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SOCIAL RELATIONS AND INCENTIVE CONTRACTS *

by Hideshi ITOH**

I Introduction

A firm is a human organization. The employer makes implicit or explicit employment contracts with workers. Based on the earlier work by Coase (1937) and Simon (1951), recent economic literature considers the employment relation as one of the most fundamental constituents of the firm, and analyzes various aspects of that relationship extensively. (See Hart and Holmström (1987) for a survey of agency theory and labor contracts, Williamson (1975, 1985) for transaction cost economics, and Kreps (1990) for an example of other theories of the firm.)

Given employment contracts and other aspects of formal organization structures, however, workers are engaged in various kinds of direct interpersonal activities with co-workers. Some actions are directly productive: workers may provide various kinds of help for co-workers, or they may behave uncooperatively each other to reduce co-workers' productivity. There exist psychologically oriented interactions as well: workers may spend resources to reduce co-workers' disutility on jobs, for example, by showing respects, cheering them up, listening to their complaints, and so on. Such "social" relationship among workers has long been an important subject of sociologists studying organizations since the Human Relations School (Roethlisberger and Dickson, 1939; Mayo, 1945).[1] Recently, sociologists Baron (1988) and Granovetter (1985) review economic literature on organizations critically to point out its under-emphasis on social relations.

In this paper, we introduce a simple model of the relationship between a firm and workers which incorporates some aspects of nonproductive social relations among workers mentioned above, and examine their implications on work incentives and wage contracts.[2] The model is a variant of standard agency models with moral hazard (which Arrow (1985) renamed hidden

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* This is a revised version of section 4 of an unpublished paper entitled "Worker Collusion and Organization Design: Effects of Interpersonal Interaction," December 1988. Much of the research was conducted while the author was visiting Graduate School of International Relations and Pacific Studies at University of California, San Diego.

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1) See also standard textbooks such as Perrow (1986) and Scott (1987) for other references, evaluations, and criticism.

2) Interactions through production externalities such as "helping" or "sabotage" are analyzed in Drago and Turnbull (1988), Itoh (1991), and Lazear (1989).

action): Workers take unobservable actions given wage contracts, while they possess no precontractual private information. More specifically, consider the following standard setting of the relationship between a risk neutral principal (a firm) and risk averse agents (workers). The firm assigns each worker to a well-defined job and selects a wage scheme to him. Given his contract with the firm, each worker exerts a level of effort. The outcome of his job depends on his effort and some noise term. Noise terms are assumed to be independent across jobs. Outcomes are publicly observable while the level of effort chosen is not, so that wage schedule for each worker can depend only on outcomes. Because of no externality of effort and the assumption of stochastic independence across jobs, relative performance evaluation does not give a reason for the wage scheme for a worker to depend on outcomes of other workers' jobs. (See, for example, Holmström (1982) and Mookherjee (1984).) Suppose that the von Neumann–Morgenstern utility function of a worker is additively separable to utility on income and disutility of effort : workers are assumed to be effort averse.

We introduce into this standard model nonproductive interpersonal activities which we call *socialization.* Each worker chooses, besides his effort, a level of socialization, which is publicly unobservable. For example, this level can be interpreted as the length of time spent for socializing with his co-workers. A worker's level of socialization with another worker enters into only the disutility terms of *both* workers, and thereby affects the productivity of neither worker. An increase in a worker's socialization reduces a level of disutility of his co-worker, while it increases the former worker's disutility for *sufficiently high levels of socialization.* However, *for small levels of socialization,* a worker may be indifferent in his socialization level or may derive some "social pleasure" from socializing so that his disutility may be decreasing in his socialization level. (We call such a worker a socializing type.) We show that when workers reach a Nash equilibrium of effort and socialization, the equilibrium levels of socialization are inffficient : they under-socialize in equilibrium. Since this proposition is not associated with the risk attitude of workers at all, it implies that whether or not workers are risk neutral, the firm cannot attain the first-best solution (which is the solution under perfect information) when nonproductive interpersonal activities exist. This contrasts with standard agency models in which the first-best solution is attained when agents are risk neutral.

Note that the existence of such externalities does not alter the optimality of independent contracts : Since socialization does not affect the probability distribution of the outcome of either job, the optimal wage scheme for a worker is still contingent on the outcome of his job only. Interdependent wages merely impose additional risks on workers.

As a control devise for workers' socializing activities, we consider a policy called *isolation.* We assume that the firm can enforce zero socialization with no additional costs. Separating workers physically is one obvious way of implementing this policy. Even in the situation where workers work together or they share the same work floor or room, it is relatively easy to find whether workers socialize or not (provided that their jobs do not require productivity-enhancing discussion as in our model). We show that if workers have no social pleasure, isolation is never preferred by the firm, under the assumption that the relation between each worker's effort and socialization *received* involves complementarity : the higher socialization he receives from his co–

worker, the smaller his marginal disutility of effort is. Stimulating social relations among workers is thus profitable to the firm because of the incentive effect that the cost of inducing them to work hard is reduced, as long as workers are not of socializing type.

We then present two cases where the firm prefers isolation, both of which contain the condition that workers, when exerting appropriate work intensity, have little incentive to socialize. Then the firm prefers isolation if either there is a worker of socializing type (who has social preasure) or each woker selects his socialization contingent on the observation of his co-worker's effort level. The reason is that without the control of socializing activities, it is more costly to induce workers to work appropriately. Each worker, when he shirks, has an incentive to increase his socialization under no control, which reduces his own disutility of effort further when he has social pleasure. Similarly, in the case of mutually observable effort, each worker receives higher socialization by shirking, so that his disutility decreases more under no control than under isolation. An observed practice of supervising workers closely to prevent them from chatting in busy working hours is indeed better from the incentive points of view than no such control.

Much of the recent literature on principal/multiple agents relationships focuses on the collusion problem associated with the multiplicity of Nash equilibrium (Demski and Sappington, 1984; Ma, 1988; Ma, Moore and Turnbull, 1989; Mookherjee, 1984; Mookherjee and Reichelstein, 1990). The same problem arises in our model exactly because of the existence of socializing activities. Given the optimal contracts, there may exist another equilibrium that both workers prefer to the one the firm wants to implement. When workers' effort is mutually unobservable before socializing, this problem does not arise as long as they have no social pleasure. We show, however, that workers of socializing type will find a Pareto superior equilibrium in which both shirk, if the effect of receiving more socialization from co-workers is sufficiently low. When effort levels are mutually observable and workers' socializing activities are contingent on the observation of effort, the problem turns out to be more serious : We always find another (Pareto superior) equilibrium in which at least one of the workers shirks. These problems under no control of socializing activities may lead the firm to the adoption of isolation beyond the restrictive conditions given above.

We also discuss collusive choice of socialization by workers. (See Tirole (1986, 1988) for related discussion.) When workers select their socialization levels to maximize their total welfare, they usually engage in higher levels of socialization than when they behave noncooperatively. However, this does not necessarily lead to the conclusion that the firm prefers workers to collude than not. The reason is that the net effect of such collusive choice of socialization on incentive compatibility constraints is ambiguous : each worker enjoyably receives higher socialization while his socialization level is too high from the firm's points of view. This implies, however, that if workers are risk neutral, collusion in socializing activities enables the principal to attain the first-best outcome by paying the whole marginal benefits to them.

The rest of the paper is organized as follows. Section 2 introduces the model and presents the under-socialization result. Section 3 examines the incentive effects of socialization and obtains results concerning the comparison between isolation and no control of socializing activities. Section 4 focuses on collusion problems. Section 5 summarizes the results.

II The Model of "Human Relations" through Socialization

In this section, we present the simple model of the relationship between a firm and two workers with nonproductive interpersonal activities. Extensions to the case of more than two workers are straightforward. The model is based on standard agency models with moral hazard, in particular, the formulation by Grossman and Hart (1983) and its extension to multi-agent situations by Mookherjee (1984).

The firm has two jobs and two workers indexed by $n=1, 2$, and assigns worker n to job n. Worker n selects an effort level a_n from a compact set of feasible effort levels. Effort a_n is expended only on his job n. The output x^n from job n depends on worker n's effort a_n and a noise term through some production function. To focus on nonproductive interactions between workers, we assume that there is no production externality such as "helping" or "sabotage." In addition, we assume for simplicity that the noise terms are stochastically independent. Suppose that x^n takes one of the M_n possible values $x_1^n < \dots < x_{Mn}^n$. For each outcome $i \in I_n = \{1, \dots, M_n\}$, let $P_i^n(a_n)$ be the probability of $x^n = x_i^n$ induced by the production function and the probability distribution of the noise term.

Worker n also selects a level of socialization s_n from a compact set S_n. Socialization does not affect the probability distribution on outcomes of jobs, while it comes into workers' utility functions. We assume that worker n has a von Neumann–Morgenstern utility function of an additively separable form, denoted by $V^n(w) - G^n(a_n, s_n \mid s_k)$, where w is the wage paid to him, and $k \neq n$.[3] Workers are assumed to prefer higher wages and to be (weakly) risk averse : V^n is strictly increasing and concave. The main feature of the model is that workers' utility is affected by their socializing activities. We will later introduce several assumptions on G^n.

The firm behaves as a Stackelberg leader to select a wage schedule for each worker. Workers then select effort and socialization levels simultaneously. We assume that both effort and socialization levels are publicly unobservable while realized outputs from each job are publicly observable. Wage schedules hence generally depend on the outcomes of two jobs. However, since there is no production externality and outputs are stochastically independent across jobs, we can restrict our attention to *independent* wage schemes : each worker is paid contingent on the outcome of his job only. The existence of nonproductive interpersonal activities does not alter the well-known result in the literature of relative performance evaluation (Holmström, 1982 ; Mookherjee, 1984). That is, given wage schedules which induce workers to select some effort levels and pay each worker depending on the outcomes of both jobs, the firm can find new wage schedules which are independent, implement the same effort levels, and improve risk sharing. Let w_i^n be the wage paid to worker n when $x^n = x_i^n$, and let $U^n(w^n, \cdot)$ be the expected utility of worker n, given his wage scheme $w^n = (w_i^n)\, i \in I_n$. It is given as

3) Whenever k and n appear together, assume $k \neq n$.

$$U^n(w^n, a_n, s_n \mid s_k) = \sum_i P_i^n(a_n) V^n(w_i^n) - G^n(a_n, s_n \mid s_k).$$

The firm is assumed to be risk neutral : The objective of the firm is to find wage schedules which maximize the expected net profits. Let B_{ij} be the benefits from output pair (x_i^1, x_j^2) and $B(a_1, a_2) = \Sigma_i \Sigma_j P_i^1(a_1) P_j^2(a_2) B_{ij}$ be the expected benefits. B_{ij} is assumed to be strictly increasing in i and j. Then the expected net profits of the firm are given by

$$B(a_1, a_2) - (\sum_i P_i^1(a_1) w_i^1 + \sum_j P_j^2(a_2) w_j^2).$$

Grossman and Hart (1983) introduced a useful decomposition of the firm's optimization problem as follows : First fix an effort pair (a_1, a_2), and find wage schedules which implement it with least costs. This problem is called the *implementation problem* for (a_1, a_2). The solution to this problem yields the *optimal* expected payments to workers for each effort pair. Once the implementation problem is solved for each (a_1, a_2), the remaining problem is to find the effort pair which maximizes the firm's expected benefits minus the optimal expected wage payments.

In this paper, we also employ the Grossman–Hart decomposition. Different from effort levels, however, the firm cannot directly control socialization levels through designing wage schemes contingent on outcomes : Th firm selects wage schedules only to implement a particular effort pair, taking into consideration the effects of workers' interaction through socialization on their choice of effort. The current paper focuses on how the firm can affect workers' choice of socialization levels in order to reduce the cost of implementing a particular effort pair. We hence assume for simplicity that each worker has two feasible effort levels h and l where h represents a "high" level of effort or "working hard," and l represents a "low" level or "being-lazy." We assume that for each n, the expected benefits under (h, h) are sufficiently higher than those under the other combinations of effort. Thus, it is sufficient to examine the firm's implementation problem for (h, h) in subsequent analysis.[4)]

Before presenting the formal definition of the firm's problem, we introduce several notations and assumptions. First, we adopt the following standard assumptions on $P_i^n(h)$ and $P_i^n(l)$. The first assumption is the stochastic dominance condition : higher effort leads to higher output in the sense of the first–order stochastic dominance. The second assumption is the no moving support condition.

ASSUMPTION 0. *For each n,* (i) $\Sigma_{i=1}^j P_i^n(h) \leq \Sigma_{i=1}^j P_i^n(l)$ *for all $j \in I_n$ with strict inequality for some j; and* (ii) $P_i^n(a) > 0$ *for each i and $a = h, l$.*

For simplicity, we assume s_n to be a scalar and let the set of feasible socialization levels S_n be an interval $[0, \bar{s}_n]$ with $\bar{s}_n > 0$: We normalize the minimum feasible socialization level to zero, representing "no socializing at all." A natural interpretation might be that s_n is the length of time worker n spends for socializing with his co–worker. However, since we do not assume that

4) Extension to more than two feasible effort levels does not alter the results of the paper if the concern of the firm is to prevent workers from shirking "downward," that is, reducing their effort.

the socialization level chosen by a worker must be equal to that chosen by the other worker, it is more appropriate to regard s_n as the "intensity" with which worker n socializes. Let $G_h^n(s_n, s_k) = G^n(h, s_n \mid s_k)$ and $G_l^n(s_n, s_k) = G^n(l, s_n \mid s_k)$. Since workers are effort averse, we have the following assumption.

ASSUMPTION 1. *For each n, $G_h^n(s_n, s_k) > G_l^n(s_n, s_k)$ for all (s_n, s_k).*

We next assume that each worker's disutility of effort decreases at a decreasing rate as a level of socialization from his co–worker increases. Each worker prefers receiving higher socialization from his co–worker, *ceteris paribus.*

ASSUMPTION 2. *For each n and s_n, $G_h^n(s_n, s_k)$ and $G_l^n(s_n, s_k)$ are strictly decreasing and convex in s_k.*

Are workers unwilling to increase socialization for co–workers? I believe that this is true for sufficiently high levels of socialization. For low levels of socialization, however, a worker's increasing his socialization level may not raise his disutility: He may be indifferent in his socialization level or he may be of socializing type, deriving some "social pleasure" from reducing his co–worker's disutility. Thus, we state the following two assumptions separately: the assumption of no social pleasure that the disutility of a worker is nondecreasing in his socialization; and the assumption of social pleasure that an increase in a worker's socialization level *reduces* his disutility of effort at a decreasing rate for small socialization levels. The results in this section, however, hold under either assumption.

ASSUMPTION 3a. (Worker n has no social pleasure.) *For each s_k, $G_h^n(s_n, s_k)$ and $G_l^n(s_n, s_k)$ are nondecreasing in s_n.*

ASSUMPTION 3b. (Worker n has social pleasure.) *There exist $s \in (0, \bar{s}_n)$, $s_k \in S_k$, and $a \in \{l, h\}$ such that $G_a^n(s_n, s_k)$ is strictly decreasing and convex in $s_n \in (0, s)$.*

Whether or not social pleasure exists, we assume that for sufficiently high levels of socialization, workers dislike giving more socialization to co–workers. In addition, we assume that the disutility increases at an increasing rate for such socialization levels.

ASSUMPTION 4. *For each n and s_k, there exist s' and s'' in $(0, \bar{s}_n)$ such that $G_h^n(s_n, s_k)$ is strictly increasing and strictly convex in $s_n > s'$ and $G_l^n(s_n, s_k)$ is strictly increasing and strictly convex in $s_n > s''$.*

We draw typical graphs of the disutility function without and with social pleasure in Figures 1a and 1b, respectively.

We next assume that both G_h^n and G_l^n are continuously differentiable in their arguments and

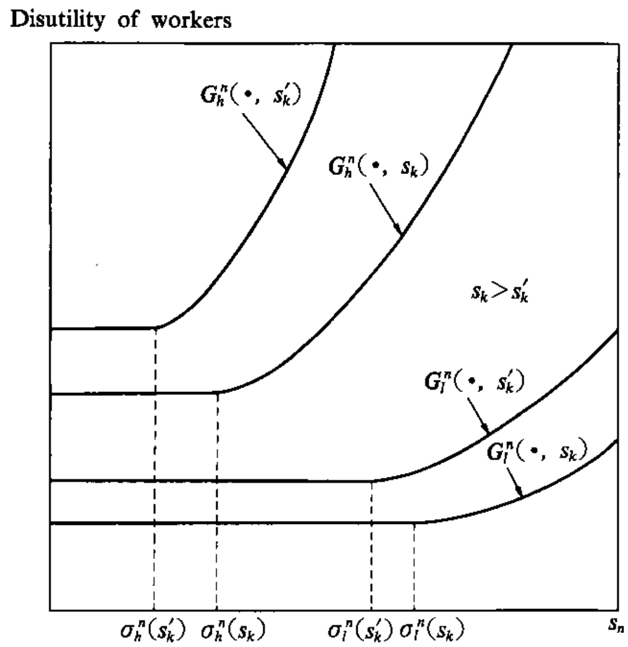

FIGURE 1a.

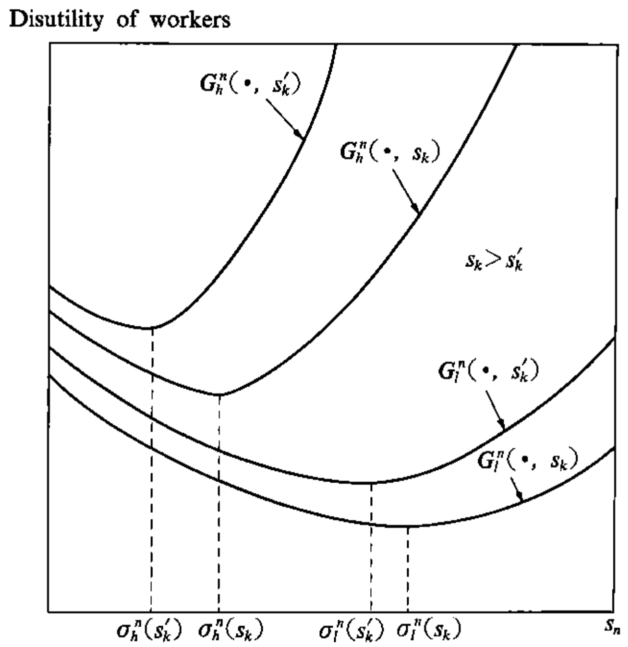

FIGURE 1b.

define

$$\sigma_h^n(s_k) = \max\{s \in S_n \mid s \in \operatorname*{argmin}_{s'} G_h^n(s', s_k)\}$$

$$\sigma_l^n(s_k) = \max\{s \in S_n \mid s \in \operatorname*{argmin}_{s'} G_l^n(s', s_k)\}$$

These functions are well defined and continuous. The definition implies that $\sigma_a^n(s_k)$ is worker n's best response to socialization s_k from his co–worker when the former worker's effort level is $a = h, l$. When several values are possible, we assume that a worker chooses the highest level of socialization that minimizes the disutility of the other worker over the set of the best responses. Let $s_{ab}^n(a, b = h, l)$ be worker n's Nash equilibrium socialization defined by $s_{ab}^n = \sigma_a^n(s_{ba}^k)$ when his effort level is a and his co–worker k's level is b. For simplicity, we assume that s_{ab}^n is unique and strictly positive for each (a, b).

Let $v_i^n = V^n(w_i^n)$. Following Grossman and Hart, we regard v_i^n rather than w_i^n as the firm's choice variables. Also let ϕ^n be the inverse function of V^n and $\overline{U}^n$ be worker n's reservation utility level. Then the firm's (implementation) problem (FP) is formally stated as follows.

$$\min_{v^1, v^2} \sum_i P_i^1(h)\phi^1(v_i^1) + \sum_j P_j^2(h)\phi^2(v_j^2)$$

subject to, for each $n = 1, 2$,

(FP)

(NIC) $\sum_i P_i^n(h) v_i^n - G_h^n(s_{hh}^n, s_{hh}^k) \geq \sum_i P_i^n(l) v_i^n - G_l^n(\sigma_l^n(s_{hh}^k), s_{hh}^k)$;

(PC) $\sum_i P_i^n(h) v_i^n - G_h^n(s_{hh}^n, s_{hh}^k) \geq \overline{U}^n$.

The firm selects wage schedules (v^1, v^2) to minimize its expected payments under the two constraints. The first one is the *Nash incentive compatibility constraint*: Given worker k's choice of effort and socialization levels (h, s_{hh}^k), worker n has no incentive to deviate from (h, s_{hh}^n). The second constraint, called the *participation constraint*, states that the expected utility of each worker must be at least as high as his reservation level.

PROPOSITION 1. *Under the assumptions stated above, the equilibrium socialization levels are inefficient.*

To see this, note that G_h^n is smooth and convex in its arguments. Thus, at the equilibrium $(s_1, s_2) = (s_{hh}^1, s_{hh}^2)$, the partial derivative of G_h^n with regard to s_n is zero. The marginal increase from s_{hh}^1 hence does not raise worker 1's disutility while it strictly decreases his co–worker's disutility of work. This is true for worker 2 as well. Workers therefore could have achieved lower disutility levels by simultaneously increasing their socialization levels.[5] This under–socialization is likely to be costly to the firm as well. If workers' disutility levels were lower, the expected payments in utility units which implement a given effort pair would also be lower.

In particular, this implies that the first–best solution (which is the solution when the firm

5) The other equilibrium socialization levels s_{hl}^n, s_{lh}^n, s_{ll}^n are also inefficient.

can monitor each agent's choice of effort and socialization levels perfectly) cannot be achieved even when workers are risk neutral. This is in contrast with the standard models of principal–agent relationships without precontractual private information, in which the principal can attain the first–best outcome by paying the whole marginal benefits to each agent.

The first–best solution is defined as follows. Suppose that effort and socialization levels are publicly observable, and define for $a=h, l$,

$$C^n_{FB}(a, s_n, s_k)=\phi^n(\overline{U}^n+G^n_a(s_n, s_k)).$$

Then the firm can implement $(h, s_n)_{n=1,2}$ by paying the fixed wage $C^n_{FB}(h, s_n, s_k)$ to worker n if workers choose the specific effort and socialization levels, and by paying a sufficiently small wage otherwise.[6] Let (s_1^*, s_2^*) be the first–best socialization. Since we have assumed that (h, h) is the first–best effort,

$$(h, s_n^*)_{n=1,2}\in \operatorname*{argmax}_{a_1, a_2, s_1, s_2} B(a_1, a_2)-C^1_{FB}(a_1, s_1, s_2)-C^2_{FB}(a_2, s_2, s_1).$$

In particular, the first–best social transfers (s_1^*, s_2^*) solve

$$\min_{s_1, s_2} C^1_{FB}(h, s_1, s_2)+C^2_{FB}(h, s_2, s_1).$$

When workers are risk neutral, this is equivalent to minimizing a weighted sum of G^1_h and G^2_h, which yields a Pareto efficient socialization pair. Thus, by Proposition 1, paying the whole marginal benefits to each worker does not resolve the incentive problem : inefficient socialization activities make the implementation of high effort more costly than the first–best costs. In particular, if workers have symmetric preferences, then the solution $s^*=s_1^*=s_2^*$ minimizes $G_h(s, s)=G^1_h(s, s)=G^2_h(s, s)$, so that we have $s^*>s^n_{hh}$ for $n=1, 2$: The first–best socialization level of each worker is higher than the equilibrium level.

III Incentive Effects of Isolating Workers

One might think that the under–socialization result in the previous section would motivate the firm to control workers' socializing activities through some instruments such that they *increase* their socialization levels. The problem is not so obvious, however, since we have not yet examined the effect of socialization on workers' incentives to exert effort, to which we turn in this section. In fact, we show that there are cases in which the firm prefers forcing workers not to socialize at all. We call such a policy *isolation.*

The term isolation represents the supposition that zero socialization can be enforced without costs by isolating worker physically. In reality, such a separation is very often costly or infeasible. However, the policy can be interpreted in a different way. We assume that the firm can find, with no additional costs, whether workers have chosen zero socialization or not (but

6) Some additional assumptions are generally required to ensure that the firm can implement $(h, s_n)_{n=1,2}$ by the payment which guarantees workers exactly their reservation utility levels. See Grossman and Hart (1983).

cannot observe the precise level when socialization has occurred). This is a plausible assumption as long as workers' jobs do not require discussion : When workers work in the same work floor or room, supervisors can force workers not to talk during working hours relatively easily. Then isolation means that the firm enforces workers not to socialize by imposing heavy penalties on them if they chose to socialize.

Since both constraints (NIC) and (PC) in the firm's problem hold with equality at the optimum, the optimal solution (v_i^n) satisfies the following two equations for each worker n :

$$\sum_i (P_i^n(h) - P_i^n(l))\, v_i^n = G_h^n(s_{hh}^n,\ s_{hh}^k) - G_l^n(\sigma_l^n(s_{hh}^k),\ s_{hh}^k)\,; \tag{1}$$

$$\sum_i P_i^n(h)\, v_i^n = \overline{U}^n + G_h^n(s_{hh}^n,\ s_{hh}^k). \tag{2}$$

Note that the right-hand side of equation (1) is strictly positive by Assumption 1. By Assumption 0, the Lagrange multiplier for constraint (NIC) is strictly positive, and hence the smaller the right-hand side is, the smaller the optimal value of the firm's expected payments to workers is. Socialization between workers has important effects on this incentive compatibility constraint.

To examine the effects of socialization on effort incentives, we introduce assumptions on workers' "marginal disutility" of effort $G_h^n - G_l^n$. We first assume complementarity between effort and socialization *received*: each worker is less effort averse when he receives more socialization from his co-worker. In other words, the harder he works, the larger the favorable effect of socialization from his co-worker.

ASSUMPTION 5. *For each n and s_n, if $s > s'$, $G_h^n(s_n,\ s) - G_l^n(s_n,\ s) < G_h^n(s_n,\ s') - G_l^n(s_n,\ s')$.*

Then we can show our first result concerning the comparison of isolation with the policy of no control (on socializing activities). Isolation enforces zero socialization, so that the optimal contract under isolation satisfies (1) and (2) with all the arguments of G_h^n and G_l^n replaced by zero.

PROPOSITION 2. *If Assumption 3a (no social pleasure) holds for both workers, then the firm never prefers isolation to no control on socializing activities.*

PROOF : We show that the right-hand sides of (1) and (2) are smaller than those under zero socialization. For (2), by Assumption 2 and the definition of s_{hh}^n, we have $G_h^n(0,\ 0) > G_h^n(0,\ s_{hh}^k) \geq G_h^n(s_{hh}^n,\ s_{hh}^k)$. Concerning (1),

$$G_h^n(0,\ 0) - G_l^n(0,\ 0) > G_h^n(0,\ s_{hh}^k) - G_l^n(0,\ s_{hh}^k) = G_h^n(s_{hh}^n,\ s_{hh}^k) - G_l^n(\sigma_l^n(s_{hh}^k),\ s_{hh}^k)$$

where the first inequality follows from Assumption 5, and the equality is by Assumption 3a.

The logic is very simple. When workers are forced not to socialize at all, their disutility levels of working hard are higher, so that the firm must compensate more. In addition, deviation from high effort to low effort is easier, and hence more risk must be imposed on workers under isolation than under no control. The assumption of no social pleasure plays a role in this second argument. Since equilibrium socialization is positive, each worker receives a higher socialization level under no control on socializing activities, which fact has a favorable effect. However, there is another effect of increasing his socialization level on his *own* disutility of effort. Under the assumption of no social pleasure, this second effect disappears since his disutility is constant when his own socialization level increases up to the best response to a given level of socialization received from his co–worker.

Is there a situation where isolation is favorable to the firm? To examine this question, we introduce two more assumptions on each worker's disutility of effort, which characterize the workers' best responses. We assume that a worker is more unwilling to increase socialization the harder he works, or the lower his co–worker's socialization level is. These assumptions seem to be quite reasonable.

ASSUMPTION 6. *For each n, s_k, and $s > s'$, $G_h^n(s, s_k) - G_l^n(s, s_k) \geq G_h^n(s', s_k) - G_l^n(s', s_k)$. The inequality is strict over the range where $G_h^n(\cdot, s_k)$ is strictly increasing or $G_l^n(\cdot, s_k)$ is strictly decreasing.*

ASSUMPTION 7. *For each n and a, $G_a^n(s_n, s_k') - G_a^n(s_n', s_k') \geq G_a^n(s_n, s_k) - G_a^n(s_n', s_k)$ holds if $s_n > s_n'$ and $s_k > s_k'$.*

LEMMA 1. (i) *Assumption 6 implies that for each n and s, $\sigma_h^n(s) \leq \sigma_l^n(s)$*; (ii) *Assumption 7 implies that for each n, both $\sigma_h^n(s)$ and $\sigma_l^n(s)$ are nondecreasing in s.*

PROOF: (i) Suppose instead $\sigma_h^n(s) > \sigma_l^n(s)$. Then Assumption 6 implies that $G_h^n(\sigma_h^n(s), s) - G_h^n(\sigma_l^n(s), s) \geq G_l^n(\sigma_h^n(s), s) - G_l^n(\sigma_l^n(s), s)$ holds. The left–hand side is nonpositive by the definition of σ_h^n. On the other hand, the right–hand side is strictly positive since $G_l^n(s_n, s)$ must be strictly increasing for $s_n > \sigma_l^n(s)$ by the definition of σ_l^n. A contradiction. (ii) Let $s > s'$ and suppose $\sigma_h^n(s) < \sigma_h^n(s')$. Then by Assumption 7, we have $G_h^n(\sigma_h^n(s'), s') - G_h^n(\sigma_h^n(s), s') \geq G_h^n(\sigma_h^n(s'), s) - G_h^n(\sigma_h^n(s), s)$. The left–hand side is nonpositive by the definition of σ_h^n. On the other hand, the right–hand side is strictly positive since $G_h^n(s_n, s)$ must be strictly increasing for $s_n > \sigma_h^n(s)$. A contradiction. The same argument holds for σ_l^n.

This lemma shows that under no control on socialization, each worker increases his socialization when he works less hard or when his co–worker provides more socialization. Based on this property, the next lemma provides some partial order of equilibrium levels of socialization: a worker's equilibrium socialization is higher the less hard he or his co–worker works.

LEMMA 2. *For each n, $s_{hh}^n \leq s_{hl}^n \leq s_{ll}^n$ and $s_{hh}^n \leq s_{lh}^n \leq s_{ll}^n$. Also $s_{ll}^n < \bar{s}_n$.*

PROOF: This lemma is a special case of more general results by de Groote (1988) and Lippman et al. (1987). The proof here follows de Groote. We compare two equilibria $(s_n, s_k) = (s_{hh}^n, s_{hh}^k)$ and $(s_n, s_k) = (s_{hl}^n, s_{lh}^k)$ here. The other comparisons proceed similarly. We consider the following fictitious, iterated choice of socialization. When worker k decreases his effort from h to l, given worker n's socialization s_{hh}^n, worker k chooses $s_k^1 = \sigma_l^k(s_{hh}^n) \geq \sigma_h^k(s_{hh}^n) = s_{hh}^k$ by Lemma 1 (i). Then, given s_k^1, worker n chooses $s_n^1 = \sigma_h^n(s_k^1) \geq \sigma_h^n(s_{hh}^k) = s_{hh}^n$ by Lemma 1 (ii). Worker k then chooses $s_k^2 = \sigma_l^k(s_n^1) \geq \sigma_l^k(s_{hh}^n) = s_k^1$. By continuing this process, we obtain nondecreasing sequences $s_{hh}^n \leq s_n^1 \leq s_n^2 \cdots$ and $s_{hh}^k \leq s_k^1 \leq s_k^2 \cdots$. Since the feasible sets of socialization are compact, these sequences converge to (s_n, s_k) in $S_n \times S_k$, which is (s_{hl}^n, s_{lh}^k) by the continuity of the best responses. Thus, $s_{hh}^n \leq s_{lh}^n$ and $s_{hh}^k \leq s_{lh}^k$. Finally, $s_{ll}^n < \bar{s}_n$ follows from Assumption 4.

Let us examine whether there is a case in which isolation has better incentive effects on effort choice. We have seen in the proof of Proposition 2 and the discussion following it that the negative incentive effect of isolation results from the fact that workers do not receive positive socialization from co–workers. Now suppose that worker 2, when working hard, has little incentive to socialize, that is, s_{hh}^2 is close to zero (e. g. because he is a junior, inexperienced worker). On the other hand, suppose that worker 1 is an experienced senior worker of socializing type (with social pleasure) and he has incentives to select socialization greater than zero even though he receives little socialization from worker 2. Then by Assumption 6 we can find s_{hh}^2 sufficiently small to satisfy the following inequality :

$$G_h^1(0, 0) - G_l^1(0, 0) < G_h^1(s_{hh}^1, s_{hh}^2) - G_l^1(s_{hh}^1, s_{hh}^2).$$

Then by the definition of σ_l^1, we have

$$G_h^1(0, 0) - G_l^1(0, 0) < G_h^1(s_{hh}^1, s_{hh}^2) - G_l^1(\sigma_l^1(s_{hh}^2), s_{hh}^2),$$

that is, to induce worker 1 to work hard, the firm must impose more risk on him under no control than under isolation.

Of course, this argument does not necessarily lead to the conclusion that the firm prefers isolation to no control under the condition above. First, since worker 1 selects a higher level of socialization in equilibrium, enforcing zero socialization will increase the expected payments (in utility units) to worker 1. Second, and more importantly, under isolation, worker 2 no longer receives socialization from worker 1, so that inducing worker 2 to work hard is more costly when worker 1 is forced to select zero socialization than when he selects the equilibrium socialization level. Whether isolation is better or not is determined by the net effect.

If *both* workers' equilibrium socialization levels are sufficiently close to zero, these costs of isolation will become negligible. More precisely, suppose that for each n,

$$\sigma_h^1(0) = 0, \tag{3}$$

that is, when a worker receives no socialization and when he works hard, he also has no incentive to socialize. We then assume that the equilibrium socialization levels s_{hh}^1 and s_{hh}^2 are sufficiently close to zero so that for each n and $a \in \{h, l\}$,

$$G_a^n(0,\ 0) \approx G_a^n(s_{hh}^n,\ s_{hh}^k). \tag{4}$$

(4) means that the difference in disutility of each effort level between isolation and the equilibrium socialization is negligible. On the other hand, suppose that for each n,

$$\sigma_l^n(s) > \sigma_h^n(s) \qquad \text{for all } s. \tag{5}$$

(We will later present an example satisfying these conditions.) This and (3) imply that when a worker is shirking, he chooses to socialize even if he receives little socialization from his co-worker. Under these conditions, we present two cases in which the firm strictly prefers isolation to no control on socializing activities; the case where a worker has social pleasure, and the case where workers' effort choice is mutually observable before they select socialization.

PROPOSITION 3. *Suppose that conditions (3), (4), and (5) hold for each n and $a \in \{h,\ l\}$. Then if at least one worker has social pleasure (Assumption 3b), then the firm prefers enforcing both workers to choose zero socialization.*

PROOF: Since (4) holds for $a = h$, each worker's expected utility on income is approximately equal between under isolation and under equilibrium socialization. Concerning incentive compatibility, supposing that worker n has social pleasure, we have

$$G_h^n(0,\ 0) - G_l^n(0,\ 0) \approx G_h^n(s_{hh}^n,\ s_{hh}^k) - G(s_{hh}^n,\ s_{hh}^k) < G_h^n(s_{hh}^n,\ s_{hh}^k) - G_l^n(\sigma_l^n(s_{hh}^k),\ s_{hh}^k) \tag{6}$$

where the last inequality holds because of (5) and Assumption 3b. (6) implies that worker n's unilateral deviation from h to l is now less easy under isolation. Thus, isolation is better when both workers have social pleasure. When only one worker, say worker 1, has social pleasure, worker 2's marginal disutility is approximately equal in the following three cases; when zero socialization is enforced to worker 1 only, to both workers, and to neither worker. Isolation is hence preferred by the firm.

When a worker is of socializing type, increasing socialization from zero strictly reduces his *own* disutility of effort as well as his co-worker's. And since $s_{hh}^n < \sigma_l^n(s_{hh}^k)$, this effect is generally more significant when he is lazy than when he works hard. Thus, when workers selecting high effort have little incentive to socialize, isolation is better to the firm since without it, the firm would have to impose more risk on the worker to prevent him shirking.

To illustrate the result above, consider the following example. Suppose that workers have an identical form of disutility of effort given by the following quadratic functions: For $s,\ t \in S = [0,\ 1]$,

$$G_h(s,\ t) = \frac{1}{2}\theta_h(1-t)^2 - \frac{1}{2}s(t+\gamma_h) + \frac{1}{2}s^2;$$

$$G_l(s,\ t) = \frac{1}{2}\theta_l(1-t)^2 - \frac{1}{2}s(t+\gamma_l) + \frac{1}{2}s^2.$$

(We drop the superscripts distinguishing workers.) We assume $\theta_h > \theta_l > 0$ and $0 < \gamma_h < \gamma_l < 1$. Then these disutility functions satisfy Assumptions stated above. In particular, workers derive social pleasure for low levels of socialization. (Assumption 3b is adopted.) The best response functions are calculated as $\sigma_h(t) = \frac{1}{2}(t+\gamma_h)$ and $\sigma_l(t) = \frac{1}{2}(t+\gamma_l)$. These functions provide the equilibrium socialization as follows : $s_{hh}=\gamma_h$; $s_{ll}=\gamma_l$; $s_{hl}=\frac{1}{3}(2\gamma_h+\gamma_l)$; and $s_{lh}=\frac{1}{3}(2\gamma_l+\gamma_h)$.

We consider the limiting case of $\gamma_h=0$. Then clearly (3), (4), and (5) are satisfied. The marginal disutility of effort in (1) is then calculated as

$$\begin{aligned} G_h(s_{hh}, s_{hh}) - G_l(\sigma_l(s_{hh}), s_{hh}) &= \frac{1}{2}(\theta_h-\theta_l)(1-\gamma_h)^2 + \frac{1}{8}(\gamma_l+3\gamma_h)(\gamma_l-\gamma_h) \\ &= \frac{1}{2}(\theta_h-\theta_l) + \frac{1}{8}\gamma_l^2. \end{aligned}$$

which is clearly larger than $G_h(0, 0) - G_l(0, 0) = \frac{1}{2}(\theta_h-\theta_l)$. That is, as in Proposition 3, the firm strictly prefers isolation to no control. The advantage of isolation solely comes from the fact that γ_l is positive, that is, workers have incentives to increase socialization when they shirk.

The firm's strict preference for isolation in the result above depends on the existence of social pleasure. However, if we modify workers' choice of effort and socialization, then we can show the similar result for workers with no social pleasure. Consider the following modification. Each worker selects his effort level simultaneously, and then, after observing the other worker's effort, selects socialization simultaneously. When workers share the same work floor or they work together, it is often the case that each worker observes how hard his co-workers work and so his decision of socialization depends on such observations. Then the marginal disutility of effort in the incentive compatibility constraint changes to $G_h^n(s_{hh}^n, s_{hh}^k) - G_l^n(s_{lh}^n, s_{hl}^k)$, which is larger than the right-hand side of (1): The effort choice of a worker can affect his co-worker's choice of socialization such that his deviation form h to l results in the increase of socialization he receives.

PROPOSITION 4. *Suppose that (3), (4), and (5) hold for each n and $a \in \{h, l\}$. If each worker selects his effort level and observes his co-worker's effort before the choice of socialization, then the firm prefers isolation to no control on socialization.*

PROOF : By following the proof of Lemma 2, we can show that (5) implies $s_{hh}^n < s_{hl}^n$ and $s_{hh}^n < s_{lh}^n$ for $n=1, 2$. This in turn implies $G_l^n(s, s_{hh}^k) < G_l^n(s, s_{hl}^k)$ for each s. We hence have

$$G_h^n(0, 0) - G_l^n(0, 0) \approx G_h^n(s_{hh}^n, s_{hh}^k) - G_l^n(s_{hh}^n, s_{hh}^k) < G_h^n(s_{hh}^n, s_{hh}^k) - G_l^n(s_{lh}^n, s_{hl}^k). \qquad (7)$$

That is, the firm has to impose more risk on workers to induce them to choose h under no control than under isolation. Since the expected payments to workers are approximately equal by (4) for $a=h$, the firm strictly prefers isolation.

As the proof shows, this result does not depend on whether or not there is a worker of socializing type. When a worker deviates from high effort to low effort, his co-worker, observing the deviation, increases socialization, which strictly reduces the former worker's disutility of effort. Thus, without controlling workers' socializing activities, providing incentives to work hard costs more to the firm.

The condition in Proposition 3 or 4 can be interpreted from the perspective of statistical inference. In the limit of $s_{hh}^{n}=0$ for each n, the firm's coarse monitoring of whether socialization is zero or positive perfectly detects their effort levels: *Under workers' equilibrium behavior,* the firm will observe nonnegligible socializing activities only when workers shirk. Then the firm's dichotomous monitoring yields information for workers' effort which are not already in outcomes, so that the optimal wage schemes should impose penalties on them contingent on the observation of positive socialization. However, the optimal wage scheme for each worker must be also contingent on his outcome though it is a coarser signal of his effort level than the dichotomous signal of socialization: since socialization is a choice variable of workers, they can shirk while selecting zero socialization.

In the example of the quadratic disutility functions above, the marginal disutility of effort under the assumption of mutually observable effort is given as

$$G_h(s_{hh},\ s_{hh})-G_l(s_{lh},\ s_{hl})=\frac{1}{2}\left(\theta_h-\theta_l\left(1-\frac{1}{3}\gamma_l\right)^2\right)+\frac{4}{18}\gamma_l^2.$$

This is strictly larger than $G_h(0,\ 0)-G_l(0,\ 0)$. The difference increases as θ_l or γ_l increases. These effects result from the fact that each worker receives higher socialization when he shirks.

In the situation where a factory or an office to which workers belong is in busy time, it is often the case that the firm supervises workers closely so that they do not chat. Our results suggest that such a policy in fact has better effects on workers' incentives to work hard than no control on their interpersonal relationships, provided that their effort is mutually observable and they select socializing activities contingent on such observation. On the other hand, it is rare to observe such isolation in many research institutes including universities. The main reason is, of course, that interactions among members in those institutions provide them with important opportunities to exchange information, ask questions, and so on, which improve their productivity. Besides such production externalities, however, interpersonal interactions are beneficial in mitigating incentive problems, as long as members work relatively independently and they are not of socializing type.

IV Worker Collusion

There are two potential problems concerning workers' action choice in our model of the firm–worker relationship. The first one comes from the multiplicity of Nash equilibrium: Given wage schemes, there may exist another Nash equilibrium preferred by both workers to the one the firm wants to implement. The second problem is that the workers may engage in side contracting to play cooperatively rather than noncooperatively. These problems seem more relevant in our model because socialization bears opportunities for workers to discuss the possibility of collusive behavior. We consider each of these problems in the following two subsections.

A. The Multiple Equilibrium Problem

Under no control on socializing activities, the firm in our model designs wage schemes so as to implement the effort pair (h, h) and the corresponding socialization (s^1_{hh}, s^2_{hh}) as a Nash equilibrium with minimum costs. However, it is easy to show that, given the solution to the firm's problem, each of the other effort pairs and the corresponding socialization levels provides both workers with higher expected utilities than the one the firm wants to implement does. For example, consider the case in which both workers select low effort. Assuming strict inequality $s^n_{ll} > s^n_{hh}$ for each n, we have, by (1) and Assumption 2,

$$\sum_i P^n_i(h)v^n_i - G^n_h(s^n_{hh}, s^k_{hh}) = \sum_i P^n_i(l)v^n_i - G^n_l(\sigma^n_l(s^k_{hh}), s^k_{hh}) < \sum_i P^n_i(l)v^n_i - G^n_l(s^n_{ll}, s^k_{ll})$$

where (v^n_i) is the optimal solution to the firm's problem (FP). Similarly, both workers obtain strictly higher expected utilities in the case where one of them selects low effort and the other selects high effort, provided that the inequalities in Lemma 2 are strict. Thus, if (l, l) or (h, l) is another Nash equilibrium effort pair in the game following the firm's choice of the optimal wage schemes for (h, h), workers will select that equilibrium undesirable to the firm.

Fortunately, when workers have no social pleasure, the effort combinations other than (h, h) cannot form Nash equilibria, and hence no problem arises.

PROPOSITION 5. *Suppose (5) for each n. If Assumption 3a (no social pleasure) holds for $n=1$, 2, then (h, h) is the only equilibrium effort pair under the optimal wage schedules.*

PROOF: We show that (l, l) is not an equilibrium effort pair. That is, we must show

$$\sum_i P^n_i(l)v^n_i - G^n_l(s^n_{ll}, s^k_{ll}) < \sum_i P^n_i(h)v^n_i - G^n_h(\sigma^n_h(s^k_{ll}), s^k_{ll})$$

for some n, where (v^n_i) is the optimal wage scheme satisfying (1) and (2). By (1), this inequality is equivalent to

$$G^n_h(s^n_{hh}, s^k_{hh}) - G^n_l(\sigma^n_l(s^k_{hh}), s^k_{hh}) > G^n_h(\sigma^n_h(s^k_{ll}), s^k_{ll}) - G^n_l(s^n_{ll}, s^k_{ll}).$$

By Assumption 3a and 5, we have

$$\begin{aligned} G^n_h(s^n_{hh}, s^k_{hh}) - G^n_l(\sigma^n_l(s^k_{hh}), s^k_{hh}) &= G^n_h(s^n_{hh}, s^k_{hh}) - G^n_l(s^n_{hh}, s^k_{hh}) \\ &> G^n_h(s^n_{hh}, s^k_{ll}) - G^n_l(s^n_{hh}, s^k_{ll}) \\ &= G^n_h(\sigma^n_h(s^k_{ll}), s^k_{ll}) - G^n_l(s^n_{ll}, s^k_{ll}). \end{aligned}$$

Similarly, we can show that (h, l) is not an equilibrium effort pair since the worker who selects l prefers deviating to h.

The intuition is that under (l, l) or (h, l), each worker receives a higher socialization level than under (h, h). Thus, by the assumptions of no social pleasure and complementarity between effort and socialization received, the marginal disutility of effort is reduced. This makes deviation from h to l more difficult and deviation from l to h easier, so that those who select l have incentives to deviate.

If at least one of the workers has social pleasure, however, (l, l) or (h, l) may be an equilibrium effort pair because the worker of socializing type, say worker n, reduces own disutility of choosing l by selecting higher socialization than s_{hh}^n. For example, (l, l) becomes an equilibrium effort pair if and only if both workers have social pleasure and

$$G_h^n(s_{hh}^n, s_{hh}^k) - G_l^n(\sigma_l^n(s_{hh}^k), s_{hh}^k) \leq G_h^n(\sigma_h^n(s_{ll}^k), s_{ll}^k) - G_l^n(s_{ll}^n, s_{ll}^k) \tag{8}$$

for each n. This implies that when worker n selects as his socialization his best response to worker k's socialization, the higher socialization worker n receives, the higher his marginal disutility of effort is. Thus, his deviation from l to h under (l, l) is more difficult than deviation from h to l under (h, h), so that (l, l) forms another equilibrium.

The necessary and sufficient condition for (l, l) not to be an equilibrium effort pair is that the reverse (strict) inequality of (8) holds for some n. In other words, a worker's degree of effort aversion is affected sufficiently more by socialization he receives (via Assumption 5) than by his own socialization (via Assumption 6).[7] In the example in the previous section, (l, l) is not an equilibrium effort pair if and only if

$$\theta_h - \theta_l > \frac{\gamma_l - \gamma_h}{2[(1-\gamma_h)+(1-\gamma_l)]}.$$

The left-hand side represents the magnitude of the effect of higher socialization received (via Assumption 5) while $\gamma_l - \gamma_h$ represents the magnitude of the effect of higher socialization selected (via Assumption 6). The larger the former effect or the smaller the latter is, the less likely (l, l) is to be an equilibrium effort pair.

The problem is more serious when each worker selects his socialization contingent upon his observation of the other worker's effort. Under the optimal contracts for (h, h), both workers enjoy higher expected utilities by choosing (l, l) or (h, l).[8] In addition, we can show that at least one of (l, l) and (h, l) is always an (subgame perfect) equilibrium effort pair.

PROPOSITION 6. *Suppose that (5) holds for each n and that each worker selects his socialization after observing his co-worker's effort level. Then under the optimal wage schemes for (h, h), there always exists another (Pareto superior) equilibrium where at least one worker selects low effort.*

PROOF : The condition for (l, l) not to be an equilibrium effort pair is, for *some n*,

$$\sum_i P_i^n(l) v_i^n - G_l^n(s_{ll}^n, s_{ll}^k) < \sum_i P_i^n(h) v_i^n - G_h^n(s_{hl}^n, s_{lh}^k)$$

7) A similar condition is sufficient for (h, l) not to be an equilibrium effort pair. However, it is not necessary : A worker who selects h under (h, l) has incentives to deviate to l if a higher level of his socialization has sufficiently large effects on his effort aversion than the socialization he receives has. In fact, we can show that in the example in the last section, (h, l) is never an equilibrium effort pair because either of the conditions above is always satisfied for each n.

8) When workers select (h, l) and the corresponding socialization levels, the one who exerts low effort obtains the same expected utility level as his level under (h, h).

where (v_i^n) is the optimal contract for (h, h). Since (v_i^n) satisfies (1) with $G_l^n(\sigma_l^n(s_{hh}^k), s_{hh}^k)$ replaced by $G_l^n(s_{lh}^n, s_{hl}^k)$, the condition is rewritten as

$$G_h^n(s_{hh}^n, s_{hh}^k) - G_l^n(s_{lh}^n, s_{hl}^k) > G_h^n(s_{hl}^n, s_{lh}^k) - G_l^n(s_{ll}^n, s_{ll}^k). \tag{9}$$

On the other hand, under (h, l), the worker who selects l has no incentive to deviate since his deviation to h does not alter his expected utility level. Thus, the condition for (h, l) not to be an equilibrium effort pair is that each worker, when selecting h under (h, l), has an incentive to deviate to l, that is, for each n,

$$G_h^n(s_{hh}^n, s_{hh}^k) - G_l^n(s_{lh}^n, s_{hl}^k) < G_h^n(s_{hl}^n, s_{lh}^k) - G_l^n(s_{ll}^n, s_{ll}^k). \tag{10}$$

Conditions (9) for some n and (10) for each n cannot be satisfied at once, and thereby at least one of (l, l) and (h, l) must be always an equilibrium effort pair.

Note that in our model these problems arise exactly because of socializing activities between workers. Without them (as in isolation), each worker's choice of effort is a single-person decision problem, and the optimal contracts for (h, h) make each worker indifferent between two effort levels: Workers have no incentive to choose effort different from the one the firm prefers. This observation suggests another potential advantage of isolation. In Propositions 3 and 4, we provided cases in which isolation is preferred to no control by the firm. Both assertions contain the restrictive condition that workers have little incentive to socialize when they work hard. The firm might want to implement isolation, however, even if this condition is not satisfied, in order to prevent workers from colluding to select undesirable effort levels.[9]

B. Collusive Choice of Socialization

Our analysis of employment relationships so far has been conducted under the assumption that each worker behaves in a self-interested way in his choice of effort and socialization. In some situations, however, workers may behave as a group to maximize their total welfare. For example, their long-term relationship may provide them with opportunities to reciprocate actions. In this subsection, we address the following question: If the firm can induce workers to collude in their socializing activities (through some personnel policies other than wage contracts), does it prefer to do so?

We only focus on the reciprocity of socialization between workers for two reasons. First of all, collusion on workers' effort introduces a new issue of the tradeoff between incentive effects and risk sharing. (See Itoh (1990) for the analysis of this issue.) Since the analysis of this problem is beyond the scope of the current paper, here I only consider collusion on socializing activities. Second, reciprocity is in fact more likely to occur for interpersonal activities such as

9) If the firm can enlarge the strategy sets of workers and design multi-stage mechanisms of communication with them, it will be able to implement the desirable effort pair and socialization as a unique sequential equilibrium as Ma (1988) demonstrated in the standard agency model with moral hazard.

socialization in our model than for each worker's effort into his own job.

For simplicity, we assume that workers have identical utility functions. Hereafter we drop the superscripts representing workers from utility functions and equilibrium socialization. Suppose that workers first select effort simultaneously, and then, after observing effort levels, select socialization to maximize the sum of their expected utilities. Let s^*_{ab} be a worker's collusive socialization level when his effort is a and his co-worker's is b. Then

$$(s^*_{ab},\ s^*_{ba}) = \underset{s_1,\ s_2}{\operatorname{argmin}}\ G_a(s_1,\ s_2) + G_b(s_2,\ s_1).$$

We assume the uniqueness of each s^*_{ab}. Since effort levels are chosen in a noncooperative way, the optimal contracts for $(h,\ h)$ given worker collusion satisfy the following equations for each n.

$$\sum_i (P^n_i(h) - P^n_i(l))\, v^n_i = G_h(s^*_{hh},\ s^*_{hh}) - G_l(s^*_{lh},\ s^*_{hl})\,; \tag{11}$$

$$\sum_i P^n_i(h)\, v^n_i = \overline{U}^n + G_h(s^*_{hh},\ s^*_{hh}). \tag{12}$$

Since $G_h(s^*_{hh},\ s^*_{hh}) < G_h(s_{hh},\ s_{hh})$, both workers in fact prefer colluding in socialization, and the firm pays smaller expected payments in utility units. Thus, if the marginal disutility of effort in (11) is smaller than that under no collusion, then we can conclude that the firm prefers worker collusion. However, this is not necessarily true. Smaller disutility and smaller marginal disutility have no logical connection here.

Under collusion, each worker receives higher socialization from his co-worker than under no collusion, which fact has the better incentive effect. However, each worker selects his socialization higher than the best response, and this results in substantial increases in his own marginal disutility. The firm prefers collusion if the former effect dominates the latter.

Note that there is one situation in which worker collusion is in fact preferred by the firm; the case where workers are risk neutral. Under the assumption of identical utility functions, the collusive socialization level given $(h,\ h)$ is exactly the first-best socialization level. Thus, by paying each worker the whole marginal benefits from his job, the firm can attain the first-best outcome.

V Concluding Remarks

Social relations among workers have been emphasized by sociologists studying organizations for a long time while economists so far have not paid much attention to them. This paper presented one way of analyzing them by incorporating nonproductive interpersonal activities into a hidden action model of the relationship between a firm and workers. The existence of such socializing activities in fact has important effects on workers' effort incentives and the optimal wage contracts. The results are summarized as follows.

1. Workers under-socialize: They could have attained higher expected utilities by simultaneously increasing their socialization levels.
2. In particular, this under-socialization result implies that, contrary to the standard agency

relationship, the firm cannot attain the first-best outcome under the relationship with risk-neutral workers when social relations among workers exist.

3. Allowing social relations among workers has better incentive effects than the policy of forcing workers not to socialize at all (isolation) if they are not of socializing type (the disutility of each worker is nondecreasing in his socialization level).
4. Under the condition that workers, when working hard, have little incentive to socialize, the firm prefers isolation to no control if there is a worker of socializing type.
5. Under the same condition as in 4, isolation is preferred by the firm if each worker with no social pleasure selects his socialization after observing how hard his co-worker works.
6. Isolation may be adopted by the firm even in the situation where workers, when working hard, have incentives to socialize, because socializing activities may create another equilibrium effort pair preferred by both workers to the one firm wishes to implement.
7. Workers who select their socializing activities to maximize their total welfare enjoy receiving higher socialization while their socialization levels are too high from the firm's standpoints. Thus, the incentive effect of collusive choice is ambiguous, and the firm does not necessarily prefer worker collusion unless workers are risk neutral.

The current paper focused on one facet of social relations, that is, interpersonal actions which change co-workers' preferences directly. However, there are more subtle, indirect relations as well. Workers are very often influenced by observing the way co-workers are rewarded, how they behave, whether they are treated in a fair manner, and so on. There is a set of economic literature analyzing the interaction of workers in the firm by assuming that they have exogenously specified interdependent preferences (Akerlof, 1982; Frank, 1984). I think, however, that such social comparison is also at workers' discretion as socializing activities in our model are. By endogenizing the comparison processes, we may be able to examine how the firm affects workers' social comparison, and obtain some implications on its personnel systems. In fact, sociologists such as Baron (1988) and Perrow (1986) suggest the importance of endogenizing workers' interpersonal preferences and summarize conditions favoring social comparison or those favoring individualistic behavior.

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