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A Cross-National Study

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A Note on the Optimality of Bonus Pay

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Abstract

This note derives the optimal compensation contract with subjective evaluation when the principal and agent may not agree regarding performance. The optimal contract takes the form of a bonus payment whenever the principal believes performance is acceptable, but with the payment of a penalty by the principal whenever the agent disagrees with a negative evaluation by the principal. The efficiency of the relationship is increasing with the degree of correlation, a result that is consistent with the importance of trust for an efficient employment relationship.

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1 Introduction

Prendergast (1999) observes that when it is too costly or expensive to use explicit pay for performance contracts firms may rely upon subjective compensation contracts.¹ However, a difficulty with subjective compensation contracts is that given that the reports are not verifiable the principal may not report truthfully the agent's performance. Two generic solutions to this problem have been suggested in the literature.² The first is the use of an "efficiency wage" as suggested by Shapiro and Stiglitz (1984). Under such a contract the agent is paid a wage that is above her market alternative, and hence faces a loss if fired. However, the fact that wages are paid above the market alternative implies that it is costless for the principal to replace the agent, and hence the principal is indifferent between keeping or firing the worker. In such a situation the principal has no incentive to misrepresent performance. An alternative to an efficiency wage, is to reward the agent at the end of the period with bonus pay, with the principal's reputation ensuring performance, as suggested by Bull (1987).

MacLeod and Malcomson (1989) show that efficiency wages and bonus pay are two sides of the same coin: as long as the relationship generates a rent ex post, then the firm may use either efficiency wages or bonus pay. A key assumption in that analysis is the requirement that the firm and worker condition their actions upon the same information.³ This is however a strong assumption for a subjective evaluation: even reasonable individuals may disagree regarding the quality of performance. The purpose of this note is to derive the optimal contract with subjective evaluation when agents may disagree regarding quality of performance. Rather than use a complex repeated game setup, I follow Myerson (1979) and use a very simple mechanism design approach to show that the optimal contract with subjective evaluation has the following features:

1. Effort is positive and increasing with the degree of correlation in beliefs

¹Prendergast (1999), page 9.

²In this note I shall be concerned with truthful mechanisms only. See Prendergast and Topel (1996) for discussion of biases in subjective compensation systems.

³Note that it is not necessary for the agents to have perfect information, a noisy signal will do. What is key is that that both parties condition upon the same, commonly observed signal. See Fudenberg and Maskin (1986) for further discussion of this point in the context of repeated games.

between the principal and agent.

2. Optimal contracts have the feature that a bonus is paid if and only if the supervisor believes performance is satisfactory. In particular efficiency wage contracts are never efficient.

2 The Model and Result

Consider the following simple model. An agent's effort is given by $\lambda \in [0, 1]$, where λ is the probability that a benefit B is realized. This effort is produced at a cost $c(\lambda)$, where $c(0) = 0$ (cost of no effort is zero), $c', c'' > 0$ (cost of effort is increasing at an increasing rate) and $c'(\lambda) \rightarrow \infty$ as $\lambda \rightarrow 1$ (perfection is impossible). Hence the net surplus of the relationship is given by:

$$S(\lambda) = \lambda B - c(\lambda), \quad (1)$$

with the first best level of effort, λ^{fb} , satisfying $B = c'(\lambda^{fb})$.

Let us assume that these parameters are commonly known, but that the actual return is realized some distance in the future, and hence cannot be used for compensation in the current period. For example the agent may be a software designer, and the product will not go to market for several years, by which time the designer may have left the company. Instead, assume that the principal must subjectively evaluate the performance of the agent in the current period. Suppose that if success does not occur, then both parties judge performance to be unacceptable (this assumption can be relaxed at the cost of complicating the analysis). When objective success does occur the principal and agent may or may not agree upon this. In the event of an objective success, let λ_{ij} , $i, j \in \{A, U\}$, be the probability that the principal believes quality is i and the agent believes quality is j , where A and U denotes "acceptable" and "unacceptable" respectively. Thus if the good outcome occurs, then λ_{AA} is the probability that both principal and agent agree on this. It is assumed that the signals are positively correlated, that is $\lambda_{AA}\lambda_{UU} - \lambda_{UA}\lambda_{AU} > 0$. If the beliefs of the principal and the agent are perfectly correlated then $\lambda_{AU} = \lambda_{UA} = 0$.

The principal and agent agree to a contract that makes payments conditional upon messages sent by the principal and agent. Formally the contract between the principal and agent is given by:

$$c_{ij} = \{\pi_{ij}, w_{ij}\}, \quad (2)$$

where π_{ij}, w_{ij} are the payments to the principal and agent under the contract as a function of the message $i, j \in \{A, U\}$, satisfying the constraint $\pi_{ij} + w_{ij} \leq 0$. It is well known that if $\pi_{ij} + w_{ij} = 0$, that is the contract is budget balancing, then there exists no contract that can enforce a positive level of effort.⁴ Implementation of the contract requires that in certain states an inefficient allocation occur. How this might occur in practice is discussed in further below. The formal game describing the relationship is as follows:

1. The principal makes a take it or leave it contract offer to the agent, who accepts or rejects.
2. The agent selects $\lambda \in [0, 1]$, which is his level of effort. This is not observed directly, but a commonly observed complex output does occur.
3. The principal and agent form subjective judgements regarding the success of the agent's output and simultaneously send messages from the set $\{A, U\}$ to the third party enforcing the contract (say upper management).
4. The payoffs are determined.

From the revelation principle we can restrict attention to truth telling contracts, and suppose the principal is able to select the most efficient contract subject to the incentive constraints. Given that $\lambda_{AA}\lambda_{UU} > 0$, then the payments under the contract to the principal and agent when they report k , but their true state is l are respectively:

$$\pi(k|l) = (\pi_{kA}\lambda_{lA} + \pi_{kU}\lambda_{lU}) / (\lambda_{lA} + \lambda_{lU}), \quad (3)$$

$$w(k|l) = (w_{Ak}\lambda_{lA} + w_{Uk}\lambda_{lU}) / (\lambda_{lA} + \lambda_{lU}). \quad (4)$$

The principal's problem is to maximize expected payoff subject to the agent's individual rationality and incentive compatibility constraints:

$$\max_{\lambda, c} \lambda B + \lambda \pi(c) + (1 - \lambda) \pi_{UU} \quad (5)$$

⁴Groves and Ledyard (1977) in the context of public goods and Holmström (1982) for a team production problem have shown the need to break the balanced budget constraint for efficiency. D'Aspremont and Gerard-Varet (1979) have a similar result for the public goods when case when there is asymmetric information, as is the case in this note.

subject to

$$\lambda w(c) + (1 - \lambda) w_{UU} - c(\lambda) \geq U^o \quad (6)$$

$$w(c) - w_{UU} = c'(\lambda) \quad (7)$$

$$\pi(l|l) \geq \pi(k|l), k, l \in \{A, U\} \quad (8)$$

$$w(l|l) \geq w(k|l), k, l \in \{A, U\} \quad (9)$$

$$\pi_{ij} + w_{ij} \leq 0, i, j \in \{A, U\} \quad (10)$$

where $\pi(c) = \sum_{i,j \in \{A,U\}} \pi_{ij} \lambda_{ij}$ and $w(c) = \sum_{i,j \in \{A,U\}} w_{ij} \lambda_{ij}$ are the expected transfers to the principal and agent respectively when the good outcome occurs. Constraint 6 requires the agent to earn at least his outside payoff, constraint 7 is the requirement that the agent select effort to maximize his payoff at stage 2. Constraints 8 and 9 are the stage 3 incentive compatibility constraints ensuring that the principal and agent truthfully report their subjective judgements to the third party enforcing the contract. The final constraint is the budget balancing constraint for the contract.

Proposition 1 *Suppose that $\lambda_{AA}\lambda_{UU} - \lambda_{AU}\lambda_{UA} > 0$. Then the optimal contract with subjective performance evaluation has the form:*

		<i>Agents Report</i>	
		<i>A</i>	<i>U</i>
<i>Principal's Report</i>	<i>A</i>	$(-b - w, b + w)$	$(-b - w, b + w)$
	<i>U</i>	$(-P - w, w)$	$(-w, w)$

where

- *The optimal effort λ solves $c'(\lambda^*) = B - \frac{\lambda_{UA}}{\lambda_{A^*}} (\lambda^* c''(\lambda^*) + c'(\lambda^*))$, where $\lambda_{A^*} = \lambda_{AA} + \lambda_{AU}$ is the probability that the principal believes performance is acceptable.*
- *The bonus satisfies: $b = c'(\lambda^*) / \lambda_{A^*}$.*
- *The fixed wage satisfies: $w = U^o + c(\lambda^*) - \lambda^* c'(\lambda^*)$.*
- *The penalty satisfies $P = c'(\lambda^*) / \lambda_{AA}\lambda_{A^*}$.*

Proof. Observe that without loss of generality we can initially set $w_{UU} = 0$ and $\pi_{UU} = 0$ since the incentive constraints are linear, and hence these values simply determine the payoff levels and can be rescaled to satisfy the IR constraint. The optimization problem is solved in two stages. First we fix the expected payment to the agent when there is a success $w(c) = \bar{w}$, which also fixes λ via equation 7.

Consider:

$$\max_c \pi(c) \quad (11)$$

subject to

$$\pi_{UU} = w_{UU} = 0 \quad (12)$$

$$w(c) \geq \bar{w} \quad (13)$$

$$\pi(l|l) \geq \pi(k|l), k, l \in \{H, L\} \quad (14)$$

$$w(l|l) \geq w(k|l), k, l \in \{H, L\} \quad (15)$$

$$\pi_{ij} + w_{ij} \leq 0, i, j \in \{H, L\} \quad (16)$$

This problem can be restated as a linear programming problem of the form:

$$\max_{y \in \mathbb{R}^6} a'y \quad (17)$$

$$\text{subject to: } Ay \leq c \quad (18)$$

by letting the choice variable and parameters be

$$y = [\pi_{AA}, \pi_{AU}, \pi_{UA}, w_{AA}, w_{AU}, w_{UA}]^T \quad (19)$$

$$a = [\lambda_{AA}, \lambda_{AU}, \lambda_{UA}, 0, 0, 0]^T \quad (20)$$

$$c = [-\bar{w}, 0, 0, 0, 0, 0]^T \quad (21)$$

and the matrix A is given by:

$$A = \begin{bmatrix} 0 & 0 & 0 & -\lambda_{AA} & -\lambda_{AU} & -\lambda_{UA} \\ -\lambda_{AA} & -\lambda_{AU} & \lambda_{AA} & 0 & 0 & 0 \\ \lambda_{UA} & \lambda_{UU} & -\lambda_{UA} & 0 & 0 & 0 \\ 0 & 0 & 0 & -\lambda_{AA} & \lambda_{AA} & -\lambda_{UA} \\ 0 & 0 & 0 & \lambda_{AU} & -\lambda_{AU} & \lambda_{UU} \\ 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 \end{bmatrix}. \quad (22)$$

The first row is the negative of the payoff to the agent when there is a success, a constraint that is always binding. The second and third rows are the incentive constraints for the high and low type principals, while the fourth and fifth rows are the similar incentive constraints for the agent. The last three rows are the budget constraints.

We solve this problem by showing that the contract given in the theorem solves this linear programming problem, that is $y^* = [-b, -b, -P, b, b, 0]$. By the complementary slackness theorem this is optimal if there is an $x \in \mathfrak{R}_+^8$ such that $A^T x = a$ and $x_i v_i = 0$ for every i , where $v = c - Ay^*$. Notice that for y^* the incentive constraints for the agent are satisfied automatically, and hence $v_4 = v_5 = 0$. The principal will set total compensation as low as possible hence $b = w(c)/\lambda_{A^*} = \bar{w}/\lambda_{A^*}$, where $\lambda_{H^*} = \lambda_{AA} + \lambda_{AU}$ is the probability that the principal has a high signal. This implies that $v_1 = 0$. The penalty P is to provide an incentive to the principal to reveal that she has observed a good signal. Since it involves a social cost, then it will be made as small as possible to ensure that the principal's incentive constraint is binding, or

$$-b \geq -P\lambda_{AA}, \text{ implying} \quad (23)$$

$$P = b/\lambda_{AA} = \bar{w}/(\lambda_{AA} \times \lambda_{A^*}). \quad (24)$$

This implies that $v_2 = 0$. Notice that $\lambda_{AA}\lambda_{UU} - \lambda_{UA}\lambda_{AU} > 0$ implies that the principal's second constraint is automatically satisfied. The first of the two budget constraints is satisfied with equality, and hence $v_6 = v_7 = 0$. Therefore we need to find an $x^* = [x_1, x_2, 0, x_4, x_5, x_6, x_7, 0]^T \geq 0$ satisfying $A^T x = a$. When $\lambda_{AU} > 0$ the latter has a unique solution given by:

$$\begin{aligned} x_1 &= \frac{\lambda_{UA} + \lambda_{AU}}{\lambda_{AU}} \\ x_2 &= \frac{1}{\lambda_{AA}} \lambda_{UA} \\ x_4 &= \lambda_{UA} \lambda_{AU} \frac{\lambda_{UA} + \lambda_{AA}}{\lambda_{AA} \lambda_{UU} - \lambda_{AU} \lambda_{UA}} \\ x_5 &= \lambda_{UA} \frac{\lambda_{UA} + \lambda_{AA}}{(\lambda_{AA} \lambda_{UU} - \lambda_{AU} \lambda_{UA})} \\ x_6 &= \lambda_{AA} + \lambda_{UA} \\ x_7 &= \lambda_{AU} \frac{\lambda_{UA} + \lambda_{AA}}{\lambda_{AA}} \end{aligned} \quad (25)$$

all of which are strictly positive under the hypothesis that $\lambda_{AA}\lambda_{UU} - \lambda_{AU}\lambda_{UA} > 0$.

If $\lambda_{AU} = 0$ the optimal contract has the same form, except that when the agent has a high evaluation he has strict incentives to reveal his information,

implying that $v_4 \neq 0$, and hence we need to allow $x_4 \geq 0$. In addition since the principal receives zero from the cell AU , this implies that both of her incentive constraints are binding, and hence we must now allow $x_3 \geq 0$. Thus we must find $x^* = [x_1, x_2, x_3, 0, x_5, x_6, x_7, 0]^T \geq 0$ satisfying $A^T x = a$, with $\lambda_{AU} = 0$. The solution is:

$$\begin{aligned}
x_1 &= \frac{\lambda_{UA} + \lambda_{AA}}{\lambda_{AA}} \\
x_2 &= \frac{1}{\lambda_{AA}} \lambda_{UA} \\
x_3 &= 0 \\
x_5 &= \frac{1}{\lambda_{UU}} \lambda_{UA} \frac{\lambda_{UA} + \lambda_{AA}}{\lambda_{AA}} \\
x_6 &= \lambda_{UA} + \lambda_{AA} \\
x_7 &= 0
\end{aligned} \tag{26}$$

This demonstrates that the optimal contract takes the form of a bonus to the agent whenever the principal has a high signal. The only role played by the agent's signal is to provide incentives for truthful revelation by the principal. The *expected* bonus pay is $\lambda \lambda_{A^*} b$. In addition the principal pays to a third party an expected penalty $\lambda \frac{\lambda_{UA}}{\lambda_{AA}} b$. The principal now chooses the expected bonus and the unconditional wage w to solve:

$$\max_{b, w, \lambda} \lambda \left(B^* - b \left(\lambda_{A^*} + \frac{\lambda_{UA}}{\lambda_{AA}} \right) \right) - w \tag{27}$$

subject to:

$$\lambda \lambda_{A^*} b + w - c(\lambda) \geq U^o \tag{28}$$

$$\lambda_{A^*} b = c'(\lambda) \tag{29}$$

from which we obtain the expressions in the proposition. ■

Under this contract the agent's payment is independent of his report, and hence he has no incentive to misrepresent his self-evaluation. The principal provides the agent with effort incentives by paying him a bonus whenever she believes that he has provided acceptable performance. If the principal reports unacceptable performance when the agent reports acceptable, then she must pay a penalty P . It is the prospect of paying a penalty when the reports from the agent and principal differ that provides the appropriate incentives for truthful revelation by the principal.

When correlation is imperfect and $\lambda_{UA} > 0$, there is a positive probability that the principal will pay the penalty. Given that the size of the penalty depends upon the size of the bonus promised, the lack of correlation increases the marginal cost of providing incentives. This is reflected in the term $\frac{\lambda_{UA}}{\lambda_{A^*}} (\lambda^* c''(\lambda^*) + c'(\lambda^*))$, the amount by which the marginal benefit from effort is reduced in the optimal contract. Thus if the probability of the principal having a poor evaluation when the agent has a positive evaluation is zero we obtain the first best effort level, even though the evaluation is imperfect.

This result shows that the optimal contract is structured so that the principal's evaluation determines whether or not the agent receives a bonus, while the role of the agent's evaluation is to provide the necessary incentives for the principal to be truthful. An efficiency wage contract has the worker and not the firm pay the penalty. In the context of this model the efficiency wage contract would take form:

		Agents Report	
		A	U
Principal's Report	A	$(-w, w)$	$(-w, w)$
	U	$(-w, w - P)$	$(-w, w - P)$

Given that the principal's payoff does not depend upon her report, it is an equilibrium for the principal to report A if and only if her judgement is A . The penalty P can be chosen to achieve any desired effort level, and therefore this contract satisfies the incentive constraints, but is not efficient. Also notice that it is possible to have an incentive contract that pays a bonus whenever the agent self-reports high performance, with a penalty paid by the agent whenever there is disagreement with the principal, however this is not optimal. The difficulty is in that case the agent is receiving pay that depends both upon performance and his reporting strategy, diluting the performance incentives. At the optimal contract each individual is receiving a reward for correctly carrying out their respective tasks: effort provision by the agent and monitoring by the principal.

3 Discussion

In this note it is shown that the optimal contract with subjective compensation entails a bonus to be paid to the agent whenever he is judged to have carried out acceptable performance by the principal. Moreover, the optimal contract entails a deadweight loss to the principal whenever there is a disagreement regarding performance between the principal and agent. I have worked out the optimal contract in a simple static framework that highlights the role of the budget breaking penalty P in the formation of an optimal contract. This model is related to many previous papers set in a dynamic framework where the issue centers upon how to generate the penalty P to provide incentives for performance, but do not explicitly address the question of optimality when there are correlated beliefs. In those papers P is generated by continuation strategies in a repeated game that are interior to the set of feasible payoffs (see Fudenberg and Maskin (1986)).

In practice we do not observe the use of money burning to provide incentives, however there are examples of mechanisms that are substitutes for money burning. For example if the firm makes relation specific investments (Becker (1975) and Williamson (1975)), this creates a loss to the firm when a worker quits because of a disagreement with a supervisor. Shapiro and Stiglitz (1984) have shown that unemployment can create a loss to fired workers that enforces high effort, though such a contract can only be efficient if the beliefs of the worker and firm are perfectly correlated, and there is no monitoring error. Holmström (1982) discusses how the firm as a residual claimant can break the budget balancing constraint, while Carmichael (1983) and Malcomson (1984) illustrate the use of tournaments to achieve the same objective. Bull (1987), Kreps (1990) and Baker and Murphy (1997) emphasize the importance of firm reputation, whose loss due to disagreements with employees would correspond to the penalty P . This note complements this work by showing that it is more efficient for the firm rather than the worker to hold the reputation.

The result also highlights a point that is often made in the management literature, namely that the efficiency of employment depends upon the degree of “trust” between workers and management. In the context of this model trust is formally represented by the degree of correlation in beliefs. A next step might be the derivation of the optimal contract with subjective evaluation in the presence of some contractible measures, as explored in Baker,

Gibbons, and Murphy (1994) and Pearce and Stacchetti (1998).

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