Center for Economic Institutions

Working Paper Series

CEI Working Paper Series, No. 2002-7

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Center for Economic Institutions

Working Paper Series

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Extremely Preliminary

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* This work was started during my visit to the Institute of Economic Research, Hitotsubashi University. I am very grateful to Katsuyuki Kubo and Yupana Wiwattanakantang for stimulating discussions, and to the Institute for warm hospitality. The usual disclaimer applies.

1. Introduction

The so-called separation of ownership and control (Berle and Means, 1932; Fama and Jensen, 1983) pertains to the fact that the nominal owners of corporations - shareholders - delegate authority to managers. The authority is vested in several important dimensions for the top managers of corporations. They make executive decisions that set directions for corporations, employ subordinates and contract with external suppliers. This multiple dimension of authority is a deciding factor for the organizational form of corporations. Rather than a set of two-tier hierarchies in which owners are at the top of each two-tier hierarchy, modern corporations are organized mostly as multi-tier hierarchies. In typical multi-tier hierarchies, shareholders hire top managers - through boards - and managers, in turn, hire subordinates or contract with external suppliers. Why are such multi-tier hierarchies, rather than multiple two-tier hierarchies, often the norm? Why are managers, instead of subordinates, at the center of the multi-tier hierarchies? This study attempts to provide answers to these questions.

A typical explanation for delegation is based on managers' expertise. According to Jensen and Murphy (1990, p. 251), "Managers often have better information than shareholders and boards in identifying investment opportunities and assessing the profitability of potential projects; indeed, the expectation that managers will make superior investment decisions explains why shareholders relinquish decision rights over their assets by purchasing common stocks". Underlying this explanation is the assumption that communicating managers' information to shareholders or boards is costly. For, otherwise, shareholders or boards will be able to make decisions based on the information that managers have.

Several studies have formalized this line of explanation in the context of the revelation mechanism. Melumad et al. (1995) show that the outcome of an optimal revelation mechanism can be achieved using decentralized contracts and proper sequencing of the contracts. Thus their main point is that, when various contracting costs such as those of communicating information for the revelation mechanism are taken into account, there may be benefits to delegation. Laffont and Martimort (1998) show that delegation can dominate centralized contracts when the possiblity of collusion down the hierarchy is combined with limits on communication. The limits on communication, according to these authors, require the centrailized contract be anonymous, and different agents be treated symmetrically. This facilitates collusion. With decentralization, such a problem disappears.

This paper provides additional insight towards why putting managers at the center of multi-tier hierarchies can benefit shareholders. The main point of this paper can be explained using a simple scenario. Consider a firm that consists of three agents: the owner, the manager and the worker. The firm has two projects, for which the owner provides necessary funds. The manager can acquire private information, which can be used in making a project choice decision. The worker puts in private effort that can increase the likelihood that the chosen project will be successful. Both the manager's private information and the worker's effort cannot be used for contracting purpose. A centralized mechansim in this setup has the owner offering contracts both for the manager and the worker. A hierarchical mechanism puts the manager in the center of the three-tier contracting relationship: the owner designs a contract for the manager, who, in turn, designs a contract for the worker.

Our main point is that a hierarchical mechanism can dominate centralized contracting.(1) The intuition is as follows. When the manager's private information cannot be used for centralized contracting purpose, there is a limit on the types of contracts the owner can offer the manager and the worker. On the other hand, under the hirarchical mechanism where the manager designs the contract for the worker, the manager can offer the contract after he learns his private information. While he cannot condition the worker's contract on his private information, he can signal his private information through the contract offered. This can alleviate the asymmetry of information between the manager and the worker, thereby enabling the manager to design a contract that can provide work incentives at lower cost than the one designed by the owner. In other words, the type of contract the manager offers the worker signals the manager's private information, based on which the worker's incentives can be better provided. Technically, the centralized mechanism should take into account *ex ante* participation and incentive compatibility constraints for both agents. With decentralization,

(1) The example presented in this paper does not establish dominance. Rather it shows that the owner is better off with a hierarchical mechanism at the cost of the worker. The reason is that, in the example where everything is dichotomous, both mechanisms implement the first best optimum, hence they are equivalent in efficiency sense. The generalization of the example discussed in section 4 describes how the hierarchical mechanism can be more efficient than the centralized mechanism when set of actions becomes richer.

only interim constraints need to be considered for the worker.[2]

Other papers that deal with delegation in a hierarchy include Baron and Besanko (1992), Gilbert and Riordan (1995), and McAfee and McMillan (1995). Baron and Besanko (1992), and Gilbert and Riordan (1995) establish equivalence between centralized mechanism and decentralized mechanism when two agents' inputs are stricly complementary. McAfee and McMillan (1995) consider a three-tier hierarchy subject to limited liability constraints, showing losses involved in a three-tier hierarchy relative to centralized contracting.

Our work differs from these and other studies on hierarchy at least in two important ways. In our model, the manager, or the intermediate agent, is not endowed with private information. Rather, he needs to incur private costs to acquire information. Because of this information acquisition, there are benefits of giving the manager the additional authority to represent shareholders in dealing with other stakeholders. In the above studies on hierarchy, there is no a priori reason why a particular agent should be at the center of the multi-tier hierarchy. It could be either of the two agents supplying inputs. In our model, beneficial delegation occurs only when the manager, not the worker, assumes the role. Second and related, the managerial input and the worker's input are quite distinct. We believe that the manager's information acquisition and subsequent decision making are what distinguish managerial inputs from those of other employees in corporations. Roughly speaking, the manager's decision making can be identified with the choice of a particular distribution of profits, while other employees' inputs affect the likelihood of profit realization given the chosen distribution. We thus expect that optimal incentives for the manager will be quite different from those for other employees. (Perhaps one of the reasons why managers are motivated through options, but not other employees?)

[2] The benefits from giving the informed party the authority to design contracts have also been shown in Choe (1998) in the context of costly verification games.

2. An Example

There are two projects, A and B. Both projects can return $x > 0$ or 0, but with different probabilities as will be described below.[3] The manager alone can acquire costly private information, which he can use for the choice of a project. The worker has two choices, work or shirk. Denote the manager's cost of information acquisition by c, and the worker's cost of work by v. We normalize reservation utilities of both agents to zero. To begin with, we assume that both agents are risk neutral at all monetary payoffs above zero.

Abusing terminology somewhat, we will say there are two possible states, θ_1 and θ_2. Common prior probabilities of the two states are equal, but once the manager acquires information, he learns the true state for sure. In state θ_1, project A (B) has probabilities $p_1(e)$ $(q_1(e))$ for x if the worker works and p_1 (q_1) if the worker shirks. In state θ_2, project A (B) has probabilities $p_2(e)$ $(q_2(e))$ for x if the worker works and p_2 (q_2) if the worker shirks. We make suitable assumptions on these probabilities so that (i) it is better to choose project A in state θ_1, and project B in state θ_2, (ii) it is worthwhile for the manager to incur the cost of information acquisition if the manager uses the information for the right project choice and (iii) whichever project is chosen, it is always desired that the worker chooses to work instead of shirk.[4] This will be called the first best.

There are several variations of mechanisms that can be considered. The first is a centralized mechanism, call it $\mathcal{C}$. In $\mathcal{C}$, the timing is as follows. At $t = 0$, the owner offers contracts to both the manager and the worker, and their acceptance decisions follow. At $t = 1$, the manager decides on information acquisition, and then makes a project choice decision. At this point, the worker does not observe the manager's project choice, nor the signal observed by the manager.[5] At $t = 2$, the worker makes an effort decisionAt $t = 3$, the return is

(3) That the return from both projects has the same support is overly strong. All we need is that the two projects have some overlapping part of the support so that, in some realizations, it is not possible to tell ex ante which project has produced them. If the two projects have distinct supports, then the worker's contract that the manager will design will be a subset of the ex ante contract that the owner will offer the worker. Thus the informational benefits of delegated contracting disappear.

(4) (i) is implied by $p_1(e) \geq q_1(e)$ and $p_2(e) \leq q_2(e)$, (ii) is implied by $p_1(e) - q_1(e) \geq \frac{c}{2}$ and $q_2(e) - p_2(e) \geq \frac{c}{2}$ and (iii) is implied by $p_1(e) - p_1 \geq \frac{v}{x}$ and $q_2(e) - q_2 \geq \frac{v}{x}$.

(5) This assumption is also overly strong. All we need is that, even if the worker can identify the chosen project, it leads to an imperfect estimation of the return distribution for the project. Otherwise, the signaling benefits of delegating authority to the manager to design the worker's contract disappear.

realized and both agents are paid.

As a variation of $\mathcal{C}$, one may suppose that the manager decides on information acquisition before his contract is offered. Since we are going to impose limited liability on the contracts for both agents, it is trivial to see that this mechanism cannot motivate the manager to gather information. So we rule out this possibility. As another variant of $\mathcal{C}$, one can consider a mechanism that has the same features as $\mathcal{C}$ except that the owner delays her offer to the worker until the manager produces some report on the signals observed. Similar to Melumad et al. (1995), one can expect this mechanism to have the same efficiency property as the hierarchical mechanism to be considered below, provided that the manager's contract satisfies truth-telling constraints. However, when it is costly to communicate the manager's information to the owner, one can follow the argument of Melumad et al. to assert possible benefits of decentralization.

The hierarchical mechanism we consider ($\mathcal{D}$) has the following time line. At $t = 0$, the owner offers a contract to the manager, and the manager's acceptance decision follows. At $t = 1$, the manager decides on information acquisition, makes a project choice decision, and then offers a contract to the worker. If the worker accepts the contract, then at $t = 2$, the worker makes an effort decision. At $t = 3$, the return is realized and both agents are paid. As a variation of $\mathcal{D}$, one may suppose that the manager offers a contract to the worker before he learns his signals. While the distribution of final return can be different, this mechanism will have the same efficiency property as $\mathcal{D}$ since the manager and the owner share the same information.

In Melumad et al. (1995), the decentralized mechanism that achieves the same outcome as the centralized one has a feature that the intermediate agent (manager in our model) should decide accepting the owner's offer before he subcontracts with the final agent. The reason for this is that, if the intermediate agent can delay the acceptance decision after he subcontracts with the final agent, he can learn additional information about the final agent, which can be used to increase his informational rent. In our model, this side of information advantage does not exist for the manager as there is nothing to be learned from the worker (unless the manager monitors the worker ex post). The core of our model is the manager's information acquisition and beneficial signaling opportunities of delegated contracting. As mentioned before, we believe that the key roles managers are expected to play are decision making based on information acquisition and representing shareholders in dealing with other stakeholders.

3. Centralized vs. Delegated Contracting

3.1. Analysis of $\mathcal{C}$

Since the only information that can be used for contractual purpose is the final outcome, x or 0, we can denote the manager's contract by (s_1, s_2), s_1 being the payment for x. The worker's contract is denoted by (w_1, w_2), w_1 the payment when x. We impose limited liability which we take to imply that all contractual terms are restricted to be nonnegative.

Consider first the problem of motivating the manager to acquire information and make the right project choice decision. We focus on the Nash equilibrium where the worker's effort choice is 'work'. Given his conjecture that the worker will choose 'work', the manager has essetially three options available. First, the manager may not gather information and always choose project A. The manager's expected utility from this option is

$$U_1 \equiv 0.5\Big\{p_1(e)s_1 + (1 - p_1(e))s_2 + p_2(e)s_1 + (1 - p_2(e))s_2\Big\}. \tag{1}$$

The second option is not to gather information and always choose project B. The resulting expected utility is

$$U_2 \equiv 0.5\Big\{q_1(e)s_1 + (1 - q_1(e))s_2 + q_2(e)s_1 + (1 - q_2(e))s_2\Big\}. \tag{2}$$

The final option is to gather information and choose project A (B) if θ_1 (θ_2) is observed.[6] His expected utility from this is

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[6] The manager can also randomize between options 1 and 2. But this will be dominated by either of the first two options. Also the manager can gather information and choose one project regardless of the observed signal. This option is again dominated by either of the first two options. Finally, the manager can gather information and make a project choice decision different from the first best one. This is dominated by the third option since $p_1(e) \geq p_1$, $q_2(e) \geq q_2$ by assumption and the incentive compatibility constraints above imply monotonicity of the managerial contract, $s_1 \geq s_2$.

$$U_3 \equiv 0.5\Big\{p_1(e)s_1 + (1-p_1(e))s_2 + q_2(e)s_1 + (1-q_2(e))s_2\Big\} - c. \tag{3}$$

Incentive compatibility requires that $U_3 \geq \max\{U_1, U_2\}$ which leads to $s_1 - s_2 \geq \max\Big\{\frac{2c}{p_1(e)-q_1(e)}, \frac{2c}{q_2(e)-p_2(e)}\Big\}$. The participation constraint requires $U_3 \geq 0$ or $\{p_1(e) + q_2(e)\}s_1 + \{2 - p_1(e) - q_2(e)\}s_2 \geq 2c$. Since the manager is risk neutral, one can see that, at an optimal contract, $s_2 = 0$. Then it is easy to see that the participation constraint is satisfied whenever the incentive compatibility constraints are. Thus the manager's contract meeting all the constraints can be restricted to $s_1 \geq \max\Big\{\frac{2c}{p_1(e)-q_1(e)}, \frac{2c}{q_2(e)-p_2(e)}\Big\}$, and $s_2 = 0$.

Consider next the worker's contract. At the Nash equilibrium, the worker's conjecture of the manager's project choice and information acquisition is self-fulfilling. Thus the worker's incentive compatibility constraint of choosing to work becomes

$$\begin{aligned} V(e) &\equiv 0.5\Big\{p_1(e)w_1 + (1-p_1(e))w_2 + q_2(e)w_1 + (1-q_2(e))w_2\Big\} - v \\ &\geq 0.5\Big\{p_1 w_1 + (1-p_1)w_2 + q_2 w_1 + (1-q_2)w_2\Big\} \end{aligned} \tag{4}$$

which simplifies to $w_1 \geq w_2 + \frac{2v}{\Delta p_1 + \Delta q_2}$ where $\Delta p_1 \equiv p_1(e) - p_1$ and similarly for Δq_2. The participation constraint requires $V(e) \geq 0$. As before, one can show that whenever the incentive compatibility constraint is satisfied, so is the participation constraint. Moreover, resorting to risk neutrality, one can set $w_2 = 0$. Since there is no reason to pay the worker more than is necessary, the optimal contract for the worker is chosen to make the incentive compatibility constraint binding. It is given by $w_1 = \frac{2v}{\Delta p_1 + \Delta q_2}$ and $w_2 = 0$.

Thus the optimal contract for $\mathcal{C}$ is $s_1 = \max\Big\{\frac{2c}{p_1(e)-q_1(e)}, \frac{2c}{q_2(e)-p_2(e)}\Big\}$, $s_2 = 0$, $w_1 = \frac{2v}{\Delta p_1 + \Delta q_2}$ and $w_2 = 0$. The manager's expected utility is then $U = 0.5\big[p_1(e) + q_2(e)\big]s_1 - c = c\Big[\max\Big\{\frac{p_1(e)+q_2(e)}{p_1(e)-q_1(e)}, \frac{p_1(e)+q_2(e)}{q_2(e)-p_2(e)}\Big\} - 1\Big] > 0$, the worker's expected utility is equal to $V = 0.5\big[p_1(e) + q_2(e)\big]w_1 - v = v\Big[\frac{p_1(e)+q_2(e)}{\Delta p_1 + \Delta q_2} - 1\Big] > 0$, and the owner's expected utility is equal to $0.5\big[p_1(e) + q_2(e)\big]\Big(x - s_1 - \frac{2v}{\Delta p_1 + \Delta q_2}\Big)$. Note that the participation constraint is not binding for either agent in this case. The reason for this is limited liability. We now turn to the hierarchical mechanism, $\mathcal{D}$.

3.2. Analysis of $\mathcal{D}$

In mechanism $\mathcal{D}$, the manager's strategy is a quadruple, (accept/reject the contract offered by the owner, information acquisition, project choice, offer of the worker's contract), and the worker's strategy is a mapping from the observed history to (accept/reject the contract offered by the manager, work/shirk). To simplify matters, let us suppose that both contracts satisfy relevant participation constraints. Thus we can ignore the acceptance decisions of the manager and the worker. Unlike in mechanism $\mathcal{C}$, the worker now observes part of the manager's strategy: accept/reject the contract offered by the owner, and the offer of the worker's contract. Although the worker cannot observe the signal observed by the manager, he can infer it based on these observations. At the sequential equilibrium, the worker correctly infers the signal observed by the manager based on the equilibrium strategy adopted by the manager. To be more precise, if the manager accepted his contract and offered a contract to the worker, the worker can infer that the contract should satisfy all the necessary constraints given the probabilities determined by the actual signal observed by the manager. For, otherwise, the worker deviates from his equilibrium strategy by either rejecting the contract or shirking. (This can be made rigorous.) Therefore the manager's offer of the worker's contract need not satisfy ex ante participation and incentive compatibility constraints. Interim constraints are enough. This is the main difference between $\mathcal{C}$ and $\mathcal{D}$. In $\mathcal{C}$, the owner should design the worker's contract subject to ex ante constraints.

We start with the worker's contract. We will fix the manager's equilibrium strategy where the manager gathers information and makes the first best project choice decision. Of course, this equilibrium strategy needs to be supported by the contract the owner will offer the manager. This will be dicussed later. Thus our focus is only the worker's contract that the manager will offer. The manager offers the worker a contract of the form $w(\theta) = (w_1(\theta), w_2(\theta))$, $w_1(\theta)$ being the payment for x when the manager observed signal θ (and made the corresponding first best project choice decision). Suppose first that the manager observed θ_1 and chose project A. Let $r(w, \cdot)$ be the worker's belief that the return will be x based on his observation of the contract offered (w) and other relevant part of the manager's strategy ($\cdot$). At the equilibrium, $r(w, \cdot) = p_1(e)$ if the worker chooses to work, and $r(w, \cdot) = p_1$ if the worker chooses to shirk. Thus the corresponding incentive compatibility constraint is

$$p_1(e)w_1 + (1 - p_1(e))w_2 - v \geq p_1 w_1 + (1 - p_1)w_2. \tag{5}$$

The participation constraint is

$$p_1(e)w_1 + (1 - p_1(e))w_2 - v \geq 0. \tag{6}$$

Since the worker is risk neutral, and since there is no reason to pay the worker more than necessary (this also needs to be clarified as it will depend on the manager's contract), the equilibrium contract for the worker is given by $w_1(\theta_1) = \frac{v}{\Delta p_1}$, $w_2(\theta_1) = 0$. Following similar steps, the equilibrium contract for the worker is given by $w_1(\theta_2) = \frac{v}{\Delta q_2}$, $w_2(\theta_2) = 0$ when θ_2 is observed and project B is chosen. The ex ante expected utility of the worker is then $V = 0.5\big[p_1(e)w_1(\theta_1) + q_2(e)w_1(\theta_2)\big] - v$.

Let us now turn to the manager's contract. To provide the manager with incentives to design an efficient contract for the worker, the owner needs to tie the manager's compensation to the return less the worker's compensation. In the current example where we imposed limited liability, the manager's compensation is relevant only when the return is x. Theoretically there are numerous ways to make the manager's compensation tied to $x - w$. Since the manager is risk neutral, there is no loss of generality in confining our attention to a contract which gives the manager a residual claim. The manager's contract can then be represented by s where s is what the manager needs to pay the owner when the return is x. To be consistent with what we presumed above when studying the worker's contract, the manager's contract needs to induce the manager to gather information and make the first best project choice. As in $\mathcal{C}$, we will look at three alternative equilibrium scenarios, each of which will be described below.

First, suppose the manager does not gather information and always chooses project A. To derive the manager's expected utility, we need to study the worker's contract the manager would offer in this case. Since the manager does not have private information, he cannot provide a signaling contract and the worker, at the equilibrium, can infer this from the contract offered. Following similar steps as before, one can show that the worker's contract that maximizes the manager's expected utility subject to the worker's participation and incentive compatibility constraints is given by $w(A) = \frac{v}{\Delta p_1 + \Delta p_2}$ whenever the return is x and 0, otherwise. The manager's expected utility in this case is

$$U_1 \equiv 0.5[p_1(e) + p_2(e)][x - s - w(A)]. \tag{7}$$

In the second alternative equilibrium scenario, the manager always chooses project B without gathering information. The worker's contract offered by the manager is then $w(B) = \frac{v}{\Delta q_1 + \Delta q_2}$ whenever the return is x and 0, otherwise. The manager's expected utility in this case is

$$U_2 \equiv 0.5[q_1(e) + q_2(e)][x - s - w(B)]. \tag{8}$$

Finally, at the equilibrium which we focus on, the manager's expected utility is

$$U_3 \equiv 0.5\Big\{p_1(e)(x - s - w_1(\theta_1)) + q_2(e))(x - s - w_1(\theta_2))\Big\} - c. \tag{9}$$

To support this last equilibrium, the owner needs to ensure that the manager's contract satisfies the participation constraint, $U_3 \geq 0$ and the incentive compatibility constraints, $U_3 \geq \max\{U_1, U_2\}$. The optimal manager's contract offered by the owner is the one that maximizes the owner's payoff (s) subject to the above constraints. Tedious algebra can be used to derive s.

The two mechanisms can now be compared. Note first that the equilibria of both mechanisms implement the first best outcome. Therefore it is not possible to assert the dominance of one mechanism over the other. However one can still study which mechanism will be preferred by the owner. After all, the choice of the hierarchical mechanism over the centralized one is the owner's discretion, and so, she will do so only when it is in her interest. In fact it is possible to show that, under suitable assumptions, the hierarchical mechanism leads to redistribution of the return in such a way that the worker is worse off and the owner and the manager are better off than under the centralized mechanism. (Algebra is quite messy.) As mentioned in footnote (1), we conjecture that, in a more general model where the first best outcome is in general not achievable, the dominance relation can be established as the second-best loss from the hierarchical mechanism becomes smaller than that from the centralized mechanism.

4. Generalization and Possible Extensions

The manager's decision making is now identified with a choice of a density function over possible realizations of return. Denote the manager's effort in gathering information by $m \in R^1$, and the corresponding private cost by $c(m)$. The manager makes a decision based on the information gathered, which is denoted by $d(m) \in R^1$. Associated to $d(m)$ is the density function, $f_{d(m)}(\cdot)$ whose support is denoted by $X_{d(m)} \subset R^1$. With the assumption that $c(m)$ is increasing and convex in m, one can capture the essence of the information gathering activity by the manager: the larger the value of m, the more 'accurate' the manager's information is about the future states of nature. (This needs to be made precise, for example, in line with Bergemann and Valimaki, or as in my earlier version of the paper.) This way of parameterizing information acquistion has been found useful in modeling auction design (Bergemann and Valimaki, 2001). In the example of the previous sections, $X_{d(m)}$ was the same for all $d(m)$. That is, $X_{d(m)} = \{x, 0\}$ for $d(m) = A, B$. For our purpose, it suffices to assume that there exists a pair of decisions $(d, \tilde{d})$, $d \neq \tilde{d}$ such that $X_d \cap X_{\tilde{d}} \neq \emptyset$.

The worker's effort decision is denoted by $e \in R^1$ with the corresponding cost function $v(e)$. Given $d(m)$ and e, the density function over $X_{d(m)}$ is denoted by $f_{d(m)}(x; e)$. As is standard in moral hazard literature, $v(e)$ is increasing and convex in e, and the distribution corresponding to $f_{d(m)}(x; e)$ satisfies the stochastic dominance property. Consistent with the previous example, we assume that $X_{d(m)}$ is the same for all values of e. Thus the worker's effort does not change the support of the return distribution.

With this generalization, it would be possible to extend the previous results further. In particular, one can compare the efficiency property of the centralized *vs.* hierarchical mechanisms: what are the equilibrium choices of m, $d(m)$ and e in each of these mechanisms, and how are they compared with the first-best choice? The insight from our example suggests that the deviation from the first-best outcome should be smaller for the hierarchical mechanism since the informational asymmetry can be reduced and, therefore, incentives can be better provided. It would be also of interest to see how the optimal contracts change depending on different mechanisms. We conjecture that the owner may be better off using option-like contracts for the manager in the hierarchical mechanism. The reasoning is as follows. The manager's decision determines a particular return distribution while the worker's effort affects the likelihood of return realizations given the distribution. As the manager's decision leads to wider fluctuations of return, so should he be given higher-powered incentives. We know that option-like contracts just do that. However, if the manager is risk averse, the benefits of using higher-powered incentives need to be weighted against the costs of risk bearing.

The model described here can be further extended to other types of multi-tier hierarchies that involve other input suppliers at the end of hierarchies. Examples include the firm's dealing with subcontractors, or raising external capital. When the manager's private information cannot be used for contracting purpose, allowing him to contract with others will again have signaling benefits.

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