



UvA-DARE (Digital Academic Repository)

Who should invest in firm specific training?

Oosterbeek, H.; Sloof, R.; Sonnemans, J.

Publication date
2001

[Link to publication](#)

Citation for published version (APA):

Oosterbeek, H., Sloof, R., & Sonnemans, J. (2001). *Who should invest in firm specific training?* (Scholar Working Paper Series; No. WP 16/01). University of Amsterdam.

General rights

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.

Who should invest in firm specific training?

Hessel Oosterbeek* Randolph Sloof Joep Sonnemans

February 2, 2001

Abstract

We study experimentally whether employers or workers should invest in firm specific training. Only workers are assumed to have an alternative trading opportunity. Both the *turnover costs* case where this alternative takes the form of an outside option and the *no-friction* case where it serves as a threat point are considered. Theory predicts that in the turnover costs case employers have better investment incentives when the outside wage is high, and therefore should make the investment from an efficiency point of view. In the no-friction case employers and workers are predicted to invest the same. Our results are by and large in line with these predictions. For the turnover costs case we do observe that employers invests more than workers do only when the outside wage is high. In the no-friction case employers and workers invest about the same when the outside wage is low, but workers invest more than employers do when this wage is high. Actual private investment returns provide a reasonable explanation for the observed differences. Overall the observed inefficiencies are remarkably similar across the different situations considered. As a result there is only weak evidence that the employer (worker) should make the investment in the turnover costs (no-friction) case.

1 Introduction

A long standing issue within labor economics is which party in an employment relationship should invest in work-related training. Starting with the seminal work of Becker (1962) it is now generally understood that workers should bear the costs of general training. When the skills obtained are

*Department of Economics, University of Amsterdam, Roetersstraat 11, 1018 WB Amsterdam, The Netherlands. e-mail: hessel@fee.uva.nl.

completely general a worker will be paid his full marginal product in a competitive labor market. He thus collects all the gains from the investment in training. Anticipating this, employers will not invest in the general skills of their employees.¹

Yet when the skills obtained through work-related training are not completely general, there will be no competitive market for them. In that case the training firm and the worker are likely to share the additional surplus created by the investment in specific skills. The costs should therefore also be shared between the employer and the worker. Only when costs are shared proportional to the benefits, investments in specific training will be efficient.

Explicit cost sharing is possible only when investments are contractible.² Typically, however, investments in work-related training are not verifiable for a third party like a court.³ In that case training investments are non-contractible and explicit cost sharing becomes cumbersome, if not impossible. Yet when a single party has to bear the full costs of training, holdup is rather likely. This occurs when the investor cannot capture the full return on his specific investment and will therefore underinvest. In the presence of such a (potential) holdup problem it becomes an interesting question which party – either the employer or the worker – should bear the full costs of the investment.⁴ In this paper we intend to provide an answer to this question based on the observed efficiency results from a series of experiments.

We consider a setting in which explicit cost sharing is not possible. Rather, as in e.g. Kessler and Lülkesmann (2000) and MacLeod and Malcomson

¹In the presence of market frictions that compress the wage structure – such that the outside wage is below the worker’s marginal product from general training – the employer may be willing to invest in general training (cf. Acemoglu and Pischke 1999). A compressed wage structure may for instance result from asymmetric information between the training firm and outside firms (Acemoglu and Pischke 1998), or from the presence of specific training provided by the training firm (Kessler and Lülkesmann 2000).

²Hashimoto (1981) theoretically derives how costs should be shared in a situation where firm-specific training is fully contractible. A crucial assumption in his model is that the wage agreed upon in the initial contract cannot be renegotiated in response to an outside offer. See also Leuven and Oosterbeek (2001).

³See also Malcomson (1999, p. 2312) who notes that: “...investments may be too complex or too multidimensional for a court to verify whether they have been carried out as specified in a contract. Although it may, for example, be feasible to specify the number of hours of specific training unambiguously, specifying the quality of training during those hours is more problematic.”

⁴The theoretical literature proposes several contractual solutions to the holdup problem. But as Malcomson (1999, p. 2333) notes: “None of the contracts discussed here for inducing efficient specific investments by both parties thus seems unproblematic when applied to labor markets. This suggests a powerful case for, wherever possible, *all* the specific investments to be carried out by either the firm or the employee...”. Incidentally, this justifies our focus on settings in which only one of the parties invests.

(1993a), it is assumed that either the employer or the worker takes the decision of how much to invest in firm specific training and bears the full costs of it. The investment is non-contractible, such that there is indeed a potential holdup problem. After the investor has chosen the investment level the employer and the worker bargain over the division of the surplus created by the specific investment. The bargaining stage is affected by the alternative trading opportunities the parties have. We normalize the value of the employers' alternative trading opportunities to zero, reflecting our assumption of a competitive external labor market. The worker's alternative opportunity consists of working for a different employer at a fixed outside wage. As the training is assumed to be completely firm specific, this outside wage is completely independent of the investment made in the original relationship.

The alternative opportunity of the worker has been modeled in two different ways in the theoretical literature. First, it has been modeled as an *outside option*. In this case the underlying assumption is that the worker can unilaterally quit the bargaining with the original employer, in order to take up his alternative employment opportunity. In case the worker opts out, he cannot return to the bargaining with his original employer. If alternative opportunities takes this form the so-called *outside option principle* applies. In equilibrium the worker gets the best of his outside option and the wage (bargaining share) he would obtain in the absence of outside options. The outside option thus only acts as a constraint on the equilibrium division.

Second, the worker's alternative opportunity has also been modeled as a *threat point*. Here the underlying assumption is that the worker obtains his outside wage during the bargaining stage as long as agreement has not been reached. Threat point payoffs are thus collected while bargaining continues. In this case the equilibrium bargaining division equals the (generalized) Nash bargaining solution, with the disagreement payoffs equal to the values of the alternative opportunities. The outside option principle does not apply here.

Whether workers' alternative employment opportunities should be modeled either as threat points or as outside options is not always clear cut, and may depend on the situation considered. Some authors incorporate them as threat points (cf. Grout 1984), others incorporate them as outside options (e.g. MacLeod and Malcomson 1993b). According to Malcomson (1997) the former is appropriate when the labor market operates frictionless (no-friction case), the latter applies in case there are costs involved when switching trading partners (turnover costs case).

In our experiments we consider both formulations of the worker's alternative opportunities. We thus consider two different bargaining games, viz. the outside option bargaining game and the threat point bargaining game. Besides that, the experiments also consider both the case where only the em-

ployer invests and the one in which only the worker invests. The main focus is on the comparison of the investment levels of employers and workers for a given bargaining regime.⁵ That is, given external market conditions – i.e., the no-friction case represented by the threat point bargaining game or the turnover costs case represented by the outside option bargaining game – it is studied whether employers or workers should make the specific investment from an efficiency point of view.

The remainder of this paper is organized as follows. Section 2 describes the two-stage game model that is used in our experiments. This section also summarizes the (subgame perfect) equilibrium predictions that are obtained for this model and spells out the particular hypotheses that are put to the test. Subsequently, Section 3 describes our experimental design. Experimental results are discussed in Section 4. The final section concludes.

2 The model

2.1 Basic setup of the model

We consider a labor relationship between an employer and a worker. The particular two-stage game considered corresponds with a nested bargaining game with advance production.⁶ It has the following setup (cf. Malcomson 1997, 1999):⁷

1. *Investment stage.* Either the employer (E) or the worker (W) makes a

⁵In our two related papers the main interest lies in the observed comparative statics relationship between the value of the worker’s alternative opportunity and the level of investment chosen by the investor. In Sloof et al. (2000) only the case where the employer invests is considered, in Sonnemans et al. (2000) only the one where the worker invests. A brief summary of the overall investment results is given at the end of Subsection 4.1.

⁶In the standard holdup game parties first negotiate and sign a contract that governs their future relationship, and subsequently renegotiate this contract after the initial investment is made and additional information about e.g. alternative market opportunities has become public. The condensed form studied here captures the essential features of this larger game. In particular, note that the investment itself cannot be part of the initial contract for the problem of efficient investments to be of interest. When the investment is not part of the contract, little is lost by considering the case where an initial contract is absent. And without an initial contract, no exogenous uncertainty is needed to justify the role for the renegotiation stage.

⁷In Sloof et al. (2000) and Sonnemans et al. (2000) we give a more general description of the model. There it is shown that the particular parameterization presented here covers all cases of interest. In particular, our choices of $w_l = 1800$, $w_m = 6800$ and $w_h = 7800$ ensure that all three theoretically relevant cases are represented.

completely relationship specific investment $I \in \{0, 1, 2, \dots, 100\}$. Investment costs equal $C(I) = I^2$ and are immediately born by the investor.

2. *Bargaining stage.* The employer and the worker bargain over the division of the gross surplus $R(I)$ created by the investment. Bargaining either takes the form of the outside option (OO) or the threat point (TP) bargaining game. The employer and the worker are assumed to have equal bargaining power. The competitive wage the worker obtains when working for the outside employer equals $w \in \{w_l, w_m, w_h\} \equiv \{1800, 6800, 7800\}$.

Gross surplus is linear in the investment made and equals $R(I) = V + 100 \cdot I$. The particular value of V is in itself not very important, yet we have chosen it with special care. In the TP-game the worker receives the outside wage w in case of delay of agreement. As a result the *joint costs of delay* would be different in the two bargaining games if the total surplus $R(I)$ would be the same. To enhance comparability we therefore have chosen V differently in the two bargaining regimes: $V^{OO} = 10,000$ and $V^{TP} = 10,000 + w$. With this choice of V the joint costs of disagreement are independent of w and the same for the two bargaining games (for a given level of investment). This facilitates the comparison of delay of agreement and of ex post bargaining inefficiency between them. It can easily be seen that under the TP-game investment incentives are not affected by the value of V (cf. Subsections 2.2 and 2.3).

The investment only affects the gross surplus $R(I)$ within the original employment relationship and does not affect the outside wage w . This reflects our assumption that the investment is completely relationship-specific. The assumptions that $w < V$ and that w is competitive ensure that employment at the original employer is always efficient, irrespective of the actual level of investment. The net social surplus created by the investment thus equals $V + 100 \cdot I - I^2$. It follows that the efficient level of investment equals $I^* = 50$.

The above description reveals that in fact four different situations are considered, which differ in the party making the investment and in the bargaining game that applies in the renegotiations. They are summarized in Table 1. The difference between the two bargaining games relates to how the alternative opportunity of the worker is incorporated in the bargaining process. This affects the equilibrium outcome predicted for the bargaining stage. As these equilibrium divisions feed back into the initial investment stage, equilibrium investment levels will be different for the various situations considered. This will be made explicit in the next two subsections.

Table 1: The four different situations considered

	Employer invests (E)	Worker invests (W)
Outside Option game (OO)	E-OO	W-OO
Threat Point game (TP)	E-TP	W-TP

2.2 Equilibrium bargaining outcomes

In the OO-game the employer and the worker alternate in making offers about how to distribute the joint surplus. 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 quit the bargaining by opting out. If an offer is accepted the employer and the worker receive payoffs according to this proposal. If there is disagreement both parties receive nothing during the round of disagreement. If one of the parties opts out, the employer receives nothing and the worker receives his outside wage w . Parties then cannot return to the bargaining table.

In the TP-game parties also alternate in making offers about the distribution of the joint surplus. The important difference is that the responder can now react in only *two* different ways: accept the offer or disagree and formulate a counteroffer. Opting out unilaterally is thus not possible here. If an offer is accepted the parties receive payoffs according to the proposal. In case of disagreement the payoffs during the round of disagreement are 0 for the employer and w for the worker.

In equilibrium agreement is reached immediately under both bargaining games. But the equilibrium division is predicted to be different. Under the OO-game the so-called *outside option principle* applies. This principle entails that the gross surplus $R(I)$ is split evenly between the employer and the worker,⁸ unless such an equal split yields the worker less than his outside wage. In the latter case he just obtains a share of the surplus equal to w , while the employer gets the remaining part $R(I) - w$. The outside wage w thus only acts as a constraint on the equilibrium division. In the words of Binmore et al. (1989), in the OO-game the equilibrium division equals the ‘deal-me-out’ solution (DMO).

In the TP-game the outside option principle does not apply. There the equilibrium prediction is that the surplus in excess of the outside wage w , i.e. $R(I) - w$, is split evenly. On top of that the worker obtains his outside wage w . Binmore et al. refer to this equilibrium outcome as the ‘split-the-

⁸The equal split follows from our assumption of equal bargaining power.

Table 2: Equilibrium bargaining divisions

	Employer's share	Worker's share
OO-game (DMO solution)	$R(I) - \max\{w, \frac{1}{2} \cdot R(I)\}$	$\max\{w, \frac{1}{2} \cdot R(I)\}$
TP-game (STD solution)	$\frac{1}{2} \cdot (R(I) - w)$	$\frac{1}{2} \cdot (R(I) + w)$

difference' solution (STD).⁹

The equilibrium predictions under the two different bargaining games are summarized in Table 2. From this table it follows that when the TP-game applies neither the employer nor the worker ever becomes residual claimant. Hence neither of them obtains the incentives to choose the efficient investment level. In contrast, when $w > \frac{1}{2} \cdot R(I)$ under the OO-game the employer gets the whole surplus over and above the outside wage w . In that case the employer gets the full (marginal) return on the investment and thus has the right incentives to invest. The worker never becomes residual claimant under the OO-game.

2.3 Equilibrium investment levels

Anticipating that the equilibrium shares equal those in Table 2, the investor chooses the investment level that maximizes his net payoffs. The equilibrium investment made depends on both the identity of the investor and the bargaining game that applies. Table 3 presents the predicted investment levels in the four different situations.¹⁰

In the E-OO situation theoretically three relevant ranges for the outside wage w can be distinguished (cf. Sloof et al. 2000). First, w can be so low that it does not put a constraint on the equilibrium division. Our choice of $w_l = 1800$ represents this case. Second, w can be that high such that the outside wage constraint is strictly binding and fully determines the equilibrium division. This applies for our choice of $w_h = 7800$. The remaining third case refers to the in-between situation where w is on the verge of becoming binding and constraining the equilibrium division. In this case it holds for the equilibrium level of investment that the division of the surplus when the

⁹Owing to our assumption that $R(I) = 10,000 + w + 100 \cdot I$ under the TP-game, we have that the employer always receives $5,000 + 50 \cdot I$ according to STD. The amount the employer receives in equilibrium is thus independent of w .

¹⁰The row corresponding to 'all' just reflects the average over the three different values of w . It can be shown that in an alternative model with exogenous uncertainty, in which the true value of w becomes publicly known only *after* the investment is made (and in which the three values of w have ex ante equal probabilities), the equilibrium investment levels are as follows: 36 under E-OO, $8\frac{1}{3}$ under W-OO and 25 under both TP situations.

Table 3: Equilibrium investment levels

	w	Employer (E)	Worker (W)
OO-game	1800	25	25
	6800	36	0
	7800	50	0
	all	37	$8\frac{1}{3}$
TP-game	1800	25	25
	6800	25	25
	7800	25	25
	all	25	25

Remark: The efficient investment level equals 50.

outside option is absent exactly matches this outside option ($\frac{1}{2} \cdot R(I) = w$). Our choice of $w_m = 6800$ belongs to this range.

The latter in-between situation cannot occur when the worker makes the investment. This holds because when $\frac{1}{2} \cdot R(I) \leq w$ the worker simply obtains his outside wage w and he gains by not investing at all, saving him the investment costs. Therefore, when the worker invests there are only two relevant ranges for the outside wage w : w_l belongs to the first and both w_m and w_h belong to the second relevant range. Note that under the OO-game the equilibrium investment of the employer (worker) is increasing (weakly decreasing) in w . Moreover, the employer always invests weakly more than the worker does.

Under the TP-game the equilibrium level of investment is independent of the outside wage. Both the employer and the worker always underinvest. Owing to our assumption of equal bargaining power they are predicted to invest the same amount in equilibrium.

2.4 Hypotheses

Equilibrium predictions based on subgame perfection are summarized in Tables 2 and 3 above. Our focus in the present paper is on which party should make the relationship-specific investment from an efficiency point of view. We are therefore mainly interested in comparing, for a given bargaining game, the situation in which the employer invests with the one in which the worker makes the investment. The corresponding hypotheses obtained from the equilibrium predictions are summarized below.

The predictions concerning investment levels are guided by those regarding bargaining outcomes. We therefore also want to test these latter pre-

dictions. In particular, we want to relate the different investment levels of the employer and the worker to the different returns they (are predicted to) obtain on their investment. Under both bargaining games it is predicted that agreement is reached immediately. But the equilibrium division of the surplus agreed upon, and thus the return on investment, differs. In practice substantial delays in reaching agreement may be observed, as well as large deviations from the predicted divisions. This may have an (additional) adverse effect on efficiency. For a final judgement of who should make the specific investment a comparison of overall efficiency levels is therefore needed. In sum, we obtain the following three hypotheses:

INV *Investment levels.* (a) Under the OO-game the employer (weakly) invests more than the worker for any value of the outside wage. (b) Under the TP-game investment levels are independent of the identity of the investor.

BAR *Bargaining outcomes.* (a) When the outside option of the worker is binding under the OO-game, the employer gets a larger return on his investment than the worker does. (b) In case the outside option of the worker is non-binding the employer and the worker get an equal return on their investment. (c) The latter also applies under the TP-game.

EFF *Efficiency.* (a) Under the OO-game efficiency losses (due to suboptimal investment) are smaller when the employer invests than when the worker invests. (b) Under the TP-game efficiency losses are independent of the identity of the investor.

3 Experimental design

The experiments cover the four situations of Table 1. We ran two sessions per investor-bargaining game combination, such that we had 8 sessions in total. Overall 160 subjects participated, 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 hours.¹¹ In the remainder of this section we only briefly discuss the setup of the experimental sessions. More detailed information about (and justification of) our setup can be found in Sonnemans et al. (2000).

¹¹The conversion rate used was 1 Dutch guilder for 2500 experimental points. At the time the experiments were ran one guilder was about 48 dollar cents, such that 1 dollar corresponds with about 5200 points.

In each session subjects played 18 times (periods) the two-stage game described in Section 2. Half of the subjects performed the role of employer, the remaining half were assigned the role of worker. Subjects kept the same role during the whole session. To rule out reputational considerations employers were in each period anonymously paired to a different worker, using a rotation scheme for the first nine periods and a different one for the last nine periods. The experiment was computerized. The instructions and the experiment were phrased as neutral as possible.

Like in Binmore et al. (1998) the three different values of the outside wage w were considered within one session.¹² In each session we used the same ordering of w 's over the 18 periods.¹³ Subjects were told how the ordering was generated (each of the three values of w had an equal chance of $\frac{1}{3}$ in each period), but were not told ex ante what this ordering was. At the beginning of each period they were simply informed about the value of w that applied in that period. In each period all ten pairs were confronted with the same outside wage value.

Another common element of all sessions was that we provided subjects with an initial endowment. Employers received 60,000 points ($\$11\frac{1}{2}$) at the beginning of the experiment, workers received 10,000 points ($\$1.90$). Endowments were used to provide investors with some initial funds to invest in the first few periods. Moreover, asymmetric endowments were needed to equalize at least somewhat the unequal (equilibrium) payoffs employers and workers obtain in the game. Actual endowments were chosen such that over all four situations (cf. Table 1) together employers and workers theoretically would earn about the same.

The bargaining stage was framed as a finite horizon multiple-pie alternating offer bargaining game in which one pie vanishes in each round of disagreement.¹⁴ The employer always made the first offer, and thus could

¹²A potential disadvantage of our design might be that variations in w theoretically do not affect investment levels under TP. But by confronting the same subjects with different values of w we may have created the impression that subjects are expected to change their behavior. It is, however, a priori far from clear in what direction investors should change their behavior and our experimental results confirm this.

¹³In the ordering that we used each of the three values of w occurred 3 times in the first block of 9 periods, and 3 times in the second block of 9 periods.

¹⁴In practice, bargaining over wages in an employer-worker relationship typically concerns the division of a stream of future payoffs, rather than the division of a single once and for all payoff. The multiple-pie framework nicely takes account of this aspect (cf. Manzini 1998). In Sloof (2000) it is shown that the subgame perfect equilibrium predictions for the multiple-pie versions of the OO-game and the TP-game employed here equal the equilibrium divisions spelled out in Table 2. The corresponding equilibrium strategies are reported in that paper as well.

formulate the proposal in all odd rounds. Bargaining lasted for exactly 10 rounds. The gross surplus $R(I)$ and the outside wage w were spread evenly over these 10 rounds. Hence in each period a pie of $\frac{R(I)}{10}$ was to be divided between the employer and the worker. As soon as agreement was reached all remaining pies, including the one of the current round, were divided according to the proposal agreed upon and the period ended. In the TP-game the worker received $\frac{w}{10}$ for every round that agreement was postponed, while the employer received nothing during rounds of disagreement. Postponement of agreement in round 10 ended the bargaining stage. In the OO-game both parties received nothing during a round of disagreement. Here opting out in round t resulted in a payoff of $(11 - t) \cdot \frac{w}{10}$ for the worker and 0 for the employer, and ended the bargaining stage.

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 $\frac{V}{10}$ and the value of w . (Recall that the base round pie differs between the OO-game and the TP-game.) Then investors were asked how much they wanted to add to the base round pie. Effectively, they chose the amount $10 \cdot I$ ($= \frac{100 \cdot I}{10}$) at costs I^2 . The size of the actual round pies was then set at the sum of the base pie and the amount added. Subsequently, the subjects bargained over the division of the ten actual round pies as described above.

4 Experimental results

We present the findings of our experiment in the form of 5 Results. The presentation follows our three main hypotheses: i.e. this section is divided into three subsections which deal respectively with investment levels, bargaining outcomes and efficiency. Observed investment levels did not vary significantly between the different sessions of the same investor-bargaining game situation.¹⁵ We have therefore pooled the observations from the sessions that considered the same situation.

4.1 Investment levels

Our first result relates to hypothesis *INV* and compares employers' investments with workers' investments.

Result 1. (a) *Under the OO-game the employer weakly invests more than*

¹⁵Twelve Mann-Whitney ranksum tests are performed to compare mean individual investment levels conditional on the value of w . No significant differences between similar sessions are found at the 5% level.

the worker for all outside wage values. (b) Under the TP-game the worker invests significantly more than the employer when the outside wage is high ($w=7800$), but not so when the outside wage is low ($w=1800$ or $w=6800$).

Evidence supporting Result 1 is provided in Table 4, which reports average investment levels by treatment. Statistical tests are based on the average investment levels of individual investors (rather than on separate investment decisions).¹⁶ In 4 out of 8 cases average investment levels of employers differ significantly from those of workers. Under the OO-game the employer typically invest significantly more than the worker does. Only when $w = 1800$ such that the outside wage never binds the observed difference is insignificant (at the 5% level). For the TP-game an opposite conclusion applies. There employers and workers typically invest about the same: differences are insignificant for the low and intermediate outside wage. Only when $w = 7800$ workers invest significantly more than employers do. In all treatments average investment levels are below the efficient level.¹⁷

The results for the OO-game correspond with theoretical predictions. In line with hypothesis *INV(a)* holdup is less severe when the employer invests than when the worker invests. The results under the TP-game contrast with theoretical predictions only when the outside wage is high ($w = 7800$). Here no significant differences were expected, but in practice workers tend to invest significantly more than employers do. Thus in contrast with hypothesis *INV(b)*, the extent of the underinvestment problem under the TP-game is not completely independent of the identity of the investor. Holdup is less severe when the worker invests. Finally, except for the single case where holdup is predicted not to occur (viz. $w = 7800$ in E-OO), average investment levels are always above the level predicted by subgame perfectness.

To make sure that our conclusions are not biased due to ignoring learning effects, we also considered the data from the last nine and the final three periods separately. As mentioned in the previous section the design of the experiment was such that the first and last nine periods included the same frequency of low, intermediate and high levels of the worker's outside wage. Moreover, each value of w was represented exactly once in the last three periods. In Table 9 in the Appendix the middle and bottom panel report the same statistics as Table 4 in the main text, but now only for respectively the

¹⁶Recall that per value of w we have six observations for each individual investor, and that for each of the four situations considered we have 20 investors.

¹⁷Of the 1440 investment decisions that were made 72% resulted in underinvestment. 19% of the investments were exactly at the socially efficient level of 50, and in only 9% of the cases overinvestment was observed. For these latter cases the mean investment rate was 69.1.

Table 4: Mean investment levels

	w	Employer (E)		Worker (W)	
OO-game	1800	38.7	[25]	28.0	[25]
	6800	^a 37.9	[36]	^a 21.5	[0]
	7800	^b 40.0	[50]	^b 21.9	[0]
	all	^c 38.9	[37]	^c 23.8	[8.3]
TP-game	1800	29.9	[25]	30.9	[25]
	6800	32.9	[25]	39.2	[25]
	7800	^d 32.5	[25]	^d 43.5	[25]
	all	31.8	[25]	37.9	[25]

Remark: Superscripts indicate significant differences at the 5% level (ranksum test; $n=20$ per treatment). Theoretically predicted investment levels are within square brackets.

last nine and final three periods. The results for these subsamples almost exactly reproduce the results reported here. Also additional tests of learning effects based on regression results are carried out. A full discussion can be found in the Appendix. Given the results from these checks, we think it is save to conclude that Result 1 is not contaminated by learning effects.

Other observations of interest can be obtained from Table 4. First, we can look at the comparative statics with respect to w for each of the four different situations considered. Under the OO-game investment levels are constant over the different values of the outside wage, irrespective of whether the employer or the worker invests.¹⁸ This also holds for the E-TP situation. Yet for W-TP we observe that workers' investment levels are increasing in the outside wage w .¹⁹ Based on the observed comparative statics for the E-OO situation it is concluded in Sloof et al. (2000) that contractual solutions to holdup that rely on the working of the outside option principle are unlikely to solve holdup in practice. The comparative statics results for the W-OO situation strengthen this conclusion: they also reject the predicted relationship

¹⁸The observation that investors do not react to variations in w under the OO-game is somewhat puzzling. It suggests that ex ante information about the outside wage is irrelevant, and thus that similar results would have been obtained in a model with ex ante uncertainty about the outside wage. As noted earlier, in such an alternative model the equilibrium investment level equals 36 in the E-OO and $8\frac{1}{3}$ in the W-OO situation. The former by and large corresponds with observed investment levels, the latter does not.

¹⁹All these conclusions follow from the statistical tests presented in Sloof et al. (2000) for the situations in which the employer invests and from Sonnemans et al. (2000) for the ones in which the worker invests.

between investment incentives and the outside option principle.

Second, we can compare average investment levels between the two bargaining games. When the employer invests investment levels are typically higher under the OO-game than under the TP-game. In case the worker makes the investment this is exactly the other way around. Both these results are in line with theoretical predictions. In Sonnemans et al. (2000) the comparison of W-OO with W-TP leads to the conclusion that when alternative trade opportunities of the investor have the form of outside options rather than threat points, there is indeed a depressing effect on the incentives to invest. And this depressing effect becomes larger the larger w is.

All the above results with respect to investment levels are conveniently summarized in Figure 1. The four boxes correspond to the four different situations distinguished (cf. Table 1). Within each box the comparative statics results obtained for that situation are reported. A + sign indicates that investment levels significantly increase with the outside wage w etc. The predicted relationship is within square brackets. The arrows connecting the boxes correspond to comparisons across different situations. For a fixed value of w investment levels are compared between the situations connected by the arrow. A + sign again indicates a significant increase in investment levels when we go in the direction of the arrow. (These signs are based on an overall evaluation of the three values of w considered.) Symbols within square brackets again reflect the predictions.

<< Insert Figure 1 about here >>

4.2 Bargaining outcomes

The return the investor actually obtains on his investment is determined by the offers finally accepted and the number of bargaining rounds needed to reach agreement. In this subsection we present results on these two aspects. Our main interest lies in whether the investment levels observed can be considered optimal (from the selfish point of view of the investor) given actual bargaining behavior.

At the beginning of the bargaining stage investment costs are sunk. Subgame perfection then predicts that the bargaining outcome is independent of the identity of the investor. When the OO-game applies it is predicted that the parties immediately agree on the DMO-outcome. Under the TP-game the predicted division equals the STD-solution (cf. Table 2). These predicted divisions affect the investor's investment incentives. Our next result relates to this.

Result 2. (a) *When the outside option of the worker is binding under the OO-game, the finally accepted offers yield a larger private return on investment when the employer invests than when the worker invests.* (b) *In case the outside option is non-binding finally accepted offers give a private return on investment that is independent of the identity of the investor.* (c) *The latter also applies under the TP-game.*

Result 2 follows from the regression results reported in Table 5. Here we have regressed the amount the investor receives according to the finally accepted offer on the base amount V , the level of investment I and the outside wage w . In order to determine whether the identity of the investor matters we have also included interaction terms with the dummy variable D_W . This variable equals 1 when the worker makes the investment and 0 otherwise. A time trend t is incorporated to control for potential learning effects. Observations in which the worker opted out under the OO-game (84 observations) and in which no agreement was reached in the TP-game (10 cases) are left out. For the OO-game the regressions have been estimated separately for the case where the outside wage is binding ($w \geq \frac{1}{2} \cdot R(I)$) and the case where it is not.

The estimated coefficients for the level of investment are of particular interest. In the OO binding situation the employer is predicted to be residual claimant.²⁰ This is apparently not the case, because the estimated coefficient on I is below one (.852) and also exceeds the coefficient on $I \cdot D_W$ in absolute value (.852 > .613). When the employer invests he thus gets about 85% of the marginal return on his investment, where a 100% return is predicted. The worker still gets about 25% of the marginal return on his own investment (.852 - .613 = .239). Here a zero return is predicted. But in line with theoretical predictions, finally accepted offers give the employer a substantially larger (marginal) private return on his investment than the worker gets if he is the investor: the coefficient on $I \cdot D_W$ is significantly negative in this case.

Under the OO-game with a non-binding outside wage and under the TP-game the prediction is that the finally agreed offer gives the investor half of the return on his investment. This is not exactly the case though. In the second and third row of Table 5 the estimated coefficients for I exceed one half. The investor gets a return of about 65 – 70% on the investment. But as theory predicts, the employer and the worker get an equal return: the

²⁰Formally the DMO and STD predictions within square brackets do not exactly apply for proposals made by the worker. Specifically, these two predictions have to be multiplied by $\frac{(9-t)}{(10-t)}$ to obtain the worker's equilibrium proposal in even round t (cf. Sloof 2000). Out of the 1346 interactions that finally ended in agreement, 400 (29.7%) were concluded upon in an even bargaining round.

Table 5: Regressions explaining investors' finally accepted shares

	OO binding	OO non-binding	TP game
V	.850 [1] (.090)	.549 [.5] (.024)	.436 [.5] (.019)
$V \cdot D_W$	-.770 [-1] (.113)	-.036 [0] (.026) [#]	.127 [0] (.023)
I	.852 [1] (.038)	.719 [.5] (.047)	.653 [.5] (.033)
$I \cdot D_W$	-.613 [-1] (.049)	-.016 [0] (.065) [#]	.039 [0] (.045) [#]
w	-.825 [-1] (.126)	-.335 [0] (.029)	-.164 [-.5] (.037)
$w \cdot D_W$	1.78 [2] (.158)	.439 [0] (.052)	.221 [1] (.050)
t	-1.47 [0] (.675)	-2.46 [0] (1.03)	-.507 [0] (.800) [#]
n	293	343	710
adj. R^2	.908	.660	.988

Remark: Numbers within square brackets refer to the predicted coefficients, numbers within parentheses to the standard errors. Insignificant coefficients (5% level) are marked with a #.

coefficients on $I \cdot D_W$ are insignificant in both cases.

Other interesting observations follow from Table 5.²¹ When theory predicts the outside wage w to be irrelevant for the final bargaining division (OO non-binding), it still has a significant influence. A higher outside wage then yields the worker a significant larger final share. When w is predicted to have a significant impact, its influence appears to be smaller than expected. For the OO binding situation the estimated coefficient on w equals $-.825$ when the employer invests while the prediction is -1 . In case the worker invests the net coefficient on w equals $.95$ ($= 1.78 - .825$) while the predicted net coefficient equals 1 . Under the TP-game the difference is much larger. Here the outside wage is predicted to have a substantial impact, yet its actual impact is very small. By and large workers appear to be unable to exploit their bargaining advantage stemming from more favorable threat points. Finally, the coefficient on t reveals that some learning effects can be detected under the OO-game, but not under the TP-game. During the course of the experiment the investors' finally accepted shares decrease under the OO-game. Even for this bargaining game, however, the other coefficients are almost identical whether a time trend is included or not (both for the binding and the non-binding situation).

Our next result relates to delay of agreement.

Result 3. (a) *Under the OO-game agreement is reached sooner when the worker invests than when the employer invests.* (b) *Under the TP-game with a low outside wage ($w=1800$) agreement is also reached sooner when the worker invests. In case the outside wage is high ($w=6800$ or $w=7800$) there are no significant differences in delay.*

Result 3 follows from Table 6 which reports for given levels of w the mean number of bargaining rounds before agreement is reached. It also presents within parentheses the numbers of observations on which these averages are based. In E-OO we observe 39 (out of 360) cases in which the worker opts

²¹Instead of using the investors' finally accepted shares as independent variable we can alternatively regress the *employers'* finally accepted shares on the explanatory variables of Table 5. Because the bargaining outcome is predicted to be independent of the identity of the investor, the three interaction terms are then predicted to have no effect. These regressions (not reported here) reveal that this is almost always the case for $V \cdot D_W$ and $w \cdot D_W$ (the single exception occurs for $w \cdot D_W$ under OO non-binding), but not so for $I \cdot D_W$. The latter interaction term is significant in all three situations. We have chosen to report the regressions of Table 5 because they immediately reveal – through the (in)significance of the coefficient on $I \cdot D_W$ – whether the private investment returns differ significantly between employers and workers. Clearly the two types of regressions lead to similar conclusions.

Table 6: Mean number of rounds before agreement

	w	Employer (E)	Worker (W)
OO-game	1800	^a 2.39 (118)	^a 1.85 (115)
	6800	^b 1.60 (101)	^b 1.27 (105)
	7800	^c 1.36 (102)	^c 1.15 (95)
	all	^d 1.82 (321)	^d 1.44 (315)
TP-game	1800	^e 2.85 (118)	^e 2.23 (118)
	6800	2.44 (118)	2.34 (118)
	7800	2.49 (120)	2.19 (118)
	all	2.59 (356)	2.25 (354)

Remark: Number of observations are within parentheses. Superscripts indicate significant differences at the 5% level (ranksum test).

out, in the W-OO situation 45 cases. (Although employers could also opt out in reaction to a proposal of the worker, they never did so in the experiment.) Under the TP-game it occurred ten times that parties did not reach agreement within ten rounds: four times under E-TP and six times under W-TP.

For all situations considered the theoretical prediction is that agreement is reached in the first round (and that opting out does not occur). Obviously, actual outcomes deviate from the theoretical predictions: the average number of rounds needed to reach agreement is well above one. The ranksum tests reveal that under the OO-game agreement is reached significantly sooner when the worker invests than when the employer invests. This holds for each level of the outside wage w (as reported in Table 6) as well as within the group of binding cases and the group of non-binding cases (not reported). The same conclusion holds when $w = 1800$ under the TP-game, but not so when $w = 6800$ or $w = 7800$. In the latter two cases the mean number of bargaining rounds do not vary with the identity of the investor.

In the Appendix we also report the average number of bargaining rounds for the last nine and final three periods separately (cf. Table 10). It is observed that average delay is typically shorter in later periods. Apparently subjects learn to avoid costly delay when they play the game. Result 3 is, however, not seriously affected by this. It is also supported when we consider only the periods 10 to 18 or when we just look at the final three periods.

In Table 6 also other comparisons can be made. On average it takes longer to reach agreement under the TP-game than under the OO-game.²²

²²The theoretical prediction of immediate agreement most often occurred in the W-OO

For the latter bargaining game it holds that when the outside wage is higher, opting out becomes relatively more attractive for the worker. The pressure to reach early agreement is then stronger, resulting in significantly lower mean number of bargaining rounds. This does not apply for the TP-game. There the worker receives his outside wage (divided by 10) in each round of disagreement, such that the private costs of delay are independent of w . Owing to this compensation the worker may perceive it less costly to disagree in the TP-game than in the OO-game, although our experimental setup ensures that the *joint costs* of disagreement are the same in all situations and are independent of the outside wage w . It appears that under the TP-game the average number of bargaining rounds does not vary with w : no significant differences can be found using ranksum tests (5% level).

Results 2 and 3 can be used to evaluate hypothesis *BAR*. The first part of this hypothesis *BAR(a)* receives mixed support. Result 2(a) provides evidence in favor of the employer getting a larger return on the investment in the OO binding situation, Result 3(a) provides evidence against it. Here the employer's larger marginal share of the final agreement and the longer delay when he invests work in opposite directions. Hypothesis *BAR(b)* is rejected, because the speed with which agreement is reached gives the worker a larger return on the specific investment made when the outside option is non-binding.²³ The third part of hypothesis *BAR* receives qualitative support. Although there is some evidence that when the outside wage is low agreement is reached sooner when the worker invests (Result 3(b)), overall the return on the investment indeed seems fairly similar for the worker and the employer.

Closely connected to the evaluation of hypothesis *BAR* is the question of whether observed investment levels can be considered optimal (from the selfish point of view of the investor) given actual bargaining behavior. Our last result of this subsection relates to this.

Result 4. *(a) When the outside wage is low ($w=1800$) under the OO-game the 'optimum' investment level of the employer is below the worker's 'optimum' investment level. (b) In case the outside wage is high (6800 or 7800) this is the other way around. (c) Under the TP-game 'optimum' investment levels are similar for both investor's identities when the outside wage is low ($w=1800$), while in case w is high (6800 or 7800) the 'optimum'*

situation (67%), followed by the E-OO (52%) situation. In E-TP (36%) and W-TP (40%) immediate agreement was less likely.

²³The opting out rates under E-OO (11%) and W-OO ($12\frac{1}{2}\%$) are fairly similar and thus do not affect the relative return on the investment in the two cases.

investment level is higher for the worker.

We estimated regression equations with the investors' net payoffs as dependent variable, and the level of investment and investment squared as independent variables (besides a constant term). In order to control for potential learning effects we included a variable that measures the time that the investor was confronted with the particular outside wage (hence this variable ranges from 1 to 6).²⁴ ²⁵ The 'optimum' levels of investment can be directly obtained from the estimated coefficients. Table 7 reports these 'optimum' investment levels for each treatment considered. In two out of twelve treatments the estimated coefficient for I and I^2 were both negative and insignificant, yielding an optimal investment level of 0.²⁶ This actually corresponds with the theoretical predictions for these two cases.

When $w = 1800$ under the OO-game the selfish worker should invest more than the employer according to our estimates of 'optimum' investment levels. (But note that the standard deviation on the worker's estimated optimum is particularly large.) For $w = 6800$ and $w = 7800$ this is exactly the other way around. When the TP-game applies the estimated optima are always larger for the worker, but the differences are only very minor when the outside wage is low ($w = 1800$). One potential caveat applies. In some of the cases the estimated standard deviations are very large. This suggests that the variance in observed bargaining behavior is that large that it may be of little help in determining the appropriate investment level.

Comparing Result 1 with Result 4 we observe that in four out of six relevant cases (i.e. bargaining game-outside wage combinations) actual bargaining behavior can provide a good explanation for the observed differences between employers' and workers' investment levels. The two exceptions occur when $w = 1800$ under the OO-game and $w = 6800$ under the TP-game. In the first case the outside option of the worker is always non-binding. Theory then predicts that employers and workers should invest the same, while actual bargaining behavior seems to indicate that workers should invest more

²⁴Except for $w = 7800$ under W-OO these time trends were never significant (at the 5% level).

²⁵We 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.

²⁶When we use the negative coefficients to calculate the unconstrained optima, the following 'optimum' investment levels are obtained (both for W-TP): -11.48 when $w = 6800$ and -2.40 when $w = 7800$. The reported standard deviations for these two treatments (Table 7) in fact refer to these unconstrained optima.

Table 7: "Optimum" investment levels

	w	Employer (E)	Worker (W)
OO-game	1800	28.47 (3.62)	34.43 (14.26)
	6800	32.17 (7.96)	0 (33.05)*
	7800	38.07 (5.82)	0 (7.69)*
TP-game	1800	23.90 (5.40)	24.28 (5.95)
	6800	18.04 (11.45)	30.10 (3.95)
	7800	30.25 (5.24)	35.71 (3.17)

Remark: Standard deviations are within parentheses. $n=120$ in all cases. Superscript * indicates that the level is set at the lower border of 0, because the estimated unconstrained optimum is negative. Reported standard deviations refer to these unconstrained optima.

(Result 4(a)). This is not what we observe though. Employers invest more than workers do, albeit not significantly so (Result 1(a)). Given our (admittedly rough) calculations of 'optimum' investment levels we can conclude that employers substantially overinvest from a selfish point of view, while workers underinvest in this case.

The second exception concerns the TP-game when $w = 6800$. From Result 4(c) we can conclude that workers should invest more in this case. We do indeed observe that workers on average invest more (cf. Table 4), but the observed differences lack significance. Given that the differences in average observed investment levels are fairly large (and that the p-values are always below .14), we conclude for this case that actual bargaining behavior can provide a reasonable explanation for employers' and workers' investments.

In case the outside wage is high under the OO-game ($w = 6800$ and $w = 7800$) relative investment levels are in line with actual private returns. Yet our calculations suggest that workers now substantially overinvest from a selfish point of view, whereas employers do only slightly so. These deviations are not substantive enough to alter the relative investment levels from the predicted direction: employers invest significantly more, in line with their higher 'optimum' investment level.

Also under the TP-game the observed differences between investment levels can partly be explained on the basis of the actual private returns on the investment. There workers invest significantly more when the outside wage equals $w = 7800$ (Result 1(b)), in line with the ordering of the 'optimum' investment levels presented in Table 7. The observed differences are, however,

larger than one would expect on the basis of actual private returns. Both the employer and the worker seem to overinvest from a selfish point of view.

Overall we conclude that actual private investment returns can explain a substantial part of observed investment levels. They cannot provide a full explanation though. This suggests that also some other motivations, like fairness and reciprocity (cf. Fehr and Falk 1999), might be at work. The observed overinvestment (from a selfish point of view) by the worker both when w is high under the OO-game and in case the TP-game applies may be due to fairness considerations. In the latter case for instance, the worker is predicted to obtain a larger share of the surplus through the positive threat point w that he has.²⁷ He may therefore invest more than individually rational to make final payoffs more evenly. The substantial overinvestment by the employers observed under the OO-game when w is low cannot be explained in that way though.

4.3 Efficiency

Subgame perfection predicts that there will be no efficiency losses in the bargaining stage. Inefficiencies will be solely due to underinvestment. Our final result concerns actually observed inefficiency.

Result 5. *(a) Under the OO-game investment (bargaining) inefficiencies are smaller (larger) when the employer invests than when the worker invests. Overall inefficiencies are by and large independent of the identity of the investor. (b) Under the TP-game with a high outside wage ($w=7800$) investment inefficiencies are larger when the employer invests. As a result overall inefficiencies are somewhat smaller when the worker invests.*

Table 8 presents the evidence supporting this result. Investment inefficiencies are calculated as the difference between the maximum net surplus achieved at $I = 50$ and actual net surplus of the investment, which is equal to $100 \cdot I - I^2$. Hence the investment inefficiency equals $(50 - I)^2$. Because the loss function is quadratic, the average investment inefficiency exceeds the investment inefficiency at the average investment level. Under the OO-game investment inefficiencies are always significantly smaller when the employer invests. Under the TP-game with $w = 7800$ investment inefficiencies are larger when the employer invests. For lower values of w the investment inefficiencies do not vary significantly with the identity of the investor.

²⁷Interestingly, however, as the regressions results of Table 5 reveal the worker cannot fully exploit the additional bargaining power stemming from his higher threat point.

Table 8: Average efficiency losses

	Employer (E)				Worker (W)		
	w	invest.	bargain.	total	invest.	bargain.	total
OO	1800	^a 429	^e 2148	2577	^a 828	^e 1545	2373
	6800	^b 401	^f 1940	2341	^b 1130	^f 894	2024
	7800	^c 387	1441	^h 1828	^c 1158	1091	^h 2249
	all	^d 406	^g 1843	2249	^d 1039	^g 1177	2206
TP	1800	698	2599	3296	759	1826	2585
	6800	581	2128	2709	470	2065	2536
	7800	ⁱ 642	1983	^j 2625	ⁱ 402	1904	^j 2306
	all	640	2237	^k 2877	544	1932	^k 2476

Remark: Superscripts indicate significant differences at the 5% level (ranksum test). n=120 for each value of w.

Bargaining inefficiencies reflect our earlier findings regarding delay of agreement and opting out, which are the two sources of this type of inefficiency. Under the OO-game bargaining inefficiencies are significantly smaller when the worker invests.²⁸ Under the TP-game average bargaining inefficiencies are also smaller when the worker invests, but the observed differences are not significant according to a ranksum test at the 5% level.

Investment and bargaining inefficiency together yield total inefficiency. Interestingly, not many significant differences are observed between the case where the employer invests and the one in which the worker invests. By and large we can conclude that under the OO-game overall inefficiencies tend to be independent of the investor, while in case the TP-game applies overall inefficiencies are somewhat smaller when the worker invests.

Result 5 provides qualitative support for hypothesis *EFF*. Under the OO-game we do observe that efficiency losses due to suboptimal investment are smaller when the employer invests than when the worker invests, in line with *EFF(a)*. Yet overall observed inefficiencies are not in line with theoretical predictions. For the TP-game we indeed observe few significant differences between the two investor types. Only when $w = 7800$ observed inefficiencies contrast with hypothesis *EFF(b)*. Inefficiencies are then smaller when the worker makes the investment.

²⁸The part of the bargaining inefficiencies that can be attributed to the worker opting out (included in the bargaining inefficiencies in reported in Table 8) does not vary significantly with the identity of the investor. For the E-OO situation the average ‘opting out’ inefficiencies equal 129, 923 and 787 and 613 for w_l , w_m , w_h and all respectively. For W-OO they are equal to 267, 559, 882 and 570.

A final interesting observation that follows from Table 8 is that inefficiencies owing to delayed agreement and opting out are substantial. In all the four situations considered they typically outweigh the investment inefficiencies observed. Bargaining inefficiencies are smallest in the W-OO situation where the investment inefficiencies are the largest. This may point at a potential trade-off between investment and bargaining inefficiency. Theoretically W-OO should perform the worst, because investment inefficiencies are predicted to be the largest. But we observe that bargaining inefficiencies are particularly large in the other three situations considered, causing them to perform even worse than the W-OO case.

5 Conclusion

In this paper we address the question whether the employer or the worker should make the investment in firm specific training. We consider a setting in which only the worker has alternative trading opportunities in the market. Depending on whether this market for alternative jobs operates frictionless (no friction case) or not (turnover costs case), bargaining between the employer and the worker is either modelled as a threat point game or as an outside option bargaining game. Theoretically investment incentives are the same for the employer and the worker when the former case applies. If, however, the outside option bargaining game applies the employer is predicted to have the better investment incentives. He therefore should make the investment from an efficiency point of view.

By and large our results are in line with these predictions. For the turnover costs case we indeed observe that only when the outside wage of the worker is high, employers invests more than workers do. For the no-friction case we obtain the opposite. There workers invest more than employers when the outside wage is high. Actual bargaining outcomes can provide a reasonable explanation for the observed differences between employers' and workers' investment levels. Only when the outside wage is low under the outside option game the observed private returns on the investment made do not justify the observed differences between employers and workers. Overall the observed inefficiencies are remarkably similar across the different situations considered. If anything, they suggest that the employer should make the investment in the turnover costs case, while the worker should invest when the no-friction case applies.

In our experiment either only the employer or only the worker could invest. It would be interesting to study a more general setup in which both parties could invest. It would then be possible to determine whether the

above suggestion that workers (employers) should invest when the market for alternatives does (not) operate frictionless also arises endogenously.

Appendix

In each session subjects played 18 times the two-stage game of Section 2. During the course of the experiment they may have changed their behavior, for instance because over time they learned how to play the game. To make sure that our conclusions are not biased due to ignoring such learning effects, we consider in this Appendix also the data from the last nine and the final three periods separately. The focus is on investment levels (cf. Result 1 and Table 4) and on delay of agreement (cf. Result 3 and Table 6). Recall that in the regressions reported in the main text that lead to Results 2 and 4 we already control for potential learning effects.

The design of the experiment was such that the first and last nine periods included the same frequency of low, intermediate and high levels of the worker's outside wage. Moreover, each value of w was represented exactly once in the final three periods. Tables 9 (investment levels) and 10 (bargaining length) appearing in this Appendix report the same statistics as in Table 4 and 6 of the main text respectively, but now also for the last nine and final three periods separately. The top panels of Table 9 and 10 correspond exactly with the tables presented in the main text (and are included here only for ease of comparison). The middle panels only consider the data from the second half of the experiment, while the bottom panels only use the data from the final three periods.

Table 9 reports average investment levels by treatment. Statistical tests are again based on the average investment levels of individual investors. The results in the middle and bottom panel almost exactly reproduce the results of the top panel. The single difference is that no significant differences (at the 5% level) are found anymore under the TP-game when $w = 7800$. This holds despite the fact that the mean levels over all investors are fairly far apart. Comparing for this particular case ($w = 1800$ under the TP-game) average investment levels across the different panels of Table 9 by means of a Wilcoxon signrank test for matched pairs we find no significant differences when the worker invests (the lowest p-value equals $p = .304$). For the case in which the employer invests the top panel differs significantly from both the middle ($p = .047$) and the bottom panel ($p = .032$). Over time employers thus tend to invest less in this case, while workers do not change their investment behavior. Based on these learning effects, we still conclude that under the TP-game workers invest more than employers when the outside wage is

Table 9: Mean investment levels

	w	Employer (E)		Worker (W)	
OO-game {1-18}	1800	38.7	[25]	28.0	[25]
	6800	^a 37.9	[36]	^a 21.5	[0]
	7800	^b 40.0	[50]	^b 21.9	[0]
	all	^c 38.9	[37]	^c 23.8	[8.3]
TP-game {1-18}	1800	29.9	[25]	30.9	[25]
	6800	32.9	[25]	39.2	[25]
	7800	^d 32.5	[25]	^d 43.5	[25]
	all	31.8	[25]	37.9	[25]
OO-game {10-18}	1800	33.8	[25]	25.7	[25]
	6800	^e 36.5	[36]	^e 18.9	[0]
	7800	^f 40.3	[50]	^f 19.7	[0]
	all	^g 36.9	[37]	^g 21.4	[8.3]
TP-game {10-18}	1800	28.7	[25]	29.4	[25]
	6800	32.3	[25]	40.7	[25]
	7800	31.0	[25]	41.0	[25]
	all	30.7	[25]	37.0	[25]
OO-game {16-18}	1800	34.9	[25]	24.6	[25]
	6800	^h 37.4	[36]	^h 19.2	[0]
	7800	ⁱ 42.4	[50]	ⁱ 20.1	[0]
	all	^j 38.2	[37]	^j 21.3	[8.3]
TP-game {16-18}	1800	29.7	[25]	30.3	[25]
	6800	32.9	[25]	40.0	[25]
	7800	29.7	[25]	41.5	[25]
	all	30.8	[25]	37.3	[25]

Remark: Superscripts indicate significant differences at the 5% level (ranksum test; n=20 per treatment). Theoretically predicted investment levels are within square brackets. Periods considered are within curly brackets.

high.²⁹

As an additional test of learning effects we regressed for each of the twelve treatments the investment levels on a variable which measures the time that the investor was confronted with this particular value of the outside wage (hence this variable ranges from 1 to 6) besides a constant term. Only in two treatments this time trend had a statistically significant (negative) coefficient: the case where $w = 1800$ under E-OO and the case where $w = 6800$ under W-OO. As can be seen from the results in Table 9, however, the differences in overall mean investment levels for both these treatments in the three panels are small (and they display a non-monotonic pattern). Taking all the above results together, we conclude that Result 1 on investment behavior is not contaminated by learning effects.

Table 10 presents for each treatment the average number of bargaining rounds before agreement is reached. Within parentheses are the number of observations on which these averages are based. Observations in which one of the parties opted out (OO-game) or no agreement was reached are left out. Comparing the middle with the top panel it is observed that average delay before agreement is typically shorter in the second half than in the first half of the experiment. This follows because in almost all treatments the average number of bargaining rounds before agreement is reached decreases compared to the overall mean when we take only the last nine periods into account (the two exceptions occur when $w = 6800$ under E-OO and W-TP). Apparently subjects learn to avoid costly delay when they play the game. Result 3 on delay of agreement is, however, not seriously affected by this. It is fully supported when we consider only the periods 10 to 18.³⁰ For the final three periods the same type of differences are found, yet not all of them are significant. But also there we observe that overall agreement is reached sooner under the OO-game when the worker invests. In case of the TP-game there are no significant differences, although when $w = 1800$ the overall observed mean bargaining length (before agreement) is substantially larger when the employer invests than when the worker invests.

²⁹An explanation for why we do not get significant results at the 5% level in the middle and bottom panel is that the averages used there are based on fewer (3 and 1 respectively) observations and thus are more noisy. Assume that each investor has a private inclination for a certain behavior. Actual behavior is determined by this inclination and some 'noise' or errors. The average behavior of the investor is an estimation of that individual inclination. More observations per individual means a better measurement of these inclinations, and so a better quality of the data used in the test. Although the test itself is independent of how many observations are included in the average, the power of the test increases if more data per individual is used.

³⁰The p-value of the ranksum test comparing E-OO with W-OO for $w = 1800$ equals $p = .060$, close to significance at the 5% level.

Table 10: Mean number of rounds before agreement

	w	Employer (E)	Worker (W)
OO-game {1-18}	1800	^a 2.39 (118)	^a 1.85 (115)
	6800	^b 1.60 (101)	^b 1.27 (105)
	7800	^c 1.36 (102)	^c 1.15 (95)
	all	^d 1.82 (321)	^d 1.44 (315)
TP-game {1-18}	1800	^e 2.85 (118)	^e 2.23 (118)
	6800	2.44 (118)	2.34 (118)
	7800	2.49 (120)	2.19 (118)
	all	2.59 (356)	2.25 (354)
OO-game {10-18}	1800	2.30 (60)	1.81 (57)
	6800	^f 1.65 (54)	^f 1.13 (53)
	7800	^g 1.30 (54)	^g 1.04 (52)
	all	^h 1.77 (168)	^h 1.34 (162)
TP-game {10-18}	1800	ⁱ 2.61 (59)	ⁱ 1.92 (59)
	6800	2.33 (60)	2.42 (59)
	7800	2.43 (60)	2.07 (59)
	all	2.46 (179)	2.14 (177)
OO-game {16-18}	1800	2.25 (20)	1.37 (19)
	6800	^j 1.94 (18)	^j 1.11 (18)
	7800	1.18 (17)	1.06 (18)
	all	^k 1.82 (55)	^k 1.18 (55)
TP-game {16-18}	1800	2.95 (20)	1.75 (20)
	6800	2.45 (20)	2.3 (20)
	7800	2.45 (20)	1.75 (20)
	all	2.62 (60)	1.93 (60)

Remark: Number of observations are within parentheses. Superscripts indicate significant differences at the 5% level (ranksum test). Periods considered are within curly brackets.

References

- Acemoglu, D. and J.-F. Pischke (1998). Who do firms train? Theory and evidence. *Quarterly Journal of Economics* 113, 79–119.
- Acemoglu, D. and J.-F. Pischke (1999). The structure of wages and investment in general training. *Journal of Political Economy* 107, 539–572.
- Becker, G. (1962). Investment in human capital: a theoretical analysis. *Journal of Political Economy* 70, S9–S49.
- Binmore, K., C. Proulx, L. Samuelson, and J. Swierbinski (1998). Hard bargains and lost opportunities. *Economic Journal* 108, 1279–1298.
- Binmore, K., A. Shaked, and J. Sutton (1989). An outside option experiment. *Quarterly Journal of Economics* 104, 753–770.
- Fehr, E. and A. Falk (1999). Wage rigidity in a competitive incomplete contract market. *Journal of Political Economy* 107, 106–134.
- Grout, P. (1984). Investment and wages in the absence of binding contracts: a nash bargaining approach. *Econometrica* 52, 449–460.
- Hashimoto, M. (1981). Firm-specific human capital as shared investment. *American Economic Review* 71, 475–482.
- Kessler, A. and C. Lülfesmann (2000). The theory of human capital revisited: on the interaction of general and specific investments. CEPR Discussion paper no. 2533.
- Leuven, E. and H. Oosterbeek (2001). Firm specific human capital as a shared investment: comment. forthcoming in: *American Economic Review*.
- MacLeod, W. and J. Malcomson (1993a). Investment, holdup and the form of market contracts. *American Economic Review* 83, 811–837.
- MacLeod, W. and J. Malcomson (1993b). Specific investment and wage profiles in labour markets. *European Economic Review* 37, 343–354.
- Malcomson, J. (1997). Contracts, holdup, and labor markets. *Journal of Economic Literature* 35, 1916–1957.
- Malcomson, J. (1999). *Individual employment contracts*, Volume 3 of *Handbook of Labor Economics*, Chapter 35, pp. 2391–2372. North Holland.
- Manzini, P. (1998). Game-theoretic models of wage bargaining. *Journal of Economic Surveys* 12, 1–41.

- Sloof, R. (2000). Finite horizon bargaining with outside options and threat points. Working paper, downloadable from: <http://www.fee.uva.nl/scholar/mdw/sloof/>.
- Sloof, R., J. Sonnemans, and H. Oosterbeek (2000). Specific investments, holdup, and the outside option principle: An experimental study. Scholar working paper series WP 08/00, downloadable from: <http://www.fee.uva.nl/scholar/mdw/sloof/>.
- Sonnemans, J., H. Oosterbeek, and R. Sloof (2000). On the relation between asset ownership and specific investments. forthcoming in: *Economic Journal*.

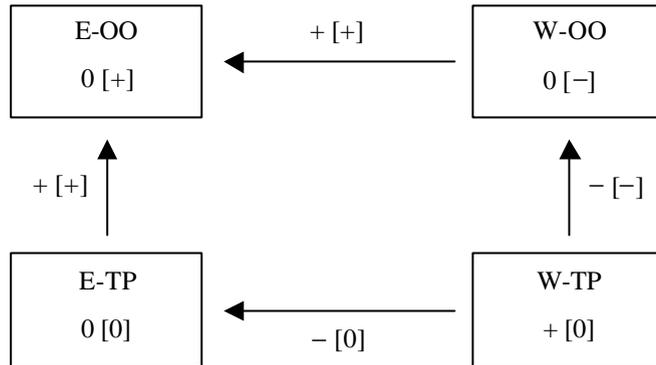


Figure 1: Overall observed variations in investment levels.

Remark: Within each box comparative statics results obtained for that situation (cf. Table 1) are reported. A + sign indicates that investment levels significantly increase with the outside wage w etc. Predictions are within square brackets. The arrows connecting the boxes correspond to comparisons of investment levels across different situations for a fixed w . A + sign indicates a significant increase in investment levels when we go in the direction of the arrow. Again predictions are in square brackets.