On the relation between asset ownership and specific investments*

Joep Sonnemans [a,b,c]

Hessel Oosterbeek [a,b,d]

Randolph Sloof [a,b,d]

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Abstract

We report results from an experiment based on a simplified version of Hart's (1995) property rights theory of the firm. Only one manager invests and this investment is completely specific. In that case the theory predicts that the level of investment is not affected by the level of no-trade payoffs if these payoffs are modeled as threat points (as Hart does). If instead no-trade payoffs are modeled as outside options (as in De Meza and Lockwood, 1998), subgame perfectness predicts that investments are reduced when the no-trade payoff increases from a non-binding (low) level to a binding (high) level.

With threat points, we find that investment levels increase (rather than remain constant) when the investor's no-trade payoff goes up. With outside options, investment levels tend to decrease (as predicted) when the value of the no-trade payoff increases, but this decrease is much smaller than predicted and lacks significance. Taken together, these comparative statics results support the theory in a relative sense. In all cases considered, the average investment level exceeds the predicted level. Actual investment behavior is consistent with the outcomes of the bargaining stage; investors typically receive a higher return on their investment than predicted. Given this, actual investment behavior is close to optimal. The actual play of the game is supported by a reciprocity mechanism in which the non-investor considers the higher investment level as fair behavior which deserves a reward in the form of a higher return. Apparently investors anticipate this reward when they make their investment decision.

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a. University of Amsterdam; Department of Economics; Roetersstraat 11; 1018 WB Amsterdam; The Netherlands.

b. Tinbergen Institute

c. CREED

d. NWO Priority Program 'Scholar'

1 Introduction

In a series of important contributions Grossman & Hart (1986), Hart & Moore (1990), and Hart (1995) develop the property rights theory of the firm. They make the case that the ownership structure may have important implications for incentives to invest. Within their framework the optimal ownership structure is determined as the one which results in the smallest deviations from the socially efficient investment levels.

The general setup of the Grossman-Hart-Moore-framework is as follows. Two managers own two assets. Before they trade both managers can choose investment levels, which affect the size of the surplus if they trade and (possibly also) their respective payoffs if no trade occurs. After the investments are sunk, the parties negotiate about the division of the surplus. When the parties agree to trade the ownership structure is unimportant because then both managers have access to both assets. If no trade occurs, however, the ownership structure is important as the possession of assets affects the parties' no-trade payoffs. According to Hart (1995, p.49) having more assets encourages investment and therefore the party whose investment is more important should own more assets.

In some recent papers this result has been criticized (De Meza and Lockwood 1998; Chiu 1998; Bolton and Xu 1999). These papers point to the fact that the driving force behind Hart's conclusion is that no-trade payoffs have the form of *threat points*. They show that when no-trade payoffs have the form of *outside options* instead of threat points, asset ownership may actually discourage investment. Conceptually, threat points and outside options differ in the following way. Threat points are no-trade payoffs which parties receive in case of disagreement while bargaining continues. Outside options are no-trade payoffs which are only available when one of the parties terminates the bargaining.

With threat points as no-trade payoffs the subgame perfect equilibrium of the bargaining stage is that both players receive their no-trade payoffs plus 50% of the remaining surplus.[1] This is the so-called split-the-difference solution (STD, cf. Binmore et al. 1989). With outside options as no-trade payoffs the equilibrium prediction of the bargaining stage is that both players receive 50% of the total surplus[2] unless this gives one of the parties less than her/his outside option. In that case, the player with the binding outside option receives this outside option, leaving the remaining surplus to the other player. This is the so-called deal-me-out solution (DMO, cf. Binmore et al. 1989).

Figure 1 exhibits the crucial difference between the bargaining solutions under these two types of no-trade payoffs, and the relation with investment incentives. To keep things simple we assume that only one of the players (M1) can make an investment and that this investment is completely relation-specific.[3] Moreover, we normalize the no-trade payoff of the other player (M2)

[1] 50% follows if we make the standard assumption that both players have equal bargaining power. With unequal bargaining power the remaining surplus is split in proportion to the relative bargaining powers.
[2] Again assuming equal bargaining power.
[3] In the papers referred to above the setup is more general. Both parties invest, and their investments are typically not completely relation-specific; i.e. they also affect the investors' no-trade payoffs. These differences do not, however, affect the crucial aspects of the analysis. In section 2 we elaborate on this.

to zero. The left hand panel gives the case where the no-trade payoffs have the form of threat points. Without investment the surplus up for division equals S. When M1's threat point equals r, the STD-solution gives M1 a payoff of r+½(S-r). Now assume that M1 makes a relation-specific investment which enlarges the surplus to S'. Again with r as M1's threat point, M1 will now receive r+½(S'-r). Hence M1's gross gain from the investment equals ½(S'-S). In other words, M1 receives only half of the return to her investment. Now consider what happens if M1 owns more assets. In Figure 1 this comes down to giving M1 a larger no-trade payoff, say r*. Repeating the previous analysis with r* instead of r reveals that M1's gain from her investment still equals ½(S'-S). Hence, with no-trade payoffs having the form of threat points we find that owning more assets has no effects on the incentives to make the specific investment.

Figure 1a. Bargaining outcomes with threat points

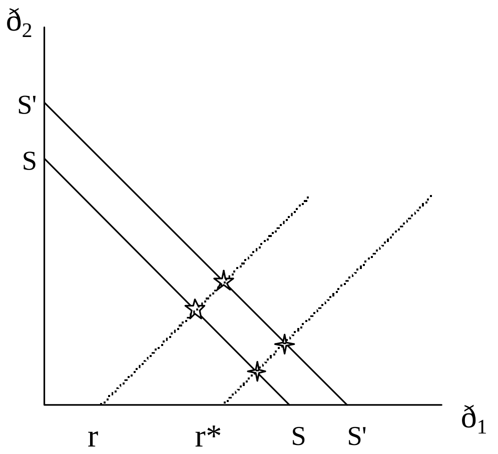
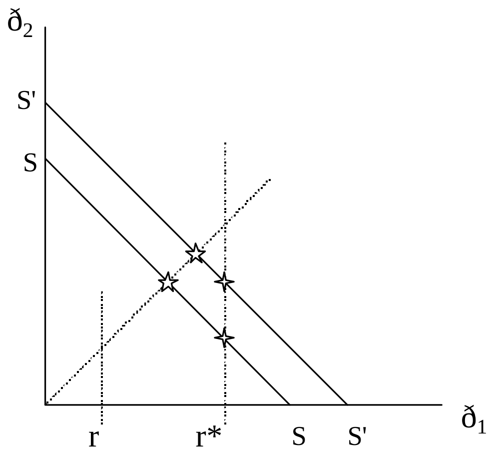


Figure 1b. Bargaining outcomes with outside options



This is different in a situation where the no-trade payoffs take the form of outside options, see the right hand panel. At level r the outside option is non-binding. Hence, the DMO-solution gives player M1 ½S when there is no investment and ½S' when the investment has been made. Thus again M1 gains ½(S'-S) from the investment. But if M1 now owns more assets such that her no-trade payoff is binding as is the case with r*, both without and with investment she receives r*. Her gain from the investment then equals 0. Hence, with no-trade payoffs having the form of outside options we find that owning more assets may weaken M1's incentives to make the relation-specific investment.

This paper reports about an experiment designed to test whether the different investment incentives under the two different bargaining regimes show up in practice.[4] Experiments are very suitable to test the predictions of well articulated formal theories in a controlled environment that allows the observations to be unambiguously interpreted in relation to the theory (Roth 1995a). If the

[4] In this paper we analyze a game where the player who has positive no-trade payoffs is also the player who invests. In a companion paper (Sloof et al., 2000) we consider the case where only the non-investing player has positive no-trade payoffs. There the focus is on the operation of the outside option principle as a solution to the holdup problem. Appendix A0 provides a brief summary of the results of that paper.

experimental design complies with all the conditions set by the theory, the results of the experiment should confirm the predictions of the theory, if the theory is sound. Outside the laboratory such tests 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). Subjects in our experiment play an alternating offer bargaining game that is preceded by an initial investment stage in which one of the two parties makes a relation-specific investment. We distinguish 2‰3 treatments. First there is a division into outside option and threat point bargaining games. Second, within each of the two bargaining games the no-trade payoff of the investor can take three levels: low, intermediate and high. Higher no-trade payoffs reflect ownership of more assets.

Our experiment basically adds an investment stage to an alternating offer bargaining game with different forms of no-trade payoffs. Predictions regarding investment behavior are based on the premise that the bargaining stage results in the divisions reflected in Figure 1. Of course, when subjects in a bargaining experiment without our initial investment stage reach bargaining outcomes that deviate substantially from these predicted outcomes, one might question the usefulness of adding an investment stage. Experimental studies by Binmore et al. (1989, 1991), however, provide ample support that actual bargaining outcomes are in line with the predicted outcomes. Subjects in their experiments do in general recognize the (subtle) difference between threat points and outside options in alternating offer bargaining games. Moreover, their results lend some support to the theoretical predictions about bargaining behavior under the two bargaining regimes. One might therefore reasonably expect that also the theoretical relationship between investment behavior and the form of the no-trade payoffs will appear in the laboratory. From this perspective, our focus on a setup that extends the one of Binmore et al. with an initial investment stage seems justified.

A number of experimental papers already study the two-stage nested bargaining game in which parties bargain over the division of a surplus created by advance investments (e.g. Gantner et al. 1997; Hackett 1993, 1994; Königstein 1997; Oosterbeek et al. 1999; Ellingsen and Johannesson 2000). In all these studies the focus is mainly on how (relative) investment levels affect subjects' subsequent bargaining behavior and the ultimate division of the surplus. Generally, it is concluded that "endogeneity matters". The sunk investments made at the earlier stage do have a significant influence on bargaining behavior at the later stage, and thus the final division of the surplus. It appears that typically concepts of equity, fairness and reciprocity play a role when subjects divide a surplus. In particular, subjects take also the (relative) investment levels into account besides their gross payoffs when bargaining over a particular division. This contradicts with subgame perfection, which predicts that sunk investments do not affect subsequent bargaining behavior.[5] As noted, all these studies focus mainly on the "one way" influence of how different (sunk) investment levels affect subsequent bargaining behavior. The primary focus of this paper is the influence in the "other" direction: the influence of different bargaining situations on initial investment levels.

The remainder of this paper is organized as follows. The next section summarizes Hart's model and the variation proposed by De Meza and Lockwood. This section establishes that the simple setup described above captures the essential difference between the two approaches. Section

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[5] See, however, Ellingsen and Robles (2000) and Tröger (2000) for recent theoretical contributions which use an evolutionary approach to explain why sunk cost may affect bargaining outcomes.

3 presents the details of the experimental design. Section 4 presents and discusses the experimental results. Section 5 summarizes and concludes.

2. Theory

This section briefly presents a simplified version of Hart's model (1995) and the variation proposed by De Meza and Lockwood (1998), and discusses the key difference between the two.

Consider two managers (M1 and M2) operating two assets (a1 and a2). M2 in combination with a2 supplies a single unit of input (a widget) to M1. M1 uses this input together with a1 to produce a final output. Before trade takes place, M1 can make a specific investment which makes the assets more productive.[6] M1's investment affects M1's revenue of selling the product. Only when the investment costs are sunk, uncertainty about the exact type of widget needed, is resolved. This makes it impossible for the parties to contract a price for the widget before the investment is sunk. Three ('leading') ownership structures are distinguished: non-integration where M1 owns a1 and M2 owns a2; type 1 integration where M1 owns both assets, and type 2 integration where M2 owns both assets. Formally the ownership structure is represented by A which is the set of assets to which M1 has access; A={a1} under non-integration, A={a1,a2} under type 1 integration and A=Æ under type 2 integration.

M1's investment is denoted by i, which represents both the level and cost of the investment. If M1 and M2 agree to trade, M1's revenue is denoted R(i) (with R'(i)>0 and R"(i)<0), which is the price for which M1 can sell her output if she could use M2's input. The ex post payoff of M1 equals R(i)-p, where p is the price of the widget where M1 and M2 agree upon. M1's ex ante payoff equals R(i)-p-i. If M1 and M2 do not trade, M1's revenue is denoted by r(i;A) (with r'(i;A)³0 and r"(i;A)<0). The ex post payoff of M1 when there is no trade with M2 then equals r(i;A)-p^s, where p^s is the spot market price of a widget (which is then not especially accommodated to M1's needs).

For M2, production cost in the case trade between M1 and M2 takes place equals C. M2's payoff then equals p-C (ex post and ex ante). If M1 and M2 do not trade, M2's cost equals c(B), where B={a1,a2}\A. The ex post payoff of M2 then equals p^s-c(B).

The ex post surplus if there is trade between M1 and M2 equals R(i)-C, while the ex post surplus without trade between M1 and M2 is equal to r(i;A)-c(B). To express the notion that investment i is relation-specific, it is assumed that the ex post surplus in case of trade between M1 and M2 exceeds the ex post surplus when there is no trade between M1 and M2. That is: R(i)-C> r(i;A)-c(B), for all i, A and B. It is further assumed that specificity also holds in a marginal sense, meaning that M1's marginal returns on her investment are larger the more assets she has access to.[7] Formally:

[6] In Hart's presentation both managers make an investment decision. For our purposes, however, nothing essential is lost when we restrict attention to one investor. We are interested in the effect of owning more assets on incentives to invest and not in the optimum ownership structure per se. Following Hart's terminology we study the case where M2's investment is unproductive. Alternatively our setup can be interpreted as M1's investment decision problem given the result of M2's investment decision.

[7] The fact that R'(i) > r'(i;a1,a2) reflects that under trade M1 has also access to M2’s human capital, while there is no access to that asset if there is no trade and M1 owns both assets.

$$R'(i) > r'(i; a1,a2) \geq r'(i; a1) \geq r'(i; \emptyset), \text{ for all } 0<i<\bar{i} \qquad (1)$$

Given these assumptions the first-best level of investment (i*) is easily derived as: R'(i*)=1. The first-best level will in general, however, not be achieved. This follows because M1 chooses her investment level in light of her own payoffs, which depend on the outcome of the subsequent bargaining stage in which the price of the widget (p) is determined.

In Hart's model the payoffs in case of trade result from dividing the ex post gains from trade equally (split-the difference). That is, both M1 and M2 receive 50% of [(R-C)-(r-c)]. Each party receives her/his no-trade payoffs and the remaining surplus is divided equally. Net ex ante payoffs for M1 are then equal to:

$$\pi = r - p^s + ½((R-C)-(r-c)) - i = ½R + ½r - ½C + ½c - p^s - i$$

Given this bargaining solution M1 will choose the investment level i for which:

$$½R'(i) + ½r'(i; A) = 1 \qquad (2)$$

Given inequality (1) and the fact that R"<0 and r"<0, this results in $i^* > i1 \geq i0 \geq i2$.[8] Here i0 denotes M1's investment level under non-integration, i1 is M1's investment level under type 1 integration and i2 is M1's investment level under type 2 integration. This establishes that owning more assets always results in an investment level which is closer to the first-best level.

De Meza & Lockwood draw attention to the fact that the exact form of no-trade payoffs is crucial for Hart's result. They consider the situation where no-trade payoffs have the form of outside options rather than threat points. In an alternating offer bargaining game with outside options, subgame perfectness predicts that each party receives the best of her/his outside option and the share s/he would obtain in the absence of outside options. This is the deal-me-out solution. Again it is possible to determine the optimal investment level for M1 under different ownership structures. Assuming that the non-investor's outside option does not bind, the investor's payoff in this bargaining game equals:

$$\pi = \max \{½(R-C), r- p^s\} - i$$

Given this payoff, M1's optimum investment level is determined either (if the investor's outside option is non-binding) by

$$½R'(i) = 1 \qquad (3a)$$

or (if the investor's outside option is binding) by

[8] Strict inequalities hold if (1) holds with strict inequalities.

$$r'(i; A) = 1 \qquad (3b)$$

The relation between asset ownership and investment levels now depends on how asset ownership affects whether (3a) or (3b) applies. Following De Meza & Lockwood we assume that the total return to investment in the outside option is (weakly) increasing in the number of assets owned: $r(i; a1,a2) \geq r(i; a1) \geq r(i; \emptyset)$. It can now happen that a shift from type 2 integration to no integration, or from no integration to type 1 integration, turns M1's outside option from non-binding into binding. M1's optimum investment level than switches from the solution to (3a) to the solution to (3b). If $R'>2r'$ this results in a drop of M1's investment level. Thus, owning more assets may result in a lower level of investment. This is in sharp contrast with the result for the case where no-trade payoffs have the form of threat points.

Above we claimed that the essential mechanism causing the differences between the models of Hart (1995) and De Meza & Lockwood (1998) also shows up when the investment is completely specific. Complete specificity implies that the investment has no effect on the no-trade payoffs, hence: $r'(i;A)=0$ for all A. Imposing this condition, equation (2) reduces to equation (3a), implying that in the case of threat points the investment level is independent of the ownership structure. Complete specificity also affects equation (3b) in the sense that $r'(i;A)$ cannot be equal to unity (the first order condition cannot be met with equality). Given that investment involves costs and investment has to be nonnegative, the optimum investment level in case of a binding outside option equals zero (second order condition).

3. Experimental design and hypotheses

Our design covers 2×3 treatments, corresponding to two bargaining games and three no-trade payoff levels. We refer to the two bargaining games as the *OO-game* and the *TP-game.* In each single session only one bargaining treatment was considered. We ran two sessions per bargaining treatment, such that we had 4 sessions in total. Overall 80 subjects participated in the experiment, with 20 participants per session. The subject pool was the undergraduate student population of the University of Amsterdam. Most of them were students in economics. They earned on average 60 Dutch guilders (approximately US$ 28.5) in about two and a half hour.

In the next subsection we discuss the basic setup of each experimental session. Subsequently we describe how the bargaining and the investment stage were framed and presented to the subjects. Finally, the hypotheses that follow from our parameter choices are summarized in Subsection 3.3.

3.1 Basic setup of a session

In each session pairs of subjects repeatedly played a nested bargaining game. Specifically, each session contained 18 periods, and each single period consisted of a single play of a two stage game. In the first stage a subject with the role of player M1 chooses an investment level, in the second stage this subject together with a subject who has been assigned the role of player M2 bargain over the division of the surplus. All subjects thus played 18 games. Half of the 20 subjects that participated in a session were assigned the role of M1, the remaining 10 were assigned the role of M2. Each participant kept the same role during the whole session. (These roles were communicated only after the complete instructions were read and understood.) In each single period all M1s were paired anonymously to a different M2. We used a rotating scheme to ensure that the same subjects were not matched more than once during the first nine periods, and a different rotating scheme to ensure the same for the last nine periods. Within the two intervals of nine periods, the rotating schemes also ensured that a subject x was never matched with a subject y who met a subject previously matched with subject x. The subjects were explicitly informed about this matching procedure. We did this in order to rule out any reputational considerations.

The experiment was computerized.[9] 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 situations. Subjects also received a summary of the instructions on paper.[10] The instructions and the experiment were phrased as neutral as possible; words like opponent, game, player, manager, buyer or seller were avoided. At the start of the first period all subjects received a message informing them about their role. After the subjects had played 18 games, they filled out a short questionnaire. At the end of the experiment the earned experimental points were exchanged for money. Subjects were paid individually and discretely.

To operationalize the experiment concrete choices had to be made regarding:

- the feasible range of investment levels;
- the form of revenue function R(i);
- the cost of investment, and
- the values of the no-trade payoffs for different amounts of assets owned by M1.

First, because our main focus is on investment behavior, we allowed for enough variation in possible investment levels. Following Hackett (1993, 1994), investments could take any integer value between 0 and 100. Second, in order to keep the payoff structure as simple as possible for the subjects, we chose R(i) to be linear and the costs of investment to be quadratic in i. The linear revenue function has the general form R(i)=V+vi, with V the base amount and v the constant increment resulting from investment. In the OO-game we set V=10,000 and v=100, along with the following values for the no-trade payoffs: r(Æ)=1800, r(a1)=6800 and r(a1,a2)=7800. A level of 1800 is always non-binding, hence M1 will collect half of the surplus (5,000+50i). Given the quadratic cost function i^2 the optimum investment level for M1 then equals 25, which is exactly half of the socially optimum level of 50. No-trade payoff levels of 6800 and 7800 are, given R(i), both binding.[11] Half of the surplus R(i)=10,000+100i exceeds 6800 (7800) if i exceeds 36 (56), but then the net payoff for M1 would be negative. Hence in these cases M1 will receive the outside

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[9] The experiments took place in the laboratory of the CREED research center in Amsterdam, in which subjects are separated through cubicles. Subjects do not know with whom they are paired.

[10] A translation of this summary in English can be found on http://www.fee.uva.nl/creed/people/joeps.htm.

[11] At r=5625 the outside option turns from non-binding into binding. There the investor is indifferent between investing 25 and receiving half of the gross surplus, and investing zero and receiving the outside option.

options and investment will be set equal to zero.[12] In the TP-game, M1 always receives half of the surplus created by the investment. Hence, in that game the optimum investment level equals 25 irrespective of the level of the no-trade payoff. Furthermore we normalized such that C=c= p^s=0.

In the TP-game, M1 receives the no-trade payoff in case of delay of agreement. As a result the joint cost of delay would be different in the two bargaining games if the total surplus would be the same. To enhance comparability between the OO-game and the TP-game we have added M1's no-trade payoff to the base amount of R(i). Thus, in the TP-game we have V=10,000+r. This facilitates the comparison of delay of agreement under the two types of bargaining games (cf. Knez and Camerer 1995, p. 84). Note that under the TP-game investment incentives are not affected by the value of the base amount.

The conversion rate used in the experiments was 1 guilder for 2500 experimental points. At the time that the experiments were run (June 1999) one guilder was about 48 dollar cents, such that 1 dollar corresponds with about 5200 points.

Like in Binmore et al. (1998) the three different values of the no-trade payoffs were considered *within* one session. In each session we used the same ordering of r's over the 18 periods. Subjects were told how the ordering was generated (each of the three values of r had an equal chance of 1/3 in each period), but were not told what this ordering was. At the beginning of each period they were simply informed about the value of r that applied in that period. In each period all ten pairs were confronted with the same value of r. The fixed sequence of r's used was not ordered in an ascending or descending order like in Binmore et al. (1998). Rather, we used a sequence in which frequent upward and downward changes in r occurred, in order to allow for additional test possibilities of comparative statics from period to period (cf. Appendix A1). To investigate whether subjects play the game differently in the first half of the experiment than in the second half, for instance because they learn during the experiment how to play the game, the 18 periods are divided into two blocks of 9 in which the three different values of r occur with the same frequency. The two different rotating schemes for the two blocks of 9 periods facilitate such a test. Moreover the last three periods include exactly one of each level of no-trade payoffs, so that these final periods can also be considered separately.

The last important element common to all sessions is that we provided the subjects with an initial endowment. Subjects with role M2 received 60,000 points ($ 11½) at the beginning of the experiment, M1s received 10,000 points (about $1.90). We used initial endowments for two reasons. First, we wanted M1s 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. Second, asymmetric initial endowments were needed to equalize at least somewhat the unequal (equilibrium) payoffs M1s and M2s obtain in the game. As initial endowments may lead to undesirable wealth effects, we used the same endowments in both

[12] The intermediate level of 6800 and high level of 7800 are relatively close to each other. This is caused by the fact that the intermediate level cannot be too close to the threshold level of 5625 and that the high level cannot be too high because otherwise subjects with the role of M2 would earn close to nothing in this treatment. Although the values 6800 and 7800 are so close together that one might expect subjects not to behave differently for these two values (thereby confirming theory), results below prove otherwise.

bargaining treatments to facilitate the comparison between them. Wealth effects then may occur, but are expected to be the same in both bargaining treatments. The actual endowments were chosen such that over both treatments M1s and M2s theoretically would earn about the same.

Note that the provision of asymmetric initial endowments may create an environment where the theory is more likely to ‘work’. Typically, game theoretical predictions fare bad when they prescribe an unequal division of the surplus as the outcome of the bargaining, because in bilateral bargaining experiments subjects usually agree to divide the surplus rather equally (cf. Roth, 1995b). The game prescribes an unequal division (when the outside option binds), and is thus likely not to be supported in the lab. Asymmetric endowments may counteract the tendency to distribute the period payoffs more equally, and may therefore give the theory a better chance.

3.2 Framing of the bargaining and the investment stage

We make use of the well-known Rubinstein alternating offer bargaining game in framing the bargaining stage. Instead of working with a single pie that shrinks over time by some discount factor, we use a multiple pie framework in which one pie vanishes in each round of disagreement. The costs of delay of agreement are thus modeled in terms of foregone trade opportunities (cf. Bolton and Whinston, 1993. See also: Chiu, 1998; MacLeod and Malcomson, 1993; Sloof et al., 2000).

The general characteristics of our bargaining stage that apply to both the OO-game and the TP-game can be described as follows. First, the bargaining stage consists of exactly 10 rounds. Second, in each of these ten rounds there is a pie to be divided between M1 and M2. The size of the round-pies equals R(i)/10. That is, the gross surplus R(i) that is obtained when the players immediately reach agreement is spread evenly over the ten bargaining rounds. Third, M1 and M2 alternate in making offers of how to split the ten round-pies. M2 always makes the proposal in the first round. Hence in all odd rounds he formulates the proposal, while in all even rounds M1 gets the opportunity to make a proposal. Fourth, as soon as agreement is reached the pie of the current round, as well as the pies of *all remaining* rounds, are divided according to the proposal agreed upon. For example, if the players agree on an equal split in round 3, all the eight pies from round 3 and onwards till round 10 are divided equally. In case the players have not reached agreement before or in the final period (and they also did not choose to break off the negotiations in the OO-game), the bargaining ends and both agents get nothing.

The OO-game and the TP-game differ in the possible responses to a proposal and in the payoffs associated with these responses. In the OO-game, if one party makes an offer the other party can react in *three* different ways: accept the offer, disagree and formulate a counteroffer in the next bargaining round, or unilaterally quit the bargaining by opting out. If a proposal is accepted the players receive payoffs according to this proposal. If there is disagreement and a counteroffer is formulated both parties receive nothing during the round of disagreement. If the responder opts out, M1 receives her no-trade payoff. With the total surplus divided in 10 equally sized round-pies, these no-trade payoffs are also divided into 10 pieces. Opting out in round t thus results in a payoff for M1 equal to (11-t)r/10. In that case M2 receives nothing. Parties then cannot return to the bargaining table.

In the TP-game, the responder can only react in *two* different ways to an offer: accept or disagree and formulate a counteroffer. Hence, opting out unilaterally is not possible here. If a proposal is accepted the players receive payoffs according to this proposal. If there is disagreement and a counteroffer is formulated the payoffs during the round of disagreement are r/10 for M1 and 0 for M2.

Finally we discuss the framing of the investment stage. At the beginning of each period subjects were informed about both the size of the base round pie and the value of the no-trade payoff. In the OO-game the size of the base round pie equaled 1000 experimental points, in the TP-game it was equal to (1000+r/10). (Recall that within one period all ten pairs were confronted with the same value of r, and thus with the same base round-pie.) Subsequently, M1 was asked how much she wanted to add to the base round pie. Thus, instead of choosing the investment level i directly, M1 in effect chose the amount 10*i. For each possible choice of 10*i between 0 and 1000, the costs of this particular choice (i.e. i^2) could be read directly from a table that was handed out to *all* subjects (thus also to M2s). The size of the actual round pies was then set at the sum of the base round pie and the amount 10*i chosen in the first stage. The game then continued to the second stage in which the two subjects bargained over the division of the ten actual round pies, as described above.

3.3 *Hypotheses*

Equilibrium predictions based on subgame perfection are summarized in Table 1. The bargaining outcome is stated as the share M1 (as investor) obtains in equilibrium.

Table 1. *Equilibrium predictions*

		OO-game			*TP-game*
		r=1800	r=6800	r=7800	all r
Stage 1	Investment	25	0	0	25
Stage 2	Outcome	*DMO:* max{r, ½(10,000+100i)}			*STD:* r + ½(10,000+100i)
	Agreement	immediate			immediate

Remark: the socially efficient investment level equals 50

The predictions in Table 1 lead to hypotheses regarding investment behavior and bargaining behavior. With respect to investment behavior we formulate hypotheses based on comparative statics predictions and hypotheses based on point predictions.

Investment behavior

- Under the OO-game, investment levels decrease when the no-trade payoff goes from low to intermediate or high.
- Under the TP game, investment levels are independent of the value of the no-trade payoff.
- Under the OO-game, investment equals 25 when r=1800, and 0 when r=6800 or r=7800.

- Under the TP-game, investment equals 25 for all r.

Bargaining behavior

- Under the OO-game, M1 receives 50% of the surplus created by the investment when the no-trade payoff is non-binding.
- Under the OO-game, M1 receives 0% of the surplus created by the investment when the no-trade payoff is binding.
- Under the TP-game, M1 always receives 50% of the surplus created by the investment.
- There is no delay of agreement.

4. Results

Our findings are presented in seven results. The presentation is divided into two parts which deal respectively with investment behavior and bargaining behavior. Actual investment behavior did not vary significantly between the different sessions of the same treatment.[13] Therefore, we have pooled the observations from the sessions that considered the same bargaining game.

4.1 Investment behavior

Our first result concerns the comparative statics of investment behavior.

Result 1: *In the OO-game average investment levels are constant over different values of the no-trade payoff. In the TP-game average investment levels increase when the no-trade payoff increases.*

Evidence for this result is obtained from the top panel of Table 2, which reports mean investment levels by bargaining game and no-trade payoff. Statistical tests are based on the average investment levels of individuals (rather than on separate investment decisions). Within a column (of a panel) we compare average investment levels from the same investors for different levels of the no-trade payoffs. For the OO-game Wilcoxon sign-rank tests for matched pairs do not reject the hypothesis of equality of the investment levels for different values of the no-trade payoffs. For the TP-game, on the other hand, sign-rank tests do reject the hypothesis of equal investment levels for different values of the no-trade payoffs. Thus, under the TP-game there is a significant pattern for the investment levels to rise with the value of the no-trade payoffs. Notice that although the no-trade payoff levels of 6800 and 7800 may seem fairly similar, in the TP-game subjects behave as if these values are different.[14]

[13] Six Mann-Whitney rank-sum tests are performed to compare mean individual investment levels conditional on the value of the no-trade payoff. No significant differences between similar sessions are found at the 5%-level.

[14] A Mann-Whitney test is the nonparametric equivalent to a t-test, and a Wilcoxon test is the equivalent to a paired t-test. A t-test assumes that the underlying densities are normally distributed, Wilcoxon and Mann-Whitney tests make no assumptions about the exact distributions. Even when the tested variables are from normal distributions, the power-efficiency of the nonparametric tests is only slightly below that of the t-tests.

Table 2. *Mean investment levels*

Periods	*No-trade payoff*	*OO-game*	*TP-game*
All (1-18)	r=1800	28.0 [25]	^{cd}30.9 [25]
	r=6800	21.5$_a$ [0]	^{ce}39.2$_a$ [25]
	r=7800	21.9$_b$ [0]	^{de}43.5$_b$ [25]
Second half (10-18)	r=1800	^{cd}25.7 [25]	^{ef}29.4 [25]
	r=6800	^{c}18.9$_a$ [0]	^{e}40.7$_a$ [25]
	r=7800	^{d}19.7$_b$ [0]	^{f}40.0$_b$ [25]
Final three (16-18)	r=1800	24.6 [25]	^{cd}30.3 [25]
	r=6800	19.2$_a$ [0]	^{c}40.1$_a$ [25]
	r=7800	20.1$_b$ [0]	^{d}41.5$_b$ [25]

Note: superscripts indicate significant differences at the 5%-level within a column of a panel (signrank test); subscripts indicate significant differences at the 5%-level within a row (ranksum test); theoretical predictions in square brackets.

These comparative statics results contrast with the theoretical predictions (the figures in square brackets). In the OO-game investment levels remain the same when the no-trade payoff goes up, while it is predicted that they should decrease when the no-trade payoff changes from low to intermediate or high. In the TP-game, investment levels increase when the no-trade payoff goes up, where it is predicted that they remain constant.

To make sure that our conclusions are not biased due to ignoring learning effects, the middle and bottom panels of Table 2 report the exact same statistics as the top panel, but now only for data from respectively the last nine and final three periods. As mentioned already in the previous section, the design of the experiment was such that the first and last nine periods included the same frequencies of low, intermediate and high levels of M1's no-trade payoff.[15] Moreover the last three periods contained one period for each of the three levels of no-trade payoffs each. The results in the middle and bottom panels almost exactly reproduce the results of the top panel.[16] As a further test we regressed for each of the six treatments the investment levels on a variable which measures the time that the investor was confronted with this treatment (hence this variable ranges from 1 to 6). Only for the treatment of the OO-game with the no-trade payoff equal to 6800, the time trend had a statistically significant (negative) coefficient. As can be seen from the results in Table 2, however, the differences in mean investment levels for this treatment in the three panels are small. Given the results from these checks, it is save to conclude that Result 1 is not contaminated by learning effects.

But if (one of) the distributions differ only to a small extent from a normal distribution a nonparametric test is superior (see e.g. Winkler and Hays 1975; Siegel and Castellan 1988). In the experimental literature nonparametric tests are most commonly used.

[15] That is: in the first and second block of nine periods, subjects were confronted with three low, three intermediate and three high levels of the no-trade payoff.

[16] In many cases the investment levels for the same treatment differ significantly across the panels in Table 2 (by a Wilcoxon signrank test). Notice, however, that there is not a clear pattern of increasing of decreasing investment levels during the periods of the experiment. Between the top and middle panel the investment levels in the OO treatment down, but between the middle and bottom panel these go up again for the higher levels of no-trade payoffs.

Further evidence that investors do not respond to changes in the no-trade payoff in accordance with the subgame perfect predictions can be obtained from the period-to-period changes of the no-trade payoffs (cf. Appendix A1). Each investor makes 18 investment decisions. Hence, for each individual investor we observe 17 (potential) changes in the investment level chosen. Depending on the no-trade payoffs in two adjacent periods, we then predict that the investment level will increase, decrease or remain the same. These predictions can be confronted with the actually observed changes. The results in Table A1 reveal that in most cases a majority of the investors do not adjust their investment level in the direction predicted.

Our second result concerns absolute investment levels.

Result 2: *In all treatments average investment levels are below the socially efficient level of 50. Average investment levels are, however, always above the level predicted by subgame perfectness.*

Figure 2a and 2b. Box plots of distribution of investment levels by bargaining game and no-trade payoffs, at the *investment decision* level.

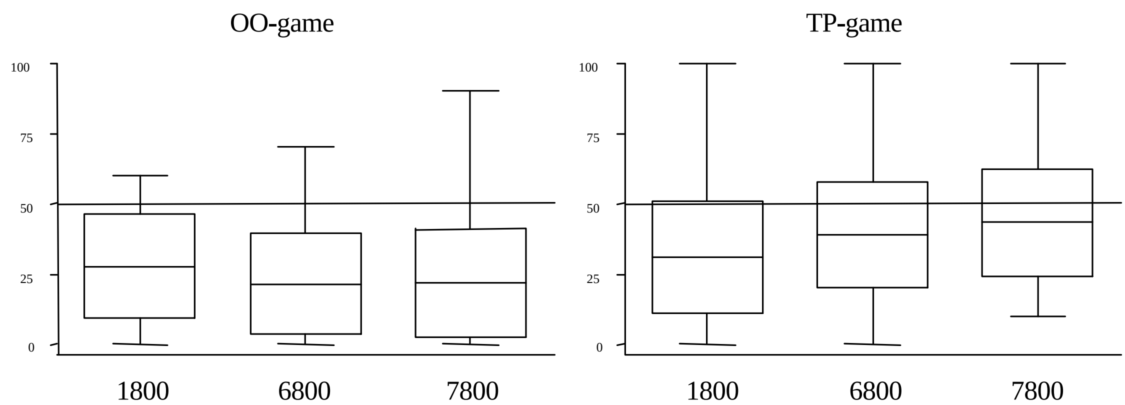
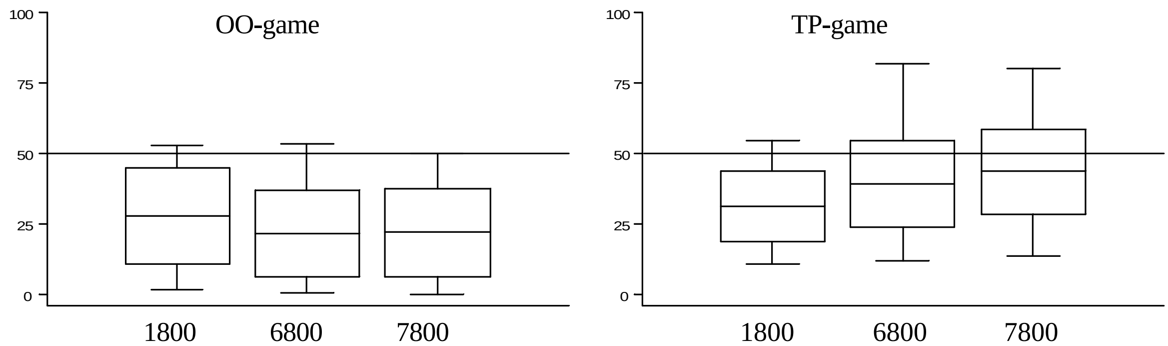


Figure 2c and 2d. Box plots of distribution of investment levels by bargaining game and no-trade payoffs, at the *investor* level.



Result 2 follows immediately from comparing the realized mean investment levels from Table 2 with the theoretically predicted levels. More detailed information regarding investment levels is given in Figures 2a to 2d. These figures show plots of the distribution of investment levels by treatment and M1's no-trade payoff. Figures 2a and 2b relate to separate investment decisions as level of observation while Figures 2c and 2d relate to average investment levels per individual investor. The line in the middle of the boxes gives the mean, while the upper and lower side of the boxes are located one standard deviation from the mean. The lines connected to the boxes extend to the largest and smallest data point observed.

The general picture that emerges from these figures is the same. In all cases (i.e. bargaining game/no-trade payoff combinations) a vast majority of the investment levels falls short of the socially optimum level of 50. Indeed, considered at the level of investment decisions, 76% of the 720 observed decisions resulted in underinvestment. 16% of the investments were exactly at the efficient level. Only a small minority of observed investment decisions (8%) is above that socially efficient level. For these latter cases the mean investment rate is 73. Although overinvestment thus may occur, it does not seem to pose a serious problem in practice. Of the 720 investment decisions only 52 (7%) coincide with the theoretically predicted level. M1s typically overinvest from an individually rational point of view. The similarity between the results in the three panels of Table 2 and the earlier mentioned insignificance of 5 out of 6 coefficients in regressions of investment on a time trend, indicate that Result 2 is not diluted by learning effects.

Our final result regarding investment behavior compares investment levels under the two bargaining regimes.

Result 3: *Average investment levels are higher under the TP-game than under the OO-game.*

Support for Result 3 is again provided in Table 2. For given levels of the no-trade payoffs, the average investment levels of individuals are higher under the TP-game than under the OO-game. This difference is not significant when the no-trade payoff equals 1800, but is significant for no-trade payoffs equal to 6800 and 7800. This is true for the results in all three panels, indicating that learning effects do not change this finding. Result 3 is in line with theoretical predictions. Thus, while the relation between investment levels and no-trade payoffs for a given bargaining regime contradicts theoretical predictions (cf. Result 1), the relation between investment levels and bargaining regime for a given level of the no-trade payoff is in accordance with theoretical predictions.[17] This means that a key point of De Meza & Lockwood is corroborated by our results: when no-trade payoffs have the form of outside options rather than threat points, there is a depressing effect on incentives to invest. And this depressing effect becomes larger when no-trade payoffs become larger. But Results 1 and 2 indicate that subgame perfection does not give a full explanation for observed investment behavior. In the next subsection we turn to the analysis of actual bargaining behavior in order to see whether the deviations between predicted and realized investment levels can be explained by features of observed bargaining behavior.

[17] This is supported by the period-to-period changes analyzed in Appendix A1. In eight instances theory predicts a difference between the two bargaining regimes in the period-to-period changes. In seven cases we do indeed find significant differences in the predicted directions.

4.2 Bargaining behavior

The return M1 actually obtains on her investment is determined by the offers finally accepted and the number of bargaining rounds needed to reach agreement. We start with presenting results on M2's first offers and on finally accepted offers. The term offer always refers to the payoffs for the investor (M1). Then we turn to the number of rounds required to reach agreement.

An important reason why actual offers may differ from game-theoretical predictions is given by considerations of fairness. One of the main regularities obtained from a vast number of bargaining experiments is that first offers and final agreements typically deviate from equilibrium predictions in the direction of an equal split (cf. Bolton, 1991, Ochs and Roth, 1989, Roth, 1995b). This may point at a concern for fairness of the proposer. But it may also simply reflect proposers' strategic considerations in view of the anticipated reaction of responders. Indeed, when the reaction of the responder is guided by the notion of being treated fairly, considerations of fairness may interact with the strategic features of the game (cf. Prasnikar and Roth, 1992, Fehr et al., 1997). To complicate matters further, what people perceive as being fair may strongly be influenced by the strategic situation they find themselves in. Binmore et al. (1991), for instance, report that what subjects describe as being a fair bargaining outcome strongly depends on whether subjects played a bargaining game like our OO-game, or one like the TP-game. Based on a large number of experimental studies Roth (1995b, p. 328) more generally concludes that "…notions of fairness are labile and appear to respond to strategic considerations." Given these problems, it may in general be rather difficult to disentangle strategic (game-theoretic) and fairness considerations. That will not be the purpose here. We just confine ourselves to reporting descriptive statistics of the offers observed that are of interest from a fairness point of view.

The exposition in this section distinguishes between three bargaining situations: the threat point game (TP), the outside option game with binding no-trade payoff (OO binding) and the outside option game with non-binding no-trade payoff (OO non-binding). Whether the no-trade payoff is binding in the outside option game or not, depends on whether r ³ ½(10,000 + 100i) or r < ½(10,000 + 100i).[18] Our first result in this subsection relates to the amounts of M2's first offers and of finally agreed offers, and how these relate to the relevant theoretical benchmarks.

Result 4: *In all three bargaining situations, the average values of first offers and finally agreed offers are in between the DMO and STD-solutions. In the OO-games mean first offers are closer to the DMO-solution than to the STD-solution, while in the TP-game the reverse holds. Mean values of finally agreed offers are closer to the STD-solution than first offers are.*

Evidence for Result 4 is given in Table 3 which presents the frequency distributions of the first offers (3a) and the finally agreed offers (3b). The first column reports the means of the first offers and the finally agreed offers. The next three columns give the values of three relevant benchmarks:

[18] For the predicted levels of investment, the OO-binding situation applies for both r=6800 and r=7800 and the OO-nonbinding situation for r=1800. As the actually observed investment levels differ substantially from theoretical predictions, this correspondence does not apply for our experimental data. But, even when investment levels differ from their equilibrium predictions, subgame perfection predicts that in the bargaining stage the first offer under the OO-game (TP-game) is given by DMO (STD).

the equal split (ES) where both players receive 50% of the gross surplus, the deal-me-out solution, and the split-the-difference solution. The outcomes predicted by subgame perfectness appear in bold in the table. The fifth columns express the actual offer as a share of the gross surplus (the pie). The next six columns give the frequency distributions of the offers in terms of the three benchmarks ES, DMO and STD. In the OO binding situation it holds that ES<DMO<STD, while in the other two situations ES=DMO<STD. For example, in the first row of Table 3a we read that in the OO binding situation, 9 first offers are below the ES outcome, 4 first offers are exactly equal to the ES outcome, 8 first offers are in between the ES and DMO outcomes, and so on.[19]

In the OO binding situation, the predicted DMO-solution gives M1 her no-trade payoff leaving the remainder to M2. First offers below the DMO-solution are in the direction of an equal split. Apparently, this is not a common result, only 10% of the first offers are below the DMO-prediction. Moreover, no more than 2% of the first offers are exactly equal to the DMO-prediction. A vast majority of the first offers are above the DMO-prediction but below the STD-solution. Thus, players with the role of M2 are prepared to give M1 somewhat in excess of her no-trade payoff. This can be either interpreted as a minimum amount needed to make M1 prefer M2's first offer over opting out, or as M2 offering M1 some positive return on her investment. The mean value of the first offer relative to the ES, DMO and STD benchmarks are in line with this. The mean offer is close to the mean DMO-solution, indicating that most of the 180 offers between STD and DMO are nearer to the predicted DMO-solution than to the STD-solution.

In the OO non-binding situation, subgame perfectness predicts that the gross surplus is split equally (ES and DMO coincide here). In 21% of the cases, M2 starts with offering less than this predicted solution. In another 15% of the cases, the first offer exactly equals the equal split, while in all other cases (65%) M2 offers more than half of the gross surplus to M1. The natural interpretation of this result is that M2 is prepared to offer M1 a return on her investment larger than 50% (which is the return in the case of an equal split).

In the TP-game, subgame perfectness predicts that M1 receives her no-trade payoff and that the remaining surplus is divided equally. In a vast majority of the cases (83%), M2 offers M1 a smaller amount of the surplus than should be offered according to the STD-solution. This is a deviation in the direction of an equal split (and DMO), suggesting that M2s are not prepared to let M1 fully exploit her advantageous bargaining position. For the 282 cases with first offers in between the DMO and STD-solution, the first offer is substantially closer to the equal split (and DMO-) solution than to the STD-solution. In fact, while under the TP-game STD is the predicted outcome, M2's first offers are closer to the DMO prediction. This observation corresponds with the findings of Binmore et al. (1991, Figures 3 and 4) for the TP-game. 51 out of 360 first offers (14%) are, however, above the STD-solution. An explanation for these high first offers is that here M2 is prepared to give M1 a higher return to her investment than the 50% predicted by subgame perfectness.

[19] Also for the bargaining stage we ran analyses separately for all periods together, only for the last 9 periods, and only for the last three periods. If we compare the shares of offers to the total pies (the Offer/Pie columns in Tables 3a and 3b), there is no indication that subjects make different first offers or reach different agreements when they have gained experience in the experiment.

Table 3a. Mean of first offers and predictions, together with frequency distribution

Situation	*Offer*	*ES*	*DMO*	*STD*	*Offer/ Pie*	*ES* ↓ *DMO* ↓ *STD* ↓	*n*
OO binding	774	586	**737**	955	0.66	9 4 8 **4** 180 0 1	206
OO non-binding	684	663	**663**	809	0.52	32 **23** 65 3 31	154
TP-game	1083	963	963	**1236**	0.56	12 4 282 **11** 51	360

Table 3b. Mean of finally accepted offers and predictions, together with frequency distribution

Situation	*Offer*	*ES*	*DMO*	*STD*	*Offer/ Pie*	*ES* ↓ *DMO* ↓ *STD* ↓	*n*
OO binding	810	587	**737**	955	0.69	0 0 3 **2** 162 0 1	168
OO non-binding	751	663	**663**	808	0.57	12 **11** 72 2 50	147
TP-game	1159	963	963	**1236**	0.60	2 2 228 **13** 109	354

Remark (for both tables): ES stands for equal split. Theoretical predictions are bold faced. In the frequency distributions (next to last column) numbers straight below the predictions represent the number of observations that exactly equal this prediction. The numbers between them represent the number of observations that fall in between these predictions.

The finally agreed offers in the OO binding situation are slightly above the first offers. More precisely, of the 168 cases in which agreement is reached, in 150 cases the finally agreed offer equals the first offer because of immediate agreement, while in the remaining 18 cases the first offer is below the finally agreed offer. In 36 instances M1 found M2’s offer so unattractive that she opted out. These results reinforce the finding we already achieved with regard to first offers in the OO-game with binding no-trade payoff: offers somewhat above the DMO-solution are the typical bargaining behavior in this game.

The same pattern emerges even stronger for the OO non-binding situation. While 36% of the first offers is below or equal to the DMO-solution, this is only true for 16% of the finally agreed offers. We also observe that the mean value of the finally agreed offers is substantially above the mean value of the first offers (751 versus 684).

For the TP-game we also observe a substantial upward shift when going from the distribution of first offers to the distribution of finally agreed offers. Nevertheless for over 65% of the cases the finally agreed offer is below the theoretically predicted STD-solution, and are thus biased in the direction of an equal split. But while the mean of the first offers in the TP-game are closer to the mean of the DMO-solution than to the mean of the STD-solution, we now find the opposite.

The finding that average finally agreed offers are higher than average first offers is not surprising. Player M2 always makes the first offer and offers are expressed as the amount player M1 obtains. If M1 accepts the first offer, finally agreed offer and first offer are equal. If M1 rejects M2's first offer, it is likely that she does so in anticipation of a higher total payoff or of a higher relative payoff. In both cases the finally agreed offer needs to exceed the first offer; in the first case the increase of the share has to offset the losses due to delay, in the second case this is not necessary.

In the discussion above we related the differences between actual offers and theoretically predicted offers to possible rewards on M1's investment and to not letting M1 fully exploit her bargaining power. We tested these explanations more formally by regressing first offers and finally agreed offers on the level of investment and the value of M1's no-trade payoff. Our next result relates to this.

Result 5: *(i) In all bargaining situations, first offers and finally agreed offers give M1 a larger return on her investment than predicted; (ii) In the OO non-binding situation, there is an unpredicted positive effect of the no-trade payoff on first and finally agreed offers; (iii) In the TP-game, the impact of M1's no-trade payoff on first and finally agreed offers is smaller than predicted.*

Evidence for Result 5 is given in Table 4 which contains for each of the three bargaining situations results from regressing M2's first offer (4a) and the finally agreed offers (4b) on the level of investment and the value of the no-trade payoff.[20] [21] The first two columns give the expressions for the DMO and the STD solutions; the theoretically predicted expressions are bold faced.[22] The estimated coefficients are reported in the third column. The fourth column reports the number of observations, the last column the adjusted R squared. In addition to the base amount, the size of the investment and M1's no-trade payoff, the equations also include the period t, in which the bargaining took place as regressor. This was done to correct the estimates for possible learning effects. For the OO binding situation and for the TP game, we find that during the course of the experiment M2's increase their first offers. Even in these cases, however, the coefficients for V, vi and r are almost identical whether a period trend is included or not.

The first rows relates to the results for the OO binding situation. Subgame perfectness predicts here that M1 receives her no-trade payoff and that M2 becomes the residual claimant and thus receives the full returns on M1's investment. The estimation results show that on average M2's first offers and finally agreed offers deviate from this prediction. While the no-trade payoff comes in with a coefficient somewhat smaller than one, M1's investment has a positively significant coefficient. First offers and final agreements give M1 a return on her investment of 25% whereas the prediction is a zero return. The finding that investors get compensated for sunk investments is not uncommon in the experimental economics literature (see for instance: Ellingsen and Johannesson 2000; Hackett, 1993, 1994; Oosterbeek et al., 1999).

In the OO non-binding situation (second rows), first offers and finally agreed shares are significantly positively affected by the no-trade payoff while theory predicts these to be independent of r. In his first offer M2 leaves slightly more than one half of the return to the investment to M1. In

[20] Similar conclusions as in Result 5 are obtained when we estimate regression equations for each of the three values of the no-trade payoff separately.

[21] Observations in which M1 opted out in the OO-game (45 cases) and in which no agreement was reached in the TP-game (6 cases) were deleted from the regressions of finally agreed offers.

[22] Formally the DMO and STD predictions in the case of finally agreed offers do not exactly apply for proposals made by M1. Specifically, these two predictions have to be multiplied by (9-t)/(10-t) to obtain M1's equilibrium proposal in even round t (cf. Sloof 2000).

the finally agreed amounts M1's share of the return of the investment raises to 71%. Thus, in this regime two mechanisms operate in the same direction of making M1 better off than theory predicts. M1 receives a return on her investment exceeding one half, and M1 gets some compensation on her non-binding outside option.

Table 4a. *Regression results explaining M2's first offers*

Situation	*DMO*	*STD*	*Realized*	*n*	*Adj R sq*
OO binding	**r**	½(V+vi+r)	.073V + .264vi + .811r + 5.87t	206	.35
			(.103)# (.045) (.143) (1.32)		
OO non-binding	**½(V+vi)**	½(V+vi+r)	.422V + .569vi + .209r + 1.60t	154	.47
			(.034) (.067) (.061) (2.19)#		
TP-game	½(V+vi)	**½(V+vi+r)**	.508V + .614vi + .062r + 3.26t	360	.83
			(.017) (.027) (.032)# (0.99)		

Table 4b. *Regression results explaining the finally agreed offer M1 receives*

Situation	*DMO*	*STD*	*Realized*	*n*	*Adj R sq*
OO binding	**r**	½(V+vi+r)	.076V + .248vi + .927r + 0.78t	168	.65
			(.058)# (.026) (.081) (0.78)#		
OO non-binding	**½(V+vi)**	½(V+vi+r)	.493V + .710vi + .111r - 0.69t	147	.77
			(.020) (.039) (.036) (1.29)#		
TP-game	½(V+vi)	**½(V+vi+r)**	.543V + .696vi + .076r + 1.47t	354	.85
			(.018) (.028) (.033) (1.02)#		

Remark: Theoretical predictions are bold faced. All coefficients are significant at the 5%-level, except when marked with a # which indicates no significant difference from zero at conventional levels.

In the TP-game, the regressions for first offers and finally agreemnts show the same pattern: M1 gains a return on her investment of more than 50%, but too low a weight is put on M1's no-trade payoff. This implies that M1 is unable to exploit her bargaining advantage stemming from more favorable threat points. In the opposite direction operates that M1 receives a higher return on her investment than predicted by subgame perfectness; more than 60% instead of the predicted return of 50%.[23]

[23] Comparing the regression results across the three situations considered in Table 4a, indicates that the three coefficients for V differ significantly (at the 5%-level) from each other. The coefficient for vi is significantly lower in the OO-game with binding outside option than in the other two regimes. The three coefficients for the no-trade payoff all differ significantly from each other (again at the 5%-level). In Table 4b the coefficients

Results 4 and 5 establish that first offers and finally agreed offers differ from the amounts predicted by subgame perfectness. As noted in the introduction of this subsection this is not an uncommon finding in bargaining experiments. Earlier bargaining experiments typically find deviations in the direction of an equal split. The preceding investment stage in our experiment is an additional source for deviations from subgame perfectness. Giving the investor a larger return on her investment than predicted, can be interpreted as reciprocal behavior of the other player. Reciprocity refers to the motivation that a player is willing to forego some amount of money in order to reward (punish) behavior that is perceived as fair (unfair). Reciprocal behavior is a common finding in many different experimental games (cf. Fehr et al. 1997, Fehr and Gächter 2000). Making a larger investment than predicted can be interpreted by the non-investor as something that is fair and therefore warrants a reward in the form of a larger return than predicted. If such reciprocal behavior is anticipated by the investor, it is optimal for the investor to invest more than predicted.

Results 4 and 5 thus provide a rationale for M1's observed investment behavior. First offers and finally agreed offers give M1 a larger return on her investment than predicted. Hence, if M1 accepts M2's first offer, she already receives a higher return than predicted. If M1 rejects M2's first offer, it is likely that she does so in anticipation of higher total payoffs (which requires that the loss due to delay is offset by a larger share).[24]

Our next result relates to losses due to delay.

Result 6: *Agreement is not always immediate. Agreement is on average reached sooner in the OO-game than in the TP-game. In the OO-game the average length of the bargaining game is shorter for higher values of the no-trade payoffs. In the TP-game the average length of the bargaining game is equal for different no-trade payoffs. When opting out is possible (OO-game), M1 is more likely to unilaterally quit the bargaining for higher values of the no-trade payoffs.*

Result 6 follows immediately from Table 5 which reports the mean number of bargaining rounds before agreement is reached, or before M1 opts out. It also presents the number of cases that lead to the particular outcome.[25] In the OO-game subjects have the possibility to opt out. We observe 45 cases (12½%) in which M1 opts out (M2 never chose to opt out in the experiment).

The theoretical prediction is that agreement is reached in the first round and that opting out does not occur. These predictions are not affected by the no-trade payoff being binding or not. We

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for the no-trade payoff differ between the three regimes. The coefficients for vi is significantly lower in the first row than in the other two (which are not different from each other). The coefficients for V are all significantly different from each other.

[24] That M1s are likely to reject first offers to receive a larger total payoff rather than to obtain a larger share of the finally divided surplus, is indicated by the very small percentages of disadvantageous counter-offers. In the OO binding situation 4 out of 20 counteroffers are disadvantageous; in OO non-binding this holds in 2 out of 62 cases, and in the TP game in only 14 out of 217 cases. The fractions of disadvantageous counteroffers are substantially smaller than the figures reported by Roth (1995b).

[25] In the TP-games it occurred 6 times (twice for each level of no-trade payoffs) that parties did not reach agreement within ten rounds. For these observations the number of rounds is set equal to 11. Similar results are obtained if we drop these 6 cases.

therefore do not distinguish here between non-binding and binding cases but rather distinguish between different levels of the no-trade payoff. Obviously, actual outcomes deviate from the theoretical predictions. Besides the occurrence of opting out, we also see that in the cases where opting out does not occur, the average number of rounds needed to reach agreement exceeds one. We also observe that in the OO-game the required number of bargaining rounds to reach agreement decreases when the value of the no-trade payoff goes up.

Table 5. *Mean number of bargaining rounds conditional on outcome*

	OO-game				*TP-game*	
	Accept		Opt out		Accept	
No trade payoff	periods 1-9	periods 10-18	periods 1-9	periods 10-18	periods 1-9	periods 10-18
r=1800	^{jk}1.90 (58)$_{ab}$	1.81 (57)$_{cd}$	^{jl}7.00 (2)$_{ef}$	3.67 (3)$_{gh}$	^{kl}2.68 (60)*	2.06 (60)$_{i}$*
r=6800	^{m}1.40 (52)$_{a}$*	^{o}1.13 (53)$_{c}$*	^{n}1.00 (8)$_{e}$	^{p}1.29 (7)$_{g}$	^{mn}2.40 (60)	^{op}2.57 (60)$_{i}$
r=7800	^{q}1.28 (43)$_{b}$*	^{s}1.04 (52)$_{d}$*	^{r}1.24 (17)$_{f}$	^{t}1.00 (8)$_{h}$	^{qr}2.45 (60)	st2.22 (60)

Remark: number of cases within parentheses. An asterisk (*) indicates a significant difference between mean number of bargaining rounds of first and last 9 periods according to a Mann-Whitney test at the 5% level. Subscripts (superscripts) indicate within-column (row) significant differences between mean number of bargaining rounds according to a Mann-Whitney test at the 5% level.

In the TP-game the average number of bargaining rounds is between 2 and 3, which is higher than in the OO-game. Also, the number of bargaining rounds in the TP-game is independent of the level of M1's no-trade payoff. These results point to an important difference between the OO-game and the TP-game: delay of agreement is shorter in OO-games than in TP-games. The same pattern is found in our related paper Sloof et al. (2000). This is a difference not anticipated by theory. Given our findings on first offers, this difference is, however, perfectly understandable. In the OO-game M2's first offer is typically above the predicted DMO-solution. Hence, according to M2's first proposal M1 is made better off than subgame perfectness predicts, and thus has a good reason to accept this first offer immediately. In the TP-game, on the other hand, M2's first offer is typically below the predicted STD-solution. This may give M1 a reason to disagree and claim a larger share of the (round) pie. Furthermore, when M1 rejects M2's first offer, she receives no payment during disagreement in the OO-game (unless she opts out), while in the TP-game she receives during each round of disagreement a payoff equal to the no-trade payoff (divided by 10). Owing to this compensation M1 may perceive it as less costly to disagree in the TP-game than in the OO-game, although our setup ensures that the *joint* costs of disagreement are the same in all treatments.

Table 5 gives the mean numbers of bargaining rounds conditional on outcome for the first nine and last nine periods separately. These results indicate that the mean number of bargaining rounds is lower in the second half of the experiment than in the first half. In three instances the reduction is significant. Apparently, subjects learn to avoid costly delay when they play the game. Result 6 is, however, not affected by this, as it is also supported by the outcomes for periods 1 to 9 or periods 10 to 18 separately.

Although Result 6 deviates from equilibrium predictions, it is line with the results obtained in other experimental studies. Ashenfelter et al. (1992), for instance, study (unstructured) bargaining followed by binding arbitration in case of disagreement. They find that disagreement rates are inversely related to the monetary costs of disputes. These results accord well with our finding that under the OO-game delay of agreement is decreasing in the value of the no-trade payoff. Recall that our experimental setup is such that the *joint* costs of disagreement are independent of the value of r, irrespective of which bargaining game is played. But under the OO-game M1's *private* costs of delay are not. The higher the value of the no-trade payoff, the higher the value of the foregone opportunities of M1. One round delay is therefore more costly to M1 when r is high, and therefore less likely to occur. A second result Ashenfelter et al. (1992) obtain is that dispute rates significantly differ across arbitration systems. Here we obtain a similar result that delay of agreement differs significantly across bargaining regimes.

We end this subsection with a result on the optimality of observed investment levels given actual bargaining behavior.

Result 7: *Observed average investment levels are all within three standard deviations of the "optimum" levels given M2's first offers.*

A nice feature of our design is that M2 makes the first proposal, which M1 can then accept or reject. Hence, M2's proposal tells us immediately how much M1 can earn on her investment if she accepts the first offer. Based on this we can then calculate how much M1 would earn if she accepts this proposal. If M1 rejects the first offer (at least) one round pie is wasted and at least one of the parties will be worse off then would have been the case with immediate acceptance. M1 might reject M2's first offer either because she expects that the subsequent bargaining rounds will result in higher payoffs for her, or because she wants a larger share of the pies that are eventually divided between the two. In the first case, M1's payoff in case of immediate acceptance gives a lower bound on M1's actual payoff. In the latter case, M1 is apparently not only motivated by the absolute level of her payoffs, but also cares about the relative level of her payoffs. If she then ends up with lower absolute payoffs, we might say that she has sacrificed some payoff to satisfy her distributional concerns.[26] For these reasons we believe that M1's potential payoff in case of immediate acceptance gives the cleanest estimate of the returns to her investment.

We estimated regression equations with M1's potential payoffs in case of immediate acceptance as dependent variable, and the level of investment and investment squared as independent variables (besides a constant term).[27] The "optimum" level of investment then can be

[26] In the OO-game there are 120 rejections of the first proposal; in 60 M1 ends up with higher payoffs than she would have earned in case of immediate acceptance. In the TP-game the respective figures are: 217 and 111. Thus, in about 50% of the cases rejection of the first offers result in lower payoffs than would have been possible.

[27] We have also estimated similar 'fixed effect' regression equations that incorporated subject-specific dummy variables (intercepts). In contrast to the standard regression results reported in the main text, these fixed effect regressions control for subject-specific characteristics. But the differences with the results obtained from the standard regressions are only minor. Therefore, we only report the latter. We also estimated a specification

directly obtained from the estimated coefficients. Table 6 reports the estimation results and the “optimum” investment levels.

Table 6. *Regression results explaining M1's net earnings if M2 first offer would have been accepted*

Regime	*No-trade payoffs*	*Coefficients*	*"Optimum" i*	*Actual i*	*Adj R sq*
OO-game	r=1800	$4713 + 59i - 1.02i^2$	28.9	28.0	0.02
		(323) (29) (.51)	(3.8)		
	r=6800	$6731 + 32i - .91i^2$	17.6	21.5	0.14
		(162) (16) (.28)	(3.7)		
	r=7800	$7715 + 22i - .96i^2$	11.5	21.9	0.32
		(173) (14)# (.23)	(4.8)		
TP-game	r=1800	$6384 + 66i - 1.06i^2$	31.1	30.9	0.67
		(173) (9) (.09)	(1.9)		
	r=6800	$8784 + 92i - 1.40i^2$	32.9	39.2	0.47
		(336) (16) (.17)	(2.2)		
	r=7800	$8590 + 117i - 1.49i^2$	39.3	43.5	0.42
		(537) (22) (.21)#	(2.6)		

Remark: All coefficients are significant at the 5%-level, except when marked with # which indicates no significant difference from zero at conventional levels. Standard deviations in brackets. For each regression n=120.

Comparing the estimated “optimum” investment levels from Table 6 with the actual mean investment levels reveals that these two levels are close to one another. In four out of six cases the point estimates are within two standard deviations, while in the other two cases the actual mean investment levels are within three standard deviations of the estimated “optimum” investment levels. This leads to the conclusion that, although the observed investment levels are quite different from the theoretically predicted investment levels, they seem fairly optimal given actual bargaining behavior. This suggests that the participants in the experiment who have the role of M1 have a pretty good idea of what to expect from the bargaining stage at the time they make their investment decision. Thus, where previous experimental studies establish that bargaining outcomes are affected by a preceding investment stage, this result concerns the relation in the other direction. It shows how (differences in) anticipated bargaining outcomes affect investment decisions.

where the linear investment term has a spline at the predicted optimum. These splines were never significant, though.

5. Conclusion

Recent contributions on the property rights theory of the firm derive contrary conclusions concerning the relation between asset ownership and incentives to make specific investments. According to Hart (1995) asset ownership encourages specific investments, while (among others) De Meza & Lockwood (1998) show that asset ownership may discourage investment. This difference is entirely due to different assumptions about the exact form the no-trade payoffs take. Asset ownership may discourage investment if no-trade payoffs have the form of *outside options*, while this does not occur when no-trade payoffs have the form of *threat points*. This paper reports about an experiment designed to test whether this difference shows up in practice.

The experimental design is based on a simplified version of Hart's model: there is only one player who invests and the investment is completely specific. In that case, subgame perfectness predicts that the level of investment is not affected by the level of no-trade payoffs if these have the form of threat points. But if the no-trade payoffs have the form of outside options, theory predicts that an increase of the outside option from a non-binding low level to a binding high level will result in a decrease of the investment level. With threat points, we find that investment levels increase (rather than remain constant) when the investor's no-trade payoff goes up. With outside options, investment levels tend to decrease (as predicted) when the value of the no-trade payoff increases, but this decrease is much smaller than predicted and lacks significance. Taken together, these comparative statics results support the theory in a relative sense. When no-trade payoffs have the form of outside options rather than threat points, there is indeed a depressing effect on incentives to invest.

In all cases considered, the average investment level exceeds the predicted level. The results from the bargaining stage provide an explanation for the differences between observed and predicted investment behavior. The non-investor's first proposal as well as the finally agreed amounts typically grant the investor a higher return on her investment than predicted. This bargaining behavior is in line with other recent experimental results which point to the importance of (positive) reciprocity as a motivation. Investments above the equilibrium level can be interpreted by the non-investor as fair behavior of the investor. This friendly behavior of the investor warrants a reward in the form of a larger return on the investment than predicted by subgame perfectness. Investors anticipate this and therefore invest more than predicted. This explains why in all cases actual investment levels exceed predicted investment levels. At the same time, the strategic elements which cause different predictions for the OO-game and the TP-game remain also at work. This explains why the theoretical predictions about investment levels in the two types of bargaining environments are confirmed in a relative sense. Given the outcomes of the bargaining stage, actual investment decisions are close to optimal.

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Appendix A0: Brief summary of Sloof et al. (2000).

In the companion paper Sloof et al. (2000) we consider an experiment which is in all but two respects similar to the experiment reported in the current paper. The differences are (i) that in that experiment it is the non-investor's no-trade payoff which is positive and takes the values 1800, 6800 or 7800, and (ii) that there the investor is the player who makes the first offer in the bargaining stage, while in the experiment in the current paper the non-investor makes the first offer.

The main motivation for this setup is that giving the non-investor a binding no-trade payoff in an outside option bargaining environment theoretically solves the holdup underinvestment problem. With a binding outside option the non-investor receives precisely his outside option and the investor earns the residual. Everything that is added to this residual as a result of an investment accrues to the investor, who then has the right incentives to invest.

Table A0 gives the mean individual investment levels together with the theoretical predictions. This is the analog of Table 2 in the current paper. For both bargaining treatments we find the investment level to be (virtually) constant in the value of the no-trade payoff. We also find that for each level of the no-trade payoff the investment level is higher under the OO-game than under the TP-game, although these differences are not significant when tested at the investor's level. In all but one case the mean investment exceeds the level predicted by subgame perfectness. The single exception is the OO-treatment with r=7800 for which it is predicted that the investment level equals the socially efficient level.

It is interesting to compare the results of Table A0 with the results of Table 2 in the main text. Only for the TP game with no-trade payoff equal to 1800, there is no significant difference between the mean investment levels in both tables. For all other treatments, the differences are significant at the 5% level. That is: in the OO-game the mean investment level is higher when the non-investor has a positive no-trade payoff than when the investor has a positive no-trade payoff. And in the TP-game the mean investment level is lower when the non-investor has a high no-trade payoff level than when the investor has a high no-trade payoff level. In terms of the ownership of assets, this means that a transfer of enough assets from the investor to the non-investor has a depressing effect on the investment level when the bargaining situation parallels a TP-setup while it has a stimulating effect on the investment level when the bargaining stage resembles an OO-game. This gives further support to the theory of De Meza and Lockwood (1998).

Table A0. *Mean investment levels*

Periods	*No-trade payoff*	*OO-game*		*TP-game*	
All (1-18)	r=1800	38.7	[25]	*29.9	[25]
	r=6800	37.9	[36]	*32.9	[25]
	r=7800	40.0	**[50]**	32.5	[25]

*Remark: theoretical predictions for individual mean investment levels are in brackets, with the socially efficient level bold faced. Superscript * indicates a significant difference (investor level) according to a Wilcoxon sign-rank test at the 5% level. Subscript † indicates a significant difference (investor level) according to a Mann-Whitney rank-sum test at the 5% level.*

Appendix A1: Detailed comparative statics of investment behavior

Table A1 presents the detailed period-to-period comparative statics results of investment choices. The first column gives the two adjacent periods that are considered. The second column gives the change in the no-trade payoff from period j to period j+1, where L, M and H stand for low, intermediate and high, respectively. The following columns present the numbers of investors that decreased (-), kept constant (0) or increased their investment level, for the OO-game and the TP-game separately. In these columns bold faced numbers refer to theoretical predictions. The last two columns present the p-values of two statistical tests, comparing the OO-game and the TP-game. The first, the Fisher exact test, only considers the signs of the changes in investment levels. This test is completely based on the numbers appearing in the previous columns. The rank-sum test statistic in the last column also takes the (not reported) magnitudes of the observed changes into account.

Table A1. *Detailed period to period comparative statics of investment behavior*

			OO-game			*TP-game*		*Fisher's exact*	*rank-sum*
		-	0	+	**-**	0	+		
1-2	MH	8	**6**	6	3	**5**	12	.134	.027**
2-3	HL	9	6	**5**	12	**4**	4	.702	.225
3-4	LL	2	**9**	9	7	**7**	6	.219	.228
4-5	LH	**7**	8	5	3	**2**	15	.007***	.001***
5-6	HM	7	**10**	3	10	**7**	3	.700	.265
6-7	MM	2	**10**	8	3	**11**	6	.824	.792
7-8	MH	4	**11**	5	2	**9**	9	.360	.083
8-9	HL	5	5	**10**	13	**6**	1	.003***	.001***
9-10	LL	4	**13**	3	6	**10**	4	.683	.892
10-11	LM	**9**	6	5	2	**5**	13	.018**	.002***
11-12	MM	1	**14**	5	0	**17**	3	451	671
12-13	MH	3	**15**	2	6	**10**	4	.341	.686
13-14	HH	3	**15**	2	3	**10**	7	.124	.250
14-15	HL	4	10	**6**	15	**3**	2	.002***	.001***
15-16	LM	**8**	9	3	2	**4**	14	.002***	.001***
16-17	ML	3	8	**9**	12	**4**	4	.018**	.006***
17-18	LH	**10**	7	3	2	**5**	13	.004***	.001***

Note: **/*** indicates significance at the 5%/1% level. Theoretical predictions are bold faced.

In 5 of the 17 period to period transitions the no-trade payoff stays the same. So, in both bargaining treatments we should not observe changes in individual investment behavior. Observed comparative statics therefore should also not differ between the two bargaining games. Indeed, for all these five transitions no significant differences are observed between the period-to-period comparative statics of the OO-game and those of the TP-game. In addition, investment behavior should also not change for the MH and HM transitions. So, for four additional period to period transitions no changes are predicted. (In fact, in one of these transitions some significant differences are found when the magnitude of differences is taken into account (rank-sum test). This, however, only concerns the first transition from period 1 to 2.) Therefore, only eight relevant transitions remain. We observe significant differences in 7 out of the 8 relevant transitions. These significant differences are all in the direction that the theory predicts, providing additional support for De Meza and Lockwood. The single exception where no significant difference is found (although predicted) concerns the HL transition from period 2 to 3. The fact that deviant comparative statics are observed only in the first three periods may point at the presence of some learning effects. The observation that the (relative) comparative statics from period 4 onwards are all as predicted may indicate that subjects learn rather quickly.