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Optimal Delegation of Authority in Organizations

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Abstract

This paper examines the effects of authority delegation within organizations. By changing the delegation structure, *ex post* total return of the organization and each worker's bargaining power, which changes *ex ante* incentive for organization specific investments, are affected. The optimal design of authorities is derived to provide proper *ex ante* as well as *ex post* incentives. We characterize cases where the authority of a decision, which affects the bargaining power of a worker, should be delegated to the worker himself. We further illustrate that, in many cases, authorities should be delegated to the workers who are less important for the organization from the viewpoint of productivity.

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1. Introduction

In his seminal paper, Coase [1937] emphasized the role of authority in understanding how firms function. More than half a century later, however, little progress has been made in understanding the economic nature of authority within organizations[1]. This paper is an attempt to fill in a part of this lacuna by analyzing a particular aspect of authorities with respect to the functioning of organizations; delegating an authority may change the incentive structure among the members in the organization. There are several reasons why the allocation of authority may change the incentive structure. For example, it may facilitate or block a worker from capitalizing his investment in skill formation. Alternatively, it may improve or harm the extent that strategic and/or operational decisions reflect relevant information possessed by members of the organization. Finally, it may affect the bargaining power of organizational members and change the manner how the *ex post* potential gains from trade are distributed within the organization. The primary focus of this paper is to analyze the optimal design of authorities in providing proper *ex ante* incentive and in efficiently dissolving the *ex post* gains from trade in an organization.

Authority in this paper is defined as a control right of decision variables, whose choice affects not only the total return of the organization but also the bargaining power of organizational members. Hence, *ex ante* incentives of the members for specific investment as well as *ex post* incentives for capturing larger income from bargaining are affected by distribution of authorities through the change in bargaining power. In this paper, we exhibit authorities that affect a worker's bargaining power are often better delegated to the worker himself, as giving the authority to other members would provide incentives to increase their bargaining return by excluding this worker from bargaining. This incentive is better checked as it obstructs *ex ante* incentive of the worker and the total organizational return may be diminished. In other cases, however, giving such authority to the worker himself would reduce *ex ante* incentives and, hence, not optimal. The optimal delegation structure must be designed to cope

[1]Works by Simon [1951], Marglin [1974] are among those few classical literatures in this area.

with tradeoffs between these two incentive effects. We shall illustrate some of these problems by an example.

Consider a winery producing and selling wines in three periods. As an organization, the winery consists of the management and workers. In period 1, workers must carefully select various types of quality grapes and process them with care. These efforts are hard to write explicitly in contracts, as they require sophisticated know-hows as well as careful attentions which are hard to describe in words. Consequently, any contract between the management and workers will be in the form of incomplete contract[2], and some mechanism other than formal contracts must be devised to reward these efforts. In our formulation, the allocation of authorities play the role of this mechanism. To simplify the exposition, suppose workers work either carefully or not carefully. If they work carefully they bear the cost C (> 0) dollars by themselves, while if they work not carefully they do not bear this cost.

In period 2, a decision is made whether the winery produces quality wines or cheap wines. We call this decision as the "output decision". This decision is irrevocable in the sense that, once it is made, the winery must commit to the type of wine it produces in period 3. Output decision affects value of workers in period 3; if it is decided to produce quality wines workers' knowledge about the grapes becomes essential in the production of wines, while if it is decided to produce cheap wines their knowledge becomes valueless. In period 3, actual production takes place. In this stage, at least two types of decisions are made: bottling decisions to bottle various qualities of wines by blending them properly, and sales decisions to price these various wines and channel them into different distribution networks. We call these decisions as "bottling decision" for short.

We assume that the winery's revenue depends upon three things: whether different types of the grapes are selected properly (which, in turn, is completely determined by the level of workers' effort in period 1), which type of wines, quality wines or cheap wines, are to be produced (output

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[2]Grossman and Hart [1986] and Hart and Moore [1990] used a similar approach to analyze the question of vertical integration.

decision made in period 2), and whether or not a proper bottling decision is made in period 3. We first describe the returns when quality wines are to be produced. In order to make a proper bottling decision for quality wines, the knowledge of workers who worked on grapes in period 1 is essential. If grapes are selected properly because workers worked carefully in period 1 and a proper bottling decision is made in period 3, the expected revenue is R (> 0) dollars. If the grapes are selected carefully but an inappropriate bottling decision is made (either because the management makes this decision without utilizing the workers' knowledge, or because workers chose inappropriate bottling decision on purpose), the expected revenue falls to R' ($R > R' > 0$) dollars. We assume $R' > \frac{1}{2}R > C$, which is essential in what follows. If the wine is bad, regardless of the bottling decision the expected revenue is 0. If it is decided that cheap wines are to be produced, bottling decision is irrelevant and workers' knowledge is valueless. The return depends only upon whether the grapes are properly selected or not. In the former case, the return will again be R' and in the latter 0.

At the beginning of period 3, negotiation is made between the management and workers what bottling decisions should be made and how the returns will be divided between the two parties. This negotiation is assumed to produce a binding outcome and, hence, the bottling decision satisfies *ex post* efficiency. Formally, if workers worked properly in period 1, and a decision is made to produce quality wine, the proper bottling decision will be made as $R > R'$, and the return will be divided evenly between the two parties. This division is made because workers have bargaining power supported by their specific knowledge. If workers worked properly in period 1 but cheap wines are to be produced, bottling decisions are irrelevant and the returns will be R'. The management will take all of R', as workers will have no bargaining power in this case. If workers did not work properly in period 1, returns will be zero and both parties receives nothing.

The situation is described as a game tree in Figure 1. As usual, pairs of numbers in the far right denote payoffs for the management and workers, respectively. The figure does not completely define a game, however, because the moves to determine whether to produce quality wines or to produce cheap wines (and, hence, the moves which determine if workers' knowledge can be utilized

in the bottling decision) are not assigned to a particular player. This is precisely the problem we intend to analyze in this paper; how the outcome of the game will change if we change the assignment of output decision from the management to workers and, from the management's (principal's) viewpoint, which of the two is better between giving this move to the management and to workers? Put in the language according to our motivation, the question is as follows; if the management anticipates resulting differences in incentive structure, would it prefer to keep the authority to make output decision or to delegate this authority to workers?

We should illustrate the problem using the example of Figure 1. Suppose the management has the authority to make the output decision, and suppose workers chose grapes carefully in period 1. The management will choose cheap wines in period 2 because, by doing so, it can assure itself R', which is larger than $\frac{1}{2}R$, as its income when it chooses quality wines. Anticipating this choice by the management and resulting payoff of 0 for themselves, workers will have no incentive to invest in good effort in period 1 which costs them C. To sum up, if the management has the authority to make output decision, it will have *ex post* incentive to choose cheap wines in order to eliminate workers' bargaining power. However anticipating this prospect, workers will not work carefully in period 1. Consequently, organizational returns as well as payoffs for both the management and workers are all zero.

Suppose, on the contrary, workers are delegated the authority to make output decision. If workers have worked carefully and they choose to produce quality wines, they will receive $\frac{1}{2}R$ thanks to the bargaining power created by their specific knowledge. If they choose to produce cheap wines, however, they will receive nothing. Hence workers, in this case, will choose quality wines to produce and receive $\frac{1}{2}R$, leaving $\frac{1}{2}R$ for the management. If workers did not select grapes carefully in period 1, they will receive nothing regardless of the development in periods 2 and 3. As $\frac{1}{2}R > C$, workers will choose to work carefully in period 1. It follows that the outcome of this authority structure gives $\frac{1}{2}R$ to the management, which is larger than the payoff outcome for the management with the previous authority structure. In other words, by delegating to workers the period 2 decision to choose the type

of output to be produced in period 3, the management can provide incentives for workers to work carefully in period 1 and assure itself of positive payoff, $\frac{1}{2}R$.

Some readers may think that this problem arises because there is no possibility of renegotiation about the period 2 authority together with the period 3 bottling decision at the beginning of period 2. So, suppose there is a possibility of renegotiation at the beginning of period 2, but the management has period 2 authority to decide the type of output to be produced in period 3. Suppose further that workers chose grapes carefully in period 1. If this negotiation yields a binding agreement, the agreement should be Pareto efficient and it is to make the quality wines with a proper bottling decision to yield organizational returns of R. However, the resulting payoffs (assuming Nash bargaining) will be $\frac{1}{2}(R - R') + R' = \frac{1}{2}(R + R')$ for the management and $\frac{1}{2}(R - R')$ for workers. This is so because when the negotiation breaks down the management can make bottling decision without workers and assure itself the default payoff of R', the payoff the management can assure itself without the help of workers. It follows that, if $\frac{1}{2}(R - R') < C$, workers will not choose grapes carefully in period 1 even if there is an opportunity of renegotiation in period 1. If, however, workers have the authority for period 2 decisions, the default payoff when the (period 2) negotiation breaks down will be $(\frac{1}{2}R, \frac{1}{2}R)$. This being efficient, the bargaining will yield the payoff of $(\frac{1}{2}R, \frac{1}{2}R)$, providing workers proper incentive. Put differently, it is critical from the management's viewpoint that commitments are made to delegate the authority of period 2 decisions to workers even if renegotiation is allowed at the beginning of period 2.

The paper is organized as follows. In section 2, the general model is explained. In section 3, some general results are presented. In section 4, an example of two sector model is presented. In section 5, the cases where renegotiation about period 2 decisions are possible among organization members are examined. Effects of introducing asymmetric information will be examined briefly in section 6, which concludes the paper.

2. Model

We consider an organization consisting of $n+1$ (≥ 2) risk-neutral individuals, the set of which is denoted as $I = \{0,1,...,n\}$. I is sometimes partitioned into sets of P and W, i. e., $I = P \cup W$. P is a singleton set consisting of individual 0 or the principal, while $W = \{1,...,n\}$ is the set of workers (employees). The principal owns this organization and has a power to allocate authorities to members of the organization. Workers contribute to the organization in three different ways; investing in relation specific assets, utilizing specific knowledge generated by this relation-specific investment, and exercising delegated authorities that affect the returns to the organization as well as its distribution. Members of the organization can quit and engage in an economic opportunity outside the organization (*outside option*) whose value is denoted as v_o^i for $i \in I$.

There are three periods, 1, 2 and 3. In period 1, a member $i \in I$ invests in non-contractible firm-specific assets, $x^i \in X^i$, with cost $c^i(x^i)$. There is no asset investment in periods 2 and 3, but whether or not the member has firm-specific knowledge in period 3 depends upon the level of period 1 investment. We assume that $x^i = 0$ denotes the situation where the member i does not invest in relation-specific investment in period 1 and, hence, has no relation-specific knowledge in period 3. For the principal, the set X^0 may be empty, representing the situation where she has no investment choice. We shall denote as $\boldsymbol{x} = (x^i)_{i \in I}$. For simplicity, we assume no member discounts the second and third period payoffs.

In period 2, several decisions concerning the operations of the organization must be made. For example, a decision may be made whether or not to continue a given project, to discharge an employee from the organization, to set the speed of a certain production line, etc. We model it so that the critical aspects of these decisions are to determine whether or not some members' firm-specific knowledge, which arises from their period 1 investment, will be utilized in the organization's operation in period 3. More specifically, let $y = (y_j)_{j \in W} \in (Y_j)_{j \in W}$ be the list of such decisions which are indexed by a set $W = \{1, 2, ..., n\}$. For all $j \in W$, $Y_j = \{0,1\}$, where $y_j = 0$ indicates the member j's firm-specific knowledge will not be utilized in period 3, while $y_j = 1$ indicates it be utilized. There is no

physical cost required to make these decisions. The return to the organization, which will be realized in period 3, is a function of x and y, and it will be denoted as $R(x,y)$.

The critical assumption of our model is that each decision y_j may be delegated by the principal to a member $i \in I$ of the organization at the beginning of period 1, so that the delegated member i can exercise this decision according to his own interest. Thus, if a member i is delegated the decision y_j, i has authority to utilize the firm-specific knowledge of the member j in period 3. We express this fact by denoting as $y_j(i)$. The way authorities are delegated in the organization is summarized by a *delegation structure*, $\alpha = \{\alpha(i)\}_{i \in I}$, a partition of W into a set of (possibly empty) subsets $\alpha(i) \equiv \{j \in W \mid y_j^{-1}(.) = i\}$ of α, i. e., $\bigcup_{i \in I} \alpha(i) = W$ and $\alpha(i) \cap \alpha(j) = \varnothing$ for all $i \neq j$. $\alpha(i)$ denotes the set of decisions the member i is delegated. We sometimes denote by $y^i \equiv (y_j)_{j \in \alpha(i)} \in Y^i(\alpha) \equiv \times_{j \in \alpha(i)} Y_j$, i.e., y^i is a vector of decisions that member i makes in period 2.

In period 3, the organizational return, $R(x,y)$, is realized and its distribution among the members will be determined by the negotiation among the members (which produces a binding agreement). Depending on the choice of x and y, however, a member of organization may have no bargaining power in this negotiation. For example, a member who did not invest in a firm specific effort x^i may have no bargaining power. Alternatively, a member i may end up with no bargaining power if a decision is made not to carry out the only project that utilizes his firm-specific investment, i.e., $y_i = 0$. Let

$I(x, y) \equiv \{i \in I \mid i$ has bargaining power in period 3 bargaining given $(x, y)\}$.

$I(x, y)$ will be called "the set of bargaining members"[3]

. Throughout the paper, we shall assume that the principal is always in the set of bargaining members regardless the choice of x and y, because the principal is the owner of the organization.

We adopt an incomplete contract approach. At the beginning of period 1, the principal

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[3]When renegotiation is allowed in period 2, the set of bargaining members may depend upon the delegation structure, α, as having authority in y may endow a member bargaining power in that period. When we discuss about this period 2 renegotiation in section 5, we will assume this set to be dependent on α.

proposes a contract specifying a certain delegation structure, α, to which she commits throughout the operation of the organization, and pays (possibly negative) transfer payments $t = (t^0, t^1,\ldots,t^n)$ to the members of the organization. For feasibility of the transfer, we assume $\Sigma_{i\in I}\, t^i = 0$ must always be satisfied. This contract is incomplete in the sense that it only enforces the choice of α and transfer payment t. Any contingent specification of period 2 operation and/or period 3 distribution of organizational return as a function of the first period effort choice and/or realized organizational returns written in period 1 is non-enforceable. Similarly, we assume that any contingent specification of period 3 distribution of organizational return as a function of period 2 authority decisions in period 2 is non-enforceable in the major part of this paper. The latter assumption will be relaxed, however, in section 5. We take these approaches, because we assume uncertainties concerning future are too complicated and non-significant transaction costs make it uneconomical to write a contingent contract. Consequently, workers choose x (and y) non-cooperatively.

We assume that the outcome of the period 3 negotiation will be characterized by the *Nash Bargaining Solution*, i.e., the return $R(x, y)$, net of sum of the bargainers' outside options, is divided equally among the members of $I(x, y)$. Hence, the return for member i will be:

$$u^i(x,\ y) = \begin{cases} \dfrac{[R(x\ ,y)\ -\ V_o(x,\ y)]}{|I(x,\ y)|} + v_o^i & \text{if } i\in I(x,\ y) \\ v_o^i & \text{otherwise} \end{cases} \qquad (1)$$

where $|\,I(x, y)\,|$ is the cardinality of the set $I(x, y)$ and $V_o(x, y) \equiv \Sigma_{h\in I(x,y)} v_o^h$. Note that our definition of $V_o(x, y)$ implies that, when a worker loses bargaining power, he will leave the organization and receive his outside option from outside. Alternatively, we can assume that, even if he loses bargaining power, he will stay within the organization and receive his outside option from this organization. This distinction is not crucial for most of what follows. Proposition 1 and related discussion, however, crucially depends on the assumption.

Members of the organization will expect the period 3 payoffs, $u^i(x, y)$, once (x, y) is determined. This naturally defines a game in period 2 and we assume that how members exercise

authorities is determined as a Nash equilibrium of this game, which is denoted as $y(x, \alpha)$. That is:

$$y^i(x, \alpha) = \underset{y^i \in Y^i(\alpha)}{\text{argmax}}\ u^i(x, y^i, y^{-i}) \quad \textit{for all } x, \alpha \textit{ and } i \in I. \tag{2}$$

where $y^{-i} \equiv (y^h)_{h \neq i}$. Given u^i, the expected payoff for each member i, $v^i(x,\alpha)$, after period 1 effort, x, and delegation structure, α, are determined as:

$$v^i(x, \alpha) \equiv u^i(x, y(x, \alpha)) \qquad \textit{for all } x, \alpha \textit{ and } i \in I. \tag{3}$$

This payoff, in turn, defines the game played in period 1 and, again, we assume (subgame perfect) Nash equilibrium to be the relevant solution concept. More formally, the outcome of period 1 effort levels must be $x(\alpha)$ where:

$$x^i(\alpha) = \underset{x^i \in X^i}{\text{argmax}}\ [v^i(x^i, x^{-i}(\alpha), \alpha) - c^i(x^i)] \quad \textit{for all } i \in I, \tag{4}$$

where $x^{-i}(\alpha) \equiv (x^h(\alpha))_{h \neq i}$. This will determine the expected payoff that each member of the organization expects to receive once he joins the organization, $w^i(\alpha)$, where:

$$w^i(\alpha, t,) \equiv v^i(x(\alpha), \alpha) - c^i(x^i(\alpha)) - t^i. \tag{5}$$

The principal can choose only those contracts which satisfy the participation constraints for members. The set of such contracts are denoted as:

$$A(v_o) \equiv \left\{ (\alpha, t) \;\middle|\; \begin{array}{c} w^i(\alpha, t) \geq v_o^i, \quad v^i(x(\alpha), \alpha) \geq v_o^i \\ \textit{for all } i \in I \textit{ and } \sum_{i \in I} t^i = 0 \end{array} \right\} \tag{6}$$

Finally, the principal, the member 0, chooses the delegation structure and the transfer payments that maximizes her expected return given the participation constraint, (α^*, t^*), i.e.,

$$(\alpha^*, t^*) \in \underset{(\alpha, t)\in A(v_o)}{\operatorname{argmax}} \; w^0(\alpha, t). \tag{7}$$

Note that, as we shall prove in the next section, the (second-best) optimal contract (α^*, t^*) not only maximizes the principal's expected return, but also maximizes the total expected return for the organization given the participation constraints, because we allowed the side payments at the beginning of period 1.

In what follows, we shall assume the following:

A.1: $R(x, y)$ is non-decreasing in x and y. Moreover, it is strictly increasing, except $R(x, y)$ is equal to $R(x, y')$ when $y_j = y_j'$ for all $j \neq i$, but $y_i \neq y_i'$ and $x^i = 0$.

Hence, $R(x, y)$ is strictly increasing in x and y, except it is constant-valued in y_i if $x^i = 0$. Namely, period 1 effort of member i as well as use of i's specific knowledge (decision $y_i = 1$) is productive, but it is not if i did not invest in specific asset in period 1 (i.e., $x^i = 0$). We also assume:

A.2: $i \in I(x, y)$ if and only if $x^i > 0$ and $y_i = 1$.

That is, the member i will have bargaining power in negotiation if and only if i invests in relation-specific asset and a decision is made to utilize his specific knowledge.

3. *Ex Ante* and *Ex Post* Incentives

In this section, we examine how *ex ante* as well as *ex post* incentives are affected by different authority structure. We first note that the delegation structure, α^*, associated with the (second) best contract, (α^*, t^*), must be efficient in the sense it maximizes the total organizational return, $\Sigma_{i\in I} w^i(\alpha^*, t^*)$. For, otherwise, the principal can obtain higher return by employing the efficient delegation

structure and absorbs the additional return through *ex ante* transfers. Thus, we state without proof:

Lemma 1: If the set $A(v_o)$ is non-empty and hence (α^*, t^*) exists, then:

$$(\alpha^*, t^*) \in \underset{(\alpha, t)\in A(v_o)}{argmax} \sum_{i\in I} w^i(\alpha, t). \tag{8}$$

(1) *ex post* incentive problem:

The way authorities are delegated affects incentives of the members in two ways; through effects on period 2 decisions, y, after x is chosen, and through effects on period 1 decisions, x. We first analyze the effects through period 2 decisions, or *ex post* efficiency question. To illustrate this problem, consider the following example.

Example 1

Consider an organization consisting of the principal and two workers. Outside options are zero for all members. For both workers, the first period effort choice (i.e., x) takes values of either 0 or e (> 0) with $c^i(0) = 0$ and $c^i(e) = C > 0$. There is a project within the organization and workers' period 1 effort is specific to this project. Second period decision y_i specifies whether in period 3 worker i can work in the project ($y_i = 1$) and exercise his specific knowledge, or excluded from the project ($y_i = 0$). For example, if $y = (1,1)$ both workers stay on the project, while if $y = (1,0)$ only worker 1 stays on the project. We assume the total organizational return, $R(x, y)$, is maximized when $(x, y) = (e,e,1,1)$ and the authorities should be delegated to implement the first best decisions. Suppose workers have chosen e.

Suppose the following inequality holds:

$$\frac{1}{2} R(e,e,0,1) < \frac{1}{3} R(e,e,1,1) < \frac{1}{2} R(e,e,1,0). \tag{9}$$

The term in the center represents the principal's and worker 1's income from the bargaining if $y =$

(1,1) is chosen, while the term in the right represents the income for worker 1 and the principal when $y = (1,0)$ is chosen, leaving no bargaining power and hence no income to worker 2. Given the period 1 choice of (e, e), both the principal as well as worker 1 have incentives to exclude worker 2 from participating in period 3 negotiation. This incentive may be harmful for the organization, since it diminishes the worker 2's incentive for period 1 effort. On the other hand, by the first inequality, the worker 2 has no incentive to exclude worker 1. It follows that the authority for y_2 should be delegated to worker 2 so that neither the principal nor worker 1 can exclude him from the project.

Notice that the above pair of inequalities can be written as follows:

$$\begin{aligned} \Delta R_1^{ep}(e,e,0,1) \equiv R(e,e,1,1) - R(e,e,0,1) > \tfrac{1}{3} R(e,e,1,1) \\ > \Delta R_2^{ep}(e,e,1,0) \equiv R(e,e,1,1) - R(e,e,1,0). \end{aligned} \tag{10}$$

That is, worker 1's knowledge is more productive than worker 2's in period 3. This result is not a coincidence. The decision to utilize some member's specific knowledge gives two opposite incentives to other members. First, it increases the total organizational return, the effect which benefits all members of the organization who have bargaining power. We call this the *output effect*. Second, this decision may provide bargaining power to the member with specific knowledge, the effect which diminishes other members' share. This effect will be called the *distribution effect*. The smaller the i's marginal productivity ΔR_i^{ep} the more dominant the distribution effect becomes, and the incentive not to utilize i's knowledge increases. This observation suggests that, in order to accommodate *ex post* incentive, it is often desirable to delegate authorities to less productive members of the organization.

More formally, we can characterize the *ex post* incentives in exercising period 2 decisions, y. For that purpose, fix (α, x) and let $y^* = y(x, \alpha)$, the non-cooperative period 2 decisions given (α, x). If $x^i > 0$ and the member i invests in specific assets, in view of **A.1**, the organizational return, $\mathbf{R}(x, y)$, is maximized by setting $y_i = 1$ and utilizing his specific knowledge. However, it does not necessarily follow that α implements $y_i = 1$. Formally:

Lemma 2: If $x^i > 0$, then $y_i^* = 1$ if and only if either (i) or (ii) holds:

(i) $i \in \alpha(i)$, *or*

(ii) $i \in \alpha(j)$ $(i \neq j)$ *and for all* $y^j \in Y^j(\alpha)$

$$\frac{[R(x, y^*) - V_o(x, y^*)]}{|I(x, y^*)|} \geq \frac{[R(x, y^{-j*}, y^j) - V_0(x, y^{-j*}, y^j)]}{|I(x, y^{-j*}, y^j)|} \tag{11}$$

where $y^{-j*} = (y^h)_{k \neq j}$.

By (i), if $i \in \alpha(i)$ (the member i is delegated the decision y_i), then he will always choose $y_i = 1$ because, by doing so, he can simultaneously assure himself that the total organizational return be maximized and that he be included in the set of bargaining members. By (ii), if j $(\neq i)$ has the authority to decide y_i, he weighs two effects, the output effect and the distribution effect, in making this decision. First, if he chooses $y_i = 1$, the organizational return, $\mathbf{R}(x, y)$, will increase and the total pie from which he gets his share increases, implying that the output effect is always positive. Second, if he chooses $y_i = 0$, i will be excluded from the set of bargaining members and j's share in bargaining outcome increases, implying the distribution effect is always negative. The condition (ii) is rather complicated because j may have authorities to utilize other members' specific knowledge. Eliminating these members, in addition to i, from the set of bargaining members may be beneficial for j, while eliminating j alone may not.

In order to illustrate the condition (ii), restrict our attention on j's choice on y_i. Formally, suppose $i \in \alpha(j)$ with $i \neq j$ so that the authority to utilize i's knowledge is in the hand of $j \in \mathrm{I}(x, y^*)$. Define y and y' so that $y_h = y'_h = y_h^*$ for all $h \neq j$, while $y_j = 1$ and $y'_j = 0$. Namely, decisions y and y' are the same as y^* except $y_i = 1$ for y but $y_i = 0$ for y', hence either $y = y^*$ or $y' = y^*$ must hold. In view of A.2, $i \in \mathrm{I}(x, y)$ but $i \notin \mathrm{I}(x, y')$. Let $|\mathrm{I}(x, y)| = \ell$ and $|\mathrm{I}(x, y')| = \ell - 1$. Under A.1 - A.3, it follows from lemma 2 that:

$$y^{j*} = 1 \quad \textit{if and only if} \quad \frac{1}{l}[R(x, y) - V_o(x, y)] \geq \frac{1}{l-1}[R(x, y') - V_o(x, y')]. \tag{12}$$

As $V_o(x, y) - V_o(x, y') = v_o^i$, this condition can be written as:

$$\Delta R_i^{ep} - v_o^i \equiv R(x, y) - R(x, y') - v_o^i \geq \frac{1}{l}[R(x, y) - V_o(x, y)]. \tag{13}$$

That is, the member j, who is endowed with the authority to decide about i's knowledge, chooses to do so if the incremental return by utilizing i's specific knowledge exceeds i's outside option at least by the per capita bargaining payoff obtained by utilizing i's knowledge. This gives rise to the following proposition.14-25

Proposition 1: Suppose the decision y_i is held in the hand of j ($\neq i$) and $x^i > 0$. Then j is more likely to choose $y_i = 1$ if either (i) ΔR_i^{ep} is larger or (ii) v_p^i is smaller.[4]

Delegation structure can be designed with less attention on *ex post* incentives when the output effect becomes more significant. This happens if (i) marginal productivity of member's knowledge is larger, and/or (ii) member's outside option is lower. If outside options for workers are low, as for workers in Japan where low labor mobility makes it costly for workers to move across firms, their bargaining power (though positive) is relatively small. It follows that, even if utilizing i's knowledge and allowing i into the bargaining set, i's share from the bargaining is relatively small and other bargaining members will gain more, making the output effect more likely to dominate the negative distribution effect. In such cases, authority can be delegated so that *ex ante* incentives (and other incentives associated with authority delegations) are solved more efficiently. Otherwise, an assured way to provide proper *ex post* incentives is to delegate the authority for y_i to himself. However, doing

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[4]If $\alpha(j) = \{i\}$, i.e., y_i is the only authority that j possesses, then "if" in this proposition should be replaced by "if and only if".

so would give i an incentive to choose $y_i = 1$ regardless of other decisions. From *ex ante* viewpoint, this may be harmful to the organization.

(2) *ex ante* incentive problem:

In the incomplete contract framework, the "hold up problem" may exist, that is, the incentive of the first period effort, x, tends to be too small for the organization because the return from this effort may be spilled over to other members *via* period 3 negotiation. By choosing the delegation structure appropriately, however, the organization is sometimes able to control this incentive problem. In this subsection we shall show, by excluding some workers from the bargaining member (when the realized x is small), the organization may be able to improve *ex ante* incentive for x when the principal can commit to the delegation structure. To illustrate, we start with an example.

Example 2

Suppose the organization consists of the principal and one agent. Effort of the agent takes values of either 0, e_L, or e_H with costs of 0, $c(e_L)$ and $c(e_H)$. Period 2 decision, y, determines if the agent can remain in the project in which he can exercise his relation-specific skills in period 3 (y = 1) or not ($y = 0$). For simplicity, all outside options are assumed to be zero. Furthermore, we assume:

$$R(e_H, 1) - c(e_H) > R(e_L, 1) - c(e_L) > 0$$
$$\frac{1}{2} R(e_L, 1) - c(e_L) > \frac{1}{2} R(e_H, 1) - c(e_H) > 0. \qquad (14)$$

By the first inequality, e_H produces larger net organizational return than e_L, and the principal wants to implement $(e_H, 1)$. However, by the second inequality, if he is assured to have bargaining power and to receive $R(e, 1)$ whether or not $e = e_H$ or e_L, he chooses the inefficient effort level e_L. This is the "hold-up problem". Therefore, the authority of the decision, y, should not be completely delegated to him, for he has the incentive to include himself in the project in order to get the bargaining power.

Suppose the following set of inequalities are satisfied in addition to (14):

$\frac{1}{2} R(e_L, 1) < R(e_L, 0)$, $\frac{1}{2} R(e_H, 1) > R(e_H, 0)$.

Then, this incentive problem can be solved if the authority is given to the principal. The first inequality assures that the principal wants to exclude the agent when his effort is e_L, while the second inequality assures the agent be included in the project when he choose e_H.

More formally, in order for x^* to be implemented under the delegation structure α, the following incentive constraint must be satisfied for all i and $x^i \in X^i$,

$$u^i(x^*, y(x^*, \alpha)) - C^i(x^{*i}) \geq u^i(x^{*-i}, x^i, y(x^{*-i}, x^i, \alpha)) - C^i(x^i). \tag{15}$$

That is, for any member of the organization, i, there is no unilateral incentive to choose period 1 effort other than x_i^*, if he anticipates period 2 decisions are also chosen non-cooperatively.

Suppose i anticipates to be in the set of bargaining members whether or not he unilaterally deviates in period 1, i.e.,

$$i \in I(x^*, y(x^*, \alpha)) \quad and \quad i \in I(x^{*-i}, x^i, y(x^{*-i}, x^i, \alpha)). \tag{16}$$

Suppose further that the above inequality is not satisfied for some x^i. The inequality (15) is written as:

$$\begin{aligned} &\frac{[R(x^*, y(x^*, \alpha)) - V_o(x^*, y(x^*, \alpha))]}{|I(x^*, y(x^*, \alpha))|} - C^i(x^{*i}) \\ &< \frac{[R(x^{*-i}, x^i, y(x^{*-i}, x^i, \alpha)) - V_o(x^{*-i}, x^i, y(x^{*-i}, x^i, \alpha))]}{|I(x^{*-i}, x^i, y(x^{*-i}, x^i, \alpha))|} - C^i(x^i). \end{aligned} \tag{17}$$

If this new inequality holds, the member i will have incentive to choose x^i and the delegation structure, α, fails to implement x^*.

In this case, the organization may be able to provide a proper *ex ante* incentive to i by excluding him from the set of bargaining members only when he chose x^i. Namely, suppose an alternative delegation structure, α', is the same as α and provides precisely the same incentive as α except:

$$i \notin I(x^{*-i}, x^i, y(x^{*-i}, x^i, \alpha')), \quad i \in I(x^*, y(x^*, \alpha')). \quad (18)$$

Then, by choosing x^i, i will have no bargaining power in period 3 and receives income only of v^i_o, the outside option, and the incentive constraint may be satisfied. The condition (18) implies as follows: First, under the delegation structure α', the authority for y_i is delegated to some member other than i, say j. Second, if i chooses x^i, j will have *ex post* incentive to choose $y_i = 0$ so that i will not be included in the set of bargaining members. Third, if i chooses x^{i*} instead, j will have *ex post* incentive to choose $y_i = 1$.

To sum up, when the organization wants to implement x^*, the worker i may be better excluded from the set of bargaining members, when (x^{*-i}, x^i) is chosen, in order to create proper *ex ante* incentive. It should be noted, however, moving authority for y_i from the hand of i to another member j not only changes *ex ante* incentive for i, but also may change *ex post* incentives for i, j, or other members of the organization.

4. Example of Two sector Organization

In the previous sections, we have only dealt with the one sector organization and assumed all members of the organization negotiate together in period 3. However, an organization may consists of two (or more) sectors and the allocation of each sector's return may be negotiated separately. In such cases, the delegation structure may become more complex, but some interesting results can be derived. We shall illustrate this fact by the following example.

Example 3: Authority for Help[5]

Suppose there are two sectors, I and II, and two workers, 1 and 2. Productivity of each sector is observed separately. Worker i = 1, 2 is responsible for sector I and II respectively, but they may work in the other sector in period 3, which we call "help". In order to make any contribution by helping sector j's production, a positive investment in the specific effort, $x^i(j)$ for i = 1 and j = II or i = 2 and j = I, is necessary in period 1. Decisions in period 2 in this case specify the help assignment in period 3:

$$y = (y_{I2}, y_{II1})$$

where y_{ji} takes 0 or 1. If $y$ji = 1 the worker i = *1, 2* is assigned to help in sector j = I, II, while if y_{ji} = 0, i is not allowed to help in j and the specific effort $x^i(j)$ becomes meaningless. Furthermore, it is assumed that all outside potions are zero.

When y = (1,1), the set of bargaining members who negotiate over the allocation of sector j's return, $I_j(x, y)$ = {0,1,2} for j = I, II, and the bargaining payoff outcome becomes,

$$\tfrac{1}{3}\,[R^I(x^2(I), 1) + R^B(x^1(II), 1)],$$

for all agents. On the other hand, when y = (0,0) and workers are not to help other workers, $I_I(x, y)$ = {0,1} while $I_{II}(x, y)$ = {0,2} and the bargaining payoff outcome becomes[6],

Principal receives, $\frac{1}{2}\,[R^I(x^2(I), 0) + R^{II}(x^1(II), 0)]$

Worker 1 receives, $\frac{1}{2}\,R^I(x^2(I), 0)$

Worker 2 receives, $\frac{1}{2}\,R^{II}(x^1(II), 0)$.

We assume that $x^i(j)$ take values of 0 or $e > 0$, while $c(0) = 0$ and $c(e) = C > 0$. We also assume $R^j(x, y) = R(x, y)$ for j = I, II, $x = 0, e$, $y = 0, 1$, and $R(e, 1) > \tfrac{1}{3}\,R(e, 1) > C$.

We examine the following three alternative delegation structures:

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[5]Problems of "Help" or "Multi-Task" situation have been analyzed, for example, by Itoh [1989a] and Holmstrom and Milgrom [1990a] and [1990b]. These papers, however, focused about problems of moral hazard.

[6]Implicitly, we are assuming that worker i has bargaining power in his responsible sector.

(α) Principal decides all help assignments: $(y_{I2}, y_{II1}) \in \alpha(0)$.

(α') Each worker decides his own help: $y_{II1} \in \alpha(1)$ and $y_{I2} \in \alpha'(2)$.

(α") Worker 1 (2, resp.) decides whether or not to allow help: $y_{II1} \in \alpha''(2)$ and $y_{I2} \in \alpha''(1)$.

In what follows, (α) is sometimes called the *centralized* decision structure, (α') the *individualized* decision structure, and (α") the *responsibility* structure.

When $\frac{1}{3} R(e,1)/3 < \frac{1}{2} R(e,0)/2$, the principal should choose $y = (0,0)$ under (α). The payoff outcome for each player is $U^0 = R(e, 0)$, $U^1 = \frac{1}{2} R(e, 0)$ and $U^2 = \frac{1}{2} R(e, 0)$. Hence, if $\frac{1}{2} R(e, 0) < C$ holds, neither agent chooses the positive effort level, e. This means that the efficient effort choice is not realized under the delegation structure (α).

Under the same condition, the responsibility structure (α") will not realize $y = (1,1)$ either. Under this structure, a worker will have no incentive to accept help, because accepting help will add an extra bargaining participant in his sector and, consequently, reduce his own payoff under the assumed condition. In other words, a worker (say, 1) has an incentive to change the decision from $y_{I2} = 1$, which accepts help from worker 2, to $y_{I2} = 0$, which rejects help from 2.

Under the delegation structure (α'), however, even if $\frac{1}{3} R(e, e) < \frac{1}{2} R(e, 0)$, the non-cooperative decision choice becomes $y = (1,1)$. The reason is simple. Under the delegation structure (α'), each worker can decide his own help. If worker 1 chooses $y_{II1} = 0$, he loses his bargaining power and gets nothing from the sector II. Hence he chooses $y_{II1} = 1$. By the same reasoning, worker 2 always choose $y_{I2} = 1$ in order to assure bargaining power for himself. As $y = (1,1)$ are assured, both workers choose the positive effort level and the efficient outcome is realized. It follows that the principal prefers the individualized delegation structure (α') most among the three possible delegation structures.

5 Renegotiation in the second period

In the previous sections, we have assumed that renegotiation is possible only in period 3. This

assumption is, we believe, quite natural. But in some situations, renegotiations about decisions y may be possible in the second period. In such cases, renegotiations would produce a binding contract which specifies; (a) the choice of second period decision of each member and (b) the allocation of the organization return among the members[7]. As information is perfect, the period 2 bargaining will choose the decisions y so as to maximize $R(x, y)$ irrespective of delegation structure. It follows that the total organizational return is independent of the original delegation structure (α), and α only affects the default payoff (threat value) of each member. If the bargaining in the second period breaks down, the decisions are chosen by the principal and each worker non-cooperatively. Hence the non-cooperative equilibrium payoff for each worker analyzed in the previous sections, (i.e. the equilibrium return when the second period negotiation is impossible), $\boldsymbol{u}$, becomes the default payoff of this bargaining. The bargaining payoff for worker i increases if the default payoff for worker i, u^i, rises relative to other members. In short, the choice of delegation structure may become important when it changes the period 2 bargaining outcome through a change in default payoffs, which in turn affects the *ex ante* incentive of workers. In what follows, we shall illustrate this effect by an example.

Example 4: Authority to approve projects:

Consider an organization consisting of the principal and two workers. In period 1, each worker develops his own project (worker 1's project will be called the project 1 and worker 2's the project 2). The quality of developed project depends upon period 1 effort, x, of the worker who develops it. For simplicity, we assume the effort level x can take value of either e (> 0) or 0, and it costs the worker C to choose $x = e$ (i.e., $c(e) = C$) but nothing to choose $x = 0$ (i.e., $c(0) = 0$). In period 2, whether or not each project be carried out is decided. Let y_i be the decision about worker i's project ($i = 1, 2$), and $y_i = 1$ (0, respectively) implies that the project i be approved (rejected, resp.).

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[7]The importance of the possibility of renegotiation within an organization was explored by Tirole [1986].

We assume that (i) if worker i chooses 0 for period 1 effort, the resulting organizational return is the same whether or not the i's project is carried out in period 2, and (ii) if i's project is rejected in period 2, even if period 1 effort is e, the resulting organizational return is the same as 0 effort. For simplicity, we shall use the following notations:

$$\Pi(e, e) = R(e, e; 1, 1),$$

$$\Pi(e, 0) = R(e, e; 1, 0) = R(e, 0; 1, 1) = R(e, 0; 1, 0)$$

$$\Pi(0, e) = R(e, e; 0, 1) = R(0, e; 1, 1) = R(0, e; 0, 1)$$

$$\Pi(0, 0) = R(e, e; 0, 0) = R(0, 0; 1, 1) = R(0, e; 1, 0) = R(e, 0; 0, 1).$$

It is further assumed:

A.4.1: $\Pi(e, e) - 2C > \Pi(e, 0) - C > \Pi(0, e) - C,$

A.4.2: $\frac{1}{2}\Pi(e, 0) > \frac{1}{2}\Pi(0, e) > \frac{1}{3}\Pi(e, e).$

By **A.4.1**, from efficiency viewpoint, it is better to induce both workers to provide positive effort, e, in period 1 and carry out the project, but worker 1's effort is more important than worker 2's for the organization. By **A.4.2**, members of the organization has incentive to exclude other members from period 3 bargaining. We shall examine the outcome of period 2 renegotiation for several different delegation structures.

Delegation Structure (α): $\{y_1 \in \alpha(0),\ y_2 \in \alpha(1)\}$.

Under this delegation structure, the principal has authority to decide the future of the project 1, while worker 1 has the authority of the project 2. First, we examine the outcome of period 3 bargaining and the default payoffs for period 2 renegotiation.

Suppose both workers chose e in period 1. If both projects are approved, period 3 bargaining will be negotiated by the principal and two workers, and will yield the following bargaining payoffs:

$$u^0 = \frac{1}{3}\Pi(e, e),\ u^1 = \frac{1}{3}\Pi(e, e),\ u^2 = \frac{1}{3}\Pi(e, e),$$

where u^i is the payoff for i. On the other hand, if the principal adopts the project 1 but worker 1 rejects the project 2, the bargaining will be negotiated by the principal and worker 1[8], and it will yield:

$$u^0 = \tfrac{1}{2}\,\Pi(e, 0),\ u^1 = \tfrac{1}{2}\,\Pi(e, 0),\ u^2 = 0.$$

If the principal rejects but worker 1 adopts, then:

$$u^0 = \tfrac{1}{2}\,\Pi(0, e),\ u^1 = 0,\ u^2 = \tfrac{1}{2}\,\Pi(0, e).$$

Finally, both rejects the proposed projects, then:

$$u^0 = \Pi(0,0),\ u^1 = 0,\ u^2 = 0.$$

This determines the period 2 non-cooperative game among three players (the principal and workers 1 and 2) whose payoffs are summarized in Table 1.

0 2	approve	reject
approve	⅓ $\Pi(e, e)$, ⅓ $\Pi(e, e)$, ⅓ $\Pi(e, e)$	$\frac{1}{2}\,\Pi(e, 0)$, $\frac{1}{2}\,\Pi(e, 0)$, 0
reject	$\frac{1}{2}\,\Pi(0, e)$, 0, $\frac{1}{2}\,\Pi(0, e)$	$\Pi(0,0)$, 0, 0

Table I

By **A.4.2**, the game of Table 1 has two Nash equilibria, (approve, reject) and (reject, approve). However, the second equilibrium requires worker 1 choosing *Approve* which is a weakly dominated strategy. Hence, we shall assume (approve, reject) is the unique equilibrium of the game with Table 1. It follows that the period 3 bargaining equilibrium (and period 2 default) payoff outcome is:

$$(v^0(e, e), v^1(e, e), v^2(e, e)) = (\tfrac{1}{2}\,\Pi(e, 0), \tfrac{1}{2}\,\Pi(e, 0) - C, - C).$$

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[8]A new additional project may be carried out to substitute worker 2's project, but we assume neither worker 2 nor new worker, who will be hired to carry out this project, will have no bargaining power.

Delegation Structure (α'): $\{y_1 \in \alpha(2), y_2 \in \alpha(0)\}$.

Period 2 non-cooperative game and their outcome for this delegation structure are similarly defined. Table II depicts payoff matrix for the case of (e, e). The equilibrium of this matrix game is (approve, reject).

0 2	approve	reject
approve	⅓ Π(e, e), ⅓ Π(e, e), ⅓ Π(e, e)	½ Π(0, e), 0, ½ Π(0, e)
reject	½ Π(e, 0), ½ Π(0, e), 0	Π(0,0), 0, 0

Table II

No Delegation (α''): $\{y_1 \in \alpha(0), y_2 \in \alpha(0)\}$

If the principal does not delegate the authority she can fire both workers, and under the assumed condition, she chooses to approve worker 1's project but rejects worker 2's project.

We now analyze how the organizational performance will be determined for each delegation structure when period 2 renegotiation is allowed. Recall that the negotiated outcome for the choice (e, e) will be always be efficient, i.e., $y_1 = y_2 = 1$, regardless of the delegation structure. However, the payoff outcomes may differ as the default payoffs are different. In the case of delegation structure (α), the default payoffs being:

$$(v^0(e, e), v^1(e, e), v^2(e, e)) = (\tfrac{1}{2}\,\Pi(e,0), \tfrac{1}{2}\,\Pi(e, 0) - C, - C),$$

the period 2 renegotiation will provide each member the following incomes:

$$V^0 = \tfrac{1}{3}\,\{\Pi(e, e) + 2v^0 - v^1 - v^2\} = \tfrac{1}{3}\,\Pi(e, e) + \frac{1}{6}\,\Pi(e, 0),$$

$$V^1 = \tfrac{1}{3}\{\Pi(e, e) + 2v^1 - v^0 - v^2\} = \tfrac{1}{3}\Pi(e, e) + \tfrac{1}{6}\Pi(e, 0),$$

$$V^2 = \tfrac{1}{3}\{\Pi(e, e) + 2v^2 - v^0 - v^1\} = \tfrac{1}{3}[\Pi(e, e) - \Pi(e, 0)].$$

Similarly in the case (α'), the default payoff outcome becomes, and

$$(v^0(e, e), v^1(e, e), v^2(e, e)) = (\tfrac{1}{2}\Pi(0,e), -C, \tfrac{1}{2}\Pi(0,e) - C), \text{ and}$$

$$V^0 = \tfrac{1}{3}\{\Pi(e, e) + 2v^0 - v^1 - v^2\} = \tfrac{1}{3}\Pi(e, e) + \tfrac{1}{6}\Pi(0, e)$$

$$V^1 = \tfrac{1}{3}\{\Pi(e, e) + 2v^1 - v^0 - v^2\} = \tfrac{1}{3}[\Pi(e, e) - \Pi(0, e)]$$

$$V^2 = \tfrac{1}{3}\{\Pi(e, e) + 2v^2 - v^0 - v^1\} = \tfrac{1}{3}\Pi(e, e) + \tfrac{1}{6}\Pi(0, e).$$

In the case (α"), the default outcome and the bargaining outcome V^i's are the same as in (α').

We can then check the implication of different delegation structures on first period effort incentives. If, for example,

$$\tfrac{1}{3}[\Pi(e,e) - \Pi(0,e)] < C < \tfrac{1}{3}[\Pi(e,e) - \Pi(e,0)],$$

both workers have incentive to invest in specific effort, i.e., $x = e$, only when delegation structure (α) is adopted. Hence it is optimal (from the principal's *ex ante* viewpoint) to delegate the authority to worker 1 in this case.

Note that in this example *ex ante* effort of worker 1 is less productive (to the organization) than worker 2, but the principal should delegate a part of his authority to this less important worker. This is similar to the property we discussed in the section 3 on *ex post* incentive. If other members (say, member 2) are given the authority to utilize worker 1's knowledge, worker 2 has incentive to deprive of worker 1's bargaining power. This incentive would make worker 1's default payoff, and hence return from period 2 renegotiation, too small to cover cost for his period 1 effort.

6 Asymmetric Information Cases and Conclusion

In this paper, we have shown that the outcomes of organizational activities depend crucially on how the authority structure is designed because it affects incentives of the organizational members. There are two different incentives we focused in the paper; *ex ante* and *ex post* incentives. One of our findings was, from the viewpoint of *ex post* incentives, delegating authority to utilize a member (say, i)'s specific knowledge to others (say, j) may harm the organization's interest because of the distribution effect. The output tends to dominate this adverse distribution effect if marginal productivity of i's specific knowledge is larger. It follows that, more productive a member is, with less cost to the organization the authority to utilize his knowledge can be delegated to other members. In view of such observation, we emphasized that, in many cases, authorities should be delegated to those members who contribute less to the organization.

One way to overcome this adverse distribution effect is to give the authority to i himself. However, this may distort i's *ex ante* incentive. If outside option for i, v_o^i, is low, the problem of *ex post* incentives is mitigated even if the authority it given to j as benefit of utilizing i's specific knowledge will be appropriated more fully to members other than i. It follows that, in an organization where members' outside options are low, authority delegation is designed more freely to enhance efficiency of organizational activities.

One of the critical factors in designing delegation structure, though we did not explicitly examined in this paper, is information. An explicit consideration of information would introduce several new aspects in understanding the optimal delegation structure. One such aspect is that delegating authority to the member who has private information would facilitate organization's decisions to reflect information more fully. For example in Japan, it is often pointed out that authorities are often delegated to lower levels in the organizational hierarchy[9], where the "on the spot" information is available. This fact may be explained by our theoretical findings above: in Japan,

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[9]See, for example, Lincoln and Kalleberg [1986], Lincoln and McBride [1990] and Itoh [1991b].

reflecting workers' immobility across firms, outside options for members are lower than other countries and the problem of *ex post* incentives may not be so serious. It follows that authorities in Japan may be delegated to lower levels in order to coordinate organizational decisions with on the spot information more effectively.

However, the existence of private information may create other problems. In particular, delegating authorities to the members who have private information may provide opportunities for them to extract information rents and/or affect *ex ante* incentives by changing the allocation of organizational return. To examine whether the merit of facilitating decisions to reflect private information dominates the demerit of allowing monopoly power, which arises from private information, to be exercised requires a careful analysis of the optimal delegation under asymmetric information. We leave the analysis of this interesting and important problem to another occasion.

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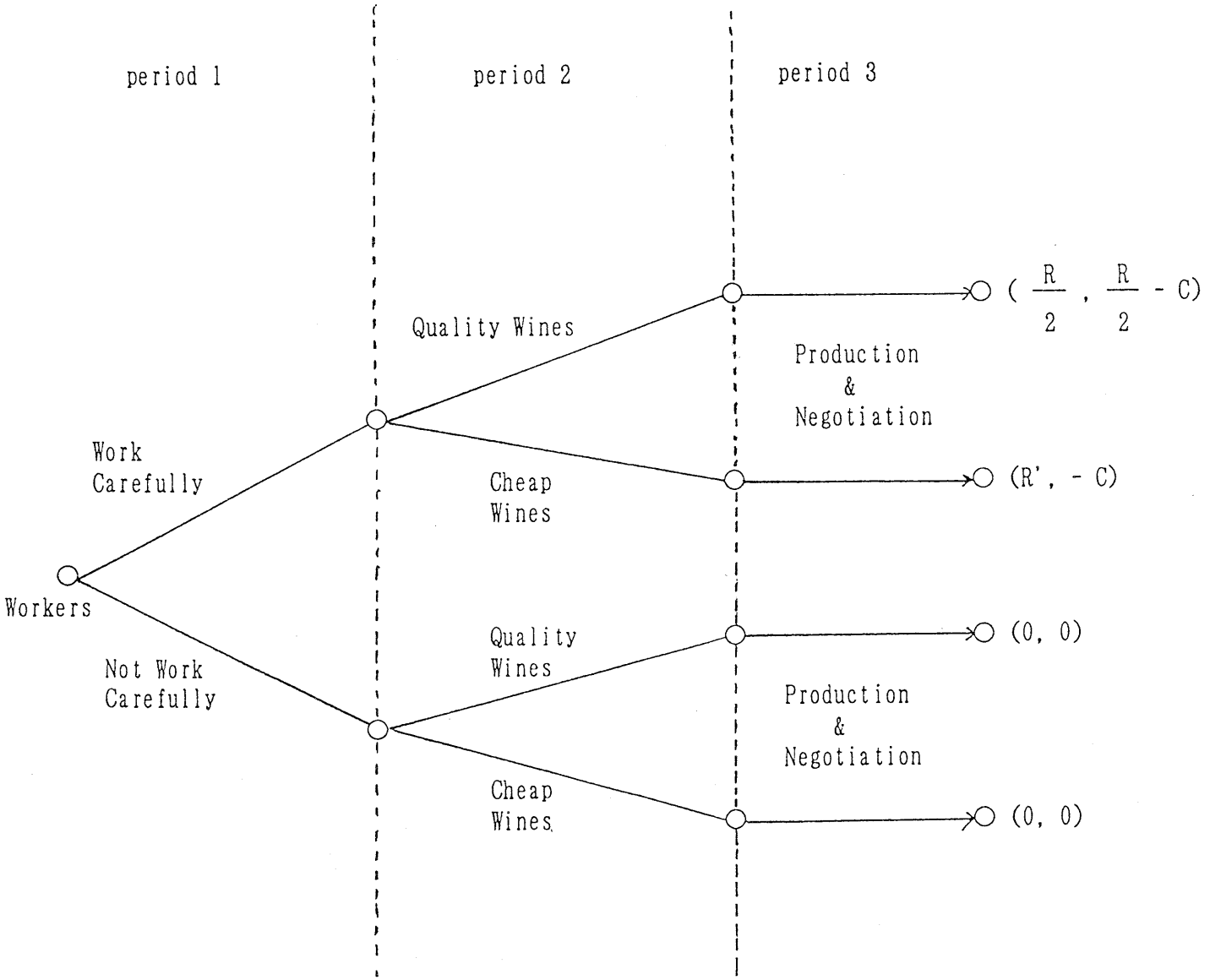
period 1
period 2
period 3
Workers
Work Carefully
Not Work Carefully
Quality Wines
Cheap Wines
Quality Wines
Cheap Wines
Production & Negotiation
Production & Negotiation
(R/2 , R/2 - C)
(R', - C)
(0, 0)
(0, 0)

Figure 1