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# Incentives in Principal-Agent Relationships

David E. M. Sappington

*If you want something done right, do it yourself.*  
This age-old maxim has some of the major concerns of modern “incentive theory” at its heart. Incentive theory, however, generally focuses on tasks that are too complicated or too costly to do oneself. Thus, the “principal” is obliged to hire an “agent” with specialized skills or knowledge to perform the task in question. The central concern is how the principal can best motivate the agent to perform as the principal would prefer, taking into account the difficulties in monitoring the agent’s activities.

The intent of this article is to identify some of the major issues that have been examined in the literature on incentives. The article begins by discussing the frictions that lie at the heart of incentive problems. Next, the principal’s optimal response to these frictions is explored, taking as given the characteristics of the agents with whom the principal interacts in a nonrepeated setting. The design of individualized contracts, contests and tournaments is analyzed. Then, the principal’s task of selecting the best agent is addressed, and repeated agency relationships are considered. Some summary comments are offered in conclusion. Until the concluding section, the discussion will focus on simple agency relationships that proceed in isolation from other agency relationships. This focus facilitates the clearest identification of the key incentive problems that arise both in the simplest of agency relationships and in more complex organizations like corporations and governments.<sup>1</sup>

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Before proceeding, briefly consider the myriad of applications of the principal-agent paradigm. In a labor setting, a boss or employer may serve the role of principal, while a subordinate or worker may act as agent. In regulated industries, the regulator might act as principal, designing an incentive scheme for the firm (agent) whose activities are being regulated.<sup>2</sup> A military leader might similarly strive to influence the activities of the troops under his command. Alternatively, the dean of a college might create incentives to motivate a faculty. The classic example of the principal-agent relationship has a landlord overseeing the activities of a tenant farmer.

## A Canonical Setting

Under certain circumstances, it may be possible for a principal to induce agents to behave exactly as the principal would if the principal shared the agents' skills and knowledge. By describing these circumstances, it becomes possible to pinpoint the sources of friction between principal and agent that typically preclude this ideal arrangement.

To begin, consider a relatively simple setting. Suppose there is only one principal, a landlord for example, and one agent, a tenant farmer. Both parties are risk neutral. Initially, the landlord and tenant farmer share the same beliefs about a critical random productivity parameter,  $\theta$ , such as the amount of rainfall. Higher realizations of the productivity parameter,  $\theta$ , like increased effort,  $e$ , on the agent's part, both increase the agent's expected performance. Realized performance,  $X$ , might be the amount of crop the farmer ultimately harvests.<sup>3</sup> For simplicity, suppose the agent can observe  $\theta$  before choosing how much effort to exert.<sup>4</sup> However, the principal can't observe either the realization of  $\theta$  or the level of effort exerted by the agent. The principal's valuation of performance level  $X$  is denoted  $V(X)$ , which is an increasing function of  $X$  with

<sup>1</sup>The interested reader is strongly encouraged to read the insightful review by Holmstrom and Tirole (1988). Their analysis of incentive issues in the firm provides a detailed critique of a variety of topics that are afforded only cursory treatment here. For related overviews, see Hart and Holmstrom (1987) and Laffont and Maskin (1982).

<sup>2</sup>For surveys that address this particular interpretation of the principal-agent paradigm, see Baron (1988), Besanko and Sappington (1987), Caillaud, Guesnerie, Rey and Tirole (1988), and Sappington and Stiglitz (1987).

<sup>3</sup>For example, if  $X = e\theta$ , then performance is proportional to the farmer's effort and to the amount of rainfall. If performance did not vary with  $\theta$ , the magnitude of the agent's effort could be inferred perfectly from  $X$ , making the incentive problem a trivial one.

<sup>4</sup>The relationship between  $X$  and both  $e$  and  $\theta$  could be deterministic, as illustrated in the preceding footnote, or it could be stochastic. This latter possibility could be captured as follows. Let  $f(X|e, \theta)$  denote the density function for performance,  $X$ , when the productivity parameter is  $\theta$  and the agent exerts effort level  $e$ .  $F(X|e, \theta)$  is the associated cumulative distribution function. Higher levels of effort and higher realizations of  $\theta$  decrease the probability that the smaller levels of performance will be realized, i.e.,  $F_e(X|e, \theta) \leq 0$  and  $F_\theta(X|e, \theta) \leq 0$ . The expected marginal impact of the agent's effort is also assumed to be greater in more productive environments, that is  $F_{e\theta}(X|e, \theta) \geq 0$ .

diminishing returns. For instance,  $V(X)$  might represent the income the principal can secure by selling the delivered crop.

The timing of the interaction between principal and agent in this simplest of settings is the following. First, the principal designs the terms of the contract, which specifies the payments  $P$  the agent will receive depending on observed performance  $X$ . The principal then offers the contract to the agent. Next, the agent decides whether to accept or reject the contract. If the agent rejects the contract, the relationship is terminated, never to occur again. If the agent accepts the contract, he begins his “employment” and observes the realization of the productivity parameter,  $\theta$ . Next, the agent decides how much effort to put forth. Finally, the agent’s performance is observed, and payments are made to the agent, as promised in the contract.

The principal is endowed with all of the bargaining power in this simple setting, and thus can make a “take-it-or-leave-it” offer to the agent. The agent will accept the contract offered by the principal if and only if subsequent self-interested behavior under the terms of the contract provides the agent with a level of expected utility that exceeds his reservation level,  $\bar{U}$ . This reservation level is presumed known to both the principal and the agent.

In this setting, the ideal outcome for the principal has two elements. First, for each realization of  $\theta$ , the agent chooses the efficient level of effort,  $e^*(\theta)$ . This level of effort maximizes the expected surplus, defined as the difference between the expected value of the agent’s performance and the agent’s cost of effort, including his opportunity cost  $\bar{U}$ . Second, the principal collects the entire surplus, always leaving the agent with exactly his reservation utility level.

In this simple canonical problem, the principal can ensure this most preferred arrangement with a simple contract. This contract promises payments,  $P$ , to the agent that are precisely the principal’s valuation of the agent’s performance less some fixed constant  $k$ . Formally,  $P(X) = V(X) - k$ . The constant  $k$  in this contract can be interpreted as a “franchise fee” paid by the agent for the right to work for the principal. This franchise fee is set equal to the expected total surplus from efficient operation.<sup>5</sup>

Here, the principal resolves the problem of motivating the agent by making the agent the residual claimant in the relationship. After “buying” the “franchise,” the agent’s goals are perfectly aligned with the principal’s initial goals. Therefore, the agent always acts as the principal would if she shared the agent’s superior information and expertise. In particular, the greater the amount of rainfall, the more diligently the farmer works because the expected

<sup>5</sup>Formally,  $k = \int_{\theta} \int_X [V(X)f(X | e^*(\theta), \theta) - e^*(\theta)]g(\theta) dX d\theta - \bar{U}$ , where

$$e^*(\theta) = \operatorname{argmax}_e \left\{ \int_X V(X)f(X | e, \theta) dX - e \right\},$$

and where  $g(\theta)$  is the density function for  $\theta$ . The term involving the double integral is the expected value of the franchise to the principal when the agent always delivers the efficient level of effort,  $e^*(\theta)$ . Notice that without essential loss of generality, the marginal cost to the agent of each unit of effort has been normalized to unity.

returns from his effort are greater. The division of the realized surplus is resolved in the principal's favor when the principal makes a take-it-or-leave-it offer that the agent is just willing to accept.<sup>6</sup>

This simple resolution of what might, at first blush, appear to be a nontrivial incentive problem relies heavily on some special features of this canonical model. These special features are what create frictions in the principal-agent relationship, and thus necessitate the use of a broader set of tools and institutions.

The first special feature is the symmetry of precontractual beliefs. If the farmer and landowner didn't share the same beliefs about the likely amount of rainfall, for example, they might not agree on the value of the right to farm the land, rendering the neat separation of incentive issues (motivating the agent to choose an efficient level of effort) and distribution issues (how the surplus is divided) problematic.<sup>7</sup> Implicit in the strong assumption of symmetric beliefs is the presumption that both parties are able to anticipate fully all possible contingencies that might arise during their relationship.<sup>8</sup>

The second special feature is the presumed risk neutrality of the agent. Notice that under the identified contract, the farmer bears all the risk associated with the random rainfall and with any inherent randomness in the production process. In general, whenever an agent is averse to risk, some sharing of the risk between principal and agent will be optimal. For example, a risk-averse farmer shouldn't be forced to bear the entire burden of a poor harvest when the weather turns out to be unusually bad.

The third special feature of this simplest of settings is the assumption that the agent can be bound costlessly to carry out the terms of any contract he agrees to. In particular, even though the agent may know when he observes an unfavorable environment (that is, a low  $\theta$  indicating little rainfall in the tenant farmer interpretation) that the best he can possibly do is earn an expected net return far below his reservation utility level, the agent is unable to abrogate or renegotiate the contract he has signed. In a sense, the agent's commitment ability is perfect in this setting. So, too, is the principal's commitment ability. The payment schedule announced by the principal cannot be changed after the output is observed. This fact assures that the agent will not be "held up" by the principal after (costly) effort has been exerted. In practice, a worker's commitment abilities are not perfect. Labor laws prohibit slavery, so an employee can't

<sup>6</sup>In most of this literature, it is assumed that when the agent is indifferent among actions, like between accepting or rejecting the contract, the agent will choose the action most preferred by the principal. This method of "breaking ties" resolves a technical open-set problem of limited economic interest.

<sup>7</sup>Notice that as long as precontractual beliefs are symmetric, the franchise contract maximizes total surplus even if the principal is not endowed with all of the bargaining power. Bargaining could serve to divide the surplus between principal and agent.

<sup>8</sup>See Williamson (1975, 1985), for example, for a detailed discussion of the practical difficulties that arise when it is costly for parties to a contract to account for all contingencies that could possibly arise. Additional thoughts on this issue are presented in the concluding section.

credibly promise to serve his employer forever. The commitment ability of a principal is often limited in practice too. Politicians routinely break campaign pledges, and downturns in the economy often force employers to implement unanticipated layoffs or wage cuts.

The fourth special feature is the presumption that the agent's performance is publicly observable. The initial contract can be readily enforced when performance under the contract is costlessly verified by both the principal and agent and, if necessary, an impartial enforcement agency (like a court). In practice, though, it will often be difficult to measure performance precisely. To illustrate, the number of ears of corn delivered by the farmer may be easily counted, but the sweetness of the corn or the water content of the kernels may be more difficult to measure exactly.

Notice that in this simplest of settings, since all contracting frictions can be avoided costlessly with the identified franchise contract, the principal would never pay to obtain information about the working environment or the magnitude of the agent's efforts. However, when frictions are caused by precontractual asymmetries of information, risk aversion, limited commitment abilities, or problems in measuring the agent's performance, the principal generally will benefit from an improved ability to monitor the agent's effort and/or working environment. The optimal use of such monitors will be discussed shortly.

## **Extensions of the Canonical Setting**

Let us consider the implications of relaxing the strong assumptions that eliminate all frictions in the canonical model. First, suppose the agent is averse to risk. In this case, if the agent were asked to bear all the risk associated with production, he would require an expected payment in excess of  $\bar{U}$ . To conserve on the risk premium she must award the agent for bearing risk, the principal will choose to bear some risk herself. Loosely speaking, this means that although the agent generally receives greater compensation the higher his realized performance, the agent's incremental reward for additional performance will generally be less than the value to the principal of that additional performance. In this sense, the agent is no longer the sole residual claimant in the relationship, as under the franchising contract.

This fact implies that the agent's goals are no longer perfectly aligned with the principal's initial goals. In particular, since the agent no longer benefits as much from outstanding performance, his incentives to supply effort are diminished.<sup>9</sup> Risk sharing between principal and agent can also act as a form of insurance for the agent. When he is effectively insured against bad outcomes

<sup>9</sup>For details of a formal model along these lines, see for example Stiglitz (1974, 1975a), Harris and Raviv (1979), Holmstrom (1979), or Shavell (1979). Also, see Grossman and Hart (1983) and Laffont and Tirole (1986).

under the optimal contract, the agent will exert less effort to avoid these bad outcomes. To illustrate, after a homeowner purchases theft insurance, he may be less careful about locking his doors at night.<sup>10</sup>

A similar effect arises when the agent's commitment ability is limited. To illustrate, suppose the tenant farmer is always free to terminate his relationship with the landlord without penalty after observing the amount of rain that has fallen. Alternatively, when a corporation's revenues turn out to be below costs, the firm can declare bankruptcy and suspend payments to creditors. The force of such arrangements can be to ensure that after becoming informed about the environment, the agent never expects to receive less than his reservation utility level,  $\bar{U}$ .

In contrast, under the franchise contract, the uninformed agent only expects to earn his reservation utility on average. When the working environment turns out to be less favorable than expected (that is, when lower values of  $\theta$  are realized), the agent will be worse off than if he had never signed a contract with the principal. Therefore, if the principal offered the franchise contract described above in an environment where the agent's maximum loss or his "liability" is limited by his right to rescind his contractual obligations, the agent would exert effort and remain in the principal's employ only for the higher realizations of  $\theta$ ; and in those more productive states, the agent would receive the entire value of his performance.

When the principal must respect the agent's right to abrogate the terms of the original contract, the principal will find it advantageous to alter the terms of the contract she offers to the agent. In particular, the optimal contract will generally induce performance by the agent even for the less favorable realizations of the environment. But this expanded performance will not be induced simply by lowering the franchise fee ( $k$ ). To do so would grant too much of the total available surplus to the agent, raising the agent's expected utility above  $\bar{U}$  so that he receives rents. Instead, the principal will implement a sharing of the total realized surplus. By promising the agent a fraction of the full value of his performance, the agent can be induced to deliver productive effort, albeit less than the efficient level of effort. Consequently, limited liability restrictions, like risk aversion on the part of the agent, result in contracts that induce too little effort from the agent.<sup>11</sup>

The principal faces the same qualitative tradeoffs when the agent's initial information about the productive environment is superior to the principal's own information as she does when the agent is protected by limited liability covenants. To see the connection, suppose once again that the landlord offered the basic franchise contract to a farmer who, because of past experience, has very accurate information about how much rainfall will occur that year. The farmer would reject the franchise contract when he felt certain that little rainfall

<sup>10</sup>These moral hazard problems have been afforded considerable attention in the insurance literature (Pauly, 1974; Arnott and Stiglitz, 1989).

<sup>11</sup>For the formal details of models in which limited liability restrictions are featured, see for example Kahn and Scheinkman (1985) or Sappington (1983).

would occur (since accepting would entail earning less than  $\bar{U}$  in expected utility). The farmer would accept the contract only when he was confident of higher levels of rainfall, exactly as he would when he is protected by limited liability clauses but discovers the level of rainfall only after signing the contract. Anticipating this behavior, the landlord will again modify the contract by inducing some effort from the farmer even for the lower levels of rainfall, without granting the farmer all of the realized surplus. Again, this is accomplished by sharing the realized returns with the farmer.

Thus, whether risk aversion, limited liability restrictions or asymmetric precontractual information complicate the canonical model presented earlier, similar qualitative effects emerge. The most important effect is that a franchise contract imposes too much risk on the agent or delivers too great a share of the realized surplus to him, and so the principal resorts to a “sharing” contract. Because the agent’s compensation is less sensitive to his performance under the sharing arrangement than under the franchise contract, the agent exerts less effort under the former contract. This reduced effort results in losses for the principal relative to the benchmark setting of the canonical model.

Nevertheless, the sharing contract is advantageous to the principal because it induces the agent to tailor his effort level to the environment. When higher levels of rainfall increase the productivity of the tenant farmer’s labor, the farmer will work harder under a sharing contract when more rain has fallen. The gains in total surplus that arise from adjusting the farmer’s labor input according to its productivity are divided between principal and agent under a sharing contract.

The exact details of the optimal sharing arrangement and the number of distinct contracts the principal offers will depend on a number of factors, including the nature of the agent’s precontractual information and whether he subsequently acquires better information. To illustrate, suppose that at the time a contract is signed, the tenant farmer has better knowledge than the landlord about likely rainfall, but the farmer’s information doesn’t provide a perfect weather forecast. Only at a later date, just before the farmer has to decide how hard to work at harvesting the crop, does the farmer learn the exact amount of rainfall. In this setting, the landlord can gain by offering the farmer a choice among sharing contracts, or equivalently (Myerson, 1979), by soliciting a weather forecast from the farmer which determines the sharing contract that will be implemented.

To see this, suppose for simplicity that the farmer initially learns whether rainfall will be above average or below average. One naive strategy the landlord could follow in this setting would be to ask the farmer to report whether he expects rainfall to be above or below average, and then design the best sharing contract presuming the farmer’s forecast to be accurate. The problem with this naive strategy is that it will always induce the farmer to predict below average rainfall, thereby preparing the landlord for a poor harvest. A superior alternative for the landlord is to link the farmer’s forecast to the sharing contract under which the farmer will ultimately toil. Loosely speaking, the landlord



should commit to implementing a “steeper” or more “high-powered” sharing contract the higher the predicted rainfall. The more high-powered the sharing contract, the more closely does the farmer’s compensation correspond to his performance. Thus, under a particularly high-powered contract, the farmer will receive very large payments if abundant rainfall leads to a plentiful harvest. However, the farmer will receive very little payment if the harvest is meager. Consequently, if the farmer truly believes rainfall will be below average, the threat of low payoffs when rainfall turns out to be scarce will dissuade the farmer from exaggerating likely rainfall. Similarly, a false report of below average rainfall is unappealing to the farmer, because the low-powered incentive contract it calls forth limits the farmer’s ability to earn large profits when rainfall turns out to be plentiful.

In this manner, a principal can solicit truthful reporting of imperfect but superior information from an agent. The agent’s report enables the principal to design an incentive scheme that secures greater expected surplus by better tailoring incentives to the environment. Of course, because the agent has unique skills and privileged information, he will generally be able to command a share of this surplus in the form of rents. Therefore, the principal could conceivably gain from additional policy instruments that provide direct (although possibly imperfect) observations of the agent’s activities or his information. The optimal use of such monitors is described in the next section.

## **Monitoring and Competition**

In the presence of the aforementioned contracting frictions, other more direct observations of the agent’s activities or information may help the principal to motivate the agent. To illustrate, consider the case where the agent is averse to risk, and suppose that an imperfect public signal about the agent’s effort level is available. For example, the signal might be the sum of the agent’s actual level of effort and the realization of a standard normal random variable. A question of interest is: “When will the principal choose to base the agent’s compensation on both the realization of the signal and on the agent’s observed performance, rather than simply on the agent’s performance?” Conceivably, the principal might choose to ignore the imperfect signal because its use would impose some risk on the risk-averse agent.

It turns out that whenever the signal and the agent’s realized performance together provide more information about the agent’s effort than does the agent’s performance alone, the agent’s compensation under the optimal contract will be based on both his performance and on the signal. The added risk imposed on the agent from slight use of the imperfect monitor will be insignificant relative to the incentive benefits achieved.<sup>12</sup>

<sup>12</sup>For a careful statement of this conclusion and a formal proof, see Holmstrom (1979). Also see Harris and Raviv (1979) and Shavell (1979).

In practice, monitors take a variety of forms. Hidden cameras and time cards can serve as imperfect monitors of a worker's effort, as can direct observations and "spot checks" by supervisors. The actions and performance of a fellow worker can also serve to discipline a worker. To illustrate, extend the canonical setting to allow a single principal to devise an incentive scheme for two risk averse agents, agents  $A$  and  $B$ . Further suppose that these agents work in correlated environments. For example,  $\theta$  might reflect rainfall or soil conditions on nearby farms. Plentiful rainfall or favorable soil conditions on one farm might suggest that the same conditions will be found on nearby farms. Formally, this correlation could be captured by assuming the productivity parameters,  $\theta^A$  and  $\theta^B$ , observed (privately) by agents  $A$  and  $B$ , respectively, are positively correlated.

The question of interest in this setting is how the principal or landlord can best exploit the correlation across environments to motivate agents or tenant farmers. One way to do so is to link each farmer's incentive contract to the reports received from both farmers about their environment. These reports are obtained simultaneously from the two farmers before they decide how hard to work at harvesting the crop. The natural tendency of a farmer working in isolation would be to understate the likely rainfall because if the landlord could be made to believe that little rainfall is likely, the landlord might not expect so much from the farmer and therefore not penalize him too severely for a poor harvest.

However, if the landlord provides rewards to both farmers when their reports are "consistent" and penalizes the farmer who predicts the least rainfall when the two predictions are sufficiently inconsistent, incentives to underpredict rainfall can be mitigated. In essence, under an incentive scheme of this form, each farmer is asked to assess not only his own environment, but also to report on his fellow farmer's environment. When farmer  $A$ , for example, learns that rainfall on his farm is plentiful, he knows that plentiful rainfall is also likely on farmer  $B$ 's land. Hence, if farmer  $B$  is expected to report his rainfall truthfully, farmer  $A$  will be less likely to understate the rainfall on his land, for fear of being penalized for reporting an inaccurate assessment of farmer  $B$ 's environment. Similar arguments explain why farmer  $B$ 's (Nash) response might also be to understate the rainfall on his land less often than he might otherwise be tempted to do in isolation. By comparing the reports of the farmers, the landlord can reduce the rents the farmers command from their private information.<sup>13</sup>

<sup>13</sup>A formal model along these lines is analyzed in Demski and Sappington (1984). Also see Nalebuff and Stiglitz (1983a). For an analysis of the setting where the output of an organization is a joint product of the effort of many agents, see Holmstrom (1982). Arnott and Stiglitz (1991), Stiglitz (1990), and Varian (1990) address the issue of peer monitoring, wherein the payment to each member of a group depends upon the performance of the entire group, and group members can monitor and insure each others' activities.

A special concern arises when self-interested actors, rather than inanimate devices, are employed as monitors. The concern is with coordinated play among the actors. For example, farmers *A* and *B* could try to thwart the landlord's attempt to make meaningful comparisons between their reports by both always reporting that the smallest possible level of rainfall has occurred. Such strategies could conceivably constitute an equilibrium and improve the expected payoff of both farmers. However, a sufficiently sophisticated landlord can preclude such informal cooperation among the farmers. The method is to single out one of the farmers, say farmer *A*, and reward him for "squealing" on farmer *B* whenever *B* attempts to behave strategically in the manner described above. The reward to farmer *A* can be structured so that he finds it profitable to "squeal" on farmer *B* if and only if farmer *B* is behaving strategically (Ma, 1988; Ma, Moore, and Turnbull, 1988; Mookherjee and Reichelstein, 1990). Essentially, farmer *A* is given a large payment if he predicts that farmer *B* will understate rainfall and farmer *B* then does report meager rainfall. Farmer *A* is penalized, though, if after squealing on farmer *B*, farmer *B* reports plentiful rainfall.<sup>14</sup>

Thus, additional agents can provide valuable information about the information or activities of any particular agent, just as an inanimate monitor can. Moreover, the presence of multiple agents can be particularly valuable to the principal when the performance of each agent is influenced primarily by a common environmental parameter that the principal cannot observe. In such a setting, the *relative performance* of the agents can provide a good indicator of their individual efforts, while controlling for the effects of the common environmental shock. Thus, effort can be motivated without imposing excessive risk on the agents.

To illustrate, suppose each farmer's harvest is influenced to some extent by the soil conditions on his farm, but is determined primarily by the number of insects that eat his crops and by his efforts in combatting the insects. Also suppose that the absentee landlord cannot communicate with the farmers about insect blight, and that the insects affect all farms in similar fashion. In this setting, a simple tournament, in which the farmers are compensated solely according to the ordinal ranking of their harvests, can often provide good incentives for the farmers. Even the simplest of tournaments, where the farmer whose harvest is the largest receives a large payment and all other farmers receive a small payment, can often motivate the farmers better than individualized contracts, wherein each farmer's payment would depend exclusively on the level of his harvest. Tournaments can level the playing field for the agents, effectively controlling for and providing insurance for risk averse agents against

<sup>14</sup>The landlord's task would be complicated if farmer *B* could communicate directly with farmer *A* and bribe him not to squeal. Formal collusion of this type is addressed in Tirole (1986).

such random events as insect blight that affect all agents in similar fashion and are beyond the agents' control.<sup>15</sup>

Of course, the ideal incentive scheme will generally be a combination of individualized and relative performance schemes (Nalebuff and Stiglitz, 1983b). Furthermore, the best tournament is not always of the winner-take-all variety; it may be better for the principal to penalize the agent with the worst performance rather than reward the agent with the best performance. Implementing such a loser-bear-all tournament is particularly beneficial when relatively little effort is desired from agents, making the optimal prize in a winner-take-all tournament relatively small.<sup>16</sup> In such a setting, an agent in a winner-take-all contest with many participants might find it optimal to exert no effort at all, assessing the likely return to his effort to be negligible. However, the same agent could be induced to exert some effort when threatened with a large penalty for finishing last (Nalebuff and Stiglitz, 1983b).

Tournaments may be particularly valuable incentive devices when the principal has only a limited ability to commit. In some situations, the performance of an agent may be difficult for a third party to observe perfectly. For example, a court might have difficulty discerning the number of broken toasters a hired repairman was actually able to fix. In such a setting, the owner of the repair shop might wish to understate the repairman's performance and therefore pay him less than he is due under the contract he signed. Tournaments mitigate this incentive to some extent because with a tournament, payments need not be based on cardinal measures of performance. By simply requiring a payment of fixed size to the "winning" agent regardless of the magnitude of that agent's performance, a tournament provides less opportunity for the principal to renege on payments after the fact (Malcomson, 1986).

Finally, it should be noted that the linking of tasks is another way of providing a monitor of the agent's activities. To illustrate, suppose the agent is a risk-neutral developer of a mechanical device and the principal's task is to procure the device at minimum cost. Also suppose the developer has private

<sup>15</sup>To illustrate this comparison somewhat more formally, consider the setting described in the previous section, but now with  $n$  risk averse agents. Suppose the performance ( $X_i$ ) of agent  $i$  is related to his effort ( $e_i$ ) by the relationship  $X_i = \theta e_i + A_i$ . Thus, the productivity parameter,  $\theta$ , represents a common shock to the productivity of each agent, while  $A_i$  represents an additional independent shock to (only) the particular performance of agent  $i$ . In this setting, a principal will choose to implement a tournament rather than to design individualized compensation schemes for the  $n$  agents if  $\theta$  is sufficiently important relative to all  $A_i$ . See Green and Stokey (1983), Lazear and Rosen (1981) and Nalebuff and Stiglitz (1983a, b) for more details of this and related arguments. Some early work that explores the merits and drawbacks of piece-rate compensation and relative performance schemes is found in Stiglitz (1975a).

<sup>16</sup>Another modification of the simple winner-take-all tournament is to require the winner to outperform all competitors by a specific amount. Doing so can induce the agents to exert more effort, as each attempts to surpass the performance of other agents by a sufficient amount. It is not surprising that a modification of this type can improve the principal's expected welfare since the modification supplements the ordinal nature of a tournament with a cardinal dimension.

knowledge of the cost of perfecting the prototype. Further suppose there is a second task, maintenance of the mechanical device, that might be performed either by the developer or by the buyer of the device. For simplicity, assume the developer and buyer are equally capable of performing the maintenance task, but neither learns the exact cost of maintenance until after development of the prototype is completed. Most importantly, the cost of maintenance is correlated with the cost of development. The question of interest here is whether the buyer should assign both the development and maintenance tasks to the developer or perform the maintenance herself.

The answer to this question depends critically on how costs are correlated across the two tasks. If the two costs are negatively correlated, the buyer will gain by assigning both tasks to the developer. The gain stems from the “countervailing incentive” introduced by linking the two stages of production. When asked to perform only the first task, the developer’s incentive will be to exaggerate his costs of doing so. When the developer knows that he will also perform the maintenance task, however, a countervailing consideration is introduced. Now when the developer reports that the costs of development are high, he implicitly claims that he expects maintenance costs to be low. Such a claim can be tied to an obligation to perform the maintenance task in return for relatively meager compensation. This obligation limits the developer’s incentive to exaggerate development costs.<sup>17</sup>

Corresponding countervailing incentives do not arise when the costs of the two tasks are positively correlated. In this case, exaggerating the costs of development also amounts to a prediction that maintenance costs will be high. Consequently, the developer’s incentive to misrepresent the costs of development is enhanced by assigning both tasks to the developer. In this case, the buyer optimally performs the maintenance task herself (Riordan and Sappington, 1987b).

## **Agent Selection**

To this point, the agent or set of agents with whom the principal deals has been taken as given. But often, an important component of the principal’s task is to select the “best” agent or agents. The procurer of an item wants to select the least-cost supplier; banks seek to identify the most reliable loan applicants.

Requiring potential agents to bid for the right to serve as the agent is one means by which the principal can identify the best agent, while simultaneously limiting his rents. To illustrate this possibility, consider the procurement setting

<sup>17</sup>A related countervailing incentive arises in Stiglitz and Wolfson (1988). There, a firm’s incentive is to understate its income to the IRS to limit tax liabilities, but to overstate its income to potential investors to increase its stock market value. For more on countervailing incentives, see Lewis and Sappington (1989a, b).

where potential producers have (independent) imperfect private knowledge of their likely production costs. Also suppose the procurer or buyer wishes to select a single firm to serve as the sole producer of a commodity, like electricity. Standard auction theory suggests that with a second-price auction, for example, potential producers can be induced to bid their true valuations of the franchise (Milgrom and Weber, 1982; McAfee and McMillan, 1987a). Thus, by awarding the sole right to produce to the highest bidder in return for a payment equal to the bid of the second-highest bidder, the buyer can be sure to select the producer with the lowest expected costs. Furthermore, the buyer will extract all rents from the selected producer, except for the difference between that producer's valuation of the franchise and the valuation of the second-highest bidder.

The auctioning of a franchise departs from standard auctions in that a producer's valuation of the franchise can be controlled to some extent by the buyer because the buyer can link the compensation rules under the franchise to the winning bid. Doing so enhances the buyer's ability to extract rents from the selected producer. One might interpret the optimal linking in the following manner. The buyer can indicate to potential producers that a low winning bid will be interpreted as a prediction that production costs are likely to be high. Therefore, to protect the winning bidder against the prospect of high cost realizations, a prospect implicitly deemed to be likely by the bidder, pronounced cost-sharing will be implemented. Under low-powered incentive schemes with pronounced cost-sharing, the producer realizes relatively little profit if costs ultimately turn out to be low. Thus, the attraction to a bidder of shading his bid is reduced. To further limit incentives to shade bids, the buyer can promise to implement a high-powered incentive scheme which involves only limited cost-sharing when the winning bid is high. Under high-powered incentive schemes, the producer's profit rises steeply as realized costs fall, making such schemes relatively attractive to producers who expect their costs to be low. Intuitively, what the buyer is doing in this linking procedure is modifying the object being auctioned—the production contract—according to the winning bid. Such modification promotes more aggressive bidding because it renders more similar the likely gains of diverse bidders. In essence, this linking is a form of handicapping that enhances competition.<sup>18</sup>

Much like bidding competition before the contract is granted, the threat of competition after the contract is granted can also serve to discipline an agent. A firm such as a local cable television operator that faces no potential competition once it is selected to serve an area may have a strong incentive to pad or exaggerate production costs or to reduce the quality of its services. These incentives may be mitigated to some extent if an alternative producer is

<sup>18</sup>For the details of formal analyses of this bidding process, see Laffont and Tirole (1987), McAfee and McMillan (1987b), and Riordan and Sappington (1987a).

available who could replace the incumbent producer. Optimal use of the alternative supplier involves calling upon his services when the actual or predicted performance of the incumbent is particularly poor (Demski et al., 1987; Nalebuff and Stiglitz, 1983a).

Because of the disciplinary role an alternative supplier can play, it may often be valuable for the principal to keep an alternative source available. Indeed, the Packard Commission report (U.S. Government, 1986) advises the U.S. Department of Defense to expand the use of second sourcing in military procurement. However, the variety of costs associated with maintaining an alternative source can be prohibitive. Aside from the direct expense of duplicative assets, an alternative production source can introduce undesirable incentive costs. In particular, if an incumbent fears forfeiting the franchise he currently operates, the incumbent will be reluctant to invest resources that improve future rather than current performance. For example, an incumbent public utility that produces electricity might be able to streamline its operations and improve long-run service to customers through diligent effort. However, if the firm knows that its tenure in the industry is limited, it will have limited incentive to provide the requisite effort unless it can secure immediate compensation for its efforts from the regulator. Such compensation is often problematic because effort is inherently difficult to monitor. When these long-term investment effects are significant relative to the discipline an alternative supplier can provide, the principal may prefer to limit the use of a second source.<sup>19</sup>

Proper selection of the most desirable agents can require subtle balancing of the policy instruments used to attract them. To illustrate, consider the case of a bank seeking to loan funds only to those agents with the best projects. The bank cannot assess the risk associated with each agent's project perfectly, although all projects are known to have the same expected return. Agents are assumed to have no wealth of their own, and to be protected by bankruptcy constraints. Therefore, if an agent's project fails, that agent cannot be forced to repay the loan to the bank.

To limit the rents that accrue to agents, the bank will want to set a high interest rate, which will ensure generous returns for the bank from successful projects. However, too high an interest rate can be detrimental for the bank. When bankruptcy laws provide insurance against the downside risk, high interest rates may not discourage borrowers with very risky projects as much as they discourage agents with less risky projects. This is because agents with very risky projects realize there is a smaller chance they will ever have to repay the high interest rate, since their probability of failure is greater. The net result of a higher interest rate can therefore be a smaller expected return for the bank. Consequently, a bank may prefer to ration its loans rather than raise the

<sup>19</sup>Laffont and Tirole (1988b) analyze how an incumbent producer is optimally favored in bidding for the right to serve as a monopoly producer.

interest rate it charges when there is excess demand for loans at the prevailing interest rate.<sup>20</sup>

## Dynamic Interaction

In many situations, the relation between principal and agent will be ongoing, and this fact can be valuable for the principal. Remember that in the models presented earlier, incentive problems arise because the effort supplied by the risk-averse agent cannot be observed by the principal. However, these problems can essentially be avoided in some dynamic settings.

In particular, suppose the relation between effort and performance is the same in each period. Also suppose there is no discounting, so both the principal and agent value future profit as highly as they do current profit and their relationship is certain to continue into the indefinite future. Then if the agency relationship is repeated a sufficiently large number of times, the principal's most preferred outcome can be approximated arbitrarily closely. The agent can be induced to put forth the level of effort the principal prefers in each period, while imposing virtually no risk on the agent, by compensating the agent on the basis of average performance. With a sufficiently large number of repetitions, randomness in average performance becomes negligible if the agent puts forth the desired level of effort in each period. Thus, by promising to ensure the agent his reservation utility if and only if his average performance is sufficiently close to the announced target over time, the principal can secure the desired behavior from an agent without imposing any risk on the agent.<sup>21</sup>

When future payoffs are discounted and/or when the duration of the agency relationship is more limited, the principal's ideal outcome can no longer be ensured. In such settings, the conflict between risk sharing and incentive effects re-emerges. Nevertheless, gains generally arise from basing an agent's

<sup>20</sup>Corresponding conclusions hold when agents appear identical, but have discretion over the projects they undertake. In this setting, a higher interest rate can induce borrowers to undertake more risky projects, as they aim for the "big payoffs" that will leave them with a profit after repaying the high loan charges. See Stiglitz and Weiss (1981) for an analysis of both interpretations. Similar logic applies in the corresponding dynamic setting where agents appear identical, but have discretion over the projects they undertake. Rather than charge an individual whose previous project failed a higher interest rate for an additional loan, the bank may prefer to terminate credit. While the threat of having to pay a higher interest rate on future loans can help discipline the current behavior of a borrower, the threat of cutting off credit can provide even greater discipline, while avoiding the temptation high interest rates provide to borrowers to undertake more risky projects. Stiglitz and Weiss (1983) offer a formal analysis of this issue.

<sup>21</sup>For the formal details of this argument, see Radner (1981, 1985) and Rubinstein and Yaari (1983). In essence, the principal serves as a "bank" here, providing loans to the agent in bad periods, and accepting repayments of the loan in good periods. When the agent has independent access to credit, so the principal's role as banker is eliminated, the gains from long term contracts can be less pronounced. See Fudenberg, Holmstrom and Milgrom (1990) and Spear and Srivastava (1987).



compensation in each period on his past performance as well as his future performance. For example, a poor harvest by the farmer in one year can be forgiven to some extent if the harvest is particularly good in preceding or succeeding years. In this manner, the landlord can insure the farmer, albeit imperfectly, against such random elements as rainfall and pestilence without eliminating the farmer's incentive to labor diligently (Arnott and Stiglitz, 1989; Lambert, 1983; Rogerson, 1985; Stiglitz and Weiss, 1983).

When the interaction between principal and agent is repeated, the friction caused by the principal's limited intertemporal commitment becomes important. To illustrate this friction, suppose the productive environment (soil quality, for example) is the same each year, and is known to the farmer at the outset of his repeated relationship with the landlord. For simplicity, also suppose the amount of crop produced is a deterministic function of the farmer's effort and the quality of his soil. In this setting, the farmer will realize that if the landlord ever infers the true soil quality, the principal will be in a position to extract all rents from the farmer from that point in time onward. Recognizing this fact, the farmer will be very reluctant to ever let his performance reveal the true soil quality. Consequently, the landlord may be completely unable to induce the farmer to use his superior information to their mutual advantage. The farmer may be asked simply to produce the same minimal harvest regardless of the soil quality, thereby ensuring the landlord can't infer anything about the soil from the realized harvest.<sup>22</sup> Incentive problems of this type are common in centrally-planned economies where the government employs past performance to set future goals. Realizing that superior performance will be rewarded by "ratcheting up" future targets, producers have limited incentive to perform up to their potential.

This ratchet effect is alleviated to some extent if the productive environment varies randomly over time. When current conditions are not a perfect indicator of future conditions, the agent can retain access to relevant privileged information and the associated rents even when his present performance allows a perfect inference of the conditions under which he labors. Thus, it may be less costly for the principal to induce the agent to tailor his performance to the environment when the environment changes over time.

In addition, a principal could conceivably gain from intentionally introducing randomness into the productive environment. For example, a principal may realize gains from constantly assigning workers to new tasks. A worker who knows he can escape the higher performance standards his superior performance will ultimately bring to bear will be less reluctant to work diligently in his present task.

There are also dynamic settings in which agents will be reluctant to have their performance observed by others even when the agents have no private

<sup>22</sup>The works of Aron (1987), Baron and Besanko (1987), Freixas, Guesnerie and Laffont (1985), Laffont and Tirole (1988a), Sappington (1986), Stiglitz (1975a) and Weitzman (1980) are just a few of the many dynamic agency models where the principal's commitment powers are limited.

information about the environment or their personal abilities. The basic reason is that an agent's performance may reveal new information about his innate ability, which makes his future compensation more risky than it otherwise would be (Stiglitz, 1975b, 1982). To be concrete, suppose agents are managers in firms, charged with identifying and carrying out attractive investment projects. Each manager is risk averse and, like his present and potential future employers, uncertain of his innate ability. A manager's performance on a given project thus provides information to himself and to the market. Therefore, if competition among potential employers drives a manager's wage to equal his perceived marginal product, undertaking a project becomes risky for the manager. Consequently, even if the manager has no aversion to the effort required to identify and carry out investment projects, he will have some aversion to undertaking projects that are in his firm's best interest (Holmstrom and Ricart i Costa, 1986). A partial remedy for this problem might involve a firm undertaking measures to limit the ability of other firms to observe the performance of its managers (Gibbons, 1986). In this way, insurance may be provided to the manager by making his wage less sensitive to his performance.

## **Conclusions and Future Directions**

The intent of this article was to review some of the insights derived in the broad and growing literature on incentives. In this concluding section, some brief observations are offered concerning a few of the many issues that received inadequate mention here.

Foremost among these issues are the concepts of "bounded rationality" and "incomplete contracting" (Simon, 1951; Williamson, 1975, 1985). In most of the analyses discussed above, the principal and agent were omniscient in an important sense. Although they may have been unaware at various points in their relationship of the exact "state of nature" ( $\theta$ ) that prevailed, they were always aware of every state that could conceivably occur, and of the relative frequencies of all states. Furthermore, the various actors were often assumed able to communicate their assessment of the environment costlessly. In particular, all of their knowledge and expertise could be accurately conveyed in a simple message. In practice, of course, communicating one's knowledge and writing complete, detailed contracts are costly activities; sometimes prohibitively costly. The question that arises, then, is how best to model the costs of identifying and delineating contingencies that are most important to include in incentive contracts.

The most popular approach to date has been an extreme one, wherein certain contingencies are assumed prohibitively costly to specify in advance.<sup>23</sup>

<sup>23</sup>One attempt to model the costs of writing more complicated contracts explicitly is Dye (1985). Also see McAfee and McMillan (1988).

An incentive contract, therefore, includes a specification of “residual rights of control,” specifying which party will have the authority to make critical decisions when unforeseen or previously unspecified contingencies arise (Grossman and Hart, 1986). The assignment of such rights can have important implications for the performance and value of the agency relationship.<sup>24</sup>

Another issue of great practical importance that has not been addressed concerns the design of incentive contracts when the principal’s information is initially superior to the agent’s information. For example, an employer may know more about the hazards involved in performing a particular task than any potential agent or employee. The particular complication that arises in this setting is that by the very nature of the incentive contract the principal offers, she may reveal some or all of her information. In some instances, the principal may wish to share her privileged information with the agent; for example, when the chemical the agent will be working with poses no health risk. In other instances, such as when the chemical is toxic, the principal may prefer that her information remain private.<sup>25</sup>

A related issue arises when the principal receives information about the agent’s activities or performance that is not verifiable, meaning that a third party (like a court) cannot directly confirm or contradict the principal’s observation. To illustrate, a supervisor may know precisely how hard an employee has worked, but be unable to prove her assessment beyond a reasonable doubt. In such settings, it may or may not be possible to make use of the principal’s information in an incentive contract. For the unverifiable information to be useful, it must be possible to induce the principal to reveal the information truthfully. For example, if a principal simply receives a fixed bonus every time she reports a worker has shirked, she will be tempted to always make such a report, regardless of the worker’s true expenditure of effort. Consequently, the report of a principal in such a situation cannot usefully motivate the worker. On the other hand, if the supervisor: (1) receives a bonus when she identifies a worker who has shirked and overall performance by that worker’s unit ultimately turns to be substandard; but (2) incurs a penalty when the performance of the identified shirker’s group is exceptionally good, then it may be possible to employ the superior’s unverifiable information to motivate the workers.

The foregoing discussion was kept simple by assuming a well-defined role for each actor as either a principal (who designed incentive schemes) or an agent (who largely followed orders). In practice, these roles may be less clearly

<sup>24</sup>See the informative discussion of this issue in Holmstrom and Tirole (1988). Also see Milgrom (1988) for a discussion of how, in the absence of complete contracting, individuals may have incentives to lobby for “influence” or special treatment when unforeseen contingencies arise. Also see Hart and Moore (1988).

<sup>25</sup>Seminal theoretical work on this issue includes Myerson (1983) and Maskin and Tirole (1988, 1990). Reinganum (1988) examines a setting where a prosecutor may reveal the strength of her case against a defendant in the settlement she proposes.

defined. When there are hierarchies of control, an actor may simultaneously be an “agent” of some “principals” and the principal to some other agents.<sup>26</sup> For example, elected officials may serve both as the agents of their constituents and as principals to their appointees. Similarly, a vice-president in a corporation may function as an agent of the firm’s president and as a principal to the division managers under his or her control. Furthermore, in some instances a number of principals may influence the activities of one or more agents.<sup>27</sup> To illustrate, municipal, state, and federal officials all have some control over the activities of individual citizens. The precise manner in which multiple principals interact is important to a complete understanding of institutions.

For the most part, the incentive literature has depicted the actors in agency models as self-interested individuals, often with the goal of maximizing net income. This approach may capture incentive problems most simply and starkly, but it avoids such issues as worker loyalty and pride which can be critical to a firm’s success, and are discussed in Simon’s insightful contribution to this symposium.

The incentive literature has also tended to focus on isolated, independent agency relationships, which precludes a complete understanding of complex organizations like firms and governments. Nevertheless, there are many insights concerning the optimal design of organizations that can be drawn from simple agency models.

To illustrate, the common practice of compensating top corporate executives in part with their company’s stock and stock options is readily explained. Stocks and stock options help align the incentives of executives and shareholders by making their payoffs coincide more closely. Furthermore, the firm’s stock price serves as a convenient and inexpensive monitor of the executives’ performance. Direct monitoring and evaluation of the daily activities of an executive is problematic given the complex nature of activities an executive performs. The salary component of executives’ compensation can provide insurance against market forces beyond their control.

Promotion within an organization can also motivate employees. Promotion might best be viewed as a tournament wherein a large prize is awarded to the best performer. Thus, it may be efficient to pay a top executive more than her marginal product if hopes of promotion to this lucrative position motivate managers of lower rank within the firm (Lazear and Rosen, 1981). The threat of dismissal can also discipline workers in a firm. Notice that the efficacy of the dismissal threat will depend upon the loss a worker suffers when he is dismissed. If an employee who is dismissed can immediately obtain a new job with comparable pay, the threat of termination may do little to motivate the employee to work diligently on the job. Consequently, firms and society may

<sup>26</sup>Formal analyses of hierarchical relationships include those of Calvo and Wellisz (1979), Tirole (1986), and Demski and Sappington (1987).

<sup>27</sup>Formal analyses of this issue are offered in Baron (1985), Bernheim and Whinston (1985, 1986), Braverman and Stiglitz (1982), and Stiglitz (1985).

benefit from involuntary unemployment to the extent that it lowers the expected utility of workers who are terminated (Shapiro and Stiglitz, 1984).

Certainly, simple principal-agent models by themselves do not provide a complete understanding of the structure and operation of complex organizations. The models do seem helpful, though, both in identifying some possible sources of friction within organizations and in exploring efficient ways to mitigate these frictions.

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- Page 7 of 15 -



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- Page 8 of 15 -



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- Page 9 of 15 -



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- Page 10 of 15 -



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