Information Production, Evaluation Risk, and Optimal Contracts

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Abstract

In the model considered here, a firm can evaluate an investment project before making a commitment to fund it, acquiring private information about the random project return. This context is used to show how incentive schemes designed to induce the transmission of information may conflict with schemes designed to induce effort. Two types of arrangements that allow investments in information to earn a competitive return are identified: (1) a contract that induces a divergence between the interests of managers and owners and (2) a policy of partial internal funding for new projects. In each case, the key to credibly transmitting information is to shift the risk associated with an evaluation away from the individual charged with revealing the results. The formal model is used to interpret features of compensation and the securities issuance process.

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1. Introduction

This paper starts from the premise that a firm can evaluate an investment project before making a commitment to fund it, and that the information so produced is private. If the costs of evaluation are not too high relative to the value of information produced, the first best outcome for an economy facing this kind of technology is one where many projects are evaluated and only the most promising ones are undertaken; that is, capital is allocated on the basis of private information. To support this outcome in a decentralized equilibrium, individuals must be willing to trade despite the presence of asymmetric information, and resources invested in producing the private information must earn the equilibrium rate of return.

In this context, it is easy to show that the asymmetry in the information held by different traders causes a simple equity market for shares to fail, just as the market for used cars fails in Akerlof (1970). More sophisticated arrangements can nevertheless support an equilibrium with information production. Specifically, we identify two types of arrangements which allow trades to take place and investments in information to earn the equilibrium rate of return: Firms may hire managers with delegated responsibility for investment decisions (and hence for transmitting private information to outsiders), or firms may hold internal funds that are used to signal the quality of a given project.

In the case where the firm hires a manager, the form of the contract between the manager and the owners of the firm is different from the one that emerges from existing principal-agent models of managerial compensation. These models typically rely on some form of asymmetric information and a fundamental divergence between the interests of the manager and the owners (e.g. utility for managers decreases with effort expended, but wealth for owners increases). Although the implications of these models can be ambiguous (see for example, Grossman and Hart 1983), the conclusion generally drawn from this literature is that a contract should at least partially align the interests of the agent with those of the principal. In a context where the principal is an employer and the agent is an employee, this means that the compensation of the agent should vary positively with performance.[1]

The setting here highlights a countervailing factor in contract design. If a firm finds that an investment project is promising but does not have enough capital to fund the project, it must raise funds from outside investors. To do so, and to earn a return on its investment in information, the firm must convince new investors that the project is good. But the owner of an evaluated project always has an incentive to claim that it is promising, regardless of its true prospects. In order to have the correct incentives to reveal the private information truthfully, the manager must not face the same state contingent returns as the owners. Thus, while standard models are concerned with mitigating an inherent divergence between the interests of owners and managers, contracts here must create one where none exists. Jensen and Meckling (1976) and Fama and Jensen (1983) suggest that a separation of ownership and control arises because the benefits of specialization in risk-bearing and decision-making activities offset the agency costs that result from diverging interests. The argument here suggests that in some

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[1]For a recent survey of the very large literature on contracts, see Hart and Holmstrom (1986). For applications of these models to issues of managerial compensation, see the April 1985 issue of the Journal of Accounting and Economics devoted to this topic. For a general discussion of the principal-agent framework see Arrow (1985).

cases these agency costs may be negative. A separation of ownership and control can be valuable because of, rather than in spite of, the divergence in incentives that it permits.

One revealing way to place this result in the context of the existing literature is to note the model here is not one of a bilateral relationship between owners and a manager. Potential new investors are a crucial third party. The model is therefore one of common agency as described in Bernheim and Whinston (1986); the manager acts as the agent of both the existing owners and the new investors when undertaking an evaluation. Even though the old owners act as the formal employer and offer the only explicit incentive scheme to the manager, this scheme must still be designed so that the manager acts in the interests of both sets of principals. Thus, interests of the old owners by themselves may not offer a good guide to the form of the contract that the manager will be offered. Previous models of project selection and managerial compensation such as Rogerson (1985), Lambert (1986), or Kihlstrom (1986) consider only the partial equilibrium problem of a single firm and do not consider the communication problem with outside investors that is necessarily present in a full equilibrium.[2]

The information produced by an evaluation may be good or bad, and the value of the firm depends on the outcome. The incentive compatible compensation for the manager operates by shifting at least part of this risk, which we call evaluation risk, away from the individual responsible for revealing the private information. Because the allocation of this risk (but not other risks) plays a key role in the incentives for revealing information,

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[2]These papers are concerned with the problem of inducing managers to exert effort in evaluating projects. The paper here assumes that effort is observable to focus on the problem posed by private information in an equilibrium setting.

this kind of insurance-like arrangement can have social value even if all individuals in the model economy are risk-neutral.

Under the alternative strategy for communicating information to outsiders, owners retain responsibility for decisions and announcements, but modify the risks they bear by changing their portfolio holdings. If a firm is formed with sufficient capital, it can finance both the initial collection of information and part (or all) of any subsequent investment in a project. Owners then hold both a risky investment in information and a risky investment in the eventual project outcome. An announcement by owners stating that a project is promising will be credible if the evaluation risk is a small enough part of the total portfolio of risks.

This result resembles results derived in Leland and Pyle (1977) and in Myers and Majluf (1984), but since the model here is one of general rather than partial equilibrium, it is possible to go beyond the observation that internal funds may help solve incentive problems. The results here demonstrate that full internal funding cannot generally be expected to support the social optimum; achieving the optimum here requires that capital be re-allocated among firms after private information is created. A signalling equilibrium with partial internal funding may or may not be able to support the optimum. In contrast, under the assumption that compensation to managers is publicly observable, the contracting solution can always support the full information social optimum.

The idea that a seller would like to be able to commit to revealing information about his goods is not new. This point was made in the context of security sales by Leland and Pyle (1977) and in the context of auctions by Milgrom and Weber (1982). In contrast to these models, agents in the model here are assumed to be ex ante identical; they can become differentially informed only by expending valuable resources on the collection of information. In contrast to models where information collection takes place in an exchange economy (e.g. Diamond (1985) and the references cited there), information in the model here influences production decisions and has social value. Like Battacharya and Ritter (1983) and Myers and Majluf (1984), we assume that it is prohibitively costly for outsiders to directly verify claims made by individuals holding private information; however, we emphasize the point that information can still be transmitted if the incentives offered to the individual charged with revealing the information are chosen correctly.

Some of the implications of this kind of model are obvious--for example, reports by an accountant will be more credible if the accountant does not have an ownership interest in the audited firm--but some are more surprising. The model suggests why owners may find it in their interests to precommit to paying large bonuses to executives in periods when a firm is retrenching and stock prices are falling. The same logic explains why research scientists at large companies generally do not receive a share of the patent rights or royalties from discoveries they make, and why agents like doctors, lawyers and technical consultants are not offered contingent compensation. The model also offers a new perspective on how a firm commitment security offering by an investment banker differs from a direct placement by the firm. In each case, a seller with private information (either the firm or the investment banker) sells securities that it owns to outsiders. Previous explanations have emphasized reputational factors, but the model here points instead to the superior allocation of evaluation risk that the underwritten offering permits.

The formal model used here is taken directly from the paper by Boyd and Prescott (1986) on financial intermediaries, but our use of the model differs from theirs. They focus on the role of adverse selection, assuming that private information is present prior to any contracting. We focus on the kind of private information that is intentionally produced by firms as part of research and product development activities; consequently, we assume that it is possible to write contracts before the private information is present. Section 2 presents the basic definitions and features of the model. Section 3 describes the kind of arrangements for dealing with private information that we emphasize. Section 4 describes possible applications. A final section offers concluding remarks.

2. The Model Economy

2a. The Environment

The stylized investment projects considered here are designed to capture the idea that returns to investment are uncertain, but that firms do not fund projects at random. Firms have the option of using resources to evaluate projects beforehand, funding only the most promising ones. A project is therefore associated with three distinct events: evaluation, funding, and the realization of returns. Correspondingly, this paper considers an economy where trades and actions take place at three points in time denoted 0, 1, and 2.

For simplicity we assume that all individuals are identical. To ensure competitive behavior, we assume that each individual is small relative to the entire economy. Formally, the number of individuals is infinite and all quantities are measured in per capita or average values[3]. At time 0, each individual in the economy is endowed with one unit of the single productive resource; it can be interpreted either as physical capital or human capital. Since output is realized at time 2, individuals consume only then. Consumption is required to be non-negative, but for non-negative values of consumption, we assume that utility is linear. The assumption of risk-neutrality over positive consumption bundles simplifies the analysis and allows for the explicit calculation of compensation schemes but is not crucial for the result that it is possible to support the social optimum.

An individual in this economy can do one of two things with the endowed unit of capital: evaluate an investment project, or fund an investment project. Unevaluated projects are available in unlimited supply, indexed on a continuum. Evaluations are undertaken at time 0 and produce information at time 1 on the return to a prospective investment project. Capital not used for evaluation can be stored without depreciation until time 1. Investment projects are funded at time 1 and produce consumption goods at time 2. To emphasize that the creation of private information need not be a by-product of other activities, we assume that the resources invested in evaluation have no direct effect on the production of output. Evaluation by itself produces no output and does not contribute to the resources needed to fund a project. Moreover, it is possible to fund a project without evaluating it.

The cost of an evaluation is one unit of capital. This allows us to consider the case where an evaluation is undertaken by a single individual, but this is not crucial to any of the results in the model. The cost of the evaluation could be either larger or smaller. The important restriction is

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[3]Strictly speaking, they are measured per unit mass of individuals in the economy.

that the endowment of any individual is small relative to the amount of resources needed to both evaluate and fully fund a project. Without this restriction, there would be no role for the sale of securities or diffuse ownership of firms.

The per unit return r on any given project is a random variable that is realized at time 2. Up to a maximum feasible level of investment denoted by χ, the total return is r times the amount devoted to funding the project. Beyond χ, additional investment yields no additional return. Allowing for a smooth, strictly concave production function instead of one that is piecewise linear with a kink would complicate the analysis but would add little insight. To keep the stochastic structure of the economy simple, we assume that r can take on either a good value or a bad value, $r=g$ or $r=b$, with $g > b \geq 0$.

The result of an evaluation on a project is a random variable e that is realized at time 1. Like r, e can take on only two values, $e=g$ and $e=b$. The random variables e and r are correlated, but given knowledge of one, it is not possible to infer the value of the other with certainty. Formally, we assume that

$$(2.1) \qquad 1 > \text{Prob}(r=g|e=g) > \text{Prob}(r=g|e=b) > 0,$$
$$1 > \text{Prob}(r=b|e=b) > \text{Prob}(r=b|e=g) > 0.$$

These probabilities are public information. All projects are assumed to be stochastically independent, but allowing for correlated returns would not significantly change the analysis.

For our purposes, the key characteristic of the evaluation technology is that a second evaluation is as costly as the first. Other evaluation technologies could be imagined. For example, the first evaluation could consist of building a demonstration model of an invention. Then checking that the model works--that is, performing a second evaluation--would be essentially costless. Instead, we imagine something closer to the kind of evaluation undertaken by an entrepreneur contemplating the introduction of a new product. After gauging potential demand, design and manufacturing costs, and the response of potential competitors, the entrepreneur can costlessly announce the results to other individuals. But an outsider has no way to verify the accuracy of an announcement other than to repeat the actions of the entrepreneur and incur the same costs. Intermediate cases where second evaluations are less expensive but still costly would complicate the model but would preserve the key feature of the analysis: information about a project is private.

2b. The Social Planner's Problem with Public Information

To establish a benchmark and describe the operation of the model, consider the problem that a social planner would face if the results of evaluation were not private information. Stated in terms of the evaluation technology, this is equivalent to assuming that any evaluation subsequent to the first one is costless. In Section 3 we will return to the case of interest in which all evaluations are costly and information is private.

Given the assumed form of utility for individuals in this economy, the social planning problem is to maximize expected per capita consumption. The planner has the option of investing in unevaluated investment projects chosen at random, or allocating some capital to evaluation and using the remaining capital to fund projects with good evaluation results. The per capita expected return to the first strategy is the unconditional expected return $E(r)$.

This naive strategy must be compared with the optimal evaluation strategy. Recall that the number of individuals in the economy is taken to be infinitely large, and that all quantities are measured in per capita terms. The social planner must allocate the single unit of per capita endowment between evaluation and investment. Let y denote the fraction of per capita resources devoted to evaluation. Under the assumption that evaluations cost one unit of resources,[4] y also equals the per capita number of evaluations. Let π denote the probability that a randomly chosen project will have a good evaluation result, $\pi = \text{Prob}(e = g)$. Then the per capita number of promising projects is πy. With a maximum level of productive investment in each project equal to χ, $\chi\pi y$ units per capita can profitably be invested in these promising projects. To ensure that resources are not wasted, the social planner will devote the smallest amount of resources to evaluation that permits all remaining capital to be invested in good projects. Thus, y is chosen so that

$$1 = y + \chi\pi y. \tag{2.2}$$

The expected per capita return to this strategy, denoted by R, is given by

$$R = \chi\pi y \; E(r|e=g).$$

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[4] Recall that there is a continuum of possible projects. Thus, a more precise statement would be that evaluations cost one unit per unit mass of evaluations.

Solving for y from (2.2) and substituting the result in the expression for R yields

$$(2.3) \qquad R = \frac{x\pi}{1 + x\pi} E(r|e=g).$$

For evaluation to be relevant in this economy, the evaluation strategy must dominate the strategy of investing at random. That is, the parameters of the model must be such that the following inequality holds:

$$(2.4) \qquad R = \frac{x\pi}{1 + x\pi} E(r|e=g) > E(r).$$

Throughout the rest of the paper, we assume that evaluation has social value and that this inequality does hold.

2c. Decentralized Equilibria

Before considering a decentralized equilibrium with private information, it is useful to show how the social optimum can be supported by means of an equity share market under the assumption of full public information. After doing so, it is a trivial observation that this share market must fail when information is private.

Consider the possible returns to an individual who does an evaluation at time 0. If the project's evaluation result is good (e=g), the evaluator will be able to sell shares in the project at time 1 and obtain a return on his investment in information. The size of this return is calculated below. If e=b, no one will invest in the project because its expected per unit return is lower than the expected return on a project with a good evaluation or even than the expected return on a randomly chosen unevaluated project. Evaluators with bad evaluation results will therefore receive no return on their investment in information.

Lucky evaluators have property rights to a project that when fully funded has an expected total output of $\chi\ E(r|e=g)$. The value of this claim can be determined as follows. For the time 1 share market to support the social optimum, the expected rate of return to capital must equal the return R from the social planner's problem. If we normalize the time 1 price of a share to one, we can calculate N, the total number of shares in the firm that can be issued. In equilibrium the per share return will be $\chi E(r|e=g)/N$. For this to equal the expression for R given in equation (2.3), N must be chosen so that

$$\frac{\chi\pi}{1+\chi\pi} E(r|e=g) = \frac{\chi}{N} E(r|e=g).$$

Equivalently, N is given by

$$N = \frac{1}{\pi} + \chi.$$

The evaluator with a good project forms a firm at time 1 with $\frac{1}{\pi} + \chi$ total shares. He sells χ shares to investors in exchange for the χ units needed to fund the project, and keeps $1/\pi$ shares for himself.

Investors store their capital at time 0 and invest at time 1, earning the expected return R. For this to be an equilibrium, it must also be the case that the expected return to being an evaluator is R. To verify that this is the case, we introduce notation that will be useful in what follows. In this full information equilibrium, a project with e=b will not be funded. A project with e=g will be funded and the evaluator will receive a share of final output proportional to his equity holdings. The return to the evaluator is therefore a function of three possible states:

state 1 ($s=1$): project is funded, and $r=b$,

state 2 ($s=2$): project is not funded,

state 3 ($s=3$): project is funded, and $r=g$.

If the evaluation result is bad, the evaluator receives nothing. If it is good and the project is funded, the evaluator receives $\frac{1}{\pi}$ shares in the firm in exchange for the property rights to the project. The total number of shares is $(1/\pi) + x$, so we can express the state contingent return on the unit invested in information, denoted $\gamma(s)$, as follows:

$$\gamma(s) = \begin{cases} \dfrac{(1/\pi)}{(1/\pi) + x}\, xb & \text{if } s=1 \\ 0 & s=2 \\ \dfrac{(1/\pi)}{(1/\pi) + x}\, xg & s=3. \end{cases}$$

Using the fact that π is the probability of a good evaluation result, it can be verified that $E(\gamma(s))$ equals R. Thus, the ex ante expected return to evaluation and to investment both equal R, and the decentralized time 1 share market supports the social optimum.

When the evaluation result e is private information observed only by the evaluator, the share market described above breaks down. Truthtelling is not an equilibrium outcome because the return to the evaluator from announcing $e=g$ is always higher than that from announcing $e=b$. If an evaluator with $e=b$ reported truthfully, his project would not be funded and he would receive nothing ($\gamma(2)=0$). If he reported $e=g$ and if investors believed this report, he would receive $1/\pi$ shares in a project with an expected total return of χ E(r|e=b) > 0. Reports at time 1 would therefore not be credible, and the market would fail just as it does in Akerlof's (1970) model of the market for used cars.

Anticipating this breakdown, no individual would do an evaluation at time 0. An evaluator would have no means of earning a return on an investment in evaluation. Thus, if the social optimum is to be supported, some other arrangement that ensures truthtelling and allows individuals to earn a return on an investment in information must be found.

3. Equilibria with Private Information

As noted in the introduction, the form of the technology in this economy implies that capital must be allocated among projects after evaluations have taken place in order to achieve the full information social optimum. If the results of evaluations are private, suppliers of capital must trade with individuals that have better information. The presence of private information per se does not imply that trading cannot take place, but the last section demonstrates that a simple new issue equity market after evaluations take place will fail to exist because the state contingent return $\gamma(s)$ creates an incentive for the owner of a project to misrepresent his information. Since private information is unavoidable in this economy, strategies for achieving the full information social optimum must consist of modifying the state contingent returns to an individual with private information to remove this incentive. This section characterizes the arrangements that achieve this, and demonstrates that it is possible for decentralized markets to support the full information social optimum.

The equilibrium condition necessary to support the full information social optimum is that the expected return on a unit of resources devoted to evaluating or to funding a project must equal the return R from the social planning problem. Since the return vector $\gamma(s)$ examined in the last section satisfies this constraint, any modification of the return to evaluation must act like a form of insurance: it must transfer wealth between states and have an expected value of zero. Thus, contracts that look like insurance contracts will arise purely for incentive reasons. One of the advantages of assuming that utility is linear is that it removes the usual motives for insurance and emphasizes the pure incentive role played by contracts that transfer or share risk.

In their analysis of this model and its extensions, Boyd and Prescott point out that the risk borne by evaluators could be entirely eliminated by pooling.[5] Since projects are assumed to be stochastically independent, it is possible to form an infinite coalition of evaluators who pool all their projects and fund the good projects by issuing debt. Because of the law of large numbers, there is no uncertainty in the number of good projects discovered per member of the coalition, or in the ultimate return to investment. The coalition's debt could therefore be risk free. Members of the coalition will still possess private information about individual project returns, but if the debt issued to outsiders is truly risk free, there is no

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[5]Their analysis of the model as presented here was given in an earlier version of Boyd and Prescott (1986) that was circulated as a working paper. The published paper focuses almost exclusively on an extension of the model that includes private information that is present before any trades take place.

asymmetry of information concerning the securities that are traded. Boyd and Prescott interpret such a coalition as a financial intermediary.

We focus on two alternatives to this pooling solution. Owners can alter the return structure they face by changing the portfolio they hold, or by arranging contracts that transfer risk. These arrangements remove the incentive problem noted above but do not necessarily remove all risk. The advantage of these alternative solutions is that they are applicable even in circumstances in which it is not possible to remove all risk by pooling. For example, if the number of projects and individuals were finite or if there were correlated uncertainty in the economy, a coalition of evaluators would not be able to issue risk free securities. The equilibrium with the intermediary described by Boyd and Prescott would then fail. Moreover, whether by choice or necessity, firms do issue risky securities and we would like to be able to describe arrangements that support this decision. Under one interpretation of the empirical evidence on the price effects of security issues, private information held by managers of firms plays a key role in this process. (See for example Myers and Majluf, 1984.)

Our approach also reflects the fact that we are studying private information that is produced by choice. Since it is possible to write contracts before this information is produced, the risk associated with evaluation can be transferred from an evaluator to other individuals in the model. Boyd and Prescott focus primarily on asymmetric information as a given part of the environment, present before any trades between individuals can take place. Consequently, the ability to transfer risk in their model is severely limited.

3a. Incentive Compatible Compensation Contracts

In the context of investment decisions by firms, the two strategies of transferring risk and changing portfolio holdings have familiar interpretations. The first strategy transfers risk away from evaluators by introducing a separation of ownership and control. The second modifies the portfolio held by owners by increasing the number of initial investors (and hence the capitalization of the firm) and financing projects partially with internal funds. This sub-section focuses on the first arrangement, whereby hired evaluators are delegated responsibility for the investment decisions of the firm. Section 3b considers the role of internal finance.

As noted above, a separation of ownership and control can have value here because of its effect on incentives to transfer information to outsiders. The simplest possible contract that provides for this separation is one in which an individual owner or a group of owners hires an evaluator and guarantees him a fixed salary for evaluating a project and making a public report of his findings. Because the decision to invest is completely determined by this report, the evaluator can equivalently be delegated authority to make decisions concerning investment and security offerings. Since the evaluator's compensation does not depend on the report he makes, he has no incentive to misrepresent his findings (nor for that matter, to tell the truth.) All of the risk associated with the evaluation outcome is transferred from the evaluator to the owners.

This invariant compensation contract differs from the usual contract in principal-agent models because the underlying problem is different. Here the activity of doing the evaluation is assumed to be observable, so the evaluator has no opportunity to shirk in the usual sense. The evaluation result itself is not observable, but the announcement of the result has no direct effect on the evaluator's utility. Problems of differential risk aversion or unknown ability are also assumed away because all individuals are risk-neutral and identical.

In a bilateral principal-agent problem with this structure, it would be trivial to achieve the optimal outcome. Since the employer prefers the truth and the employee is indifferent, no conflict in their interests need arise. In the context of a sale of securities to outside investors, the problem is more interesting because of the presence of the new investors as an interested third party and resulting the features of common agency. Although there is no inherent divergence between the interests of the owner and the evaluator acting as manager, there is a conflict between the owner and the potential new investors. To resolve this conflict, the owner gives the manager incentives to act in their joint interest to achieve the social optimum.

What makes it feasible to achieve the optimum here is that the announcement made by the manager, or equivalently the action taken by the manager, does not have any direct effect on the preferences of the manager. This stands in contrast to the standard hidden action model with disutility of effort, but in a context where the transmission of information is the crucial task, it is the natural assumption to make. As is shown by Bernheim and Whinston (1986), this assumption is sufficient to ensure efficient outcomes in a general common agency framework.[6] Risk neutrality on the part of the

[6] The setting here is slightly different from that considered by Bernheim and Whinston. The extensive form of the game is different because one principal (the old owners) must move first in setting compensation for the agent, but the essence of their argument is still applicable. Because there are a large number of existing firms competing for a large number of new investors, the indeterminacy they identify in the division of the gains among the principals does not arise here.

manager here is not important for this result. The invariant compensation contract will support the optimum regardless of the form of utility assumed for the manager.

Invariant compensation for the manager is sufficient for the report to be credible, but it is not necessary. Under the assumption of risk neutrality for the manager, it is easy to characterize the set of compensation contracts that are incentive compatible. The evaluator's compensation can be a function of the investment decision and, if investment takes place, of the realized outcome on the project. At time 0, suppose an individual uses his endowment as start-up capital in a firm and hires an outsider to act as an evaluator. Using the three states defined earlier, let m(s) denote the state contingent schedule of fees (payable at time 2) offered to the evaluator by the owner. In exchange, the evaluator offers his services and agrees to make a public report of the evaluation result at time 1, or equivalently, accepts responsibility for investment and funding decisions. At time 2 the evaluator receives

m(1)	if the project was funded and r=b	(state 1),
m(2)	if the project was not funded	(state 2),
m(3)	if the project was funded and r=g	(state 3).

The evaluator maximizes expected consumption, conditional on his knowledge of e. If he announces e=b, he receives m(2). If he announces e=g the project is funded and he receives either m(1) or m(3) depending on the realized value of r. Since consumption must be non-negative, the lower bound on m(s) is zero. To ensure truthful revelation of e, the compensation schedule m(s) must satisfy the following incentive compatibility conditions:

$$(3.1a) \qquad m(3)\ \mathrm{Prob}(r{=}g \mid e{=}g) + m(1)\ \mathrm{Prob}(r{=}b \mid e{=}g) \geq m(2),$$

$$(3.1b) \qquad m(3)\ \mathrm{Prob}(r{=}g \mid e{=}b) + m(1)\ \mathrm{Prob}(r{=}b \mid e{=}b) \leq m(2).$$

The first inequality ensures that the evaluator is at least as well off reporting e=g when this is true. The second ensures that he is at least as well off reporting e=b when this is true. In addition to satisfying the incentive compatibility constraints (3.1), compensation m(s) for an evaluator must also satisfy the equilibrium condition that the expected return be equal to R. Formally,

$$(3.2) \qquad R = p_3 m(3) + p_2 m(2) + p_1 m(1),$$

where

$$p_3 = \pi \cdot \mathrm{Prob}(r{=}g \mid e{=}g),$$
$$p_2 = 1-\pi,$$
$$p_1 = \pi \cdot \mathrm{Prob}(r{=}b \mid e{=}g).$$

(Recall that π is the unconditional probability that for any given project, e=g.)

In fact, all equilibrium return vectors must satisfy equation (3.2). Given some inessential parameter restrictions, we can depict any equilibrium return vector using the geometrical representation in Figure 1. The triangle T has sides 1, 2, and 3 with lengths proportional to the probabilities p_1, p_2, and p_3, with the factor of proportionality chosen so that the area of T equals R/2. Let x be any point inside the triangle, and let x(1), x(2), and x(3) denote the perpendicular distance from x to sides 1, 2, and 3.[7] Using the fact that the area of T must equal the sum of the areas of the three interior triangles formed by connecting x with the verticies of T, it is easy to show that the coordinates (x(1),x(2),x(3)) satisfy the equation

$$p_1x(1) + p_2x(2) + p_3x(3) = R.$$

Thus, the triangle T depicts the set of all non-negative triples satisfying the equilibrium condition (3.2).

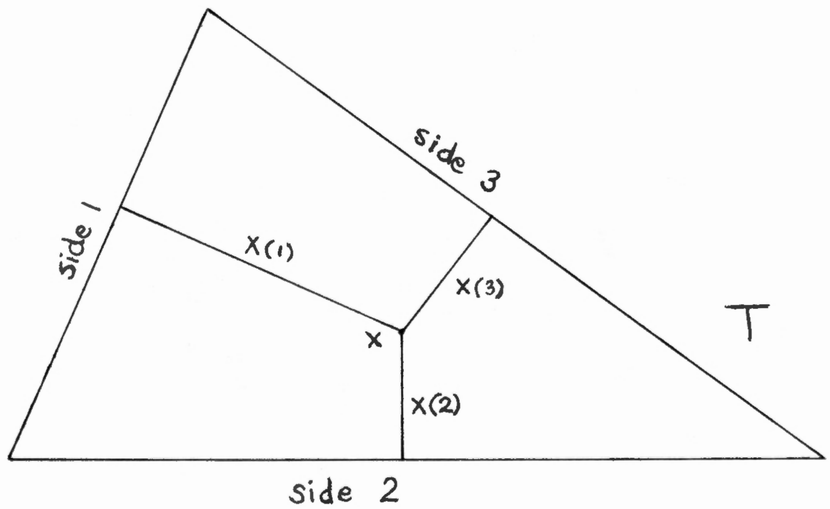

Figure 1

[7]The restrictions are needed to ensure that the sum of the lengths of any two sides is greater than the length of the third side. For some parameter values, this need not be satisfied (e.g. when π is less than 1/2). In these cases, a similar but more complicated triangular representation can be achieved by embedding the triangle in $\mathbb{R}^3$ and measuring coordinates in the usual fashion. The analytical results described here hold for all parameter values.

Since the incentive compatibility conditions (3.1a) and (3.1b) are inequality constraints that are linear in the state contingent returns, they can be represented as regions in T bounded by straight lines. In Figure 2, points satisfying the constraint (3.1a) ensuring truthful announcement of a good evaluation can be characterized as points in T lying below the line m(2) = R. Points satisfying the constraint (3.1b) ensuring truthful announcement of a bad evaluation are those lying above a positively sloped line in T that intersects side 1 and passes through the point (R,R,R) where both constraints hold with equality. (Both of these results follow by substituting (3.2) into (3.1).) Thus, all points within the shaded region satisfy the incentive constraints, the non-negativity constraint, and the equilibrium condition. Any one of them can be chosen in equilibrium. Invariant compensation (R,R,R) satisfies both constraints with equality, so that an evaluator is indifferent between truthtelling and misrepresentation regardless of the value for e. Any point in the interior of the shaded region offers a strong incentive for truthtelling for either value of e.

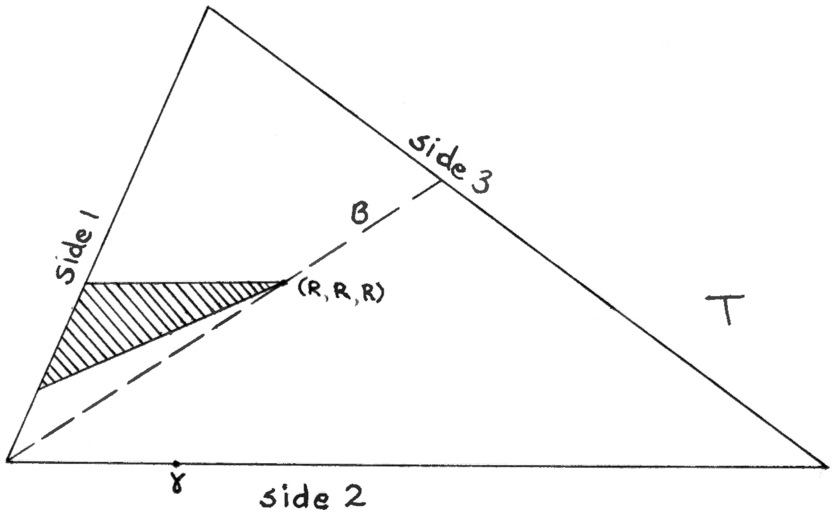

Figure 2

Simple algebra shows that the lower boundary of the incentive compatible region in the triangle T must lie above the line B in Figure 2 which bisects the angle between sides 1 and 2. This means that undertaking a project and realizing a bad return must lead to lower compensation than abandoning the project after evaluation. The incentive compatible region touches B only at the point (R,R,R). Thus, compensation in state 2 must be strictly greater than compensation in state 1 except in the case of invariant compensation. For a firm that uses one of these incentive compatible contracts with an evaluator to resolve incentive problems, returns to owners lie in the triangle T but outside the incentive compatible region. The time 1 share market described in section 2 fails to exist because the return γ to the individual acting as both owner and evaluator is a point on the state 2 side of the triangle, with $\gamma(2) = 0$.

To ensure truthtelling, the evaluator's return structure must differ from the owners', because the evaluator must be willing to report that a project is bad even though this makes owners worse off. In the appendix we explore in more detail the nature of the admissible relations between owner and evaluator returns. The main conclusion is that evaluator compensation need not be a monotonic function of stock returns, and that even if it is, it is a strictly concave function, not convex or linear. Thus, compensation cannot consist simply of a base salary plus non-negative quantities of stock or put and call options on stock.

Given that incentive compatible contracts are feasible, it is easy to see that the only possible equilibrium in this economy is the one which supports the full information social optimum. If too few projects were evaluated relative to the full information social optimum, capital at time 1 would be in excess supply and would earn a return less than R. Firms with good evaluations would be able to pay less than R for the resources needed to fund projects, and the expected return to forming a firm at time 0 and hiring an evaluator would be greater than R. Anticipating this, additional firms would be formed at time 0 and additional evaluations would be undertaken.

The feasibility of the equilibrium with incentive compatible contracts relies crucially on the assumption that compensation between owners and evaluators is publicly observable. If it were possible for owners to make secret side payments to evaluators, potential investors would not be able to verify that evaluators have the correct incentives to reveal information truthfully. The equilibrium with evaluation would fail. In the next section we show that the use of partial internal financing of projects may allow firms to earn a return on an investment in evaluation in the absence of incentive compatible contracts. However, the resulting signalling equilibrium cannot always support the full information social optimum.

3b. Internal Financing

The contracts presented in the last section worked by transferring risk from the evaluator to owners. This introduces a divergence between the ex post interests of the owners and the individual who announces the evaluation results, but such a divergence may not always be necessary. A firm with internally held funds may be able to signal that a particular project is good by committing those funds to the project. Even without an independent evaluator who can announce the evaluation result, potential new investors will be willing to invest in such a firm if the internal funds at stake are sufficiently large. In effect, owners modify their portfolio of security holdings, changing their state contingent return so that they will have no ex post incentive to misrepresent the results of the evaluation. The internal funds act as a kind of bond. When this bond is large enough, a market for shares in these firms may exist, and under some conditions the social optimum can be supported.

Suppose that we start from an economy-wide equilibrium with a rate of return R, for example an equilibrium with the compensation contracts described in the last section. Let ℓ denote some number of initial investors (and therefore also the capitalization) of a firm formed at time 0. Suppose that this firm decides not to use the compensation contracts. No evaluator is hired, so one of the ℓ individuals is designated as the evaluator and uses his unit of capital to undertake an evaluation at time 0. The remaining $\ell-1$ individuals contribute their capital to the firm for investment at time 1. All firm owners, including the evaluator, receive a $1/\ell$ share of firm returns at time 2.

Recall that the state contingent return to investment in information is $\gamma(s)$ as defined in section 2c. The firm has $\ell-1$ units of capital remaining after the investment in information, so its total return is the sum of the return $\gamma(s)$ to the unit invested in evaluation and the return on its time 1 investment of the remaining $\ell-1$ units. At time 1, this firm can invest in its own project or can purchase shares in other firms. Without loss of generality, we assume that if it does invest in other firms, it purchases a completely diversified portfolio, earning with certainty the equilibrium rate of return R on investment at time 1. (This allows us to avoid further refining the set of states to reflect the possible outcomes of the investment in other firms.) Accordingly, if the evaluation result is bad, the $\ell-1$ units of internal capital are invested in other firms and earn the equilibrium return R.

Provisionally, suppose that a decision by the firm to invest the $\ell-1$ units acts as a credible signal that the evaluation result is good; we will specify incentive compatibility conditions ensuring that this is the case shortly. Then if the evaluation result is good, the firm can sell $\chi-(\ell-1)$ shares at time 1 and fund the project up the maximum level χ. As derived in section 2c, the total number of shares that can be issued per project is $N = (1/\pi) + \chi$, given that time 1 shares are normalized to have a price of one unit of capital. For the original investors in a firm, let $\mu(s)$ denote the state contingent return on each of the $\ell-1$ units of capital invested at time 1. Then $\mu(s)$ is given by

$$\mu(s) = \begin{cases} \dfrac{1}{(1/\pi) + \chi}\, \chi b & \text{if } s=1 \\ R & s=2 \\ \dfrac{1}{(1/\pi) + \chi}\, \chi g & s=3. \end{cases}$$

The total return to each of the ℓ original investors in this firm is a weighted average of the returns to evaluation and the returns to project investment, with weights determined by $\ell-1$, the amount of capital held internally subsequent to evaluation. If $\omega(s)$ denotes this state contingent rate of return to the original investors in the firm, then

$$\begin{aligned} \omega(s) &= \frac{1}{\ell}\left[\, \gamma(s) + (\ell-1)\, \mu(s) \,\right] \\ &= \frac{1}{\ell}\, \gamma(s) + \frac{\ell-1}{\ell}\, \mu(s). \end{aligned}$$

This shows clearly the sense in which increasing the degree of internal funding--that is, increasing ℓ--alters the portfolio of each individual, shifting it away from γ and toward μ.

If the decision to invest the internal funds in the project is to serve as a credible signal of project type, the gain from using internal investment to fool outside investors must be less than the cost of the signal. Assume that the original investors decide to invest all of the remaining $\ell-1$ units of internal funds in the project even though e=b, and that new investors infer from this willingness to commit funds that e=g. The old owners get $1/\pi$ shares for the investment in evaluation and $\ell-1$ shares for the internal funds. Their per share expected return is

$$(3.3) \quad \omega(3)\ \mathrm{Prob}(r=g|e=b) + \omega(1)\ \mathrm{Prob}(r=b|e=b) = \frac{(1/\pi)+(\ell-1)}{(1/\pi)+\chi} \chi\ E(r|e=b).$$

The opportunity cost of the resources that the old investors put into the project is the market rate of return R times the amount invested, $\ell-1$. Using the expression for R from equation (2.3) to evaluate this cost, and comparing it with the expression in equation (3.3), the incentive compatibility condition ensuring that old investors have no incentive to invest in a bad project even if they can fool new investors is

$$(3.4) \quad \frac{1}{\pi} \frac{\chi}{1/\pi + \chi} E(r|e=b) \le (\ell-1) \frac{\chi}{1/\pi + \chi} [E(r|e=g) - E(r|e=b)].$$

The left hand side of this expression is the value of misleading the new investors; old investors get $1/\pi$ shares in exchange for their property rights in the project. The value of each of these shares is expected total output, χ E(r|e=b), divided by the number of outstanding shares. The right hand side is the opportunity cost of investing the $\ell-1$ units of internal funds in the bad project. Since $E(r|e=g)$ is strictly greater than $E(r|e=b)$, this condition can be satisfied for large enough values of Ω.

The maximum amount of internal investment $\Omega-1$ is χ since this is the limit on investment in any particular project. The minimum firm size needed to satisfy equation (3.4) and make signalling credible depends on the parameters of the problem. By replacing $\Omega-1$ in equation (3.4) with χ and using assumption (2.4) (which guarantees that information has social value), it follows that signalling is always possible for a firm that is strictly smaller than the maximum size. Thus, if the amount of internal funds being invested by the old investors is large enough, potential new investors can rationally infer that e=g from the decision to invest the internal funds. There is always some level of partial internal funding that is sufficient to signal that the project is good.[8]

This result can be illustrated using the triangular diagram from above. Recall that the return per investor in a firm of size Ω is a weighted average ω of the returns to information production and to project investment, γ and μ respectively, with weights determined by $\Omega-1$. Because $\mu(2) = R$ and $\mu(1) < \mu(3)$, μ lies on the upper boundary of the incentive compatible region. When $\Omega=1$, $\omega = \gamma$. As firm size and the amount of internal funds increase, the state contingent return to investors moves along the line segment connecting the points γ and μ in Figure 3, with ω approaching μ as Ω increases. For some value of $\Omega-1$ strictly less than χ, ω will lie in the incentive compatible set.

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[8] Similar results can be derived for debt financing. If firms issue debt instead of equity to augment the internal funds, the minimum firm size Ω needed to make the signal credible is smaller. Debt reduces the return to the original investors in bad states, because debt holders have first claim on firm returns. For any given value of Ω, this reduces the return to misrepresenting the result of the evaluation.

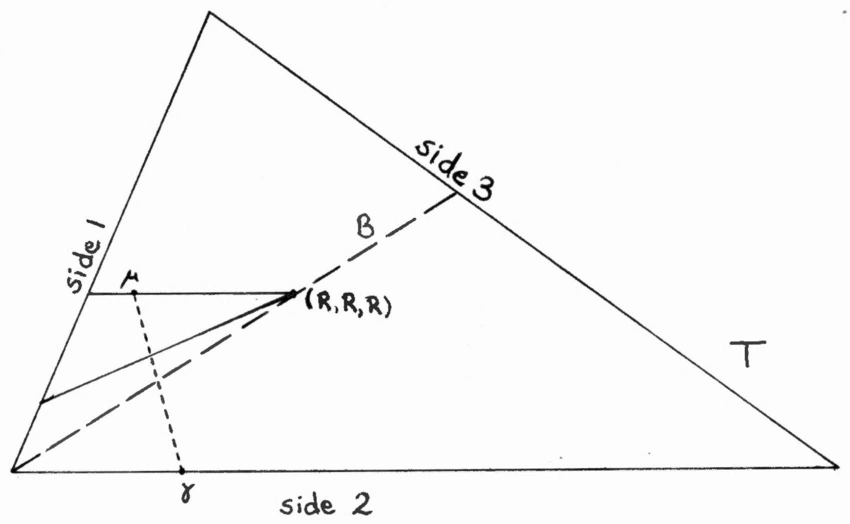

Figure 3

In terms of the connection between incentives and the allocation of risk, the effect of the partial internal funding by firms is to shift the portfolio holdings of owners away from the return γ associated with the investment in evaluation. The opportunity to take advantage of new investors by investing in a bad project arises only from γ; the structure of returns from funding the evaluated project μ offers an incentive not to invest when e=b. As the number of investors in the original firm increases, the per capita risk with bad incentive effects is diversified and the per capita risk in the project μ with the correct incentive effects is increased.

The arguments so far demonstrate that if the economy is in an optimal equilibrium with evaluator contracts of the form described in the last section, it may be possible for a group of investors at time 0 to deviate and use partial internal funding instead. This does not show that it is possible to support the full information optimum solely by means of internal funding. For example, suppose that evaluator compensation is never observable by outsiders, so that the equilibrium based on incentive compatible evaluator contracts is not feasible. The total number of firms that can be formed at time 0 and still be able to signal credibly is limited by the minimum firm size implicit in the incentive constraint (3.4). If this minimum size is too large, the number of firms will be too small and the number of evaluated projects that can be undertaken will be too small.

Specifically, let ℓ^* denote the minimum value of internal investment necessary to satisfy equation (3.4). Recall that $y = 1/(1+\chi\pi)$ is the number of evaluations (per capita) necessary to achieve the social optimum. Assuming each firm evaluates only a single project, the optimal number of firms (per capita) is y and the maximum feasible amount of initial capital available per firm is $1/y = 1+\chi\pi$. After the expenditure of one unit on evaluation, $\chi\pi$ units of capital are left for internal investment. If $\chi\pi$ is less than ℓ^*, the optimal number of evaluations would force firms to be too small to signal. Even if firms are large and can undertake many evaluations, one can show that $\ell^* > \chi\pi$ implies that it is not possible to support the social optimum in a signalling equilibrium with firms of finite size. (If firms represent an infinite number of investors and can undertake an infinite number of evaluations, we are back to the case discussed above in connection with the Boyd and Prescott pooling equilibrium.) Finally, we note that 100% internal financing for all firms (i.e. $\ell = \chi+1$) can never be an optimal outcome. The essential feature of the technology in this economy is that to achieve the efficient outcome, capital must be allocated among projects after evaluations have taken place. Firms evaluating a finite number of projects face some uncertainty about the number of promising projects that will result. If each firm started out with enough capital to fund all of its projects internally, then on average firms would have capital left over after funding the promising projects. Too few evaluations would be taking place relative to the social optimum.[9]

Neglecting issues of optimality, the incentive compatibility condition (3.4) is necessary for the existence of a signalling equilibrium, but by itself is not sufficient. A point made in Myers and Majluf (1984)--attributed to George Constantinides--is that any argument about internal financing depends crucially on the assumptions one makes concerning the existence of a secondary market for shares in the firm. Equation (3.3) implicitly assumes that the old shareholders must hold their shares in the firm until returns are realized. It does not allow for the possibility that they can sell their shares--that is, sell their share in the bond they have posted--in the secondary market. When this is possible, the signalling equilibrium fails. Either the signal would not be believed, or the secondary market for shares would fail to exist.

4. Applications

Taken literally, the two solutions described in section 3 are optimal only in a model that abstracts from many of the usual problems considered in principal-agent models. In practice such problems may be quite important, but our conjecture is that there are cases of interest where the problem of ensuring information transfers dominates other incentive problems. In these cases, we expect that arrangements of the form described above will prevail.

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[9] In an extended version of the model with a sequence of overlapping periods periods 0, 1, and 2, a firm with excess internal capital could always undertake an additional evaluation in a subsequent period, but this would still be suboptimal because of the delay it induces.

This section considers examples of this kind and discusses possible applications of the model.

4a. Compensation Contracts

The incentive compatible contracts from section 3a are most likely to be relevant when problems associated with the communication of unverifiable information are more important than those arising from unobservable effort. In some agency relationships, one of these problems is clearly dominant. Someone in a sales position exerts effort that is difficult to monitor, yet reports information that can be costlessly verified. It is therefore not surprising that individuals working in sales are often compensated on a commission basis. But as noted by Arrow (1985), performance-based compensation is not observed in many other obvious agency relationships. Doctors, lawyers, and accountants are generally not paid on the basis of the eventual outcome of their services.[10] In these cases, the problem of credible information transmission may help explain the fact that compensation is not contingent.

For example, a prospective purchaser of a house pays a structural engineer a flat fee for information about the house. The qualifications of the engineer can be monitored to some extent, as can the time spent acting on the client's behalf; but the information that is provided can only be verified by hiring another engineer to make a similar report--in terms of the model, by performing another evaluation. One would not expect the engineer to be paid

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[10]One notable exception is the use of contingency fees in personal injury lawsuits, but this seems to be a risk-sharing device more than an incentive device. It presumably arises because the legal system does not allow a plantiff any other means to sell shares in the outcome of a lawsuit. It is not used in lawsuits brought by clients like corporations who can pay legal fees regardless of the outcome of the suit.

with a commission that is contingent on the purchase of the house, since doing so would offer an incentive not to report information that could cause the sale not to take place.

The standard disutility of effort model might be taken to suggest that the engineer should be compensated based on the aggregate value of the required repairs that are identified, but this offers an obvious incentive to overstate the repairs. Not only would this undermine the value of the information provided to the buyer, it would also destroy the value of the engineer's report in any subsequent negotiation with the seller concerning the sale price. Incentives for truthtelling are important to both interested parties. The flat fee typically offered is equivalent to the invariant compensation described in the last section earlier. Except in extreme cases of misrepresentation that could result in a lawsuit, the compensation leaves the engineer indifferent between correctly revealing information or choosing not to do so. Given this indifference, reputational forces are presumably sufficient to enforce truthtelling.

This example differs from the model of a securities issuing firm because the buyer employs the evaluator, not the seller, but the form of the contract needed to insure truthtelling is the same. One could equally well imagine a case where the seller paid for the engineer's report rather than the buyer, in which case the example here would be completely analogous to that of the firm. In a case like a house sale where the evaluation typically takes place after a single buyer has been identified, one would expect the buyer to employ the engineer to minimize the possibility of side payments from the seller. In the case of sales of securities with many buyers, who cannot be identified before the time of the sale, it is natural for the seller to be the employer. The form of the compensation to the agent is determined by the incentives for truthfully reporting information, and is independent of who the formal employer is.

Within the structure of a major corporation, we can think of two instances where the transmission of information plays a particularly important role and may help explain the form of compensation. The first is the case of a research scientist. At various stages in the pursuit of a discovery, the scientist in charge must supply unverifiable information about the expected value of continued research. He or she must have the correct incentive to report that a project should be abandoned if this is the case. Casual evidence suggests that scientists generally are not compensated with a share in the royalties from a successful discovery, even though the elements typically used to justify performance-based compensation appear to be relevant. Effort exerted by a scientist is likely to be difficult to observe. A senior scientist is likely to have firm specific human capital that will lead him or her to take too little risk from the point of view of maximizing the value of the firm's equity. Information about the ability of the scientist is likely to be revealed over time and be correlated with the value of the discoveries that are made.

In a case where a firm suffers serious setbacks, similar considerations may apply for senior executives. Managers must have incentives that make them willing to abandon activities that do not deserve further investment and to truthfully reveal information to creditors and possible new investors. Compensation that is too highly dependent on share prices may make them unwilling to report negative information. Ex post, the optimal strategy for the managers (and the existing owners) may be to misrepresent this information and induce new investment either in the form of debt (e.g. in the form of a debt rescheduling) or new equity. The results from the model suggest that when stock price returns are low because a firm is forced to abandon projects and retrench, managerial compensation should not fall. In this sense, instances where executives receive large bonuses despite poor firm performance may not necessarily indicate that stockholders' long run interests have been undermined.[11]

Direct evidence suggests that the factors like unobservable effort that we have excluded do play an important role in the design of contracts. Bonus plans are ubiquitous in major corporations and Murphy (1985) documents a statistically significant positive relation between stock price performance and changes in executive compensation. These observations may still be consistent with a concern for information transfer. The incentive compatible contracts described in Section 3 leave wide latitude for performance-based compensation if investment is undertaken. Compensation and stock price performance move in opposite directions only when abandoning a project is the optimal choice. The results in the appendix on the relation between stock price performance and compensation demonstrate that it is possible for compensation to be positively correlated with firm performance.

What the results in the appendix rule out is the possibility that compensation is a monotonically increasing, convex or linear function of stock

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[11]This observation seems especially relevant in examining the case of Archie McCardell during his tenure at International Harvester (Marsh, 1985). He and his immediate subordinate were hired with a contract that placed a substantial fraction of their net worth at risk, depending on the performance of Harvester relative to several key competitors. As a series of events drove Harvester near bankruptcy, this contract came to be viewed as a serious mistake (and has not been used for any subsequent executives.) McCardell was slow to abandon expansion plans and unprofitable product lines; his predictions were consistently too optimistic and he eventually lost his credibility with the investors being asked to provide new funds--more than 200 banks involved in two major debt reschedulings. A public outcry was provoked when the board of directors tried to unwind the contract after Harvestor's position had deteriorated. Ultimately, this proved possible only with McCardell's resignation.

prices. It must be either non-monotonic or strictly concave. Healy (1985) offers evidence that concave compensation schedules are observed. He finds that a sizable fraction of the short term bonus plans he examines tied bonuses to accounting earnings, but set a maximum level for bonus payments in terms of an individual's base salary. This induces a region of concavity into the performance compensation relationship for which no other explanation has been offered.

To the extent that there is a tension between the need to ensure truthful revelation of information to outsiders and the need to reward ability or induce additional risk-taking or unobservable effort by managers, one possible solution may be to divide responsibilities. Some employees can specialize in information production and transmission while others provide effort, etc. To a first approximation, we believe that an accounting firm can be modeled as one such specialized agent of the owners of a corporation. The form of the contract offered by the firm can be modeled in terms of the incentive compatible evaluator contracts described in this paper. In contrast to the hidden-action model of effort by an accountant as presented in Antle (1984), it seems reasonable to model effort by the accountant as being observable. In Antle's model, accountants who are independent in the strongest sense will typically be offered compensation that varies substantially with the reported result of an audit; in the absence of this variation, the accountant would choose to exert minimal effort and the audit would be "valueless" (Antle 1984, p. 15). To us, this premise seems too strong because much of the effort exerted by an auditor can be observed at relatively low cost. Moreover, actual compensation to accounting firms seems not to be contingent on the result of the audit or on any other variable. It resembles the invariant compensation contract described in Section 3.

Professional and regulatory rules concerning auditor independence appear designed to enforce this invariance and to minimize the cost of enforcing prohibitions on side payments that would have the effect of violating the incentive to report truthfully. As in the case of an engineer hired by the purchaser of a house, invariant compensation leaves the accountant indifferent between telling the truth and lying, but reputational forces are presumably sufficient to tip the balance in favor of truthtelling.

Similar arguments seem to apply to outside members of the board of directors of a corporation. They do not typically make public announcements, but they do play a role in deciding whether to undertake major capital investments. Their effort on behalf of the corporation can for the most part be monitored; either they attend board meetings and contribute to the proceedings or they do not. As far as we know, compensation is generally not contingent on the performance of the corporation. As in the previous cases, invariant compensation leaves them indifferent between fulfilling an obligation to reject suboptimal investment projects and not doing so, but reputational forces can once again be decisive.

4b. Reputational Considerations and Investment Banking

The allocation of evaluation risk may also be important in the viability of a firm commitment offering of securities by an investment banking firm. Since the underwriter in effect buys the securities from the firm with the intention of reselling them to the public, it is not immediately clear what distinguishes its position from that of the firm. In each case, someone with private information attempts to sell the securities to the public. Booth and Smith (1986) and Beatty and Ritter (1986) argue that reputational considerations enforce truthtelling in this market, and that the investment banking firm is better able to develop reputational capital and earn a competitive return on that capital because it is in the market more often. Without contesting this observation, we note only that reputational forces are much more likely to overcome indifference than a strong financial disincentive, and that the transfer of the securities from the firm to the underwriter insulates the underwriter from evaluation risk and greatly reduces the incentive to mislead new investors.

In a firm commitment offering, the investment banker agrees to evaluate the prospects of a company and to set an offering price for the securities just before the offering. The banker and the company agree to the underwriter's spread, which represents the difference between the offering price that is set and what the firm receives for the securities. The investment banker guarantees this amount to the firm on all the shares in the offering. Once the price is set, the underwriter bears all the risk associated with the sale of the securities.

Superficially, it appears that the underwriter places itself in a position as seller identical to that of the firm. It has securities it wants to sell, and because of the evaluation it has undertaken, it has private information about the value of those securities. The difference is that the spread received by the investment banker is fixed prior to the evaluation. If the evaluation result is less favorable than expected, the offering price will be lower and the old owners of the firm receive less for the securities. The owners of the firm bear all of the risk associated with the result of the evaluation, and an underwriter working on a fixed spread bears essentially none. The underwriter does bear other forms of risk--for example the risk associated with a general movement in the market during the offering period--but these risks need not have any effect on the incentives for truthfully revealing information about the issuing firm.

If outsiders had no information about the value of the securities being issued (and if the spread were set in absolute rather than percentage terms) the underwriter would be completely indifferent about the price set on the offering. But if outsiders have independent information about the prospects of the firm, a reduction in the offering price below the expected value of the shares conditional on the information internal to the firm will increase the probability that the offer sells out at the offering price. In this case, the underwriter has an incentive to take advantage of the firm ex post and set a price that is too low. Since the firm and the underwriter have the same information, the right retained by the firm to withdraw from the offering once the price is set prevents it from being exploited by the underwriter.[12]

In essence then, the case here is such that one principal (the existing owners and managers) and the agent (the underwriter) share the same information. This principal designs compensation for the agent so that the agent is indifferent with respect to the choice of the price, or has an incentive to represent the interests of the other principal (the new investors), ensuring that the offering price is not too high. In this example, the assumption that the firm's owners and managers know the

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[12]The incentive for an investment banker to exploit the issuing firm is distinct from the problem of initial abnormal returns, which appear to be an equilibrium phenomenon. The underwriter would like to set the issue price lower than the optimal price conditional on the internal information held by the underwriter and the firm, regardless of how that optimal price is determined. If, as in Rock (1986), there is additional information held by an informed subset of outsiders, this optimal price will be less than the expected value of the shares conditional on the internal information. In this case, new issues will still earn initial abnormal returns.

evaluation result prior to hiring the underwriter does not cause any problem. Selection goes in the right direction. To the extent that they have private information that can be confirmed (at a cost) by an underwriter, only good firms will seek out new financing through an underwritten offering.

4c. Internal Funding and Signalling

All of the applications so far involve versions of the contracts described in Section 3a, but as noted above, internal funding can also be used to signal the desirability of a given project. For a large corporation with publicly traded stock, concentration of equity holdings in the hands of managers or members of the board of directors may help sustain the signalling equilibrium with internal funding. Insider holdings are observable and are constrained by rules on insider trading. In large trades, the purchaser is also more likely to know the identity of the seller. Any attempt to sell off the bond implicit in the internal funds that have been invested is therefore likely to reveal negative information, forcing the price down sufficiently to make an attempt to exploit new investors unprofitable.

Internal funding also appears to play a role in communicating information about new firms prior to a public offering. An entrepreneur or start-up firm will typically not have sufficient resources to be able to offer a credible signal about the prospects of the firm, but a venture capitalist may. Thus, the venture capitalist does an evaluation, invests private funds, and helps the firm raise additional capital. Prior to the time of a public offering, the venture capitalist has only a limited ability to sell his or her holdings. Thus, the possibility that the bond implicit in internal funding can be undone by secondary market sales is of little concern.

4d. Extensions

Finally, we note that the information problem we identify is not restricted to the case of firms issuing new securities to fund new projects. As noted above, it arises in many standard agency relationships entered into by individuals. It may even be present for a firm that undertakes projects exclusively from internal funds if there is a separation between ownership and control that arises for the kind of reasons identified by Fama and Jensen (1983). In this case, the information transfer problem is internal to the firm. The manager must not be given incentives to incorrectly reveal information to owners, or equivalently, to make incorrect investment decisions. If the manager receives invariant compensation, no problem with incentives for doing this arises. If the manager is paid exclusively with predetermined amounts of stock that cannot be sold (either directly or indirectly), no problem arises because the incentives faced by the manager will be identical to those of other stockholders. In contrast, if a bonus plan is specified purely in terms of an earnings target, the manager's incentive to withhold dividends in favor of any productive investment is obvious. The same incentives are present if the bonus is a function of the stock price alone, not the total return including dividends.

Less obviously, problems can arise even when compensation is a function of the rate of return earned on the firm's equity over a specified interval of time. If the alternative to funding a given project with internal funds is to pay dividends or buy back stock, the manager will be willing to invest in a suboptimal project as long as it raises the average return on all projects undertaken during the given period. Owners care about the marginal return on the new project, but a manager with this kind of compensation package is concerned with the influence of the project on the average rate of return. The key feature of the investment opportunities considered in this paper is that the return on the first project--the evaluation--is necessarily zero. In this case, any investment, even a bad one, will lead to a larger average return. More generally if the return on a first project is low, a second project that offers a marginal return that is too low may still raise the average rate of return on the two projects taken together.

5. Conclusion

Stripped of all the formalism, the argument here starts from a simple premise and makes two basic points. The premise is that firms contemplating an investment project can, and should, look before they leap. The first point is that someone hired to do the looking will not give a truthful report if the pay is higher when the news is good. Trivial as this observation may seem, we think that it helps explain why compensation for managers does not always move together with shareholder returns, and why contingent compensation is avoided entirely in many agency relationships.

The second and more subtle point is that the roles of employer and employee need not coincide with those of principal and agent as typically used in the economics literature. As has previously been noted (e.g. Arrow 1985), the implicit contracts literature reverses these roles, treating the employer as an agent who is delegated responsibility for deciding on the amount of labor to employ. The new case considered here is one where the employee working for a single employer is still the agent, but the employer is not the only principal. Instead of contracting directly with the agent, a second principal can have the first principal make all compensation payments to the agent. Offsets to the transactions between the principals can then be used to set their shares in the compensation. Thus, common agency as described by Bernheim and Whinston (1986) is not ruled out merely by the presence of a single employer and compensation scheme. In the context of a firm, this observation suggests that the interests of owners may not always offer a good guide to the form of the compensation offered to employees of the firm. In many cases it may be appropriate to treat outsiders like new investors or banks as principals, and to treat employees like managers, directors, auditors, and investment bankers as agents acting on the behalf of the outsiders as well as on the behalf of the owners of the firm.

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Appendix: The Relation Between Compensation and Stock Price Performance

In sections 3a and 3b we considered two extreme cases. In the first, evaluators are compensated so that they have sharply divergent interests from those of the owner. For the evaluator the worst outcome is state 1; for the owner the worst is state 2. In the second case, owners can completely remove the incentive compatibility problem by making sufficiently large investments of internal funds. Then one of the owners can serve as evaluator, or an evaluator can be hired with a contract that aligns his interest with that of the owners. The evaluator could be compensated entirely with stock in the firm. In between these two cases, we can parameterize firms by the number Ω of initial investors, or equivalently by the initial capitalization. Then for firms with arbitrary values for Ω, we can consider the relation between compensation to managers and stock price performance.

Referring to Figure 3, the return ω received by the original stockholders moves along the line segment from γ to μ as Ω increases. When $\Omega=1$, $\omega = \gamma$ and we are in the first case above. When Ω exceeds Ω^* and ω passes into the incentive compatible region, we are in the second. In between, there are two distinct cases depending on where ω lies relative to the bisector B along which returns in states 1 and 2 are the same. If ω lies below B, shareholders have the wrong ranking of states from the point of view of incentives for truthtelling. To ensure incentive compatibility, evaluator contracts must provide a different ranking, and weight returns so that the incentive constraints (3.1a) and (3.1b) both hold. In this case the relation between evaluator compensation m(s) and stockholder returns $\omega(s)$ is as illustrated in Figure 4.

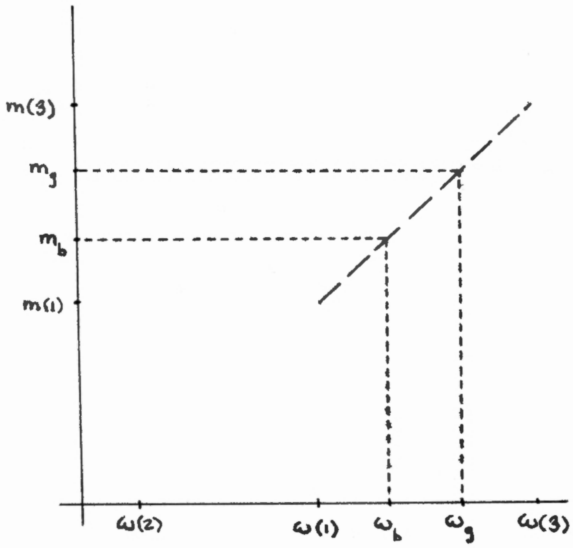

Figure 4a

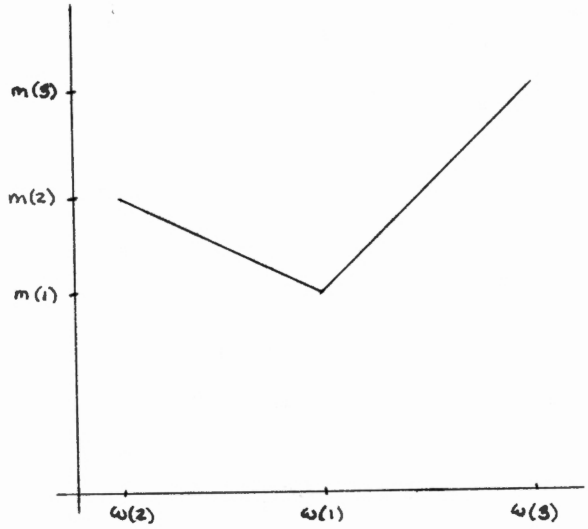

Figure 4b

This figure illustrates the calculation of m(2), the compensation to the evaluator in state 2, given values for compensation m(1) and m(3) in the other states and given the stockholder returns ω(1), ω(2), and ω(3). The stockholder returns plotted on the horizontal axis satisfy $\omega(3) > \omega(1) > \omega(2)$ since by assumption, ω lies below the line B. In Figure 4a, ω_b and ω_g denote expected shareholder returns from investing when e=b and e=g respectively. Thus ω_b and ω_g are weighted averages of ω(1) and ω(3) with $\omega_b < \omega_g$. Given values for m(1) and m(3), the expected returns m_b and m_g to the evaluator from investing when e=b and e=g can be calculated from the ω_b and ω_g. Since the conditional probabilities in the calculation of the expected returns to owners and evaluators are the same, the points (ω_b, m_b) and (ω_g, m_g) must lie on the line segment connecting (ω(1),m(1)) and (ω(3),m(3)). The incentive compatibility conditions (3.1a,b) for the evaluator require that m(2) lie between m_b and m_g. Then as is illustrated in Figure 4b, evaluator compensation cannot be a monotonically increasing function of shareholder returns.

If the shareholder return ω lies above the bisector B, shareholders have enough of their own internal funds at risk so that they prefer state 2, in which there is no investment, to state 1, in which they invest and the returns are bad. But they would still prefer to invest when e=b if they could mislead new investors. That is, $\omega(3) > \omega(2) > \omega(1)$, but the weighted average

$$\omega_b = \text{Prob}(r=g|e=b)\omega(3) + \text{Prob}(r=b|e=b)\omega(1)$$

is still greater than $\omega(2)$. This is illustrated in Figure 5a. In this case compensation to the evaluator can be a monotonically increasing function of the return to shareholders.

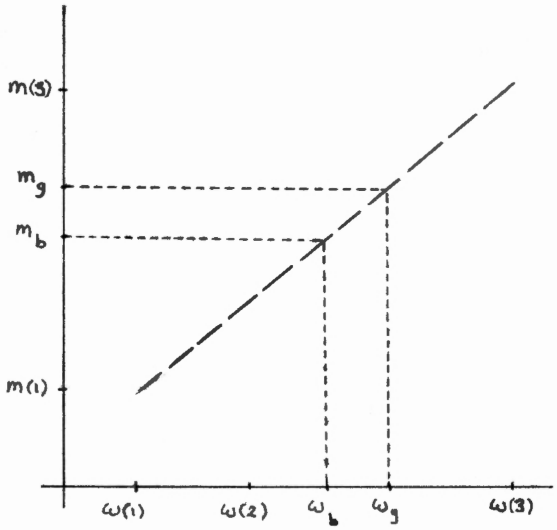

Figure 5a

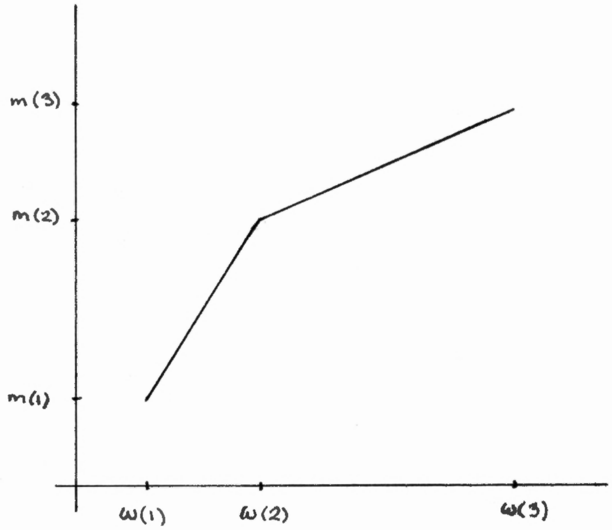

Figure 5b

Once again, let $\omega(1)$, $\omega(2)$, $\omega(3)$, $m(1)$ and $m(3)$ be given. As above, the points (ω_b, m_b) and (ω_g, m_g) must lie on the line segment connecting $(\omega(1), m(1))$ and $(\omega(3), m(3))$. Since the incentive compatibility conditions force $m(2)$ to lie between m_b and m_g, and since $\omega(3) > \omega(2) > \omega(1)$, it follows that $m(s)$ as a function of $\omega(s)$ must be as drawn in Figure 5b. The point $(\omega(2), m(2))$ must lie above the line segment connecting the points $(\omega(1), m(1))$ and $(\omega(3), m(3))$. In this sense, compensation to the evaluator must be a concave function of realized stock returns.

In both of the these cases where evaluators play a role in resolving incentive problems, evaluator compensation cannot consist of a base salary plus non-negative quantities of stock and put and call options on stock. Such arrangements cannot generate a non-monotonic relation between compensation and stock price performance or a monotonic but concave relation.

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