MANAGERIAL INCENTIVES AND CAPITAL MANAGEMENT*

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The paper shows how career concerns rather than effort aversion can induce a natural incongruity in risk preferences between managers and superiors. A model, based on learning about managerial talent, is developed to study second-best contractual remedies. We show that the optimal wage contract is an option of the value of the manager's human capital for insurance reasons and that consequently rationing of capital is often required to counterbalance the manager's resulting incentive to overinvest. Rationing is strictly superior to price decentralization, offering one reason for the prevalence of centralized capital budgeting procedures.

I. INTRODUCTION

Moral hazard—the problem of controlling unobservable actions by subordinates—has been studied extensively in recent years. Most of the research has focused on the case where actions can be interpreted as effort—for good reason, it seems. Sincerity of labor input is inherently unobservable; an effort interpretation permits further restrictions on the model formulation; and effort, being a costly input, provides a natural source of incongruity in preferences between superiors and subordinates.

In a managerial context, however, effort is only part of the overall incentive problem. It is likely that many executives believe their managers are industrious enough; what they worry about more is how effective these managers are at making decisions.[1] Part of this concern relates to the managers' willingness

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1. This view is shared by Kaplan [1984, p. 405], who in his review of managerial accounting research considers effort-based models highly inadequate for capturing the incentive issues that management faces.

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or unwillingness to take risks. Extensive capital budgeting procedures are concrete signs that the control of investment incentives is an important issue for the firm. To the extent that these incentive problems cannot be fully removed by monitoring (as marginalist thinking would readily suggest), they have allocational consequences not only for the firm but for the economy as a whole. The consequences could be significant in view of the economic scope of management. It seems important therefore to take a more careful look at what, if anything, may go wrong in decentralized management.

Why would managers be inclined to act against the best interests of shareholders and superiors? Two early papers in agency theory (Wilson [1969]; Ross [1973]) suggested that incentive problems may arise as a consequence of attempts to utilize the manager's risk absorption capacity. Optimal risk-sharing—barring exceptional cases—leads to incongruities in risk preferences, and a second-best solution will have to trade off some of the benefits of risk sharing against better investment incentives. In reality, this tradeoff seems negligible. The value of the manager as a risk carrier is minimal in a firm of even modest size, particularly if the firm is publicly held. Consequently, an almost costless solution to the incentive problem could be obtained by paying the manager a flat wage and asking him to act in the best interests of the owner.

Another possible source of incongruity in risk preferences stems from costly (and unobservable) effort choice. To be motivated, the manager has to carry some risk, and this leads him to value risky projects differently than the owners or superiors do. Little has been done along this line, however, because the analysis quickly becomes very complicated. A model with a highly simplified technological structure has recently been studied by Lambert [1986] (see also Holmstrom and Weiss [1985] and Holmstrom and Milgrom [1985]).

Here we want to suggest a third and perhaps more relevant reason for potential misalignment of incentives, based on the simple idea that managers are concerned about the impact of decisions on their future careers. We formalize the notion of career concerns using a model of learning. Managerial competence is initially uncertain and being inferred over time. This makes the manager's past performance a rational basis for forecasting future performance. The manager, recognizing that performance is used as a signal about productivity, tries to influence the evaluation process by his choice of actions. Divergent preferences arise from the dissonance between the financial value of present performance and its reputation value. In effect, decisions influence two separate capital returns, one human and one financial. Absent explicit incentive schemes, a manager is concerned only about his human capital stream; while owners are concerned only about the financial returns. To bridge the preference gap, some form of contracting is essential.[2]

If the manager could sell himself to the firm, an optimal contract with risk-neutral owners would offer full insurance and remove any distortions in the manager's incentives. A key assumption in our model is that this is prohibited by effective constraints on involuntary servitude (including bonding). The implication is that future wages have to rise with perceived increases in marginal product. This rules out full insurance and makes the contract incomplete. The situation is much like that in Harris and Holmstrom [1982], but with decision making added to the model.

The interaction between decision making and learning provides a broad framework for understanding managerial conduct. We shall focus on a very simple investment model, largely for expositional reasons. In our model the manager (privately) gathers information about potential projects and supervises their implementation. Investments are undertaken by making a proposal, which reveals the private information to a superior. The manager cannot misrepresent information about project returns, but he can propose wrong projects or refrain from proposing projects altogether. The question is what an optimal wage contract and investment rule should look like, recognizing the problems with quitting and the potential incentives to withhold information.

Briefly, we show the following. An optimal (second-best) contract offers the manager a downward rigid wage, which can be interpreted as an option on the value of his human capital. (Unlike the Harris-Holmstrom solution, the option may include a bonus for investing.) Since the option carries residual human capital risk, it turns out that projects will not be undertaken as frequently as they would be under a full insurance contract. In other words, the effective cost of capital on total returns (financial plus human)

2. It is worth stressing that in our argument reputation is the source rather than the resolution of incentive problems. This contrasts with the common theme that time is helpful in overcoming moral hazard (e.g., Fama [1980]; see also Holmstrom [1982]).

exceeds the market rate. The most interesting feature of a downward rigid wage is that it will often induce the manager to overinvest. To prevent excess investment, the firm will have to ration capital. Rationing is strictly superior to price decentralization, since the latter would not permit as high a degree of insurance. Rationing is most naturally implemented via centralized capital budgeting. Thus, our model offers a new and unorthodox explanation of central management of funds in firms.

The next section introduces the basic model via an example illustrating the nature of divergent risk preferences that arise from learning. Section III analyzes optimal contracting and presents its economic implications. Section IV discusses qualifications and extensions. Section V concludes with a summary and a view of future research on learning and managerial behavior.

II. Market Outcome Without Contracting

In the following example we consider the investment behavior of a manager, who is not on any kind of contingent incentive contract and is therefore guided only by his concern for reputation in a managerial labor market. This assumption is made to highlight the nature of preference incongruities and to rationalize the need for contingent contracting, which we investigate subsequently.

Model

There are two periods $t = 1,2$, technologically independent and identical. In each period an investment can be made, which yields a publicly observed net payoff y_t at the end of the period. The manager decides on investing based on a signal s_t, which is a predictor of y_t. Specifically, the net payoff from investing can be written as the sum,

$$y_t = s_t + \varepsilon_t, \tag{1}$$

where ε_t is a random factor realized subsequent to investment. If no investment is made, the net payoff is zero.

For concreteness, let the possible outcomes of s_t and ε_t be -1 or $+1$, so that y_t could be either -2, 0, or $+2$. The distribution of s_t puts equal weight on the two outcomes, while the distribution of ε_t depends on the characteristics of the manager. The manager is either good or bad. For a good manager $Pr(\varepsilon_t = +1) = \frac{3}{4}$, and

$Pr(\varepsilon_t = -1) = \frac{1}{4}$. For a bad manager these probabilities are reversed.

Managerial ability is uncertain. The probability that he is good is p_1 initially. We shall assume that the labor market and the manager share this assessment as well as information about the technology. Furthermore, we assume that after investing in period 1, y_1 and s_1 will become publicly known. Therefore, ε_1 can be inferred, and all parties will update beliefs about managerial ability in the same way. This retains symmetry in beliefs.

The second-period updated probability of ability, p_2, can take on three values, which we denote p_2^+ (if the investment is successful), p_2^0 (if no investment is made), and p_2^- (if the investment is unsuccessful). Since the distribution of s_t is independent of managerial ability $p_2^0 = p_1$. Also, it is well-known that beliefs form a martingale, implying that

$$E(p_2|p_1) = p_1. \tag{2}$$

We assume that the managerial labor market consists of a large number of identical firms with the investment technology (1). They will bid the manager's wage in each period to the point where it equals his perceived marginal product. Since we are excluding explicit contingent contracts (which also could be rationalized by the assumption that output can be observed but not verified in a court), we can view the manager as being paid at the beginning of each period—before either s_t or ε_t are realized. Thus, the first-period wage w_1 is noncontingent. The second-period wage $w_2(p_2)$ will depend (implicitly) on the outcome in the first period, because of changed perceptions in managerial product.

Analysis

Let us analyze the market outcome recursively, starting with the second period. At this point the manager's perceived ability is described by p_2. The expected financial returns from investing in period 2, conditional on the signal value s_2, are $E(y_2|s_2 = +1) = p_2 + \frac{1}{2} > 0$ and $E(y_2|s_2 = -1) = p_2 - \frac{3}{2} < 0$. The socially preferred decision rule is therefore to invest if $s_2 = +1$ and not to invest if $s_2 = -1$. Note that this decision rule is independent of managerial ability.

Since the second period is the last in the manager's career, he has no reason not to follow the socially preferred rule, and firms can trust him to do so. The second-period value of the manager, given that he follows the optimal rule, is therefore $E(y_2) = \frac{1}{2}(p_2 + \frac{1}{2})$, before s_2 is observed. Firms will pay his marginal product in advance, so

$$w_2(p_2) = \tfrac{1}{2}p_2 + \tfrac{1}{4}. \tag{3}$$

Now go back to the first period. The manager is paid the fee w_1 first. Then he observes s_1 and has to decide on the course of action. If he does not invest, he knows he will receive $w_2 = \frac{1}{2}p_1 + \frac{1}{4}$ in the second period (by (3)), because then $p_2 = p_1$. If he invests, he faces a lottery because p_2 will depend on the investment outcome, or rather the inferred value of ε_1. An outcome $y_1 = +2$ (implying $\varepsilon_1 = +1$) will give him $w_2^+ = \frac{1}{2}p_2^+ + \frac{1}{4}$, and an outcome $y_1 = -2$ (implying that $\varepsilon_2 = -1$) will give him $w_2^- = \frac{1}{2}p_2^- + \frac{1}{4}$ (by (3)). The expected value of this lottery is $\frac{1}{2}p_1 + \frac{1}{4}$, by (2).

We find then that, whatever the value of s_1, a manager who invests will face an income lottery that pays in expected value the same as he would certainly get without investing. Consequently, if the manager is risk averse, no investments will ever be undertaken in the first period, and the first-period marginal product and wage will equal zero.

Our conclusion is not dependent on the two-period structure. With any finite number of periods it is easy to see (by backward induction) that the manager will only be willing to invest in the very last period so long as the manager cannot fully insure himself by borrowing and lending in the capital market. (Indeed, even a risk-neutral manager is indifferent only between investing and not.) What our conclusion is sensitive to, however, is the specific information structure of the example. This is useful to understand, and we shall illustrate it by a slight modification of the distribution of s_t.

Variation

Let us change the example so that s_t is uniformly distributed between -1 and $+1$. This changes the optimal investment rule in the second period to the following: invest if and only if $s_2 + p_2 - \frac{1}{2} \geq 0$. The manager's fee and his marginal product in the second period will now be

$$w_2(p_2) = \int \max(0, s_2 + p_2 - \tfrac{1}{2})ds_2 = \tfrac{1}{2}(p_2 + \tfrac{1}{2})^2.$$

This is a convex function in p_2. By Jensen's inequality,

$$(4) \qquad E(w_2(p_2)|\text{investment}) > w_2(E(p_2)) = \tfrac{1}{2}(p_1 + \tfrac{1}{2})^2,$$

where the last equality again follows from the martingale property of beliefs (2). The last term in (4) is the second-period wage the manager would get if he did not invest in the first period; while the first term in (4) is the expected value of his second period wage if he invests in the first period (note that it is independent of the value of s_1). Unlike in the preceding case, the expected second-period wage is now higher if the manager invests. The reason is that the information about ability that an investment in the first period provides, is being used in the second-period decision rule because that rule now depends on assessed ability. The increase in the expected wage reflects the value of ability information.

We conclude from this that a manager may want to invest in the first period, depending on his risk preferences. A risk-neutral manager will surely invest (by (4)), while a sufficiently risk-averse manager will still opt for no investment. The problem in either case is that the decision to invest is independent of s_1 because the manager's income lottery depends only on the inferred value of ε_1. Thus, the manager will invest for all s_1 or no s_1. If he never invests, his first-period marginal product and wage is zero. If he always invests, his wage will be $p_1 - \frac{1}{2}$.

Conclusion

Both variations on the example make the point that there may be a significant incongruity in investment preferences due to the manager's career concerns. Without contracting, the manager worries only about the human capital returns from investments, while owners are interested only in the financial returns. The divergent interests are so severe in the example that the manager's private information about s_1 is left entirely unexploited; in fact, this is true whenever learning is independent of the proposal characteristics (as here). In order to capitalize on the manager's expertise, some form of contingent contracting is necessary.

III. Contracting

We shall study contracting in the context of $0 - 1$ investment decisions, using essentially the same model as described in the previous section. The only change is that we shall work with general rather than specific distributions for the signal and the random shocks in (1); this is notationally simpler. Thus, signals s_t are drawn from a distribution N (time-invariant and independent of ability as before). The shocks ε_t are drawn from the distribution G, if the manager is good, and B, if the manager is bad. The means of G and B are denoted μ_G and μ_B, respectively.

The firm (represented by an owner or a superior) is assumed risk neutral and the manager risk averse with an atemporal utility function over consumption given by

$$u(c_1,c_2) = u(c_1) + \beta u(c_2).$$

Both parties discount at the same rate β. The manager is assumed to be unable to borrow or save and hence consumes his wage in each period. It turns out that the savings restriction is inconsequential, but the borrowing constraint is not; we shall return to this in the next section. Wage payments are made at the beginning of the period as before. This saves on notation without materially altering the results.

Contractual opportunities depend on what kind of contracts one assumes can be enforced, which in turn depends on the information structure of the model. We shall make the simplest possible assumptions consistent with a nontrivial analysis and return to variations in the next section.

After observing the value of the signal s_t, the manager can report it to his superior. This report is meant as a stylized investment proposal. The superior is able to verify the validity of an investment proposal, if one is made, but he cannot force the manager to make one: In effect, the manager can withhold, but not misrepresent, individual project information. One way of interpreting the manager's veto power is to assume that there are always sufficiently bad projects around to be proposed and rejected.

We shall assume that the manager and his superior can agree in advance to follow an investment rule that takes into account the manager's reported value s_t (if he makes a proposal). Thus, the superior does not have veto power ex post. This may be unrealistic if the characteristics of a proposal are hard to identify or verify, but again, it will be easy to see the ramifications of the alternative hypothesis once the simpler case has been covered. Also, a binding decision rule covers as a special case full managerial discretion.

All parties share beliefs about managerial ability at the out-set. If an investment is made, the market gets to observe both the outcome y_t and the signal s_t before the beginning of the next period. Since the mere observation of a signal does not give any information about managerial ability (N is independent of ability), symmetric beliefs will be maintained at all times. This is important for tractability.

Our other key assumption is that the manager cannot be forced to stay with the firm if he gets a better offer from the outside market. This is rationalized by de facto constraints on involuntary servitude. The assumption, which appears quite realistic, is critical for the analysis, because it forces the contract to be incomplete.

With the informational assumptions we have made, a *contract* δ is a pair (ω,α) where $\omega = (w_1,w_2(s_1,y_1))$ specifies the wages to be paid at the beginning of each period and $\alpha = (\alpha_1(s_1), \alpha_2(s_1,y_1,s_2))$ specifies the investment rules to be followed. Here $\alpha_t = 0$ or 1 as an indicator of rejecting or accepting an investment. We shall occasionally use a_t as a generic for the investment decision in period t.

First-Best Contract

It is useful to begin by considering what an ideal contract would look like, one that is designed in the absence of quitting and reporting restrictions on contract design. Clearly, such a first-best contract will offer the manager full income insurance because the firm is risk neutral. Furthermore, wages will be equal in each period due to the equal rate of discounting.

In order to determine first-best decision rules, we study the problem recursively. Beginning again with the second period, the optimal investment rule, denoted $\alpha_2^*(p_2)$, simply maximizes expected financial returns, $E(y_2|p_2)$, given present information about managerial ability p_2. Under this rule, an investment is undertaken if and only if $E(y_2|p_2) = s_2 + \mu(p_2) \geqslant 0$, where

$$\mu(p_t) \equiv p_t\mu_G + (1 - p_t)\mu_B, \tag{5}$$

is the mean of ε_t of a manager of ability p_t. The rule can also be expressed by a "hurdle rate" $s_2^*(p_2)$ such that one invests if and only if $s_2 \geqslant s_2^*(p_2)$; where $s_2^*(p_2)$ is defined via

$$s_2^*(p_2) + \mu(p_2) = 0. \tag{6}$$

In the absence of learning effects, s_2^* would give the hurdle rate in both periods, since it maximizes the financial returns. But with learning there are also returns to human capital in the first period. To determine the optimal first-period rule, $\alpha_1^*(p_1)$, we need to know how the value of the manager changes with information about his ability. Let $z_2(p_2)$ denote the second-period value of a manager of ability p_2, who follows the rule $\alpha_2^*(p_2)$. We have

$$(7) \qquad z_2(p_2) = E(\max[0, s_2 + \mu(p_2)]) = E(s_2 + \mu(p_2) | s_2 + \mu(p_2) \geq 0).$$

We shall occasionally refer to $z_2(p_2)$ as the market value of the manager (in the second period) because this is what he could earn in an outside firm if he were to switch after the first period.

Since $\mu(p_2)$ is linear in p_2 (by (5)), the integrand in (7) is the maximum of two linear functions. Consequently, $z_2(p_2)$ is a convex function. From Jensen's inequality it follows that

$$(8) \qquad v(p_1) \equiv E(z_2(p_2))|p_1 - z_2(p_1) \geq 0,$$

because of the martingale property (2). Here $v(p_1)$ represents the value of learning about managerial ability: in other words, the returns to human capital from investing. The gains come about because the decision rule (in the second period) can respond to new information (if it does not, then $v(p_1) = 0$). Note that the value of learning is only a function of the prior p_1, because of the particular technology (1).

The optimal first-period decision rule now maximizes the discounted sum of the financial and human capital returns from investment, i.e, $E(y_1 + \beta v(p_1)|p_1, s_1)$. In analogy with the second-period rule, we express the first-period rule by a hurdle rate $s_1^*(p_1)$, such that one invests if and only if $s_1 \geq s_1^*(p_1)$, where $s_1^*(p_1)$ is defined via

$$(9) \quad E(y_1 + \beta v(p_1)|p_1, s_1^*(p_1)) = s_1^*(p_1) + \mu(p_1) + \beta v(p_1) = 0.$$

We summarize our discussion of first-best in the following:

PROPOSITION 1. A first-best contract satisfies

(a) $w_1 = w_2(s_1, y_1) = w$; a constant wage;
(b) $\alpha_t(s_t) = 1$ (invest) if and only if $s_t \geq s_t^*(p_t)$, where $s_1^*(p_1)$ is given by (9) and $s_2^*(p_2)$ is given by (6).

B. Second-Best Contract

Next consider second-best, where the manager can quit and where incentives may have to be provided in order to induce a proposal. A preliminary observation will simplify the formulation of the problem notationally: it is always feasible and optimal to follow the first-best rule α_2^* in the second period, irrespective of what the other dimensions of the contract are. This is obvious because the manager receives his last payment at the beginning of the second period and does not care what happens thereafter. In particular, he will be happy to reveal s_2 unconditionally so that whatever rule the superior wants, can indeed be implemented.

With this in mind, define

$$(10) \qquad U(\omega,a_1,s_1) = u(w_1) + \beta E(u(w_2)|a_1,s_1),$$

$$(11) \qquad \Pi(\omega,a_1,s_1) = E(y_1 + \beta z_2(p_2)|a_1,s_1) - w_1 - \beta E(w_2|a_1,s_1).$$

These expressions give the manager's expected utility and the firm's expected profit as functions of the first-period action, signal, and the wage contract, given that the first-best rule will be used in the second period. With this notation, the second-best contract solves

$$(12) \qquad \text{maximize} \int U(\omega,\alpha_1(s_1),s_1)dN(s_1),$$

subject to

(i) $\int\Pi(\omega,\alpha_1(s_1),s_1)dN(s_1) \geqslant 0$,
(ii) $w_2 \geqslant z_2(p_2)$, for all p_2,
(iii) $U(\omega,\alpha_1(s_1),s_1) \geqslant u(w_1) + \beta u(z_2(p_1))$, for all s_1.

Constraint *(i)* is the firm's zero profit constraint; *(ii)* makes sure that the manager does not want to quit; and *(iii)* assures that he will always reveal his project information s_1.

The way we have accounted for the manager's quitting and veto options needs brief elaboration. In general, it could be mutually beneficial to have the manager quit, once more information about his ability is known, simply because of comparative advantage. But in our model we explicitly assumed that outside firms are technologically identical to the present employer. Moreover, outside firms will pay the manager his market value and earn zero profits. Thus, by meeting competitive wage bids, the present employer neither loses nor gains anything, and it becomes a matter of indifference whether the manager sticks around as assumed in *(ii)*.

Regarding (iii), recall that we assumed the manager can veto projects by withholding information. This option is implicit in *(ii)* because the decision rule $\alpha_1(s_1)$ can be agreed to in a binding manner. In cases where the manager would like to veto a project because (iii) is not met, one simply sets $\alpha_1(s_1) = 0$, and the veto will be effective with (iii) satisfied.

Without the constraints (ii) and (iii), the program above would have the first-best solution described in Proposition 1. With the constraints included we have the following characterization.

PROPOSITION 2. There is a unique (almost surely) second-best solution to program (12). It satisfies

(a) $w_1 < E(y_1|\alpha_1) < z_2(p_1)$,
(b) $w_2(s_1,y_1,s_2) = w_1 + \max\{0,z_2(p_2) - w_1\}$, if $\alpha_1(s_1) = 0$, $w_2(s_1,y_1,s_2) = w_1 + \max\{0,\max\{(b_1,z_2(p_2)\} - w_1\}$, if $\alpha_1(s_1) = 1$,
(c) $\int\Pi(\omega,\alpha_1(s_1),s_1)dN(s_1) = 0$,
(d) $\alpha_1(s_1) = 1$ if and only if $s_1 \geqslant \hat{s}_1(p_1)$, defined indirectly by $\hat{s}_1(p_1) + \mu(p_1) + \beta v(p_1) - \beta H(w_1) = 0$,
(e) $\alpha_2(s_1,y_1,s_2) = 1$ if and only if $s_2 \geqslant s_2^*(p_2)$, defined by (6).

Here b_1 and H are defined by

$$u(z_2(p_1)) = E[u(\max\{b_1,z_2(p_2))|a_1 = 1], \tag{13}$$

$$H(w_1) = [u(z_2(p_1)) - u'(w_1)z_2(p_1)]/u'(w_1) - E(u(w_2) - u'(w_1)w_2|\alpha_1(s_1) = 1)/u'(w_1). \tag{14}$$

The proof of this proposition is given in the Appendix. Here we shall give an intuitive explanation for the characterization. Before that, we note that (13) and (14) indeed make sense, because the distribution of $z_2(p_2)$, and hence also of w_2, depend only on the decision to invest and not on the specific value of s_1 (because of (1)).

Intuition of Proof. For the moment, ignore the problems associated with constraint (iii), and assume that the manager always reports his signal honestly. Whatever decision rules are used, the optimal wage schedule in that case will be as in (a)–(c) with $b_1 = 0$. This follows essentially from Harris and Holmstrom [1982]. The manager will be paid a constant wage, unless the quitting constraint becomes binding, in which case the firm will match the outside bid. The resulting option structure offers maximal feasible insurance to the manager. The firm, which stands to lose in the second period, gets its offsetting reward in the first period by paying a wage that is below the expected marginal product of the manager as stated in (a). In effect, the manager pays a premium in advance for insuring the risk of having his marginal product decrease below w_1 in the second period.

Next, given the structure of the wage schedule, ask what decision rule one should use (still ignoring *(iii)*). The answer is the rules described in (d)–(e), with $b_1 = 0$. Part (e) merely repeats that the first-best rule should be used in the second period. Part (d) is the more interesting one. We see that the first-period decision rule (expressed here in the form of a hurdle rate $\hat{s}_1(p_1)$) is different from first-best in which the total value of the firm is maximized. Because of the quitting constraint, the manager is forced to carry some residual risk and a premium has to be charged accordingly. This premium is captured by H, which measures the differential costs (due to imperfect income smoothing) between investing and not investing. We shall see shortly that H is positive.

Now return to the question of *(iii)* and the role of b_1. Start with the solution discussed above, where *(iii) is ignored. Check whether the manager is willing to report* s_1 honestly given that solution. If so, we have a solution to the full program. Indeed, one might think that this is the only relevant case because of the option structure of the wage, but that is not so. Since, $w_1 < z_2(p_1)$ in general, a sufficiently risk-averse manager would value the guaranteed wage increase $z_2(p_1) - w_1 > 0$ from no investment more than the uncertain increase $\max\{0, z_2(p_2) - w_1\}$ that comes with investing. If this is the case (and there are realizations of s_1 for which the firm would prefer investment), then the optimal way to induce a report from the manager is to add a bonus to his wage guarantee, raising it to b_1. (Note that this is quite different from adding an unconditional bonus to the wage.) The minimum required bonus is given by (13), which makes the manager just indifferent between investing and not. Such a bonus is the cheapest incentive device, because the value of money is highest at the lowest utility level. Also, there is no way of threatening the manager if he does not report, because he can quit and be assured $z_2(p_1)$ outside. It is a familiar phenomenon (see, for instance, Becker and Stigler [1974]) that bribing is the second-best alternative when punishments are infeasible.

Example. It may be useful to illustrate the characterization with an example, so consider the first case in Section II (with $s_1 = -1$ or $+1$). Assume in addition that $p_1 = \frac{1}{2}$ and that the manager's utility function is of the form $u(c) = -\exp(-rc)$, where r is the coefficient of absolute risk aversion.

Ignoring (iii) initially, we see that the optimal investment rule is to accept the project if $s_1 = +1$. Calculating the optimal wage schedule form (a)–(c) gives $w_1 = \frac{11}{24} \approx 0.46$ and $w_2 = \max\{w_1, \frac{5}{8}\}$, where $\frac{5}{8}$ is the second-period market value (z_2) of a successful manager. (Note that w_1 is indeed less than the manager's first-period marginal product, which is $\frac{1}{2}$.) To see whether the manager is in fact willing to invest given this wage schedule, evaluate (13). If $r = 1$, one finds that $b_1 \approx 0.38$. This is the minimum wage guarantee that the manager wants for the second period in order to go along with investment. Since $b_1 < w_1$, he is indeed happy to invest, and consequently we have a case where (iii) is not binding and a bonus is unnecessary.

Suppose, however, that the manager is more risk averse—for instance $r = 100$. Then $b_1 \approx 0.49$, which is higher than w_1 above. Thus, (iii) will be binding. Paying $b_1 > w_1$ in order to induce the manager to invest will make the firm earn less than zero expected profits. An adjustment in w_1 is therefore required. The value of w_1 that will restore zero profits is $w_1 \approx 0.44$. The complete solution then is pay $w_1 = 0.44$ in the first period, invest in the first period if $s_1 = +1$, and pay $w_2 = 0.49$ if the project fails and $w_2 = \frac{5}{8}$ if the project succeeds. Do not invest in the first period if $s_1 = -1$ and pay $w_2 = \frac{1}{2}$.[3]

C. Economic Implications

Having explained and illustrated the reasoning behind the second-best solution, we turn to the economic implications.

Wage Structure. The most notable feature of the wage policy is its option structure. Note, however, that it is not an option on the output y_1, but rather on the manager's human capital (his market value). In fact, little can be said in general about the connection between wage and output because the relationship between $z_2(p_2)$ and y_1 can be quite arbitrary. It all depends on the precise form of G and B (the distribution functions of ε_t for a good and a bad manager, respectively). G and B, or more precisely the likelihood ratio of the corresponding density functions g/b, determine what will be inferred about ability from $\varepsilon_1 = y_1 - s_1$, i.e.,

3. In this example, though not generally, the second-best solution always involves investing when $s_1 = +1$, irrespective of the manager's utility function. This can be seen by noting that the firm would be willing to guarantee a second-period wage of $\frac{1}{2}$ if an investment is undertaken when $s_1 = +1$ and still pay the manager $\frac{7}{16}$ as a first period wage (making expected profits zero). This is obviously better for the manager than never investing in the first period, since then he would earn zero in the first period and $\frac{1}{2}$ in the second.

how p_2 is updated. The likelihood ratio can be altered with significant effects on the distribution of the manager's market value (hence wages) without changing expected financial returns materially.[4]

The loose connection between the inference value and the financial value of performance, which is responsible for the ambiguous relationship between output and pay, is familiar from standard moral hazard models (see Hart and Holmstrom [1985] and Holmstrom and Milgrom [1985]). This ambiguity may appear disturbing from a positive point of view. But in our context it is not, because here the wage is actually tied in a natural way to the value of the firm (which, we note, bears no explicit relationship to output either).

In the simplest interpretation, the manager is the only employee of the firm (or the firm cannot function at all without him). Hence the value of the manager, $z_2(p_2)$, is also the value of the firm. It follows that the downward rigid wage schedule is precisely an option on the stock of the firm. In general, of course, the manager will not be as critical an input factor, but to the extent that his human capital is aligned with the total value of the firm, a stock option (of a fraction of the firm) will be a good proxy for the wage schedule in Proposition 2. This interpretation seems both realistic and important in view of the extensive use of stock options in executive compensation packages.[5]

Decision rule. As the presence of H in (d) indicates, the second-best decision rule differs from the first-best rule, because income is imperfectly smoothed. This is true both when an investment is undertaken and when it is not, because in the latter case the wage will rise above w_1 (as $w_1 < z_2(p_1)$). The function H then represents the difference in the premiums associated with no investment and investment. This is quite transparent if we approximate utility with a Taylor series expansion around w_1. We have

$$(15) \qquad H(w_1) \simeq (\tfrac{1}{2})R(w_1)E[(w_2 - w_1)^2|\alpha_1(s_1) = 1] - (\tfrac{1}{2})R(w_1)(z_2(p_1) - w_1)^2,$$

4. While it is possible to specify G and B so that $z_2(p_2)$ is, for instance, linear in y_1 (and hence w_2 is an option on y_1), there is no compelling economic rationale for such a restriction. The only natural restriction to place on the distributions is that the likelihood ratio g/b is increasing, because that assumption is equivalent to assuming that higher values of output signal higher ability (see Milgrom [1982]). In that case, of course, p_2 (hence w_2) will be increasing in y_1.

5. One problem with associating the wage option with an option of firm stock is that the latter can be traded (usually subject to exercising restrictions, however).

where $R(w_1)$ is the Arrow-Pratt measure of absolute risk aversion and $w_2 = \max\{w_1, b_1, z_2(p_2)\}$. Note that if the manager were risk neutral, H would be zero. If he is risk averse, it is easy to see that (15) is strictly positive because of the variance in w_2. This suggests the following.

PROPOSITION 3. Assume that the manager is strictly risk averse. Then

(a) $\hat{s}_1(p_1) > s_1^*(p_1)$; i.e., fewer investments are undertaken in second-best than first-best.

(b) $\hat{s}_1(p_1) > (<)\ s_2^*(p_1)$ if $v(p_1) < (>)\ H(w_1)$; i.e., either fewer or more investments may be undertaken when there is learning than when there is not, depending on the net benefits of learning.

Proof of Proposition 3. For part (a) we need to show that $H(w_1) > 0$. Define the function

$$g(x) \equiv u(x) - u'(w_1)x.$$

This function is strictly concave, since u is. It is increasing for $x < w_1$ and decreasing for $x \geqslant w_1$. By the definition of b_1 (equation (13)),

$$u(z_2(p_1)) \leqslant Eu(\max\{z_2(p_2), b_1\}),$$

where $z_2(p_2)$, of course, depends on the investment outcome. Since $w_2 = \max\{w_1, z_2(p_2), b_1\}$ if an investment is made,

$$u(z_2(p_1)) \leqslant Eu(w_2) < u(E(w_2)),$$

by Jensen's inequality. Therefore, $z_2(p_1) < E(w_2)$. Now, using the fact that g is concave and decreasing for $x \geqslant w_1$, we see it follows by a second application of Jensen's inequality that

$$g(z_2(p_1)) \geqslant g(E(w_2)) > E(g(w_2)),$$

which is the same as $H(w_1) > 0$. This proves (a).

Part (b) follows directly by comparing (6) and part (d) of Proposition 2.

Q.E.D.

Part (a) can be interpreted as saying that the cost of capital is higher in second-best than first-best. We cannot claim, however, that this matches the common observation that the internal cost of capital in firms is above the market cost because the comparison above refers to the total returns rather than the financial returns from investing. Since it is unlikely that firms include human capital returns in their investment figures, the empirically relevant comparison would be the one in part (b), where the cutoff value for total returns in second-best is compared with the cutoff value for financial returns alone, ignoring learning effects (recall that s_2^* is the hurdle rate if learning effects are absent).

The reason for the ambiguous comparison in part (b) deserves emphasis. The important insight is that there is a tradeoff in learning about ability. Learning is good to the extent that it improves future decision making (including matching the manager with tasks suitable for his ability). This positive effect is captured by $v(p_1)$. But learning is also costly because it imposes risk on the manager when insurance is incomplete. This negative effect is captured by $H(w_1)$. Whether fewer or more investments are undertaken when learning is present than when it is not depends on the net benefit $v - H$, which can have either sign.

Rationing. Capital is frequently rationed (rather than priced) in firms. Therefore, it is empirically relevant to ask whether rationing is consistent with our model. The answer is no—if there is a need to use a bonus. A bonus makes the manager indifferent between investing or not (see (13)), so in that case he need not be constrained, but merely told what to do.

However, if there is no need for a bonus, which is always the case for sufficiently low risk aversion, then the manager wants to invest independently of s_1. That is desirable neither from the firm's point of view, nor socially. It is dealt with precisely by rationing, embedded in the rule $\alpha_1(s_1)$. This was illustrated by the numerical example given earlier. If $r = 1$, the manager always prefers investment, but the second-best rule only approves projects with $s_1 = +1$.[6]

6. Note that with the ability to commit to an investment rule in advance, there is generally less rationing than the firm would like ex post (if the signal takes on a continuum of values). Since the manager derives positive value from investing (by the assumption of rationing), it must be that at s_1 values just below the hurdle rate $\hat{s}_1$, the firm derives negative value from investing (or else it would be Pareto improving to lower the hurdle rate). By continuity the firm is against investing just above the hurdle rate as well.

On the other hand, if the firm cannot commit to an investment rule in advance (a plausible scenario, given the subjective nature of proposal assessments), only investments that both sides prefer, will be undertaken. The solution to this problem has a downward rigid wage schedule, but the wage guarantee in the second period may be below w_1. Also, w_2 will generally be above $z_2(p_1)$ if no investment is undertaken. The changes are intended to make investments more appealing to the firm. Contrary to a claim we made earlier, there may still be investments even if the financial returns are negative, but there will be fewer investments than in the case the firm can commit to an investment rule in advance.

In fact, it is the ability to ration the manager via $\alpha_1(s_1)$ that makes the high degree of insurance in the second-best solution possible. One could not hope to achieve such a good solution by pricing capital, for instance. This option is feasible in our second-best program, but it is suboptimal, because the downward rigid wage structure would be ruined.

A word on the mode of rationing is in order. We have set up our model so that rationing is carried out by the superior; he receives and screens proposals much like in commonly observed centralized capital budgeting. Sometimes, however, rationing could also be implemented in a decentralized fashion in our setting. The superior could delegate the manager the decision to invest and try to control his incentives by ex post punishments instead (imposed if the manager were found to deviate from the agreed-upon rule, which is something observable by our assumptions). The maximal punishment is to pay the manager his market wage $z_2(p_2)$, rather than offering any insurance. If the manager is sufficiently risk averse, this threat will work. Specifically, if $u(z_2(p_1))$ is higher than $E[u(z_2(p_2))]$, the manager will not deviate.

There are two reasons why ex post punishments of this kind constitute a less effective mode of rationing than ex ante screening. One is that it will not work if the manager is sufficiently close to being risk neutral.[7] He will invest even without insurance. The other is that if we alter the model slightly (and realistically) so that the superior cannot observe ex post what the manager knew at the time of investing (because the manager has additional information ex post, which he can use to conceal a wrong decision), then controlling his incentives will necessarily entail punishing him erroneously at times. This is suboptimal relative to offering downside insurance and screening ex ante.[8]

We conclude that the desire to know the circumstances under which a manager invests, so as to be able to evaluate and insure him more efficiently, favors centralized capital budgeting as the desired mode of rationing. This provides a new and interesting rationale for centralized control of funds inside firms.

7. Interestingly, this shows that ex post control is not always equivalent to ex ante control as in customary incentive models.

8. A careful analysis of this case would assume that s_1, while observable, cannot be used in a contract for reasons explained in footnote 6. Only the decision to invest or not could enter the contract. Our claim that ex ante rationing is generally better holds up for this case.

IV. Qualifications and Extensions

We shall briefly discuss some robustness issues. Our results survive substantial extensions on the technological side, but they are generally vulnerable to changes in informational assumptions.

A. General Technology

An important insight from Proposition 2 is that the second-best solution is sensitive to much less information than was specified in the primitive data. Closer scrutiny reveals that the only information that has bearing on the optimal design is the distribution of signals and the mapping from actions and signals into a joint distribution over financial and human capital returns. The detailed knowledge about the learning process and the technology is inessential. More precisely, we could have started with a reduced-form model, specifying directly joint distributions $F(y_1,z_2|a_1,s_1)$ and a signal distribution N. As long as N is independent of the manager's ability, the preceding results on second-best remain intact (with the one exception that in general the bonus (b_1) and the risk premium (H) may be contingent on the signal value s_1; see the earlier version of our paper).

It follows that there is no need to constrain oneself to the $0-1$ investment case, nor to investment problems alone; the same wage structure and the same principles behind second-best decision rules would apply in any decision setting (where decisions can be observed). In particular, second-best decision rules would be distorted due to the undiversified part of the human capital risk in a way that reflects the costs and benefits of learning that we identified before: learning enhances human capital on average, but it also increases the risk burden.

Thus, we could have looked at investment scale or the degree of correlation with market risk that the firm would prefer in second-best. If the benefits of increased learning exceeded the costs, the firm would prefer to overinvest, respectively, position itself closer to the market, than if financial returns alone were considered. (Relative to first-best, however, there would be both underinvestment and less correlation.)

As an example of an interesting decision problem outside the investment framework, we mention task assignments. The interaction of contracts and career paths could be studied in a model that fits the reduced-form paradigm sketched above. Waldman [1985] has started to analyze this case, which seems rich in implications for organizational design (see also the important paper by Prescott and Visshher [1980]).[9]

Another easy technological extension is to introduce firm-specific capital by allowing firms to be heterogeneous. Now there would be three streams of capital to keep track of: one financial, one general human (equal to the manager's market value), and one firm-specific human. In a reduced-form model analogous to the one sketched above, the joint distribution over all three streams (conditional on signals and actions) would be specified. In the optimal solution, wages would again be downward rigid and bid up only in response to external offers. (In some cases severance would be paid to induce efficient quits.) With regard to decisions, it is clear that they would be biased in favor of firm-specific rather than general human capital returns. As in standard human capital theory the bias occurs because firms cannot appropriate the returns from investments in general human capital (or more precisely, it would be excessively costly to appropriate them fully).

Finally, neither is the two-period structure an essential restriction, nor is the assumption that actions influence the outcome in only a single period (see Ricart i Costa [1984a]). In fact, extending the model to include many periods and long-term returns brings up an interesting issue about investment criteria. Received financial theory states that net present value should be the sole criterion for choosing between investments, yet firms often seem to use additional measures, in particular, the payback criterion. Narayanan [1983] has offered as an explanation that managers prefer investments that pay off quickly (other things equal) because that enhances their human capital value faster. Looking at the issue as an optimal contracting problem, as here, we see that the ideal criterion is still net present value, but of *total* capital reduced by a premium for human capital risk. But since human capital returns are hard to quantify in reality, it may be rational to use the payback criterion as a proxy for the speed and value of learning. Note, however, that a premium for quick returns is

9. Sociologists (in particular, Jacobs [1981]) have derived some interesting hypotheses about the relationship between the nature of learning in different occupations (the likelihood of being successful versus failing) and the characteristics of organizational structure. These hypotheses could readily be explored rigorously in models of task assignment as discussed here. We are grateful to James Baron for alerting us to this connection.

only consistent with the view that benefits of learning exceed the costs.

B. Different Information Structures

Our assumptions concerning the information structure were carefully designed to maintain symmetry in beliefs between the three relevant parties: the manager, the owner, and the market. Minor changes in the information structure would give rise to asymmetries in information and lead to a substantially more complicated analysis because of adverse selection and moral hazard problems. Typically, the characteristics of the optimal contract would be altered.

As an example, suppose that ability influences the quality of proposals, i.e. the distribution of the signal depends on ability. Then the mere reception of the signal s_t will inform the manager of something about his ability. If he does not propose the project for investment, he will remain better informed about his ability, and the information symmetry is destroyed. More directly, of course, the same will be true if the signal cannot be truthfully communicated so that the manager's basis for judging performance is better than the firm's upon investing and observing the output.

The implications of informational asymmetries between the manager and the firm is that contracts will be designed partly to reduce the information gap via self-selection or signaling. Such contracts will certainly not have downward rigid wages. Also, the determinants for the implemented decision rules are bound to be less transparent because of the interference caused by signaling. Altogether, the problem is a difficult one to analyze, but a promising start has been made in Ricart i Costa [1984c].

Similar comments apply to the case where there are no signals, but the manager controls some unobservable actions (say production decisions). Now the asymmetry in information concerns actions rather than ability. An analysis of this case would proceed much like standard moral hazard models and leads again to much vaguer predictions about wages and investment rules than here.

One tractable scenario, which adds to the realism of our model, puts the asymmetry in information between the market and the firm. This is plausible, because the market is hardly able to observe managerial undertakings at the same level of detail as the firm. The problem then is to decide what the market value of the manager is. A solution has been presented in Ricart i Costa [1984b] (building on work by Waldman [1984]). The solution is of interest in its own right, but for our purposes, the relevant fact is that given the derived value of the manager, the analysis proceeds pretty much as in the present paper with similar conclusions concerning decision rules and wage contracts.

Another realistic and tractable information scenario is that firms cannot commit to investment rules in advance. This case was discussed in footnote 6, where we noted that the wage contract would change slightly (wages could go down in the second period).

C. Borrowing and Saving

Giving the manager an option to save would not alter the conclusions in the basic model, because the wage contract is already implicitly saving as much as the manager desires. A borrowing option would affect the outcome. If borrowing can be contracted for, then borrowing would be used to place a bond with the firm, which would reduce the manager's incentives to quit and in effect act as a mobility cost. The implication is that the market value would have to exceed the present wage guarantee by more than the mobility cost before the wage is bid up. This is favorable for both sides ex ante, because it allows more insurance. But to the extent that bonding is incomplete, the second-best contract will retain the features of our solution.

It is more difficult to say what happens if borrowing cannot be observed (except that borrowing will be used). We merely note that if borrowing is entirely unconstrained so that the manager can essentially self-insure himself (this requires an infinite horizon), then a buyout of the firm by the manager would lead to an efficient solution.

V. Concluding Remarks

Our purpose has been to advertise career concerns as an alternative reason for managerial incentive problems by offering a formal model of reputation based on learning. We feel that reputation concerns may well be more central than effort aversion in explaining incongruities in risk preferences between managers and owners or superiors. Our argument allows the manager to be industrious and turns instead on legal constraints on involuntary servitude and imperfect capital markets, which limit the degree of income smoothing. The approach imposes discipline by assuming that managers only value their lifetime income stream; a concern for growth or other dimensions of performance become endogenous to the model.

Ultimately, of course, the problem of identifying the most relevant managerial incentive costs is an empirical one. While it is certainly too early to make firm judgments at this stage, we do see our results as modestly promising. The reason is not so much that our results match particular stylized facts; discrepancies with reality can easily be spotted. The promise lies simply in the fact that we got predictions on relevant variables, such as investment decisions, with relative ease. By comparison, effort-based theories have been hard to work with and generally quite weak in generating predictions on observable quantities (see Hart and Holmstrom [1985]).

The learning hypothesis has one general, but not useless, implication that deserves mentioning in this connection. The need to harmonize preferences between superiors and managers should be strongest in areas where ability (rather than financial stakes or effort) plays a significant role. Arduous but routine decision making should be of little incentive concern no matter what the financial scope of the actions are. On the other hand, (strategic) investment decisions, which are likely to involve sizable human capital risks and opportunities for the manager, need incentive alignment and control. We offered this as a partial explanation for the detailed capital budgeting procedures that firms commonly employ. Indeed, rationing of capital rather than decentralized pricing of capital—a prominent feature of real world investment planning—was a typical outcome in our contracting solution.

There are many extensions of our model that seem useful and tractable to pursue. Looking at multiperiod models in order to generate discriminating time-series predictions would be valuable (see Murphy [1985] for a preliminary account). High on the agenda would also be a study of interfirm managerial competition for capital and customers. What implications does learning have for the allocation of resources across firms? What kinds of projects will be undertaken by managers who compete for capital? Will "surival of the fittest" drive behavior toward efficient investments and optimal matching of talent and technological opportunities? As Knight [1965] and Hayek [1945] have emphasized, understanding this kind of competition is essential for a proper appreciation of our free enterprise system.[10]

APPENDIX: PROOF OF PROPOSITION 2.

It is easy to see that there is a unique pair (ω,α) that satisfies the characterization. Start with any w_1, find the corresponding decision rules obeying (d) and (e), and evaluate firm profits as defined in (c), using (b). Note that all components of the contract are uniquely determined in this chain once w_1 is fixed; in other words, w_1 parameterizes the contracts satisfying (b), (d), and (e). The mapping from w_1 to firm profits is continuous and strictly monotone in w_1; moreover, profits are negative for sufficiently large w_1 and positive for sufficiently small w_1. Hence, there is a unique value w_1 for which profits are zero; that is, (c) is satisfied. Part (a) follows because the firm can lose only in the second period and breaks even on average.

Let (ω',α') be the unique solution to (b)–(e). Consider the Lagrangian problem:

$$\text{(A.1)}\quad \max_{\delta} L = \int\{U(\omega,\alpha_1(s_1),s_1) + \lambda\Pi(\omega,\alpha_1(s_1),s_1)\}dN(s_1),$$

subject to (ii) and (iii). Take $\lambda = u'(w_1') > 0$ in L and keep α fixed for the moment. Maximizing L over the wage part of the contract (ω), it is readily seen that the unique solution (because of concavity) is $w_1 = w_1'$ and w_2 as described by (b); (w_2 is not necessarily equal to w_2', because α may be different from α'). Given this wage schedule, consider the decision rule α in (A.1). Note that the option-like wage schedule interacts with the decision rule α only through the (possible) need to have constraint (iii) met via a bonus b_1; in particular, $w_1 = w_1'$, independently of α. It follows that the decision to invest is determined by the rule in (d), which compares point-wise the value of investing with the value of not investing, taking into account that constraint (iii) is met by adding a bonus (if necessary) when $\alpha(s_1) = 1$. Thus, the solution to $(A - 1)$ satisfies (b), (d), and (e) with $w_1 = w_1'$; hence it must be equal to

10. Given that firms have many employees, a few additional issues of importance need to be mentioned here. One is the ability of managers to pick out suitable subordinates to help in collecting information and running projects (Knight considered this the central input of management). The other is the question of how ability information is updated when there is team production. The hierarchical structure of firms may be related to a resolution of this problem. Finally, as Kenneth Arrow pointed out to us, the degree to which responsibility for decisions is shared among several managers, has an impact on the willingness to take risks. Arrow suggested that Japanese firms, for instance, might have been able to take more risks (with higher expected payoffs) than U. S. firms, because of the way responsibility is shared in their managerial culture. This may partly explain their rapid growth.

(ω',α') (since w_1 parameterizes the contracts satisfying (b), (d), and (e)). Therefore, (c) holds and by duality (ω',α') also solves (12).

Our argument also makes clear that there could not be any other solutions to (12), because all of them would have to have the wage structure described by (b).

Q.E.D.

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