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SHORT-TERMISM AS OPTIMAL EXPERIMENTATION POLICY

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Abstract

Models of managerial short-termism rely on a number of assumption, such as limited availability of capital, fixed compensation schemes and an additive impact of managerial ability on revenue. We discuss the role of these assumption in generating short-termism.

We show that when managerial ability ha a multiplicative impact on revenue then the first best investment policy may require the implementation of short-term projects with negative NPV in order to generate information on managerial ability that can be exploited in later periods. We also show that, when the firm is free to design the compensation scheme, the first best is attained even if only short-term contracts are allowed. Short-termism is therefore the result of an optimal experimentation policy rather than the consequence of managerial misbehavior.

Keywords: Managerial compensation, Corporate investment policy

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1 Introduction

Do managers overinvest in short-term projects and under-invest in long-term projects? And if so, why? The theme of managerial misbehavior has attracted much attention, both in the popular press and in the academic literature. An argument which has enjoyed some degree of popularity is that a) Managers' horizon is indeed too short and b) this happens because of the emphasis put on short-term results in evaluating managerial performance. A parallel argument has been that economic systems in which capital markets play a lesser role in corporate control turn out to be more efficient and long-term oriented.

Theoretical models have looked at reputational or informational factors as the source of short-termism. How a concern for managerial reputation may lead to short-termism has been first analyzed by Narayanan (1985). In his model each manager is endowed with an unobserved level of ability, and the market uses past performance to assess the ability of managers. Managers have the possibility of taking two mutually exclusive actions, which can be thought of as undertaking a short-term or a long-term project. Narayanan shows that when such decision is unobservable, the managers may undertake the short-run project even in cases in which the NPV of the long-term project is higher.

Bebchuk and Stole (1993) have shown that, depending on whether the amount invested or the project's return are observable by investors, managerial horizon can be either too short or too long. Their model take as given both the amount of capital available to the managers and their compensation scheme.

Narayanan (1996) studies the impact of payments in cash or stock over managerial horizon. While he considers the problem of designing the optimal compensation scheme, he makes the implicit assumption that long-term projects can only be financed using short-term cash flow. He shows that in this case inefficient under-investment in long-term projects is possible. Other models showing how the presence of asymmetric information may cause a managerial bias towards short-term projects have been proposed by Stein (1988, 1989). In Stein (1989) it is assumed that managers can boost current earnings by 'borrowing' towards future earnings at an unfavorable rate. This allows for financing short-term projects by borrowing money in capital markets at a cost greater the project's return. The model takes as given the managerial utility function, and in particular it does not allow for changing compensation schemes in order to eliminate the short-term bias.

Furthermore, Stein does not consider managerial reputation concerns and only analyzes the steady state.

In general, papers analyzing the issue of managerial horizon have adopted the following set of assumptions. First, the amount of capital available to managers is taken as given, and it is investigated whether managers allocate efficiently the capital amount between short and long-term projects. This assumption may be adequate if the firm is severely credit constrained, but there are many relevant situations in which this is clearly not the case. It is therefore interesting to analyze what happens when managers have the possibility of raising money in capital markets to finance new projects.

Second, the managerial compensation scheme is taken as given. While it may be unrealistic to assume that complete contracts are possible, this is obviously a disturbing assumption.

Third, it is assumed (following the tradition of Narayanan (1985) and Holmström and Ricart i Costa (1986)) that managerial ability enters additively the revenue function, so that its effect on the firm's performance is independent of the project's size. Again, while this assumption may be a sensible one in some circumstances, it is interesting to study an alternative formulation in which there is an interplay between managerial ability and projects size. We will consider the simplest functional form with such property, making total revenue depending on the product between managerial ability and project size.

We find out that the possibility of external financing is basically irrelevant in generating the short-termist result, while short-termism disappears when compensation schemes can be optimally designed. Furthermore, we show that when ability interacts with revenue then short-term project have an information value, which is absent in the additive case. This implies that the first best investment policy may precribe the implementation of short-term projects with negative NPV, since the financial loss is compensated by the value of the information generated by the project. Furthermore, even in the case in which only short-term contracts are allowed, the first-best investment policy can be implemented by appropriately choosing the managerial compenation schemes.

The result suggests an alternative explanation of why short-termism may be observed. An external observer who looks only at the financial return of the investment projects will observe that on average short-term projects have a lower return than long-term ones. This may lead to the conclusion that managers are wrongly implementing 'too many' short-term projects. We suggest an alternative explanation of why this may occur. Profit-maximizing managers may choose short-term projects with a lower return because they generate information which helps the managers to increase the value of the firm in later periods. Since the result of short-term projects is observed quickly, the information generated is particularly valuable. In other words, short-termism is not the result of managerial misbehavior, but it i the consequence of an optimal experimentation policy.

The rest of the paper is organized as follows. Section 2 discusses what happens in previous models of short-termism when the possibility of raising external capital in capital markets in order to finance investment projects is introduced. We also observe in this section that the possibility of optimally designing managerial compensation schemes eliminates short-termism. Section 3 introduces an alternative model in which managerial ability interacts with projects size. We analyze the first best policy, and show that it leads to the implementation of negative NPV short-term projects. In section 4 we analyze what happens when managers can be offered contracts depending on performance. We show that the first best is attained even if attention is restricted to short-term contracts. At last, section 5 contains the conclusions.

2 External Financing

Models discussing the issue of managerial horizon can be divided in two classes. In the first class managers are characterized by an unknown (both to the manager and to the market) ability parameter. Their future wage depends on the estimate of such parameter. Since current firm's performance is used to update the estimate of managerial ability, short-termism results from an attempt by managers to improve market's perception of their ability by boosting short-term performance. Narayanan (1985) was the first to make this argument.

The second class of models takes as given the managerial utility function, assuming that a positive weight is put on the current stock price. Managers try to increase the current stock price by artificially inflating short-term results at the expense of long-term performance. Models in this tradition include Stein (1989) and Bebchuk and Stole (1993).

In this section we want to see what happens when the possibility of raising funds in capital markets is introduced. In order to avoid a time-consuming review of the whole literature we consider just two papers, representative of the two classes of models discussed above. Narayanan (1985) will be used as the basis for the discussion of models based on managerial reputation, while Bebchuk and Stole (1993) will be used to discuss models of signaling.

2.1 Reputational Models

In the Narayanan model a manager with ability γ lives T periods. For simplicity, let $T = 2$. At the beginning of the first period γ is normally distributed $N(\gamma_0, \sigma_\gamma)$. The output of a firm employing a manager of ability γ at time t is given by:

$$y_t = \gamma + h_t + \epsilon_t$$

where h_t is the result of some investment decision and ϵ_t is a stochastic term which is normally distributed $N(0, \sigma_\epsilon)$ and independent of γ. The interest rate is zero and everybody is risk neutral.

At time 1, the manager can take two mutually exclusive actions. The first one is the implementation of a short-term project yielding $k < 1$ at the end of period 1, while the second is the implementation of a long-term project yielding 1 at the end of period 2. Both projects are worthy, but the long-term project is better. Since the projects are mutually exclusive, the action that maximizes the value of the firm is the implementation of the long-term project. The labor market is competitive and only one-period contracts are available. The implication is that at the beginning of each period the manager is paid a wage equal to the expected value of its ability. The market cannot observe whether the manager implements the short-term or the long-term project. Under this circumstance, it is easy to see that the only equilibrium is that the manager implements the short-term project, in an attempt to increase y_1 and the market anticipates this, thus updating correctly the distribution of γ.

The result heavily relies on the fact that the implementation of the short-term and the long-term project are mutually exclusive. One possible interpretation is that there is a fixed amount of funds which can be invested in one or the other project. The market can observe the total amount of funds invested, but it cannot observe whether the funds are invested in long-term or short term projects. Under this interpretation it is clear that short-termism disappears when managers can raise funds in capital markets, as long as there is a maximum amount that can be invested in each project.

To see this, consider the following reformulation of the model. There are two projects, one short-term and one long term. Both projects require a fixed investment I. The short term project delivers $I + k$ at the end of the first period, while the long term project yields $I+1$ at the end of the second period. Funds can be obtained in competitive capital markets at zero interest rate. The equilibrium in this case is that the manager borrows an amount $2I$ at the beginning of period 1 and invests in both projects. The market observes the amount borrowed and correctly infers that both projects are implemented. Therefore, short-termism disappears and efficiency is attained.

However, we should not jump to the conclusion that short-termism does not survive when capital markets can be used to finance investment projects. Such result depends on the assumption that only a fixed and known amount of funds could be invested in each class of projects. Consider the following natural generalization of the model. At time 0 the manager can invest and amount K^s in short-term projects and K^l in long-term projects. An investment K^s yields $S(K^s)$ at the end of period 1, while an investment K^l yields $L\left(K^l\right)$ at the end of period 2. Assume that S and L are strictly increasing and concave functions such that $S(0)=L(0)=0$. Given a zero interest rate the efficient amount of investment maximizes:

$$V\left(K^s,K^l\right)=S(K^s)-K^s+L\left(K^l\right)-K^l$$

Let $\overline{K}^s$ and $\overline{K}^l$ be the efficient levels of investment in the short and in the long term project respectively, and define $\overline{K}=\overline{K}^s+\overline{K}^l$ as the total amount needed for efficient investment at time zero. It is *not* an equilibrium that the manager borrows $\overline{K}$ at time zero and then invests the quantities $\overline{K}^s$ and $\overline{K}^l$ in the short and long term projects. The reason is exactly the same as in the original Narayanan model: Since the market cannot observe directly how much of current performance is due to ability and how much to short-term investment, for any given expectation of K^{s*} the manager wants to maximize the amount spent in the short term projects. Therefore, the manager will put all available capital in the short-term projects and zero in the long term project[1].

It therefore appears that in reputational models the presence of short-termism does not depend on how the funds for investment are obtained (retained profits or capital markets). If the market cannot observe how

[1]This extreme results depends on the assumption that the manager only lives two period, so that the second period performance has no influence on the future wage. If the manager were to live $T>2$ periods the effect would be less extreme, but underinvestment in the long-term project and overinvestment in the short-term projects would still be present.

much capital is devoted to the short-term project then a short-term bias will be present whenever the marginal return from short-term investment is positive[2]. The result holds *a fortiori* when the market cannot observe the total amount of investment, and not only its division between short and long term projects.

2.2 Signalling Models

In the Bebchuk and Stole (1993) model a manager is given a fixed amount of capital K. The manager decides the quantity K^s to be invested in the short-term project, with the residual quantity K^l to be invested in the long-term project. Such quantities yield an amount $\tilde{S} = S(K^s) + \epsilon$ at time 1, with ϵ a white noise, and $L\left(K^l\right)$ at time 2. The world lasts two periods, the interest rate is zero and everybody is risk-neutral. At the end of period 1 investors observe $\tilde{S}$, and they may try to use such signal to infer the amount invested in the long-term project. The value of the firm at the end of the first period is therefore:

$$V_1 = \tilde{S} + E\left[\tilde{L}\middle|\tilde{S}\right]$$

where the notation $\tilde{L}$ is used to indicate that investors may be uncertain over the amount of capital put in the long term project (and consequently on its outcome L).

In the second period the outcome of the long-term project is also observed, so that the value of the firm becomes:

$$V_2 = \tilde{S} + L$$

Managers are assumed to maximize the following utility function:

$$U = \alpha_0 + \alpha_1 V_1 + \alpha_2 V_2$$

with $\alpha_1 > 0$ and $\alpha_2 > 0$. One way to interpret this assumption is that managers are risk-neutral and their compensation depends linearly on the stock price in both periods. Managers maximize their expected utility, so that they solve:

$$\max_{K^s} \quad \alpha_1\left[S(K^s) + E\left(\tilde{L}\middle|\tilde{S}\right)\right] + \alpha_2\left[S(K^s) + L(K - K^s)\right] \qquad (1)$$

Assuming that ϵ has a sufficiently wide range, in a pure strategy Nash equilibrium the investors have fixed expectations on K^s which do not change

[2]This condition is violated in the case of investment projects of fixed size.

upon observing $\tilde{S}$. This implies that $E\left(\tilde{L}\middle|\tilde{S}\right)$ does not depend on K^s. It is now easy to check that, whenever $\alpha_1 > 0$, the first order conditions for utility maximization do not coincide with the condition for efficient investment (see Bebchuk and Stole (1993) for details). The consequence is overinvestment in the short-term project and underinvestment in the long-term project.

Consider now the case in which projects can be financed raising funds in capital markets. Suppose again that the interest rate is zero and that the market observes the total amount $K^s + K^l = \overline{K}$ borrowed on capital markets[3].

When investors observe an amount of capital $\overline{K}$ raised in capital markets they expect that the amounts K^s, K^l allocated to short and long term projects will be obtained solving problem (1). Let $K^l\left(\overline{K}\right)$ be the amount invested in the long term project when $\overline{K}$ is available, so that $K^s\left(\overline{K}\right) = \overline{K} - K^l\left(\overline{K}\right)$. It turns out that $K^l\left(\overline{K}\right)$ is obtained solving the first order condition:

$$S'\left(\overline{K} - K^l\right) = \frac{\alpha_2}{\alpha_1 + \alpha_2} L'\left(K^l\right) \tag{2}$$

How much capital will the manager raise? Given our assumptions on S and L, the function $K^l\left(\overline{K}\right)$ is differentiable. Furthermore, we have:

$$\frac{\partial E\left(\tilde{L}\middle|\tilde{S}\right)}{\partial \overline{K}} = L'\left(K^l\left(\overline{K}\right)\right)\frac{dK^l}{d\overline{K}}$$

Then the manager solves:

$$\max_{\overline{K}} \quad \alpha_1\left[S\left(\overline{K} - K^s\left(\overline{K}\right)\right) + E\left(\tilde{L}\middle|\tilde{S}, \overline{K}\right) - \overline{K}\right] + \alpha_2\left[S\left(\overline{K} - K^s\left(\overline{K}\right)\right) + L\left(K^l\left(\overline{K}\right)\right) - \overline{K}\right]$$

The first order condition is:

$$\left(\alpha_1 + \alpha_2\right)\left(S'\left(\overline{K} - K^l\right)\left(1 - \frac{dK^l}{d\overline{K}}\right) + L'\left(K^l\right)\frac{dK^l}{d\overline{K}} - 1\right) = 0$$

Using (2) we obtain:

$$L'\left(K^l\right) = \frac{\alpha_1 + \alpha_2}{\alpha_2 + \alpha_1\frac{dK^l}{d\overline{K}}} \tag{3}$$

[3]Given the greater degree of transparency of external capital markets this appears a reasonable hypothesis. Furthermore, we are trying to be as close as possible to the original Bebchuk-Stole model, where the amount of capital K available to the firm is known.

Furthermore, differentiating both sides of (2) with repect to $\overline{K}$ we obtain:

$$\frac{dK^l}{d\overline{K}} = \frac{S''\left(\overline{K} - K^l\right)}{S''\left(\overline{K} - K^l\right) + \frac{\alpha_2}{\alpha_1 + \alpha_2} L''\left(K^l\right)}$$

so that $\frac{dK^l}{d\overline{K}} \in (0, 1)$. We conclude that $L'\left(K^l\right) > 1$and underinvestment in the long-term project occurs. Analogously, combining (2) and (3) we have:

$$S'\left(K^s\right) = \frac{\alpha_2}{\alpha_1 \frac{dK^l}{d\overline{K}} + \alpha_2} \tag{4}$$

Therefore $S'\left(K^s\right) < 1$ and overinvestment occurs, as in the case in which funds were internally generated.

The conclusion is that in signalling models of short-termism, allowing for external financing of investment project generates the same results as in the case in which funds are internally generated.

2.3 Optimal Compensation Schemes

Models of short-termism invariably take the compensation scheme for managers as given. It is easy to see that both in Narayanan (1985) and in Bebchuk and Stole (1993), when the compensation scheme can be changed in order to provide incentives for correct investment decision then the first best is achieved. This holds both with and without the possibility of external financing. In Bebchuck and Stole it is sufficient to set $\alpha_1 = 0$. In Naranyan, it is obvious that the problem can be solved if the manager can sign a two-period contract and commit to stay in the firm. However, even if no such commitment it is possible to induce efficient investment using only short-term contract. The trick in this case is to make the compensation of young managers to depend *negatively* on first period performance. This negative dependence counterbalances the positive effect on reputation induced by current performance. We will further discuss.the issue of the optimal compensation scheme in the following sections.

3 Ability Interacts with Project Size

As previouly oberved, models of short-termism based on repuational reasons usually assume that managerial ability has an additive impact on the firm's revenue, thus implying that there is no interaction between managerial ability and the size of the investment projects. We want to explore what happens when we introduce the alternative assumption that the effect of managerial ability on the revenue of the firm is larger when invetment projects are 'bigger'.

We consider the following model. Each manager lives 2 periods and is characterized by an ability parameter γ, drawn from a distribution with mean γ_0 and variance σ_γ^2. Ability is not observable by anybody, including managers. Managers are risk neutral, there interest rate is zero and no moral hazard problem exists.

At the beginning of each period t there are two projects. The first project is a short-term one, and produces a return $(\gamma + \theta^s) R(K_t^s)$ at the end of period t, where θ^s is a parameter, R is the return function and K_t^s is the amount of capital invested in the short-term project. The other is a long-term one, producing a return $\left(\gamma + \theta^l\right) R\left(K_t^l\right)$ at the end of period $t+1$, where θ^l is a parameter, and K_t^l is the amount of capital invested in the long-term project. The two parameters $\left(\theta^s, \theta^l\right)$ are known to everybody. The manager can finance projects borrowing money on the capital market. The amount of capital obtained by the managers in each period is observed, but the division of capital between short-term and long-term projects is not.

The following assumption will be maintained on R.

Assumption 1 *The function R is positive, twice differentiable, $R(0) = 0$, $R'(K) > 0$ for each K, $R''(K) < 0$ for each K, $R'(0) < +\infty$.*

The total revenue of the firm at any time t is the result of managerial ability, past investments and a random shock:

$$y_t = (\gamma + \theta^s) R(K_t^s) + \left(\gamma + \theta^l\right) R\left(K_{t-1}^l\right) + \epsilon_t$$

where ϵ_t is a white noise. At each period t capital can be raised paying an interest $r = 0$.

Assumption 2 *The variable γ and ϵ_t are independent and normally distributed, with $\gamma \sim N\left(\gamma_0, \sigma_\gamma^2\right)$, and $\epsilon_t \sim N\left(0, \sigma_\epsilon^2\right)$.*

For future reference, define $\tau_\gamma = \frac{1}{\sigma_\gamma^2}$ and $\tau_\epsilon = \frac{1}{\sigma_\epsilon^2}$.

3.1 A Simple Example

We start analyzing a very simple model which provides intuition for the main results, and then proceed to generalize it.

We assume that projects have fixed size $\bar{K}$. This means that $F(K) = K$ and the amount of capital that can be chosen is fixed at level $\bar{K}$. Furthermore, $1 < \gamma_0 + \theta^s < 1$ and $\gamma_0 + \theta^l > 1$.

We want to find the first best investment policy. Since the interest rate is zero, it is clear that the long-term project has a positive NPV and should therefore be implemented. The short-term project has a negative NPV, but this does not imply that it should not be implemented. The reason is that, while the expected financial rate of return is less than the cost of capital, the performance on the short-term project generates additional information on managerial ability. This superior information can then be exploited in period 2 to decide the investment policy. If, for example, as a consequence of a strong performance in the short-term project the expected value of managerial ability is revised to $\gamma_1 > \gamma_0$, then it may be the case that investment in the short-term project in period 2 becomes optimal. Analogously, a downward revision may discourage investment in the long-term project in the second period. Let us define $\bar{\gamma}$ and $\underline{\gamma}$ as the solutions to:

$$\bar{\gamma} = 1 - \theta^s \qquad \underline{\gamma} = 1 - \theta^l$$

Thus, $\bar{\gamma}$ is the lowest expected value of γ such that the short-term project in the second period becomes profitable, and $\underline{\gamma}$ is the lowest expected value of γ such that the long-term project in the second period becomes unprofitable. Notice that $\bar{\gamma} > \gamma_0 > \underline{\gamma}$. For a given level of investment $\bar{K}$ in the short run project define:

$$p_1 = \frac{y_1}{\bar{K}} - \theta^s \qquad v_1 = \frac{\epsilon_1}{\bar{K}}$$

The variable p_1 is observable, since y_1 is observable and the other parameters are known. Furthermore:

$$p_1 = \gamma + v_1$$

where γ and v_1 are normal and independent random variables, and the precision of v_1 is $\bar{K}^2\tau_\epsilon$. Therefore, when the short-term project is implemented at time 1, the revised expectation is given by:

$$\gamma_1 = E(\gamma|\, p_1) = \frac{\tau_\gamma}{\tau_\gamma + \bar{K}^2\tau_\epsilon}\gamma_0 + \frac{\bar{K}^2\tau_\epsilon}{\tau_\gamma + \bar{K}^2\tau_\epsilon}p_1$$

The precision of the revised expectation over γ is given by:

$$\tau_1 = \tau_\gamma + \bar{K}^2 \tau_\epsilon$$

Let us now define:

$$\begin{aligned} \pi^s(\gamma) &= ((\gamma + \theta^s) - 1)\bar{K} \\ \pi^l(\gamma) &= \left(\left(\gamma + \theta^l\right) - 1\right)\bar{K} \end{aligned} \tag{5}$$

Notice that, if γ^m is the expected value of γ then $E\left(\pi^i(\gamma)\right) = \pi^i(\gamma^m)$, with $i = s, l$. Let us now define $V\left(\bar{K}\right)$ as the value of the firm when the short term project is implemented in period 1. Then:

$$\begin{aligned} V\left(\bar{K}\right) &= \pi^s(\gamma_0) + \pi^l(\gamma_0) + E^1\left[\max\left\{0, \pi^s(\gamma_1)\right\}\right] + & (6) \\ & E^1\left[\max\left\{0, \pi^l(\gamma_1)\right\}\right] & (7) \end{aligned}$$

where the expectation E^1 is taken with respect to γ_1 (the expected value of γ conditional to p_1 when the short-term project in implemented in period 1). The first term is the expected value of a short term project at time 1, and given our assumptions it will be negative. The second term is the expected value of the long term project in the first period, a positive term. The third term is the value of the short term project in the second period. The project will be implemented only if $\gamma_1 \geq \bar{\gamma}$, i.e. if the signal on managerial ability at time 1 is sufficiently high. The fourth term is the value of the long-term project in the second period. The project will be implemented unless $\gamma_1 \leq \underline{\gamma}$, i.e. unless the signal on managerial ability at time 1 is sufficiently low.

When the short-term project is not implemented in the first period, then it is not implemented in the second period as well. The long-term project is instead implemented in both periods with probability 1. If we define $V(0)$ the value of the firm when the first period project is not implemented we have:

$$V(0) = \pi^l(\gamma_0) + \pi^l(\gamma_0)$$

Since $E^1\left(\pi^l(\gamma_1)\right) = \pi^l(\gamma_0)$ we can write:

$$\begin{aligned} V\left(\bar{K}\right) - V(0) &= \pi^s(\gamma_0) + E^1\left[\max\left\{0, \pi^s(\gamma_1)\right\}\right] + \\ & E\left[\max\left\{0, \pi^l(\gamma_1)\right\} - \pi^l(\gamma_1)\right] \end{aligned} \tag{8}$$

Using the definitions in (5) this becomes:

$$\begin{aligned} V\left(\bar{K}\right) - V(0) &= \pi^s(\gamma_0) + \bar{K}E^1\left[\max\left\{0, \gamma_1 - \bar{\gamma}\right\}\right] + \\ & \bar{K}E\left[\max\left\{0, \underline{\gamma} - \gamma_1\right\}\right] \end{aligned}$$

Let us analyze the terms in this expression. The first term is simply the cost of implementing the short-term project in period 1 (recall that $\pi^s(\gamma_0) < 0$). The second term is the value of increased opportunities for short-term investment in the second period due to the new information accrued in the first period. It is equivalent to $\bar{K}$ call options with exercise price $\bar{\gamma}$ on the value of managerial ability. The third denotes the savings which are made when, as a consequence of better information on managerial ability, the long-term project is not implemented in the second period. It is equivalent to $\bar{K}$ put options on managerial ability with exercise price $\underline{\gamma}$.

The conclusion is that it is optimal to implement the short-term project, despite the negative NPV, if $V(\bar{K}) - V(0) \geq 0$. This happens when the increase in value of the firm due to better information is greater than the cost of generating such information.

3.2 Variable Project Size

When the project has variable size then an expression similar to (8) can be obtained. Define:

$$\begin{aligned} \pi^s(\widehat{\gamma}, K) &= (\widehat{\gamma} + \theta^s) R(K) - K \\ \pi^l(\widehat{\gamma}, K) &= \left(\widehat{\gamma} + \theta^l\right) R(K) - K \end{aligned}$$

so that $\pi^s(\widehat{\gamma}, K)$ is the NPV obtained implementing the short-term project when managerial ability is $\widehat{\gamma}$ and the capital invested in K (and similarly for $\pi^s(\widehat{\gamma}, K)$).-Let us now define $K^s(\gamma_1)$ as the amount of capital solving:

$$\max_K \quad (\gamma_1 + \theta^s) R(K) - K$$

and $K^l(\gamma_1)$ as the analogous quantity for long term projects:

$$\max_K \quad \left(\gamma_1 + \theta^l\right) R(K) - K$$

Thus, these are the efficient levels of capital to be chosen in the last period when the expected value of managerial ability is γ_1. Then define:

$$\pi^s(\gamma_1) = \pi^s(\gamma_1, K^s(\gamma_1)) \qquad\qquad \bar{\pi}^l(\gamma_1) = \pi^l\left(\gamma_1, K^l(\gamma_1)\right)$$

The value of the firm when an amount $\widehat{K}$ is invested in the short-term project at period 1 is given by:

$$V\left(\widehat{K}\right)=\pi^s\left(\gamma_0,\widehat{K}\right)+\bar{\pi}^l\left(\gamma_0\right)+E^1\left[\bar{\pi}^s\left(\gamma_1\right)\right]+E^1\left[\bar{\pi}^l\left(\gamma_1\right)\right] \tag{9}$$

where E^1 denotes that expectation of γ_1 is taken using the probability distribution generated when the amount $\widehat{K}$ is invested in the short-term project.

Let us take a closer look to the distribution of γ_1. For a given level of investment $\widehat{K}$ define:

$$p_1=\frac{y_1}{R\left(\widehat{K}\right)}-\theta^s \qquad v_1=\frac{\epsilon_1}{R\left(\widehat{K}\right)}$$

so that:

$$p_1=\gamma+v_1$$

The revised expectation is therefore given by:.

$$\begin{aligned}\gamma_1 &= E\left(\gamma|\,p_1\right)=\frac{\tau_\gamma}{\tau_\gamma+R^2\left(\widehat{K}\right)\tau_\epsilon}\gamma_0+\frac{R^2\left(\widehat{K}\right)\tau_\epsilon}{\tau_\gamma+R^2\left(\widehat{K}\right)\tau_\epsilon}p_1= \\ &\frac{\tau_\gamma}{\tau_\gamma+R^2\left(\widehat{K}\right)\tau_\epsilon}\gamma_0+\frac{R^2\left(\widehat{K}\right)\tau_\epsilon}{\tau_\gamma+R^2\left(\widehat{K}\right)\tau_\epsilon}\gamma+\frac{R\left(\widehat{K}\right)\tau_\epsilon}{\tau_\gamma+R^2\left(\widehat{K}\right)\tau_\epsilon}\epsilon_1\end{aligned}$$

This implies that, upon choosing $\widehat{K}$, the variable γ_1 will have mean γ_0 and variance:

$$Var\left(\gamma_1\right)=\left[\frac{R^2\left(\widehat{K}\right)\tau_\epsilon}{\tau_\gamma+R^2\left(\widehat{K}\right)\tau_\epsilon}\right]^2\sigma_\gamma^2+\left[\frac{R\left(\widehat{K}\right)\tau_\epsilon}{\tau_\gamma+R^2\left(\widehat{K}\right)\tau_\epsilon}\right]^2\sigma_\epsilon^2$$

Notice that the profit functions $\bar{\pi}^s\left(\gamma_1\right)$ and $\bar{\pi}^l\left(\gamma_1\right)$ are convex, since:

$$\bar{\pi}'\left(\gamma_1\right)=R\left(K\left(\gamma_1\right)\right) \qquad \bar{\pi}''\left(\gamma_1\right)=R'\left(K\left(\gamma_1\right)\right)K'\left(\gamma_1\right)\geq 0$$

Furthermore, they are non-negative, since $K=0$ is feasible and yields zero NPV. In general, $\bar{\pi}\left(\gamma_1\right)$ will be a continuous function taking value 0 up to some point γ^* and increasing thereafter, and there is some K^* that maximizes the expression. Again, $\bar{\pi}^s\left(\gamma_0,K^*\right)$ is the price that the firm is willing to pay in order to increase the information about the manager and therefore increase the accuracy of the investment choices in the following periods. This discussion leads to the following proposition.

Proposition 1 *If managerial ability enters multiplicatively the revenue function then it may be optimal to implement short-term projects with negative NPV.*

When the impact of managerial ability is multiplicative rather than additive (as in the papers following the tradition of Narayanan (1985) and Holmström and Ricart i Costa (1986)) it turns out that the implementation of negative NPV short-term projects may have nothing to do with short-termism. Rather, it may well be part of a value-maximizing strategy which involves some rational experimentation intended to learn more about managerial ability. When ability enters revenue additively, this 'experimentation value' of the implementation of short-term projects is absent.

This has the following empirical implication. Suppose that we observe that investment projects with a short life are on average less profitable than long-term projects, maybe up to the point that the NPV of short-term projects is negative. This result may have two different explanations. The first one is the traditional 'overinvestment' theory previously discussed. However, remember that the theory relied on sub-optimal compensation schemes for the managers. The alternative explanation is the one offered in this paper: Negative NPV projects are optimally implemented because of their information value, and they are not incompatible with value-maximizing behavior on the part of managers. We will show in the next section that it is possible to design optimally managerial compensation schemes so that managers maximize the value of the firm.

4 Variable Compensation Schemes

In this section we want to analyze what happens when ability enters the revenue function in a multiplicative way and long-term labor contracts are impossible. This is useful in order to see whether the short-termist conclusions obtained in the previous literature (in which ability entered additively) still hold.

In line with the rest of the literature, we assume that the managerial labor market is competitive. With risk-neutral firms and managers this implies that the expected payment of managerial compensation is equal to the expected profit of the firm. Therefore, a manager at period 1 with an expected value of ability γ_1 is offered:

$$w(\gamma_1) = \bar{\pi}^s(\gamma_1) + \bar{\pi}^l(\gamma_1) \tag{10}$$

where we have assumed that in period 1 the manager will invest at the level that maximizes the value of the firm.

The wage offered to the manager in the first period depends on the behavior that such wage scheme is expected to induce. We will first discuss the case in which managers can only be offered fixed wages, and we will see that in this case the outcome is in general inefficient. We will next proceed to show that when the wage scheme can depend on the first period performance y_1 then the first best can in general be achieved.

4.1 Constant Wages

We first analyze what happens when firms are constrained to offer constant compensation schemes to their managers. Suppose that the manager has raised an amount of capital $\bar{K}$ and that she is paid a constant wage w_0. Let $w^*(y_1)$ be the wage that the manager will command in the next period if y_1 is realized today (notice that the function w^* depends on the level K^s that the market expects the manager to choose today). When the first period wage is constant the maximization problem for the manager is:

$$\max_{K^s \in [0,\bar{K}]} \quad E\left[w^*\left(y_1\left(K^s\right)\right)\right]$$

where we have highlighted the dependence of y_1 on K^s. In this case the following proposition is obtained.

Proposition 2 *Assume that managers are paid a constant wage in the first period. There is no equilibrium in which $K^s > 0$ and $K^* - K^s > 0$. Either all capital is put in the short-term or in the long-term project.*

Proof. When $K^s > 0$ the revised value of managerial ability γ_1 is given by:

$$\gamma_1 = E\left(\gamma | p_1\right) = \frac{\tau_\gamma}{\tau_\gamma + R^2\left(K^s\right)\tau_\epsilon}\gamma_0 + \frac{R^2\left(K^s\right)\tau_\epsilon}{\tau_\gamma + R^2\left(K^s\right)\tau_\epsilon}p_1 \tag{11}$$

where:

$$p_1 = \frac{y_1}{R\left(K^s\right)} - \theta^s \tag{12}$$

If the actual amount of capital invested in the short-term project is $\widehat{K}$ then

$$p_1 = \left(\gamma + \theta^s\right)\frac{R\left(\widehat{K}\right)}{R\left(K^s\right)} - \theta^s + \frac{\epsilon_1}{R\left(K^s\right)}$$

so that it is convenient for the manager to increase $\widehat{K}$ as much as possible. This implies $K^s = K^*$, and no capital is put in the long-term project.

On the other hand, when the market expects all the capital to be invested in the long-term project, then the manager has no interest in trying to fool the market diverting capital to the short term project. To see this, observe that when the market expects $K^s = 0$ then $y_1 = \epsilon$, so the market disregards y_1 in assessing managerial ability. In such a situation the manager has no incentive to artificially increase the value of y_1 by shifting capital to the short-term project. ■

The proposition implies inefficient investment whenever the optimal investment policy requires a positive investment in both the long-term and the short-term project. Observe that the equilibrium in which all capital is invested in the long-term project would not survive if managerial ability appeared additively in the revenue function of the firm. In that case y_1 is *always* an informative signal about managerial ability, so the manager is always interested in diverting capital to short-term project in order to boost y_1. When managerial ability affects the revenue only when applied to projects, things are different. In this case when the market does not expect a positive level of investment in the short-term project, short-term performance is not considered relevant in assessing managerial ability. This in turn implies that managers have no incentives in boosting short-term performance.

How much capital will the manager raise? If the firm can impose limits on the amount that the manager can borrow, then the limit will depend on the behavior of the manager after capital has been raised. If the manager is expected to invest in the long-term project then the amount chosen will be the one that maximizes $\bar{\pi}^l(K)$. If the manager is expected to invest in the short-term project then it is better for the firm not to hire any manager (or, equivalently, impose $\bar{K} = 0$ and offer a salary of zero). If firms cannot impose limits on the amount of capital that the manager can raise then it is not profitable to hire a manager if she is expected to invest only in short term projects.

4.2 Optimal Compensation Schemes

If firms are allowed to offer a wage $w(y_1, \bar{K})$ depending on the outcome in the first period and on the total amount of capital obtained (which are the verifiable variables in our model) then the first best can be achieved despite the impossibility of long-term contracts.

Proposition 3 *There exists a wage scheme $w(y_1, \bar{K})$ which induces efficient investment.*

Proof. Let $\bar{K}^s$ and $\bar{K}^l$ be the efficient amount of investment in the short and long term project respectively, and let $\bar{K} = \bar{K}^s + \bar{K}^l$. Let $w^*(y_1)$ be the wage obtained by the manager in the second period when the market has observed y_1 and believes that an amount K^s was invested in the first period. Since the wage can be made dependent on $\bar{K}$, we can assume that the manager can be forced to borrow the 'right' amount of capital (we can think of setting $w(\cdot, K) = -\infty$ if $K \neq \bar{K}$). If $\bar{K}$ is observed, the wage function offered to the manager is:

$$w_0(y_1) = by_1 - cy_1^2 - w^*(y_1)$$

where b and c are positive parameters chosen to satisfy the condition:

$$\frac{c}{b} = \frac{(\theta^s + \gamma_0)}{2\left[(\theta^s + \gamma_0)^2 + \sigma_y^2\right] F(\bar{K}^s)} \tag{13}$$

The maximization problem for the manager is:

$$\max_{K^s \in [0, \bar{K}]} \quad E[w_0(y_1(K^s))] + E[w^*(y_1(K^s))]$$

Substituting $w_0(y_1)$ and y_1 the problem becomes equivalent to:

$$\max_{K^s \in [0, \bar{K}]} \quad b(\theta^s + \gamma_0) F(K^s) - cE\left[((\theta^s + \gamma) F(K^s) + \epsilon_1)^2\right]$$

which in turn becomes:

$$\max_{K^s \in [0, \bar{K}]} \quad b(\theta^s + \gamma_0) F(K^s) - c\left[\left((\theta^s + \gamma_0)^2 + \sigma_\gamma^2\right) F^2(K^s) + \sigma_\epsilon^2\right]$$

The first order condition implies that:

$$b(\theta^s + \gamma_0) F'(K^s) = 2c\left((\theta^s + \gamma_0)^2 + \sigma_\gamma^2\right) F(K^s) F'(K^s)$$

Using $F' > 0$ we have:

$$F(K^s) = \frac{b(\theta^s + \gamma_0)}{2c\left((\theta^s + \gamma)^2 + \sigma_\gamma^2\right)}$$

which yields $K^s = \bar{K}^s$ once $\frac{c}{b}$ is substituted from (13). ■

Will managers be offered in equilibrium the wage scheme inducing efficient investment? Let $w_0(y_1)$ be the wage schedule inducing the efficient investment $\left(\bar{K}^s, \bar{K}^l\right)$. Given risk neutrality, the firm can always offer to the manager a wage $a + w_0(y_1)$ such that:

$$a + E[w_0(y_1)] = \bar{\pi}^s(\gamma_0) + \bar{\pi}^l(\gamma_0)$$

where the expectation on y_1 is taken assuming an investment $\bar{K}^s$ in the short-term project. A manager accepting such a wage will receive a total expected payoff of:

$$\bar{\pi}^s(\gamma_0) + \bar{\pi}^l(\gamma_0) + E\left[\bar{\pi}^s(\gamma_1) + \bar{\pi}^l(\gamma_1)\right]$$

where the expectation on γ_1 is taken assuming that $\bar{K}^s$ was invested in the first period. This is clearly the highest utility that a manager can obtain, since it implies that the intertemporal value of the firm is maximized and entirely appropriated by the manager.

5 Conclusion

This paper has analyzed the robustness of results about short-termism appearing in the literature to three important aspects:

1. The possibility to raise external capital to finance investment projects.
2. The possibility of introducing optimal compensation schemes.
3. The interaction between managerial ability and project size.

Our conclusion is that the possibility of raising external capital is not important, while the possibility of introducing optimal compensation schemes is crucial. We have shown that even if long-term contracts are impossible, it is possible to design short-term contracts such that the first best is achieved.

The interaction between managerial ability and project size may help to explain why the public may perceive short-termism where none is present. We have shown that, under the optimal compensation scheme, managers implement projects with negative NPV because such projects generates early information on managerial ability which is then optimally incorporated in the investment decisions of subsequent periods.

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