Long–Term Work Contracts versus Sequential Spot Markets: Experimental Evidence on Firm–Specific Investment*

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Abstract

The length of work contracts may be irrelevant for firm-specific investment if rational behavior generates endogenous job security. In an experiment we implement such a situation and study actual investment behavior. In contrast to the game-theoretic prediction, we find reduced investment in case of short-term contracting compared to long-term contracting. This is due to non-equilibrium behavior which generates a substantial risk of unemployment if contracts are short-term. Since the effect of non-equilibrium behavior differs between institutions, the length of contract is in fact relevant for firm-specific investment.

1. Introduction

Investments into firm-specific skills of workers are costly and induce uncertain future returns, which are lost if the work contract terminates. Consequently neither the employer nor the worker might be willing to invest in the first place. This is a version of the well–known hold–up problem: As returns on relation–

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specific investments are lost if one party terminates the relationship, the other party reduces investment.[1]

Consider the case where it is the worker who undertakes the relevant investment, for example he learns to operate a particular machine or develops a good relationship with colleagues or clients. In these instances, the hold-up problem can be avoided by the provision of job security, e.g. through a long-term work contract. Job security is also influenced by explicit dismissal rules as well as social norms such as "no discharge without cause", governing termination of many employment relations in the U.S. While job security may increase efficiency due to larger investments into firm–specific human capital[2], it may also lead to lower work effort of employees ("shirking").[3] Furthermore, there might be situations where job security does not solve the investment problem[4] or where the same level of investment may be achieved by sequential short–term contracts. The latter holds if the employer (the principal) benefits from the worker's firm–specific investment via rent sharing.[5] MacLeod and Malcomson (1989) demonstrate that an implicit contract providing job security for the worker is self-enforcing if the rent from the relationship is large enough. This suggests that job security may be irrelevant for firm–specific investments and that the design of labor market institutions may be guided solely by other considerations (e.g. to reduce shirking).

However, these conclusions derive from theoretical models that rely on perfectly rational individuals. If actual behavior differs from theoretically assumed behavior, the conclusions may be invalid. Specifically, labor market institutions may differ systematically with respect to non-equilibrium behavior and economic policy analyses should take this into account. Our study is based on these intuitive arguments. Within a laboratory experiment we investigate and compare the effectiveness of long-term contracts and sequential short-term contracts in inducing firm-specific investment. The experimental game is designed such that with perfectly rational agents both types of contracts provide the same investment incentives. But they differ with respect to non-equilibrium choices. Non-equilibrium choices increase the risk of unemployment when the contract is short-term. We show that this risk is substantial, but it is not large enough to solely account for the observed underinvestment. The data rather reveal that players hold too pessimistic beliefs about the risk of unemployment, which reduces investment incentives even further.

Job security has also been investigated using cross-country data. Most studies focus on the influence of employment protection legislation on unemployment and

[1] For a general description of the hold-up problem see e.g., Milgrom and Roberts (1992), p.136 ff.

[2] For instance, Rock and Wachter (1996) stress this point with respect to the rule "no discharge without cause".

[3] A theoretical model based on the disciplining effect of unemployment is e.g., Shapiro and Stiglitz (1984).

[4] See Lazear (1988) for a model along these lines.

[5] See Becker (1964) for a discussion of human capital formation and rent sharing.

turnover.[6] Very few studies consider the impact of (endogenous) job security on firm productivity[7], and we are not aware of any study trying to measure the impact of contract length on firm-specific skill formation by workers. This lack of empirical data might be due to difficulties in measuring firm–specific investment in natural environments. The experimental laboratory, however, allows for such measurement.

The paper proceeds as follows: The next section introduces the model and characterizes the equilibrium. In section 3 the experimental design is described. In sections 4 to 6 we present the data and state our key findings as Results 1 to 4. Section 7 provides a discussion and some concluding remarks.

2. Theory

2.1. The Game

Before presenting the model in detail, we briefly outline the economic situation we have in mind. Consider a firm owner P (principal) who plans to employ a worker for up to two periods. She may offer a work contract with one–period duration $\tau = S$ (short–term contract) or two–period duration $\tau = L$ (long–term contract). P's offer is announced to two competing workers (A and B) who simultaneously submit wage bids. P may select one of the workers or none to work for one or two periods depending on the contract duration. In case P has chosen a short–term contract, a new round of wage bidding occurs at the beginning of period 2. In each period the employed worker produces output y (which is collected by P) and earns his wage bid minus production cost, while the non–employed worker earns an outside option wage (e.g., the market wage or unemployment benefits).

A crucial feature of the game is that the employed worker can make a firm–specific investment. Investment is costly and reduces the worker's production cost in the current and all future periods. Firm–specificity is reflected by the fact that the investment does not influence the outside option wage. The parameters of the model are chosen such that investment is not optimal if the worker is employed only for a single period, since investment costs are higher than the current (one–period) cost reduction. But if the worker is employed for another period, the cost reduction from both periods more than offsets the investment cost. This set–up allows us to investigate our main research question, namely whether the

[6]Lazear (1990) reports negative effects of job security provisions on employment. On the other hand, theoretical and data analysis as well as simulations by Bertola (1990) and Bentolila and Bertola (1990) suggest that employment need not be lower on average in countries with strict employment protection and dismissal rules. Even evidence regarding turnover under different regimes is not clear. Boeri (1998) finds more turnover in countries with strong firing restrictions than in less regulated countries which he explains by job–to–job changes.

[7]For a study on productivity effects see Ichniowski et al. (1997). They find that job security in combination with a whole cluster of complementary human resource management practices (such as incentive pay, teams, training etc.) increases productivity in the steel industry.

worker's willingness to choose firm–specific investment is sensitive to the length of the work contract.

The structure of the game is summarized in Figure 1.

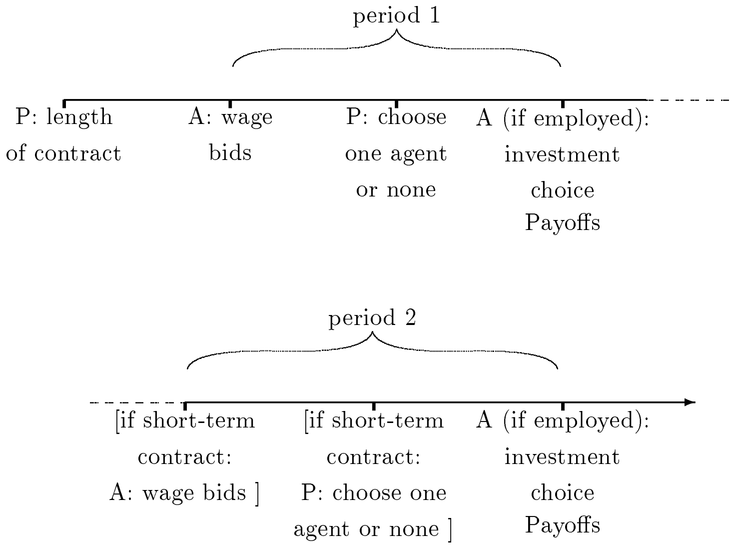

Figure 1: Time line of the game

In the following we describe the game in detail including the numerical specifications of the parameters applied in the experiment.

Stage 1: [Contract duration]. P chooses either $\tau = S$ or $\tau = L$. This is announced to both agents.

Stage 2: [Wage bidding, period 1]. A and B are informed about the contract length and simultaneously submit wage bids $w_{i,1}^{\tau}$ ($i = A, B$ and $\tau \in \{S, L\}$) with

$$w_{i,1}^{\tau} \in \{0, 1, ..., 27\}$$

where $w_{i,1}^{\tau}$ represents agent i's wage bid for period 1, given the contract duration τ. If $\tau = L$, i's bid $w_{i,1}^{\tau}$ holds for both periods; i.e. by definition $w_{i,2}^{L} \equiv w_{i,1}^{L}$. The wage bids are announced to P, but the agent is not informed about the other agent's bid.

Stage 3: [Selection among agents, period 1]. P chooses whether to employ A or B or neither of them. If $\tau = S$, this determines employment for period 1. If $\tau = L$, P's decision holds for both periods. The unemployed worker(s) (called 'outsider(s)'in the following) earn(s) a reservation wage of $\bar{w} \equiv 4$ per period. If no agent is employed, P earns an outside option profit $\bar{\pi} \equiv 2$ per period. Each agent learns whether he or the other agent or neither of them was chosen.

Stage 4: [Firm–specific investment, period 1]. The production costs of the employed worker (called 'incumbent' in the following) are $d \equiv 8$. He can make a firm-specific investment which reduces his current and subsequent production cost by the amount $s \equiv 4$. Let $\delta_{i,1} = 1$ ($\delta_{i,1} = 0$) indicate that i invested (did not invest) in period 1. The investment itself costs αs with $\alpha \equiv \frac{3}{2}$. Thus, the incumbent's cost function in period 1 is

$$\begin{aligned} c_1(\delta_{i,1}) &= d + \delta_{i,1} s\alpha - \delta_{i,1} s \\ &= d - \delta_{i,1} s(1-\alpha) \\ &= 8 + 2\delta_{i,1}. \end{aligned}$$

The principal learns whether the worker invested or not, but the unemployed worker is not informed about the other worker's investment decision.

The investment choice completes period 1. The employed agent earns his wage bid minus his production cost. The principal receives output (return) $y \equiv 18$ minus the wage paid to the employed worker. If no agent was employed, output is 0.

Stage 5: [Wage bidding, period 2]. If $\tau = S$, A and B submit wage bids $w_{i,2}^S$

$$w_{i,1}^S \in \{0, 1, ..., 27\}$$

($i = A, B$). If $\tau = L$, no wage bidding occurs; as explained above, second period wages are $w_{i,2}^L \equiv w_{i,1}^L$. The principal is informed about the two bids, but no agent is informed about the other agent's bid.

Stage 6: [Selection among agents, period 2]. If $\tau = S$, P chooses whether to employ A or B or neither of them. If $\tau = L$, no selection among agents occurs, since employment was determined in period 1. The outsider(s) earn(s) $\bar{w}$. If no agent is employed, P earns $\bar{\pi}$. Again, each agent learns whether he or the other agent or neither of them was chosen.

Stage 7: [Firm–specific investment, period 2]. The incumbent worker decides whether to invest or not, $\delta_{i,2} = 1$ or $\delta_{i,2} = 0$. Investment reduces his current production cost by s and costs αs with $\alpha = 3/2$. So far, this is analogous to period 1. But note that if the worker was already employed in period 1, he may have invested in period 1 already. Accordingly, the cost function for period 2 of agent i depends not only on his current investment decision $\delta_{i,2}$, but also on his first period investment decision $\delta_{i,1}$. To simplify notation we set $\delta_{i,j} = 0$ if agent i is unemployed in period j. Then, the period 2 cost function of the incumbent, $c_2(\delta_{i,2})$, can be written as follows:

$$\begin{aligned} c_2(\delta_{i,2}) &= (d - \delta_{i,1} s) + \delta_{i,2} s\alpha - \delta_{i,2} s \qquad (2.1) \\ &= (d - \delta_{i,1} s) - \delta_{i,2} s(1-\alpha) \\ &= (8 - \delta_{i,1} 4) + 2\delta_{i,2}. \end{aligned}$$

Note that in the first line on the right–hand side of this equation the term in parentheses is the period-2 production cost before period-2 investment. It is d minus the cost reduction induced via period-1 investment, where the latter is zero in case i did not invest or was unemployed in period 1. Finally, the period-2 investment cost and its cost reduction are added.
As in period 1, only the principal but not the outsider knows whether the incumbent invested or not.

The investment choice completes period 2. The employed agent i earns $w^{\tau}_{i,2} - c_2(\delta_{i,2})$ and P earns $y - w^{\tau}_{i,2}$ in period 2. If no agent was employed, output is 0. In order to describe the two–period payoff functions of all players, let $\gamma_{i,t} = 1$ ($\gamma_{i,t} = 0$) indicate that worker i was employed (not employed) by P in period t. Then the two–period payoff functions are given by:

$$\begin{aligned}\Pi^{\tau}_{i} &= \sum_{t=1}^{2} \gamma_{i,t} \left(w^{\tau}_{i,t} - c_t(\delta_{i,t}) \right) + \sum_{t=1}^{2} \left(1 - \gamma_{i,t} \right) \bar{w} \quad \text{for } i = A, B, \text{ and} \\ \Pi^{\tau}_{P} &= \sum_{t=1}^{2} \gamma_{A,t} \left(y - w^{\tau}_{A,t} \right) + \sum_{t=1}^{2} \gamma_{B,t} \left(y - w^{\tau}_{B,t} \right) + \sum_{t=1}^{2} \left(1 - \gamma_{A,t} - \gamma_{B,t} \right) \bar{\pi}\end{aligned}$$

where $\tau = S, L$ and $\gamma_{A,t}$ and $\gamma_{B,t}$ cannot both be 1 for the same period t.

Note that investment is firm specific in the sense that it reduces the incumbent's production cost not only in period 1 but also in period 2. However, the incumbent benefits from the second-period cost reduction only if he is employed in period 2 as well. Investment does not influence the reservation wage $\bar{w}$ (which is the worker's wage in case he is not employed in period 2). Furthermore, the inequality $1 < \alpha < 2$ implies that investment is profitable for worker i only if he is employed in both periods.

2.2. Perfect Equilibria and Predicted Investment

To solve the game we apply the notion of ('trembling hand') perfect equilibrium (see Selten, 1975). In addition, we assume that the employer randomizes with probability of one half if she receives two identical wage bids.[8]

Proposition 1. *The perfect equilibrium is characterized as follows:*

1. *P chooses short–term contracting $\tau = S$.*
2. *P employs a worker in each period. Moreover, she employs the same worker in each period.*

[8] This assumption is in line with our experimental finding that in the case of short–term contracts and equal wage bids in $t = 2$, the employer reemploys the incumbent in about half the cases. See Section 5.2.

3. *The employed worker chooses firm–specific investment in $t = 1$ but not in $t = 2$.*

4. *Equilibrium wage bids are:*

$$(w^S_{i,1} = w^S_{j,1} = 11, w^S_{i,2} = 12, w^S_{j,2} = 13) \tag{2.2}$$

with $i, j \in \{A, B\}$, $i \neq j$ and where i (j) refers to the employed (unemployed) worker.

Proof in the appendix.

The proposition characterizes the equilibrium path of the unique solution of the game. The derivation in the appendix also explains off–equilibrium path play. One noteworthy result of this analysis concerns the subgame after P has chosen $\tau = L$ (which is never reached in equilibrium, but which will play a role in the data). In this subgame, the perfect equilibrium wages are $w^L_{i,1} = w^L_{j,1} = w^L_{i,2} = w^L_{j,2} = 12$. Notice that in equilibrium, the incumbent earns one unit more than his outside-option payoff (and two units more in the subgame with long-term contracts). Thus, the principal who is on the short side of the market captures almost all the surplus from the relationship.

The proposition characterizes the benchmark for the subjects' behavior to which we will compare the data. In particular, we are interested in investigating the influence of the contract length on the workers' choice of firm–specific investment. Therefore we state

Corollary 2. *Perfect equilibrium implies that the length of the work contract is irrelevant for firm–specific investment. Furthermore, in both subgames starting in stage 2, the same worker is employed in both periods, and he invests in period 1 but not in period 2.*

This is the game-theoretical prediction regarding investment (and employment) under different contract lengths. In contrast to this we propose:

Investment Hypothesis: *Firm–specific investment is significantly more frequent under long–term than under short–term contracts.*

The rationale for this hypothesis is that a worker in period 1 who is employed for a short term might fear becoming unemployed in period 2. This fear is irrational given equilibrium play. However, in the laboratory as well as in real life, decisions are not always rational. And institutions affect the impact of non-equilibrium behavior on investment choices in different ways. In our game, strategic considerations about period 2 choices are obviously more important with short-term contracts than with long-term contracts where both investment decisions have dominant strategies.

3. Experimental Procedure

The experiment was conducted in the computer lab at Humboldt University, Berlin.[9] Subjects were undergraduate students (mostly economics and business administration), who were not recruited from the same course. The participants were randomly assigned to computer screens and identified by identification numbers only. They received written instructions (see the appendix for a translation) and after reading them, they could privately ask clarifying questions.

12 subjects participated in each of the three sessions. Six subjects formed one matching group consisting of two employers and four workers. The roles were assigned randomly[10] and remained constant for the entire session. Each subject participated in 14 repetitions of the above game (i.e., 14 rounds), with random matching after each round. Random matching took place separately within each matching group. Thus, the 6 subjects in each group were matched such that each firm owner faced two workers, whose identities varied after each round.[11]

Each session lasted between 60 and 90 minutes. Mean earnings were DM 40.02 for employers and DM 29.76 for workers (about $23.00 and $17.00 respectively). During the experiment all monetary amounts (as given in the description of the game) were denoted in points. The exchange rate was: 4 points = 1 DM. After each round subjects were informed about their own earnings in that round and their total payoff from all earlier rounds.

Two further remarks concerning the experimental design seem warranted. First, to investigate the investment hypothesis, the contract duration could have been imposed as an exogenous experimental treatment; e.g., we could have collected data from two different treatment groups with fixed duration $\tau = S$ and $\tau = L$, respectively. But the choice of contract duration was left to the principal, thereby making duration an endogenous treatment variable. We expect that whether the principal offers a contract with $\tau = S$ or $\tau = L$ might be behaviorally relevant for the workers' decisions. E.g., if the principal deliberately induces job insecurity, this may undermine the worker's trust in being reemployed more than if the rules are fixed exogenously by the experimenter.

Second, according to our parametrization, the efficiency gain that can be reached via investment is 2 monetary units (i.e., 0.50 DM per game and thus 7 DM for all games).[12] Namely, in case of investment, the joint profit of P and the

[9] The software z-tree was used to run the experiment, see Fischbacher (1999).

[10] In the instructions firm owners were called 'participant X', and workers were called 'participant Y'. Both groups of participants received the same instructions except for a single statement on the first page assigning the respective role.

[11] One might wonder about repeated game aspects here even though the matching was random. However, note that the players only knew that they would be randomly matched, but did not know the exact matching procedure. On the screen the players were never named by their identification number. For instance, workers were represented as players Y1 and Y2 and which physical person was represented by Y1 or Y2 changed between rounds. Thus, we think it is very unlikely that e.g., a principal was able to recognize a person she had played before.

[12] See the description of experimental procedures below.

incumbent over both periods is 22 (which is 10 units more than the sum of the outside option payoffs), whereas in case of no investment the joint profit is 20 (8 units more than the outside option payoffs). Hence, after adjusting for outside option payoffs, the relative efficiency gain is 25%. Compared to other studies, this is rather moderate.[13] However, even with moderate efficiency gains, investments are frequently made in the real world.

4. Investment Behavior

We now turn to the empirical results. First we study the investment hypothesis. Table 1 reports the percentage of cases in which workers chose to invest in the first period for short–term and long–term contracts.

Duration of Contract	Rounds 1 to 7	Rounds 8 to 14	All Rounds
Short-term ($\tau = S$)	61%	69%	65%
	($N = 44 \widehat{=} 100\%$)	($N = 49 \widehat{=} 100\%$)	($N = 93 \widehat{=} 100\%$)
Long-term ($\tau = L$)	88%	97%	92%
	($N = 34 \widehat{=} 100\%$)	($N = 33 \widehat{=} 100\%$)	($N = 67 \widehat{=} 100\%$)

Table 1: Investment in period 1 (relative frequency of $\delta_{i,1} = 1$)

The data support the investment hypothesis. Over all rounds, the relative frequency of investment is higher by 27% for $\tau = L$ than for $\tau = S$. And the difference between the two treatment conditions is statistically significant as the frequency of investment is higher in case of $\tau = L$ compared to $\tau = S$ for all 6 matching groups. Thus, a binomial test leads to a p–value of 0.016 ($N = 6$, one–tailed) and clearly rejects the null hypothesis of equal investment rates across different contract lengths.[14] We conclude:

Result 1: *The data support the investment hypothesis. Firm-specific investment is significantly higher for long–term contracts compared to short–term contracts.*

With experience (rounds 8 to 14 compared to 1 to 7) investment increases by 8 percentage points for $\tau = S$ and by 9 percentage points for $\tau = L$. The difference between investment levels under short- and long-term contracting does not decrease with experience[15] and it is economically substantial. Defining the relative investment loss caused by job insecurity as

[13] In the experiment of Berg, Dickhaut and McCabe (1995) for example, investments were tripled, which generates extreme incentives for efficient behavior.

[14] Note that the test is run on group data rather than individual data. Since individuals interacted within each group, such interaction might induce a correlation between individual decisions. Consequently, tests based on individual data would be unreliable. A discussion of this and related problems can be found e.g. in Davis and Holt (1993), p. 527–28, and Königstein (2000, chapter 2).

[15] The influence of experience is not statistically significant on the basis of a binomial test using matching group data.

$$1 - \frac{\% \text{ investment if } \tau = S}{\% \text{ investment if } \tau = L},$$

yields a loss of about 31% for rounds 1 to 7 and 29% for rounds 8 to 14.

Underinvestment in the first period with short-term contracts might be due to errors of the participants. An obviously non-rational choice is to invest in period 2. Since this is the final period of the work relationship, specific investment does not pay. Nevertheless such decisions occurred in 16% of all games. They occurred equally often (13 times) for both contract lengths and the frequency dropped to 9.5% in rounds 8 to 14.[16] While this is evidence of non-equilibrium behavior, it cannot explain result 1. There is no systematic difference in second-period investment rates between contract lengths.

In the following we investigate wage bidding and employment decisions separately. We then combine these analyses to determine the unemployment risk and return to the question of what drives the investment decisions.

5. Explaining Low Investment Under Short-term Contracts

5.1. Submitted Wage Bids and Actual Wage Payments

Figure 2 displays the distribution of wage bids (for all 14 rounds and both periods). Remember that with short-term contracting optimal wage bids are 11 in period 1 and 12 for the incumbent, respectively 13 for the outsider in period 2. With long-term contracts, the optimal wage bid is 12. In fact, with long-term contracts, the data show many bids of 12. But with short-term contracts there are only a few bids of 11. Furthermore we observe wage bids smaller than 11 and greater than 13, which are not consistent with the theoretical solution.

[16] That experimental subjects choose dominated strategies once in a while is not uncommon. E.g., Costa-Gomes et al. (2001) find that players choose the dominated strategy in about 10% of all cases in simple normal-form games.

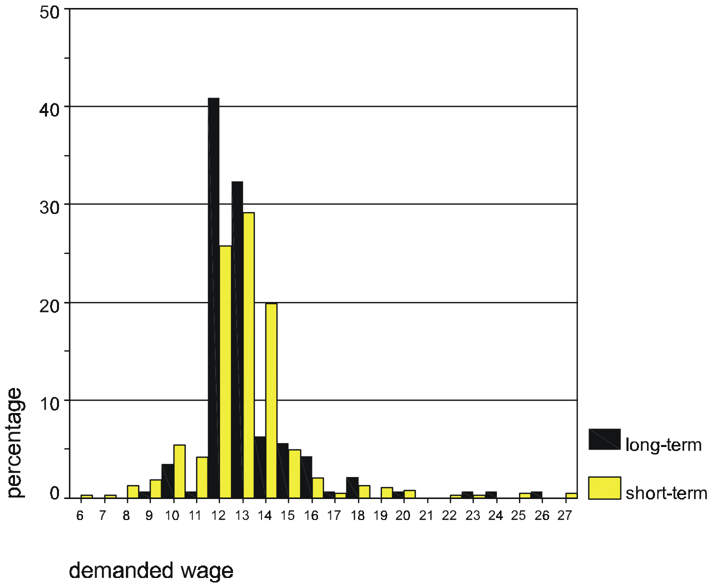

Figure 2: Submitted wage bids

	Mean	Variance
Short–term, period 1	12.08	2.31
Short–term, period 2	11.89	1.77
Long–term	12.25	2.86

Table 2: Paid wages

Table 2 reports means and variances of wages that are actually paid (as opposed to submitted wage bids shown in Figure 2). Under short–term contracts the average wage paid is lower than under long–term contracts, which is in line with theory. However, the difference is not statistically significant. For long-term contracts the optimal wage profile ($w_1 = 12, w_2 = 12$) is observed in 63% of the cases. The optimal wage profile of short–term contracts ($w_1 = 11, w_2 = 12$) is found in 2% of the cases. The reason is that contrary to the theoretical solution, wages under short-term contracts are decreasing from period 1 to period 2. Game theory predicts increasing wages, since in period 1 workers anticipate and bid away the incumbent's period 2 rent.

Table 3 shows statistics of period 2 wage bids under short-term contracts for outsiders, incumbents who invested in $t = 1$ and incumbents who did not invest in $t = 1$. Wage bids of incumbents who did not invest and the bids of outsiders are almost identical (12.11 and 12.14). But wage bids of incumbents who did invest are lower than those of outsiders and incumbents who did not invest.

This difference clearly reflects the cost advantage due to investment. Given the relatively large variance it is nevertheless conceivable that some incumbents who did invest in $t = 1$ did not get re-employed in $t = 2$.

	Mean	Variance
outsiders	12.14	1.53
incumbents	11.78	1.86
No investment in period 1	12.11	3.87
Investment in period 1	11.66	1.10

Table 3: Period 2 wages under short–term contracts

5.2. The Principal's Hiring Decision

In theory the employer always selects the worker who submits the lower wage (if this wage is below 16). Empirically this holds almost always. The more expensive worker is hired only in about 2% of the cases. In case of equal wage bids – this occurred in about 20% of the cases – the hiring probability for each worker is about 50% in both periods. While this is trivial in period 1 it could not necessarily be expected for period 2. In period 2 this means that hiring is not biased in favor or disfavor of the incumbent. Given equal wage bids in $t = 2$, the incumbent is re-employed in 11 out of 20 cases.[17]

	$\tau = S$	$\tau = L$
No Employment	4 (4%)	4 (6%)
Employment	93 (96%)	67 (94%)
$\sum$	97 (100%)	71 (100%)

Table 4: Employment versus no employment decisions

Table 4 reports a few cases in which no worker is employed at all (5% on average). In these cases, the smaller of both submitted wage bids is 14.38 on average, which is higher than the average wage paid when a worker is actually employed (12.63).[18] Thus, the principal refuses to hire anybody if it is rather costly.

5.3. Unemployment Risk

Now we combine the analysis of wage bidding behavior and hiring decisions to determine the actual risk of the incumbent worker to become unemployed in the

[17] This is in line with the assumption we used to derive the equilibrium, namely that the employer randomizes if the two wage bids are equal.

[18] The difference is statistically significant according to a Mann-Whitney U-test (N=168, p=.002, two-sided). Here we ignore statistical problems caused by repeated measurement and strategic interaction. Note that for all rounds there are only 8 cases of no employment.

second period. Theoretically the probability of unemployment (employment) is 0% (100%). However, due to non-equilibrium wage bids of outsiders the actual risk of unemployment might be substantial. Since the principal almost always hires the cheaper worker and flips a coin in case of indifference, the probability of unemployment for an incumbent bidding wage w is (approximately) equal to the relative frequency of outsider wage bids w plus half the relative frequency of outsider wage bids equal to w. Accordingly, we determined the incumbent's unemployment probability for each wage bid w and report this in Figure 3.

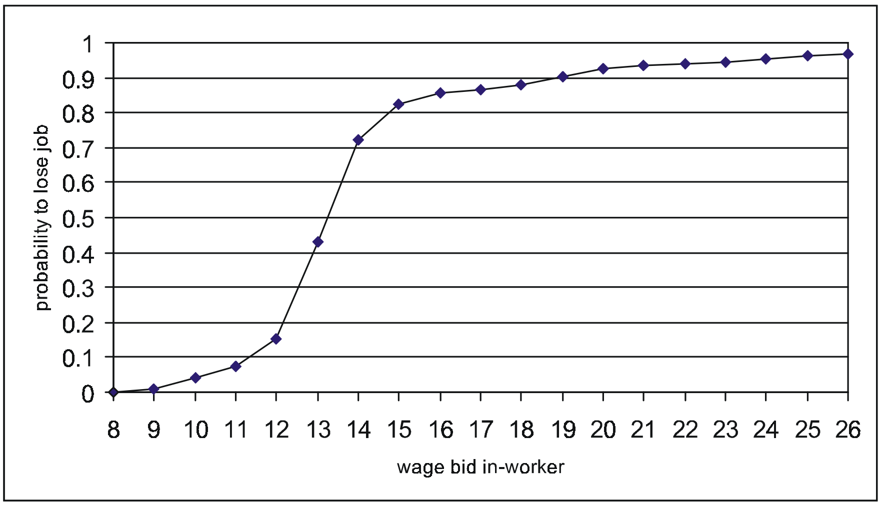

Figure 3: Probability of incumbents losing the job in $t = 2$

For $w = 12$ the unemployment probability is about 15%. Theoretically, it should be 0% since $w = 12$ is the equilibrium bid. Thus, the incumbent faces a substantial risk of loosing the returns on his period-1 investment. This risk is caused by non–equilibrium choices of outsiders who submit wages below the equilibrium bid of 13. Figure 3 also shows that if the incumbent chooses $w = 13$, his risk of unemployment in period 2 is more than 40%. Thus, deviating from the equilibrium bid is quite costly for incumbents.

If the probability to become unemployed due to non-equilibrium wage bids is sufficiently high, it may be rational for the incumbent not to invest. Specifically, one may ask whether an expected-income-maximizing player with rational expectations regarding the distribution of wage bids should invest or not. Using the probabilities of Figure 3 one easily finds that it is optimal for such a worker to invest in the first period and to subsequently choose $w = 12$, as prescribed by the perfect equilibrium. Thus, reduced investment under short-term contracts cannot be explained by non-equilibrium wage bids of outsiders alone. It rather seems that incumbents do not correctly anticipate the risk of unemployment.

Limitations and errors of subjects in predicting other players' choices have been reported in a number of experiments. For instance, Beard and Beil (1994) observe for extensive form games that most players choose the best response assuming the other player to randomize with equal probabilities over all possible actions. Goeree and Holt (2000), Weizsäcker (2002), and Kübler and Weizsäcker (2002) find that players behave as if attributing a higher error probability to other players' decisions than committing errors themselves. Note that in our game, underestimating the rationality of other players leads to too pessimistic evaluations of the probability to be reemployed in the second period.

An alternative explanation for reduced investment under short-term contracting could be provided by the combination of non-equilibrium wage bids and risk or loss aversion. Given that the actual risk of unemployment is substantial, such attitudes could play a role, in principle. However, given the small stakes we think that risk aversion does not have much explanatory power here.[19] Moreover, even if a worker invests in the first period and is not reemployed in the second period, he will not make losses in absolute terms.[20] Thus loss aversion does not seem to drive the reluctance to invest either.

We summarize our analysis of the reasons for low investment as follows:

Result 2: *In case of short-term contracting, non-equilibrium wage bids of outsiders create a substantial unemployment risk for incumbents. However, the observed level of investment is below the optimal level for a risk neutral decision maker with rational expectations.*

6. Surplus Splitting, Efficiency, and Optimal Contract Length

Finally, we are interested in how the surplus generated inside the firm is split between the principal and the agent. Surplus is defined as the sum of incomes earned by the firm owner and the employed worker(s) in both periods minus their outside option payoffs. The game-theoretic solution predicts a rather asymmetric surplus distribution favoring the principal. Figure 2 above shows that some workers submit higher wage bids than predicted by the equilibrium. This behavior might be interpreted as attempts to capture higher surplus shares. But as the bottom half of Table 5 reveals, on average workers did not get much of the pie.

	Short–term contract	Long–term contract
Predicted Surplus	10.00	10.00
Mean Observed Surplus	8.08	8.93
Predicted Share Agent	0.10	0.20
Mean Observed Share Agent	0.04	0.21

Table 5: Mean surplus and worker's surplus share (predicted and observed levels) for both contract lengths

[19] See Rabin and Thaler (2001).

[20] A worker's effort and investment costs are 6+4=10 (not considering his opportunity cost of 4) while he gets a wage of 11 in equilibrium.

In particular, with short–term contracts the worker captures 4% and with long–term contracts 21% of the surplus. Surplus splitting is rather asymmetric and favors the principal, as predicted by the theory. This finding is stable across rounds (Figure 4).

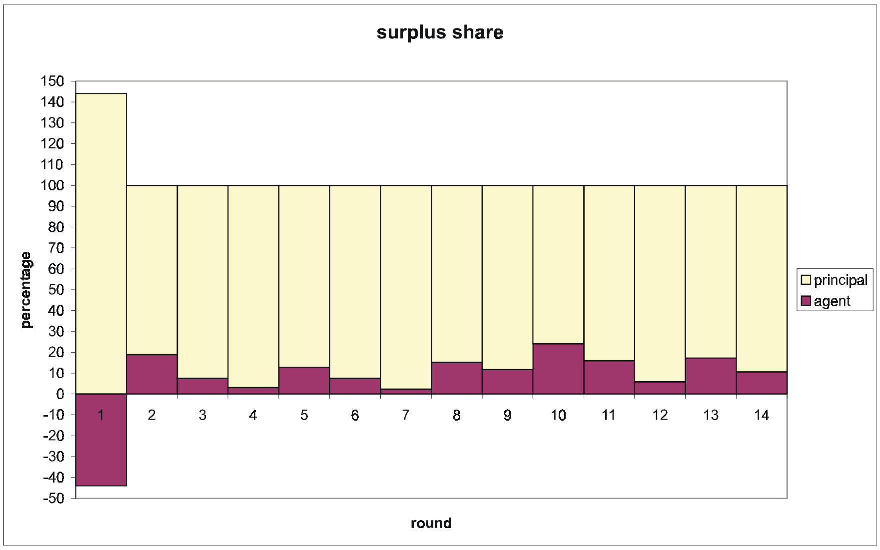

Figure 4: Surplus share across rounds

Average surplus shares are close to the equilibrium levels (Table 5). The difference between the two contract lengths is qualitatively as predicted by perfect equilibrium. We conclude:

Result 3: *The principal captures most of the surplus. The agent's surplus share is larger in case of long–term contracting. These findings are qualitatively as predicted by the theory.*

Table 5 also reports the levels of observed and predicted total surplus. Remember that the efficiency loss is due to underinvestment in period 1, no employment at all and investments in period 2. Given the behavior of the workers in the experiment, the overall surplus is maximal for long-term contracts. However, the principal's surplus share and, in fact, her profit are larger for $\tau = S$. Therefore, profit maximization dictates the choice of $\tau = S$ and there is a trade–off between profit maximization and efficiency.

	Rounds 1 to 7	Rounds 8 to 14	All Rounds
$\tau = S$	46 (55%)	51 (61%)	97 (58%)
$\tau = L$	38 (45%)	33 (39%)	71 (42%)
$\sum$	84 (100%)	84 (100%)	168 (100%)

Table 6: Principal's choice of contract duration

Table 6 reports that short–term contracts are chosen more often than long–term contracts. The difference in frequencies gets larger with experience (rounds 8 to 14 versus rounds 1 to 7). We summarize:

Result 4: *Given the workers' actual decisions, surplus maximization calls for long–term contracts whereas profit-maximization should lead to the choice of short–term contracts. We observe short-term contracts more frequently than long-term contracts. The difference in frequencies increases with experience.*

7. Discussion and Conclusions

The impact of deviations from rationality on economic outcomes depends on the structure of social interaction. Camerer (1995) argues that "the institutional veils separating individuals doing business" may be thin or thick and that the "thickness of institutional veils is important because there is a strong intuition that institutional forces correct errors people make". In this vein, we investigate two labor market institutions, long-term and short-term contracts, that induce different levels of firm-specific investment due to non-equilibrium behavior.

Perfect equilibrium predicts the same level of investment for both types of contracts. Empirically, however, we find significantly lower investment rates for short-term contracts (result 1). We show that due to non-equilibrium wage bids of outsiders the risk of getting unemployed in period 2 is substantial under short-term work contracts (result 2). Besides the systematic deviations from equilibrium behavior observed in the experiment, there are some findings which are qualitatively in line with equilibrium. As predicted by the theory, workers receive only a small fraction of the surplus (result 3). Hence, wage bidding among the two workers is quite effective in driving down their surplus shares. We also find that in the majority of cases the principal chooses short-term contracts rather than long-term contracts, thereby reducing efficiency but maximizing his earnings (result 4).

Taking things together we propose that the finding of reduced investment under short-term contracting is driven (1) by the fact that non-equilibrium decisions occur sufficiently often, (2) by the differential impact of institutions (long-term versus short-term) on the risk of not being reemployed in the second period, (3) by the fact that this risk is anticipated, and (4) by the players' pessimistic beliefs.

Non-equilibrium choices and biased (non-rational) beliefs are in our view not an artifact of the experimental laboratory, but must be taken into account in natural environments as well. Perceptions of job insecurity are the focus of recent field research. A British study indicates that the perceived job insecurity can be much higher than the real threat to lose one's job, and that there is a negative correlation between job insecurity and motivation at work.[21] Also in the U.S.

[21] See Burchell et al. (1999). The study was conducted by social scientists from Cambridge University. It relies on interviews conducted in 20 institutions from different industries in Great Britain. Overall, 340 workers and employees on all levels of the internal hierarchy were inter-

employees' expectations to lose their job have been found to be exaggerated and overly pessimistic compared with the real probability of becoming unemployed.[22] These findings are consistent with our explanation of the subjects' investment behavior in the experiment.

A number of open questions remain. First, we do not investigate the case of exogenous contract lengths. It would be interesting to study whether the employer's choice of contract length in our setup has a different effect on investments than when the contract length is legally mandated. Second, in our experiment the contract length could not be conditioned on the investment choice of the worker, i.e., the contract is incomplete.[23] One could run a similar experiment without this restriction. Third, from a theoretical perspective it may not make a difference whether the worker's investment decreases her effort cost or increases the employer's profit directly. However, there might be significant behavioral differences between the two situations which seem worth investigating.

viewed. The study also shows that perceived job insecurity does not lead to a higher work morale. The researchers conclude that there were many short-term gains from deregulating the labor market in Great Britain, but that its long-term costs must not be overlooked.

[22]This was particularly pronounced in the 1990's, see Schmidt (1999).

[23]See e.g,. Kahn and Huberman (1988) and Prendergast (1993) for a similar setup.

A. Proof of Proposition 1

We derive the game theoretical solution by first looking at the subgames starting at stage 2 (wage bidding in period 1) for $\tau = L$ (Lemma 1) and $\tau = S$ (Lemma 2) separately. Thereafter we collect these partial results and solve for stage 1, i.e., the principal's choice of contract length.

A.1. Solution for Stage 2 Subgame given $\tau = L$

Lemma 1. *Given $\tau = L$, perfect equilibrium in the subgame starting at stage 2 implies that P strictly prefers to employ a worker rather than not employing anyone, that the incumbent $i \in \{A, B\}$ invests in $t = 1$ but not in $t = 2$, and that wage bids are $w_{i,1}^L = w_{j,1}^L = 12$.*

Proof. Let i represent the incumbent; i.e., $\gamma_{i,1} = \gamma_{i,2} = 1, \gamma_{j,1} = \gamma_{j,2} = 0$ $(i, j \in \{A, B\}, i \neq j)$. Obviously, i does not invest in period 2 ($\delta_{i,2} = 0$), since investment costs are higher than the additional cost reduction. But, i does invest in period 1 ($\delta_{i,1} = 1$), since this induces a two–period cost reduction which is higher than the investment cost. Accordingly, i's two–period costs are $c_1(\delta_{i,1} = 1) + c_2(\delta_{i,2} = 0) = 2(8 - 4) + 6 = 14$. When bidding $w_{i,1}^L$ worker i has to consider his payoff in case he gets employed $\Pi_i^L \left(\gamma_{i,1} = 1\right)$ compared to his payoff in case of no employment $\Pi_i^L \left(\gamma_{i,1} = 0\right)$. We refer to $\Delta\Pi_i^L = \Pi_i^L \left(\gamma_{i,1} = 1\right) - \Pi_i^L \left(\gamma_{i,1} = 0\right)$ as i's payoff margin. Since $\Pi_i^L \left(\gamma_{i,1} = 1\right) = 2w_{i,1}^L - 14$ and $\Pi_i^L \left(\gamma_{i,1} = 0\right) = 2 \cdot 4 = 8$, it follows that i's payoff margin is non–positive for all $w_{i,1}^L \leq 11$. But if i submits a higher wage bid, then in every perturbed game there is a strictly positive probability that i will get employed at this wage which proves that in perfect equilibrium $w_{i,1}^L > 11$ (and with symmetry $w_{j,1}^L > 11$).

If both workers submit the same wage bid, P is indifferent regarding the selection among workers and by assumption, P randomizes with equal probability for each worker. Accordingly, perfect equilibrium in the subgame with $\tau = L$ requires $w_{i,1}^L = w_{j,1}^L = 12$.

It remains to be shown that P's profit is larger in case he employs a worker $\Pi_P^L(\gamma_{i,1} = 1, \gamma_{j,1} = 0)$ compared to not employing anyone $\Pi_P^L(\gamma_{i,1} = \gamma_{j,1} = 0)$. Since $\Pi_P^L(\gamma_{i,1} = 1, \gamma_{j,1} = 0) = 2y - 2w_{i,1}^L = 12$ is larger than $\Pi_P^L(\gamma_{i,1} = \gamma_{j,1} = 0) = 2\bar{\pi} = 4$, this concludes the proof of Lemma 1. ■

A.2. Solution for Stage 2 Subgame given $\tau = S$

Lemma 2. *Given $\tau = S$, perfect equilibrium in the subgame starting at stage 2 implies that P employs the same worker i in both periods, that the employed worker chooses firm–specific investment only in the first period ($t = 1$) and that the wage bidding profile is $(w_{i,1}^S = w_{j,1}^S = 11, w_{i,2}^S = 12, w_{j,1}^S = 13)$.*

Proof. Let $i \in \{A, B\}$ represent the incumbent in period 2. Since the game ends after period 2, i does not invest ($\delta_{i,2} = 0$) in $t = 2$, because the one–period cost reduction that would be induced is less than the investment cost. As agent i's costs in $t = 2$ depend on whether or not he was employed and did invest in $t = 1$, .they can be written as

$$c_2(\delta_{i,2} = 0) = \begin{cases} 8 & \text{if } \delta_{i,1} = 0 \\ 4 & \text{if } \delta_{i,1} = 1. \end{cases}$$

Furthermore, i's second–period payoff is

$$\Pi^S_{i,2}\left(\gamma_{i,2} = 1\right) = w^S_{i,2} - c_2(\cdot) = \begin{cases} w^S_{i,2} - 8 & \text{if } \delta_{i,1} = 0 \\ w^S_{i,2} - 4 & \text{if } \delta_{i,1} = 1 \end{cases}$$

in case of employment and $\Pi^S_{i,2}\left(\gamma_{i,2} = 0\right) = 4$ in case of no employment. Symmetry implies the same second–period payoff function for worker j.

As before, we assume that P randomizes with equal probability between the workers if they submit equal wage bids. With respect to investment a symmetric case, in which neither worker has invested before ($\delta_{A,1} = \delta_{B,1} = 0$), and asymmetric cases ($\delta_{i,1} = 1$, $\delta_{j,1} = 0$, $\forall i, j = A, B$ and $i \neq j$), where i represents the incumbent must be distinguished. Worker j does not know whether he faces the symmetric or the asymmetric case. Since j did not invest in $t = 1$, every bid $w^S_{j,2} \leq 12$ implies a non–positive second–period payoff margin $\Delta\Pi^S_{j,2} = \Pi^S_{j,2}\left(\gamma_{j,2} = 1\right) - \Pi^S_{j,2}\left(\gamma_{j,2} = 0\right)$,i.e., j's payoff in case of employment minus his outside option payoff. Consequently, in every perturbed game j should submit a wage bid strictly greater than 12.

Worker i knows whether or not he has invested before. Suppose $\delta_{i,1} = 0$ (symmetry). Then, similar arguments as those given for worker j lead to the conclusion that i should submit a bid strictly greater than 12 as well. In case of asymmetry ($\delta_{i,1} = 1$), since i knows that j will bid at least 13, it follows that i gets employed (almost surely within perturbed games) and earns a strictly positive second–period payoff margin by any bid $8 < w^S_{i,2} < 13$. Since i's payoff is increasing in wage, it is optimal for him to marginally undercut j's bid. Taking together our findings for the case of symmetry and the case of asymmetry it follows: Perfect equilibrium requires $w^S_{j,2} = 13$ in any case while worker i should bid $w^S_{i,2} = 12$ in case of asymmetry ($\delta_{i,1} = 1$) and $w^S_{i,2} = 13$ in case of symmetry ($\delta_{i,1} = 0$). To see this, note that bidding above 13 cannot be part of a perfect equilibrium. If in case of symmetry a single worker would do so, he would earn strictly less. If both would do so, either one could improve by (unilateral) undercutting. In case of asymmetry, if $w^S_{j,2} > 13$, then i should increase his bid above 12. But, in the latter case, worker j in turn could increase his expected payoff by reducing his bid.

Having solved period 2 we can now proceed to period 1. The analysis above has shown that if the incumbent i does not invest in $t = 1$, his second period net payoff is either $\Pi^S_{i,2}(\delta_{i,1} = 0) = 13 - 8 = 5$ (if he is employed in $t = 2$) or $\bar{w} = 4$ (if he is not employed in $t = 2$). But in case he does invest in $t = 1$, he will become employed in period 2 (almost surely within perturbed games) and earn $\Pi^S_{i,2}(\delta_{i,1} = 1) = 12 - 4 = 8$. The net cost of investment (investment cost minus period 1 cost reduction) is 2, so that in perturbed games investing in $t = 1$ almost surely induces a strictly higher payoff than not investing. Consequently, if perturbations are sufficiently unlikely (perfectness), rationality calls for $\delta_{i,1} = 1$. Thus, the perfect equilibrium path implies the asymmetric case. This also implies that if any worker is employed at all (which will be shown below), the same worker will be employed in both periods.

It remains to solve for optimal wage bids in period 1. Following the above arguments worker i's ($i = A, B$) two–period payoff function is $\Pi^S_i = \Pi^S_{i,1} + \Pi^S_{i,2} = w^1_{i,1} - 4 - 6 + 12 - 4 = w^S_{i,1} - 2$ in case i gets employed and $\Pi^S_i = 8$ otherwise. Thus for all $w^S_{i,1} \leq 10$ worker i earns a non–positive payoff margin. Rationality in the perturbed game therefore requires $w^S_{i,1} \geq 11$, and due to symmetric Bertrand competition one gets $w^S_{i,1} = w^S_{j,1} = 11$ as the unique result for perfect equilibrium wage bidding in $t = 1$. Given the decisions derived above, it can easily be verified that the principal P is indeed better off by employing a worker rather than not employing anyone which completes the proof of Lemma 2. ■

B. Solution for Stage 1

By Lemma 1 and Lemma 2 we have shown that for each contract duration $\tau = S$ and $\tau = L$ one worker i is employed in both periods and chooses $\delta_{i,1} = 1$ and $\delta_{i,2} = 0$. Furthermore, perfect equilibrium in the subgames starting at stage 2 implies:

$$\begin{aligned}(w^S_{i,1} &= w^S_{j,1} = 11, w^S_{i,2} = 12, w^S_{j,1} = 13),\\ &\text{and}\\ (w^L_{i,1} &= w^L_{j,1} = w^L_{i,2} = w^L_{j,2} = 12).\end{aligned}$$

Obviously, the wage profile for short–term contracts is preferred by the principal, which concludes the proof of the Proposition.

C. Translation of the instructions

General remarks

In the course of this experiment you can earn money. The amount you earn depends on your own decisions. Losses are possible in theory, but generally not expected. In addition you can always avoid the risk of losses.
During the experiment your income will be calculated in points. The conversion rate between points and DM is:

4 points = 1 DM

At the end of the experiment all points that you earned are added and converted into DM.

Your participant ID is: XXX

You will need this sheet with participant ID to collect your earnings. Please keep it and have it with you collecting your earnings.
Please do not talk to each other during the experiment. If you do not understand something or if you want to ask a question, please raise your hand.

Instructions

In the course of this experiment we will present to you a decision problem involving three persons. In the following, one of these persons will be called 'participant X', and the others 'participant Y' ($Y1$ and $Y2$ respectively). All participants are split into two groups: the group of participants X and the group of participants Y.

You are a member of group X!

This means you will take decisions as participant X.
All other participants receive information identical to yours and will be treated in the same way. You make all your decisions on the computer. If necessary we will explain to you, how to use the computer. Your decisions will be communicated to both of the other participants via the computer. They will be informed about your decision, but will know neither your name nor your participant ID; this means that your decisions remain anonymous.

Decision–path

The experiment consists of 2 periods. Imagine the following situation: Participant X plays the role of an employer. The employer can employ one of two workers (participant $Y1$ or $Y2$), whose work will generate the employers period income. The employed participant Y can reduce his personal labor costs by investing (e.g. firm–specific skills) or moving closer to the workplace. In the following, the decision process is presented and will be explained afterwards:

1. X decides about the length of contract: 1 or 2 periods. Both participants Y will be informed about this decision.

If the contract length is 1 period:

2. Both participants $Y1$ and $Y2$ submit a wage bid for period 1 (this is the respective wage, that X is supposed to pay in period 1). Each participant knows only his own bid.

3. X is informed about the wage bids and decides which of the two participants Y he is going to employ or whether not to employ either. Both participants Y are informed about this decision.

4. The employee decides whether to invest in a reduction of his personal labor costs or not.

5. The unemployed participant does not make any further decisions during period 1.

End of period 1. The incomes of the participants are calculated according to the rules of payment detailed below. Beginning of period 2.

6. Both participants $Y1$ and $Y2$ submit a wage bid for period 1 (this is the respective wage, that X is supposed to pay in period 1). Each participant knows only his own bid.

7. X is informed about the wage bids and decides which of the two participants Y he is going to employ or whether not to employ either. Both participants Y are informed about this decision.

8. The employee decides whether to invest in a reduction of his personal labor costs or not.

9. The unemployed participant does not make any further decisions during period 2.

End of period 2. The payoffs of the participants are calculated according to the rules of payment detailed below.

If the contract length is 2 periods:

2. Both participants $Y1$ and $Y2$ submit a wage bid for both periods (this is the respective wage, that X is supposed to pay in each period). Each participant knows only his own bid.

3. X is informed about the wage bids and decides which of the two participants Y he is going to employ or whether not to employ either. Both participants Y are informed about this decision.

4. The employee decides whether to invest in a reduction of his personal labor costs or not.

5. The unemployed participant does not make any further decisions.

End of period 1. The payoffs are calculated according to the rules of payment detailed below. Period 2 starts.

6. The employee decides whether to invest in a reduction of his personal labor costs or not.

End of period 2. The payoffs of the participants are calculated according to the rules of payment detailed below.

Wage bids, period payoffs, labor cost, and investment

Now, knowing the sequence of decisions, you will be informed about the details of the decisions to be made:
The wage bids range between 0 and 27 points (in integers). Employee Y generates 18 points of income for X. The employee receives the demanded wage, but pays his personal labor costs. He can reduce his labor costs by investing, which again has costs itself. Only the employed participant Y can invest. In each period Y can invest only once. If the same participant Y is employed in both periods, he can invest twice (once in period 1 and once in period 2).

The labor costs of the employee are:

8 points	(without investment)
4 points	(one investment)
0 points	(two investments)

The cost of investment is 6 points per investment.

Important

An investment carried out in period 1 reduces the labor costs of period 1 as well as of period 2 (as long as the same participant Y is employed again). For example, the labor costs of a participant Y who is employed in period 2 and has carried out an investment in period 1 are 0 points with repeated investment and 4 points without another investment.
At the end of each period, participant X is informed whether the employee has carried out an investment or not. The unemployed participant is not notified about the investment decision.

Rules of payment

Participant X
· If X has employed a participant Y in period t, his profit is (in points):

	period income
–	wage in period t
=	profit in period t

· If X has not employed a participant Y in period t his profit is:

2 points

Participant Y
· The profit of the participant Y employed in period t is (in points):

	wage in period t
–	cost of investment in period t
–	labor costs in period t
=	profit in period t

· The profit of the participant not employed in period t is:

4 points

Each participant earns the sum of his profits from both periods.

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