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Long-term Work Contracts versus Sequential Spot Markets: Experimental Evidence on Firm-specific Investment*

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Abstract

Dismissal rules, i.e. legally enforced long-term contracts, have been defended against criticism for, among other things, providing efficient incentives to invest in relationship-specific skills. However, in many situations efficient investment can also be attained by spot contracts. We replicate such a situation with our experimental design based on a simple two period game, involving the choice of the contract length by the principal and an investment choice by the agent. In contrast to the game theoretic predictions, we find that investment of the worker and length of contract are strictly positively correlated. We interpret our finding as an indication for a perceived market risk due to other players' actions although the model is fully deterministic. This could imply a behaviorally relevant difference between contract and market administered incentives.

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1. Introduction

Dismissal rules for workers have been propagated and defended against criticism on many grounds, one of them being the problem of relationship specific investments. Since such an investment loses its value once the relationship breaks up, and since the employment relation typically involves irreversible investments in relationship-specific capital, long-term work contracts have been justified as a means to secure efficient investment.¹ If the length of the relationship is insecure, neither the employer nor the worker might be willing to undertake such investments that are profitable only in the longer run.

However, the literature has put forward a number of arguments how incentives to invest in specific human capital can be provided with spot contracts. Becker (1964) argues that in the case of firm-specific human capital, the employer compensates the worker for his investment cost because she can recoup these costs in the course of the relationship. As the worker's productivity is lower when working for other employers, he won't be bid away by them if the current employer pays him a wage below marginal productivity in the firm. This requires verifiability of the investment, i.e. worker and employer can contract on skill collection and its remuneration. Otherwise the employer has an incentive to appropriate the returns from investment without compensating the worker, which in turn leads to underinvestment. This point has been made by Lazear (1988) who assumes that the worker's investment is ex-post observable by the firm, but no contract can be conditioned on it. Ex post Nash bargaining leads to some split of the returns from investment between employer and worker, thus implying underinvestment. Lazear (1988) emphasizes that this problem cannot be solved by dismissal rules or long-term contracts because the length of contract cannot be conditioned on investment by the worker.

Kahn and Huberman (1988) and Prendergast (1993) show that the double moral hazard problem can be solved with the help of the internal job market. Kahn and Huberman (1988) propose up-or-out contracts while Prendergast (1993) shows that if the employer can commit to different wages for different jobs, a promotion system can induce workers to invest into specific skills. For the rule that the worker is promoted after investing into specific skills to be self-enforcing, the jobs must be designed such that the skills of the worker render him more productive in the better job.

Finally, it has been argued that implicit contracts together with spot markets for labor are sufficient to solve moral hazard problems such as choice of investment or effort. That is, even if the relationship-specific investments cannot be contracted upon, self-enforcing agreements may lead to optimal investment decisions. MacLeod and Malcomson (1989, 1998) use a repeated game with spot con-

¹Examples for such investments are acquisition of firm-specific know-how or skills that reduce a worker's effort cost or investment into a good relationship with colleagues or clients. Also, a worker may move closer to his workplace thereby reducing commuting time.

tracts to show that if the rent from the relationship is sufficiently large, i.e. parties incur losses if it breaks up, implicit contracts (contracts that cannot be enforced by courts) may be self-enforcing. This is due to the disciplining effect of the market wage and the employer's lower profit from employing a new worker who shirks or is unskilled.

Dismissal rules have also been investigated empirically using cross-country data in order to analyze the impact of different legal regimes on unemployment, turnover, the value of firms etc. These studies reach different conclusions as far as unemployment is concerned. 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.²

We investigate firm-specific investment under different dismissal rules in a laboratory experiment. We use a simple two-period model in which the employed worker can invest in specific skills and the employer can reemploy him in the second period or not. Investment enables a worker to produce a good at lower cost than competing unskilled workers. If this leads to a lower second period wage bid, the employer will indeed employ the skilled worker again. Therefore, the skilled worker is able to cover his investment cost in the course of the relationship. Thus, the implicit contract consisting of the worker investing and the employer employing him again in the second period is self-enforcing.

In the game played in the experiment, first the employer determines whether he offers a long-term (two-period) or a short-term (one-period) contract. Then two workers compete for the job that involves some disutility of effort. Competition is organized as a wage bidding game such that each player asks for the wage at which he is willing to perform the job. The employer picks one of the two or none and pays the wage asked for by the worker who is selected. The worker who gets the contract then decides whether he wants to invest in job-specific skills decreasing her disutility of performing the job. This investment is valuable for two periods and it is efficient only if the worker is employed for two periods. After the investment decision the contract is fulfilled by the worker performing the task and the employer making the wage payment. In the second period, the same worker performs the task at the prespecified wage of the two-period contract and can invest again or, in the case of a short-term contract, workers again bid for the contract, the employer picks one of them who can then decide whether to invest or not and the contract is fulfilled. A worker only lives for two periods, i.e. his investment is destroyed after the second period.

The game can be solved using backwards induction. The main features of the

²For a survey of the empirical literature see Büchtemann and Walwei (1994).

game theoretic solution, providing the benchmark for the experimental study, are that in the unique perfect equilibrium the employer offers a short-term contract, the worker who gets the job in the first period always invests in that period, the same worker is employed over both periods, no investment is made in the second period, and the worker gets almost no rent from the contract.³ Note that in the subgame following the employer's (out-of-equilibrium) long-term contract offer, the worker also invests in the first period, but not in the second.

The game has been set up so as to account for several features of the employment relation cited in the ongoing debate of firm-specific skills and dismissal rules. First, the game provides a simple illustration of the hypothesis that the market is sufficient to provide optimal investment incentives. Second, wage bidding of symmetric workers should converge to the market wage, thus (almost) eliminating their rents and making the employer the residual claimant who profits from efficient investments. Third, notice that contracts are incomplete because the investment choice of the worker can be observed by the employer, but it cannot be contracted upon. Thus, employment in period 2 cannot be tied to the investment choice. However, if either worker or employer do not comply (the worker does not invest, the employer does not hire the worker in period 2), separation occurs and harms the offending party. Finally, the worker's willingness to invest in the first period with a short-term contract crucially depends on his expectations about the other player's wage bid in the second stage. The assumption of common knowledge of rationality makes it optimal to invest in the first period as the other player will never be able to bid a wage low enough to beat the wage of the incumbent who made the job-specific cost-reducing investment. However, if a player has some doubt about the other player's behavior in the second period, he might find the investment too costly and not undertake it.

The game is repeated for fourteen rounds to allow for learning. Players may not fully understand the game immediately, but it should become clear after a number of rounds. In order to reduce the potential influence of strategic interaction across rounds we use random matching between rounds.

Our main findings are underinvestment of workers with short-term contracts and almost efficient investment with long-term contracts. In addition, employers offer short-term contracts more frequently than long-term contracts. We also find that workers earn small rents as wages are above the market wage under both types of contract. In particular, wages do not reflect the investment differential between long- and short-term contracts.

Risk aversion might seem the first candidate to explain the lower investment rate under the short-term contract. If players fear that for some reason they might not receive the contract in the second period, they will not invest and ask for a higher wage in both periods. However, in equilibrium the incumbent worker of period 1 is employed again in period 2, i.e. the game theoretic solution involves

³Due to the discrete grid of possible wage bids, the employed worker earns one point more than his reservation wage.

no uncertainty.⁴

The next section introduces the model and its game theoretic solution. In Section 3 the experimental design is described. In Section 4, we report our results and confront them with the benchmark model. Section 5 concludes the paper.

2. Theory

2.1. The Game

Before presenting the model in detail we briefly outline the economic situation we had in mind when designing the game. Consider a firm owner (principal) P 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 (market wage, unemployment benefits).

A crucial feature of the game is that the employed worker may choose a firm-specific investment. Investment is costly and, to keep things simple, it is only the worker who benefits from it, but not the employer. Investment induces a reduction in the worker's production cost in the current and all future periods. Firm-specificity is reflected by the fact that investment does not influence the outside option wage. The parameters of the model are chosen such that investment is suboptimal if the worker is employed only for a single period, since investment cost 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 issue: whether the 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.

⁴Similar to the "trust game", which has been investigated by Berg, Dickhaut, and McCabe (1995) for example, underinvestment in our game with worker investment may be due to uncertainty about the other players' actions. But the trust game differs fundamentally from the game we consider in that its game theoretic solution predicts zero investment while in our game, the game theoretic solution entails efficient investment. Our approach is to analyze under which conditions less investment than in equilibrium occurs, not more.

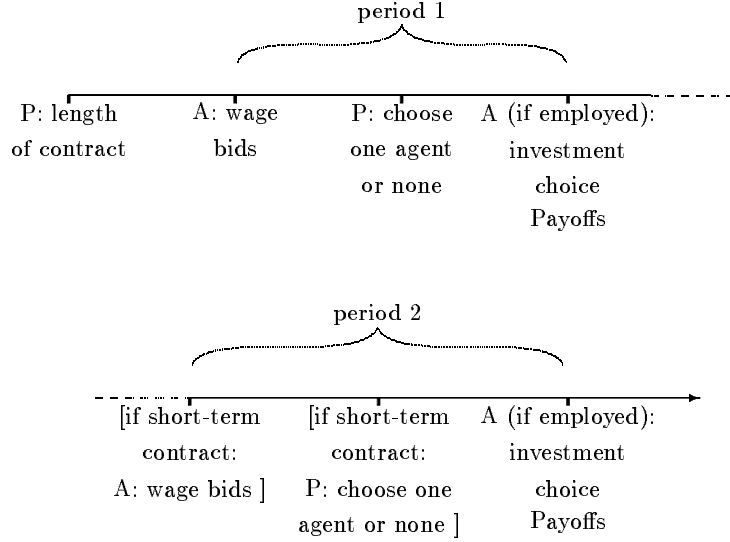


Figure 1: Time line of the game

In the following we describe the game in detail including the numerical specifications of 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

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

where $w_{i,1}^\tau$ represents agent i 's wage bid for period 1 for the given 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 no agent is informed about the other agent's bid.

Stage 3: (Selection among agents, period 1). P chooses whether to employ A or B or none. If $\tau = S$, this determines employment for period 1. If $\tau = L$, P 's decision holds for both periods. The unemployed worker(s) — ‘out-worker(s)’ — 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 or neither of them was chosen.

Stage 4: (Firm-specific investment, period 1). Production cost of the employed worker (‘in-worker’) are $d \equiv 8$. He may choose 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 did invest (did not invest) in period 1. Investment itself causes some cost αs with $\alpha \equiv \frac{3}{2}$. Thus, the in-worker's cost function in period 1 is

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

The principal knows whether the worker invested or not, but the unemployed worker is not informed about it.

The investment choice completes period 1. The employed agent earns his wage bid minus his 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.

Note that investment is firm specific in the sense that it reduces the in-worker's production cost not only in period 1 but also in period 2. However, the in-worker 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 does not get employed in period 2). Furthermore, note that $1 < \alpha < 2$ implies that investment is profitable for worker i only if he is employed in both periods.

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

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

($i = A, B$). 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 none. If $\tau = L$, no selection among agents occurs, since employment was determined in period 1. The out-worker(s) earn(s) $\bar{w}$. If no agent is employed, P earns $\bar{\pi}$. Again, each agent learns whether he or the other or neither of them was chosen.

Stage 7: (Firm-specific investment, period 2). The in-worker may choose (not choose) firm-specific investment $\delta_{i,2} = 1$ ($\delta_{i,2} = 0$) which reduces his current production cost by s . Again, investment itself causes cost αs with $\alpha = 2/3$. 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 'period 2 cost function' 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’ $c_2(\delta_{i,2})$ of the ‘period 2 in-worker’ can now be written as follows:

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

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. To this production cost the ‘period 2 investment cost’ are added and the ‘period 2 cost reduction’ is subtracted.

As in period 1, only the principal but not the out-worker knows whether the in-worker invested or not.

The investment choice completes period 2. The employed agent i earns a second period payoff $w_{i,2}^\tau - c_2(\delta_{i,2})$. P earns the ‘second period output’ y minus $w_{i,2}^\tau$. 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:

$$\begin{aligned} \Pi_i^\tau &= \sum_{t=1}^2 \gamma_{i,t} (w_{i,t}^\tau - c_t(\delta_{i,t})) + \sum_{t=1}^2 (1 - \gamma_{i,t}) \bar{w} \\ \Pi_P^\tau &= \sum_{t=1}^2 \gamma_{A,t} (y - w_{A,t}^\tau) + \sum_{t=1}^2 \gamma_{B,t} (y - w_{B,t}^\tau) + \sum_{t=1}^2 (1 - \gamma_{A,t} - \gamma_{B,t}) \bar{\pi} \\ &\text{for } i = A, B \text{ and } \tau = S, L, \end{aligned}$$

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

In the experiment each subject played 14 games (with random matching as described below). Total payoff was determined as the sum of payoffs of the 14 games.

2.2. Perfect Equilibria and Predicted Investment

To solve the game we apply the notion of (‘trembling hand’) perfect equilibrium (see Selten, 1975).

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.

3. *The employed worker chooses firm-specific investment in $t = 1$ but not in $t = 2$.*
4. *Equilibrium wage bids are:*

$$(w_{i,1}^S = w_{j,1}^S = 11, w_{i,2}^S = 12, w_{j,2}^S = 13) \quad (2.2)$$

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

The proof is provided in the appendix. Essentially the proposition describes a unique solution. Since the workers are symmetric, either A or B may be employed. Thus, formally the game has two perfect equilibria. However, they are symmetric and the labelling of players is irrelevant for our purposes. Note furthermore that the proposition only describes the equilibrium paths. The derivation in the appendix also explains off-path play.

In equilibrium, the in-worker earns one unit more than his outside option pay-off. 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 model for subjects' behavior against which we can compare the empirical data. In particular, we are interested in investigating the influence of the contract length on workers' choices of firm-specific investment. Therefore we compare perfect equilibrium investment behavior in the two subgames starting at stage 2 after a choice of $\tau = S$, respectively $\tau = L$.

Corollary 2. *Perfect equilibrium implies that the length of the work contract is irrelevant for firm-specific investment. Furthermore, in both stage 2 subgames, 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 higher for long-term contracts.

A rationale for our hypothesis is that a period 1 in-worker who is employed for a short term might fear becoming unemployed in period 2. This fear is irrational given equilibrium play. Nevertheless, we expect a higher frequency of investment decisions if $\tau = L$.

2.3. Experimental Design Issues

We do not investigate the investment hypothesis by imposing the contract duration as an exogenous experimental treatment; e.g. we could have collected data

from two different treatment groups with fixed duration $\tau = S$ or $\tau = L$, respectively. Rather we left the choice of contract duration up to the principal, thereby making duration an ‘endogenous treatment variable’. We expect that whether or not the principal decides for $\tau = S$ or $\tau = L$ might be behaviorally (in contrast to theoretically) relevant for the workers’ decisions. If the principal deliberately induces job insecurity, this may reduce the worker’s trust in re-employment even more than if the rules are fixed exogenously by the experimenter.

According to our parametrization, the efficiency gain that can be reached via investment is 2 monetary units (i.e., DM 0.5 per game and thus DM 7 for all games⁵). Namely, in case of investment, the joint profit of P and the in-worker over both periods is 22 (which is 10 units more than the sum of outside option payoffs), whereas in case of no investment 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 a rather moderate efficiency gain. In the experiment of Berg, Dickhaut and McCabe (1995) for example, investments were tripled, which generates extreme incentives for efficient behavior. We deliberately avoided such strong incentives for efficiency. It is known from other experiments that subjects tend to choose efficient actions even if it contradicts equilibrium behavior. Thus, it seems even more likely to observe efficient outcomes when this is in line with equilibrium, which is the case in our experiment. But, if most subjects would choose to invest no matter what the length of the contract, it would have been difficult to investigate our hypothesis. So we tried to avoid investment becoming a dominant action (in a behavioral sense) in order to retain statistical power, and therefore induced only moderate efficiency gains.

In our experimental design it is only the worker who benefits from the investment choice. One might as well be interested in models where firm-specific investment is beneficial for both the principal and the worker. This might have similar behavioral consequences as allowing for larger efficiency gains (see the discussion above), since then even the principal would clearly prefer long-term contracts.

3. Experimental Procedures

The experiment was conducted in June and July 1997 at Humboldt University. Subjects were undergraduate students (mostly economics and business administration), who were, in general, not recruited from the same course. They were randomly assigned to computer screens, identified by identification numbers and received written instructions.⁶ Upon reading they could privately ask clarifying questions.

12 subjects participated in each of the three sessions. Six subjects formed one

⁵ See the description of experimental procedures below.

⁶ For the translated instructions see the appendix.

matching group consisting of two employers and four workers. The roles were assigned randomly⁷ 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.⁸

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.

4. Experimental Results

In presenting the results we start by reporting some basic statistics on demanded wages and the employer's selection among workers. Thereafter we address the main issue of our investigation: the workers' choice of firm-specific investment and its relation to contract length. Finally, we look at the employer's choice of contract duration possibly depending on observed wages and at the division of surplus.

4.1. Submitted Wage Bids and Actual Payments

Figure 2 displays the distribution of wage bids. It includes the data of all 14 rounds and both periods for short- and long-term contracts separately. Remember that the perfect equilibrium wage bids are 11 in period 1 and 12 (in-worker), respectively 13 (out-worker), in period 2. The distribution displays many bids of 12, but only a few bids of 11. Furthermore there are a substantial number of wage bids greater than 13 which are not in line with perfect equilibrium. For the subgame following the principal's choice of a long-term contract, the equilibrium wage bid is 12. Although 12 is the mode of demanded wages, a substantial proportion of subjects ask for a higher wage.

Table 1 reports some statistics on the wages that were actually paid (as opposed to submitted wage bids). Accordingly, under short-term contracts the

⁷In 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.

⁸One 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 they did not know the matching procedure exactly. On 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 and Y2 changed between rounds. Thus, we think it is very unlikely that e.g. any principal was able to recognize a person she had played before.

average wage paid was lower than under long-term contracts. This comparative static result is in line with perfect equilibrium.⁹

	Mean	Variance	Median
Short-term, period 1	12.08	2.31	12
Short-term, period 2	11.89	1.77	12
Long-term contract	12.25	2.86	12

Table 1: Paid wages

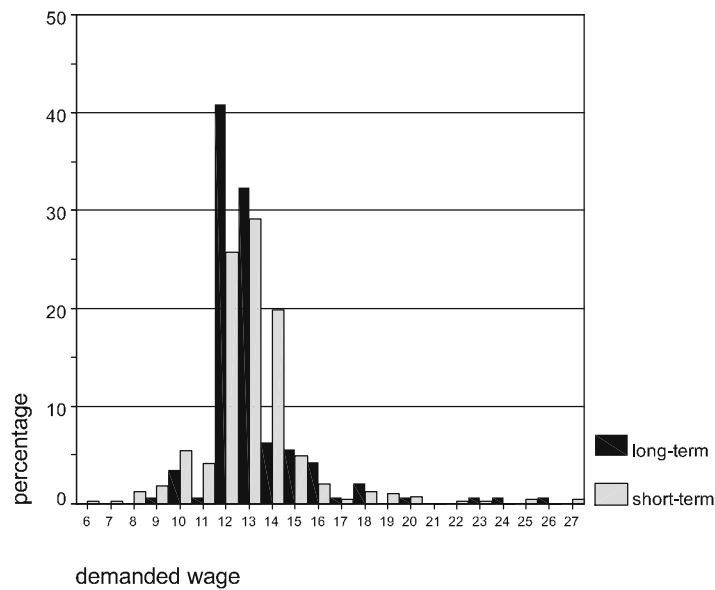


Figure 2: Demanded wages

Workers who were unemployed in period 1 (on average) reduced their wage bids in period 2. Nonetheless, their average bid was higher than the average bid of period 1 in-workers.

Table 2 reports some statics on adjustments in wage bidding between periods (under short-term contracts). It shows the average period 2 bid of workers that were unemployed in $t = 1$ compared to those that were employed (in-worker). The latter statistic is shown for all In-workers together as well as separately for those who had (had not) invested in $t = 1$. The three last rows report the changes in bids difference between periods 1 and 2 (Δ wage bid). The numbers are positive representing decreasing bids. In general, the differences between in- and

⁹The percentage of cases in which the paid wages of both periods are compatible with equilibrium is 2% for short-term contracts ($w_1 = 11, w_2 = 12$) and 63% for long-term contracts ($w_1 = 12, w_2 = 12$).

out-workers as well as between periods are small (except for the between periods adjustment of out-workers). In-workers who did invest in $t = 1$ submitted lower bids in $t = 2$ compared to in-worker who did not invest in $t = 1$ and compared to out-workers. This clearly reflects the cost advantage of investors. They may offer lower wages without incurring a loss.

	Mean	Variance
Out-workers	12.14	1.53
In-workers	11.78	1.86
No investment in period 1	12.11	3.87
Investment in period 1	11.66	1.10
Δ wage bid (all workers)	0.19	1.41
Δ wage bid (out-workers)	1.64	4.39
Δ wage bid (in-workers)	0.08	0.24

Table 2: Period 2 wage bids under short-term contracts

One might have feared the out-workers to submit ‘dumping wages’ in period 2 in order to get employed even if this implied a monetary loss. In a laboratory experiment one should not a priori exclude such gambling behavior to occur. But, except for a few cases, we found no indication of such behavior.

4.2. Selection Among Workers

In equilibrium the principal does employ a worker rather than not employing anyone. Table 4 reports only few cases of non-employment (5% on average). Furthermore the employer should select the worker who submits the lower demanded wage which was almost always the case. Only in about 2% of the cases principals decided for the higher wage (which we attribute to noisy play). Equal wage bids occurred in about 20% of the cases. Given equal wage bids in $t = 2$ (and short-term contracting) — i.e. P is indifferent whether or not to employ the same worker again —, the same worker was employed again in about half of the cases (11 times out of 20 occurrences). Overall, under $\tau = S$ the same worker was employed in period 1 and 2 in 72% of all cases.

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

Table 4: Employment versus no employment decisions

4.3. Investment

Now we investigate our main issue as formulated by the investment hypothesis. Namely, whether the worker's willingness to choose firm-specific investment is smaller if he faces a short-term employment contract compared to a long-term contract. Perfect equilibrium requires that an employed worker should choose firm-specific investment in period 1, but not in period 2. This holds for both types of work contracts, short-term as well as long-term. Thus, from the theoretical viewpoint the duration of the work contract should have no influence on subjects' investment decisions. Table 5 reports the percentage of cases in which workers did choose investment in the first period for short-term versus long-term contracts. The data are divided into rounds 1 to 7 versus rounds 8 to 14.

Duration of Work Contract	Games 1 to 7	Games 8 to 14
Short-term ($\tau = S$)	61% ($N = 44 \hat{=} 100\%$)	69% ($N = 49 \hat{=} 100\%$)
Long-term ($\tau = L$)	88% ($N = 34 \hat{=} 100\%$)	97% ($N = 33 \hat{=} 100\%$)

Table 5: Investment in period 1 (relative frequency of $\delta_{i,1} = 1$)

Obviously, the data support our hypothesis. The relative frequency of investment is much higher for $\tau = L$ than for $\tau = S$. Note also that investment is less than 100% even for long-term contracts. While this may be attributed to decision errors, the shift between the two treatment conditions is systematic and can be backed up by formal statistical testing. In particular, the frequency of investment is higher in case of $\tau = S$ versus $\tau = L$ 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. Note that we chose a very conservative way of testing our hypothesis. The test is based on group data rather than individual data since individuals interacted within each group. Such interaction might induce a correlation between individual decisions so that tests based on individual data would have been unreliable.¹⁰

The influence of experience (rounds 8 to 14 compared to 1 to 7) is less pronounced than the influence of contract duration. It raises investment by 8 percentage points for $\tau = S$, respectively 11 percentage points for $\tau = L$.¹¹

¹⁰ A discussion of this and related problems can be found e.g. in Davis and Holt (1993), p. 527–28, and Königstein (1998).

¹¹ Furthermore, the influence of experience is not statistically significant due to a binomial test based on matching group data. If one is less conservative in testing, one might run an analogous test using firms (12 observations) as units of analysis rather than matching groups (6 observations). This makes sense if the problem of correlated decisions is negligible, and it may increase the statistical power of the test. In this case one finds that experience increases investment in 9 out of 12 cases leading to a rejection of the null-hypothesis ($p = 0.073$, one-tailed).

Given our finding of increased investment under long-term contracting, one may now wonder about its causes. One explanation we can offer is based on occasional decision errors and heterogeneous risk attitudes among workers. If $\tau = S$ there is some (out of equilibrium) risk of not getting employed again in period 2 due to errors in wage bidding or in the employer's selection among workers. Therefore, a rational worker who assigns positive probability to such erroneous decisions should be less inclined to invest if $\tau = S$ compared to $\tau = L$. Furthermore, if risk attitudes are asymmetric, some workers may still choose investment while others don't, which would generate the observed effect.

This influence of off-equilibrium uncertainty, which may arise in short-term contracting, could be a general feature of labor markets. Moreover, one can easily imagine that it becomes more important if labor market competition is stronger. For instance, if more agents compete, the more likely a worker may lose his job to an underbidding out-worker.

Besides providing some arguments for the plausibility of the observed decisions, we want to emphasize their consequences for economic surplus. Cases of full efficiency occur much less often for short-term rather than long-term contracts. Specifically, the efficiency loss due to short-term contracts, which we define as

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

is about 31% for rounds 1 to 7 and 29% for rounds 8 to 14. Thus, the loss is substantial, and it is stable against experience.

Some workers chose firm-specific investment even in period 2, which is another source of efficiency loss. Such decisions occurred equally often (13 times) for both contract lengths, and overall this comprised 16% of the cases. In contrast, in period 1 efficient investment occurred (on average) in 77% of the cases. So this 'between periods asymmetry' is qualitatively in line with the prediction.

4.4. Duration of Work Contracts

The theoretical solution proposes $\tau = S$, since the perfect equilibrium wages are lower than those resulting for $\tau = L$ (given rationality in the stage 2 subgames). Indeed, we did find lower wages (on average) for short-term contracts (see above). Thus, given the observed wages the principal should on average prefer $\tau = S$ to $\tau = L$. As table 6 reports, this is actually the case. Short-term contracts are chosen more often than long-term contracts. The difference in frequencies gets larger with experience, i.e. subjects in the role of employers seem to react to the lower demanded wages under short-term contracts.

Thus, while surplus maximization would call for long-term contracts – since it increases investment rates and thus efficiency –, income maximization by principals leads to short-term contracting.

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

Table 6: Duration of work contracts

4.5. Division of surplus

Figure 2 shows that many workers submit higher wage bids than predicted by equilibrium. This might be interpreted as an attempt by workers to capture higher surplus shares. Theoretically, P gets almost all surplus. Specifically, equilibrium predicts surplus shares of 10% ($\tau = S$), respectively 20% ($\tau = L$) for the worker. Table 3 reports the observed mean surplus and the mean surplus share of the agent for both contract lengths.

	Short-term contract	Long-term contract
Mean Surplus	8.08	8.93
Mean Surplus Share Agent	0.04	0.21

Table 3: Surplus shares

With short-term contracts the worker captures 4% of the surplus generated by the match, with long-term contracts 21%. Thus, the difference in the agent’s surplus share is qualitatively as predicted by perfect equilibrium. Furthermore, surplus splitting is rather asymmetric and favors the principal. Notice that the observed average surplus shares and the equilibrium surplus shares are quite close, especially for long-term contracts.

5. Conclusions

Some of the results we found in our experiment are in line with economic theory. First, we observed almost competitive wages. Specifically, while submitted bids were higher than perfect equilibrium bids in many cases, the actually paid wages were close to the perfect equilibrium. Secondly, the asymmetry in surplus splitting was roughly as predicted. Third, in most cases the same worker was employed in both periods. And finally, investment rates were substantially reduced in $t = 2$.

However, our main issue here was the investigation of the investment hypothesis, predicting higher investment under long-term contracting compared to short-term contracting. The data clearly support this hypothesis and reject the perfect equilibrium prediction. The latter proposes within the model we study that contract length is irrelevant for firm-specific investment. In contrast, we

find that high job security ($\tau = L$) induces higher investment rates than if job security is low ($\tau = S$).

Since in perfect equilibrium (efficient) investment in $t = 1$ should occur under both contract lengths, there is no conflict between social welfare maximization and employer's profit maximization. However, empirically we find a trade-off. Namely, given the observed investment rates, maximization of social welfare requires $\tau = L$. But maximizing firm profit calls for a choice of $\tau = S$ (more often than $\tau = L$ since average wages are lower for short-term contracts). We observe P choosing $\tau = S$ more often than $\tau = L$, which indicates profit maximization rather than social welfare orientation.

Transferring the results to real world work contracts suggests that job security may improve welfare even in situations where dismissal rules should be irrelevant according to the rational actor model. For economic policy this could mean e.g. that welfare gains due to labor market deregulation have to be traded off against welfare losses due to underinvestment into firm-specific skills. Claims that reducing job security is irrelevant for the level of firm-specific investment should therefore be taken with care.

A. Proof of the Proposition

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 one worker rather than not employing anyone, that the in-worker $i \in \{A, B\}$ invests in $t = 1$ but not in $t = 2$, and that wage bids are $w_{i,1}^L = w_{j,1}^L = 12$.*

P proof. Let i represent the in-worker; 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 cost 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 investment cost. Accordingly, i 's two-period cost 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 $\Pi_i^L(\gamma_{i,1} = 1)$ compared to his payoff in case of no employment $\Pi_i^L(\gamma_{i,1} = 0)$. We refer to $\Delta\Pi_i^L = \Pi_i^L(\gamma_{i,1} = 1) - \Pi_i^L(\gamma_{i,1} = 0)$ as i 's payoff margin. Since

$$\begin{aligned} \Pi_i^L(\gamma_{i,1} = 1) &= 2w_{i,1}^L - 14 \\ &\text{and} \\ \Pi_i^L(\gamma_{i,1} = 0) &= 2 \cdot 4 = 8 \end{aligned}$$

it follows that i 's payoff margin is non-positive for all $w_{i,1}^L \leq 11$. 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 $w_{i,1}^L > 11$. Symmetry implies that worker j chooses $w_{j,1}^L > 11$ as well.

If both workers submit the same wage bid, P is indifferent regarding selection among workers. Suppose in this case that P randomizes with equal probability for each worker. Accordingly, perfect equilibrium in the subgame we consider here requires $w_{i,1}^L = w_{j,1}^L = 12$. Note that the workers' wage bidding is a kind of Bertrand-game.

It remains to show that P 's profit is larger in case he employs one worker $\Pi_P^L(\gamma_{i,1} = 1, \gamma_{j,1} = 0)$ compared to employing none $\Pi_P^L(\gamma_{i,1} = \gamma_{j,1} = 0)$. Since

$$\Pi_P^L(\gamma_{i,1} = 1, \gamma_{j,1} = 0) = 2y - 2w_{i,1}^L = 12$$

is larger than

$$\Pi_P^L(\gamma_{i,1} = \gamma_{j,1} = 0) = 2\pi = 4$$

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 will employ the same worker i in both periods, that the employed worker will choose firm-specific investment only in the first period ($t = 1$) and that the wage bidding profile is $(w_{i,1}^S = w_{j,1}^S = 11, w_{i,2}^S = 12, w_{j,1}^S = 13)$.*

P proof. Let $i \in \{A, B\}$ represent the in-worker in period 2. Since the game ends after period 2, i does not invest ($\delta_{i,2} = 0$) in $t = 2$; the one-period cost reduction that would be induced is less than the investment cost. According to equation (2.1) i 's cost in $t = 2$ also depend on whether or not he was employed and did invest in $t = 1$. Thus his cost are

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

Furthermore, i 's second-period payoff is

$$\Pi_{i,2}^S(\gamma_{i,2} = 1) = w_{i,2}^S - c_2(\cdot) = \begin{cases} w_{i,2}^S - 8 & \text{if } \delta_{i,1} = 0 \\ w_{i,2}^S - 4 & \text{if } \delta_{i,1} = 1 \end{cases}$$

in case of employment and $\Pi_{i,2}^S(\gamma_{i,2} = 0) = 4$ in case of non-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. In order to look for rational bids note again that the wage bidding stage resembles Bertrand competition. However, the analysis here is complicated by the fact that at this stage the players are only imperfectly informed about the history of the game up to that stage. Specifically, no worker knows the other worker's first period wage bid and the 'period-1 out-worker' does not know whether the 'period-1 in-worker' has invested in $t = 1$. In deriving the solution we have to take these information conditions into account.

First, notice that the previous wage bid of the other worker is irrelevant for each worker's continuation payoff. So, the imperfectness of information regarding previous wage bids is inessential. Secondly, with respect to investment we need to distinguish between 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 'period-1 in-worker'.

Worker j does not know whether he faces the symmetric or the asymmetric case. Since j did not invest in $t = 1$, every bid $w_{j,2}^S \leq 12$ implies a non-positive second-period payoff margin $\Delta \Pi_{j,2}^S = \Pi_{j,2}^S(\gamma_{j,2} = 1) - \Pi_{j,2}^S(\gamma_{j,2} = 0)$, 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

$$8 < w_{i,2}^S < 13.$$

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 $w_{j,2}^S = 13$ in any case while worker i should bid $w_{i,2}^S = 12$ in case of asymmetry ($\delta_{i,1} = 1$) and $w_{i,2}^S = 13$ 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 $w_{j,2}^S > 13$, 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 'period-1 in-worker' i does not invest in $t = 1$, his second period payoff is either

$$\Pi_{i,2}^S(\delta_{i,1} = 0) = 13 - 8 = 5$$

(if he is employed in $t = 2$) or $\bar{w} = 4$ (if he is not employed in $t = 2$). On the contrary, in case he does invest in $t = 1$, he will become 'period-2 in-worker' (almost surely within perturbed games) and earn

$$\Pi_{i,2}^S(\delta_{i,1} = 1) = 12 - 4 = 8.$$

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

$$\begin{aligned} \Pi_i^S &= \Pi_{i,1}^S + \Pi_{i,2}^S = w_{i,1}^1 - 4 - 6 + 12 - 4 \\ &= w_{i,1}^S - 2 \end{aligned}$$

in case i gets employed and $\Pi_i^S = 8$ otherwise. Thus for all $w_{i,1}^S \leq 10$ worker i earns a non-positive payoff margin. Rationality in the perturbed game therefore requires $w_{i,1}^S \geq 11$, and due to symmetric Bertrand competition one gets $w_{i,1}^S = w_{j,1}^S = 11$ 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:

$$\begin{aligned} (w_{i,1}^S &= w_{j,1}^S = 11, w_{i,2}^S = 12, w_{j,1}^S = 13), \\ &\text{and} \\ (w_{i,1}^L &= w_{j,1}^L = w_{i,2}^L = w_{j,2}^L = 12). \end{aligned}$$

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:

$$4 \text{ points} = 1 \text{ DM}$$

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):

$$\begin{array}{r} \text{period income} \\ - \text{wage in period } t \\ \hline = \text{profit in period } t \end{array}$$

· 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):

$$\begin{array}{r} \text{wage in period } t \\ - \text{cost of investment in period } t \\ - \text{labor costs in period } t \\ \hline = \text{profit in period } t \end{array}$$

· 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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