How Much to Pay in Cash?
Employee Retention via Stock Options*

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Abstract

Stock option grants may allow to retain employees in firms facing short-term financial constraints. We investigate the optimal combination of cash and stock options that a firm can use to keep qualified personnel to overcome bankruptcy. Parties first bargain about a compensation scheme. Then, on the labor market, the employee decides between a stock option grant and alternative job offers. We use the cooperative Nash bargaining solution to distribute a surplus of random size and find the structure of the optimal compensation scheme.

Keywords: Stock Options, Employee Retention, Nash Bargaining, Laboratory Experiment

JEL-Classification: J32, J33, M12, M5

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1 Introduction

Although punctual and full payment of wage obligations is a standard feature of most employment relationships in developed economies, unpaid, delayed, deferred or reduced wages may occur in firms under stress, e.g., firms about to shut down, start-up companies with severe liquidity constraints or in occasional situations bankrupt debtors or even of fraud. This model captures the problem of employee retention in firms that suffer from cash constraints but have a good chance of recovering. It would be appropriate to analyze wage arrears in the framework of a monopsonic labor market (Friebel and Guriev, 1999) in the case of low-skilled labor in geographic areas heavily dominated by a single firm (e.g., mining or heavy industries in hinterland regions of Eastern European countries). Here, however, we focus on high-skilled, non-substitutable employees who are likely to receive several attractive job offers on the labor market.

Cash constraints make it necessary to design compensation schemes which are attractive enough to prevent employees from leaving their job until recovery of liquidity takes place. One such possibility is to substitute a claim on a share of future profits of the company for cash payments. Indeed, non-vested stock option grants are one of the most practiced form of equity compensation. While any form of deferred compensation could make it costly for employees to leave, Oyer (2001) presents conditions under which stock options are especially useful for this purpose: If stock prices and labor market conditions are positively correlated, non-vested stock options may serve to index employees deferred compensation to their outside opportunities. In this paper we examine this generally accepted form of profit sharing between firms and employees, and consider its use as part of a payment scheme in the context of liquidity constraints.

2 Equity compensation

Many firms issue stock options not only to top executives but to all employees (Oyer and Schaefer, 2004). Moreover, quite a few authors (e.g., Core and
Guay, 2001) find greater use of employees options in firms facing financial constraints. Although employees are not always the cheapest source of credit for a company facing cash constraints, other effects of stock options make this practice common. In particular, equity payments may induce employees to exert higher effort, improve the ability of the company to attract skilled employees, and help firms to retain them. While the first two justifications are more general and have to do with information asymmetries, the classic moral hazard and adverse selection problems, the use of stock options for retention purposes particularly concerns firms facing temporary liquidity constraints, and could be considered in the framework of symmetric information. Obviously the importance of retaining employees is greatest in firms requiring high skilled personnel and in firms where human capital is the relatively more important factor of production. Following this reasoning we focus on the use of stock options in lieu of cash with the primary objective of retaining skilled employees.

It is usually argued that employees are more risk-averse\(^1\) and have shorter planning horizons than their employers. Therefore, one could expect employees to require a risk premium in order to accept equity compensation instead of cash. However, the value of the tax deferral that employees receive from stock compensation may also reduce this premium. In addition, provided that information asymmetries between the firm and its employees are lower than those between firm and outside investors, equity compensation can have cost advantages relative to external financing.

Stock options can serve as salary buffers to keep employees from leaving their firms when salaries or other benefits start to rise in the labor market. Therefore, we expect this kind of equity compensation to be substituted for cash payments in companies with cash-flow constraints, high capital needs, high cost of accessing capital markets, and a greater interest in retaining non-substitutable workers.

The relation between market wages and stock options is not entirely new. According to Oyer (2001), stock options and other compensation based on

\(^1\)One, however, wonders why risk averse employees do not buy shares of other firms to diversify their income risks.
firm performance may help companies to design payment schemes that will retain workers facing fluctuating market wages, specially if the costs of employee turnover are high. In his empirical analysis, Oyer found that stock options are more effective in industries where individuals’ market wages vary widely, in tight labor markets where replacing workers is costly, and when the specific sector of a particular industry experiences greater common shocks, such as a sudden downturn in product demand. Oyer’s model basically considers how the firm must account for three types of costs: negotiating with current employees (or replacing them), passing risks to employees, and overpayment of wages.

Faced with these costs, a firm has three ways to tackle its compensation strategy. First, the firm may choose to incur the cost of renegotiating wages every time an employee gets an outside offer or at every major fluctuation in the labor market. Companies may use this method when wages do not change often or when employees are especially averse to risk. Second, the firm may pay a bonus contingent on the firm’s profit, while lowering the employee’s risk premium by fixing his total pay above the market wage. A company might prefer this alternative when the costs of renegotiating wages are high and the correlation between the firm’s stock price and the employee’s outside opportunities is low. Finally, the firm may write employment contracts that include salary and stock options. If options, or some other measure of the firm’s performance, are highly correlated to the outside labor market, then the company can make the employee virtually unsusceptible to the outside opportunities.

The latter case is the focus of this paper. Although the topic is widely discussed in the empirical literature, little attention has been paid to the bargaining aspect of this problem. We focus on how employer and employee bargain about a combination of cash payments and stock options making the employee stay with the company.

The paper is organized as follows. In section 3 we present the theoretical model; in section 4 we state the bargaining problem and obtain its solution; in section 5 we examine whether there is an optimal combination of cash and stock options that allows of employee retention. A laboratory experiment
implementing the bargaining stage of our theoretical model is presented and analyzed in Sections 6 and 7. Section 8 concludes with a discussion of the implications that follow from our results.

3 The Model

Consider a labor relationship between a firm and an employee facing the risk of breaking up due to the firm’s lack of finance. In particular, suppose that the firm (she, F) faces severe liquidity constraints (e.g., because the payments from customers or the revenues from some investment project did not arrive on time) and is not able to pay the salary to her only employee (he, E). Therefore, the firm has two possibilities: either to shut down or to engage into further debts to cover her payroll. The first possibility terminates the relationship by declaring bankruptcy, thus obtaining a profit normalized to zero in both the first and the second period, $U^F_1 = U^F_2 = 0$. The alternative is an attempt to continue the work relationship when expecting a sufficiently high revenue in a second stage of the game. In this case, F could engage into additional debts to get some cash from a bank, the government, etc. and renegotiate the labor contract in order to dissuade E from leaving the firm, at least until expectations regarding future revenue (or the lack of it) become clear.

The decision process is shown in Figure 1. It includes two decision stages (1 and 2), as well as an interim stage in which some random event occurs. The analysis of stage 1 begins at a point of time in which E is already an employee of F. Here, we assume that E has already delivered work effort but due to some exogenous event (e.g., payment delays from customers) the firm is short of cash to pay the employee’s salary, regardless of E’s level of productivity. Thus, the only decisions to be made in stage 1 concerns the renegotiation of the original salary, $w_1$. In particular, we let F and E bargain in stage 1 about a new compensation scheme specifying the fraction (percentage) of future profits that the firm can offer the employee in lieu of immediate cash payments. Stage 2, on the other hand, is a labor market stage, in which E has the choice among several job offers. We proceed now
Stage 1: bargaining over future risky surplus

Interim period: realization of productivity

Stage 2: labor market competition

Figure 1: Time sequence of the game
to describe each stage in detail.

3.1 Stage 1: Renegotiating the labor contract

The game begins with both parties bargaining about a compensation scheme $b(\alpha)$ such that, if $F$ pays only a fraction $\alpha$ of the salary $w_1$ to the employee in the first period, she is obliged to give him a fraction $1 - b(\alpha)$ of the second period profits, which are denoted by $S^*$ and defined as the difference between the firm’s revenues and the employee’s salary (see section 3.3).

This form of deferred compensation (in our case, a stock-option grant) is lost if the employee leaves the firm. In what follows, we show that the equity-compensation scheme $b(\cdot)$ that results from the salary renegotiation is an increasing function of $\alpha$, meaning that it is possible to substitute stock options for immediate cash payments in order to retain the employee. Moreover, if the outcome of the renegotiation includes some payment in cash in stage 1 (i.e., if $\alpha > 0$), we assume that it has to be financed by a credit at interest rate $r \in \mathbb{R}$. Therefore, paying a fraction $\alpha \in [0, 1]$ of $w_1$ to the employee in stage 1 results in an additional liability equal to $(\alpha w_1)r$ for the firm.

If the renegotiation of $w_1$ fails, we assume that $E$ leaves the company without being paid and $F$ goes bankrupt, both obtaining a zero utility level in the first period: $U_1^E = U_1^F = 0$. In contrast, if an agreement is reached at $2b(\alpha)$ and $1 - b(\alpha)$ represent the second-period shares of the firm and the employee, respectively.
stage 1 the employee obtains

\[ U_1^E = \alpha w_1, \]

while the firm ends up with a total liability of

\[ U_1^F = -\alpha w_1(1 + r). \]

Although the employee is non-substitutable for the firm, \( F \) is not the only employment opportunity for \( E \): As a skilled employee, \( E \) could easily find an alternative job on the labor market, where there are other *ex ante* identical firms (indexed by the set \( L = \{1, \ldots, n\} \)) ready to make competitive salary offers \( w_i^2, i \in L \), in the second period, depending on the different productivity levels \( (p_1, \ldots, p_n) \) that the employee can attain at each of the \( n \) firms. Although these future productivity levels are uncertain during stage 1, it is common knowledge that \( \forall i \in L, p_i \sim \text{Uniform}[0, P] \) and that the productivity that \( E \) will be able to attain at the second stage at \( F \), if their partnership is preserved, is \( p_F \sim \text{Uniform}[0, P_F] \), with \( P_F > P > 0 \). Assuming \( P_F > P \) means that \( E \) has already acquired some firm-specific abilities at the first stage, which are not transferrable to other firms. If the partnership is preserved (at least until the second stage-labor market competition), \( F \)'s prospects of being the most productive among all potential employers of \( E \) are better than for any of the other \( n \) firms. Thus, \( F \) has a better chance to compete for the employee in the second stage. More specifically, the ex ante probability that \( F \) will be able to profitably overbid the salary offers made by the other \( n \) firms increases with \( P_F - P \). It therefore may be profitable for \( F \) to retain \( E \) even at the cost of additional debts.

### 3.2 Interim Stage: Realization of productivity levels

Before stage 2 begins, there is an interim stage at which the levels of employee productivity in each firm (i.e., the realized values of the \( p_i \)'s) are observed. The fact that these firm-specific levels of productivity are observed before production takes place accounts for a situation in which companies receive
orders in advance.\textsuperscript{3} We write $p_{(1)} = \max_{i \in L} p_i$ for the highest productivity level among the $n$ competing firms, and denote by $i^* = \arg \max_{i \in L} p_i$ the most productive one. Similarly, we let $p_{(2)} = \max_{i \in L \setminus i^*} p_i$ be the second highest productivity level among the competitors.

### 3.3 Stage 2: Labor market competition

Stage 2 of the game begins after the potential productivity of the employee in each of the existing firms becomes commonly known. In this stage, the firms on the market make simultaneous salary offers to $E$.\textsuperscript{4} and Bertrand competition leads each of them, except for the most productive one, to offer a salary equal to its own productivity level. Only the most productive of all existing firms offers a salary lower than the own productivity, namely the employee’s opportunity-cost salary,\textsuperscript{5}

\[
w_2 = \begin{cases} p_{(1)}, & \text{if } p_F \geq p_{(1)} \geq p_{(2)} \\ p_F, & \text{if } p_{(1)} > p_F \geq p_{(2)} \\ p_{(2)}, & \text{if } p_{(1)} > p_{(2)} > p_F. \end{cases} \tag{1}
\]

Here, it is important to stress that $E$’s share $1 - b(\alpha)$ of profits is a fraction of his productivity in firm $F$, $p_F$, minus his opportunity cost salary, $w_2$, conditioned on $E$ being hired by $F$. Therefore, $E$ always prefers firm $F$ being able to bid in the labor market, since this can only increase his expected competitive salary $Ew_2$. In other words, $E$ has an interest in helping $F$ to avoid bankruptcy in the first stage, regardless of who finally hires him in stage 2.

Assuming that the employee always accepts the highest salary offer in the second period, two types of employment are possible for him:

\textsuperscript{3}For instance, this is a usual practice in the production of software and consulting services.

\textsuperscript{4}Firm $F$ may or may not exist in period 2, depending on whether the employee $E$ was retained or not.

\textsuperscript{5}The employee’s opportunity cost salary, $w_2$, is equal to the second order statistic of the sample of all productivities (including the productivity of firm $F$, which is equal to zero if it did not survive bankruptcy) since it is the salary that the employee would receive upon contracting with the second most productive firm.
1. If his initial employer $F$ survives bankruptcy and becomes the most productive firm at stage 2 (i.e., if $p_F \geq p_{(1)}$), she employs him by offering a second period salary equal to $w_2 = p_{(1)}$ according to (1). Additionally, $E$ is entitled to a share $(1 - b(\alpha))$ of the second stage profits $S$, as agreed upon during the wage renegotiation process in stage 1, where

$$S = p_F - p_{(1)}.$$

2. In case that $F$ does not become the most productive firm (i.e., if $p_F < p_{(1)}$), $E$ is hired by the firm $i^*$ with salary $w_2 = \max \{p_F, p_{(2)}\}$, and any stock options held by the employee become void.

Therefore, at the end of stage 2 the employee receives his second period salary $w_2$ and, if his initial employer $F$ turns out to be the most productive company, he also receives a share $(1 - b(\alpha))S$ of the surplus. Only in this latter case $F$ receives a payoff equal to $b(\alpha)S$. Put it differently, $F$’s utility in the second stage is equal to

$$U_F^E = b(\alpha)S^*,$$

where, $S^* = \max \{0, S\}$, while the utility of $E$ in stage 2 is given by

$$U_E^E = w_2 + [1 - b(\alpha)]S^*,$$

with

$$w_2 = \begin{cases} p_{(1)}, & \text{if } S^* > 0 \\ \max \{p_F, p_{(2)}\}, & \text{otherwise.} \end{cases}$$

4 The bargaining outcome

In this section we present the cooperative bargaining solution for stage 1 of the game, assuming that both $E$ and $F$ have equal bargaining power. Specifically, we apply the Nash bargaining solution to the problem of finding the share $b(\alpha)$ of future (uncertain) profits that the firm would have to offer
to the employee (given an fixed immediate cash payment $\alpha w_1$) in order to retain him.

The utility of the firm and the employee for two periods can now be written as

$$EU^F = E[U_1^F + U_2^F] = E[-\alpha w_1 (1 + r) + b(\alpha)S^*]$$

and

$$EU^E = E[U_1^E + U_2^E] = E[\alpha w_1 + w_2 + (1 - b(\alpha))S^*],$$

respectively.

Notice that, since the productivity levels of stage 2 are still unknown in the first one, an agreement about a combination of cash and stock options must be reached considering expected utilities. Thus, the bargaining problem in the next section is solved by taking into account both the probability that the $F$ becomes the most productive firm in the future, and the expected size of the bargaining surplus.

4.1 The bargaining setting

The bargaining situation in our model is characterized by two important features: First, we assume that utility is not completely transferrable between the firm and the employee, and second, we allow for the possibility of bankruptcy, which means that liabilities acquired by the firm in stage 1 can only be paid back to the creditor in its full amount if the firm makes enough profits in stage 2.

The non-transferability assumption captures the idea that payments made to the employee in the first stage are non-refundable, and more importantly, cannot be contingent on the realization of productivity levels. This means that the total expected utility of the firm is constrained by

$$EU^F \leq ES^* - \alpha w_1 (1 + r)\theta,$$  \(2\)
where

\[ \theta = \Pr(\text{p}_F > \text{p}_{(1)}) = 1 - \frac{n}{n+1} \frac{P}{P_F} \]

is the probability of \( F \) being the best employment opportunity for \( E \) (the most productive firm) in stage 2, and

\[ E S^* = \frac{(P_F - P)^2}{2P_F} + \frac{(n + 3)}{(n+1)(n+2)} \cdot \frac{P^2}{P_F} \]

is the expected value of profits in that stage (see Appendix 1).

The limited liability assumption, \( EU^F \geq 0 \), requires the introduction of an exogenous actor (e.g., a bank or the government) that is willing to provide credit to the firm during stage 1, knowing that this credit will be unrecoverable if the firm is not able to hire the employee in stage 2 (an event which occurs with probability \( 1 - \theta > 0 \)), and that the credit is recoverable only up to the realized value of \((1 - b(\alpha))S^*\). In other words, while the employee receives \( \alpha w_1 \) in stage 1 with certainty, the firm pays back to the creditor \( \alpha w_1 (1 + r) \) in stage 2 only with probability \( \theta < 1 \), and this payment is subject to the limited liability constraint of the firm (see Section 5).

Assuming for a moment that the limited liability constraint is not binding, and denoting the difference between the amount received from the bank and the expected payback as

\[ \beta(\alpha) \equiv \alpha w_1 (1 - (1 + r)\theta), \]

it is possible to distinguish three cases, depending on the value of the interest rate \( r \). First, if \( r < \left( \frac{1-\theta}{\theta} \right) \), the value of \( \beta(\alpha) \) can be interpreted as an increase in the agreement surplus, since the creditor is providing funds in excess to what the firm will pay back in expected value. In contrast, if the interest rate is such that stage 2’s expected refund is greater than what the employee received in stage 1, i.e., if \( r > \left( \frac{1-\theta}{\theta} \right) \), then the resulting negative value of \( \beta(\alpha) \) decreases the agreement surplus. In fact, an interest rate \( r^* \) that exactly
matches $F$’s odds of bankruptcy,

$$r^* = \left( \frac{1 - \theta}{\theta} \right), \quad (3)$$

can be easily shown to be the unique competitive interest rate at which creditors make neither loses nor profits in expected value, since $(1+r^*)\theta = 1$.\(^6\)

As explained in section 3.3, another particular feature of our model is the fact that the competitive salary expected by the employer in stage 2, $E(w_2)$, depends on the success of the agreement in stage 1. Defining $k = 1$ if bargaining succeeds, and $k = 0$ otherwise, it is possible to show that (see Appendix 1):

$$E(w_2|k) = \begin{cases} \left( \frac{n}{n+1} - \frac{n}{(n+1)(n+2)} \cdot \frac{P}{P_F} \right) P, & \text{if } k = 1, \\
\left( \frac{n-1}{n+1} \right) P, & \text{otherwise.} \end{cases}$$

Thus,

$$\Delta E(w_2) \equiv E(w_2|1) - E(w_2|0) > 0$$

is the additional gain in the joint surplus corresponding to the employee’s direct interest in helping the firm to survive.

### 4.2 Bargaining solution

We can now state the bargaining problem faced by $E$ and $F$ in the canonical form $(B_\alpha, d)$, where $B_\alpha$ is the set of feasible agreements (bargaining set) and $d = (d^E, d^F)$ are the conflict payoffs. Taking into account the non-transferability and limited liability assumptions, and defining $\tilde{U}_j \equiv E(U_j - d^j)$, $j = E, F$, we get

$$B_\alpha = \left\{ (\tilde{U}^E, \tilde{U}^F) : \tilde{U}^E + \tilde{U}^F \leq ES^* + \Delta E(w_2) + \beta(\alpha), \quad \tilde{U}^F \leq ES^* - \alpha w_1 (1 + r) \theta \right\},$$

with conflict payoffs $(d^E, d^F) = (E(w_2|k = 0), 0)$.

\(^6\)Notice that according to expression (3) a firm with high probability of success should be able to obtain financial support at a lower interest rate.
Then, the Nash bargaining solution with symmetric bargaining power
\[
f^N(B_\alpha, d) = \arg\max_{(\tilde{U}_E, \tilde{U}_F) \in B_\alpha} \tilde{U}_E \cdot \tilde{U}_F
\]
results in the following two cases (see Figure 2):

1. Internal solution:
\[
\tilde{U}_E^{int} = \tilde{U}_F^{int} = \frac{ES^* + \Delta E w_2 + \beta(\alpha)}{2}, \tag{4}
\]

implying
\[
b(\alpha)^{int} = \frac{1}{2} + \frac{\Delta E w_2 + \alpha w_1 (1 + (1 + r) \theta)}{2ES^*}.
\]

2. Corner solution:
\[
\tilde{U}_E^{cor} = \Delta E w_2 + \alpha w_1, \text{ and } \tilde{U}_F^{cor} = ES^* - \alpha w_1 (1 + r) \theta \tag{5}
\]

which implies \(b(\alpha)^{cor} = 1\).

Whether the bargaining problem results in a corner solution or in an internal one depends on the restriction (2) being binding or not. Substituting
in (2) it is straightforward to obtain the threshold value

\[ \alpha^* \equiv \frac{E_S^* - \Delta E w_2}{w_1 (1 + (1 + r) \theta)}. \]

The solution, therefore, can be summarized by the compensation schedule⁷

\[ b^*(\alpha) = \begin{cases} \frac{1}{2} + \frac{\Delta E w_2 + \alpha w_1 (1 + (1 + r) \theta)}{2E_S^*}, & \text{if } \alpha \in [0, \alpha^*] \\ 1, & \text{otherwise.} \end{cases} \]

5 How much to pay in cash

In the previous section we have shown that all values \( \alpha \in [0, \alpha^*] \) would yield to the employee the same expected utility (under the assumption of risk-neutrality), given the solution schedule \( b^*(\alpha) \). In other words, they would provide the same incentive to stay with the firm at least until the productivity levels of the second stage become common knowledge. In this section, we examine whether there is an optimal value of \( \alpha \) which can help the firm to retain the employee and to overcome bankruptcy. To do this, we consider the consequences of different values of \( \alpha \), both from firm’s and from the creditor’s perspective.

Note that the cost of credit in stage 1 is a key determinant of the firm’s expected utility. In particular, from expression (4) it is clear that the utility of the firm is a monotonically increasing (resp. decreasing) function of \( \alpha \) if the interest rate is \( r < r^* \) (resp. \( r > r^* \)), as long as the firm’s limited liability constraint is not binding. Also, from equation (5), it is readily evident that cash payments higher than \( \alpha^* w_1 \) always decrease the firm’s expected utility.⁸

Thus, from the viewpoint of the firm, the preferred value of \( \alpha \) is \( \alpha^F = \alpha^* \) if \( r < r^* \), and \( \alpha^F = 0 \) if \( r > r^* \). On the other hand, if the interest rate is equal to competitive value \( r^* \), the firm is indifferent between any value of \( \alpha \) within the range \([0, \alpha^*]\).

Also, notice that the firm’s expected creditworthiness (i.e., its expected

⁷Notice that the threshold \( \alpha^* \) can be any real number, i.e., it need not be restricted to the unit interval.

⁸We neglect the case \( r \leq -1 \).
ability to pay at the end of stage 2) is given by \( b^*(\alpha)E \). It is the straightforward to show that, for all values \( \alpha \in [0, \alpha^*] \),

\[
b(\alpha)E \geq \alpha w_1 (1 + r) \theta,
\]

meaning that all cash payments to the employee that lead to an internal solution in the bargaining stage will, in expectation, allow the firm to avoid bankruptcy. On the other hand, recalling that \( b^*(\alpha) = 1 \) for all \( \alpha \geq \alpha^* \), one can similarly show that there is a threshold value

\[
\alpha' \equiv \frac{E}{w_1 (1 + r) \theta} > \alpha^*
\]

above which the firm is not expected to make enough profits to pay back the full amount of the credit incurred in stage 1. This is due to the fact that, given a corner solution, a greater value of \( \alpha \) only increases the firm’s liabilities, but not its expected ability to pay. Thus, the creditor should not lend an amount higher than \( \alpha' w_1 \), regardless of the value of \( r \), since this would likely lead the firm into bankruptcy.

Finally, it should be clear by now that whereas the creditor’s return is identically equal to zero at the competitive interest rate \( r^* \), it is increasing
(resp., decreasing) in $\alpha \in [0, \alpha']$ in case that $r > r^*$ (resp. if $r < r^*$). Therefore, a profit-oriented creditor should lend money up to $\alpha'$ as long as the interest rate is greater than or equal to the firm’s odds of bankruptcy, and it should not provide any credit otherwise (see Figure 3).

6 Laboratory experiment

We have designed a laboratory experiment in order to explore two questions:

1. What may the function $b(\alpha)$ look like empirically;

2. Are there regularities in bargaining about surplus of random size given existence of some fixed payments.

In order to keep the experiment simple, we consider the decisions of $F$ and $E$ only during the bargaining stage. For the experiment design we use following parameters: $n = 1$, $P_F = 200$ and $P = 100$. These parameters allows us to calculate probability that $F$ will become most productive firm at the second stage $\theta = \frac{3}{4}$; expected value of the joint surplus $E S^* = 58 + \frac{1}{3}$; employee’s cost opportunity salary in case if $F$ on the market at the second stage $E w_2 = 41 + \frac{2}{3}$, and if she is not - $E p_{(2)} = 0$ (see Appendix 1).

6.1 Experimental design

We conducted three experimental sessions at the laboratory of the Max-Planck-Institute in Jena, Germany, with a total of 82 subjects. Two sessions were conducted with 28 subjects each, while a third session was run with 26 participants. At the beginning of each session half of the participants was randomly assigned to the $F$ role, and the other half to the $E$ role. They kept their roles throughout the whole experiment. Each session consisted of 20 repetitions of the same stage game. The first 10 repetitions were only for training purposes (without payment and partner design), whereas the last 10 repetitions were played in a perfect stranger matching design with real monetary incentives. Participants were fully aware of the fact that during the 
last 10 repetitions they would never meet the same partner more than once. The instructions were explained in terms of ECUs (Experimental Currency Unit), and payments were calculated on the basis of earned ECUs (at the exchange rate 60 ECU = 1,00 Euro) plus 2,50 Euro as show-up fee. The experiment was implemented using the zTree software.

6.2 Rules of the experiment

We used the strategy method to elicit the way in which each couple of $F$ and $E$ participants would like to split the unknown surplus among themselves, contingent on different possible values of cash payments ($\alpha w_1$). For that purpose we chose a Nash-bargaining setting with high and low demands (Gantner et al., 2001), where each participant $j = \{E, F\}$ is asked to state both a “Maximal demand”, $\bar{d}_j$, and a “Minimal requirement”, $d_j$. Specifically, each participant was requested to fill out all the cells in a table similar to the one depicted here:

Figure 4: Split of the profit according the experimental parameters. Shaded area represents employee’s share.
Therefore, the payoffs of the each pair of $F$ and $E$ participants were determined as follows:

1. If both the maximal and the minimal demands were non-compatible (i.e., if both $d_F + d_E > 100\%$ and $d_F + d_E > 100\%$), both participants received zero profit:

   Payoff $F = 0$,
   Payoff $E = 0$.

2. If the maximal or the minimal demands were compatible (i.e., if $d_F + d_E \leq 100\%$ or $d_F + d_E \leq 100\%$), but the surplus was equal to zero ($p_F < p_{(1)}$):

   Payoff $F = 0$
   Payoff $E = \alpha w_1 + p_F$.

3. If the maximal demands are compatible (i.e., if $d_F + d_E \leq 100\%$), and the available surplus was greater than zero ($p_F > p_{(1)}$):

   Payoff $F = -(1 + r)\alpha w_1 + (p_F - p_{(1)})d_F$
   Payoff $E = \alpha w_1 + p_{(1)} + (p_F - p_{(1)})d_E$.

4. If only the minimal demands are compatible (i.e., if $d_F + d_E > 100\%$ but $d_F + d_E \leq 100\%$), and the available surplus was greater than zero ($p_F > p_{(1)}$):

   Payoff $F = -(1 + r)\alpha w_1 + (p_F - p_{(1)})d_F$
   Payoff $E = \alpha w_1 + p_{(1)} + (p_F - p_{(1)})d_E$.
Some aspects of our experimental design deserve extra attention. First, in order to allow some additional level of coordination between players, two kinds of demands - the high requirement and minimal requirement - were introduced. Although only the minimal demand is relevant in game theoretic terms, giving players the chance of stating two different demand levels allows us to increase the number of compatible demands between employer (player $F$) and employee (player $E$).\footnote{See, e.g., Gantner et al. (2001).} Second, taking into account the complex structure of the experiment, we let participants play first 10 round in every session as a trial run, without receiving real money for that. The data have shown that most of the participants used this opportunity for the purpose of training and experimenting with different strategies. And finally, in order to include in experiment the cost of credit for the firm, and to check the sensitivity of the model to this variable, we defined $r_1 = 0.2$, $r_2 = 0.0$ and $r_3 = -0.2$ for the first, the second and the third sessions respectively.

7 Results of the experiment

7.1 Actual payoffs in case of agreement

First of all, we note that allowing for two kinds of demands - "maximal demand" and "minimal demand" - gives us compatibility for quite a number of demands. Most of the minimal demands turned out to be compatible (see Figure 5 and Table 1 for rates of agreement).

Table 1 also provides some descriptive statistics about the payoffs of both players - $F$ and $E$ - for all three sessions. The payoffs of those players who were assigned to the $F$ role (firm) are much lower than payoffs of $E$- players. However, the fact that all medians in Table 1 have positive values, tells us that even under such "tough" conditions experienced by the $F$ players, there is still a very high possibility to finish the game at least without losses. This experimental observation supports the theoretical predictions about the positive effects of renegotiation via profit sharing.

The rate of agreement is almost the same through out all sessions and
Figure 5: Compatibility of demands by $E$ and $F$ in each session
Table 1: Distribution of profits obtained by $F$ and $E$ players, in tokens

<table>
<thead>
<tr>
<th></th>
<th>Firms:</th>
<th>Employees:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Session 1</td>
<td>Session 2</td>
</tr>
<tr>
<td>Cost parameter $r$</td>
<td>0.2</td>
<td>0</td>
</tr>
<tr>
<td>Agreement rate</td>
<td>78.6%</td>
<td>77.7%</td>
</tr>
<tr>
<td>Min</td>
<td>-59.2</td>
<td>-31.4</td>
</tr>
<tr>
<td>1st. Quartile</td>
<td>-1.9</td>
<td>0.0</td>
</tr>
<tr>
<td>Median</td>
<td>0.0</td>
<td>4.3</td>
</tr>
<tr>
<td>2nd. Quartile</td>
<td>19.9</td>
<td>34.0</td>
</tr>
<tr>
<td>Max</td>
<td>90.0</td>
<td>99.0</td>
</tr>
<tr>
<td>Average profit</td>
<td>5.9</td>
<td>19.2</td>
</tr>
</tbody>
</table>

equal approximately to 78%. The fact that in sessions 1 and 3 the employees’ behavior seems to be less aggressive, leads on average to higher payoffs for the firm.

Figure 6 shows that there is a strong tendency for $F$-participants (firms) to require more than 50% of future profits, and that the higher the amount of cash payments the higher the firm’s claims on future surplus are. This is in line with the theoretically predicted shrinking part of the bargaining set due to the firm’s participation constraint as $\alpha$ grows. On the other hand, the behavior of the $E$-players (employees) suggests that they take into account the fact that there is less room to make big demands on the future surplus if the current cash payment is high. In other words, the demand curves of the firm and the employee skew in the direction predicted by the model: a higher transfer induces a higher demand by the firm and a lower demand by the worker. These observations support our expectation that, the employee is taking into account participation constraint of the firm ($U^F \geq 0$) while deciding upon the demand, and therefore adjusts his demand downward (see Figure 1).

Interestingly, we observe an almost equal division with respect to the bargaining set $ES - \theta \alpha w_1 (1 + r)$. Whatever the transfer is, the division of the possible future surplus has a strong tendency to be divided equally. Moreover, since the demand curve of the firm does not have a concave shape, it is possible to conclude that $F$ would always choose $\alpha = 0$ if she could
Figure 6: Median high and low requirements made by $F$ and $E$ in each session. The straight dashed line represents the $F$’s participation constraint.

8 Concluding remarks

We have argued that the firm may not only have an incentive to retain her employee, but also the means to do that. Our results show that it is possible to renegotiate the initial contract in order to keep the employee and try to overcome bankruptcy. Indeed, under certain circumstances, we can define an optimal amount of cash that a firm may offer to her employee, together with a corresponding share of stock options, in order to prevent him from leaving.

The optimal combination of cash and equity compensation derived in our model crucially depends on how the firm’s odds of failure is compared to the interest rate of available credit. If the later is smaller than the former, then it will be profitable for the firm to engage in further liabilities in order
to make a cash payment to the employee, while offering nothing in terms of stock options. In contrast, when the interest rate is higher than the firm’s odds of failure, then the firm should offer a payment consisting only of stock options. This payment is greater the less important it is for the employee that the firm survives (i.e., the smaller the improvement in the employee’s expected opportunity cost salary that results from $F$ being able to bid for $E$ in the labor market.) This, in turn, relates to the number and quality of the alternative job offers that he can expect to receive in the future.

The conclusions of the model to a great extent are dependent on the knowledge shared by all actors (including potential creditors) about the firm’s probability of overcoming short-term liquidity constraints. This common knowledge assumption, unfortunately, can hardly be verified on the field. This makes it difficult to test the validity of our theoretical solution using field data. Therefore, we believe that two interesting avenues for future research would be, on the one hand, to relax the common knowledge assumption, and on the other to make use of laboratory experiments allowing direct control of the probability parameters.

The paper has been inspired by specific cases of start-ups with liquidity constraints. Nevertheless, we believe that using a simple two-stage structure and the axiomatic Nash bargaining solution makes our model flexible enough to provide insights in issues of more general interest.

References


Appendix 1

The productivity levels of the competing firm are iid Uniform(0, P) random variables. Thus, the productivity of the most productive firm, \( p_{(1)} \), has a density function \( f(p_{(1)}) = \frac{n p_{(1)}^{n-1}}{P^n} \). On the other hand, the productivity of the firm \( F \), denoted \( p_F \), has density \( f(p_F) = \frac{1}{P_F} \), with \( P < P_F \). Since all productivity levels are independent, the joint density of \( p_F \) and \( p_{(1)} \) is given by

\[
f(p_F, p_{(1)}) = \frac{1}{P_F} \frac{n p_{(1)}^{n-1}}{P^n}.
\]

The probability that firm \( F \) is more productive than any other firm is equal to

\[
\theta = \Pr(p_F > p_{(1)}) = \int_0^P \int_y^{P} f(x,y) \, dx \, dy
\]

\[
= \frac{n}{P_F P^n} \int_0^P y^{n-1}(P_F - y) \, dy
\]

\[
= \frac{n}{P_F P^n} \left[ \frac{P_F P^n}{n} - \frac{P^{n+1}}{n+1} \right]
\]

\[
= 1 - \frac{P}{P_F} \cdot \frac{n}{n + 1}.
\]

Note that \( \lim_{n \to \infty} \theta = 1 - \frac{P}{P_F} \).

To calculate the expected value of profits, \( E S^* \), where \( S^* = \max\{0, S\} \) with \( S = p_F - p_{(1)} \), we make use of the following

**Lemma 1** \( S \) is a random variable with density function

\[
f_s(s) = \begin{cases} 
\frac{1}{P_F} - \frac{(-s)^n}{P_F P^n} & \text{if } -P \leq s \leq 0 \\
\frac{1}{P_F} & \text{if } 0 < s \leq P_F - P \\
\frac{(P_F - s)^n}{P_F P^n} & \text{if } P_F - P < s \leq P_F.
\end{cases}
\]

**Proof.** Define the bivariate transformation \( S = U(p_F, p_{(1)}) = p_F - p_{(1)} \)
and \( T = V(p_F, p_{(1)}) = p_F + p_{(1)} \) with Jacobian

\[
J = \begin{bmatrix}
\frac{1}{2} & -\frac{1}{2} \\
\frac{1}{2} & \frac{1}{2}
\end{bmatrix}.
\]

Then, the joint density of \( S \) and \( T \) is given by

\[
f_{S,T}(s, t) = |J| f_{X,Y}(U^{-1}(s, t), V^{-1}(s, t)) = \frac{n}{2^n P_F P^n} (t - s)^{n-1},
\]

with support \( S \in [-P, P_F] \) and

\[
T \in \begin{cases}
[-S, 2P + S], & \text{if } -P \leq S \leq 0 \\
[S, 2P + S], & \text{if } 0 < S \leq P_F - P \\
[S, 2P_F - S], & \text{if } P_F - P < S \leq P_F
\end{cases}
\]

Integrating with respect to \( T \) the marginal density \( f_S(s) \) is obtained. \( \blacksquare \)

Thus, taking expectations,

\[
E(S^*) = \frac{(P_F - P)^2}{2P_F} + \frac{P^2}{P_F(n+1)} \left[ 1 + \frac{1}{(n+2)} \right].
\]

We now calculate the expected value of the employee’s opportunity-cost wage given that renegotiation succeeds, \( E(w_2|k = 1) \). Since its value is equal to the second-order statistic of the sample of all productivities (including the productivity of firm \( F \)), it is possible to prove the following:

**Lemma 2** The opportunity-cost wage is distributed as

\[
F_{w_2}(x|k = 1) = \left( \frac{x}{P} \right)^{n-1} \left[ \frac{x}{P} + n \left( 1 - \frac{x}{P} \right) \left( \frac{x}{P_F} \right) \right].
\]

**Proof.** We offer only a sketch of the proof, while referring to Casella and Berger (1990, Theorem 5.5.2) for its underlying logic. For any real value \( x \),
define the random variable $Y_n$ as the number of firms other than $F$ whose productivity turns out to be less than $x$. Recall that these productivities are *iid* Uniform$[0, P]$, so that $Y_n \sim \text{Binomial}(n, \frac{x}{P_F})$. Also, define $Y_F$ as a Bernoulli variable with $\Pr(Y_F = 1) = \frac{x}{P_F}$. The employee’s opportunity-cost wage is the second-order statistic of the whole sample of productivities (which includes $n + 1$ numbers). Thus, its distribution is given by $F_{w_2}(x|k = 1) = \Pr(W = n) + \Pr(W = n + 1)$, where $W = Y_c + Y_F$. ■

Using Lemma 2, the expected value of the employee’s opportunity-cost wage is equal to

$$E(w_2|k = 1) = \left[ \frac{n}{n + 1} - \frac{n}{(n + 1)(n + 2)} \cdot \frac{P}{P_F} \right] P.$$

Appendix 2

**Instruktionen**

Allgemeine Instruktionen


Im Laufe des Experiments sprechen wir nicht von Euro sondern von ECU (Experimental Currency Unit). 60 ECU sind 1,00 Euro wert.


Das Befolgen dieser Regeln ist sehr wichtig. Wenn Sie sich nicht daran halten, müssen wir Sie leider von der weiteren Teilnahme an diesem Experiment und der Auzahlung ausschliessen.

Gleich am Anfang des Experiments bekommen Sie die Rolle eines $X$-Teilnehmers bzw. eines $Y$-Teilnehmers zugewiesen. Diese Rolle bleibt während des gesamten Experiments
Das Experiment besteht aus 20 Perioden. In jeder Periode interagiert je ein X-Teilnehmer mit einem Y-Teilnehmer.


- Im Gegensatz dazu sind die letzten 10 Perioden mit tatsächlichen Auszahlungen verbunden. In jeder dieser 10 Perioden interagiert ein X-Teilnehmer mit einem neuen Y-Teilnehmer (ein und dieselbe Person wird nicht mehr als einmal getroffen).

Jede Periode besteht aus 2 Teilen:

1. Im ersten Teil wird ein "Gewinn" und ein "Transfer" vom Computer generiert.

2. Im zweiten Teil treffen die Teilnehmer ihre Entscheidungen.

Obwohl die Auszahlung eines Teilnehmers davon abhängt, welche Rolle (X bzw. Y) er innehat, müssen beide Teilnehmer-Typen identische Entscheidungsformulare ausfüllen. Welche Entscheidungen jeder Teilnehmer in jeder Periode treffen muss, und wie die Auszahlungen ermittelt werden, wird Ihnen im weiteren erklärt.

Erster Teil
(Computer)

1. Gewinn


Die erste Nummer $P_1$ kann zwischen 0 und 100 liegen, während die zweite Nummer $P_2$ zwischen 0 und 200 liegen kann. In anderen Worten sind

$$0 < P_1 < 100 \quad \text{und} \quad 0 < P_2 < 200.$$ 

- Falls $P_2 \geq P_1$ ist, dann gibt es einen Gewinn, und zwar

  \[ \text{Gewinn} = P_2 - P_1. \]
• Falls $P_1 > P_2$ ist, dann gibt es keinen Gewinn, was bedeutet, dass Gewinn = 0.

**Beispiel**

Ist $P_2 = 140,2$ und $P_1 = 80,1$, so ist der Gewinn = $140,2 - 80,1 = 60,1$.

Wenn $P_2 = 78,5$ und $P_1 = 80,1$, dann ist der Gewinn = $0,0$.

2. **Transfer**


Es gibt sechs Werte, die alle gleich wahrscheinlich sind:

Transfer = \{0, 10, 20, 30, 40, 50\} ECUs.

**Zweiter Teil**

(Teilnehmer)

**Anforderungen**

Ohne die Höhe des Gewinns oder des Transfers zu wissen, müssen beide Teilnehmer bestimmen, wie der eventuelle Gewinn aufgeteilt werden soll.

Dafür müssen beide Teilnehmer gleichzeitig zwei Prozent-Werte angeben (und zwar für jeden möglichen Transfer):

1. Eine höhere Anforderung, und

2. Eine Mindestforderung.

Eine Anforderung bezeichnet den Prozentsatz des Gewinns den der jeweiliger Teilnehmer für sich beansprucht. Da die Anforderungen ohne Kenntnis des vom Computer ausgewählten Transfers bestimmt wird, muss diese Entscheidungen für jeden möglichen Transfer getroffen werden.

Diese Anforderungen werden in den Zellen der folgenden Tabelle auf dem Bildschirm eingegeben:

<table>
<thead>
<tr>
<th>Falls der Transfer gleich diesem Betrag ist...</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>meine höhere Forderung ( % des Gewinns):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>meine Mindestforderung ( % des Gewinns):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. Falls die Summe der höheren Forderungen beider Teilnehmer nicht mehr als 100% ist, dann sind die höheren Forderungen kompatibel.

2. Wenn die höheren Forderungen nicht kompatibel sind, dann wird überprüft, ob die Mindestforderungen kompatibel sind, d.h., ob die Summe der Mindestforderungen nicht mehr als 100% beträgt.

3. Sind sowohl die Summe der höheren als auch die der Mindestforderungen größer 100%, dann sind die Forderungen nicht kompatibel.

Was die Kompatibilität bzw. nicht Kompatibilität für die Auszahlungen der beiden Teilnehmern bedeutet, wird im weiteren erklärt.

Auszahlungen

Die Auszahlungen des X- und des Y-Teilnehmers hängen von den Ergebnissen der beiden Teilen ab:

1. Computer-Ergebnisse:
   - Wie gross der Gewinn ist
   - Wie gross der Transfer ist

2. Entscheidungen der Teilnehmer:
   - Kompatibilität der höheren bzw. Mindestforderungen

Insbesondere:

- Der “Transfer” wirkt auf die Auszahlungen beider Teilnehmern nur wenn ihre höheren oder die Mindestforderungen kompatibel sind.
- Wenn die Forderungen nicht kompatibel sind, dann verschwindet auch der aufzuteilende Gewinn.
- Falls die höheren oder die Mindestforderungen beider Teilnehmern kompatibel sind, dann bekommt jeder Teilnehmer die von ihm gestellt Forderung aus dem Gewinn.
- Ausserdem bekommt der Y-Teilnehmer den kleinsten Wert von $P_1$ und $P_2$ als zusätzliche Auszahlung, falls die höheren oder die Mindestforderungen kompatibel sind.

*Aus den oben genannten Regeln ergeben sich die folgende Auszahlungskonstellationen:*

1. Falls keine der beiden Forderungen (höheren bzw. Mindestforderungen) kompatibel sind, dann bekommen beide Teilnehmer Null:
   
   Auszahlung von $X = 0$,  
   Auszahlung von $Y = 0$.  

2. Falls die höheren oder die Mindestforderungen kompatibel sind, aber der Gewinn gleich Null ist ($P_1 < P_2$):
   
   Auszahlung von $X = 0$  
   Auszahlung von $Y = [\text{Transfer}] + P_2$.  

3. Falls die höheren Forderungen kompatibel sind, und der Gewinn positiv ist ($P_2 \geq P_1$):
   
   Auszahlung von $X = - [0,8 \times \text{Transfer}] + [\text{Gewinn} \times \text{höhere Forderung von } X]$,  
   Auszahlung von $Y = [\text{Transfer}] + [\text{Gewinn} \times \text{höhere Forderung von } Y] + P_1$.  

4. Falls nur die Mindestforderungen kompatibel sind, und der Gewinn positiv ist ($P_2 \geq P_1$):
   
   Auszahlung von $X = - [0,8 \times \text{Transfer}] + [\text{Gewinn} \times \text{Mindestforderung von } X]$,  
   Auszahlung von $Y = [\text{Transfer}] + [\text{Gewinn} \times \text{Mindestforderung von } Y] + P_1$.  

*Bitte beachten Sie:* Wenn der Transfer einen Effekt hat, dann ist dieser Effekt für den X-Teilnehmer negativ bzw. für den Y-Teilnehmer positiv.

**Beispiele**

Stellen Sie sich vor, dass ein X-Teilnehmer die folgende Entscheidungen getroffen hat:

<table>
<thead>
<tr>
<th>Falls der Transfer gleich diesem Betrag ist...</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>meine höhere Forderung ( % des Gewinns):</td>
<td>34</td>
<td>82</td>
<td>97</td>
<td>54</td>
<td>70</td>
<td>96</td>
</tr>
<tr>
<td>meine Mindestforderung ( % des Gewinns):</td>
<td>18</td>
<td>50</td>
<td>90</td>
<td>50</td>
<td>61</td>
<td>96</td>
</tr>
</tbody>
</table>

Der Y-Teilnehmer, mit dem er in dieser Periode interagiert, hat seinerseits die folgende Entscheidungen getroffen:

<table>
<thead>
<tr>
<th>Falls der Transfer gleich diesem Betrag ist...</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>meine höhere Forderung ( % des Gewinns):</td>
<td>96</td>
<td>91</td>
<td>16</td>
<td>24</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>meine Mindestforderung ( % des Gewinns):</td>
<td>95</td>
<td>50</td>
<td>12</td>
<td>20</td>
<td>16</td>
<td>1</td>
</tr>
</tbody>
</table>

Seien $P_1 = 40$ und $P_2 = 120$ die vom Computer ausgewählte Größen.

Dann ist der Gewinn $= 120 - 40 = 80$.

Die jeweiligen Auszahlungen der beiden Teilnehmern sind,

- falls der Computer einen Transfer $= 10$ bestimmt:
  
  Auszahlung des X-Teilnehmers $= 0,8 \times 10 + [80 \times 50\%] = -8 + 40 = 32$
  
  Auszahlung des Y-Teilnehmers $= 10 + [80 \times 50\%] + 40 = 10 + 40 + 40 = 90$

- falls der Computer einen Transfer $= 40$ bestimmt:
  
  Auszahlung des X-Teilnehmers $= 0,8 \times 40 + [80 \times 70\%] = -32 + 56 = 24$
  
  Auszahlung des Y-Teilnehmers $= 40 + [80 \times 22\%] + 40 = 40 + 17,6 + 40 = 97,6$

- falls der Computer einen Transfer $= 0$ bestimmt:
  
  Auszahlung des X-Teilnehmers $= 0$
  
  Auszahlung des Y-Teilnehmers $= 0$
Seien \( P_1 = 90 \) und \( P_2 = 40 \) die vom Computer ausgewählte Größen. Dann ist der Gewinn = 0.

Die jeweiligen Auszahlungen der beiden Teilnehmern sind,

- falls der Computer einen Transfer = 30 bestimmt:
  
  Auszahlung des \( X \)-Teilnehmers = 0
  
  Auszahlung des \( Y \)-Teilnehmers = 30 + 40 = 70

- falls der Computer einen Transfer = 20 bestimmt:
  
  Auszahlung des \( X \)-Teilnehmers = 0
  
  Auszahlung des \( Y \)-Teilnehmers = 0.

_Bitte bleiben Sie während der Dauer des gesamten Experiments an Ihrem Platz und sprechen nicht mit anderen Teilnehmern. Wenn Sie Fragen haben, melden Sie sich bitte per Hand-zeichen._