High-Powered Incentives vs. Low-Powered Incentives: Why Low-Powered Incentives within Firms?

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This paper explains why high-powered incentives are more common than low-powered incentives in market arrangements, while low-powered incentives are more common than high-powered incentives within firms. In a firmlike principal-agent framework in which a common principal participates in the multiple agents' production processes with his own productive efforts, social efficiency can be obtained by relative performance schemes when the agents are risk-neutral. We derive a group of relative performance schemes which achieve a socially efficient outcome. They are different in their pay-for-performance sensitivity, ranging from a high-powered pricelike relative contract to a seemingly low-powered promotion-based contract. We show that the high-powered relative contract is the most efficient among the first-best relative contracts when the agents have private information, and the promotion-based contract is the most efficient when the agents' limited liabilities are of serious concern. (*JEL* Classifications: D80, J00)

I. Introduction

It is observed that 'high-powered' incentives are more common than 'low-powered' incentives in market arrangements, and 'low-powered' incentives are more common than 'high-powered' incentives within firms.[1] For example, franchisees pay to franchisers fixed upfront fees and royalties which are proportional to their sales, whereas managers of company-owned outlets generally receive fixed

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[1] See Chapter 6 in Williamson (1985).

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salaries which are independent of their performances.[2] Lafontaine (1992) finds that in her sample 7% of franchisers charge a zero royalty rate and the remaining 93% charge only around a 6% royalty rate, implying that the franchisees face highly sensitive pay-for-performance schemes.

High-powered incentives found in market transactions are consistent with what standard agency theory suggests. According to the standard agency theory, highly sensitive compensation schemes must be designed in places where incentive problems are prominent. However, low-powered incentives within firms provide a puzzle for the theory since workers in firms also face various incentive problems.[3]

Based on the standard principal-agent model, several theories have recently been offered to explain why low-powered incentives are employed in firms. They argue that low-powered incentives within firms arise from the incompleteness of contracts (Williamson 1985), multiple tasks of workers (Holmstrom and Milgrom 1991), and obscure performance measures for workers (Baker 1992). These theories basically provide stories of why firms should attempt to *reduce* their workers' incentives.

The main purpose of this paper is to explain the above puzzling phenomenon from a different perspective. As observed by many economists, although most firms pay fixed salaries to their workers which are seemingly low-powered, they also provide their workers with 'promotion opportunities' as alternative incentive devices.[4] Usually, workers with high performance are promoted, and such opportunities provide all workers with an incentive to work hard. Thus, to explain the above puzzle, the theory should focus on why firms rely on promotion-based incentives more than on other incentives, rather than focusing on why they are attempting to reduce their workers' incentives.

In this paper, we analyze the benefits that promotion-based incentives generate for firms, which other incentives do not, by

[2]See Brickley and Dark (1987), and Krueger (1991).

[3]For the standard agency theory, see Harris and Raviv (1979), Holmstrom (1979), Shavell (1979), and Grossman and Hart (1983) among others. Also, for survey literature on incentive contracts, see Hart and Holmstrom (1987), and Holmstrom and Tirole (1989).

[4]See Baker, Jensen and Murphy (1988), and Baker, Gibbs and Holmstrom (1993, 1994) among others.

adopting a different principal-agent model. One of the typical assumptions which the standard agency theory has adopted is the principal's absenteeism in the agent's production process, which is not quite appropriate especially for explaining internal incentive structures in firms. Here, we formulate a firmlike principal-agent framework in which a principal also participates in multiple agents' production processes by inputting his own productive efforts which have a common effect on the agents' performances.

Many principal-agent relations, either in markets or in organizations, are double-sided. For example, a franchiser invests resources into advertising to maintain his reputation and market share. Also, he provides each franchisee with intermediate goods, market information, and managerial training, etc. Each franchisee's final performance is affected by the franchiser's such effort inputs, and some of these inputs are not observable.[5] This bilateral relation arises even more obviously between a manager and his workers in a firm. The manager, as a principal, designs each worker's wage contract, organizes the workers' inputs, maintains the working environment, and decides on investment plans. All of these efforts, whether measurable or not, can substantially influence each worker's productivity. Consequently, all the agents want to be assured of the principal's full dedication, and the contract should take into account the principal's incentive problem as well.

We assume that the agents are risk-neutral to exclusively focus on the effect of the principal's incentive problem on the characteristics of optimal contracts. Given the fact that the principal's commitment to his own incentive is also important in a bilateral situation, each agent's incentive contract should be a relative performance scheme. The principal can demonstrate his full incentive to the agents by paying a fixed amount to the group of agents, and thus making himself a residual claimant. However, to provide the agents with full incentives as well, he should promote competition among the agents, and such competition can be established by a relative performance scheme.

There are two typical ways for principals to promote such

[5]Lafontaine (1992) concludes that a double moral-hazard argument for franchising best explains the data. Also, see Mathewson and Winter (1985) and Brickley and Dark (1987) for evidence of moral-hazard on the franchiser's side.

competition among their agents. One is to use a price system in which each agent is paid according to what he contributes, and the other is to use an auction system in which only the winner gets all. In this paper, we derive a group of relative performance schemes that attain a socially efficient outcome in our firmlike principal-agent model. On one extreme is a relative performance scheme that relies only on the price system so that a better performing agent can extract benefits from a lower performing agent by their performance margin, indicating a high-powered incentive scheme. The other extreme is that one relies only on the auction system so that the winner is promoted, indicating a seemingly low-powered fixed salary scheme combined with a promotion opportunity.

It is well known that the price system performs efficiently when there are precise measures on which prices can be based. However, if such measures are not available, alternative systems must be introduced. What we show in this paper is that the high-powered relative performance scheme using the price system is the most efficient among the group of first-best relative performance schemes when there are precise measures for the agents' performances. However, if the agents' performance measures are very inaccurate, which is usually the case in most firms, then it tends to violate the agents' limited liabilities. When the agents can bear only limited liabilities, the promotion-based incentive scheme using the auction system performs most efficiently among the group of first-best relative performance schemes.

The rest of this paper is organized as follows. In Section II, we formulate a simple firmlike principal-agent model in which a common and productive principal contracts with many risk-neutral agents. In Section III, we derive a group of relative performance schemes which achieve a socially efficient outcome, ranging from a high-powered relative incentive scheme to a promotion-based incentive scheme. In Section IV, we show that the high-powered incentive scheme is the most efficient when the agents have private information, and the promotion-based incentive scheme is the most efficient when the agents' limited liabilities are seriously considered. In Section V, we discuss why the agents' limited liability constraints become more serious in firms than in markets, and thus why low-powered promotion-based incentive schemes are often found within firms. Concluding remarks are given in Section VI.

II. The Model

To analyze contractual arrangements in firms in a simple-setting, we begin with a model in which a risk-neutral principal contracts with two risk-neutral agents who are identical in every respect. The principal chooses his productive effort $e \in [0, \infty)$ which has a common effect on both agents, and the agents choose their respective efforts $a_i \in [0, \infty)$, $i=1, 2$.[6] Each agent's revenue is assumed to be $x_i = A(a_i, e) + \theta_i$, where $A(\bullet)$ represents an increasing, concave, and twice differentiable function of a_i and e, and θ_i denotes the state of nature which is idiosyncratic to agent i.[7] It is also assumed that θ_1 and θ_2 are both i.i.d. with mean zero and variance σ^2.

The revenue generated by each agent is commonly observable and verifiable, but the effort chosen by one party cannot be observed by others. Thus, agent i's incentive scheme, s_i, must be based on both observables x_1 and x_2. Let $C(e)$ and $c(a_i)$ denote the cost functions of the principal and agent i's efforts respectively, which are increasing, convex, and twice differentiable.

The socially efficient effort combination, (a_1^*, a_2^*, e^*), should solve

$$\underset{a_1, a_2, e}{Max} \quad E(x_1 + x_2) - c(a_1) - c(a_2) - C(e).$$

Since $E(x_1 + x_2) = A(a_1, e) + A(a_2, e)$, it is straightforward to show that

$$\begin{aligned} &A_e(a_1^*, e^*) + A_e(a_2^*, e^*) = C'(e^*), \\ &A_a(a_1^*, e^*) = c'(a_1^*), \\ &A_a(a_2^*, e^*) = c'(a_2^*), \end{aligned} \tag{1}$$

where the first derivative is denoted by the subscript or the prime.[8]

Such a first-best outcome can be achieved if the principal can observe the effort choices of both agents. However, if the principal cannot observe the agents' efforts, the moral-hazard problem exists

[6]Thus, our framework is an extension of the simple double moral-hazard model to a multiple agent case. For the simple double moral-hazard model, see Romano (1994), Bhattacharyya and Lafontaine (1995), and Kim and Wang (1998).

[7]A more general setting is $x_i = X(A(a_i, e), \theta_i)$. But none of the results in this paper change qualitatively under the general setting.

[8]To guarantee the existence of (a_1^*, a_2^*, e^*), we need the additional assumption that $\partial^2 A/(\partial a_i \partial e)$ be bounded from above.

not only on each agent's side but also on the principal's side, because the principal also participates in both agents' production processes. Thus, when designing incentive schemes for both agents, the principal should consider his own incentive as well as those of both agents.

Therefore, the principal's optimization problem is:

$$\underset{s_1,\ s_2,\ e,\ a_1,\ a_2}{Max} \quad E(x_1+x_2-s_1-s_2)-C(e),$$

$$\begin{aligned} \text{s.t. (i) } & Es_i - c(a_i) \geq \overline{U}, \quad i=1,\ 2, \\ \text{(ii) } & (a_i,\ e),\ i=1,\ 2, \text{ satisfies} \\ & a_i \in argmax\ Es_i - c(a_i), \text{ and} \\ & e \in argmax\ E(x_1+x_2-s_1-s_2)-C(e), \end{aligned}$$

where $\overline{U}$ denotes each agent's reservation level of utility that could be obtained from the best alternative employment. The first constraint in (ii) addresses agent i's incentive compatibility constraint, while the second addresses the principal's own incentive constraint.

III. First-Best Incentive Schemes

It is well known that, when the principal also participates in each agent's production process by inputting his own productive effort, a socially efficient outcome cannot be obtained by any individualistic contract which is based solely on absolute performance measures, i.e. $s_i = s_i(x_i)$, $i=1,\ 2$.[9] However, it is easy to see that there are a certain group of relative performance schemes which can obtain a socially efficient outcome.

Consider a group of incentive schemes $\{s_i(x_i - x_j;\ k,\ B) \mid 0 \leq k \leq 1\}$, $i=1,\ 2$, such that

$$s_i(x_i - x_j;\ k,\ B) = \begin{cases} W + k(x_i - x_j) & \text{when } x_i \leq x_j,\ i,\ j=1,\ 2, \\ W + k(x_i - x_j) + B & \text{otherwise,} \end{cases} \tag{2}$$

where $B \geq 0$. Here, W denotes a basic salary, while B is prize money to be awarded to the winner. Also, k denotes the extent to which each agent's compensation depends on the performance margin between both agents.

Since the total payment that the principal makes to the agents is

[9]See Holmstrom (1982), and Carmichael (1983).

fixed, i.e. $s_1+s_2=2W+B$, the principal remains a residual claimant with respect to the total output, x_1+x_2, and thus he has an incentive to work to his full potential.[10] On the other hand, each agent's incentive will be given by his attempts to increase the performance margin and to win the prize money B.

The probability that agent i, $i=1, 2$, wins the prize money B is:

$$\begin{aligned}\text{Prob }[x_i \geq x_j] &= \text{Prob}[\theta_j - \theta_i \leq A(a_i, e) - A(a_j, e)] \\ &= \text{Prob}[\varepsilon \leq A(a_i, e) - A(a_j, e)] \\ &= G(A(a_i, e) - A(a_j, e)),\end{aligned}$$

where $\varepsilon \equiv \theta_j - \theta_i$, $\varepsilon \sim g(\varepsilon)$ and $G(\varepsilon)$ is the cumulative distribution function of ε with $E(\varepsilon)=0$. Since both agents are identical, and since θ_1 and θ_2 are assumed to be i.i.d., $a_1=a_2$ in equilibrium. Thus, the probability that agent i wins, in equilibrium, is 1/2. In order to make each agent participate given that the principal chooses his first-best effort e^*, we substitute (2) into each agent's participation constraint, and obtain

$$W + \frac{1}{2}B = \overline{U} + c(a_i^*), \quad i=1, 2. \tag{3}$$

Also, to motivate each agent to take his efficient effort level a_i^*, $i=1, 2$, by substituting (2) into each agent's incentive compatibility constraint, we obtain, assuming an interior solution,[11]

$$\{k + Bg\,(A(a_i^*, e^*) - A(a_j^*, e^*))\}A_a(a_i^*, e^*) = c'\,(a_i^*), \; i \neq j, \; i, j=1, 2. \tag{4}$$

Since, in equilibrium, $A(a_i^*, e^*)=A(a_j^*, e^*)$, by using (4) and the fact that $A_a(a_i^*, e^*)=c'\,(a_i^*)$, we have

$$g(0)B = 1-k. \tag{5}$$

Therefore, if (W, k, B) are designed so that

[10]The residual claimant here implies a person who receives all the residuals except a fixed amount. It is obvious that a person who is a residual claimant has a full incentive to work hard since he receives all the marginal benefits of an additional effort input.

[11]To guarantee a unique interior solution at (a_1^*, a_2^*, e^*), g must be differentiable and the second-order condition should be satisfied, that is,

$$Bg\,(A(a_i, e^*) - A(a_j^*, e^*))A_{aa}(a_i, e^*) + BA_a^2(a_i, e^*)g'(\cdot) - c''(a_i) \leq 0, \; \forall a_i.$$

For more discussion on this point, see Bhattacharyya and Guasch (1988).

$$W^* = \overline{U} + c(a_i^*) - \frac{1-k}{2g(0)},$$
$$B^* = \frac{1-k}{g(0)}, \tag{6}$$

then both agents will participate and make an effort $a_1^* = a_2^*$ given that the principal chooses e^*. Thus, the group of relative performance schemes, $\{s_i(x_i - x_j;\ k,\ B) \mid 0 \leq k \leq 1\}$, result in the socially efficient outcome.

Note that k captures the sensitivity of the agent's compensation to relative performance, $x_i - x_j$, and it is negatively related to prize money B. In particular, if $k=1$, then $B=0$. Thus, the first-best contract, $s_i(x_i - x_j;\ k,\ B)$, reduces to

$$s_i(x_i - x_j;\ k,\ B) = (x_i - x_j) + W,\ i \neq j,\ i, j = 1,\ 2,$$
$$W = \overline{U} + c(a_i^*), \tag{7}$$

which has been previously discussed by Carmichael (1983).[12]

Under this contract, each agent receives a fixed salary of $W = \overline{U} + c(a_i^*)$, which is the same as a fixed salary scheme would offer. In addition, however, both agents are engaged in a zero sum game in which the higher performance agent extracts benefits from the lower performance agent by an amount equal to their performance margin. In this incentive contract, each agent's compensation depends solely on the performance margin, and is the most sensitive to the relative performance (i.e. it has the highest power) among the first-best relative performance schemes. This is a pricelike relative contract in which competition among the agents is promoted by a price system.

Another extreme case arises when $k=0$. Under this circumstance, the first-best contract in (2) is reduced to a tournament scheme, in which each agent's compensation depends solely on his, ranking rather than the performance margin. If we interpret the prize money B as a salary increment that a promoted worker can enjoy, then this tournament scheme becomes the promotion-based contract which is composed of a fixed salary and a promotion opportunity. This is a relative contract in which competition among

[12]Carmichael (1983) shows that the relative performance scheme in (7) can result in the first-best outcome in our simple setting.

the agents is promoted by an auction system.

IV. Comparisons

In the previous section, we have derived a group of relative performance schemes which all achieve a socially efficient outcome in our simple firmlike principal-agent model.[13] In this section, we relax the underlying assumptions, and then identify the situations in which one relative performance scheme dominates the others.

A. Agent's Superior Information

It is generally true that each agent, after signing a contract with the principal, can obtain some private information about his production process which is not available to the principal. The agents usually have better knowledge about field situations such as technological and market conditions. At the very least, the agents can observe their interim performances during the period of production which the principal can hardly observe. Usually, exerting an effort is a continuing process, and each agent can adjust his effort level from time to time according to information obtained from the production process.

The exact modelling will depend on the various sources of each agent's superior information and its time of realization. However, a simple model will suffice to compare the relative efficiencies of the group of our first-best relative performance schemes in the presence of the agents' private information.

We assume that everything is the same as in the previous model, except that agent i, after signing a contract with the principal but before taking an action, observes his own state of nature, θ_i, but does not know his competitor's state of nature, θ_j, $i \neq j$, i, $j = 1, 2$. Since agent i has a revenue function $x_i = A(a_i, e) + \theta_i$, which is additively separable, the socially efficient effort combination, (a_1^*, a_2^*, e^*), is invariant to the realization of θ_i.

***Proposition* 1**
If $k=1$ in (2), then the socially efficient outcome can still be obtained even with the agents' private information. However, if $k<1$,

[13] Carmichael (1983) calls this an 'agent-agents' model.

then the socially efficient outcome cannot be obtained unless θ_i, $i=1, 2$, is uniformly distributed.

Proof: Agent i's effort choice with given θ_i is

$a_i \in argmax\ W + k\{A(a_i, e) + \theta_i - A(a_j, e)\} + B \cdot \text{Prob[agent } i \text{ wins} \mid \theta_i] - c(a_i)$.

Thus, each agent's choice of effort level according to the realization of θ_i, $i=1, 2$, can be denoted as $a_i(\theta_i)$, $i=1, 2$. When agent i chooses a_i given θ_i, the probability that he outperforms his opponent j who is using $a_j(\theta_j)$ is:

$$\begin{aligned}\text{Prob}[x_i \geq x_j \mid \theta_i] &= \text{Prob}[A(a_j(\theta_j), e) + \theta_j \leq A(a_i, e) + \theta_i] \\ &= H[A(a_i, e) + \theta_i],\end{aligned}$$

where H is the c.d.f. of $A(a_j(\theta_j), e) + \theta_j$. Let $a_i^*(\theta_i)$ be the equilibrium strategy of agent i, $i=1, 2$. In order for $a_i^*(\theta_i)$ to be the equilibrium strategy of agent i given agent j's equilibrium strategy $a_j^*(\theta_j)$, assuming an interior solution, it should satisfy the following condition:

$$\{k + Bh[A(a_i^*(\theta_i), e^*) + \theta_i]\} A_a(a_i^*(\theta_i), e^*) = c'(a_i^*(\theta_i)), \ \forall \theta_i, \tag{8}$$

where h is the p.d.f. of $A(a_j^*(\theta_j), e^*) + \theta_j$. Since $a_i^*(\theta) = a_j^*(\theta)$ in equilibrium, and since $A(a_i^*(\theta_i), e^*) + \theta_i$ is increasing in θ_i (see Appendix A), we have

$$H[A(a_i^*(\theta_i), e^*) + \theta_i] = \text{Prob}[\theta_j < \theta_i] = F(\theta_i),$$

where F is the c.d.f. of θ_j. Therefore, by a transformation of distribution, we have

$$h[A(a_i^*(\theta_i), e^*) + \theta_i] = \frac{f(\theta_i)}{A_a a_i^{*\prime}(\theta_i) + 1},$$

and (8) reduces to

$$\left\{k + \frac{Bf(\theta_i)}{A_a a_i^{*\prime}(\theta_i) + 1}\right\} A_a(a_i^*(\theta_i), e^*) = c'(a_i^*(\theta_i)), \ \forall \theta_i. \tag{9}$$

If $k=1$, then it is straightforward to show that $B=0$ and $a_i^*(\theta_i) = a_i^*$, $\forall \theta_i$. Thus, we can obtain the socially efficient outcome for any realization of θ_i, $i=1, 2$. However, if $k<1$, then B should be strictly positive. To guarantee that $a_i^*(\theta_i) = a_i^*$, $\forall \theta_i$, we should have $a_i^{*\prime}(\theta_i) = 0$. Thus, (9) changes to

$$\{k + Bf(\theta_i)\} A_a(a_i^*, e^*) = c'(a_i^*), \ \forall \theta_i. \tag{10}$$

However, since B is constant, it is impossible that $a_i^*(\theta_i)=a_i^*$, $\forall\,\theta_i$, unless f is uniform.

Q.E.D.

Proposition 1 shows that only the pricelike relative contract, which has the highest pay-performance sensitivity, remains efficient when the agents have some superior information after the contract. However, any contract which adopts some degree of tournament contest is inefficient in this situation. Fundamentally, the pricelike relative contract is a linear affine function of the agents' performance margin, x_i-x_j, and it is not surprising that a linear affine function provides the agents with incentives that are independent of their private information. In contrast, any contract which has some tournament characteristics inevitably distorts the agents' incentives according to their private information.

As a matter of fact, it is one of the most frequent criticisms against promotion-based incentive schemes, as noted by Baker, Jensen and Murphy (1988):

> "Promotion incentives are reduced for employees who have been passed up for promotion previously and whose future promotion potential is doubtful, and incentives will be absent for employees who clearly fall short of the promotion standard or who cannot conceivably win a promotion tournament. In addition, promotion possibilities provide no incentive for anyone who exceeds the standard or substantially outperforms his or her coworkers."

B. The Agents' Limited Liabilities

Very often, because of the agents' limited access to capital markets and legal restrictions limiting the agents' full responsibilities, the contract that the principal will design must take these financial constraints into account.[14] When each agents' limited liability is an important concern, that is, $s_i(x_i,\ x_j)\geq \underline{s}$ for all $(x_i,\ x_j)$, then the group of first-best relative incentive schemes in (2), which differ in their pay-performance sensitivity, perform differently.

For this discussion, we assume that the random variable θ_i, $i=1,\ 2$, is bounded in a given interval $[\underline{\theta},\ \overline{\theta}]$. In other words, $x_i\in[\underline{x},\ \overline{x}]$, where $\underline{x}=A(a_i^*,\ e^*)+\underline{\theta}$ and $\overline{x}=A(a_i^*,\ e^*)+\overline{\theta}$. Since our first-best

[14] For details of the agents' limited liability issues in contract theory, see Sappington (1983), Innes (1990), and Kim (1991).

relative performance schemes are increasing in $x_i - x_j$, the sufficient condition for $s_i(x_i - x_j;\ k,\ B) \geq \underline{s}$ for all $(x_i,\ x_j)$ is

$$s_i(\underline{x} - \overline{x};\ k,\ B) \geq \underline{s}.$$

***Proposition* 2**
If $s_i(\underline{x} - \overline{x};\ k_0,\ B_0) \geq \underline{s}$, then any first-best relative performance scheme with $k < k_0$ satisfies $s_i(\underline{x} - \overline{x};\ k,\ B) \geq \underline{s}$.

Proof: Using (6), we can rewrite our first-best relative performance scheme with given $0 \leq k \leq 1$ as follows:

$$s_i\,(x_i - x_j;\ k,\ B) = \begin{cases} k(x_i - x_j) + \overline{U} + c(a_i^*) - \dfrac{1-k}{2g(0)} & \text{when } x_i \leq x_j \\[2ex] k(x_i - x_j) + \overline{U} + c(a_i^*) + \dfrac{1-k}{2g(0)} & \text{otherwise.} \end{cases}$$

Let $k_1 < k_0$, and contrarily assume that

$$\begin{aligned} s_i\,(\underline{x} - \overline{x};\ k_1,\ B_1) &= k_1(\underline{x} - \overline{x}) + \overline{U} + c(a_i^*) - \frac{1-k_1}{2g(0)} \\ &< \underline{s} \\ &\leq k_0(\underline{x} - \overline{x}) + \overline{U} + c(a_i^*) - \frac{1-k_0}{2g(0)}. \end{aligned} \tag{11}$$

Then, we can easily show that

$$s_i\,(x_i - x_j;\ k_1,\ B_1) < s_i\,(x_i - x_j;\ k_0,\ B_0) \text{ when } x_i < x_j.$$

Furthermore, it immediately follows from (11) that

$$k_1(\overline{x} - \underline{x}) + \overline{U} + c(a_i^*) + \frac{1-k_1}{2g(0)} > k_0(\overline{x} - \underline{x}) + \overline{U} + c(a_i^*) + \frac{1-k_0}{2g(0)}.$$

Thus, we have

$$s_i\,(x_i - x_j;\ k_1,\ B_1) > s_i\,(x_i - x_j;\ k_0,\ B_0) \text{ when } x_i > x_j.$$

In other words, $s_i\,(x_i - x_j;\ k_1,\ B_1)$ pays more than $s_i\,(x_i - x_j;\ k_0,\ B_0)$ when the performance is high (i.e. $x_i \geq x_j$) and less than $s_i\,(x_i - x_j;\ k_0,\ B_0)$ when the performance is low (i.e. $x_i < x_j$). However, as shown by Innes (1990), the agent's effort that is induced by $s_i\,(x_i - x_j;\ k_1,\ B_1)$ is higher than the first-best effort level a_i^* that would be induced by $s_i\,(x_i - x_j;\ k_0,\ B_0)$ (see Lemma 1 in Innes). Thus, there is a contradiction.

Q.E.D.

Proposition 2 shows that the promotion-based incentive scheme ($k=0$) weakly dominates any other first-best relative scheme ($k>0$) under the condition that the agents would bear only limited liabilities. The more is an incentive scheme sensitive to the performance margin, the more likely it will violate agents' limited liability constraints. In contrast, agent i's compensation is not sensitive to the performance margin when the promotion-based incentive scheme is designed. When $k=0$, the only requirement for agent i's limited liability constraint is

$$W=\overline{U}+c(a_i^*)-\frac{1}{2g(0)}\geq \underline{s}. \tag{12}$$

Whether an individual agent's limited liability constraint is binding under the promotion-based incentive scheme or not depends on the randomness of the outcome. For example, if θ_i, $i=1, 2$, is normally distributed with variance σ^2, then $g(0)$ in (5) is $1/(2\sqrt{\pi}\sigma)$. Thus, if the randomness of the outcome, σ^2, is very large, then it may be the case that

$$W=\overline{U}+c(a_i^*)-\frac{1}{2g(0)}=\overline{U}+c(a_i^*)-\sqrt{\pi}\sigma<\underline{s}, \tag{13}$$

implying that even the promotion-based incentive scheme violates the agent's limited liability. However, the following proposition shows that the principal can achieve the socially efficient outcome even in this case by designing a simple variant of the promotion-based incentive scheme.

***Proposition* 3**
If

$$\lim_{\varepsilon\to 2\overline{\theta}}\left[\frac{g(\varepsilon)}{1-G(\varepsilon)}\right]>\frac{1}{\overline{U}+c(a_i^*)-\underline{s}},$$

then the following promotion-based incentive scheme

$$s_i(x_i-x_j;\ k=0,\ B,\ D)=\begin{cases}\underline{s}+B & \text{when } x_i-x_j\geq D\\ \underline{s} & \text{otherwise,}\end{cases} \tag{14}$$

achieves social efficiency even when $W=\overline{U}+c(a_i^*)-1/\{2g(0)\}<\underline{s}$ as in (13).

Proof: For simplicity, we assume that θ_i, $i=1, 2$, has a symmetric density with mean zero on a given interval, $[-\overline{\theta}, \overline{\theta}]$. It is easy to see that $s_i\,(x_i - x_j;\ k=0,\ B,\ D) \geq \underline{s}$ for all $(x_i,\ x_j)$ if $B \geq 0$. Now, the probability that agent i wins the prize money B is:

$$\begin{aligned}\Pr[x_i \geq x_j + D] &= \Pr[\theta_j - \theta_i \leq A(a_i,\ e) - A(a_j,\ e) - D] \\ &= \Pr[\varepsilon \leq A(a_i,\ e) - A(a_j,\ e) - D] \\ &= G(A(a_i,\ e) - A(a_j,\ e) - D).\end{aligned}$$

Since both agents are identical, $a_i = a_j$ in equilibrium. Thus, in order for $s_i(x_i - x_j;\ k=0,\ B,\ D)$ to achieve the social efficiency, $(a_i^*,\ a_j^*,\ e^*)$, agent i's participation constraint is

$$B = \frac{\overline{U} + c(a_i^*) - \underline{s}}{G(-D)}, \tag{15}$$

and the incentive compatibility constraint, assuming an interior solution, reduces to

$$B = \frac{1}{g(-D)}. \tag{16}$$

Accordingly, showing that $s_i(x_i - x_j;\ k=0,\ B,\ D)$ achieves social efficiency is equivalent to showing the existence of $(B^*,\ D^*) \gg 0$ in the space of $(B,\ D)$ which satisfies both (15) and (16). Note that $\varepsilon \equiv \theta_j - \theta_i$ is symmetrically distributed between $-2\overline{\theta}$ and $2\overline{\theta}$. When D approaches 0,[15] B in equation (15) becomes

$$B_{(15)} = \frac{\overline{U} + c(a_i^*) - \underline{s}}{G(0)} = 2(\overline{U} + c(a_i^*) - \underline{s}),$$

and B in equation (16) becomes

$$B_{(16)} = \frac{1}{g(0)}.$$

From (13), we obtain

$$B_{(15)} < B_{(16)} \quad \text{when} \quad D \to 0.$$

Thus, for the existence of $(B^*,\ D^*) \gg 0$ satisfying equations (15) and (16), it is enough to show that B in equation (15) is greater than B in equation (16) when $D \to 2\overline{\theta}$. In other words,

$$B_{(15)} = \frac{\overline{U} + c(a_i^*) - \underline{s}}{G(-D)} > B_{(16)} = \frac{1}{g(-D)} \text{ when } D \to 2\theta. \tag{17}$$

[15]Note that we are only considering the solution $(B^*,\ D^*) \gg 0$.

Since $g(\cdot)$ is symmetric, when D approaches $2\overline{\theta}$, (17) becomes

$$\lim_{\varepsilon \to 2\overline{\theta}} \left[\frac{g(\varepsilon)}{1-G(\varepsilon)} \right] > \frac{1}{\overline{U}+c(a_i^*)-\underline{s}}. \tag{18}$$

Thus, (18) is a sufficient condition for guaranteeing the existence of $(B^*, D^*) \gg 0$, which induces each agent to participate and make his first-best effort. The term in square brackets in (18) is known as a "hazard rate". If we assume the "hazard-rate" to be increasing in ε, as in most of the literature, then (18) can generally be satisfied.

Moreover, this incentive scheme also gives full incentive to the principal. Since each agent's probability of winning the prize depends not only on his performance but also on his competitor's performance, and also since the principal's effort input commonly affects both agents' performances, the principal, by changing his effort, cannot effectively lower any agent's probability of winning. This implies that the principal cannot strategically distort his effort to reduce the total payment to the agents. Thus, the principal is also provided with full incentive to make a first-best effort.

Q.E.D.

The incentive scheme $s_i(x_i - x_j;\ k=0,\ B,\ D)$ is a simple variant of the promotion-based incentive scheme, which gives a promotion to a winner only when the winner's performance margin is greater than D. By adjusting the winner's targeting margin D, the principal can successfully overcome the agents' limited liability problems even when they are serious, which is technically intuitive.[16]

Note that B is increasing in D in both equations (15) and (16), but B is decreasing in the seriousness of the agent's limited liability, $\underline{s}$, while it is independent of $\underline{s}$ in (16). Hence, one can easily verify that the optimal B^* and D^* are increasing in $\underline{s}$. This implies that if the agents' limited liabilities are becoming more serious (higher $\underline{s}$), then the principal can cope with each agent's limited liability problem by increasing the targeting margin as well as the value of promotion.

[16]Technically speaking, introducing D into the contract is equivalent to giving one more design variable to the principal in designing the contract.

***Corollary* 1**

If

$$\lim_{\varepsilon \to 2\overline{\theta}} \left[\frac{g(\varepsilon)}{1-G(\varepsilon)} \right] < \frac{1}{\overline{U}+c(a_i^*)-\underline{s}},$$

then no relative performance scheme exists which achieves social efficiency in the presence of the agents' limited liabilities such as $s_i(x_i, x_j) \geq \underline{s}$ for all (x_i, x_j).

Proof: See Appendix *B*.

Consequently, Propositions 2 and 3, together with Corollary 1, indicate that the promotion-based incentive scheme which has the seemingly lowest pay-performance sensitivity is the most efficient form of contract that the principal can design when the agents' limited liabilities must be taken into account.

V. Discussion

As mentioned in the introduction, one puzzling phenomenon associated with different contractual forms in different arrangements is that 'low-powered' incentive contracts are more common within firms, whereas 'high-powered' incentive contracts are more common in market arrangements. Williamson (1985) argued that the use of high-powered incentives in firms would give rise to undesirable side problems such as inefficient asset utilization of employees and accounting manipulation of employers, whereas the use of low-powered incentives coupled with periodic auditing in markets would incur inefficient interfirm auditing. As a result, low-powered incentives plus intrafirm auditing were favored within firms and high-powered incentives were favored in market arrangements.

Later, Williamson's idea was systematically developed by Holmstrom and Milgrom (1991) in their multitask model. They showed that a fixed salary scheme could be more desirable than any explicit incentive contract if the agent was to perform several tasks and if his performance measures were correlated with only a subset of those tasks. According to their argument, given that no ownership is shared among the workers in firms, low-powered incentive contracts in firms are due to the presence of the workers' tasks (e.g. careful maintenance of the machinery) which are important but would not be motivated by high-powered incentives based on such performance measures.[17]

On the other hand, Baker (1992) showed that low-powered incentive schemes in a firm might arise when the performance measures which would be used to motivate the workers were weakly correlated with the firm's true objectives. If the performance measures are 'bad' in this sense and if the wage contracts are highly sensitive to those measures, then the workers will capitalize on the performance measures for their own interests rather than try to achieve the firm's true objectives. Therefore, to reduce such gaming incentives of the workers, the wage contract should also be weakly tied to the performance measures.

One common theme in these arguments is that, to explain firms' intensive use of low-powered incentives, they focused on the reasons why the firms wanted to *reduce* the workers' incentives in a particular dimension but to increase their incentives in a different dimension. However, it is generally true that, although most firms design fixed salary schemes for their workers, they also introduce other incentive devices to the workers such as 'promotion opportunities'.[18] Baker, Jensen and Murphy (1988) noted,

> "Promotions are used as the primary incentive device in most organizations, including corporations, partnerships, and universities. The empirical importance of promotion-based incentives, combined with virtual absence of pay-for-performance compensation policies suggests that providing incentives through promotion opportunities must be less costly or more effective than providing incentives through transitory financial bonuses."

Therefore, the rationale for the use of low-powered incentives in firms should not originate from the firms' interests in reducing their workers' incentives, but from their interests in designing promotion-based contracts rather than other contracts.

As we showed earlier, there is a group of relative performance schemes which achieve a socially efficient outcome in our simple firmlike principal-agent model. They differ in their pay-for-performance sensitivity, ranging from a high-powered pricelike relative

[17]Their result is strongly based on the assumption that the workers do not have an incentive problem in extending their total efforts but have an incentive problem in allocating given efforts into various tasks.

[18]Also, Baker, Gibbs and Holmstrom (1993) empirically show that promotions are a major source of reward for the workers in firms.

contract to a promotion-based contract. As a result, to explain the puzzling phenomenon, we should clarify the benefits that the promotion-based incentive schemes have in firms, which other relative incentive schemes do not have.

Lazear and Rosen (1981) show in a standard single moral-hazard framework that, when an agent is risk-neutral, the promotion-based incentive scheme can achieve a socially efficient outcome which can also be obtained by other individualistic contracts such as a piece-rate linear scheme or a standard bonus scheme. They informally argue that the dominance of the promotion-based incentive scheme over the piece-rate linear scheme and the standard bonus scheme arises from the fact that obtaining ordinal measures generally requires less resources than obtaining cardinal measures.

Green and Stokey (1983) and Nalebuff and Stiglitz (1983) show also in the single moral-hazard framework that the promotion-based incentive scheme may dominate such a piece-rate incentive scheme and a standard bonus scheme when the agents are risk-averse and there are shocks which are common to all the agents. Obviously, the promotion-based incentive scheme, by filtering out common randomness, can reduce the risk that would otherwise be imposed on the agents.

However, their comparisons were not related to the dominance of a promotion-based incentive scheme over other relative performance schemes but addressed its dominance over some absolute performance schemes, which is a trivial outcome in our firmlike principal-agent model. Furthermore, any relative performance scheme can effectively filter out the common randomness.[19] Therefore, their arguments cannot offer a complete explanation of why promotion-based incentive schemes are often designed for workers in firms, while other contractual forms with high pay-performance sensitivity are designed in market arrangements.

In the previous section, we have shown that the high-powered pricelike relative incentive scheme is the most efficient when the agents have some private information, while the promotion-based incentive scheme is the most efficient when the agents' limited liability constraints are serious.

Although we only present the agents' private information as a reason for the dominance of pricelike relative incentive scheme over

[19]See Holmstrom (1982).

other first-best relative performance schemes, it is robust in various environments (e.g. heterogeneous agents) since it is basically a linear contract. Thus, there may be several other reasons why pricelike incentives are common in market arrangements. One thing to note here is that unfortunately we do not know yet whether real world contracts in market arrangements are of a relative type or not. However, our result indicates that, at least in the relationships between manufacturers and their independent retailers which very much resemble our simple firmlike principal-agent model, relative performance contracts should be designed. Thus, if the real world contracts among them are not of a relative type, it would be interesting to find out why this is the case.[20] However, this is beyond the scope of this paper.

On the other hand, it is true that the workers in firms face more serious limited liability constraints than independent economic agents in markets such as franchisees. Generally, measuring an individual worker's true performance in team production is hardly feasible. Most workers in team production are interrelated with each other by affecting and being affected by others' behaviors. Furthermore, either the firm's total profits or the branch's profits which are relatively easy to observe are too fluctuating to be imposed on a single worker's hand. Therefore, most firms, by investing a limited amount of resources into auditing, generally design the workers' incentive schemes based on measures which are only approximately reflecting each worker's individual contribution to the firm.

In the previous section, we have shown that whether an individual agent's limited liability constraint is binding or not, when a certain contract is designed, largely depends on the distance between the best and worst possible performances, $\overline{x}-\underline{x}$. This distance will be enlarged as the performance measure gets less accurate. Let $y_i = x_i + \varepsilon_i$, where y_i is agent i's measured performance, and $x_i \equiv A(a_i, e) + \theta_i$ is his true performance. Thus, $\varepsilon_i \in [\underline{\varepsilon}, \overline{\varepsilon}]$ denotes the principal's measurement error. The magnitude of measurement error can be captured by $\overline{\varepsilon}-\underline{\varepsilon}$. The less accurately the performance measure represents the true performance, i.e. the bigger $\overline{\varepsilon}-\underline{\varepsilon}$ is,

[20]Most of the franchise contract literature implicitly assumes that the franchise contracts are of an absolute type. See Bhattacharyya and Lafontaine (1995).

the more likely $s_i(y_i - y_j;\ k,\ B)$ with $k>0$ violates the agent's limited liability constraint. Consequently, it is more likely that a promotion-based incentive scheme is designed.

VI. Conclusion

In this paper, we introduce an alternative way of analyzing internal incentive structures in organizations which cannot be well explained by the standard agency model. One of the typical assumptions which has been adopted by the standard principal-agent model is that the principal does not participate in the agent's production process. Thus, a firm is treated as a 'black box' which is summarized by a stochastic production function provided for a single representative agent. However, most principal-agent relationships within real organizations are double-sided in the sense that the principals also participate in the agents' production processes.

This paper analyzes the characteristics of incentive contracts which will emerge in this bilateral situation. First, a group of first-best relative incentive contracts are derived in a simple setting. Then, by relaxing some simplifying assumptions, we show that the pricelike relative contract is most efficient when agents have private information, but the promotion-based contract is most efficient when agents bear only limited liabilities.

In the pricelike relative contract, a particular agent's final compensation continuously depends on the distance between his absolute performance and his co-worker's performance. Thus, it will be observed as 'high-powered'. However, the promotion-based contract will be observed as 'low-powered', once one focuses on fixed salaries while overlooking 'promotion opportunities'. Therefore, this paper answers the question of why 'high-powered' incentive contracts are more common in market arrangements, while 'low-powered' incentive contracts are more common in firms.

To derive the main result, we have made two strong assumptions. The first assumption is that all the agents are risk-neutral. In much of the principal-agent literature, the agents have been assumed risk-averse. Thus, the principal's design of an incentive contract has been thought of as his optimal balancing between incentive provision and risk-sharing. There, the principal's own incentive problem has been assumed away. What we have assumed away in this paper, however, is the risk-sharing aspect between the principal and the agents in order to exclusively focus on the effect of the principal's incentive problem on the characteristics of the incentive contract.

The second and probably more crucial assumption we have made in this paper is that each agent's performance measures, no matter how vague they are, are not contaminated by other agents' actions. However, in team production, each agent's performance measures, if any, are also affected by his co-workers' action choices. He needs other workers' cooperation to achieve a good performance, and also is vulnerable to other workers' possible sabotage activities. The principal might not be able to achieve the social efficiency by designing relative performance schemes in this case, since competition among the agents will produce some adverse effects. Thus, incorporating these aspects into the model may provide a better understanding of internal incentive structures.

Appendix

Appendix A

Let a_i^0 be agent i's optimal action choice when θ_i^0 is realized. Thus, from (8), it should satisfy

$$\{k + Bh[A(a_i^0,\ e^*) + \theta_i^0]\}A_a(a_i^0,\ e^*) = c'(a_i^0).$$

Likewise, let a_i^1 be agent i's optimal action choice when θ_1 is realized. Thus, it should satisfy

$$\{k + Bh[A(a_i^1,\ e^*) + \theta_i^1]\}A_a(a_i^1,\ e^*) = c'(a_i^1).$$

Let a_i' be such that

$$A(a_i^0,\ e^*) + \theta_i^0 = A(a_i',\ e^*) + \theta_i^1.$$

Then, since $a_i' < a_i^0$,

$$\begin{aligned}\{k + Bh[A(a_i',\ e^*) + \theta_i^1]\}A_a(a_i',\ e^*) &> \{k + Bh[A(a_i^0,\ e^*) + \theta_i^0]\}A_a(a_i^0,\ e^*)\\ &= c'(a_i^0)\\ &> c'(a_i').\end{aligned}$$

Accordingly, a_i^1 should be greater than a_i', and

$$A(a_i^0,\ e^*) + \theta_i^0 = A(a_i',\ e^*) + \theta_i^1 < A(a_i^1,\ e^*) + \theta_i^1.$$

Therefore, $A(a_i^*(\theta_i),\ e^*) + \theta_i$ is increasing in θ_i.

Appendix B:[21] *Proof of Corollary* 1

Contrarily assume that there exists a relative performance scheme $s_i^0(x_i - x_j)$, $i=1,\ 2$, which make agent i participate and take his efficient effort a_i^*. Then, there always exists a promotion-based contract, $s_i(x_i - x_j;\ k=0,\ B^0,\ D^0)$ such that

$$s_i(x_i - x_j;\ k=0,\ B^0,\ D^0) > s_i^0(x_i - x_j),\ \text{when } x_i - x_j \geq D^0,$$

$$s_i(x_i - x_j;\ k=0,\ B^0,\ D^0) < s_i^0(x_i - x_j),\ \text{when } x_i - x_j < D^0,$$

and guarantees each agent the reservation level of utility, $\overline{U}$. Thus, $s_i(x_i - x_j;\ k=0,\ B^0,\ D^0)$, $i=1,\ 2$, makes the agents participate but expend an effort level which is greater than a_i^*(See Innes 1990). In this case, we can find another promotion-based incentive scheme, $s_i(x_i - x_j;\ k=0,\ B^1,\ D^1)$ with $(B^1,\ D^1) \ll (B^0,\ D^0)$, which makes the agents participate and take a_i^*. However, this is a contradiction according to Proposition 3.

Q.E.D.

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[21]This is a sketch of the proof. A detailed proof is available from the author upon request.

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