Centralized and Decentralized Decision Making in Organizations

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This article identifies a new type of cost associated with centralization. If workers are liquidity constrained, it may be less costly to motivate a worker who is allowed to work on his own idea than a worker who is forced to follow the manager's idea. Thus, it may be optimal to let workers decide on the method for doing their job even if managers have better information. This conclusion holds even if more general contracts are considered that are based on communication of information between the worker and the manager, as long as these general contracts are not entirely costless.

> I believe people will do much more with their bad idea than they will with your good idea. (Dave Checketts, president and CEO of Madison Square Garden [Boeck 1996])

I. Introduction

In recent years, many U.S. companies have adopted innovative work practices, frequently including greater decentralization of decision making. In a recent survey of private-sector establishments with 50 or more

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employees, about 45% of nonsupervisory workers directly involved in production had substantial discretion over the method for doing their job (Osterman 1994). An extreme example may be the department store Nordstrom, which issues its workers only one instruction: "Use your own judgment" (*Economist* 1995).

The question of centralized decision making versus delegation has long been present in the management literature. The typical focus has been on a trade-off between two opposite effects of delegation: on the one hand, delegation leads to a better utilization of information scattered throughout the lower levels of the firm's hierarchy; on the other hand, it entails a loss of control for the upper-level managers.

This article identifies a new type of cost associated with centralized decision making. This cost comes from the interplay among Bayesian updating, moral hazard, and workers' liquidity constraints. In this environment, it may be more costly to induce a worker to work on someone else's (i.e., the manager's) idea than on his own idea. For illustration, consider a research team of two, a boss and a worker, trying to develop a commercially viable alternative to gas-fueled cars. Suppose that the manager decides that they will follow her (the manager's) idea and concentrate on alternative fuels, say alcohol. If the worker originally believed that they should rather concentrate on solar energy, he is now quite pessimistic about their chances to succeed. Therefore, he may not be very enthusiastic about providing effort and needs a strong incentive contract to get motivated. However, if the worker is liquidity constrained, a stronger incentive contract will be more costly. The reason is that it is hard to punish him for a failure and therefore he must be rewarded more for success. I show that, because of this motivation effect, it may be optimal to delegate decision-making authority to the worker even if the manager is better informed than the worker. Moreover, for some parameter values, delegation to a less informed worker is optimal, even if a more general class of contracts is allowed in which the project choice and the agent's pay depend on communication of information between the principal and the agent.

The rest of this article is organized as follows. In Section II I discuss the related literature, and in Section III I describe the assumptions and the basic model with one manager and one worker. In Section IV, I provide a comparison of centralized and decentralized decision making, and in Section V I allow for general contracts that condition the agent's pay and the project choice on whether the agent and the manager agree on which project is optimal. In Section VI I conclude. All proofs are in the appendix.

II. Related Work

Much of the research dealing with optimal design of hierarchical organizations does not look at the optimal allocation of decision-making authority. Rather, it is concerned with the costs of communicating and processing information and with the technological aspects of this problem.[1] An early analysis of decentralization is the comparison of unitary (U-form) versus multidivisional (M-form) companies by Chandler (1962) and Williamson (1975). According to Chandler, as a U-form firm expands, it experiences inefficiencies because of the loss of control by top management, and it is replaced by a more efficient, less centralized M-form organization.

One recent work related to the current article is that of Prendergast (1995), who considers a model in which the manager decides whether to carry out a task herself or to assign it to a subordinate. He shows that because of a moral hazard problem, the manager will carry out more tasks than is efficient because by doing so she can earn future rents through on-the-job learning. However, Prendergast is not concerned with optimal ex ante allocation of decision-making authority within the firm, which is central to the current article.

Three papers whose focus is close to the focus of the current article are Aoki (1986), Athey et al. (1994), and Aghion and Tirole (1997). Aoki (1986) argues that decentralization should be prevalent where quick response to changing technologies and environment is necessary and the flow of new information is upward through the hierarchy. On the other hand, centralization can have beneficial coordination effects. Athey et al. (1994) study management by exception, which can be described as a state-contingent decision making under which the manager interferes in the lower levels of hierarchy only in "exceptional" states of the world. This arrangement serves to conserve scarce managerial resources. Finally, Aghion and Tirole's (1997) paper is probably the most closely related to the current article. In their model, as in the current one, delegating formal authority to the worker increases his incentive to provide effort, because it increases his expected payoff. However, in Aghion and Tirole, this higher expected payoff comes from a private benefit derived from the project that the worker chooses. In the current model, it comes from the fact that, under delegation, the agent works on his own idea. This means that he may be more optimistic about the possibility of success than if he was forced to work on the manager's idea. Also, while in the Aghion and Tirole study, incentive contracts play no interesting role, they are essential in the current model. In fact, in this model, the cost of centralization is that the incentive contract for the worker becomes stronger and, therefore, more costly.

Finally, this article is also related to models that focus on revelation

[1] See, e.g., Calvo and Wellisz (1978), Rosen (1982), Waldman (1984), Sah and Stiglitz (1986), Geanakoplos and Milgrom (1991), Radner (1993), and Bolton and Dewatripont (1994), to name a few.

mechanisms, for example, those of Melumad and Reichelstein (1987) and Melumad, Mookherjee, and Reichelstein (1992). The connection to this literature will be explored in greater detail in Section V, which allows for general contracts based on communication of information between the worker and the manager.

III. The Model

Preferences.—Consider a firm with a risk-neutral owner-manager (a woman) hiring one risk-neutral worker (a man). The manager's objective is to maximize the firm's expected profit while providing the worker with at least his reservation utility, $u \geq 0$.

Production technology.—The firm can choose between two projects, 1 and 2, that are mutually exclusive (i.e., only one of the two projects can be adopted). Each project requires an investment, $C \geq 0$, incurred by the firm, and effort $e \in \{0, 1\}$, provided by the worker. If the firm does not invest in a project, this project is not undertaken and the worker cannot work on it. After a project is chosen, the worker decides whether to provide effort ($e = 1$) or not ($e = 0$). The worker's choice of effort is not observable to the manager, which introduces a moral hazard problem. The cost of providing effort is disutility $H \geq 0$ for $e = 1$.

The project's payoffs depend on the state of the world and on the worker's effort in the following manner. There are two equally probable states of the world, denoted s ($s = 1, 2$). Project j ($j = 1, 2$) pays $V > 0$ if the state of the world is $s = j$ and the worker provides effort, and it pays W (normalized to zero for simplicity) otherwise. In other words, project 1 cannot be successful if the state of the world is 2, and vice versa.

To sum up, the firm's output y is given by $y = keV$, where $k = 1$ if $j = s$ and $k = 0$ if $j \neq s$. Thus, effort and accuracy of project choice are complements here. This setting could also be interpreted as a problem of choosing the right technology of production. If the wrong technology is chosen, it will not give the desired outcome.[2]

Complementarity between effort and accuracy of project choice is not crucial here. Appendix B examines the validity of the model's qualitative results under an alternative technology specification, where effort and accuracy of project choice are substitutes. It demonstrates that the main theoretical result of this article, as represented by part *b* in proposition 2, is preserved in this alternative setting.

[2] In yet another interpretation, the worker accumulates firm-specific human capital instead of providing effort. In this interpretation, there would be two possible types of firm-specific human capital, say learning the details about the firm's product market versus mastering a production technology, and the manager would be able to force the worker to choose the type she thinks is more beneficial. For models dealing with specific human capital accumulation, see Kahn and Huberman (1988), Prendergast (1993), and Zábojník (1998), for example.

Information structure.—The worker and the manager have different abilities to distinguish between the two projects (states of the world). After nature decides which state occurs, both the manager and the worker receive imprecise and independent signals about the state that was realized. If state s occurred, the manager receives signal s with probability $q \in (1/2, 1)$, so that her belief that s occurred is q. Similarly, the worker's posterior belief that state s occurred, after observing a signal for s, is $p \in (1/2, 1)$. The prior probability of 1/2, as well as the signals' precisions, are common knowledge to both agents.

Contracting.—Note that, because the worker's effort is not observable, his pay must depend on the outcome of the project; otherwise he would always provide zero effort. The worker's employment contract will therefore be characterized by a wage he receives if the project fails and a wage he receives if the project is successful. In Section V, these wages can depend on whether the manager and the worker agree on which project is optimal. They are determined and the employment contract is signed before the signals are received.

I will assume that there is a lower bound D on the wages, where $D \leq u$. This means that, if the project fails, the worker cannot be forced to pay a large fine to the manager. Similarly, when entering the employment relationship, it is not possible for the worker to place a large bond with the manager that would be returned only if the project is successful. This is an important assumption, driving the main results. This assumption seems quite realistic and is quite common in the literature.[3] It allows two interpretations. First, the worker may be liquidity constrained because of imperfect capital markets, so that he cannot borrow from a bank to pay a fine to the firm in the case of a bad outcome or to finance his consumption in earlier periods. Second, there may be legal provisions in the economy under which the worker has limited liability and cannot be forced to place a bond with the firm when hired. It is interesting to note here that, as shown in an earlier version of this article, the model's main result would remain unchanged if the worker was risk averse instead of being liquidity constrained.

Decision making.—I will consider three alternative decision-making arrangements:

1. *Decentralization.* Here the decision-making authority is delegated to the worker with no interference from the manager. This includes delegating to the worker the authority to invest C into the project of his choice. I will sometimes refer to this arrangement as delegation.

[3] See, e.g., Sappington (1983) for a discussion and an analysis of the principal-agent problem with limited liability.

2. *Centralization.* Here the manager makes the project choice and the investment without consulting the worker.
3. *Joint decision making*. This represents a general mechanism where the manager and the worker announce their respective signals and both the project choice and the worker's pay depend on these announcements. This arrangement will be described in greater detail in Section V.

Commitments.—No renegotiation is allowed after an employment contract is signed. More specifically, the manager is able to commit not to reveal her signal to the worker or, alternatively, not to receive any signal at all. Similarly, she is able to commit not to obtain any information from the worker regarding the worker's signal. This renders all three arrangements feasible and comparable.

Parameter restriction.—In order to make production profitable under both centralization and decentralization, as well as to limit the number of cases that need to be considered, I will assume that the parameter values are restricted as follows.

Assumption 1. $V > \max[2H, (H + C + u)/m]$, where $m = \min(p, q)$.

IV. The Analysis of Centralization and Decentralization

I will first compare centralization and decentralization and show that delegation can be preferred even if the manager is better informed than the agent (i.e., $q > p$). I will then show, in Section V, that, under some parameter values, delegation to a less informed agent remains optimal, even if the third arrangement is considered, where the project choice and the agent's pay depend on signal announcements, as long as this arrangement is not entirely costless. I will start with the case of decentralization.

A. Decentralization

In this case, both the choice of the project and the investment of C are made by the worker, based solely on his own signal. Therefore, the worker's belief that the project will be successful is p.

As is standard in models with risk-neutral agents facing liquidity constraints, it is optimal to set the worker's pay in the case of failure to be equal to the constraint D. This allows the manager to provide the worker with the strongest possible incentives while holding his expected pay constant. Let the wage that the worker receives in case of success be denoted b.

The difference between the two wages, b and D, must be such that the worker is willing to provide effort; otherwise, the manager is better off closing the firm. The worker's incentive compatibility condition is thus $p(b - D) - H \geq 0$. The worker's expected wage is then $w = pb + (1 -$

$p)D$, so that his participation constraint can be written as $p(b - D) - H \geq u - D$. Because $u - D \geq 0$, the manager chooses the wage b such that the participation constraint is binding and the worker gets exactly his reservation utility. The liquidity constraint thus has no effect on the firm's expected profit under decentralization. This profit is $\pi^d = pV - C - u - H$.[4]

B. Centralization without a Liquidity Constraint

Under centralization, the liquidity constraint plays an important role. I will first look at the benchmark case where there is no liquidity constraint.

In this arrangement, the project is chosen and C is invested by the manager, who does not consult the worker before deciding. After the manager decides, the worker forms a posterior belief about the probability of success given the selected project. As the problem is symmetrical with respect to states of the world, it is enough to restrict attention to the case where the manager chooses project 1. Then there are two possibilities: (*a*) the worker gets the same signal as the manager, and (*b*) the worker gets signal 2. In the former case, the worker's posterior probability of success is $p(1, 1) = pq/[pq + (1 - p)(1 - q)]$, while in the latter case it is $p(1, 2) = q(1 - p)/[p(1 - q) + (1 - p)]$. It is easy to check that $p(1, 1)$ is always greater than both $p(1, 2)$ and p.

Denote the wage in the case of success as d^s and the wage in the case of failure as d^f. Let the worker's signal be $x = 1, 2$, so that his posterior is $p(1, x)$. The worker's two incentive compatibility constraints are then

$$(d^s - d^f)p(1, x) \geq H. \tag{1}$$

Because $p(1, 1) > p(1, 2)$, the constraint (1) is satisfied for both posteriors if it holds when the worker's posterior is $p(1, 2)$. The worker's participation constraint is

$$qd^s + (1 - q)d^f \geq H + u. \tag{2}$$

Note that the probability of receiving the bonus d^s is q in the above participation constraint. This follows from the fact that the project is chosen by the manager, so that the ex ante probability of success is q.

Since $p(1, 2) > 1/2$, assumption 1 implies $p(1, 2)V > H$. Hence, it is optimal to elicit effort under both of the worker's posteriors if this can be

[4] The reason first best can be achieved here is that the probability of success under no effort is zero. This, combined with the fact that the worker's ex post (i.e., after choosing the project) belief about the probability of success is the same as his ex ante belief, implies that an incentive-compatible contract only needs to offer him his reservation utility. In app. B, probability of success under no effort is positive, which means that first best is not always attainable.

done without increasing the worker's expected utility above u. Therefore, the best the manager can do under centralization in terms of ex ante expected profit is $\pi^* = qV - C - H - u$. This profit would be achieved if the worker's expected utility were exactly equal to his reservation utility (i.e., if [2] were binding) and if the worker always provided effort (i.e., if [1] were satisfied for the posterior $p(1, 2)$. Because one can always find d^s and d^f such that these two conditions hold, we have the following result.

Proposition 1. If the worker is not liquidity constrained, then

a) the expected profit under centralization is $\pi^* = qV - C - H - u$, and
b) centralization is preferred to decentralization if and only if the manager's signal is better than the worker's signal, that is, $q > p$.

The second part of the proposition comes from a straightforward comparison of the expected profit under centralization, π^*, with the profit under decentralization, π^d. This result seems intuitive and hardly surprising—the decision is made by the party who is better informed. However, in the next subsection, I will show that when the worker faces a liquidity constraint, this result no longer holds.

C. Centralization with a Liquidity Constraint

Now suppose there is a lower bound D on wages. Again, it is optimal to set $d^f = D$. To see how the liquidity constraint changes the situation, let d_1 be the smallest wage d^s that elicits effort for both of the worker's posteriors, that is, $d_1 \equiv H/p(1, 2) + D$. Using the wages d_1 and D, the participation constraint becomes

$$[q - p(1, 2)]H \geq (u - D)p(1, 2). \tag{3}$$

It is immediate that if D is close to u, constraint (3) holds with strict inequality, the worker enjoys a rent, and the first best profit π^* cannot be attained. This makes it possible for delegation to dominate centralization even when the manager is better informed than the agent. I will now investigate under what conditions this can happen.

There are two possible candidates for the optimal contract under centralization with a binding liquidity constraint. These will be termed as

i) the full incentives contract, with $d^s = d_1$, in which the wage d^s is high enough to elicit effort regardless of the worker's posterior but the worker can enjoy a rent;[5] and

[5] If the optimal wage were $d^s > d_1$, the liquidity constraint would not be binding, the worker could be held down to his reservation utility u, and centralization would be always preferred to decentralization for $q > p$. This case is not interesting.

ii) the partial incentives contract, with $d^s < d_1$, in which the worker gets exactly his reservation utility but provides effort only if his posterior is $p(1, 1)$.[6]

The respective expected profits under these two alternative contracts are

$$\pi^c(i) = qV - C - H - U^c(d_1), \tag{4}$$

where $U^c(d_1) \equiv qd_1 + (1-q)D - H$ is the worker's expected utility when $d^s = d_1$, and

$$\pi^c(ii) = pqV - C - [pq + (1-p)(1-q)]H - u. \tag{5}$$

Thus, delegation is optimal if and only if $\pi^d > \max[\pi^c(i), \pi^c(ii)]$.

PROPOSITION 2.

a) When the worker is better informed ($q < p$), the manager prefers delegation.

b) For any worker, there is a manager who, for some parameter values, strictly prefers decentralization even though she is better informed than the worker. Formally, for any given $p < 1$ and u, there exist values for q, H, and V such that $q > p$ and $\pi^d > \max[\pi^c(i), \pi^c(ii)]$.

c) When $q > p$, delegation becomes relatively more profitable as the lower bound on wages, D, increases and as the worker's reservation utility, u, decreases.

Part *b* of proposition 2 represents the main theoretical result of this article. According to this result, the decision-making authority within organizations need not always rest with the better informed, or more able, party. The intuition is as given in the "Introduction": Suppose that the manager chooses a project different from the one preferred by the worker. If the manager is only slightly better informed than the worker, the worker's posterior belief in success, $p(1, 2)$, will drop below his original belief, p. This low posterior makes it more costly to induce the worker to provide effort. This is because, due to the worker's liquidity constraint, it is hard to punish him for bad outcomes. Therefore, the incentives must be provided by paying a bonus for success. But the lower is the worker's belief that his effort will make any difference, the higher must be this bonus and, hence, the worker's expected pay. Therefore, if the difference between the quality of the agents' signals is low, the worker receives an expected utility higher than his reservation utility, and he enjoys a rent. If the worker's information is not much worse than the manager's in-

[6] In fact, the wage d^s could also be so small that it would not elicit effort for any of the posteriors. However, this cannot be optimal, because the maximum value for expected profits in this case equals zero.

formation, this effect offsets the manager's higher ability to choose the correct technology and makes decentralization more attractive.

The intuition for the comparative statics effects in part *c* is simple. An increase in the worker's reservation utility makes it less likely that he receives a rent under centralization. A decrease in the lower bound on wages has the same effect, because it decreases the need to pay the worker a high bonus for success, thus decreasing his expected wage. Both of these effects make centralization relatively more profitable in comparison with delegation.

V. Joint Decision Making

In this section, I will allow for general contracts in which the project choice and the worker's pay can depend on signal announcements. The goal is to demonstrate that, if communicating information from the worker to the manager is not entirely costless, these general contracts cannot dominate both centralization and decentralization, unless the cost of investment C is relatively high. This then implies that, for low values of investment costs, the main conclusion of proposition 2 still holds; that is, delegation can be optimal even if the manager is better informed than the worker.

In the joint decision-making arrangement, the employment contract specifies (*a*) how the worker and the manager announce their signals, (*b*) how the project choice depends on these announcements, and (*c*) how the worker's remuneration depends on the announcements and on the project's outcome. I will concentrate on the following timing:[7]

1. The worker and the manager sign a contract.
2. Both the worker and the manager receive their private signals.
3. The worker announces his signal to the manager (not necessarily truthfully). It is not possible for the manager to verify the truthfulness of the worker's announcement. Thus, in the terminology of Aghion and Tirole (1997), the information conveyed by the worker is soft.
4. The manager considers the worker's suggestion and announces her own signal (again, not necessarily truthfully). I will assume that it may be costly for the manager to consider the worker's suggestion and this cost will be denoted as R, $R \geq 0$.
5. A project is chosen based on the above announcements (perhaps randomly), as determined by the contract.
6. The worker updates his belief using the manager's announcement and decides whether to provide effort.

[7] Qualitatively, very little would change if the worker and the manager announced their signals simultaneously and not sequentially as assumed here.

7. Payments are made conditional on announcements and success.

The arrangement considered here is more sophisticated than either of the two arrangements considered earlier. At a first glance, its main advantage seems to be the possibility to extract the worker's rent by tailoring his pay depending on whether he and the manager agree on which project is optimal. After all, the reason for the delegation result of proposition 2 was that under centralization with full incentives the worker received a rent that could not be extracted by the manager because only one bonus had to be used to provide incentives under two different posteriors. Here, in contrast, the manager can use two different bonuses, which may seem enough to extract the worker's rent: the bonus could be high when the two announcements disagree and low when they agree.

However, things are more complicated here than meets the eye. There are two problems with this scheme, which imply that the worker's rent cannot be extracted completely.

First, if the bonus is high when announcements disagree and low when they agree, then the worker has an incentive to misrepresent his signal. To see this, suppose that the contract specifies that, in the case of disagreement, the project that is chosen is the one announced by the manager.[8] In this case, the worker's announcement does not influence the project choice; it only affects the worker's expected payoff. Hence, the worker has an incentive to lie, which in effect means that his bonus is high when his posterior is high and vice versa. If anything, this makes his rent even higher than before.

Second, the manager has an incentive to lie, too. Suppose that the bonuses are such that they elicit effort only if the two announcements agree. Then, if the manager sees that her signal differs from the worker's announcement, she knows that if she announces her signal truthfully, the worker will provide no effort. Thus, to elicit effort from the worker the manager misrepresents her signal, de facto replicating delegation.[9]

Nevertheless, under some conditions, joint decision making can improve on both centralization and decentralization. The relative advantage of this arrangement is that it pools information of both the worker and the manager. Given this pooled information, some projects may turn out to be of negative expected profit, even if they have positive expected profit under both centralization and decentralization. This can happen if the

[8] If the contract specified that the project suggested by the worker should be chosen, such a contract would, in effect, replicate decentralization.

[9] The first argument would apply even if the announcements were simultaneous. The second argument would, obviously, not apply. Instead, the situation where the bonuses are not high enough to elicit effort in case of the lower posterior would completely replicate the outcome of the partial incentives contract under centralization.

investment cost, C, of the project is relatively high. Joint decision making then allows the firm to skip these negative-expected-value projects.

Proposition 3.

a) There exists a $\hat{C} > 0$ such that if $C < \hat{C}$ and $R > 0$ ($R = 0$), joint decision making is strictly (weakly) dominated by either centralization or decentralization, and proposition 2 applies.

b) There exist parameter values $C^* > 0$, $u^* > 0$, and $R^* > 0$, such that if $C > C^*$, $u > u^*$, and $R < R^*$, then joint decision making is the optimal decision-making arrangement.

Part *a* of proposition 3 implies that the central conclusion of proposition 2 is preserved here: if the cost of investment is relatively small, then delegation to a less able worker may be strictly optimal, provided that communication of information is not entirely costless. As discussed earlier, this part is rather surprising. Suppose that the cost R of considering the worker's suggestion is very small (close to zero) and that the first best profit under centralization, π^*, can be attained neither by centralization nor by decentralization. Then one might expect that joint decision making, with its more sophisticated incentive scheme and a richer strategy set, should be able to improve on delegation even if the cost of investment, C, is very low. Yet, according to proposition 3, if C is small and R is positive, the joint decision making is strictly dominated. If R is zero, then the best that joint decision making can do is to replicate either centralization or decentralization. The key to this result lies in the fact that, if the incentive scheme is designed so as to extract the worker's rent, then either the worker or the manager have an incentive to "game" the contract, as discussed earlier.

Part *b* of proposition 3 is quite intuitive. It follows from the fact that pooled information allows for better decision making, which makes it possible for the manager to save the investment cost C by sorting out projects with negative interim expected value $p(1, 2)V - C - H - u$.

Note that, because the information conveyed by the worker in his announcement is soft, the game played between the worker and the manager in this section can be viewed as a cheap talk problem, as analyzed in Crawford and Sobel (1982). For example, it is easy to see that there always exists a babbling equilibrium, in which the manager completely ignores the worker's announcement, and vice versa. In such a case, joint decision making has no value, and the conclusions of proposition 2 apply automatically. However, the result in part *a* of proposition 3 is stronger than one obtained by relying solely on the existence of a babbling equilibrium: part *a* says that, for some parameter values, the qualitative results of proposition 2 go through, even if the manager pays attention to what the worker announces. This result can thus be better appreciated, in the context of the mechanism-design literature, as saying that the best revelation mechanism that the manager can design in this setting is not good enough to always make joint decision making strictly better than both plain centralization and decentralization. Therefore, if there is a cost, no matter how small, associated with joint decision making, then the latter can sometimes be strictly dominated by either centralization or decentralization, in which case one can revert to the conclusions of proposition 2.

The analysis in this section is thus related to the literature on delegation and the value of communication, as exemplified by Melumad and Reichelstein (1987) or Melumad et al. (1992), among others. The focus of Melumad and Reichelstein (1987) is on identifying the conditions under which delegation can do equally well as an optimally designed revelation mechanism. In their model, though, unlike in the current article, the principal has no private information. They, therefore, do not study what happens if the principal is better informed than the agent, which is a case that plays an important role here.

Melumad et al. (1992) investigates the value of delegation when a revelation mechanism is costly. As shown by Myerson (1982), if the use of a revelation mechanism is costless, then delegation has no value, because it is always weakly dominated (as is any other organizational arrangement) by centralized decision making that relies on a revelation mechanism (joint decision making in the context of the current article). Myerson's result is very elegant, but, as Melumad, Mookherjee, and Reichelstein (1997) point out, it makes it hard to explain why delegation is used so often in organizations. For delegation to be optimal, it must therefore be that there is some cost associated with the use of a revelation mechanism. In the current article, this cost is represented by R, the cost to the manager of considering the worker's suggestion. In Melumad et al. (1992), this cost is associated with communicating information. They develop a model in which the principal can either contract directly with two agents, or, alternatively, let agent 1 contract with agent 2. The latter arrangement is more flexible, but it entails a loss of control for the principal. It is this trade-off that is central to their paper. Again, they do not consider the possibility that the manager is better informed than the agent, which plays an important role in the current article.

VI. Conclusion

This article identifies a new type of cost associated with centralized decision making when effort and accuracy of project choice are complements. Under centralization, a manager can choose a project that the worker dislikes. This can make it costly to motivate the worker to work on this project if he is liquidity constrained. Delegation thus may be the optimal organizational arrangement even if the manager is better able to choose a profitable project. This result is robust to introduction of more general employment contracts, based on signal announcements by the worker and the manager.

An implication of the model, not mentioned in the main text, is worth mentioning here. Note that the central result of this article, described by part *b* of proposition 2, has force only if the difference between the abilities of the worker and the manager is not too big. This implies that the firm's manager might prefer hiring a less able worker, who would be more inclined to "trust" the manager's decision. Casual observation suggests that this might be consistent with the practice of some firms who are not willing to consider "overqualified" workers (e.g., Ph.D.'s) for some positions.

Appendix A

Proofs of Propositions

Proof of Proposition 2

a) The highest expected profit attainable under centralization is $\pi^* = qV - C - H - u$, which is less than $\pi^d = pV - C - H - u$ when $q < p$.

b) $\pi^d > \pi^c(i)$ if and only if

$$\frac{H(1-q)(2p-1)}{1-p} - (q-p)V - u + D > 0, \tag{A1}$$

and $\pi^d > \pi^c(ii)$ if and only if

$$p(1-q)V - [p(1-q) + q(1-p)]H > 0. \tag{A2}$$

Fix a reservation utility u and a constraint D. Let $A \equiv (1-q)(2p-1)$, $B \equiv (1-p)(q-p)$, $\tilde{u} \equiv (u-D)(1-p)$, and $M \equiv 1 - p(1,2)$. Then (A1) and (A2) reduce to $AH > BV + \tilde{u}$ and $MV > H$, respectively. If $AM - B \neq 0$, one can always find V^+ and H^+ such that (A1) and (A2) hold with equality for given p and q. V^+ and H^+ are given by $V^+ = \tilde{u}/(AM - B)$ and $H^+ = \tilde{u}M/(AM - B)$. Now, $AM - B > 0$ if and only if

$$\frac{(1-q)^2(2p-1)p}{p(1-q) + q(1-p)} > (1-p)(q-p).$$

If this condition holds, then both V^+ and H^+ are positive. But it is easy to see that for any $p > 1/2$ there exists a $q > p$ such that the above condition holds—it is enough to take q sufficiently close to p. Choose such a q.

Now, if $AM - B > 0$, then it is possible to find ΔV and ΔH such that (A1) and (A2) hold for $\hat{V} = V^+ + \Delta V$ and for $\hat{H} = H^+ + \Delta H$. To see this, note that inequalities (A1) and (A2) hold for $\hat{V}$ and $\hat{H}$ if and only if $\Delta VM > \Delta H$ and $\Delta HA > B\Delta V$. And because $AM - B > 0$, such ΔV and ΔH exist.

c) This result follows from a straightforward differentiation of (A1), noting that (A2) is independent of u and D. Q.E.D.

Proof of Proposition 3

Without loss of generality, let $D = 0$.

Part *a*

For the moment, set $R = 0$. I will show that, for $C = 0$, joint decision making (JDM) is weakly dominated by either centralization or decentralization. By continuity, this result will hold also for small $C > 0$.

First, note that it is sufficient to concentrate on contracts that force both the worker and the manager to reveal their signals truthfully. This follows from the revelation principle.

Let α be the probability assigned by the contract to project j if both parties announce signal j, and let β be the probability assigned by the contract to project j if the manager announces j and the worker announces $i \neq j$. Because both parties announce their signals truthfully, it follows that it is optimal to always set $\alpha = 1$ and to set $\beta = 1$ if $q > p$ and $\beta = 0$ if $q < p$. To see this, suppose first that $\alpha < 1$. Then if both parties announce signal j (truthfully) and the contract calls for the project $i \neq j$, the expected success of the project, as well as the worker's posterior, is $1 - p(1, 1)$. But $1 - p(1, 1) < p(1, 1)$. Hence, the probability of success is lower and the bonus needed to elicit effort is higher in this case than if the contract called for project j (resulting in the posterior $p(1, 1)$). Higher α can therefore increase the firm's expected profit. The same reasoning applies for β, where the argument is completed by noting that $p(1, 2) > 1 - p(1, 2)$ if and only if $q > p$.

So, let $\alpha = 1$.

Step 1.—Assume $q < p$. By the above analysis, it is optimal to set $\beta = 0$, so that the worker's suggestion is always followed. In such a case, the expected revenue is pV. Since the worker must get at least his reservation utility, the expected profit in this case cannot be higher than $pV - C - u - H$, which is π^d, the profit under decentralization.

Step 2.—Now suppose $q > p$, so that it is optimal to set $\beta = 1$, that is, the project is always chosen according to the manager's suggestion. Suppose that the worker's bonus is d' (d'') if the two announcements coincide (differ). For the worker to be willing to reveal his signal truthfully, it must be $d' \geq d''$. Otherwise, he has an incentive to lie in order to influence the probability that his announcement differs from the manager's signal. If he announces his signal truthfully, this probability is $\theta_1 = 1 - pq - (1 - p)(1 - q)$; otherwise it is $\theta_2 = pq + (1 - p)(1 - q) > \theta_1$. So suppose $d' \geq d''$.

Step 3.—As in the case of centralization, there are two candidates for the optimal contract here.

Case (i) The worker always provides effort. To elicit effort under both posteriors, it must be that $d'' \geq d_1 \equiv H/p(1, 2)$. The worker's expected utility is then $d'qp + d''q(1 - p) - H$, which is greater than $U^c(d_1) \equiv d_1 q - H$, so that the worker's rent is no lower (and the firm's profit no higher) than under centralization with full incentives.

Case (ii) The worker provides effort only when his posterior is $p(1, 1)$ (if $d' > d''$, it is not possible to design a contract where the worker provides effort only when his posterior is $p(1, 2)$, because $p(1, 2) < p(1, 1)$). Because the worker does not provide effort when his posterior is $p(1, 2)$, with this posterior, the expected profit is zero and the manager has an incentive to misrepresent her signal in order to make the worker's posterior equal to $p(1, 1)$ instead of $p(1, 2)$. But then the manager does not always reveal her signal truthfully, which is a contradiction.

Thus, the best that JDM can achieve if $C = 0$ and $R = 0$ is to replicate either centralization or decentralization. Therefore, if $R > 0$, JDM is strictly dominated by either centralization or decentralization. By continuity, there then exists a $\hat{C} > 0$ such that this result holds for all $C < \hat{C}$.

Part *b*

Suppose the bonus is *d*, and the interim expected profit $p(1,2)(V - d) - C$ is negative. Then, under JDM, the manager invests only if her signal is the same as the worker's suggestion, so that the ex ante expected profit is $\pi^{\mathrm{JDM}} = pqV - R - [pq + (1 - p)(1 - q)](C + H) - u$. This is more than $\pi^c(ii)$ (given by [5]) if and only if

$$[p(1 - q) + q(1 - p)]C > R. \tag{A3}$$

Similarly, π^{JDM} is more than $\pi^c(i)$ (given by [4]) if and only if

$$[p(1 - q) + q(1 - p)](C + H) > R + q(1 - p)V. \tag{A4}$$

Finally, JDM yields higher expected profit than decentralization if and only if

$$[p(1 - q) + q(1 - p)](C + H) > R + p(1 - q)V. \tag{A5}$$

Let $q > p$. Then, if C is high enough and R small enough, (A3) and (A4) hold, and (A5) also holds, because $q > p$. Also, if (A4) holds, then, if u is large enough, $p(1, 2)(V - d) - C$ is negative as assumed at the beginning of the proof. Similarly, if $p > q$, then if (A5) holds, (A3) and (A4) hold too, and if u is large, $p(1, 2)(V - d) - C$ is negative. Therefore, the claim follows. Q.E.D.

Appendix B

Effort and Accuracy of Project Choice as Substitutes

The purpose of this appendix is to examine the validity of the model's qualitative results in a setting with an alternative specification of production technology. In particular, instead of being complements, effort and accuracy of project choice are substitutes here. Formally, this is represented by a technology $y = kV + (1 - k)eV$, where, as before, $k = 1$ if

$j = s$ and $k = 0$ if $j \neq s$. Thus, while under the technology used in the main text effort exerted on a good project was more productive than effort exerted on a bad project, here the situation is reversed. The good project is a sure success even if the agent exerts no effort, while a bad project requires effort to be successful. Under this specification, the agent's incentive compatibility and participation constraints, as well as the firm's expected profit, are given as follows.

Centralization

Under centralization, the agent's incentive compatability constraints are given as $d^s - H \geq d^s p(1,x) + d^f[1 - p(1,x)]$, $x = 1, 2$, which reduces to

$$(d^s - d^f)[1 - p(1,x)] - H \geq 0, \; x = 1, 2.$$

i) *Full incentives.*—In this case, the agent provides effort regardless of his posterior, which means that the participation constraint is

$$d^s - H \geq u.$$

ii) *Partial incentives.*—In this case, the agent provides effort only when his posterior is $p(1, 2)$, and his participation constraint is

$$d^s[q + (1 - q)p] + d^f(1 - q)(1 - p) - H[p(1 - q) + q(1 - p)] \geq u.$$

iii) *No incentives.*—In this case, the agent never provides effort, so that his participation constraint can be written as

$$d^s q + d^f(1 - q) \geq u.$$

Using $d^f = D$, the expressions for expected profit under centralization are as follows:

i) *Full incentives.*—When the agent always provides effort, the firm's expected profit is

$$\pi_i^c = V - C - H - U^c(i), \tag{B1}$$

where $U^c(i) = \max\big(u, D + \{H/[1 - p(1,1)]\}\big)$ is the agent's expected utility under the full incentives contract.

ii) *Partial incentives.*—

$$\pi_{ii}^c = V[q + (1 - q)p] - C - H[p(1 - q) + q(1 - p)] - U^c(ii), \tag{B2}$$

where $U^c(ii) = \max\{u, D + H[q + p(1 - q)]/[1 - p(1, 2)]\}$ is the agent's expected utility under the partial incentives contract.

iii) *No incentives.*—Since in this case the agent provides no effort, the expected profit is

$$\pi_{iii}^c = Vq - C - u. \tag{B3}$$

Decentralization

Under decentralization, the agent's incentive compatibility constraint is

$$(d^s - d^f)(1 - p) - H \geq 0.$$

i) *Full incentives.*—Under this contract, the agent always provides effort, and his participation constraint is

$$d^s - H \geq u.$$

ii) *No incentives.*—When the contract never induces the agent to provide effort, his participation constraint is

$$d^s p + d^f(1 - p) \geq u.$$

Again, using $d^f = D$, the profits are

$$\pi_i^d = V - C - H - U^d(i) \tag{B4}$$

under the full incentives contract, where $U^d(i) = \max\{u, D + [H/(1 - p)]\}$ is the agent's expected utility under this contract, and

$$\pi_{ii}^d = Vp - C - u. \tag{B5}$$

The Effects of a Liquidity Constraint on the Optimal Decision-Making Arrangement

Proposition 4 below describes the effects of a liquidity constraint on the optimal decision-making arrangement when effort and accuracy of project choice are substitutes. Proposition 4 can be viewed as a counterpart of proposition 2 in this alternative setting.

Proposition 4.

a) For any given $H > 0$ and $q \in (1/2, 1)$, there exist parameter values for p, D, and V such that, in the absence of a liquidity constraint, decentralization is strictly optimal, but in the presence of a liquidity constraint, centralization is strictly optimal.

b) For any given $H > 0$ and $q \in (1/2, 1)$, there exist parameter values for p, D, and V such that in the absence of a liquidity constraint centralization is strictly optimal, but in the presence of a liquidity constraint, decentralization is strictly optimal.

Proof of proposition 4 (*a*). Suppose, first, there is no liquidity constraint. Comparing profits under centralization with those under decentralization, one can see that

$$\pi_i^c > \pi_i^d \text{ iff } q > p, \tag{B6}$$

$$\pi_{ii}^c > \pi_i^d \text{ iff } V[1 - p(1, 1)] < H, \tag{B7}$$

$$\pi_i^c > \pi_{ii}^d \text{ iff } V(1 - p) > H, \tag{B8}$$

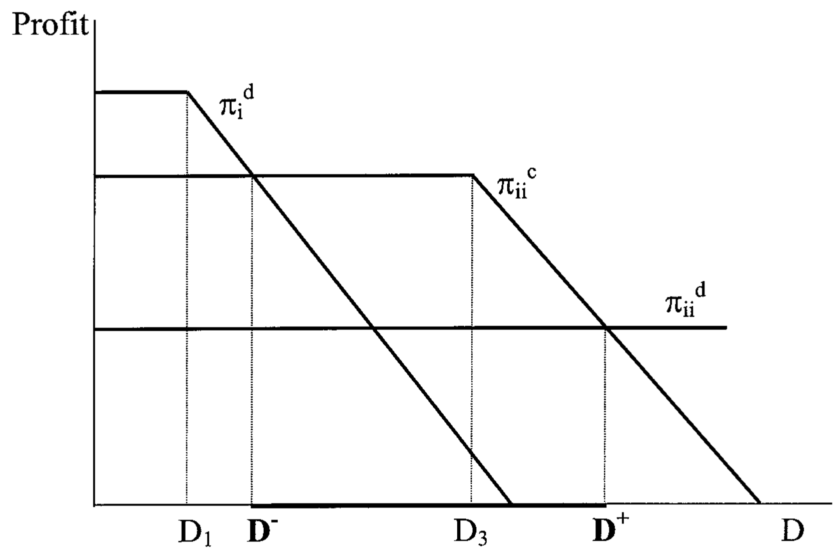

Fig. B1.— Decentralization is optimal in the absence of a liquidity constraint (i.e., $D < D_1$), but it is suboptimal when a liquidity constraint is present such that $D^- < D < D^+$.

$$\pi_{ii}^c > \pi_{ii}^d \text{ iff } V[1 - p(1, 2)] > H, \tag{B9}$$

$$\pi_{iii}^c > \pi_{ii}^d \text{ iff } q > p. \tag{B10}$$

Fix an $H > 0$ and a $q \in (1/2, 1)$. Consider $p = q$, and choose V such that $V[1 - p(1, 1)] = H + \varepsilon$, where $\varepsilon > 0$ is close to zero. This means that the reverse of (B7) holds. Then, by (B6), $\pi_i^c = \pi_i^d$; by (B7), $\pi_{ii}^c < \pi_i^d$; and, by (B10), $\pi_{iii}^c = \pi_{ii}^d$. Therefore, without a liquidity constraint, delegation is strictly optimal under these parameter values.

Now introduce a liquidity constraint. Note that there exists a $D_1 \geq 0$, such that π_i^d is independent of D for $D \leq D_1$ and is linear and decreasing in D for $D > D_1$ (see fig. B1). Similarly, for π_i^c (π_{ii}^c), there exists a D_2 (D_3), such that π_i^c (π_{ii}^c) is constant for $D \leq D_2$ ($D \leq D_3$) and linearly decreasing in D for $D > D_2$ ($D > D_3$).

Now, the reverse of (B6) implies that (B8) holds, because $1 - p(1, 2) > 1 - p(1, 1)$. This means that $\pi_{ii}^c > \pi_{ii}^d$ if D is not binding (i.e., for $D < D_3$). Moreover, even when D is binding, looking at figure B1, one can see that there exists a parameter value $D^+ > D_3$ such that $\pi_{ii}^c > \pi_{ii}^d$ for $D < D^+$.

Next, compare π_{ii}^c and π_i^d under a liquidity constraint. After a few algebraic manipulations, it turns out that $\pi_{ii}^c > \pi_i^d$ if and only if

$$V[1 - p(1, 1)] < H + \Delta, \tag{B11}$$

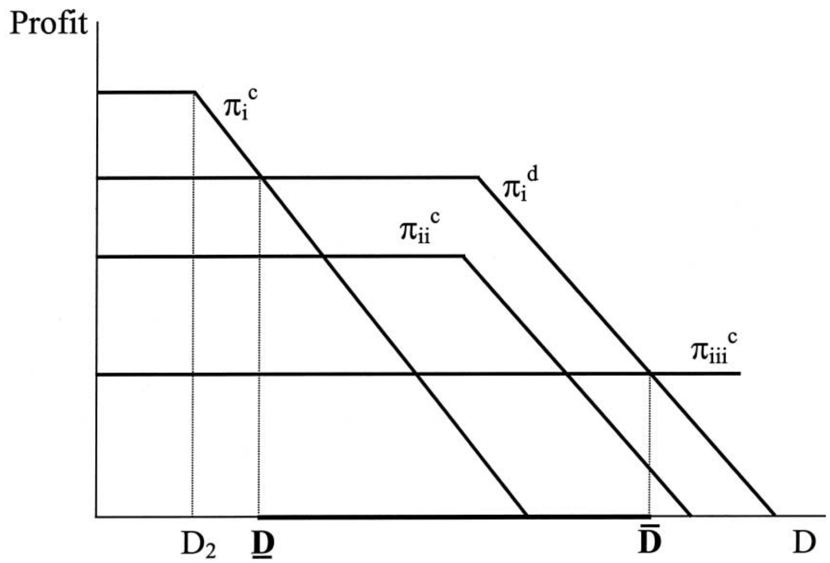

FIG. B2.—Centralization is optimal in the absence of a liquidity constraint (i.e., $D < D_2$), but it is suboptimal when a liquidity constraint is present such that $\underline{D} < D < \overline{D}$.

where

$$\Delta = H\frac{p(1,1)}{pq}\left[\frac{1}{1-p} - \frac{1}{1-p(1,2)}\right].$$

Because $1 - p < 1 - p(1,2)$, it follows that $\Delta > 0$. Also, if ε is chosen sufficiently small (so that $\varepsilon < \Delta$), then (B11) holds, and there exists a $D^- < D^+$ (see fig. B1) such that $\pi^c_{ii} > \pi^d_i$ for $D > D^-$. Hence, for $p = q$, $\pi^c_{ii} > \max(\pi^d_i, \pi^d_i)$ if $D \in (D^-, D^+)$. Continuity then implies that similar results hold also for $p \neq q$ if p is close to q. This concludes the proof of part *a* of proposition 4.

Proof of proposition 4 (*b*). Again, start by choosing p very close to q, but $p < q$. Next, select V large enough so that (B7) holds. Then centralization is strictly optimal in the absence of a liquidity constraint, because $\pi^c_{ii} > \max(\pi^d_i, \pi^d_{ii})$.

Now introduce a liquidity constraint, and consider $p = q$. Comparing π^d_i and π^c_i, it follows that $\pi^d_i > \pi^c_i$, because $1 - p(1,1) < 1 - p$, and this implies $U^c(i) > U^d(i)$. By continuity, there exists a $\underline{D}$ (see fig. B2) such that $\pi^d_i > \pi^c_i$ also for p slightly lower than q.

Next compare π^d_i and π^c_{ii}. It is immediate from (B11) that if $p = q$ and V is chosen large enough, then $\pi^d_i > \pi^c_{ii}$. Again, using continuity, $\pi^d_i > \pi^c_{ii}$ even when $p < q$ if p is close enough to q. Finally, compare π^d_i and π^c_{iii} for p slightly smaller than q. In the absence of a liquidity constraint, $\pi^d_i > \pi^c_{iii}$ if and only if $V(1 - q) > H$, which holds because (B11) holds.

Therefore, there exists a $\overline{D} > \underline{D}$ such that $\pi_i^d > \pi_{iii}^c$ whenever $D < \overline{D}$. Thus, in the presence of a liquidity constraint, there exists a nonempty interval $(\underline{D}, \overline{D})$ such that decentralization is strictly optimal if $D \in (\underline{D}, \overline{D})$.Q.E.D.

Part *b* of proposition 4 is a qualitative equivalent of part *b* of proposition 2, and it demonstrates that this result is robust to extensions into settings with alternative production technology. On the other hand, part *a* in proposition 4 differs from part *a* in proposition 2: when effort and accuracy of project choice are substitutes, it is possible that the presence of a liquidity constraint makes centralization optimal where otherwise it would be dominated by decentralization. However, when effort and accuracy of project choice are complements, this is never possible. The intuition for this difference in the parts *a* of propositions 2 and 4 is as follows. Consider decentralized decision making. When effort and accuracy of project choice are complements, as in the main text, it is relatively cheap to elicit effort from the agent, because the project can be successful only if the agent provides effort. Without providing effort, he gets no bonus. On the other hand, when effort and accuracy of project choice are substitutes, as in this appendix, the project can be successful even if the agent provides no effort. This makes it expensive to elicit effort in the presence of a liquidity constraint, and the profitability of decentralization declines as the constraint becomes more binding. This makes it possible for centralization to dominate.

References

Aghion, Philippe, and Tirole, Jean. "Formal and Real Authority in Organizations." *Journal of Political Economy* 105 (February 1997): 1–29.

Aoki, M. "Horizontal vs. Vertical Information Structure of the Firm." *American Economic Review* 76 (December 1986): 971–83.

Athey, Susan; Gans, Joshua; Schaefer, Scott; and Stern, Scott. "The Allocation of Decisions in Organizations." Graduate School of Business Research Paper no. 1322. Stanford, CA: Stanford University, 1994.

Boeck, Greg. "Big Apple Sport Supplier Checketts Sees Garden Come into Full Bloom." *USA Today* (November 20, 1996), p. 1C.

Bolton, Patrick, and Dewatripont, Mathias. "The Firm as a Communication Network." *Quarterly Journal of Economics* 109 (November 1994): 809–39.

Calvo, Guillermo A., and Wellisz, Stanislaw. "Supervision, Loss of Control, and the Optimum Size of the Firm." *Journal of Political Economy* 86 (October 1978): 943–52.

Chandler, Alfred D., Jr. *Strategy and Structure: Chapters in the History of the Industrial Enterprise.* Cambridge, MA: MIT Press, 1962.

Crawford, Vincent P., and Sobel, Joel. "Strategic Information Transmission." *Econometrica* 50 (November 1982): 1431–51.

Economist. "Trust in Me." (December 16–22, 1995), p. 61.

Geanakoplos, John, and Milgrom, Paul. "A Theory of Hierarchies Based on Limited Managerial Attention." *Journal of the Japanese and International Economy* 5 (September 1991): 205–25.

Kahn, Charles, and Huberman, Gur. "Two-Sided Uncertainty and Up-or-Out Contracts." *Journal of Labor Economics* 6 (October 1988): 423–44.

Melumad, Nahum; Mookherjee, Dilip; and Reichelstein, Stefan. "A Theory of Responsibility Centers." *Journal of Accounting and Economics* 15 (December 1992): 445–84.

———. "Contract Complexity, Incentives, and the Value of Delegation." *Journal of Economics and Management Strategy* 6 (Summer 1997): 257–89.

Melumad, Nahum D., and Reichelstein, Stefan. "Centralization versus Delegation and the Value of Communication." *Journal of Accounting Research* 25, supp. (1987): 1–18.

Myerson, Roger. "Optimal Coordination Mechanisms in Generalized Principal-Agent Problems." *Journal of Mathematical Economics* 10 (June 1982): 67–81.

Osterman, Paul. "The Role of Promotion in Inducing Specific Human Capital Acquisition." *Quarterly Journal of Economics* 108 (May 1993): 523–34.

———. "Supervision, Discretion, and Work Organization." *American Economic Review, Papers and Proceedings* 84 (May 1994): 380–84.

Prendergast, Canice J. "A Theory of Responsibility in Organizations." *Journal of Labor Economics* 13 (July 1995): 387–400.

Radner, Roy. "The Organization of Decentralized Information Processing." *Econometrica* 61 (September 1993): 1109–46.

Rosen, Sherwin. "Authority, Control, and the Distribution of Earnings." *Bell Journal of Economics* 13 (Autumn 1982): 311–23.

Sah, Raaj Kumar, and Stiglitz, Joseph E. "The Architecture of Economic Systems: Hierarchies and Polyarchies." *American Economic Review* 76 (September 1986): 716–27.

Sappington, David. "Limited Liability Contracts between Principal and Agent." *Journal of Economic Theory* 29 (February 1983): 1–21.

Waldman, Michael. "Worker Allocation, Hierarchies and the Wage Distribution." *Review of Economic Studies* 51 (January 1984): 95–109.

Williamson, Oliver. *Markets and Hierarchies: Analysis and Antitrust Implications.* New York: Free Press, 1975.

Zábojník, Ján. "Sales Maximization and Specific Human Capital." *Rand Journal of Economics* 29 (Winter 1998): 790–802.