protected against a potential breach. Under high liquidated damages ($\delta_{LI} > b_h - f$) this trivially follows from breach being prohibitively costly to the seller, such that it never occurs. In the case of EX this follows because the buyer is completely insured against potential separation. Irrespective of the breach decision of the seller, the buyer always obtains her expectancy. She therefore just sees reliance as an investment with a certain payoff. Under the RE breach remedy the buyer always recovers at least her investment costs. This effectively insures her against the risk that the investment may appear (socially) unprofitable after all. Recall that Assumption 1 was made such that an efficient investor has to take account of the fact that separation is efficient when $b = b_h$. From a social point of view the investment thus only pays off when $b = b_l$, and an efficient investor should takes this into account. This is reflected in the fact that the probability $(1-p)$ that $b = b_l$ appears in the expression for I^*: $I^* = \frac{1}{2}(1-p)v$. When the investor is fully insured her investment is independent of $(1-p)$ and equals $\frac{1}{2}v$. Full insurance thus constitutes over-insurance from a social point of view and leads to overinvestment.

The second motive to overinvest is only present under reliance damages. This motive will be referred to as the *breach prevention* motive. Because the buyer is worse off under breach compared with no-breach, she has an incentive to effectively reduce the probability of breach through higher investments (Chung 1995). Higher investments increase the damage payment $\delta_{RE}(I)$ the seller has to pay when he breaches, and therefore make breach less attractive and likely. This second motive to overinvest aggravates the overinvestment problem due to the full insurance motive. In Table 1 the breach prevention motive is only effective in the second case of RE that applies when p is relatively high. There the buyer overinvests even relative to the level $I = \frac{1}{2}v$ which she would have chosen in case only the full insurance motive were present.

In the experiment reported about in this paper we examine both the full insurance and the breach prevention motive to overinvest. As will be explained in the next section, this will be done in two complementary ways. For each of the breach remedies considered we will test the comparative statics predictions concerning the level of investment chosen with respect to p (cf. Table 1). Moreover, we will compare the observed investment levels with the efficient ones and also compare them across the three different breach remedies.

3 Experimental design and hypotheses

This section consists of three parts. The first subsection discusses the choice of parameter values used in the experiment. The next subsection summarizes the hypotheses obtained from the game-theoretical predictions and discusses some alternative hypotheses based on fairness and reciprocity considerations. The final subsection gives an overview of the experimental treatments and sessions.

3.1 Choice of parameters

To convert the model of Section 2 into an experiment we have to choose specific values for the basic parameters v, V, f, b_l, b_h, and p. Because we (also) want to test the comparative statics predictions with respect to p, two values for p have been chosen. These are referred to as p_1 and p_2. Our choices are led by the following considerations. First, recall that v by assumption equals both the largest possible level of investment and the marginal increment in valuation with each unit of investment. Because our main focus is on investment behavior, we allowed for enough variation in investment levels. We therefore chose v=100 and restricted the possible investment levels to multiples of 5. Effectively, 21 different investment levels were thus allowed for, viz. {0, 5,..., 100}.[11] Second, equilibrium predictions remain exactly the same when we add a positive constant K to the 'level' parameters V, f, b_l, b_h. Because we have $b_l < f < V < b_h$ by assumption, we normalized b_l to zero.[12] Third, the probabilities p_1 and p_2 were chosen such that they (i) equal a reasonable intuitive number, (ii) would not be considered negligible by the subjects, and (iii) such that the potential equilibrium investment levels $\frac{1}{2}v$, $\frac{1}{2}(1-p_1)v$ and $\frac{1}{2}(1-p_2)v$ were sufficiently far apart (but not too close to 0). We therefore chose $p_1 = \frac{1}{5}$ and $p_2 = \frac{3}{5}$.

Given the above choices, we determined V, f and b_h in the following way. First of all, we needed to have $b_h > V + 4500$, in order to satisfy Assumption 1. Second, we chose them such that under reliance damages the first case in Table 1 applies when $p = p_1$ and the second case when $p = p_2$. The equilibrium investment level is then indeed increasing in p under RE, yielding the comparative statics prediction we want to test. Third, for the case where $p = p_2$ we wanted $I_{RE} = \sqrt{b_h - f}$ to be both an integer and an intuitive number, such that it was easily seen which minimum level of investment would (theoretically) prevent breach. Because Assumption 1 requires $I_{RE} \geq 67.08$ in this case and the comparative statics prediction with respect to p does not hold for $I_{RE} = 70$, we chose $I_{RE} = 80$. Thus, $b_h = f + 6400$. Given this latter restriction, V and f were chosen such that interesting alternative hypotheses concerning the operation of the full insurance motive and the breach prevention motive could be formulated (see Subsection 3.2). This led to V=1000 and f=600.

Finally, for the case of liquidated damages also the value of the fixed amount δ_{LI} had to be determined. Here we chose δ_{LI}=3400. This value equals the mean of the efficient expectation damages values ($\delta_{LI} = \delta_{EX}(I^*)$) under $p = p_1$ (4400) and $p = p_2$ (2400) respectively. We chose the mean because equilibrium predictions for $\delta_{LI} = 2400$ and $\delta_{LI} = 4400$ (and thus also the mean) are exactly the same, and we did not want to change

[11] We did not allow for every integer value between 0 and 100 for the following two reasons. First, by restricting investment levels to multiples of five, different investment levels lead to non-trivial differences in final payoffs. This strenghtens subjects' (relative) incentives to choose a particular investment level. Second, the experiment was easier to explain to the subjects. In particular, we presented all 21 net payoff tables, one for each possible investment level, on one single sheet (cf. Appendix A.3). Clearly we could not have done so with 101 different investment levels.

[12] Under our assumption that $b_l < f < V < b_h$ actually a positive constant K' can be added to only f, V and b_h (leaving b_l intact) without affecting equilibrium predictions.

Table 2: Equilibrium predictions

Breach remedy	Specification	Investment level		Breach set	Breach set
		$p=\frac{1}{5}$	$p=\frac{3}{5}$		at I_{eq}
LI	$\delta_{LI}(I)=3400$	40	20	$\{b_h\}$	$\{b_h\}$
EX	$\delta_{EX}(I)=400+100\cdot I$	50	50	$\{b\geq 1000+100\cdot I\}$	$\{b_h\}$
RE	$\delta_{RE}(I)=I^2$	50	80/85	$\{b\geq 600+I^2\}$	$\{b_h\}$, $\emptyset$
Efficient		40	20	$\{b\geq 1000+100\cdot I\}$	$\{b_h\}$

Remark. v=100, V=1000, f=600, b_l=0, b_h=7000, $p_1=\frac{1}{5}$, $p_2=\frac{3}{5}$ and δ_{LI}=3400.

anything else besides the value of p when we considered the effect of changes p. Given all the above choices for the parameters, the net payoff tables that result under the three different breach remedies are given in Appendix A.3.[13]

3.2 Hypotheses

3.2.1 Hypotheses based on equilibrium predictions

Equilibrium predictions based on subgame perfection are summarized in Table 2.[14]

The above equilibrium predictions – in particular, the (comparative statics) predictions with respect to the equilibrium investment levels – lead to the following hypotheses:

1. Under LI the investment levels observed are *decreasing* in p;
2. Under EX the investment levels observed are *independent* of p;
3. Under RE the investment levels observed are *increasing* in p;
4. Under LI the investment levels observed equal the socially efficient levels;
5. Investment levels are significantly *higher* under EX and RE than under LI;

[13]These net payoff tables are shown in the same way as they were presented to the subjects. In this presentation player A corresponds to the buyer and player B to the seller. The columns under Blue correspond to the payoffs after $b=b_l=0$, the columns under Yellow to the net payoffs after $b=b_h=7000$. In the experiment we used T rather than I to denote the investment. Lastly, X corresponds to no-breach, and Y corresponds to breach.

[14]The equilibrium predictions presented in Table 1 of Section 2.3 refer to the model with continuous action spaces. Clearly, the number of possible investment levels is necessarily finite in an experiment. As a result, the equilibrium investment level may not always be unique. The discrete model used in our experiment allows for two subgame perfect equilibria when $p=\frac{3}{5}$ and the RE remedy applies: $I_{RE}=80$ and $I_{RE}=85$. The first equilibrium level requires that the seller chooses to breach after $b=b_h$ with a probability below $\frac{13}{80}$. In all other cases the equilibrium investment level is unique.

6. Investment levels are significantly *higher* under RE-High than under EX-High;
7. The seller's breach decision is always based on own payoff maximization;
8. The Pareto ranking of the three breach remedies equals LI>EX>RE.

In the sixth hypothesis RE-High and EX-High both refer to the case where p is high and equals $p = p_2 = \frac{3}{5}$.

The first three hypotheses are based on the within remedy comparative statics predictions. The observed comparative statics in p can be used to establish whether the two motives to overinvest are indeed operative in practice. When the observed investment level is decreasing in p neither the full insurance nor the breach prevention motive appears to be effective. This is the situation predicted for the liquidated damages measure. Under LI the buyer only obtains a return on her investment when $b = b_l$ and the seller does not breach. She thus realizes that her investment does not always pay off. When the probability p that this latter situation applies increases, she will invest less. When the observed investment level is independent of p, (only) the full insurance motive appears to be operative. This is the situation predicted for expectation damages. Under EX the buyer is completely insured against potential breach because she always obtains her expectancy, and her investment is therefore predicted to be independent of p. In case the observed investment level is increasing in p, both the full insurance and the breach prevention motive appear to exist. This situation theoretically only applies for the reliance damages case. Because the buyer always recovers at least her investment costs under RE, she is effectively fully insured against potential breach. But, she gets a positive payoff only when the seller does not breach. When breach is rather likely to occur (p is high such that RE-High applies), the buyer is more inclined to prevent breach by increasing the damage payment $\delta(I)$ through higher investments.

Hypotheses 4 through 6 are based on the point predictions for the level of investment and on a comparison of these predictions across the three different remedies. These hypotheses provide a complementary way to establish whether the two motives to overinvest are present.

The penultimate hypothesis simply conjectures that the seller will always make his breach decision solely on the basis of his own payoffs. The final hypothesis translates the equilibrium predictions concerning investment and breach behavior into a prediction about observed efficiency losses. These are predicted to be smallest (even absent) under LI and largest under RE. The prediction that EX performs *strictly* better on efficiency grounds than RE follows from our consideration of a non-optimal contract in the RE-High case. For optimal contracts EX only performs *weakly* better than RE: EX$\geq$RE.

3.2.2 Alternative hypotheses based on fairness and reciprocity

The equilibrium predictions of the previous subsection are all based on the assumption that both the buyer and the seller are solely motivated by own payoff maximization. In reality players may deviate from simple income maximization for various reasons. They may for instance be guided by altruism or spitefulness and care for the *absolute* payoffs the other player obtains. Alternatively, they may take the *relative* payoffs into account (see the inequality aversion models of Fehr and Schmidt 1999 and Bolton and Ockenfels 1999). If that is the case, we will say that they are guided by considerations of fairness. Yet another possibility is that a player is willing to sacrifice own payoffs in order to reward fair or punish unfair behavior of the other player. This type of behavior is usually referred to as reciprocity. In this subsection we discuss whether for our parameter choices the above three considerations of altruism (spitefulness), fairness and reciprocity lead to reasonable alternative hypotheses.

A first important observation is that for all standard breach remedies it holds that $\partial\delta(I)/\partial I \geq 0$. Higher investments typically lead to larger damage payments, which in turn hurt the seller by lowering his expected payoffs. A buyer that cares also for the payoffs of the seller may therefore want to invest less. Now, under LI the seller's payoff is actually independent of the buyer's investment; $\partial\delta(I)/\partial I = 0$. The buyer therefore cannot directly hurt the seller. Reciprocity considerations are thus likely to be absent, just like altruism considerations on the side of the buyer. From a fairness point of view the buyer could choose a suboptimal level of investment in order to balance expected payoffs more equally. This would be like burning money, and given our parameter choices not very likely.[15] A similar conclusion applies for the seller when choosing between no-breach and breach. By making a suboptimal choice he may lower the payoffs to the buyer, but only at considerable costs to himself. In sum, for the LI case we do not obtain interesting alternative predictions.

Under the other two remedies higher investments by the buyer do hurt the seller. But the important difference between EX and RE is that in the first case the seller does not have a possibility to punish the buyer for overinvesting; under EX the buyer's payoffs are independent of the seller's breach decision. Lacking a punishment device,

[15]Under LI expected equilibrium payoffs for the buyer (seller) equal 2600 (1200) when $p = \frac{1}{5}$, while in case of $p = \frac{3}{5}$ they equal 2600 (2400).

reciprocity considerations are necessarily absent under EX. This also holds for the seller's altruism. Deviations from equilibrium behavior can only be reasonably explained by the buyer's concern for altruism or fairness. By investing less than the predicted level of 50, she can make the seller better off. But, by investing less she herself becomes worse off. Two reasonable alternative hypotheses can now be formulated. Under the first one – the *fairness* hypothesis – the buyer invests less than the predicted level of 50, until (almost) the point of equal expected payoffs is reached.[16] Under the second one – the *efficiency constrained fairness* hypothesis – the buyer invest less until either the point of equal expected payoffs is reached, or investing less becomes socially inefficient. In the latter case efficiency acts as a constraint on fairness. These alternative hypotheses lead to different (comparative statics) predictions with respect to the investment level chosen, as Table 3 below illustrates.

Under the RE breach remedy the buyer's payoffs depend on the seller's breach decision. In particular, the seller now has the opportunity to punish the buyer for overinvesting by simply breaching the contract. Reciprocity considerations may therefore become important when this damage rule applies. A first alternative prediction here is based on the *negative reciprocity* hypothesis: in case the buyer chooses an investment weakly larger than 80 in order to prevent breach and the outside bid turns out to be high, the seller punishes her by choosing breach rather than the predicted no-breach. A second alternative prediction follows from the *anticipated negative reciprocity* hypothesis: the buyer anticipates that the seller will reciprocate negatively, and therefore chooses $I = 50$ when $p = \frac{3}{5}$ rather than the predicted $I = 80$ or $I = 85$. These alternative predictions are also summarized in Table 3. Clearly, also under RE buyer's fairness considerations might play a role, but given our parameter choices this is not very likely.[17] In particular, choosing $I = 50$ rather than e.g. $I = 85$ when $p = \frac{3}{5}$ would turn around the relative payoffs of the buyer and the seller.[18] It seems rather unlikely that the buyer invests less as to make herself worse off than the seller out of fairness considerations.

The alternative predictions for the EX rule point at the interesting possibility that the full insurance motive to overinvest may be less strong in practice than theory predicts. When fairness or efficiency considerations play a role, there will be less overinvestment and the investment level chosen may depend on the value of p. Even when the buyer is

[16]Under EX expected equilibrium payoffs for the buyer (seller) equal 2900 (800) when $p = \frac{1}{5}$, while in case of $p = \frac{3}{5}$ they equal 2900 (1200).

[17]Under RE expected equilibrium payoffs for the buyer (seller) equal 2320 (1380) when $p = \frac{1}{5}$, while in case of $p = \frac{3}{5}$ and $I_{RE} = 85$ they equal 1675 (600).

[18]When $p = \frac{3}{5}$ and the buyer chooses $I = 50$ under RE, expected payoffs for the buyer (seller) are 1160 (2940).

Table 3: Alternative predictions

Breach remedy	Alternative considerations	Investment level $p_1 = \frac{1}{5}$	Investment level $p_2 = \frac{3}{5}$	Breach set at I_{eq}
EX	fairness	$\underline{15}$	$\underline{30}$	$\{b_h\}$
EX	efficiency constrained fairness	$\underline{40}$	$\underline{30}$	$\{b_h\}$
RE	negative reciprocity	50	80/85	$\{b_h\}$, $\underline{\{b_h\}}$
RE	anticipated negative reciprocity	50	$\underline{50}$	$\{b_h\}$

Remark. Relevant alternative hypotheses are underlined.

completely insured against potential separation, she may take the social or seller's loss due to overinvestment into account. In case of RE negative reciprocity considerations may directly undermine the second motive for overinvestment. If the seller is willing to reciprocate negatively, trying to prevent breach by increasing the investment is ineffective. (Note that when the seller reciprocates negatively, the trading partners will inefficiently separate. The breach decision is then inefficient.) The buyer may anticipate this and therefore abstain from additional overinvestment. In sum, the breach prevention motive may be limited in practice due to anticipated negative reciprocity.

3.3 Treatments and sessions

The experiment is based on a 3x2 design. We consider three breach remedies and two values of p ($p = \frac{1}{5}$ and $p = \frac{3}{5}$). In each single session only one remedy was considered. All subjects within a session were confronted with both values of p. We ran two sessions per remedy, such that we had six sessions in total. These six sessions were held in February 2000. Overall 120 subjects participated in the experiment, with 20 participants per session. The subject pool consisted of the undergraduate student population of the University of Amsterdam. Most of them were students in economics (58 percent). They earned on average 44 Dutch guilders (approximately US$ 20) in about one and a half hour.

Each session contained 32 rounds. In each round the three-stage game of Figure 1 was played. The 32 rounds were divided into four blocks of eight rounds. In the first (rounds 1 through 8) and the third block (rounds 17 through 24) the value of p equalled $\frac{1}{5}$, in the other two blocks p was equal to $\frac{3}{5}$. Subjects' roles varied over the rounds. Within each block of eight rounds each subject was assigned the role of buyer exactly four times, and the role of seller also four times. In each single round subjects were anonymously paired. One of them was assigned the role of buyer, the other one the role of seller. Within each block of eight rounds subjects could meet each other only once. Subjects were explicitly informed about this aspect of the matching procedure. What they did not know was that within each session subjects were actually divided into two separate groups of 10 subjects. Matching of pairs only took place within this group. We did this in order to generate two independent aggregate observations per session.

In order to enhance comparability the empirical distribution of the outside bid b was exactly the same over the different groups and sessions. We used an empirical distribution that in the aggregate exactly matches the theoretical distribution, but contains sufficient variation over the individual subjects. Another common element to all sessions was that we provided subjects with an initial endowment. Each subject received 6000 experimental points at the start of the experiment. The conversion rate was 1 guilder for 1500 points, such that 1 US dollar corresponded with about 3300 points. We provided subjects with an initial endowment because we wanted buyers to have already some amount to spend when they had to take their first investment decision. Otherwise they may have felt somewhat reluctant to invest in order to avoid an immediate debt.

The main difference between sessions that considered different breach remedies was that the second row in the net payoff table (cf. Appendix A.3) – corresponding to breach of contract – differed across remedies. The second difference was that we added a second part to the experiment only in the sessions that considered reliance damages. This second part was announced *after* the 32 rounds were played. Thus, when playing the first 32 rounds, subjects did not know that a second part would follow. In that way the first part of the RE sessions remained completely comparable to the other sessions.

In the second part of the RE sessions subjects had to formulate complete strategies of how to play the three stage game for the case where $p = \frac{3}{5}$. Specifically, they were asked their investment choice were they assigned the role of buyer, and their responses to each possible combination of investment level and realized outside bid (21x2 combinations) they could be confronted with as a seller. We subsequently simulated the play of another block of eight rounds using the strategies formulated by the subjects. Subjects were paired, assigned roles, and paid in exactly the same way as in the first part. We organized this strategy part to obtain an additional test of the negative reciprocity hypothesis. This hypothesis predicts that sellers will still breach even when buyers choose $I = 85$ (or $I = 80$) to prevent this. It therefore can only be tested when we actually observe these investment levels. Because there are plausible reasons why one might expect these levels to be observed rather infrequently (cf. the anticipated negative reciprocity hypothesis), we added the strategy method part in the RE-High sessions. As it turned out such an expectation was somewhat pessimistic (see Section 4).

The equilibrium point predictions appearing in Table 2 only hold under the assumption of risk neutrality. When subjects are risk-averse, these point predictions may change.[19] It must be noted, though, that the comparative statics hypotheses continue to apply, even in the presence of risk averse subjects. This also holds for the predictions based on the comparison of investment levels across different breach remedies. Our main hypotheses thus do not crucially depend on the assumption of risk neutrality. We therefore chose not to use a lottery-ticket payoff procedure in order to induce risk-neutrality, also because previous experiments indicated that this procedure may be ineffective (cf. Cooper et al. 1990, Millner and Pratt 1991, Walker et al. 1990).

The experiment was computerized. Subjects started with on-screen instructions. All subjects had to answer some questions correctly before the experiment started. For example, they had to calculate the earnings of subjects for some hypothetical – not necessarily realistic – situations. Subjects also received a summary of the instructions on paper (see Appendix A.3). The instructions and the experiment were phrased as neutral as possible; words like opponent, game, player, buyer or seller were avoided. Subjects received on paper a table which 21 payoff matrices for all feasible investment levels. At the end of the experiment subjects filled out a short questionnaire and the earned experimental points were exchanged for money. Subjects were paid individually and discretely.

4 Experimental results

In this section we present the findings of our experiment in the form of 5 Results. The presentation is divided into three subsections which deal respectively with investment levels, breach decisions and efficiency.

4.1 Investment levels

The first result concerns the comparative statics regarding the relation between investment levels and the probability of a high outside bid.

Result 1. *Under LI investment levels decrease when p increases. Under EX investment levels remain virtually constant when p changes. Under RE investment levels*

[19]Under EX the buyer effectively faces no uncertainty at all, so for that case predictions remain exactly the same for any risk attitude of the buyer and the seller. This does not apply to the two other breach remedies. Also the theoretical Pareto-ranking of the different damage rules may change under alternative risk attitudes, because the various rules lead to different allocations of risk (cf. Shavell 1984, Mahoney 1995).

increase when p increases.

Evidence supporting Result 1 is provided in Table 4, which reports average investment levels by treatment.[20] For each subject we calculated the mean investment level for the low p-level and for the high p-level. For each breach remedy we can then test for the equality of these individual mean investment levels using Wilcoxon signrank tests. The test results are indicated by the subscripts a, b and c in Table 4. For LI and EX it is found that the mean investment levels decrease when the probability of a high outside bid increases from $\frac{1}{5}$ to $\frac{3}{5}$, while for RE an increase in the individual mean investment levels is observed.

Similar conclusions are obtained from the group level data. Recall that we divided the 20 subjects within a session into two groups that were independently matched. Members of one group were never matched with a member of the other group. We thus have for each remedy four independent observations at the aggregate group level. Under both LI and EX all groups invest less in the Low treatment than in the High treatment. For all four groups that were confronted with the RE breach remedy we observe the opposite. Investment levels are higher in the RE-High treatment.[21] With only four matched pairs of observations per remedy, the smallest possible significance level that a one-tailed signrank test can attain equals $(\frac{1}{2})^4 = \frac{1}{16}$ (6.25 percent). For each remedy we then obtain a significant difference at this level of 6.25 percent between the Low and the High treatments.

The observed comparative statics under LI and RE are in line with equilibrium predictions. Those for EX are not. Subgame perfection namely predicts that the investment level does *not* change when the level of p changes. The negative relation actually observed can be attributed to the role of efficiency constrained fairness considerations (see Table 3). But, although the fall of the mean investment level in the EX-treatment is statistically significant, it is fairly small in absolute magnitude. According to the efficiency constrained fairness explanation the investment level should fall by 25 percent, while the

[20] Using Mann-Whitney ranksum tests, we found no differences at the 10 percent level in investment levels between the two sessions that were held for each of the three breach remedy treatments. These tests are based on the mean investment levels per p-level of each subject. Therefore we report results based on pooled sessions. Furthermore, using Wilcoxon signrank tests we did not find any statistical differences at the 10 percent level between rounds 1-8 and rounds 17-24 (Low treatments), and between rounds 9-16 and rounds 25-32 (High treatments).

[21] Under LI the group investment levels equal (38.63; 40.31; 41.44; 40.88) when $p = \frac{1}{5}$, and (20.25; 20.44; 20.69; 24.44) in case $p = \frac{3}{5}$ with an equal position in the vector corresponding to the same group. Under EX they are equal to (49.88; 49.75; 50.31; 50.13) and (46.44; 48.38; 48.38; 46.75) respectively. Under RE group investment levels when $p = \frac{1}{5}$ equal (51.75; 50.75; 51.38; 53.44), in case $p = \frac{3}{5}$ they are equal to (77.94; 67.5; 73.38; 76.44).

Table 4: Mean investment levels by treatment

	Probability b_h			
Breach remedy	$p = \frac{1}{5}$		$p = \frac{3}{5}$	
LI	$^{de}40.31_a$	[40]	$^{fg}21.45_a$	[20]
EX	$^{d}50.02_b$	[50]	$^{fh}47.48_b$	[50]
RE	$^{e}51.83_c$	[50]	$^{gh}73.81_c$	[80/85]

Remarks. Subscripts indicate significant differences at the 1 percent level within a row according to a Wilcoxon signrank test. Superscripts indicate significant differences at the 1 percent level within a column according to a Mann-Whitney ranksum test. Investment levels predicted by subgame perfection are in square brackets.

results in Table 4 show a decrease of only 5 percent. Hence, we interpret the findings in Table 4 as supportive for the equilibrium predictions set out in Section 3.2.

The next result relates to the absolute investment levels and to a comparison across different breach remedies.

Result 2. *Under LI average investment levels are very close to the socially efficient levels. Investment levels are significantly higher under EX and RE than under LI, and significantly higher under RE-High than under EX-High.*

Evidence for Result 2 is again provided in Table 4. In 5 out of 6 cases the realized average investment level is within a 10 percent range of the investment level predicted by subgame perfection. The single exception occurs under reliance damages when the probability of a high outside bid equals $\frac{3}{5}$. Here the average investment level is lower than predicted by subgame perfectness, but it is above the level predicted by anticipated negative reciprocity ($I = 50$). Taken together these observations imply that under LI the average investment levels are almost equal to the socially efficient levels of 40 and 20, while under the other two damage schedules investment levels exceed the first best levels.

Results from Mann-Whitney ranksum tests confirm that investment levels are significantly higher under EX and RE than under LI, and also significantly higher under RE-High than under EX-High. Two types of ranksum tests are performed. The first one is based on data of individuals and uses the mean investment levels per p-level of each subject. The results of these subject level tests are reported in Table 4, see the superscripts d through h. The second ranksum test is based on group level data. Given the value of p we have for each treatment four independent observations at the aggregate group level. For both values of p, group investment levels under LI are always lower than those under EX, while the latter are always lower than those under RE.[22] Comparing any two remedies we therefore reject equality of distributions well below the 5 percent level; p=0.014 for a one tailed test and p=0.028 for a two-tailed test. As predicted, both expectation damages and reliance damages induce overinvestment, with the latter leading to the largest investment distortions.

Results 1 and 2 together provide strong evidence that both motives for overinvestment are at work. First, the operation of the full insurance motive is supported by the difference between the comparative statics results for EX and LI observed in Result 1, and by the across remedies comparison between EX (and RE) and LI reported in Result 2. Second, both the difference between the comparative statics results for RE and EX (Result 1) and the significant difference between observed investment levels under RE-High and EX-High (Result 2) point at the presence of the breach prevention motive. Our experimental results thus confirm the distortionary impact of breach remedies on the incentives to invest.

Although the breach prevention motive is clearly operative under reliance damages, the finding that in the RE-High treatment the mean investment level falls short of the equilibrium levels of 80 and 85 indicates that it causes less overinvestment than predicted. This lower level may reflect that investment decisions in this treatment are also based on anticipated negative reciprocity. Our next result makes this explicit.

Result 3. *Under the RE-High treatment the distribution of investment levels is bimodal with peaks at the levels predicted by subgame perfectness (80/85) and by anticipated negative reciprocity (50).*

Table 4 only presents mean investment levels. More detailed information concerning separate investment decisions is given in Figure 2 which depicts the distributions of investment levels by treatment. From these distributions it is apparent that the mean levels in Table 4 disguise quite some dispersion. In the LI treatments actual investment levels cluster around the predicted levels of 40 (for LI-Low) and 20 (for LI-High), with values in a -10 to +10 neighborhood occurring frequently. In the LI-Low treatment the mode is 50 rather than 40, but this is compensated for by choices of 30. In the EX treatments a vast majority of actual investment decisions equals the predicted value of 50. In the EX-High treatment it occurs somewhat more often that subjects choose investment levels a bit below 50. The RE-Low treatment shows the least variation in investment levels, with

[22] See the previous footnote.

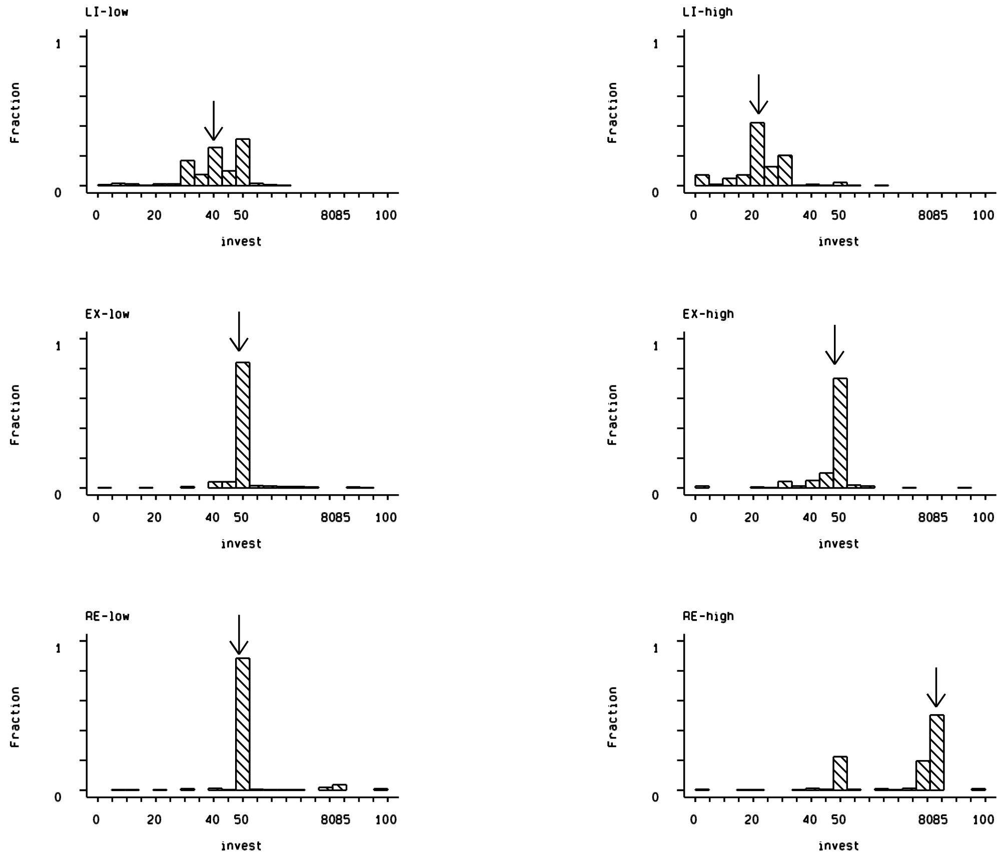


Figure 2: Distributions of investment levels by treatment (the arrows point at the equilibrium predictions)

almost 90 percent of the investment decisions equal to 50.[23] RE-High is the only treatment with a clear bi-modal distribution of investment levels. Besides at the investment levels of 85 and 80 predicted by subgame perfectness, there is a second peak at 50.[24] This second peak coincides with the investment level predicted under investors' anticipation of negative reciprocity.

[23]There is a small other peak in the distribution near 80-85 (5.6 percent). In the RE-Low treatment there is no rationale for these particular investment levels. Probably it occurs sometimes that subjects think that they are playing the RE-High instead of the RE-Low treatment (although we explicitly tried to avoid this by announcing the change in p-regime also verbally, in addition to the announcement on the computer screen).

[24]The frequencies belonging to these investment levels are respectively 50 percent, 20 percent and 22.5 percent. Similar frequencies are observed in the strategy part that we conducted only for the RE-High treatment. There 55 percent of the 40 subjects chose $I = 85$ in their role of buyer, 15 percent chose $I = 80$ and 27.5 percent of the subjects chose $I = 50$. Only one subject (2.5 percent) chose a different investment level, viz. $I = 0$.

Table 5: Breach decisions by breach remedy and outside bid

Breach remedy	Action	Outside bid b $b < f + \delta(I)$	$b = f + \delta(I)$	$b > f + \delta(I)$
LI	No breach	384	0	**2** (2)
	Breach	**0**	0	254 (1)
EX	No breach	386	5	**4** (4)
	Breach	**1** (1)	1	247
RE	No breach	476	16	**4** (3)
	Breach	**7** (7)	20 (20)	117 (5)

Remark. Non-equilibrium choices are bold faced. Numbers in parentheses refer to inefficient decisions.

4.2 Breach decisions

The return the buyer obtains on her investment may depend on the seller's breach decision. We next present our main result with respect to the breach decisions actually observed.

Result 4. *Sellers' breach decisions are almost always in line with own payoff maximization.*

Table 5 tabulates for each breach remedy the breach decisions against an index indicating whether the seller gains from breaching ($b > f + \delta(I)$) or loses from doing so ($b < f + \delta(I)$). Also a third case is distinguished in which the seller's payoff is independent of his breach decision ($b = f + \delta(I)$). Clearly, actual breach decisions almost always coincide with equilibrium predictions. Of the overall 1920 breach decisions less than 1 percent (18 decisions) contradicts with own payoff maximization. Moreover, the breach decision is typically also socially efficient. Only in slightly more than 2 percent of the cases inefficient trades with either the original or the outside buyer occur, see the numbers within parentheses in Table 5. Inefficient breach decisions mostly occur under reliance damages. There sellers in the aggregate indeed show a tendency of breaching too often from a social point of view. Of the 144 breaches observed under RE about 22 percent are inefficient.

The fact that sellers typically base their breach decision on own payoff maximization also implies that in the RE treatment sellers typically do not breach when the buyer invested 85 or more and the outside bid turns out to be high. Although one might expect that the seller reciprocates negatively when the buyer overinvests to prevent breaching, this occurs in only 4 out of 95 cases. (In 92 of these cases the buyer chooses $I = 85$.) Apparently the seller is not offended enough by the overinvestment or finds a punishment in the form of breaching too costly. It is instructive to compare these results with those where the investment equals 80 and the outside bid is high. In that case the seller's payoff is independent of the breach decision because $b = f + \delta_{RE}(80)$. In 16 out of 36 cases the seller then chooses not to breach, which suggests that these sellers don't feel offended by the buyer's overinvestment decision. Otherwise they could have punished the buyer at no cost. In the other 20 cases the seller uses the opportunity to costlessly punish the buyer. But of course, the 16-20 division might as well reflect that the sellers randomize over two equivalent alternatives.[25] In any case, raising the investment level from 80 to 85 clearly prevents breaching under reliance damages. Sellers are typically not willing to punish the buyer when it is costly to do so.

Additional information information about subjects' responses to different investment levels can be obtained from the strategy part that we conducted for the RE-High treatment. Figure 3 plots the frequencies of breach decisions for both low and high outside bids against the possible investment levels. The results obtained from the strategy part are completely in line with the results presented above. When it is in the seller's best interest to breach then he does so, otherwise he does not. In case the seller's payoffs are independent of the breach decision ($b = f + \delta_{RE}(80)$), breaching and non-breaching are equally likely.

The above results with respect to sellers' observed breach behavior suggest that preventing breach almost surely through a choice of $I = 85$ is beneficial to the buyer, compared with investing either $I = 80$ or $I = 50$. Indeed, for the RE-High treatment buyers' expected payoffs given sellers' actually observed breach decisions (cf. Table 5) equal 1624 when the investment equals 85, 1309 for an investment of 80, and 1188 when the investment equals 50. (Equilibrium predictions for the expected payoffs of the buyer equal 1675 when $I = 85$, 2000 when $I = 80$ and the seller never breaches, and 1160 when $I = 50$.) Similar results are obtained when we look at the breach frequencies in the strategy part of the RE-High treatment (cf. Figure 3). Given these frequencies the optimal investment level equals $I = 85$, which yields the buyer 1575 in expected payoffs. Here $I = 80$ and $I = 50$ are also second and third best, with expected payoffs of 1430 and 1305 respectively.

[25] Of the 9 subjects that had to take a breach decision more than once after $I = 80$ and the outside bid turned out to be high, six subjects always took the same decision (with 5 out of 6 always choosing to breach) while three subjects made different decisions at different occasions. From these obervations no clear picture emerges whether sellers on average purposely choose one of the two (own) payoff equivalent alternatives, or simply randomize.

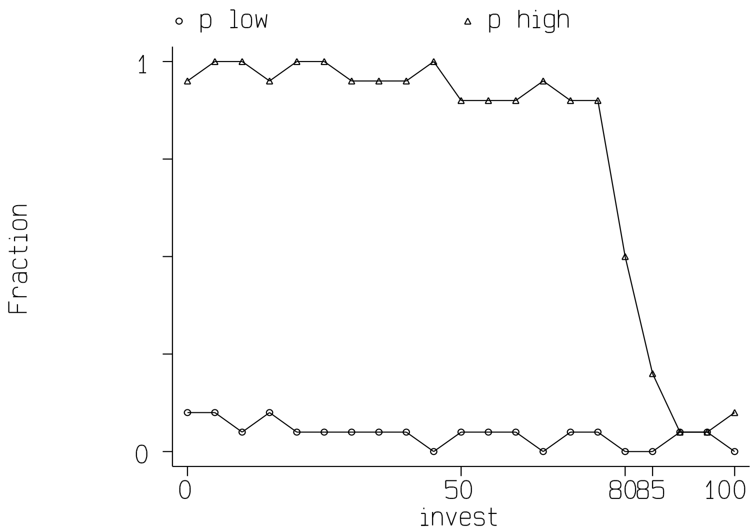


Figure 3: Breach frequencies in the strategy part of the RE-High treatment

Overall we conclude that, given the sellers' breach behavior, it is not in a buyer's best interest to invest 50. Buyers who nevertheless choose this investment level apparently overestimate the probability that the seller will punish them for overinvesting. In other words, some buyers incorrectly anticipate negative reciprocity.[26]

Anticipated negative reciprocity provides one explanation for the deviations from equilibrium investment levels in the RE-High treatment, and the data offer partial support for this explanation. Another explanation for such deviations is that subjects make errors in their comparison of payoffs. McKelvey and Palfrey's (1995, 1998) quantal response model provides a statistical version of subgame perfect equilibrium in extensive form games that takes account of such errors. We estimated this model for the data of the RE-High treatment using a logit specification. The results are summarized in Figure 4 (details of the estimation are given in Appendix A.4).

The dashed line in the top panel of Figure 4 gives, for each level of investment, the estimated probability that the seller breaches when the outside bid is high. The dots in the figure give the realized frequencies with the corresponding number of observations. The line tracks the dots in this figure very well. The middle panel represents the same plot for the case where the outside bid is low. Notice that the vertical axis in this panel ranges from 0 to 0.065. Only for investment levels below 20 it is predicted that sellers will sometimes breach. (At low investment levels breaching is less costly than at high investment levels.) In practice this did not happen, however. In only 2 out of 128 breach

[26]Recall from Section 3.2 that a choice of $I = 50$ rather than $I = 85$ cannot convincingly be explained by (efficiency constrained) fairness considerations.

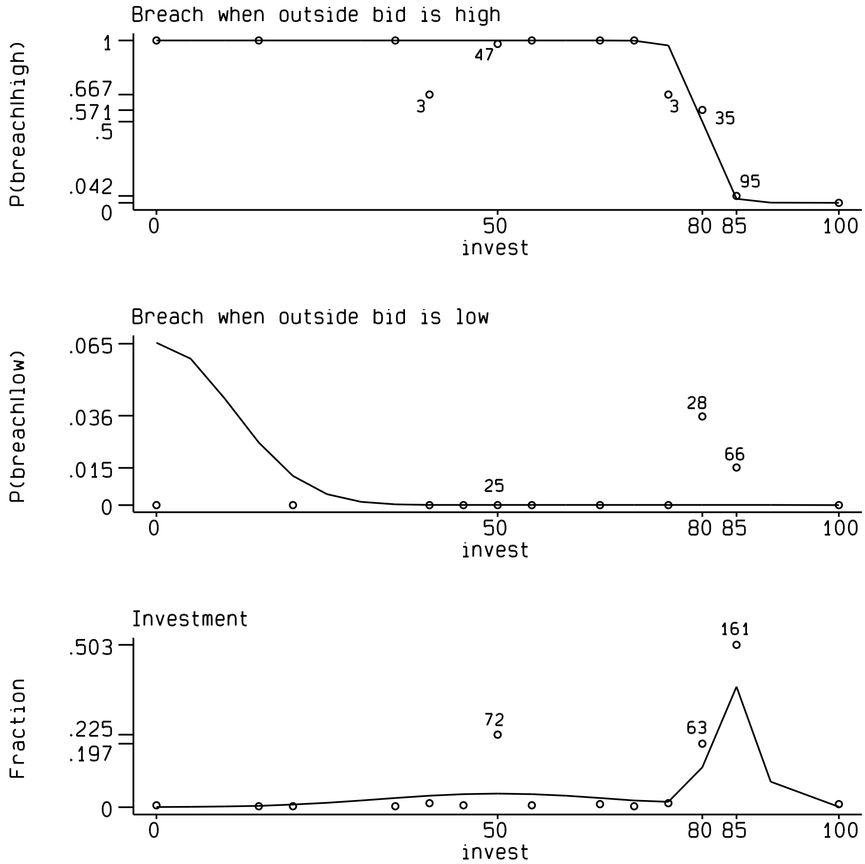


Figure 4: Results from Quantal Response Model of RE-High treatment

decisions the seller actually breached, and these two cases occurred for the relatively high investment levels of 80 and 85. A common sense explanation for these two outliers is that the two different sellers registered the actual value of the outside bid incorrectly.

The bottom panel of Figure 4 gives the realized and predicted investment frequencies in the RE-High treatment. Clearly, the quantal response model has difficulties tracking the realized frequency belonging to the investment level of 50. From this we conclude that also a statistical version of the equilibrium predictions that allows for errors in decision making does not do a good job in explaining observed investment levels in the RE-High treatment.

4.3 Efficiency

Our final result relates to the realized efficiency of the different breach remedies.

Result 5. *The ranking of the remedies in terms of attained efficiency levels is:*

LI>EX>RE. Efficiency is higher when the probability of a high outside bid is low.

This result is supported by the findings reported in Table 6. Column (1) gives the expected value of the joint payoffs of the seller and the buyer when investment levels and breach decisions are equal to the subgame perfect predictions. The predicted expected joint payoffs under LI equal the largest possible expected payoffs $S(I^*)$, because equilibrium behavior under LI corresponds with socially efficient behavior. The second column contains the average value of the actual joint payoffs. By subtracting the entries in column (2) from $S(I^*)$ the overall observed inefficiencies are obtained. Columns (3) to (5) disentangle this overall inefficiency into three different sources. The first type of inefficiency is due to inefficient investments. This inefficiency is obtained from calculating $S(I^*) - S(I_{chosen})$ for each interaction and subsequently averaging out over all 320 observations within a treatment. In calculating the investment inefficiencies it is thus assumed that breach behavior is always efficient. Column (4) depicts the average loss in joint payoffs that can be attributed to inefficient breach decisions. For each interaction the difference in joint payoffs under the efficient and the actual breach decision is calculated, taking the actual investment level chosen as given. The reported breach inefficiencies reflect the average difference within a treatment. The third source of inefficiency is due to the fact that the empirical distribution of b *conditional on the investment level chosen* may differ (slightly) from the theoretical distribution.[27] The resulting (in)efficiency cannot be attributed to the decisions of individual subjects and is therefore referred to as being residual. The last two columns present fractions between predicted expected joint payoffs, actual joint payoffs and maximal expected joint payoffs $S(I^*)$.

In line with the theoretical predictions LI performs best. Ranksum tests both at the individual level (1 percent) and at the group level (below 5 percent) reveal that only the realized payoffs under EX-Low and RE-Low are not significantly different from each other. In all other cases the amounts in column (2) belonging to the same value of p (either Low or High) differ significantly across remedies. All these (in)differences are as predicted.

Although the average investment levels in the LI treatments are close to the efficient investment levels, average realized payoffs are below the predicted expected payoffs. This is caused by the fact that each deviation from the efficient investment level results in

[27]Our experimental procedures ensured that the realized frequencies of high outside bids exactly equalled 20 percent and 60 percent in the Low and High treatments respectively. That is, we controlled the unconditional empirical distribution of b. We did not control the empirical distribution of b conditional on the value of I, such that also this conditional distribution exactly equalled the theoretical distribution. Clearly, this would also have been impossible because some investment levels (viz. $I = 90$ or $I = 95$) only occured twice.

Table 6: Joint payoffs

	Predicted expected (1)	Average realized (2)	Investment inefficiency (3)	Breach inefficiency (4)	Residual inefficiency (5)	(1)/S(I*)	(2)/S(I*)
LI-Low	**3800**	3711	112	9	-32	1	0.98
LI-High	**5800**	4891	897	11	1	1	0.84
EX-Low	3700	3650_a	138	22	-10	0.97	0.96
EX-High	4100	4144	1616	9	31	0.71	0.71
RE-Low	3700	3586_a	210	22	-18	0.97	0.94
RE-High	2275	2616	2952	236	-4	0.39	0.45

Remarks. $S(I^*)$ bold faced. It holds that $S(I^*) - (2) = (3) + (4) + (5)$. Subscript a indicates that amounts in the second column are *not* significantly different.

an efficiency loss. While over- and underinvestments cancel out and make the average investment level close to socially optimal (Result 1), they both lead to reduced payoffs. Average realized payoffs in the EX treatments are close to the predicted levels, and in case of EX-High they even exceed the predicted level. This results from the fact that deviations from the predicted investment level are typically in the direction of the efficient level. A similar picture emerges for the RE treatments.

Breach inefficiencies are typically negligible, except in the RE-High treatment. Negative reciprocity provides an explanation for the larger inefficiencies observed in that treatment. Punishing overinvestment ($I \geq 80$) through breaching is namely not only costly for the seller, but also socially inefficient (cf. Section 2). The fractions reported in the last column reveal that efficiency in the Low treatments is higher than in the High treatments. Comparing these fractions with those in the penultimate column it is observed that for EX and RE this is in line with theoretical predictions, while for LI it is not.

5 Concluding discussion

Breach remedies serve an important role in protecting relationship-specific investments. The theoretical literature predicts that in various situations some commonly used types of breach remedies protect too well, in the sense that they induce overinvestment. The two driving forces behind this result are the complete insurance against potential separation that breach remedies may provide (full insurance motive), and the potential possibility to prevent breach by strategically increasing the damage payment due through the investment made (breach prevention motive). Whether these two motives are of any practical significance and indeed induce overinvestment is an empirical issue. This paper reports about an experiment that addresses these issues.

The experiment covers three different breach remedies, viz. liquidated damages, expectation damages and reliance damages. For each remedy, two treatments are distinguished: one in which the probability of a high outside bid is low and one in which this probability is high. The resulting 3x2 design allows us to base conclusions concerning the relevance of the two overinvestment motives on a comparison of the comparative statics results across breach remedies, as well as on a comparison of investment levels across remedies.

The results provide convincing evidence that both overinvestment motives play a role. But the extent to which the two motives affect the investment level is somewhat less severe than subgame perfection predicts. The effect of the full insurance motive is slightly dampened by considerations of fairness, while the working of the breach prevention motive is flattened as some investors anticipate that a high level of investment may trigger negative reciprocity. Although there indeed seems some reason to anticipate negative reciprocity, it turns out that in only a very few cases the non-investing party is prepared to bear the costs of punishing the investor for her overinvestment.

The finding that overinvestment occurs when damages are determined on the basis of expectation damages or reliance damages calls for some caution with the use of these types of damages. Especially in circumstances where a favorable outside opportunity is rather likely, expectation damages and reliance damages can substantially reduce efficiency. Appropriately chosen liquidated damages are likely to perform much better in that case. Alternatively, the expectation damages and reliance damages rules could be modified by imposing some upper bound on recoverable damages. Ideally this upper bound would be based on the efficient level of investment. For instance, the optimal *bounded expectation damages* rule equals the standard expectation damages rule for investment levels up to the efficient level, and specifies a fixed amount equal to efficient expectation damages for investment levels that are higher.[28] By returning the investor's expectancy only up to the efficient investment level, bounded expectation damages protect only "reasonable" or "foreseeable" amounts of reliance expenditures (Cf. Cooter and Ulen, 1997, p. 179). In a similar way reliance damages could be limited to the efficient reliance costs. In case expectation damages and reliance damages are bounded investment levels will theoretically equal the efficient levels (cf. Leitzel 1989, Proposition 1).

One clear problem that arises in practice is the determination of the ex ante efficient

[28]Formally, the optimal bounded expectation damages rule is given by $\delta_{BEX}(I) = \min\{\delta_{EX}(I), \delta_{EX}(I^*)\}$.

level of investment. This efficient level will in general depend on the probability distribution of the ex post contingencies. These probabilities might be very hard to come by, making a precise calculation of the efficient investment level cumbersome. When it is impossible to accurately determine the ex ante efficient level of reliance, (upper bounds on) the damage schedule could alternatively be based on the largest possible efficient level. For instance, in the setup of the model presented in Section 2, the efficient investment level never exceeds $\frac{1}{2}v$. Using an upper bound of $\delta_{RE}(\frac{1}{2}v)$ on the reliance damages measure would then already solve that part of the overinvestment problem that is due to the breach prevention motive. But the full insurance motive would not disappear in this case.

The overinvestment results that are the focus of the present experiment only hold for certain types of investments. For instance, when cooperative rather than selfish investments are considered generally underinvestment results are derived (Che and Chung 1999). In that case also opposite conclusions are obtained about the Pareto ranking of the various breach remedies. In our setup the case of cooperative investments corresponds to one in which the buyer's investment does not affect her valuation of the seller's product, but rather lowers the seller's production costs. In that case the investment does not directly benefit the buyer, but only directly benefits her trading partner. It might be interesting to test experimentally whether indeed underinvestment is observed in such a setting.

Another, related, avenue for future research would be to consider the case where the investment is not completely relation-specific, but also has some general component. For instance, the buyer's investment does not only affect her valuation of the seller's product, but also influences the value of the seller's outside bid. Especially in the context of firm-related training that has a general component, i.e. the skills obtained through training are also of some value outside the particular labor relationship, this is an interesting situation to consider. It seems rather likely that also then underinvestment will be observed.

Another driving force behind the overinvestment result obtained in our setup is that the contracted amount (which equals one) exceeds the expected efficient amount of trade given the efficient level of investment $(1 - p)$. When contract quantity can be treated as a continuous variable, overinvestment can be avoided by contracting upon the ex ante efficient amount of trade. Ex post, after the uncertainty has been resolved, the parties then renegotiate to the ex post efficient quantity. Note that to solve overinvestment in this way, ex post renegotiation should be allowed for. Actually, the combination of an initial contract specifying an intermediate quantity together with the possibility of ex post renegotiation is used by Edlin and Reichelstein (1996) to provide a solution for the holdup underinvestment problem. The main idea is to set the contracted amount such that the ex post efficient amount may be either lower or higher. In case the first contingency applies the buyer's investment is over-compensated due to the breach remedy in place; i.e. the investor obtains a "breach subsidy" on her investment.[29] In the latter contingency the investment is under-compensated and the holdup underinvestment problem arises. The investor then faces a "holdup tax" on her investment. By balancing the breach subsidy against the holdup tax through an appropriate choice of contract quantity, efficient investment incentives can be provided.[30] It seems worthwhile to study also these types of contracts that allow for an intermediate quantity in the lab, in order to establish whether they indeed induce efficient investments in practice.

[29] The actual size of the breach subsidy depends on the breach remedy in place. Edlin and Reichelstein (1996) only consider the case of specific performance and expectation damages.

[30] When the contracted amount always weakly exceeds the ex post efficient amount, as is the case in our setup, the investor only obtains a breach subsidy. She thus has an incentive to overinvest, because "...there is no holdup tax to balance against the breach subsidy" (cf. Edlin and Reichelstein, 1996, p. 494).

A Appendices

A.1 Derivation of the efficient level of investment

We have to solve the following maximization problem:

$$\max_{I} \; S(I) = (1-p)(V + v \cdot I) + p \cdot max\{V + v \cdot I, b_h\} - I^2$$

First observe that an investment level of $I = (b_h - V)/v$, such that $V + v \cdot I = b_h$ and the max term is at its kink, can never be optimal. For this investment level the right derivative of $S(I)$ equals $v - 2I$, while the left derivative equals $(1-p)v - 2I$. The right derivative is thus larger than the left derivative for this investment level, which immediately yields that $I = (b_h - V)/v$ cannot be the optimum.

Therefore, only two cases have to be considered. First, assume that $b_h > V + v \cdot I$ for the efficient level of investment. It immediately follows that $I = \frac{1}{2}(1-p)v$ in that case. For the assumption to hold it is required that $b_h > V + \frac{1}{2}(1-p)v^2$. Second, suppose $b_h < V + v \cdot I$ for the socially optimal level of investment. Then $I = \frac{1}{2}v$ and it is required that $b_h < V + \frac{1}{2}v^2$. Now when $V + \frac{1}{2}(1-p)v^2 < b_h < V + \frac{1}{2}v^2$ both candidates for the optimum exist. Expected net social surplus when $I = \frac{1}{2}(1-p)v$ equals $(1-p)V + p \cdot b_h + \frac{1}{4}(1-p)^2v^2$, while in case $I = \frac{1}{2}v$ it equals $V + \frac{1}{4}v^2$. Comparing these two expected payoffs it immediately follows that when $b_h > V + \frac{1}{4}(2-p)v^2$ the former is strictly larger, and when $b_h < V + \frac{1}{4}(2-p)v^2$ the latter is strictly larger. The result immediately follows. QED.

A.2 Derivation of the equilibrium levels of investment

We have to solve the following maximization problem:

$$\max_{I} \; \pi(I) = (1-p)(V + v \cdot I - f) + p \cdot \delta(I) \cdot 1_{\{I \in B(I)\}} + p \cdot (V + v \cdot I - f) \cdot (1 - 1_{\{I \in B(I)\}}) - I^2$$

Here $1_{\{I \in B(I)\}}$is used to denote the indicator function which is equal to 1 iff $b_h \in B(I)$ for the value of I chosen, and 0 otherwise. The function simply indicates whether breach occurs when $b = b_h$ for the particular I chosen. We next consider the three different breach remedies separately.

- (LI). When $\delta_{LI} < b_h - f$ the seller breaches (only) when $b = b_h$. The buyer thus obtains $(1-p)(V + v \cdot I - f) + p \cdot \delta_{LI} - I^2$. We directly get $I_{LI} = \frac{1}{2}(1-p)v$. In case $\delta_{LI} > b_h - f$ the seller never breaches. Thus $I_{LI} = \frac{1}{2}v$.

- (EX). Here we have $\delta_{EX}(I) = V + v \cdot I - f$, such that $\pi(I) = V + v \cdot I - f - I^2$. We immediately get $I_{EX} = \frac{1}{2}v$.

- (RE). There are two relevant ranges for I to consider. In the range where $I \leq \sqrt{b_h - f}$ the seller breaches the contract (only) when $b = b_h$. The buyer's expected payoff is then $(1-p)(V + v \cdot I - f - I^2)$. In case $I > \sqrt{b_h - f}$ the seller never breaches and the buyer obtains $V + v \cdot I - f - I^2$. Given these two ranges, in principle two relevant different situations have to be distinguished (ignoring knife-edge cases): $\sqrt{b_h - f} < \frac{1}{2}v$ and $\frac{1}{2}v < \sqrt{b_h - f}$. (Note that $\frac{1}{2}v$ equals the investment level the buyer would have chosen in the absence of possible breach of contract.) Now, our assumption that $f < V$ together with Assumption 1 entails that $b_h - f \geq \frac{1}{4}v^2$, such that the first situation cannot occur. Only the second situation of $\frac{1}{2}v < \sqrt{b_h - f}$ remains. Here the seller would surely breach if the buyer chose investment level $I = \frac{1}{2}v$ and b turned out to be high ($b = b_h$). The buyer may want to forestall such a breach by choosing $I = \sqrt{b_h - f}$ instead. The equilibrium level of investment immediately follows from comparing the expected payoffs under these two levels of investment: $\pi(\frac{1}{2}v) = (1-p)(V + \frac{1}{4}v^2 - f)$ and $\pi(\sqrt{b_h - f}) = V + v\sqrt{b_h - f} - b_h$. QED.

A.3 Summary of the instructions

The experiment started with on line computer instructions. In the first part of the instructions the rules of the experimental game are explained to the subjects. Subsequently, the subjects are asked to answer three questions. These questions were used to establish whether the rules of the game were understood. Subjects could only proceed after they had filled in the correct answers. In the third and final part of the on line instructions the subjects are made familiar with the windows that they would see on their computer screen during the experiment. Besides the on line instructions a summary sheet of these instructions was handed out to the subjects. Below a direct translation of this summary sheet is given to provide some information on exactly how the experiment was framed to the subjects.

Summary of the instructions

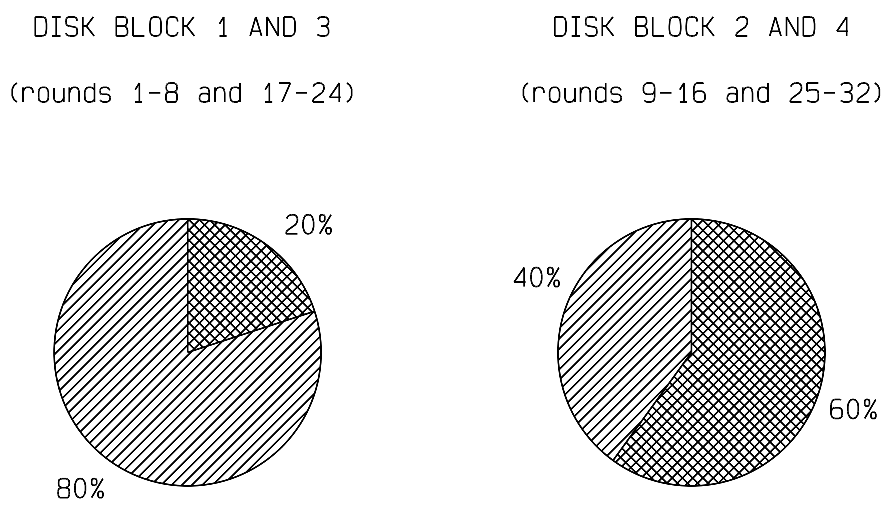
This experiment consists of 32 rounds. At the beginning of each round the participants are paired in couples. The division into couples is chosen such that it is impossible that you are paired with the same other participant in two consecutive periods. It also holds that within each of the four consecutive blocks of eight rounds viz. rounds 1 up to 8, rounds 9 up to 16, rounds 17 up to 24 and rounds 25 up to 32 you will never be paired with the same other participant in more than one round. Whenever you meet the same participant again is unpredictable. With whom you are paired within a particular round is always kept secret from you.

One of the participants in a pair has role A, the other has role B. Within a round you will keep the same role. What exactly your role is, you will hear at the beginning of each round. Over the rounds your role varies. This variation is chosen such that you will be assigned the role of A in exactly half of the total number of rounds, and the role of B in the other half.

Each of the 32 rounds consists of 3 stages. In stage 1 the participant with role A takes a decision. In stage 3 the participant with role B makes a decision. In stage 2 a disk is turned around by the computer, in order to determine the color that applies in this round. During the three stages of one round you remain to be coupled with the same other participant. The three stages take the following form:

1. Participant A within a couple chooses the amount T. This amount has to be between 0 and 100 and, moreover, has to be a multiple of 5. After A has made his/her decision, B is informed about this choice. The choice of A for a particular amount T influences the final payoffs of both participants within a couple. Exactly how this dependency is, will be explained below when we discuss stage 3.

2. In order to determine the color that applies in this round, a disk is turned around by the computer. When the disk has come to a stop, it will point at a particular color: blue or yellow. The color indicated by the disk is communicated to both participants within a pair. This color co-determines the number of points the participants receive at the end of the round. The probability that the disk will point at yellow depends on the number of the round. The total number of 32 rounds is divided into four blocks of 8. In the rounds 1 up to 8 and the rounds 17 up to 24 the probability of obtaining yellow is 20%. In the rounds 9 up to 16 and 25 up to 32 the probability of obtaining yellow is 60%. The two disks are reproduced below.



1. Participant B chooses between two options: X and Y. After participant B has made his/her choice, A is informed about this choice. The rounds then comes to an end for both participants within a couple.

The general table appearing at the top of the additional sheet handed out reflects the number of points both players have earned in the particular round. The number of points received depends on A's choice of amount T in stage 1, the color indicated by the disk in stage 2 (blue or yellow), and B's choice in stage 3 (X or Y). In this general table you have to fill in yourself the particular value of T chosen by A in order to obtain the appropriate number of points. You can also make direct use of the specific table that applies for the particular value of T chosen by A. For each possible choice of T {0, 5,..., 100} the regarding specific table is also printed on the additional sheet. (In the upper left corner of these specific tables you will find the relevant value of T in **bold**.)

At the start of the experiment you receive 6000 points for free. At the end of the experiment you will be paid in guilders, based on the total number of points you earned. The conversion rate is such that 1500 points in the experiment correspond to one guilder in money.

General tables

Below are the general tables appearing on the additional sheet. Of course, the indications LI, EX and RE in these tables were left out in the actual experiment. The 21 specific tables per remedy were simply obtained from the general table by substituting the appropriate values of T {0, 5,..., 100}.

General Table (LI). Number of points for both participants.

LI	Blue		Yellow	
	A	B	A	B
X	$400 + 100T - T^2$	600	$400 + 100T - T^2$	600
Y	$3400 - T^2$	-3400	$3400 - T^2$	3600

General Table (EX). Number of points for both participants.

EX	Blue		Yellow	
	A	B	A	B
X	$400 + 100T - T^2$	600	$400 + 100T - T^2$	600
Y	$400 + 100T - T^2$	$-400 - 100T$	$400 + 100T - T^2$	$6600 - 100T$

General Table (RE). Number of points for both participants.

RE	Blue		Yellow	
	A	B	A	B
X	$400 + 100T - T^2$	600	$400 + 100T - T^2$	600
Y	0	$-T^2$	0	$7000 - T^2$

A.4 Details of the quantal response estimation of the RE-High treatment

McKelvey and Palfrey (1995) have proposed a statistical version of Nash equilibrium. In these so-called quantal response equilibria (QRE) individuals compare expected payoffs from different strategies but with error. As a consequence individuals play better responses with higher likelihood, but best responses are only played with certainty in the limit. In McKelvey and Palfrey (1998) they also developed a version of QRE for sequential games (Agent Quantal Response Equilibria AQRE). An often used parametric specification is the logit-(A)QRE which we will also use.

For RE-High we get the following, using the payoffs reported in the RE table in appendix A.3. First the probability that the seller breaches given that the outside bid is high (which has probability p):

$$P_H \equiv \Pr(Breach|b = 7000) = \frac{\exp(\lambda \cdot (7000 - I^2))}{\exp(\lambda \cdot (7000 - I^2)) + \exp(\lambda \cdot 600)} \tag{1}$$

and the probability of breach given that the outside bid is low:

$$P_L \equiv \Pr(Breach|b=0) = \frac{\exp(\lambda \cdot (-I^2))}{\exp(\lambda \cdot (-I^2)) + \exp(\lambda \cdot 600)} \tag{2}$$

Finally we have the probability that the buyer invests I. Note that $I \in \{0, 5, \ldots, 100\} = \Im$. The expected pay-off of choosing I, is

$$\pi^e(I) = (1 - p \cdot P_H - (1-p) \cdot P_L) \cdot (400 - 100 \cdot I - I^2)$$

the probability we seek then becomes

$$P_I \equiv \Pr(I) = \frac{\exp(\lambda \cdot \pi^e(I))}{\sum_{i \in \Im} \exp(\lambda \cdot \pi^e(i))} \tag{3}$$

We estimated λ using standard ML techniques. The estimated value of λ equals $\hat{\lambda} = 0.0044$ with a standard error of $\hat{\sigma} = 0.00017$ (Log $\mathcal{L}$=-965.01).

References

Aghion, P. and P. Bolton (1987). Contracts as a barrier to entry. *American Economic Review 77*, 388–401.

Bolton, G. and A. Ockenfels (1999). ERC a theory of equity, reciprocity and competition. *American Economic Review forthcoming.*

Burguet, R., R. Caminal, and C. Matutes (1999). Golden cages for showy birds: optimal switching costs in labour markets. Discussion Paper 2070, CEPR.

Che, Y.-K. and T.-Y. Chung (1999). Contract damages and cooperative investment. *Rand Journal of Economics 30*, 84–105.

Chung, T.-Y. (1992). On the social optimality of liquidated damage clauses: An economic analysis. *Journal of Law, Economics & Organization 8*, 280–305.

Chung, T.-Y. (1995). On strategic commitment: Contracting versus investment. *American Economic Review (Papers and Proceedings) 85*, 437–441.

Cooper, R., D. DeJong, R. Forsythe, and T. Ross (1990). Selection criteria in coordination games. *American Economic Review 80*, 218–233.

Cooter, R. and T. Ulen (1997). *Law and Economics* (Second ed.). Addison-Wesley Reading.

Edlin, A. (1996). Cadillac contracts and up-front payments: Efficient investment under expectation damages. *Journal of Law, Economics & Organization 12*, 98–118.

Edlin, A. (1997). Breach remedies. Working paper, NBER.

Edlin, A. and S. Reichelstein (1996). Holdups, standard breach remedies, and optimal investment. *American Economic Review 86*, 478–501.

Fehr, E. and K. Schmidt (1999). A theory of fairness, competition, and cooperation. *Quarterly Journal of Economics 114*, 817–868.

Leitzel, J. (1989). Damage measures and incomplete contracts. *Rand Journal of Economics 20*, 92–101.

MacLeod, W. and J. Malcomson (1993). Investment, holdup and the form of market contracts. *American Economic Review 83*, 811–837.

Mahoney, P. (1995). Contract remedies and options pricing. *Journal of Legal Studies 24*, 139–162.

Malcomson, J. (1997). Contracts, hold-up, and labor markets. *Journal of Economic Literature 35*, 1916–1957.

McKelvey, R. and T. Palfrey (1995). Quantal response equilibria for normal form games. *Games and Economic Behavior 10*, 6–38.

McKelvey, R. and T. Palfrey (1998). Quantal response equilibria for extensive form games. *Experimental Economics 1*, 9–42.

Millner, E. and M. Pratt (1991). Risk aversion and rent-seeking: An extension and some experimental evidence. *Public Choice 69*, 81–92.

Rogerson, W. (1984). Efficient reliance and damage measures for breach of contract. *Rand Journal of Economics 15*, 39–53.

Roth, A. (1985). Introduction to experimental economics. In J. H. Kagel and A. Roth (Eds.), *Handbook of Experimental Economics*. Princeton University Press, Princeton NJ.

Shavell, S. (1980). Damage measures for breach of contract. *Bell Journal of Economics 11*, 466–490.

Shavell, S. (1984). The design of contracts and remedies for breach. *Quarterly Journal of Economics 99*, 121–148.

Spier, K. and M. Whinston (1995). On the efficiency of privately stipulated damages for breach of contract: entry bariers, reliance, and renegotiation. *Rand Journal of Economics 26*, 180–202.

Walker, J., V. Smith, and J. Cox (1990). Inducing risk-neutral preferences: An examination in a controlled market environment. *Journal of Risk and Uncertainty 3*, 5–24.

Williamson, O. (1985). *The economic institutions of free capitalism.* New York: Free Press.