Who should invest in firm specific training?

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Abstract

We study experimentally whether employers or workers should invest in firm specific training. Workers have an alternative trading opportunity that either takes the form of an outside option or of a threat point. Theory predicts that with outside options employers have (weakly) better investment incentives than workers and should therefore be the investing party. With threat points employers and workers are predicted to invest the same. Our results are by and large in line with these predictions. Due to offsetting inefficiencies in the bargaining stage, however, realized inefficiencies are remarkably similar across the different situations considered.

1 Introduction

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

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[1] In 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 Lülfesmann 2000).

When training is not completely general, however, 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 only possible when investments are contractible. Typically, however, investments in training are not verifiable for a third party like a court.[2] In that case training investments are non-contractible and explicit cost sharing becomes cumbersome, if not impossible. But when a single party has to bear the full costs of training, underinvestment due to holdup is rather likely. This occurs when the investor cannot capture the full return on his specific investment. 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.[3] In this paper we investigate this by means of a series of experiments.

We consider a setting in which explicit cost sharing is not possible. As in Kessler and Lülfesmann (2000) and MacLeod and Malcomson (1993a), it is assumed that either the employer or the worker decides how much to invest in specific training and bears the full costs of it. 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 parties' alternative trading opportunities. Employers' alternative trading opportunities are normalized to zero, reflecting a competitive external labor market. A worker's alternative opportunity consists of working for a different employer at a fixed outside wage. Because training is assumed to be firm specific, this outside wage is independent of the investment made.

The theoretical literature models alternative trading opportunities in bargaining situations in two different ways. First, they has been modeled as *outside options*. The underlying assumption is that the worker can unilaterally quit the bargaining with the original employer, in order to take up an alter-

[2] See 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."

[3] The 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...". Incidently, this justifies our focus on settings in which only one of the parties invests.

native employment opportunity. If the worker opts out, he cannot return to the bargaining with his original employer. If alternative opportunities take 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 can be modeled as a *threat point*. The underlying assumption is then 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.

Whether workers' alternative employment opportunities should be modeled as threat points or as outside options is not always clear cut and depends on the situation considered. Some authors incorporate them as threat points (cf. Grout 1984), others 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 the experiment we consider both forms of alternative opportunities. We thus consider two different bargaining games: the outside option bargaining game and the threat point bargaining game. The experiment also considers both the case where the employer invests and the one in which the worker invests. The main focus is on the comparison of the investment levels of employers and workers for a given bargaining game.[4] In particular, given external market conditions (i.e. no-frictions or turnover costs), we investigate 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 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 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.

[4] Two related papers focus on the effect of the value of alternative opportunities on the level of investment. Sloof et al. (2000) examine the situation where the non-investing party has alternative opportunities, Sonnemans et al. (2001) consider the situation in which the investor has alternative opportunities. Some of the data used in the current paper have also been analyzed in Sonnemans et al. (2001).

2 The model

2.1 Basic setup of the model

Consider a labor relationship between an employer and a worker. Their interaction can be described as a nested bargaining game with advance production.[5] It has the following setup (cf. Malcomson 1997, 1999):

1. *Investment stage.* Either the employer (E) or the worker (W) makes a specific investment $I \in \{0, 1, 2, .., 100\}$. Investment costs equal $C(I) = I^2$ and are immediately borne 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 worker's outside wage equals $w \in \{w_l, w_m, w_h\} \equiv \{1800, 6800, 7800\}$.

Gross surplus is linear in the investment and equals $R(I) = V + 100 \cdot I$. Although the value of V is in itself not very important, 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 games: $V^{OO} = 10,000$ 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. It can easily be shown that under the TP-game investment incentives are not affected by the value of V (cf. Subsections 2.2 and 2.3).

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

[5] In 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 sunk 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.

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

thus equals $V + 100 \cdot I - I^2$. It follows that the efficient level of investment equals $I^* = 50$.

The above description reveals that four different situations are considered, which differ by the identity of the investor and the type of bargaining game. Table 1 gives the abbreviations we use to refer to each of these four situations. The different bargaining games yield different equilibrium divisions of the surplus. As these equilibrium divisions feed back into the investment stage, equilibrium investment levels will be different for the various situations considered. The next two subsections describe this in further detail.

2.2 Equilibrium bargaining outcomes

In the OO-game the employer and the worker alternate in making offers about how to divide the joint surplus. If one party makes an offer, the other party can react in *three* 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 a party opts out, the employer receives nothing and the worker receives his outside wage w. After opting out parties cannot return to the bargaining table.

In the TP-game parties also make alternating offers. The important difference is that the responder can now react in only *two* ways: accept the offer or disagree and formulate a counteroffer. Opting out is not possible. 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 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,[6] unless this yields the worker less than his outside wage. In that case he just obtains a share of the surplus equal to w, while the employer gets the remaining

[6] The 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)	$\frac{1}{2} \cdot (R(I) - w)$	$\frac{1}{2} \cdot (R(I) + w)$

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).

The equilibrium prediction for the TP-game 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-difference' solution (STD).[7]

The equilibrium predictions under the two bargaining games are summarized in Table 2. In the TP-game neither party ever becomes residual claimant. No party thus obtains the incentives to invest efficiently. 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 investment and has the right incentives to invest. The worker never becomes residual claimant under the OO-game.

2.3 Equilibrium investment levels

Anticipating the equilibrium shares in Table 2, the investor invests the amount that maximizes his net payoffs. The equilibrium investment level depends on the identity of the investor and on the bargaining game that applies. Table 3 presents the predicted investment levels in the four situations.[8]

In the E-OO situation three relevant ranges for the outside wage w can be distinguished. 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

[7] Owing to our specification of $R(I) = 10,000 + w + 100 \cdot I$ 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.

[8] The 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)
	1800	25	25
OO-game	6800	36	0
	7800	50	0
	all	37	$8\frac{1}{3}$
	1800	25	25
TP-game	6800	25	25
	7800	25	25
	all	25	25

Remark: The efficient investment level equals 50.

w is on the verge of becoming binding. In this case the equilibrium level of investment equalizes $\frac{1}{2} \cdot R(I)$ and w; $w_m = 6800$ belongs to this range.

This 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 just 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 one. 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. Due to the 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 is on which party should make the 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 does so. The corresponding hypotheses are summarized below.

The predictions concerning investment levels are guided by those regarding bargaining outcomes. We therefore also want to test these latter predictions. In particular, we want to relate the different investment levels of the employer and the worker to the 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 then 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, giving 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 27 Euro's in about two and a half hours.

In each session subjects played the two-stage game described in the previous section 18 times (periods) in a row. Half of the subjects performed the role of employer, the other half were assigned the role of worker. Subjects kept the same role during the whole session. To rule out reputational considerations subjects were in each period anonymously paired, 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 neutrally.

Like in Binmore et al. (1998) the three different values of the outside wage w were considered within each session.[9] In each session we used the same ordering of w's over the 18 periods. Each of the three values of w occured 3 times in the first block of 9 periods, and 3 times in the second block of 9 periods. 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 informed about the relevant value of w.

We provided subjects with an initial endowment. Employers received 60,000 points at the beginning of the experiment, workers received 10,000 points. The conversion rate was 1 euro for 5500 points. Endowments were used to provide investors with funds to invest in the first periods. 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 treatments 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.[10] The employer always made the first offer, and thus could 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 round 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.

[9] A 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.

[10] In 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.

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 $\frac{w}{10}$. (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, subjects bargained over the division of the ten actual round pies as described above.

4 Results

The presentation of our findings follows the three hypotheses formulated in Subsection 2.4. In three subsections we 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.[11] We have therefore pooled the observations from sessions that consider the same treatment.

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 invests significantly more than the worker when the outside wage is intermediate or high (w=6800 or w=7800), but not when the outside wage is low (w=1800). (b) Under the TP-game the worker invests significantly more than the employer when the outside wage is high (w=7800), but not when the outside wage is low or intermediate (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).[12] In 4 out of 8 cases average investment levels of employers differ significantly from those of workers. Under the OO-game employers typically invest significantly more than workers do. Only when $w = 1800$ such that

[11] Twelve 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.

[12] Recall 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.

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.

the outside wage never binds the observed difference is not significant at the 5% level. For the TP-game an opposite conclusion holds. 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.

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 deviate from theoretical predictions only when the outside wage is high ($w = 7800$). Here no significant differences were expected, but in practice workers 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 totally 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 analyzed the data from the last nine and the final three periods separately. A full discussion can be found in the Appendix. The results reported there indicate 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. This also holds for the E-TP situation. But for W-TP we observe that workers' investment levels are increasing in the outside wage w.[13] The observed comparative statics for the E-OO situation suggest 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 in w for the W-OO situation strengthen this conclusion: they also reject the predicted relationship between investment incentives and the outside option principle.[14]

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. These results are in line with theoretical predictions.

4.2 Bargaining outcomes

The investor's actual return on investment is determined by the offers finally accepted and the actual number of bargaining rounds. This subsection presents results on these two aspects. Our main focus is on whether observed investment levels are optimal – from the selfish point of view of the investor – given actual bargaining behavior.

When the bargaining stage starts investment costs are sunk. Subgame perfection then predicts that the bargaining outcome is independent of the identity of the investor. In case 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 worker's outside option 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*

[13] Since these comparisons are not the main focus of the paper, we have suppressed symbols indicating results from these statistical tests in Table 4.

[14] The experiment reported in Sloof et al. (2000) provides an explanation for these findings. There it is found that a self-serving bias induces investors to overlook the difference between a binding and a non-binding outside option when making their investment decision.

investment that is independent of the investor's identity. (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. Time trend t controls 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. Because the regressions are based on multiple observations per subject, we calculated robust standard errors that take this into account.

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.[15] This is apparently not the case, because the estimated coefficient on I is significantly 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 both the OO-game with a non-binding outside wage and the TP-game it is predicted 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 columns of Table 5 the estimated coefficients for I exceed one half. The investor gets a return of about $65 - 70\%$ on investment. But as theory predicts, the employer and the worker get an equal return: the coefficients on $I \cdot D_W$ are not significantly different from zero in both cases.

[15] Formally 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]	.549 [.5]	.436 [.5]
	(.084)**	(.028)**	(.020)**
$V \cdot D_W$	$-$.770 [$-$1]	$-$.036 [0]	.127 [0]
	(.095)**	(.026)	(.026)**
I	.852 [1]	.719 [.5]	.653 [.5]
	(.070)**	(.074)**	(.044)**
$I \cdot D_W$	$-$.613 [$-$1]	$-$.016 [0]	.039 [0]
	(.079)**	(.083)	(.104)
w	$-$.825 [$-$1]	$-$.335 [0]	$-$.164 [$-$.5]
	(.111)**	(.046)**	(.038)**
$w \cdot D_W$	1.78 [2]	.439 [0]	.221 [1]
	(.129)**	(.055)**	(.042)
t	$-$1.47 [0]	$-$2.46 [0]	$-$.507 [0]
	(1.03)	(1.19)*	(.894)
n	293	343	710
adj. R^2	.910	.666	.988

Remark: Numbers within square brackets refer to the predicted coefficients. Robust standard errors (in parentheses) take account of correlated disturbance terms of multiple observations per subject. Significant coefficients at the 1% level (5% level) are marked with a * ().

Other interesting observations follow from Table 5.[16] 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 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 ($= 1.78 - .825$) and is not signficantly different from the predicted net coefficient of 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 (weak) learning occurs only in the OO non-binding situation. Here the investors' finally accepted shares decrease during the course of the experiment. Even for this bargaining situation, however, the other coefficients are almost identical whether a time trend is included or not.

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. In parentheses are the numbers of observations on which these averages are based. These numbers differ from the maximum of 120 (360 for all) due to opting out (in the OO-game) and no agreement (in the TP-game).

[16] Instead 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 (5% level) in OO non-binding and the TP game. 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)
	1800	^{a}2.39 (118)	^{a}1.85 (115)
OO-game	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)
	1800	^{e}2.85 (118)	^{e}2.23 (118)
TP-game	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).

Theory predicts that agreement is always reached immediately (in the first round) and that opting out does not occur. Actual outcomes deviate from these predictions: the average number of rounds needed to reach agreement is well above one and opting out does occur. For each level of the outside wage w, ranksum tests reveal that under the OO-game agreement is reached significantly sooner when the worker invests than when the employer invests. The same holds for the TP-game when $w = 1800$, but not when $w = 6800$ or $w = 7800$. In the latter cases the mean number of bargaining rounds do not vary with the identity of the investor.[17]

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 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 investment when the outside option is non-binding.[18] The third part of hypothesis BAR receives qualitative support. Although there is some

[17]The Appendix reports the average number of bargaining rounds for the last nine and final three periods separately (cf. Table 10). Average delay is typically shorter in later periods. Apparently subjects learn to avoid costly delay. Result 3 is, however, not affected by this. It is supported when we consider only the periods 10 to 18 or when we just look at the final three periods.

[18]The 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.

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 whether observed investment levels are optimal (from a selfish point of view) given actual bargaining behavior. The 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 investors when the outside wage is low (w=1800), while in case w is high (6800 or 7800) the 'optimum' 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. 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).[19] The 'optimum' levels of investment can be directly obtained from the estimated coefficients. Table 7 reports these 'optimum' investment levels, along with their standard errors.[20] 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.[21] 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 error 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, although the differences are very minor when the outside wage is low ($w = 1800$). One potential caveat applies. In some of the cases the

[19] Except for $w = 7800$ under W-OO and $w = 1800$ under W-TP these time trends were never significant (at the 5% level).

[20] We again calculated robust standard errors that take account of correlated disturbance terms of multiple observations per subject.

[21] When 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 robust standard errors 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 (3.56)	34.43 (13.04)
	6800	32.17 (5.23)	0 (24.50)*
	7800	38.07 (4.28)	0 (5.46)*
TP-game	1800	23.90 (4.76)	24.28 (7.60)
	6800	18.04 (7.68)	30.10 (3.52)
	7800	30.25 (3.42)	35.71 (2.51)

Remark: Robust standard errors (in parentheses) correct for multiple observations per subject. 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 errors refer to these unconstrained optima.

estimated standard errors are rather high. This suggests that the variance in observed bargaining behavior is so large that it is of little help in determining the appropriate investment level.

Comparing Results 1 and 4 we observe that in four out of six relevant cases (i.e. bargaining game-outside wage combinations) actual bargaining behavior can explain differences between employers' and workers' actual investment levels. The first exception occurs when $w = 1800$ under the OO-game. In this case the worker's outside option is always non-binding. Theory then predicts that employers and workers invest the same, while actual bargaining behavior seems to indicate that workers should invest more (Result 4(a)). This is not what we observe though. Employers invest more than workers do, albeit not significantly so (Result 1(a)). Given the calculated 'optimum' investment levels we 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 difference lacks 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, somewhat 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.[22] Overall we conclude that actual private investment returns can explain observed investment patterns reasonably well.

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 actual inefficiency.

Result 5. *(a) Under the OO-game investment (bargaining) inefficiencies are smaller (larger) when the employer invests than when the worker invests. Total 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 for this result. Investment inefficiencies are calculated as the difference between the maximum net surplus of 2500 achieved at $I = 50$ and actual net surplus of the investment made, which is equal to $100 \cdot I - I^2$. 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.

[22] One possible explanation for the observed over-investment is the presence of self-serving biases. Both employers and workers may have a self-serving assessment of what is a fair or reasonable return on investment. Some experimental evidence that such self-serving biases can indeed explain over-investment is provided by Sloof, Sonnemans, and Oosterbeek (2000) and Sloof (2003).

Table 8: Average efficiency losses

	w	Employer (E) invest.	Employer (E) bargain.	Employer (E) total	Worker (W) invest.	Worker (W) bargain.	Worker (W) 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.[23] Under the TP-game average bargaining inefficiencies are also smaller when the worker invests, but the observed differences are not significant at the 5% level.

Investment and bargaining inefficiency together yield total inefficiency. Interestingly, not many significant differences are observed between different investor's identities. 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)*. But 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.

[23]The part of the bargaining inefficiencies that can be attributed to the worker opting out (included in the bargaining inefficiencies 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 treatments bargaining inefficiencies typically outweigh investment inefficiencies. Bargaining inefficiencies are smallest in the W-OO situation where the investment inefficiencies are the largest. This points to a potential tradeoff between investment and bargaining inefficiency. Theoretically W-OO should perform worst because investment inefficiencies are predicted to be the largest. In practice 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 an investment in firm specific training. We consider a setting in which only the worker has alternative trading opportunities in the market. Depending on whether the 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.

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Appendix: learning effects

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) below report the same statistics as in Table 4 and 6 of the main text, 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. 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 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 (i.e. $w = 7800$ under the TP-game) average investment levels across the different panels of Table 9 by means of a Wilcoxon signrank test 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

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.

employers when the outside wage is high.[24]

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 (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 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 checks 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 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 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.[25] For the final three periods the same type of differences are found, although 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, in line with Result 3(b).

[24] An 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 personal 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.

[25] The 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.