Peer-dependent incentives and ownership rights

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Abstract

In the literature on multiagent moral hazard it is (implicitly) assumed that residual control rights are exclusively in the hands of the principal. And in the literature on incomplete contracts and allocation of ownership rights, the multiagent moral hazard problem is not considered. In a recent paper (Kvaløy and Olsen (2006b), we seek to fill this gap by analyzing the conditions for implementing peer-dependent incentive regimes when agents have ownership rights. We show that compensation tied to peer-performance can induce employee-hold-up and obstruct the implementation of relational incentive contracts. In this paper we present some extensions: We argue that the costs of transferring ownership rights to agents may depend on whether there exist conditions that calls for peer-dependent incentives. In particular, we show that if there exists common noise that makes relative performance evaluation optimal, or peer pressure that makes joint performance evalauation optimal, then the firm will be more reluctant to give up ownership rights.

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1 Introduction

Assume you work at a University that bases some of your wage on the department's performance. The idea is to exploit peer pressure e¤ects that naturally develops at a research department. One day you get accepted in a top ranked journal. The department chair celebrates (and so do you), but you are a bit worried about this year's bonus because your colleagues haven't been too productive lately. What do you do? Well, no-one is able take your publication away from you, and since a number of Universities are willing to pay for your achievements, you go back to the department chair, show her your job o¤ers, and renegotiate the wage. The department chair then has a dilemma. By agreeing to renegotiate the bonus, she obstructs the whole idea of paying on the basis of group performance.

Next year, your University decides to implement bonuses based on relative performance. Each department is asked to rank their researchers' performance and then pay bonuses according to this ranking. Again you achieve a nice publication. The problem this year, however, is that so do also your colleagues. In fact they do even better than you, and your bonus becomes rather poor. What do you do? Again you take your publication with you, apply for job elsewhere and come back to renegotiate the wage. The University evaluates their incentive system and concludes: They have to base bonuses on individual performance.

Your university collaborates with a high-tech company who shares some of the same problems. The engineers run away or renegotiate wage once they have developed a promising concept. The trouble is that both group incentives and tournaments are crucial for promoting cooperation and competition among the engineers. So instead of changing to individual based incentives, the company chooses the strategy of asset control. By carefully developing a system of patent protection, and by assuring that their engineers do not get access to a larger share of strategic assets than necessary, they are able to implement peer-dependent incentives without running the risk of opportunism and expropriation.

In an ongoing research program, we investigate the conditions for providing peer-dependent incentives when two problems arise: (i) incentive contracts are incomplete and not protected by court of law, and (ii) workers possess indispensable human capital.

With respect to (i): true performance is often difficult to verify by third parties. Objective measures of performance seldom exist, and even if they do, looser assessments of performance also affect compensation (see e.g. MacLeod, 2003). Consequently, incentive contracts specifying criteria for performance pay are seldom fully protected by the court. With respect to (ii): human capital blurs the allocation of ownership rights. According to the standard view of ownership, it is the owner of an asset who has “residual control right” over the asset; that is "the right to decide all usages of the asset in any way not inconsistent with a prior contract, custom or law" (Hart, 1995). If the asset involved in the worker’s production is his own mind and knowledge, then he also is to decide all non-contractual usages. An indispensable "knowledge worker" can therefore threaten to walk away with ideas, clients, techniques etcetera. As noted by Liebeskind (2000), human-capital-intensive firms must induce their employees to stay around long enough so that the firm can establish some intellectual property rights with respect to the ideas generated by these employees, or else these firms run the risk of being expropriated or held-up by their own employees.

We (Kvaløy and Olsen, 2006a) analyzed the consequence of the first problem (incomplete contracts) in a recent paper. The problem of incomplete contracting can be mitigated by repeated interaction, which is a key ingredient in any employment relationship. Through repeated transactions the parties can make it costly for each other to breach the contract, by letting breach ruin future trade. The parties can thus commit to engage in so-called self-enforcing relational contracting. There is a growing literature on relational contracting (see in particular Baker, Gibbons and Murphy, 2002, and Levin 2003). Our contribution was to consider the implementation of team incentives in relational contracts.

We now extend this research, by focusing on the second problem, indispensable human capital. Indispensability is only a problem if contracts are incomplete. Hence, we must still rely on relational contracting, but now we also have to deal with the workers’ hold-up power. A worker is indispensable if the firm is unable to realize the values that the worker creates without the worker's approval. Indispensability implies that the worker is able to hold-up values ex post production, i.e. he can threaten to sell his value-added in an alternative market, and put the surplus in his own pocket.

In Kvaløy and Olsen (2006b) we analyze the conditions for implementing peer-dependent incentive regimes when workers have ownership rights - or possess indispensable human capital. We show that the larger the share of values that the workers can hold-up, the lower is the implementable degree of peer-dependent incentives. In a setting with team e¤ects - complementary tasks and peer pressure, respectively - we show that while group-based incentives are optimal if workers are dispensable, it may be costly, and in fact suboptimal, to provide team incentives once the workers become indispensable. The reason behind these results is quite intuitive: With team incentives, a worker is not paid well if his peers' performance is poor. This peer-dependence may lead to contract breach: a worker who is paid a low bonus after realizing a high output, has incentives to hold-up his output and renegotiate payments. Of course, a hold-up strategy is only possible if the worker actually is able to prevent the principal from realizing the worker's value added. But if hold-up is possible, then peer-dependent incentives are more susceptible to hold-up than incentive schemes based on independent performance evaluation.[1]

The paper …lls a gap: In the vast literature on "multiagent moral hazard" (which deals with optimal provision of incentives to several workers), it is (implicitly) assumed that residual control rights are exclusively in the hands of the …rm (in‡uential papers include Lazear and Rosen, 1981, and Holmstrom, 1982). And in the litera-

[1] Several studies indicate a positive relationship between the intensity of human capital and the prevalence of individual performance pay: Long and Shields (2005) …nd that individual performance pay is more likely to be found in …rms with highly educated employees, while studies by Kato (2002) and Torrington (1993) indicate that workers with more education are particularly interested in receiving rewards tailored to individual performance. Tremblay and Chenevert (2004) …nd that high-tech …rms (characterized by a high percentage of scientists and engineers in the workforce) are more likely to use individual performance pay, but not group pay, and a recent study by Barth et al. (2006) indicates that group-based incentives is decreasing for those with higher education, while it is increasing for blue-collar workers. Individual performance pay, on the other hand, is found to be strongly associated with …rms with a highly educated workforce

ture dealing with optimal allocation of control rights, the multiagent moral hazard problem is not considered (starting with Grossman and Hart, 1986; and Hart and More, 1990[2], who analyze static relationships, and more recently Halonen, 2002; and Baker, Gibbons and Murphy, 2002, who analyze repeated bilateral relationships). Our contribution is thus to consider the e¤ect of workers possessing residual control rights when the …rm faces a multiagent moral hazard problem.

Allocation of ownership rights

In his paper "The …rm as a subeconomy" Holmström (1999) asks: why do modern …rms own essentially all of the productive assets that it employs? And he answers: when a …rm owns the critical assets involved in production, it has the ability to restructure the incentives of those who join the …rm (the employees). In particular, by owning assets the …rm can avoid problems of multitasking and rent seeking. (The ideas from Holmström's 1999-paper are based on Holmström and Milgrom, 1991 and 1994.) We develop this idea: if a …rm does not control its assets, or more precisely if its agents are able to hold-up values ex post production, then multilateral incentive contracts based on relative or joint performance evaluation are costly to implement. Hence, while Holmstrom and Milgrom show how a …rm by giving up ownership rights, loses the ability to balance incentives between various tasks, we show how the …rm by giving up ownership rights loses the ability to balance incentives between agents, (or more precisely, to exploit the advantages that lies in designing peer-dependent incentives.) An implication from Holmstrom and Milgrom's analysis is that the …rm will want to control assets if it is hard to measure the agents performance. An implication from our analysis, which we will present here, is that the …rm will control its assets if there exists conditions that make non-independent performance evaluation desirable.[3] In particular, we show that if there exists common noise that

[2] Although Hart and Moore (1990) analyze a model with many agents, they do not consider the classical moral hazard problem that we address, where a principal can only observe a noisy measure of the agents' e¤ort.

[3] The literature has pointed on numerous reasons for why it may be e¢cient to tie an agent's compensation to the performance of the agent's peers. By tying compensation to the agent's relative performance, the principal can …lter out common noise so that compensation to the largest possible extent is based on real e¤ort, not random shocks that are outside the agent's control (see Holmström,1982; and Mookherjee, 1984). With RPE's special form, rank-order tournaments, the

makes relative performance evaluation optimal, or if there exists peer pressure that makes joint performance evaluation optimal, then the …rm will be more reluctant to give up ownership rights.

Our approach involves assuming that the parties incur some costs by holding assets. For the principal, this can be the costs of protecting property rights or avoiding that agents expropriate values. Assuming then that the principal can choose how much ownership rights (or assets) she will transfer to her agents, we show that she will transfer less ownership rights if there exists common noise that makes relative performance evaluation desirable. This idea is related to the literature on human capital and problems of expropriation (see e.g. Liebskind, 1996; Rebitzer and Taylor, 2001; and Rajan and Zingales, 2001). The focus in this literature is on how organizational design and incentive structure can a¤ect the …rm's ability to protect strategic assets. While the costs of trying to avoid expropriation is at the heart of this literature and is thus endogenous, the costs of losing control over strategic assets is exogenous. We endogenize the costs of losing asset control by showing that these costs vary with the gain from being able to implement peer-dependent incentives.

2 The Model

The …rst part of the model complements Kvaløy and Olsen (2006b) by adding a common noise component: Consider an economic environment consisting of one principal

agents are also completely insulated from the risk of common negative shocks (see Lazear and Rosen, 1981; Nalebu¤ and Stiglitz, 1983; Green and Stokey, 1983). Moreover, tournaments need only rely on ordinal performance measures. It may thus be easier and less costly to measure relative than absolute performance (Lazear and Rosen, 1981). In addition, it may be easier for the principal to commit to tournament schemes if output is not veri…able, since the number of 'high bonuses' are smaller than under independent contracts (Carmichael, 1983; Malcomson, 1984; Levin 2002).

There are also obvious arguments for tying compensation to the joint performance of a group of agents. Joint performance evaluation can promote cooperation since an agent is rewarded if his peers perform well (see e.g. Holmström and Milgrom, 1990; Itoh 1993; and Macho-Stadler and Perez-Castrillo, 1993). JPE can also provide implicit incentives not to shirk (or exert low e¤ort), since shirking may have social costs (as in Kandel and Lazear, 1992), or induce other agents to shirk, which again reduces the shirking agent's expected compensation (as in Che and Yoo, 2001).

and two identical agents who each period produce either high, Q_H, or low, Q_L, values for the principal. Each agent's effort level can be either high or low, where high effort has a disutility cost of c and low effort is costless. The principal can only observe the realization of the agents' output, not the level of effort they choose. Similarly, agent i can only observe agent j's output, not his effort level.[4]

The agents' outputs depend on efforts and noise. We follow Che and Yoo (2001), assuming that a favorable shock occurs with probability $\sigma \in (0,1)$, in which both agents produce high values for the principal. If the shock is unfavorable, the probability for agent i of realizing Q_H is q_H if the agent's effort is high and q_L if the agent's effort is low where $1 > q_H > q_L \geq 0$.

It is assumed that all parties are risk neutral, but that the agents are subject to limited liability: the principal cannot impose negative wages.[5] Ex ante outside options are normalized to zero. The participation constraint then holds trivially by the limited liability assumption.

We assume that if the parties engage in an incentive contract, agent i receives a bonus vector $\beta \equiv (\beta^i_{HH}, \beta^i_{HL}, \beta^i_{LH}, \beta^i_{LL})$ where the subscripts refer to respectively agent i and agent j's realization of Q_i, $(i = H, L)$.

Let agents i and j choose efforts $k \in \{H, L\}$ and $l \in \{H, L\}$ respectively. Agent i's expected wage is then

$$\pi(k, l, \beta^i) \equiv \sigma\beta^i_{HH} + (1-\sigma)\left[q_k q_l \beta^i_{HH} + q_k(1-q_l)\beta^i_{HL} + (1-q_k)q_l\beta^i_{LH} + (1-q_k)(1-q_l)\beta^i_{LL}\right] \qquad (1)$$

For each agent, a wage scheme exhibits joint performance evaluation if $(\beta_{HH}, \beta_{LH}) > (\beta_{HL}, \beta_{LL})$[6]. (For the most part, we suppress agent-notation in superscript since the agents are identical.) In this case $\pi(k, H, \beta) > \pi(k, L, \beta)$, so an agent's work yields positive externalities to his partner. A wage scheme exhibits relative perfor-

[4] Whether or not the agents can observe each others effort level is not decisive for the analysis presented. However, by assuming that effort is unobservable among the agents, we do not need to model repeated peer monitoring.

[5] Limited liability may arise from liquidity constraints or from laws that prohibit firms from extracting payments from workers.

[6] The inequality means weak inequality of each component and strict inequality for at least one component.

mance evaluation if $(\beta_{HH}, \beta_{LH}) < (\beta_{HL}\ \beta_{LL})$. In this case $\pi(k, H, \beta) < \pi(k, L, \beta)$, so an agent's work generates a negative externality for his partner. A wage scheme exhibits independent performance evaluation if $(\beta_{HH}, \beta_{LH}) = (\beta_{HL}\ \beta_{LL})$, which implies $\pi(k, H, \beta) = \pi(k, L, \beta)$, so an agent's work has no impact on his partner.

2.1 Optimal contract when output is verifiable

As a benchmark, we first consider the least cost incentive contract when output is verifiable. For an incentive contract to be viable, the value of high effort must weakly exceed the cost of effort, that is

$$(1 - \sigma)\Delta q \Delta Q \geq c \tag{2}$$

where $\Delta q = q_H - q_L$ and $\Delta Q = Q_H - Q_L$. Assuming that (2) holds, the principal's problem is to minimize the wage payments subject to the constraints that the agents must be induced to yield high effort. A contract β induces both agents to work if

$$\pi(H, H, \beta) - c \geq \pi(L, H, \beta) \tag{3}$$

The left hand side (LHS) shows the expected wage from exerting high effort, while the right hand side (RHS) shows the expected wage from exerting low effort. The condition ensures that high effort from both agents is an equilibrium, given the contract β. The agents' equilibrium is unique if high effort is a dominant strategy, i.e. if $\pi(H, L, \beta) - c \geq \pi(L, L, \beta)$ holds in addition to (3). We will discuss uniqueness below.

The principal solves

$$\min_{\beta \geq 0} \pi(H, H, \beta), \text{ subject to (3)} \tag{4}$$

The incentive compatibility (IC) constraint (3) can be written

$$q_H\beta_{HH} + (1 - q_H)\beta_{HL} - q_H\beta_{LH} - (1 - q_H)\beta_{LL} \geq \frac{c}{(1 - \sigma)\Delta q} \tag{IC}$$

Now, by IC and the definition of π we have

$$\begin{aligned} \pi &= \sigma\beta_{HH} + (1-\sigma)q_H[q_H\beta_{HH} + (1-q_H)\beta_{HL}] + (1-q_H)[q_H\beta_{LH} + (1-q_H)\beta_{LL}] \quad (5) \\ &\geq q_H\frac{c}{\Delta q} + \sigma\beta_{HH} + (1-\sigma)[q_H\beta_{LH} + (1-q_H)\beta_{LL}] \end{aligned}$$

Hence, the optimal incentive contract is a stark RPE scheme:

Lemma 1 With common noise $\sigma > 0$ there is a unique optimal static wage scheme $\beta^s = (0, \beta_{HL}, 0, 0)$, where $\beta_{HL} = \frac{c}{(1-\sigma)\Delta q(1-q_H)}$. The minimal wage cost is $\pi = q_H\frac{c}{\Delta q}$.

Remark. As noted above, a contract will induce high effort from both agents as a unique equilibrium in the agents' game in addition to IC it satisfies $\pi(H, L, \beta) - c \geq \pi(L, L, \beta)$. It can be shown that for any contract that satisfies IC with equality, this condition will hold if the contract is RPE or IPE.

2.2 Relational contracting

Assume now that output is non-verifiable. The incentive contract must then be self-enforcing, and thus 'relational' by definition. We consider a multilateral punishment structure where any deviation by the principal triggers low effort from both agents. The principal honors the contract only if both agents honored the contract in the previous period. The agents honor the contract only if the principal honored the contract with both agents in the previous period. A natural explanation for this is that the agents interpret a unilateral contract breach (i.e. the principal deviates from the contract with only one of the agents) as evidence that the principal is not trustworthy (see Bewley, 1999, and Levin, 2002).[7]

The relational incentive contract is self-enforcing if the present value of honoring is greater than the present value of reneging. Ex post realizations of values, the principal can renege on the contract by refusing to pay the promised wage, while the agents can renege by refusing to accept the promised wage, and instead hold-up

[7] Modelling multilateral punishments is also done for convenience. Bilateral punishments will not alter our results qualitatively.

values and renegotiate what we can call a spot contract. The spot price is denoted ηQ_i. If values accrue directly to the principal, then $\eta = 0$. But if the agent is able to hold-up values ex-post, then η is determined by bargaining power, outside options and the ability to hold-up values. Assume that there exists an alternative market for the agents' output, and that the agents are able to independently realize values θQ_i, $\theta \in (0,1)$ ex post.[8] If we assume Nash bargaining between principal and agents, each agent will then receive θQ_i plus a share γ from the surplus from trade i.e. $\theta Q_i + \gamma(Q_i - \theta Q_i) = \eta Q_i$ where $\eta = \gamma + \theta(1 - \gamma)$.

The parties are assumed to play trigger strategies. If the principal reneges on the relational contract, both agents insist on spot contracting forever after. And vice versa: if one of the agents (or both) renege, the principal insists on spot contracting forever after.

For a relational contract to dominate a spot contract, the agents cannot have incentives to exert high effort in a spot contract, that is

$$\eta(1 - \sigma) \cdot q \cdot Q < c \tag{6}$$

Hence, if (2) and (6) hold, an incentive contract inducing both agents to exert high effort dominates a spot contract. Throughout the paper it will be assumed that both these conditions hold, so that we have

$$\eta < \frac{c}{(1 - \sigma) \cdot q \cdot Q} \leq 1.$$

2.2.1 Contract constraints

Consider now the conditions for the incentive contract to be self-enforcing, i.e. the conditions for implementing a relational incentive contract. The parties decide whether or not to honor the incentive contract ex post realization of output, but

[8] The parameter θ depends on the specificity of the agents' value-added. The higher specificity, the lower is θ.

ex ante bonus payments. The principal will honor the contract if

$$
\begin{aligned}
& -\beta_{ij} - \beta_{ji} + \frac{2\delta}{1-\delta}\left[Q_L + (\sigma + (1-\sigma)q_H) \cdot Q - \pi(H, H, \beta)\right] \\
\geq \; & -\eta(Q_i + Q_j) + \frac{2\delta}{1-\delta}\left[Q_L + (\sigma + (1-\sigma)q_L) \cdot Q - S\right], \qquad i, j \in \{H, L\}
\end{aligned}
$$

where $S = \eta(Q_L + (\sigma + (1-\sigma)q_L) \cdot Q)$ is the expected spot price. The LHS of the inequality shows the principal's expected present value from honoring the contract, while the RHS shows the expected present value from reneging. We see that the constraint binds when $\beta_{ij} + \beta_{ji} - \eta(Q_i + Q_j)$ is maximal. We can thus write the condition as

$$
\begin{aligned}
& \max\{2\beta_{HH} - 2\eta Q_H, \beta_{HL} + \beta_{LH} - \eta(Q_H + Q_L), 2\beta_{LL} - 2\eta Q_L\} \\
& \qquad \leq \frac{2\delta}{1-\delta}\left[(1-\sigma) \cdot q \cdot Q + S - \pi(H, H, \beta)\right] \qquad \text{(EP)}
\end{aligned}
$$

Agent i will honor the contract if

$$
\beta_{ij} + \frac{\delta}{1-\delta}(\pi(H, H, \beta) - c) \geq \eta Q_i + \frac{\delta}{1-\delta} S, \qquad i, j \in \{H, L\}
$$

where similarly the LHS shows the agent's expected present value from honoring the contract, while the RHS shows the expected present value from reneging. The constraint binds when $\beta_{ij} - \eta Q_i$ is minimal. We can thus write the condition as

$$
\begin{aligned}
& \min\{\beta_{HH} - \eta Q_H, \beta_{HL} - \eta Q_H, \beta_{LH} - \eta Q_L, \beta_{LL} - \eta Q_L\} \\
& \qquad \geq \frac{\delta}{1-\delta}\left[S - \pi(H, H, \beta) + c\right] \qquad \text{(EA)}
\end{aligned}
$$

2.2.2 Optimal relational contract

To minimize expected wage costs, the principal will solve

$$\min \pi(H, H, \beta)$$
$$\text{subject to (IC), (EP) and (EA)}$$

Now, we showed that IC implies (5), and from this relation and EA (applied to β_{LH} and β_{LL}) we have

$$\pi \geq \sigma\left(\eta Q_H + \frac{\delta}{1-\delta}[S - \pi + c]\right) + q_H\frac{c}{\Delta q} + (1-\sigma)\left(\eta Q_L + \frac{\delta}{1-\delta}[S - \pi + c]\right)$$

Hence

$$\frac{1}{1-\delta}\pi \geq q_H\frac{c}{\Delta q} + \sigma\eta\Delta Q + \left(\eta Q_L + \frac{\delta}{1-\delta}[S + c]\right)$$

Collecting terms involving π and substituting for $S = \sigma\eta Q_H + (1-\sigma)\eta(Q_L + q_L\Delta Q)$ we obtain

$$\pi \geq q_H\frac{c}{\Delta q} + \eta Q_L + \sigma\eta\Delta Q - \delta\left[\frac{c}{\Delta q} - (1-\sigma)\eta\Delta Q\right]q_L$$

Since IC and limited liability ($\beta_{LH}, \beta_{LL} \geq 0$) implies $\pi \geq q_H\frac{c}{\Delta q}$, we see that we have the following lower bound for the wage cost

$$\pi \geq q_H\frac{c}{\Delta q} + \max\{0, \eta Q_L + \sigma\eta\Delta Q - \delta q_L(\frac{c}{\Delta q} - (1-\sigma)\eta\Delta Q)\} = \pi_{\min}$$

where $\pi_{\min} > q_H\frac{c}{\Delta q}$ for $\delta < \delta_0$ given by $\delta_0 = \frac{\eta(Q_L + \sigma\Delta Q)}{q_L(\frac{c}{\Delta q} - (1-\sigma)\eta\Delta Q)}$. Following the reasoning in Kvaløy and Olsen (2006b) it can be shown that the lower bound $\pi_{\min}$

is attained when δ exceeds some critical factor $\bar{\delta} < 1$.[9]. The lower bound is then attained when IC binds and EA is binding for β_{HH}, β_{LH} and β_{LL}. In particular, this means that

$$\beta_{HH} - \beta_{LH} = \eta \cdot Q, \qquad q_H \eta \cdot Q + (1 - q_H)(\beta_{HL} - \beta_{LL}) = \frac{c}{(1-\sigma)\cdot q} \tag{8}$$

Note that, contrary to the verifiable case, the minimal wage costs increase with more common noise here ($\frac{\partial \pi_{\min}}{\partial \sigma} = \eta \cdot Q(1 - \delta q_L) > 0$). This is so because the principal is prevented from using the stark RPE scheme. The intuition behind the result is simple: With RPE, an agent is not paid well if his peer performs better. This peer-dependence triggers breach of the relational contract since an agent who is paid a low bonus after realizing a high output, has incentives to hold-up his output and renegotiate payments. Hence, when contracts are incomplete and the agents possess ownership rights, it is more costly to exploit common noise when designing incentives

3 Transfer of ownership rights

If the principal/firm bears no cost of withholding ownership rights, then the firm's wage costs are minimized if η is minimized, (subject to the constraints that ensure high-effort equilibria). But assume now that there are costs associated with managing assets. For the principal, these costs will then be a decreasing function of η, while for the agents it will be a increasing function of η. Note that these costs will not affect the constraints of the problem since they appear at both sides of the equations. Analytically, it will only appear in the principal's objective function (still assuming that the principal has ex ante bargaining power to set wages.) Hence we need only care about the principal's costs $C(\eta)$, where $C'(\eta) < 0$. If we interpret the agents as employees that are able to achieve $\eta > 0$ because of essential human capital, the asset management costs for the principal can be interpreted as the costs of protecting

[9] The critical factor $\bar{\delta}$ is given by $\frac{1-\bar{\delta}}{\bar{\delta}} = \frac{2[(1-\sigma)\cdot q \cdot Q - c](1-q_H)}{(c-(1-\sigma)\eta \cdot q \cdot Q)}(1-\sigma)\cdot q$

intellectual property rights and avoiding expropriation (this is a major issue in human capital intensive industries, see e.g. Rajan and Zingales, 2001).

If $C''(\eta) > 0$ there is an interior solution satisfying

$$\pi'_{\text{min}}(\eta) = Q_L + \delta \cdot Qq_L = -C'(\eta)$$

Observe that the higher $\pi'_{\text{min}}(\eta)$, the lower η the firm will choose. If an increase in η increases the cost of providing incentives, we would get a higher $\pi'_{\text{min}}(\eta)$ and thus less transfer of control rights from firm to agents.

Observe that (for $\delta > \bar{\delta}$) we have

$$\begin{aligned} \frac{\partial \pi_{\text{min}}}{\partial \eta} &= Q_L + \sigma \cdot Q + \delta q_L (1 - \sigma) \cdot Q \\ \frac{\partial \pi_{\text{min}}}{\partial \eta \partial \sigma} &= \cdot Q (1 - \delta q_L) > 0 \end{aligned}$$

Hence, the more common noise, the higher are absolute wage costs (π_{min}), and the higher are the marginal wage costs ($\frac{\partial \pi_{\text{min}}}{\partial \eta}$) associated with transferring ownership rights to the agents. The more common noise, the lower is thus the optimal η; the firm wishes to take a stronger control over the agents' assets if the agents are exposed to common noise. Note that there are two effects that makes a higher η more costly when common noise is introduced. The first, least interesting effect, is through the higher expected spot price that the agents can achieve when our specific specification of common noise is introduced. This higher spot price must be matched through higher fixed payments $\beta_{HL} = \beta_{LL}$.

The more interesting effect is the cost of losing the ability to implement the optimal degree of peer-dependence, namely, the starkest RPE scheme. In contrast, when there is no common noise, there are no costs of not being able to implement peer-dependent incentives.

We can summarize this discussion in the following proposition.

Proposition 1 For $\delta_0 \geq 1$ and $\delta \geq \bar{\delta}$ we have: (i) With more common noise, the more the principal loses from her inability to implement the optimal degree of peer-dependence in the wage scheme. (ii) With more common noise, the higher is the value for the firm of keeping the agents' assets under its control.

3.1 Peer pressure

In Kvaløy and Olsen (2006b), we show that in settings with team effects (complementary tasks and peer pressure), group-based incentives are optimal if agents are dispensable, but costly once the agents become indispensable. The peer pressure case gives the most striking example, where any JPE-scheme becomes suboptimal once the relational contract constraints bind. The reason is that once the outside market becomes tempting, the principal can no longer use JPE to exploit peer pressure effects, but has to compensate the agents for any disutility that team incentives provide.

We will here briefly present this result (see Kvaløy and Olsen, 2006b for details) and show how it affects the decision to transfer to ownership rights: To keep the argument clean, we assume no common noise, i.e. $\sigma = 0$:

Assume that there are costs associated with lowering the peer's wage by realizing low output, i.e. that agents experience disutility from being the "weakest link". Such an event will occur with probability $(1 - q_H)q_H$ if $\beta_{HH} > \beta_{HL}$. We represent this disutility by $d = \max\{\nu(\beta_{HH} - \beta_{HL}), 0\}$, where ν is a cost parameter. This yields an IC constraint of the form:

$$q_H\beta_{HH} + (1 - q_H)\beta_{HL} - q_H(\beta_{LH} - \max\{\nu(\beta_{HH} - \beta_{HL}), 0\}) - (1 - q_H)\beta_{LL} \geq \frac{c}{\Delta q} \qquad (IC_d)$$

From this constraint and the definition of π we get

$$\pi \geq q_H\frac{c}{\Delta q} - q_H^2 \max\{\nu(\beta_{HH} - \beta_{HL}), 0\} + q_H\beta_{LH} + (1 - q_H)\beta_{LL} \qquad (9)$$

We now see that if $\nu > 0$, then in the verifiable case it is uniquely optimal to set

$\beta_{HL} = \beta_{LH} = \beta_{LL} = 0$, and (solving from IC_d) $\beta_{HH} = \frac{c}{q_H \Delta q(1+\nu)}$. The wage cost is now lower than in the case where $\nu = 0$, i.e. $q_H \frac{c}{\Delta q}\frac{1}{\nu+1} < q_H \frac{c}{\Delta q}$ for $\nu > 0$ Hence, by offering incentives based on JPE, the principal can exploit the disutility effect of being the weakest link.

If output is non-verifiable, on the other hand, the optimal scheme is not only a less stark JPE scheme. As we will now demonstrate, any JPE scheme is sub-optimal once the relational contract constraints bind:

Using (9), which follows from the present IC-constraint, and EA for bonuses β_{LH} and β_{LL}, we get:

$$\pi \geq q_H \frac{c}{\Delta q} - q_H^2 d + \left(\eta Q_L + \frac{\delta}{1-\delta}\left[S - \pi + (1-q_H) q_H d + c\right] + q_H d \right)$$
$$= q_H \frac{c}{\Delta q} + \eta Q_L + \frac{\delta}{1-\delta}\left[S - (\pi - (1-q_H) q_H d) + c\right] + (1-q_H) q_H d$$

Collecting terms involving $\pi - (1-q_H)q_H d$ and substituting for S we then obtain

$$\pi \geq q_H \frac{c}{\Delta q} + \eta Q_L - \delta \left[\frac{c}{\Delta q} - \eta \Delta Q \right] q_L + (1-q_H) q_H d$$

We see that to minimize π, the principal will want to set $(1-q_H)q_H d$ as small as possible i.e. make $d = \max\{\nu(\beta_{HH} - \beta_{HL}), 0\}$ as small as possible. This means setting $\beta_{HH} - \beta_{HL} = 0$, provided this is feasible by EP. It follows that no JPE scheme that satisfies IC_d with equality can be optimal once the enforceability condition EA binds. Moreover, given that $\eta Q_L - \left[\frac{c}{\Delta q} - \eta \Delta Q \right] q_L \geq 0$, it also follows that the minimal wage cost is then at least $q_H \frac{c}{\Delta q}$.

Hence, if peer pressure is present, the principal only needs to pay $\pi_m = q_H \frac{c}{\Delta q}\frac{1}{\nu+1}$ if the relational contract constraints do not bind, while she must pay at least $q_H \frac{c}{\Delta q}$ once the constraints do bind. Thus it is easy to see that there are extra costs of transferring ownership rights when team effects exist, since the principal then loses the ability to exploit these effects. We will thus expect the firm to choose a lower η if team effects, such as peer pressure, exist:

Proposition 2 The more peer pressure ($\nu > 0$) the more the principal loses from her inability to implement the optimal degree of peer-dependence in the wage scheme. (ii) The more peer pressure the higher is the value for the …rm of keeping the agents' assets under its control.

In some sense, this complements Alchian and Demsetz (1972) seminal paper on team production. Their idea is that the …rm is set up to monitor input (e¤ort) when team-based production makes individual output di¢cult to measure. Our corollary is di¤erent. We assume that monitoring e¤ort is impossible, but that individual output is measurable. The …rm then wishes to control assets in order to exploit positive team externalities when designing incentives.

4 Concluding remarks

In Kvaløy and Olsen (2006b) we show that compensation tied to peer-performance can induce employee-hold-up and obstruct the implementation of relational incentive contracts, which may explain the extensive use of individual performance pay in human-capital-intensive industries.

In this paper we present an extention by showing that the costs of transferring ownership rights to agents may depend on whether there exist conditions that calls for peer-dependent incentives. In particular, we show that if there exists common noise or peer pressure, that makes, respectively, RPE or JPE, optimal, then the …rm may be reluctant to give up ownership rights.

It should be noted that we do not discuss Pareto optimal asset allocation. In fact, this question is trivial here. The critical discount factor for implementing …rst best (high) e¤ort decreases with the agents' share of ownership rights, simply because it is the agents that take on investments (e¤ort). However, by constraining our attention to the range of parameters where …rst-best e¤ort is implemented (as we do in Section 4) we can ask how the …rm optimally will transfer ownership rights to her agents. In such, it is related to Holmström and Milgrom who also take a "…rm perspective" by discussing how much asset ownership it should give its agents. In their model, the …rm optimally trades o¤ the "incentive costs" (i.e. the lower-powered agent-incentives) of controlling assets with the bene…ts of being able to balance incentives between tasks. In our model, the …rm trades o¤ the "protection costs" of controlling assets with the bene…ts of exploiting peer-dependence.

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