CAREER CONCERNS AND CONTINGENT COMPENSATION*

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Abstract: This paper considers an environment in which managers have unknown abilities to forecast the consequences of their decisions and in which these decisions are publicly observable. We construct a two-period model in which firms compete for managers by offering short-run contracts contingent on managers' decisions and their consequences. As salaries depend on managerial reputation, the manager's investment decisions are affected by their concern for their future careers. We analyze the interaction between the implicit incentives created by career concerns and the explicit incentives made possible by contingent compensation. Managers' career concerns create perverse incentives that can be mitigated by contingent contracting, but this requires payments which are nonmonotonic in performance. Two numerical exercises relate our results to the literature on the link between executive pay and corporate performance. In line with empirical findings, we find that: i) the pay-performance sensitivity is higher in the final period of managers' employment; ii) higher pay-performance sensitivities are associated with a lower variance of profits.

1 Introduction

Consider a firm that is contemplating the possibility of a takeover. Shareholders perceive it as a desirable opportunity. But they prefer to leave the final decision to the CEO who may have better information on whether the takeover will generate or destroy value. Suppose that the CEO decides to execute the takeover. Its result will then change the market's perception of the CEO's ability. If the takeover destroys shareholders' value, for instance, the CEO's reputation is likely to deteriorate. As a consequence, he would suffer a loss in the form of lower future salaries. In this paper we study situations similar to the one described and address the following questions: i) What are the effects of managerial reputational concerns? ii) Can contingent

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contracting guarantee optimal managerial decisions? iii) What is the shape of the resulting compensation schemes? and (iv) What are the implications for the link between executive pay and company results?

It is well known that the agency relationship between ownership and management arises because shareholders lack information on managers' choices and/or the way in which these choices are made. But in this paper we point out that, depending on the environment, the shareholders' informational disadvantage has different repercussions on the agency relationship and on the means employed to mitigate it, such as executive compensation.

In a minimal operating uncertainty environment, shareholders may be able to distinguish the set of available choices and identify the optimal one. In such a case shareholders could simply direct the manager to make a particular choice, e.g., an acquisition. In a maximal operating uncertainty environment, shareholders may be unable to recognize the set of actions available to management, or determine which action is taken by management. For instance, shareholders may not know the set of feasible investment projects and may be unable to observe the allocation of resources to the different projects.

Most of the literature on managerial compensation has analyzed environments with either minimal or maximal operating uncertainty. In these extreme environments managerial compensation is based upon corporate performance, but is independent of operating choices. In the case of minimal operating uncertainty this happens because operating choices are made by shareholders (or boards of directors) and managerial pay is made dependent on corporate performance simply to ensure that management executes these choices with appropriate levels of effort. In the case of maximal operating uncertainty, managerial compensation is independent of operating choices simply because these are unobservable.

As the example in the opening paragraph suggests, in this paper we want to study an *environment with intermediate operating uncertainty*, i.e., a situation in which *managers may have an informational advantage in making operating choices*, but in which *operating choices are observed by shareholders*. Analyzing this type of environment seems important because shareholder activism is increasing the scrutiny of the conduct of CEOs and other top executives.

The fact that operating decisions are observable has two important consequences. First, if a manager's ability to forecast the consequences of operating decisions is unknown, a career or reputational concern arises because observing his decisions influences the market's beliefs about his ability. Second, contracting possibilities are expanded because a manager's pay can be made contingent not only on company results, but also, directly, on the manager's observable operating decisions.

We construct a two-period model of managerial compensation with career concerns and characterize equilibrium contracts. We find that managers' reputational concerns create perverse incentives that can be partially offset by contingent compensation. To do this, however, may require promising the manager generous compensation in events in which corporate performance falls below expectations. This happens in period 1 when reputational concerns may induce managers to deliberately avoid operating choices that signal limited ability.

The fact that generous compensation may be associated with poor company results has important implications for the debate on how closely executive pay should be tied to corporate performance. We highlight that to correct the dysfunctional properties of managers' career concerns, optimal contracting may require large payments when company results are disappointing. We also indicate that it is important to examine the link between executive pay and operating decisions in intermediate operating uncertainty environments.

To check whether the implications of our results are compatible with empirical evidence we perform two numerical exercises on the joint distribution of equilibrium salaries and performance measures. Our first numerical exercise finds that the pay-performance sensitivity is higher in the final period of managers' employment than in the initial one. This is because in the final period, in the absence of career concerns, compensation increases with performance. By contrast, in the first period career concerns make it necessary to compensate the manager for the reputational loss he suffers when performance is below expectations. This result is in line with Gibbons and Murphy's (1992) empirical finding that the pay-performance elasticities of CEO's of large US companies increase as they approach retirement.

Our second numerical exercise demonstrates that the pay-performance sensitivity is decreasing in the firm's profit variance. The reason is that managers with the highest pay-performance sensitivities—managers with a good reputation in their second period—produce a low profit variance. This result is in line with the empirical findings of Aggarwal and Samwick (1999), but offers a different interpretation. Rather than seeing low pay-performance sensitivity as an optimal response to an exogenously high profit variance, we suggest that both the pay-performance sensitivity and the variance of results endogenously depend on the manager's ability and on his reputational concerns.[1]

Our study is obviously related to the literature on managerial career concerns. In line with the initial works of Fama (1980) and Holmström (1982) many authors have pointed out that reputational concerns may (partially) resolve static inefficiencies.[2] But in this paper we center our attention on environments in which "reputation is the source rather than the resolution of incentive problems"[3] and our work is therefore closely related to the literature on perverse reputational concerns.[4]

Our work is in particular related to Prat (2005) and Dasgupta and Prat (2006). As they do, we emphasize the reputational implications of observing actions and not only consequences. Our paper differs, however, because it studies more the remedies for reputational concerns than the inefficiencies that they cause. Dasgupta and Prat (2006) for instance show that, in the absence of contingent compensation, mutual fund managers are likely to execute trades that have a negative expected value and then verify that this result is robust to the introduction of contingent contracting if the prior probability of the manager being good is sufficiently small. By contrast, we exclusively consider the case in which compensation can be made contingent on actions and results. We note the conditions under which contingent compensation cannot guarantee efficiency, but we also analyze the implications of our results on the way in which executive compensation is shaped.

The main contributions of this paper derive from its focus on contingent compensation. We show that the perverse incentives of career concerns are eliminated by contingent contracting when a manager has a sufficiently good initial reputation, but are otherwise only mitigated. We show that offsetting reputational

[1] Prendergast (2002) has also indicated the importance of considering the endogeneity of risk to understand its relation with incentives.

[2] Among others, this line of research has been explored by Diamond (1989), Gibbons and Murphy (1992), Meyer and Vickers (1997), and Dewatripont, Jewitt, and Tirole (1999a, 1999b).

[3] Holmström and Ricart i Costa (1986), page 837, fn. 2.

[4] See, for example, Ricart i Costa, (1988), Prendergast (1993), Zwiebel (1995), Prendergast and Stole (1996), Morris (2001), Prat (2005), and Dasgupta and Prat (2006).

incentives requires making payments that the financial press or investors' groups often consider outrageous, such as for instance letting a CEO receive a large paycheck despite lackluster results. At a more general level we believe that our work points out the importance of operating decisions as a determinant of managerial compensation. This is important because, while many managerial decisions may be unobservable, many others that are likely to have a large impact on company results–mergers, acquisitions, joint ventures, corporate restructuring–are publicly observed.

The paper is organized as follows. Section 2 presents the model. Section 3 offers a characterization of the equilibrium. Section 4 studies the implications of our analysis on the link between managerial pay and firms' performance measures. Section 5 concludes. All proofs are presented in the Appendix.

2 The Model

Consider a manager who lives for two periods, $t = 1, 2$, and has a congenital ability. For simplicity, we assume that only two types of manager exist, good and bad, $\tau \in \{G, B\}$. At the beginning of period 1, the manager's type is unknown to everybody, but he is commonly believed to be good with probability $\mu \in (0, 1)$ and bad with probability $1 - \mu$.

In period 1 two identical firms compete to hire the manager by offering one-period contracts. A contract is a promise to make payments at the end of period 1 which are conditional on the public history following acceptance. If the manager rejects all offers, first period play ends and the manager and the firms obtain their reservation values.

If the manager accepts an offer, he has to decide whether the firm should undertake an investment project. The project has a cost of 1 and has two possible revenue realizations, $s > 0$ with probability $p \in (0, 1)$ and 0 with probability $1 - p$ and therefore an expected profit (gross of salary payments) of $ps - 1$. If no investment takes place the firm bears no cost and receives no revenue and therefore obtains a profit (gross of salary payments) equal to 0. We assume that $ps - 1 > 0$ so that the ex-ante optimal decision is to invest.[5]

Before deciding whether to invest the manager receives a signal $\omega \in \{V, L, H\}$ on the realization of the investment project. V is a void signal and L and H are a low and high signal, respectively. The probability of the project having the high return ($s > 0$) conditional on the received signal is

$$\Pr(s \mid \omega) = \begin{cases} p & \text{if } \omega = V \\ 0 & \text{if } \omega = L \\ 1 & \text{if } \omega = H \end{cases} .$$

In other words, signals H and L respectively ensure the success or the failure of the investment project, but the void signal, V, provides no additional information. We assume that a good manager receives signal H with probability p, and L with probability $1 - p$, whereas a bad manager receives signal V with probability 1. This means that a good manager is always able to perfectly forecast the realization of the investment project and that a bad manager receives no additional information beyond the prior probability distribution.

[5] This implies that the operating choice which is viewed as best by the firm (the shareholders) is one that entails risk. Our qualitative results, however, do not depend on the assumption that N has no risk, but only on the fact that N generates a lower expected payoff than I.

After observing the signal, the manager decides whether to invest (I) or not (N) and his decision is publicly observed. If the manager invests, the final realization of the investment project is also publicly observed. After this the firm pays the manager according to the contract that he had accepted and period 1 ends.

Period 2 is identical to period 1 with one important exception. A manager's type is the same in both periods. At the beginning of period 1 the manager does not know his type, but at the beginning of period 2 he does. The reason is that the manager learns his type in the course of period 1, when he receives the signal on the investment project. If he receives signal L or H he learns that he is good with probability 1, but if he receives signal V he learns that he is bad with probability 1. We also assume that all investment projects (of both firms and in both periods) are independent of each other.

The public history following acceptance in each of the two periods t is an element of $\{N, F, S\}$, where N indicates that no investment took place and F and S indicate that the investment was carried out and it was, respectively, a failure or a success. We assume that the manager has limited liability. This implies that in each of the two periods a contract is a nonnegative triple $w^t = (w_N^t, w_F^t, w_S^t) \in \mathbb{R}_+^3$, $t = 1, 2$. We describe the manager's play in each of the two periods through an investment action profile, i.e., a vector $\rho^t = (\rho_V^t, \rho_L^t, \rho_H^t) \in [0,1]^3$ where ρ_V^t, ρ_L^t, and ρ_H^t denote the probability of investment at date $t = 1, 2$ conditional on the manager having received signal V, L, or H, respectively.

We assume that the manager is risk neutral and maximizes his expected discounted lifetime salary

$$E\left[w^1 + \delta w^2\right],$$

where $\delta \geq 0$ is the discount factor. We assume that firms are also risk-neutral. Given that contracts are short run and the investment projects are serially independent, firms' time horizons are irrelevant and we treat them as short-run profit maximizers without loss of generality.

To conclude the description we only need to mention reservation values. We assume that if the manager rejects all offers he receives a payoff of 0. We also assume that a firm can function without the manager and that in this case it undertakes the investment project, i.e., it makes the ex-ante optimal operating decision. This implies that a firm with no manager obtains an expected profit of $ps - 1$.[6]

The equilibrium concept we use is perfect Bayesian equilibrium.

2.1 Discussion of the model

In our model we only admit short-run contracts, but we allow salary payments to be made *after* the realization of the investment process. We therefore introduce the possibility for compensation to depend also on *contemporaneous* measures of performance. This seems important as it guarantees that our results are robust to the introduction of optimal short-run contracting.

We assume that no long term contracts are possible. This assumption is at the core of our results. If at the beginning of the manager's working life firms could offer a long term binding contract, it would be possible to design it in such a way that the manager has no incentives to distort his investment decisions

[6] The qualitative nature of the results of the paper would not change if we made the assumption that the reservation level for the firm is 0 rather than $ps - 1$, i.e., if we assumed that a manager is an essential input in the production process.

away from the optimum. We rule out such binding contracts, as the information revealed after the first period creates incentives for at least one of the parties to break the contract.

In this paper we consider a screening model, i.e., a situation in which the uninformed parties (firms) make offers. Our results are not sensitive to this choice. One could consider a signaling setting, i.e., one in which the informed party (the manager) makes contract offers. In this case the sets of accepted contracts and equilibrium path investment actions are the same as in the present paper as long as the second period continuation equilibria (i) give zero profits to firms, (ii) are Pareto optimal in terms of the investment action profile played on the equilibrium path, and (iii) survive the *intuitive criterion*. An alternative formulation of a signaling environment is one in which, in the spirit of Maskin and Tirole (1992), the manager offers a menu of contracts, the firm accepts or rejects the menu, and finally the manager chooses one contract out of the previously proposed (and accepted) set. With this formulation, in all equilibria the set of accepted contracts and the equilibrium path investment decisions would be the same as in the present paper.

This paper takes the view that it is important to study the implications of career concerns when differential learning on managerial ability takes place. We assume that information is initially symmetric but that an asymmetry arises in the course of the first period (when the manager learns his type). We consider the assumption of initial symmetry of information to be realistic, but the equilibrium outcomes of our model also arise when information is asymmetric from the beginning. In the latter case, however, the arbitrariness in off-the-equilibrium beliefs leads to a larger set of equilibria.

The purpose of the paper is to show that reputational concerns in an environment with asymmetric information on managers' forecasting abilities may help explain the compensation patterns documented by empirical evidence. To isolate these effects we assume that the manager is risk-neutral. This assumption is not important for our results but it implies that, because the manager is indifferent among contracts with the same expected value, multiple equilibria contracts may exist. For this reason, in subsection 3.3 we focus on the minimum variance contract that is arbitrarily close to the contract that would be preferred by a manager with an arbitrarily low degree of risk aversion.

3 Equilibrium

Let $E[\pi \mid \rho, \mu]$ denote the expected profit gross of salary payments as a function of the investment action profile ρ and of the beginning-of-period probability of the manager being good, $\mu \in [0, 1]$. Notice that $(1, 0, 1)$ is the efficient investment action profile.

In subsection 3.1 we study second period continuation equilibria. Then, in subsection 3.2, we move back to the first period and characterize the equilibrium path investment decisions and contracts.

3.1 Second Period

The following Proposition characterizes continuation equilibria at the beginning of the second period, when the manager has already privately learned his type.

Proposition 1 *Assume that at the beginning of period 2 firms believe that the manager is good with probability $\mu^2 \in [0, 1]$. Then, in any continuation equilibrium:*

1. *The unique contract which is accepted by both types of manager is:*

$$w^2(\mu^2) = (w_N^2(\mu^2), w_F^2(\mu^2), w_S^2(\mu^2)) = \left(\frac{\mu^2(1-p)}{1+(1-p)\mu^2}, 0, \frac{\mu^2(1-p)}{p(1+(1-p)\mu^2)}\right).$$

2. *The investment action profile played by the manager on the equilibrium path is:*

$$\rho^2 = (1, 0, 1)$$

Proposition 1 shows that all second period continuation equilibria are pooling and lead to efficient investment decisions and that salaries are increasing in performance.

Second period continuation equilibria are pooling because a bad manager has zero value and if his type were known, he would receive zero wages. This implies that no separating equilibrium can exist.

Investment decisions are efficient because competition for the manager leads to surplus maximization. In the manager's second period of life, his last, nothing counters this tendency towards efficiency as the manager's only incentives are the explicit ones provided by contracts.

To see why equilibrium salaries are increasing with performance, suppose first that a salary offer accepted in equilibrium gives a positive salary payment in case of failure. This implies that another salary offer that gave zero payment in case of failure and a slightly higher payment in case of no investment would attract only the good manager. This would constitute a profitable deviation. The same argument suggests that in order for no profitable deviations to exist, the payment for the case in which the manager chooses not to invest has to be maximized. Notice, however, that an inordinately large payment for this realization would induce the bad manager to deviate from the efficient investment action profile. Therefore, it is essential that for the bad manager the expected payoff from investing be at least as large as the payoff from not investing. Given that it has already been argued that $w_F^2(\mu^2) = 0$, this incentive compatibility condition translates to

$$w_N^2(\mu^2) \leq p w_S^2(\mu^2). \tag{1}$$

To maximize $w_N^2(\mu^2)$, condition (1) has to hold with equality. This implies that $w_N^2(\mu^2) < w_S^2(\mu^2)$, i.e., that salaries accepted in equilibrium are increasing in gross profit. They are highest when the outcome is success, intermediate when the outcome is no investment, and lowest when the outcome is failure. For expositional purposes, Figure 1 depicts $w_S^2(\mu^2)$ and $w_N^2(\mu^2)$ when $p = .6$, a case we also consider in subsection 3.3.

3.2 First Period

The next proposition provides a characterization of the investment action profiles played on the first period equilibrium path. We first introduce the following definition:

$$\mu^* = \frac{\delta}{2+\delta-p} < 1.$$

Proposition 2 *An equilibrium exists. An equilibrium with an efficient first period equilibrium path investment strategy exists if only if $\mu \in [\mu^*, 1]$.*

Proposition 2 shows that inefficiency in first period investment decision arises when μ is low. The reason is that in this case reputational incentives are strong and contingent compensation insufficient to counterbalance them.

To see this, suppose first that the manager plays according to $(1, 0, 1)$ on the first period equilibrium path. The reputational incentives for the bad manager to deviate and play N are decreasing in μ because the deviation payoff is independent of μ (if he deviates he will be believed to be good with probability 1 regardless of his initial reputation) while the equilibrium payoff is increasing in μ. On the other hand, the surplus that can be used to offset the reputational incentives through explicit compensation is increasing in μ because the zero profit condition requires that the expected wage payment to a manager of type μ be equal to his expected value, $\mu(1 - p)$. This implies that $(1, 0, 1)$ is played in the first period in equilibrium only when μ is sufficiently high. Proposition 2 provides an explicit calculation of the threshold, μ^*.

The next subsection completes the analysis of equilibrium by turning attention to first period equilibrium accepted contracts.

3.3 First Period Contracts: An example

Because multiple equilibria may exist, we now concentrate on perfect Bayesian equilibria that maximize the manager's ex-ante payoffs. Notice also that the assumption of managerial risk neutrality implies that different first period equilibrium contracts (with the same expected value) may exist. All these equilibria are identical in the distribution over investment outcomes and in the expected first period payoff to the manager and the firm. Although the objective of the paper is to focus on career concerns alone, the multiplicity of equilibria in first period accepted contracts is an artificial product of the extreme assumption of risk neutrality. Any arbitrarily small amount of risk aversion would break the tie among all first period contracts with the same expected value. It is easy to verify that for any sequence of strictly concave utility functions that tend to a linear utility function, the limit optimal contract in a set of contracts with the same expected value is the one that minimizes variance. For this reason, whenever multiple equilibrium accepted contracts exist in the rest of the paper we focus on the one with the minimum variance.

To provide some intuition for our results we consider a numerical example in which we assume that $\delta = 1$, $p = .6$, and $s = 2$. This implies that $\mu^* = .4167$. The qualitative nature of the results for this example can be verified to be independent of the parameter values. First period equilibrium contracts are plotted against the beginning-of-period probability of the manager being good in Figure 2.

Consider first a manager with a high initial reputation in his first period of life, $\mu \geq .42$. From Proposition 2 we know that a set of contracts exists with the property that the manager plays the efficient investment strategy, $\rho^1(w^1) = (1, 0, 1)$, in the continuation equilibrium. Recall, however, that the bad manager has reputational incentives not to invest. To counterbalance these implicit incentives and ensure that the bad manager makes the efficient decision to invest, his expected compensation from investing must be sufficiently higher than the expected compensation from not investing.

Figure 2 plots the minimum variance contract that satisfies this condition. Because $w_F^1 > w_S^1 > w_N^1$, managerial compensation is nonmonotonic in firm performance. Notice that the nonmonotonicity of salaries does not depend on the choice of the contract that minimizes the variance, but is driven by the incentive motives. This is illustrated in the case in which $\mu = \mu^*$, when the unique first period contract that is accepted on the the equilibrium path by the manager is such that $0 = w_N^1 < w_S^1 = w_F^1$.

When the initial reputation of the manager is lower, $\mu < \mu^*$, from Proposition 2 we know that the perverse reputational incentives of the manager have to be mitigated by an inefficiency in the investment decisions.

If the manager has an intermediate reputation in his first period of life, $\mu \in [.19, .41]$, in the equilibrium path he plays $\rho^1 = (\rho_V, 0, 1)$ with $\rho_V < 1$. This makes the reputational value of not investing smaller than when the efficient investment decisions are made, and therefore the bad manager has no incentives to deviate. As can be seen in Figure 2, in this region $w_F^1 > w_S^1 > w_N^1$, and managerial compensation is therefore also nonmonotonic in firm performance.

If the manager's initial reputation is sufficiently bad, $\mu \in [0, .18]$ he accepts a first period contract $w^1 = (0, 0, 0)$ that is independent of firm performance and plays $\rho^1 = (1, 1, 1)$. Notice that $w^1 = (0, 0, 0)$ implies that the manager has no explicit incentives to invest or not, regardless of the signal he receives. But because $\rho^1 = (1, 1, 1)$ implies that the posterior probability of the manager being good is equal to the prior regardless of the realization, the manager also lacks reputational incentives to invest or not, regardless of the signal he receives. This implies that the manager's payoff from investing and not investing is the same regardless of the signal he receives and the incentive compatibility conditions are obviously satisfied.

Figure 3 plots the equilibrium expected surplus in periods 1 and 2. By Proposition 1 no inefficiency arises on the equilibrium path in period 2 and the expected surplus is therefore equal to

$$(1 - \mu)(pz - 1) + \mu p(z - 1) = .2 + .4\mu.$$

By Proposition 2 we also know that the expected surplus of period 1 is also maximal for $\mu \geq \mu^*$. But the fact that the equilibrium path investment decision is not the efficient one below μ^* makes expected surplus in period 1 lower than with efficiency.

For the rest of the discussion in the paper it is useful to compare the equilibrium wages for period 1 (Figure 2) with the equilibrium wages for period 2 (Figure 1) and in particular to notice that: i) Equilibrium wages are monotonic in performance in period 2, but not in period 1; ii) The pay performance sensitivity is increasing in the beginning of period reputation in period 2, but no clear relation emerges for period 1: For sufficiently low initial reputations the sensitivity is 0, but for intermediate and higher values of the reputation the nonmonotonicity of the pay schedule makes it difficult to summarize how pay responds to performance.

4 The Link Between Pay and Performance

The goal of this section is to make use of our equilibrium characterization and derive some implications on the link between managerial compensation and firm performance. In particular we ask whether equilibrium outcomes are consistent with documented evidence. We take into account managerial heterogeneity by considering a population of managers with different prior probabilities of being good at the beginning of their careers. We first compute the joint probability distribution over salaries and profit generated by equilibrium play. As was done in the previous section, we cope with the multiplicity of first period equilibrium contracts by singling out the equilibrium contract with the lowest variance for each value of μ. We then turn to the link between pay and performance by performing regression analyses on the equilibrium distribution over salaries and profits.

In these analyses we take the view that market participants (managers and firms) are able to assess managers' ex-ante probabilities of being good and observe managers's operating decisions, but that the econometrician has information on neither and is therefore unable to condition on them.

To check the robustness of our results we have performed our analysis for many different initial distributions of managers' types (their μ's) given by Beta distributions, Be(α, β), with different values for the parameters α and β. Given that the qualitative results are the same for all distributions, we report our results for four different distributions representing a uniform distribution ($\alpha = \beta = 1$), two skewed distributions ($\alpha = 3$, $\beta = 1.5$, right skewed, and $\alpha = 1.5$, $\beta = 3$, left skewed) and a symmetric distribution with a lower variance than the uniform distribution ($\alpha = \beta = 3$). Figure 4 provides the plots of densities for each of these four cases.

In the following two subsections we compare the equilibrium predictions of our model with documented evidence by reproducing the econometric analyses of two works on the link between pay and performance, Gibbons and Murphy (1992) and Aggarwal and Samwick (1999).

4.1 Career Concerns and Pay/Performance Sensitivities

We analyze the link between pay and performance by considering separately the joint distribution of compensation and profit for each of the two periods.[7] We consider profits both net and gross of salary payments. We use each of these distributions to regress salaries on profits and we interpret the resulting OLS coefficients as measures of pay-performance sensitivities.

The computations presented below are performed for the same parameter specification used in the example in subsection 3.3 above. The qualitative nature of the results was unchanged in all the other parameter specifications that we have considered.

The first and second columns of Table 1 report the OLS coefficients for the first and second period when salaries are regressed on profits gross of salary payments. The results show that the magnitude of the pay-performance sensitivity is always higher in the second period than in the first.[8] The third and fourth columns of Table 1 report the OLS coefficients for the first and second period when salaries are regressed on profits net of salary payments. The results on the relative magnitude of the pay-performance sensitivity in the first and the second period are preserved although the pay-performance sensitivity in the first period is now negative.

To perform comparisons with empirical studies that use changes in firms' stock market valuations the appropriate measure would seem to be profits net of salary payments because firms' market valuations should discount the cost of managerial compensation. Despite this observation, we regard the results for the case of profits gross of salary payments as more interesting for the following reason. For simplicity, our model makes the extreme assumption that competition ensures that the manager appropriates all the surplus. This implies that in our model the manager's compensation package may be sizable with respect to the firm's profit and managerial compensation may reverse the relative orderings of profit realizations. In other

[7] Notice that the second period aggregate distribution is computed using the posterior probability of each manager being good at the beginning of period 2, given equilibrium play and equilibrium learning about his type.

[8] We also computed pay-performance elasticities and pay–performance correlations and found that the values of the coefficients are always larger in the second period than in the first.

words, we believe that the negative coefficients in the regressions of first period salaries and net profits are an artificial consequence of the disproportionate relative size of managerial compensation to firms' profits and we therefore focus our attention on the relationship between salaries and profits gross of managerial compensation.[9]

The results reported in Table 1 are in line with Gibbons and Murphy's (1992) empirical finding that the sensitivity of managerial pay to firm performance increases as retirement nears. Gibbons and Murphy's (1992) theoretical explanation for this result is that as retirement draws near, stronger explicit compensation has to provide stronger explicit incentives to substitute the fading implicit (reputational) incentives. The reason behind the same result in our model is, however, completely different.

The difference between the joint distributions of salaries and profits in the first and the second periods depends on two main factors: (a) Managerial compensation in period 2 is increasing in profit but is nonmonotonic in period 1 (see Figures 1 and 2); (b) As time goes by, firms receive additional information about managers and update their estimates of their abilities. This suggests that the difference between pay-performance sensitivity in the first and the second period could be decomposed into two effects : the *career concerns effect* arising because of (a) and the *learning effect* due to (b). Because learning in our model is sometimes rather extreme–at the end of the first period firms learn that some managers are good and some bad with probability 1–it is important to assess the contribution of each of these effects to the overall result to ensure that it is not driven by these somewhat extreme assumptions. To do so, we performed the same exercise in the second period but, instead of using the posterior distribution over μ generated by equilibrium play and learning, we used the prior distributions (as in Figure 4) and thereby shut out the learning effect. The resulting slopes (not reported here) are very close to the slopes reported in Table 1, though they are between 6.8% and 9.4% higher. The implication of this is that in these cases the learning effect is not very sizable in absolute terms, and is in fact negative. Given this, the difference in compensation schedules, the career concern effect emerges as the driving force behind the increasing pay-performance sensitivity.[10]

4.2 Risk and Executive Compensation

The relationship between executive pay and firm performance has been the object of extensive research. Holmström and Milgrom (1987) studied the optimal compensation schedule for a repeated agency problem and found that, under appropriate conditions, it is linear in firm performance and that its slope is decreasing in the variance of profits, which is equal to the (exogenous) variance of a firm specific error term. To test this prediction, Aggarwal and Samwick (1999) propose the following specification as an approximation of the optimal contract:[11]

$$w_{ijt} = \gamma_0 + \gamma_1 \pi_{jt} + \gamma_2 F\left(\sigma_{jt}^2\right) \pi_{jt} + \gamma_3 F\left(\sigma_{jt}^2\right) + \lambda_t + \varepsilon_{it}. \tag{2}$$

[9] This idea can be formalized as follows. Suppose that the regression coefficient with profits gross of salary payments is positive and the one with profits net of salary payments is negative. If managerial salaries w are multiplied by a constant κ, then it is easy to show that for a sufficiently low value of κ the regression coefficient with profits net of salary payments is also positive.

[10] Other simulations we performed produced both positive and negative learning effect, but never very sizable.

[11] See equation (2) in Aggarwal and Samwick (1999), page 77.

Subindices i, j, and t refer, respectively, to the executive, the firm and the period, w_{ijt} is the executive's compensation, π_{jt} is the return to shareholders, $F\left(\sigma_{jt}^2\right)$ is the (cumulative) distribution function of the variance of firm returns, λ_t is a year effect, and ε_{it} is the error term. The pay-performance sensitivity for a manager working for a firm with variance σ_{jt}^2 is $\gamma_1 + \gamma_2 F\left(\sigma_{jt}^2\right)$, and this specification makes it easy to compute the pay-performance sensitivity at any percentile of the distribution of variances. For example, the pay-performance sensitivities of the managers working for the firm with the lowest, median, and highest variances are γ_1, $\gamma_1 + 0.5\gamma_2$, and $\gamma_1 + \gamma_2$, respectively. The prediction of the standard moral hazard model is that $\gamma_1 > 0$, $\gamma_2 < 0$, and $\gamma_1 + \gamma_2 > 0$. In other words, while higher performance leads to higher compensation, the effect of returns on compensation is smaller at firms with more variable returns. The classical moral hazard model makes no clear prediction about the relationship between variance of returns and the *level* of compensation (as opposed to the slope of the pay-performance schedule), but Aggarwal and Samwick (1999) also introduce $\gamma_3 F\left(\sigma_{jt}^2\right)$ to make sure that their estimates of γ_2 "are not affected by any relationship between the variance and the level of compensation that may happen to exist in the cross section."[12]

Aggarwal and Samwick's (1999) main results on the relationship between pay-performance sensitivity and variance of firm returns are presented in column 1 of their Table 3 where they provide the median regression estimates of the coefficient in the above specification: $\gamma_1 = 27.596$, $\gamma_2 = -26.147$.[13] Both coefficients are significantly different from 0 and are consistent with the predictions of the standard moral hazard model.[14] The estimated pay-performance sensitivities of the managers working for the firm with the lowest, median, and highest variances turn out to be, respectively,

$$\begin{aligned} \gamma_1 &= 27.596 \\ \gamma_1 + 0.5\gamma_2 &= 14.5225 \\ \gamma_1 + \gamma_2 &= 1.449. \end{aligned}$$

To verify whether our model is consistent with Aggarwal and Samwick's (1999) results we estimate the coefficients of the same specification as in (2) using the joint distribution of salaries, profits and theoretical profit variances generated by our model. Because Aggarwal and Samwick (1999) do not take into account the numbers of years before retirement, we use the average of the joint distributions for the first and the second period, thereby implicitly assuming that half of the managers are in the early stage of their careers (period 1) and the other half in their final stage (period 2) with the idea that two overlapping generations of managers live at the same date.[15] Since we only consider one date, we ignore the year effect, λ_t. Finally, because our

[12] Aggarwal and Samwick (1999), page 78.

[13] Given the right skewness of compensation distributions due to the fact that some CEO's are also the founders and main shareholders of some companies, Aggarwal and Samwick (1999) use median regression rather than OLS to get estimates that depend less on these outliers.

[14] Notice that the existing evidence on the relationship between pay-performance sensitivity and risk is not conclusive. Some authors as Aggarwal and Samwick (1999) and Lambert and Larcker (1987) find a negative relationship; Core and Guay (2002) find a positive relationship by including firm size as a control; other authors find no statistically significant relationship. For a review of this literature see Prendergast (1999).

[15] If we define the second period of a CEO as the last three years in office, and the previous years as the first period (as in Gibbons and Murphy, 1992), assuming that half of the population of CEOs is in its second period is probably an overestimate. We checked that our results were valid as well for lower fractions of old managers in the population, but given that we do not regard our analysis as a quantitative calibration exercise, we present the results for equal fractions of young and old managers.

compensation realizations do not exhibit the same outliers as the data, we compute OLS estimates of the coefficients.

Our results are summarized in Table 2. As in Aggarwal and Samwick (1999), γ_1 is positive and γ_2 negative;[16] Table 2 also provides the pay-performance sensitivities for the managers who are employed by the firm with the lowest, median, and largest variance in the population.

Since the pay-performance sensitivity is in fact decreasing in the (theoretical) variance of firm returns, our model turns out to be observationally equivalent to the standard moral hazard model and the documented relationship between risk and pay-performance sensitivity may be due to different reasons.

Figures 5 and 6 show the variance of profits of a firm as a function of its manager's age and beginning-of-period probability of being good. When a manager is in his first period and has a low initial value of μ, the variance of gross profit is maximal (Figure 5) and his pay does not depend on realized profit ($w_N = w_F = w_S = 0$, Figure 2). For both intermediate and higher values of μ, the variance of profit is lower (Figure 5) and his pay depends on profits but in a nonmonotonic way (Figure 2). While the first observation seems to contribute to a negative association between pay-performance sensitivity and variance, the second has an unclear effect.

Consider now a manager in his second period. From Figure 1 it is easy to see that both $w_S - w_N$ and $w_N - w_F$ are increasing in μ. Given that profit realizations (before salaries) are independent of μ, the previous observation clarifies that in the second period a manager's pay-performance sensitivity is increasing in μ, his beginning-of-period probability of being good. Figure 6 shows, on the other hand, that the variance of profits is decreasing in the same probability so that a negative association between pay-performance sensitivity and profit variance arises.

The previous arguments suggest that the negative association between pay-performance sensitivity and variance of profits is mainly due to the compensation patterns of heterogeneous managers in the late stages of their careers. This intuition is confirmed by running similar regressions for managers in their first and second periods separately: the results we have presented are confirmed (and in fact magnified in absolute terms) for managers in their second period, but are unclear for managers in their first period.

Aggarwal and Samwick (1999) also show that omitting variances (i.e., imposing $\gamma_2 = \gamma_3 = 0$) leads to an estimate of the pay-performance sensitivity of 3.47 (a result in line with Jensen and Murphy's (1990) findings) as opposed to a pay-performance sensitivity at the median variance of 14.52. We performed a similar exercise and also found that in this case the pay-performance sensitivities are lower than the corresponding estimates of pay-performance sensitivities at the median variance reported in Table 2.

5 Conclusions

A common recommendation to resolve managerial agency problems is to make managerial compensation contingent on company results. But how do things change when shareholders observe important operating decisions, such as takeovers, divestitures, or corporate restructurings? Operating decisions provide informa-

[16] While Aggarwal and Samwick (1999) find a positive value for γ_3, our numerical experiments provide negative values. This divergence is likely to derive from the fact that managers working for larger firms (with higher variances of returns) are known to be better paid. This effect is absent in our exercise because we do not consider heterogenous firms.

tion on a manager's ability and behavior. But then his compensation should and will depend also on these operating decisions.

In this paper we study these issues in an environment in which good managers have an informational advantage in making operating decisions compared to shareholders, but bad managers do not. This creates perverse reputational concerns. Managers have incentives to deliberately avoid courses of action that may lead the market to think that they have a limited ability. We find that making compensation contingent on both performance and observable decisions offsets the perverse reputational incentives of the manager if his initial reputation is sufficiently good, but otherwise only mitigates them. In other words, we find that the inefficiency caused by reputational concerns is robust to the introduction of optimal contracting.

The main preoccupation of this paper is to see how reputational concerns can shape managerial compensation. One of our findings is that in the early stages of his career, it may be in the shareholders' interest to promise the manager a large payment if he takes a decision that they view as desirable (e.g., a takeover) and that results in a failure. The reason is that a failure indicates that the manager is more likely to be bad and this would make a bad manager (who has no informational advantage over shareholders) more inclined to avoid making that decision that is ex-ante optimal given the available information. Because this effect has a cost in terms of foregone expected profit for shareholders, the latter may wish to neutralize it by offering the manager a large payment if disappointing company results indicate that he has a limited managerial ability. By contrast, we find that compensation is increasing in corporate performance in the late stages of the career of a manager, when his reputational concerns disappear.

Two numerical simulations verify that our results are in line with the empirical evidence on the link between executive pay and performance and in particular on the increase in pay/performance sensitivity with tenure documented by Gibbons and Murphy (1992) and in the negative association between pay/performance sensitivity and risk documented by Aggarwal and Samwick (1999). We do not claim that Gibbons and Murphy (1992) or Aggarwal and Samwick (1999) constitute empirical tests of our model. But our results suggest that the relationship between compensation and performance measures documented by these authors may arise for reasons different from the ones proposed by a standard moral hazard model. In other words we see our model as an alternative or possibly complementary explanation of the agency relationship between ownership and management.

Our work has evident implications for the debate on the link between executive pay and company results. For instance, the fact that pay is not necessarily increasing in company results can explain the limited sensitivity of pay to performance. But it also questions the common view that compensation practices such as "golden parachutes" or "pay-for-failure" are aberrant consequences of corporate governance failures.

Finally, our work points out that when more information on the conduct of a CEO is available, for example when he is closely scrutinized by institutional investors, it may be in the interest of shareholders to make his pay depend not only on financial results but also directly on his operating decision. In such cases analyzing the response of pay to financial performance measures may be insufficient and lead to erroneous conclusions.

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A Appendix

The following Lemma is used in the proofs below.

Lemma 1 *On the equilibrium path* $\rho^t \notin \{(0,0,0), (0,1,0), (0,1,1), (1,1,0), (0,1,1)\}$, $t = 1,2$.

Proof. Suppose that on the equilibrium path $\rho^t \in \{(0,0,0), (1,0,0), (0,1,0), (1,1,0), (0,1,1)\}$. Given that the expected gross profit from such action profiles are strictly less than $ps - 1$ and given that a firm with no manager earns $ps - 1$, withdrawing all offers is a profitable deviation for the firm and a contradiction arises. ■

A.1 Proof of Proposition 1

In the second period there are no career concerns, and managers just respond to explicit incentives. In case of indifference, we assume that managers take the investment action which maximizes profits. In this way, in the second period one can abstract from mixed strategies. We prove a sequence of claims.

1. No separating equilibrium exists, that is to say no equilibrium exists in which different types of manager accept different offers.

   Suppose such an equilibrium exists, and let $\left(w_N^B, w_F^B, w_S^B\right)$ denote the offer accepted by a bad manager. For a firm offering this contract not to have an incentive to withdraw it, it is necessary that $w_N^B = w_F^B = w_S^B = 0$. Let $\left(w_N^G, w_F^G, w_S^G\right) \neq \left(w_N^B, w_F^B, w_S^B\right)$ denote the offer the good manager accepts. Since $\left(w_N^G, w_F^G, w_S^G\right) \in \mathbb{R}_+^3$, the salary in at least one state has to be strictly positive. Given this, the bad manager would prefer $\left(w_N^G, w_F^G, w_S^G\right)$ to $\left(w_N^B, w_F^B, w_S^B\right) = (0,0,0)$ and a contradiction is obtained.

   Consider now pooling equilibria.

2. If a pooling equilibrium exists it has to be such that firms's expected profits are exactly $ps - 1$.

   If firms's expected profits were less than $ps - 1$ a profitable deviation for them would be to withdraw all offers and invest on their own, which gives an expected profit of $ps - 1$. Let (π_1, π_2) denote the expected equilibrium payoffs to firms 1 and 2. Suppose, without loss of generality, that $\pi_1 = \max(\pi_1, \pi_2) > ps - 1$. Let $\widetilde{w} = (\widetilde{w}_N, \widetilde{w}_F, \widetilde{w}_S)$ denote the offer made by firm 1 and which is accepted with positive probability by the manager. Then, one can construct a profitable deviation for firm 2, $\widehat{w} = (\widetilde{w}_N + \varepsilon, \widetilde{w}_F + \varepsilon, \widetilde{w}_S + \varepsilon)$ with $\varepsilon > 0$, such that $\widehat{w}$ is strictly preferred by the manager and the expected profit for firm 2 is strictly larger than π_2.

3. If a pooling equilibrium exists it has to be such that the efficient investment strategy is played.

   Let (w_N, w_F, w_S) denote the offer which is accepted by both types of manager. Suppose that the manager does not play according to $(1,0,1)$. By Lemma 1 he plays either $(1,1,1)$ or $(0,0,1)$:

   (a) Suppose the manager plays $(1,1,1)$. This implies that $(w_N, w_F, w_S) = (0,0,0)$. Consider (w'_N, w'_F, w'_S) such that $w'_N = w'_F = w'_S = \mu^2(1-p) - \varepsilon$ with $\varepsilon \in \left(0, \mu^2(1-p)\right)$. This offer is strictly preferred by both types of manager, and since after accepting this offer the manager would play $(1,0,1)$, the expected profit to the firm would be $ps - 1 + \varepsilon$, a contradiction

(b) Suppose the manager plays $(0,0,1)$. This implies that $w_N > pw_S + (1-p)\,w_F$. Consider now an alternative offer $(w'_N, w'_F, w'_S) = (w_N - \alpha, 0, w_S + \varepsilon)$ with $\varepsilon \in \left(0, \frac{w_N}{p} - w_S\right)$ and $\alpha \in \left(0, \frac{p}{(1-p)}\varepsilon\right)$. It is easy to check that such an offer is strictly preferred only by the good manager and it would yield expected gross profits of $p\,(s - 1 - w'_S) - (1-p)w'_N$ which, for ε sufficiently small, can be shown to be larger than $\mu p\,(s - 1 - w_S) - (1 - \mu p)w_N$. Therefore, (w'_N, w'_F, w'_S) would be a profitable deviation and a contradiction arises.

4. If a pooling equilibrium exists, the offer accepted by both types of manager is such that $w_F = 0$.

Recall from 3 above that if a pooling equilibrium exists it has to be such that the efficient investment action profile is played. Suppose, contrary to the claim that the offer accepted in equilibrium by both types of manager, $w = (w_N, w_F, w_S)$, is such that $w_F > 0$. Consider another offer $\widehat{w} = (\widehat{w}_N, \widehat{w}_F, \widehat{w}_S) = (w_N, 0, w_S + \varepsilon)$. It is easy to recognize that there is an $\varepsilon > 0$ such that $\widehat{w}$ is strictly preferred only by the good manager and that gives an expected payoff to the firm strictly larger than $ps - 1$, a contradiction.

5. No equilibrium can exist in which both types of manager accept an offer different from

$$\left(w_N^2, w_F^2, w_S^2\right) = \left(\frac{\mu^2(1-p)}{1+(1-p)\mu^2}, 0, \frac{\mu^2(1-p)}{p\,(1+(1-p)\mu^2)}\right).$$

$>$From 2-4 above we know that if a pooling equilibrium exists, it is such that the manager plays the efficient investment action profile, such that firms' expected profits are $ps - 1$ and such that the accepted offer is such that $w_F = 0$. Given this, if a pooling equilibrium exists the accepted offer $(w_N, 0, w_S) \in \mathbb{R}^3_+$ has to be such that

$$pw_S \geq w_N \qquad (3)$$

$$pw_S + (1-p)\,\mu^2 w_N = \mu^2\,(1-p) \qquad (4)$$

The thick segment on Figure 7 depicts the contracts that satisfy all previous conditions. The lines (IC) and (FE) correspond to conditions (3) and (4). Notice that their intersection lies on $\left(w_S^2, w_N^2\right)$. Since expected salaries for the good and the bad manager are, respectively, $pw_S + (1-p)\,w_N$ and pw_S, U_G and U_B represent the indifference curves of the good and the bad manager. Consider any contract on the thick segment of (FE) different from $\left(w_S^2, w_N^2\right)$ such as contract w depicted in Figure 7. All contracts in the interior of the triangle marked with a circle are strictly preferred by the good manager and give an expected payoff strictly larger than $ps - 1$, thus constituting a profitable deviation.

6. There exists an equilibrium in which both types of manager accept offer

$$\left(w_N^2, w_F^2, w_S^2\right) = \left(\frac{\mu^2(1-p)}{1+(1-p)\mu^2}, 0, \frac{\mu^2(1-p)}{p\,(1+(1-p)\mu^2)}\right).$$

First notice that if $w_S \geq w_N$ a good manager invests efficiently and gets utility $pw_S + (1-p)\,w_N$. Thus, if one represents contracts as in Figure 8, for all contracts below the 45 degree line, a good manager's indifference curve is like the U_G negatively sloped line depicted. Consider now the bad manager. Since the bad manager invests if and only if $pw_S \geq w_N$, i.e., if the contract he accepts is below the (IC) line, his utility below the (IC) line will be w_S and above it will be w_N so that his indifference curve will be like the kinked line in Figure 8.

Consider now the indifference curves of the two types of manager passing through the contract mentioned in the claim (at the intersection of the rightmost part of (FE) and (IC) as in Figure 8). Suppose that a profitable deviation for a firm exists that attracts only the good manager. This means that there is a contract below the 45 degree line, above the indifference curve for the good manager and below the indifference curve for the bad manager. From Figure 8 it is easy to see that if the good manager prefers a contract to

$$\left(\frac{\mu^2(1-p)}{1+(1-p)\mu^2}, 0, \frac{\mu^2(1-p)}{p\,(1+(1-p)\mu^2)}\right),$$

the bad manager will too and a contradiction is obtained. Suppose now that a profitable deviation exists that attracts both types of manager. It is easy to see that any contract preferred by both types of manager will be above the full extraction condition (FE) and will therefore imply a profit less than $ps-1$ for the firm, a contradiction. It is thus clear that no profitable deviation can exist that attracts only the bad manager, and the claim follows.

Proposition 1 follows from claims 1-6. ■

A.2 Proof of Proposition 2

>From Proposition 1 we know that for any beginning of period 2's probability of the manager being good, $\mu_2 \in [0,1]$, an equilibrium of the continuation game exists and in all equilibria the manager receives an expected payoff equal to

$$\frac{\mu^2\,(1-p)\,(2-p)}{1+\mu^2\,(1-p)}$$

if he is good and equal to

$$\frac{\mu^2\,(1-p)}{1+\mu^2\,(1-p)}$$

if he is bad. Given that all second period continuation equilibria are payoff equivalent, all the statements to be proved are valid for all continuation equilibria and therefore no explicit reference to second period continuation equilibria will be made.

Consider now the continuation game that starts after a manager accepts an arbitrary first period offer $\left(w_N^1, w_F^1, w_S^1\right) \in \mathbb{R}_+^3$. Straightforward but tedious calculations show that a perfect Bayesian equilibrium of this game exists.[17] All that remains to be shown is that there exists an equilibrium for the overall game. First, consider (ρ^*, w^*), a solution to the following program:

$$\begin{aligned} \max_{\rho^1, w^1} \quad & E\left[w^1 + \delta E\left[w^2(\mu^2(\rho^1)) \mid \tau\right] \mid \rho^1, \mu\right] \qquad \text{(P)} \\ \text{s.t.} \quad & \text{Incentive Compatibility Conditions (IC)} \\ & \text{Bayes Rule (BR)} \\ & E\left[\pi - w^1 \mid \rho^1\left(w^1\right), \mu\right] = ps - 1. \end{aligned}$$

[17] The continuation equilibrium may be in mixed strategies. The proof is available upon request from the authors.

where (BR) stands for the Bayes rule that determines believes in the second period

$$\begin{aligned}
\mu^2(N) &= \frac{((1-p)(1-\rho_L)+p(1-\rho_H))\mu}{((1-p)(1-\rho_L)+p(1-\rho_H))\mu+(1-\rho_V)(1-\mu)} \\
\mu^2(F) &= \frac{\rho_L\mu}{\rho_L\mu+\rho_V(1-\mu)} \\
\mu^2(S) &= \frac{\rho_H\mu}{\rho_H\mu+\rho_V(1-\mu)}.
\end{aligned}$$

and the (IC) conditions are

$$\begin{aligned}
(1-p)w_F^1+pw_S^1-w_N^1 &\lesseqqgtr \delta\left(\frac{\mu^2(N)(1-p)}{1+\mu^2(N)(1-p)}-(1-p)\frac{\mu^2(F)(1-p)}{1+\mu^2(F)(1-p)}-p\frac{\mu^2(S)(1-p)}{1+\mu^2(S)(1-p)}\right) \\
w_F^1-w_N^1 &\lesseqqgtr \delta\left(\frac{\mu^2(N)(1-p)(2-p)}{1+\mu^2(1-p)}-\frac{\mu^2(F)(1-p)(2-p)}{1+\mu^2(F)(1-p)}\right) \\
w_S^1-w_N^1 &\lesseqqgtr \delta\left(\frac{\mu^2(N)(1-p)(2-p)}{1+\mu^2(N)(1-p)}-\frac{\mu^2(S)(1-p)(2-p)}{1+\mu^2(S)(1-p)}\right)
\end{aligned}$$

where the relation of the first condition is $\geq$, $=$, or $\leq$, depending on whether $\rho_L=1$, $\rho_L\in(0,1)$, or $\rho_L=0$, and similarly for the second and third condition.

A solution (ρ^*,w^*) to program (P) exists because: (i) the objective function and the constraints are continuous in the arguments; (ii) the arguments can be compactified (the investment profile $\rho\in[0,1]^3$, and the wages w are nonnegative and can be bounded above) and (iii) $(\rho,w)=(0,0)$ is always a valid candidate. Now, this solution (ρ^*,w^*) can be used to construct a perfect Bayesian equilibrium for the whole game: On the equilibrium path firms start offering w^*, and managers play ρ^* in response. For any other offer w, one may choose any equilibrium for that continuation game.

We now want to show that on the equilibrium path the first period investment strategy is efficient if and only if $\mu\in[\mu^*,1]$. We do this through a series of Lemmas. Notice that because we concentrate on perfect Bayesian equilibria in which the manager's ex-ante utility is maximized, in the following we require the expected wage paid by a firm in equilibrium to be such that the offering firm earns $ps-1$ in expected terms. The reason is that if an equilibrium exists in which the offering firm makes strictly more than $ps-1$, another equilibrium exists in which the offering firm makes exactly $ps-1$ but in this equilibrium the manager receives a higher ex-ante expected utility.

Lemma 2 *Suppose that there exists a $w^1\in\mathbb{R}_+^3$ such that $\rho^1(w^1)=(1,0,1)$. Then $\forall(\mu',s'):\mu'\geq\mu$ and $s'\geq\frac{1}{p}$, there exists a $w^{1\prime}\in\mathbb{R}_+^3$ such that $\rho^1(w^{1\prime},\mu)=(1,0,1)$.*

Proof. Suppose that there exists a $w^1\in\mathbb{R}_+^3$ such that $\rho^1(w^1)=(1,0,1)$. This means that

$$\begin{aligned}
w_N^1+\delta\frac{1-p}{2-p} &\leq (1-p)w_F^1+p\left(w_S^1+\delta\frac{\mu(1-p)}{1+\mu(1-p)}\right) && (5)\\
w_N^1+\delta(1-p) &\geq w_F^1 && (6)\\
w_N^1+\delta(1-p) &\leq w_S^1+\delta\frac{\mu(1-p)(2-p)}{1+\mu(1-p)} && (7)\\
\mu(1-p) &= \mu(1-p)w_N^1+(1-\mu)(1-p)w_F^1+pw_S^1 && (8)
\end{aligned}$$

It is easy to see that (5)-(8) hold for all $s\geq\frac{1}{p}$ as they are independent of s.

Now consider $\mu' > \mu$ and note that μ appears only in (5), (7), and (8). Totally differentiating (8) with respect to w_S^1 and μ and rearranging we get

$$\frac{dw_S^1}{d\mu} = \frac{1-p}{p}\left(1 - w_N^1 + w_F^1\right) \geq 0 \tag{9}$$

with the inequality following from the fact that, by (8) and non-negativity of salaries, $w_N^1 \leq 1$.

Consider now $\mu' > \mu$. By (9) one can choose $w_S^{1\prime} > w_S^1$ such that given $\left(w_N^1, w_F^1\right)$ (8) holds. Now it is easy to check that (5)-(7) are also satisfied, due to the fact that $w_S^{1\prime} > w_S^1$ and $\mu' > \mu$ and therefore

$$\frac{\mu'(1-p)}{1+\mu'(1-p)} > \frac{\mu(1-p)}{1+\mu(1-p)}.$$

■

Lemma 3 *Suppose that $\mu = \mu^* = \frac{\delta}{2+\delta-p}$. Then $\rho^1\left(w^1\right) = (1,0,1)$ if and only if*

$$\left(w_N^1, w_F^1, w_S^1\right) = \left(0, \frac{\delta(1-p)(1+\delta-p)}{(1+\delta)(2-p)}, (1-p)\frac{\delta}{1+\delta}\right).$$

Proof. Let $\mu = \mu^* = \frac{\delta}{2+\delta-p}$. From (5) and (7), substituting the full extraction constraint (8), we have

$$\begin{aligned} w_N^1 &\leq (1-p)\,\delta\frac{w_F^1(1+\delta)(2-p) - \delta(1-p)(1+\delta-p)}{(2-p)^2(1+\delta)^2} \\ w_N^1 &\leq (1-p)\frac{w_F^1(1+\delta)(2-p) - \delta(1-p)(1+\delta-p)}{(1+\delta)(-2p+p^2-\delta)} \end{aligned}$$

whose only nonnegative solution is $w_N^1 = 0$, $w_F^1 = \frac{\delta(1-p)(1+\delta-p)}{(1+\delta)(2-p)}$. It is easy to verify that this solution satisfies (6). From the full extraction condition we get $w_S^1 = (1-p)\frac{\delta}{1+\delta}$ which concludes the proof. ■

Lemma 4 *Suppose that $\mu < \mu^* = \frac{\delta}{2+\delta-p}$. Then, there exists no $w^1 \in \mathbb{R}_+^3$ such that $\rho^1\left(w^1\right) = (1,0,1)$.*

Proof. Let $(\mu, s) \in [0,1] \times \left(\frac{1}{p}, \infty\right)$ be given and consider any $w^1 \in \mathbb{R}_+^3$ such that $\rho^1\left(w^1\right) = (1,0,1)$. From (5) and (7), substituting the full extraction constraint (8), we have

$$w_N^1 \leq \frac{\mu(1-p)}{1+\mu(1-p)}w_F^1 - (1-p)\frac{\left(\mu(p-1)^2 + (1-\mu p)\right)\delta - \mu(1+\mu(1-p))(2-p)}{(1+\mu(1-p))^2(2-p)} \tag{10}$$

$$w_N^1 \leq -\frac{(1-\mu)(1-p)}{(p+\mu(1-p))}w_F^1 + (1-p)\frac{\mu(1+\mu(1-p)) - p(1-\mu)\delta}{(p+\mu(1-p))(1+\mu(1-p))} \tag{11}$$

A necessary condition for existence of $\left(w_N^1, w_F^1\right) \in \mathbb{R}_+^2$ satisfying (10) and (11) is that $w_F^1 \in \mathbb{R}_+$ exists that satisfies (10) and (11) for $w_N^1 = 0$. We therefore have

$$\begin{aligned} w_F^1 &\geq \frac{\left(\mu(p-1)^2 + (1-\mu p)\right)\delta - \mu(1+\mu(1-p))(2-p)}{\mu(1+\mu(1-p))(2-p)} \\ w_F^1 &\leq \frac{\mu(1+\mu(1-p)) - p(1-\mu)\delta}{(1-\mu)(1+\mu(1-p))} \end{aligned}$$

and a necessary condition for existence of $w_F^1 \in \mathbb{R}_+$ satisfying the above inequalities is[18]

$$\frac{\left(\mu(p-1)^2 + (1-\mu p)\right)\delta - \mu(1+\mu(1-p))(2-p)}{\mu(2-p)} \leq \frac{\mu(1+\mu(1-p)) - p(1-\mu)\delta}{(1-\mu)}$$

which can be shown to be equivalent to $\mu \geq \mu^*$. ■

[18] Notice that $\mu(1+\mu(1-p)) - p(1-\mu)\delta > 0$.

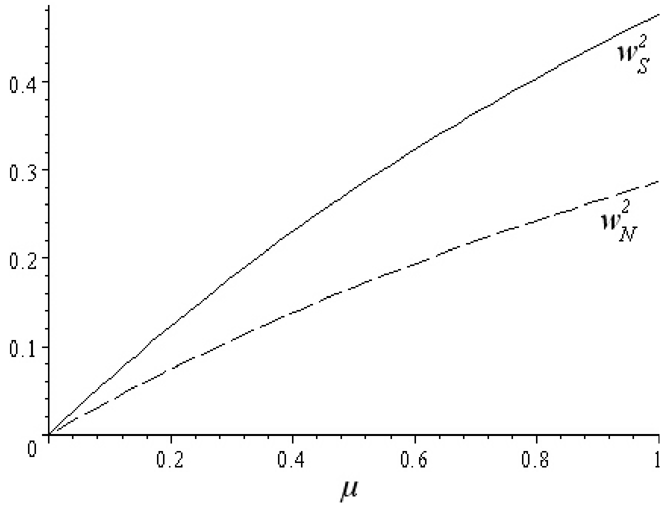

Figure 1: Second period equilibrium contracts ($w_F^2(\mu)$ is equal to 0).

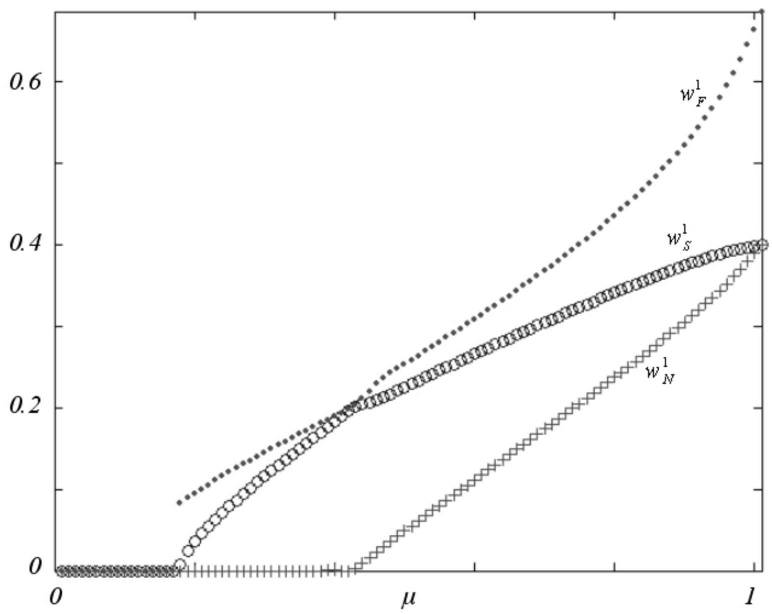

Figure 2: First period equilibrium contracts.

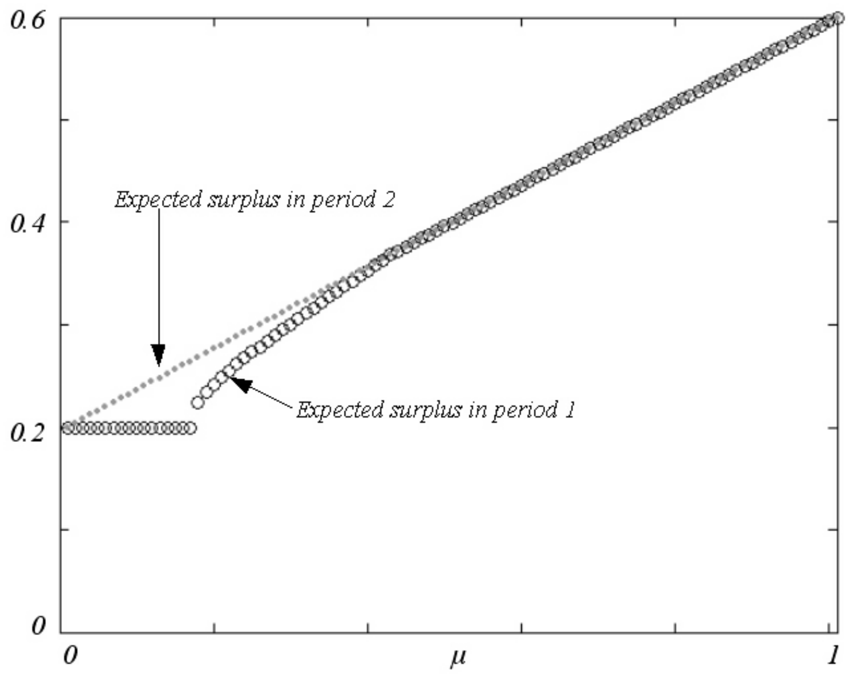

Figure 3: Equilibrium expected surplus

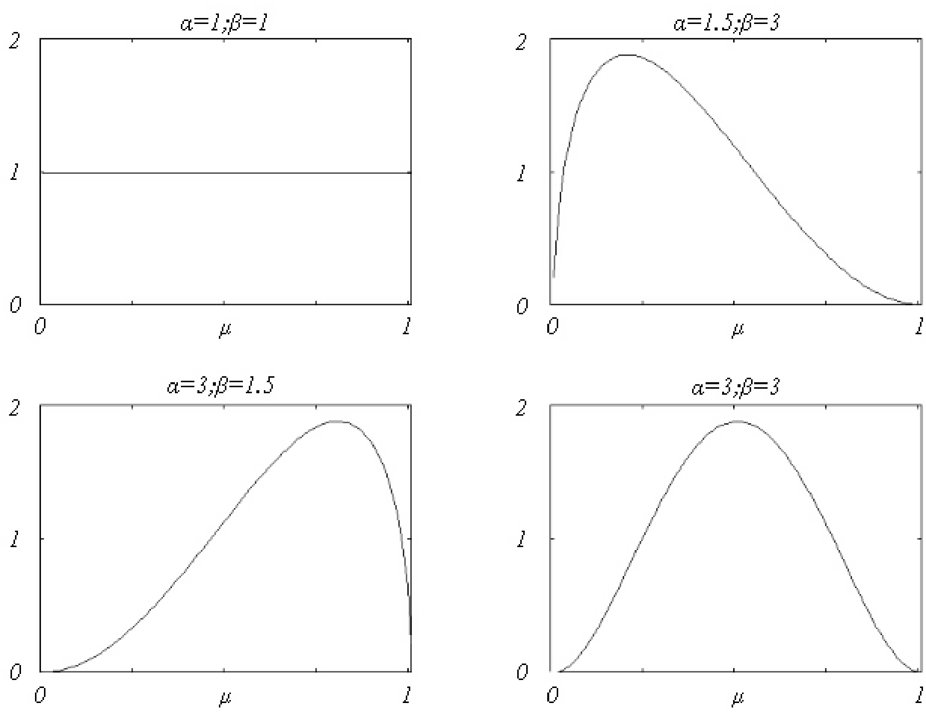

Figure 4: Density functions of Beta distributions

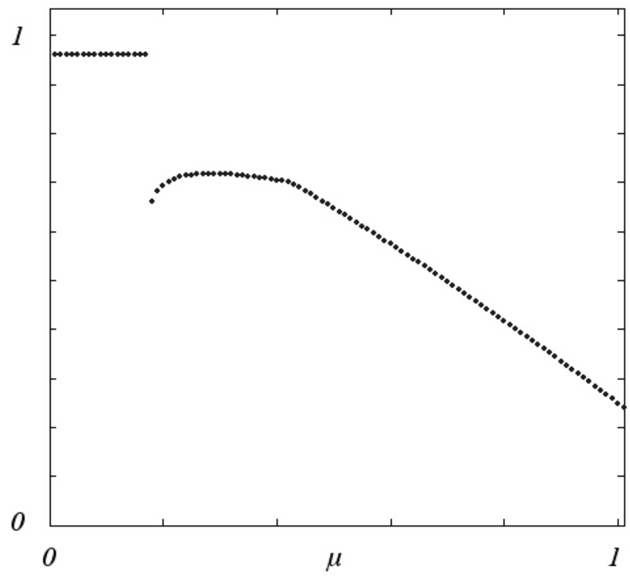

Figure 5: Variance of profits for a firm with a manager in his first period and beginning-of-period probability of being good equal to μ.

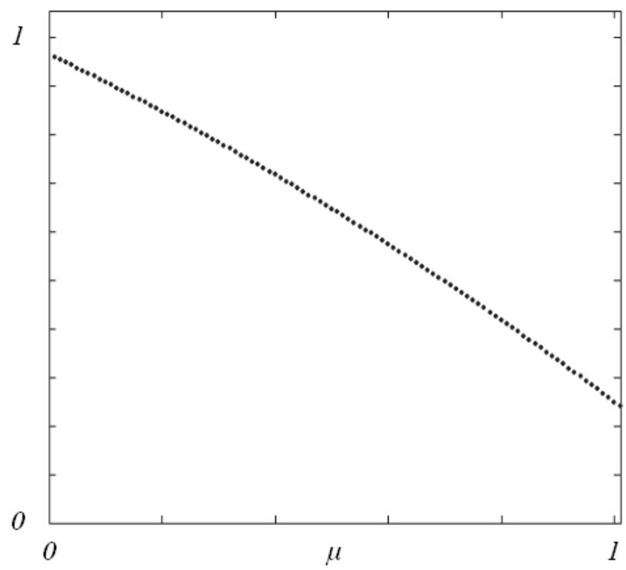

Figure 6: Variance of profits for a firm with a manager in his second period and beginning-of-period probability of being good equal to μ.

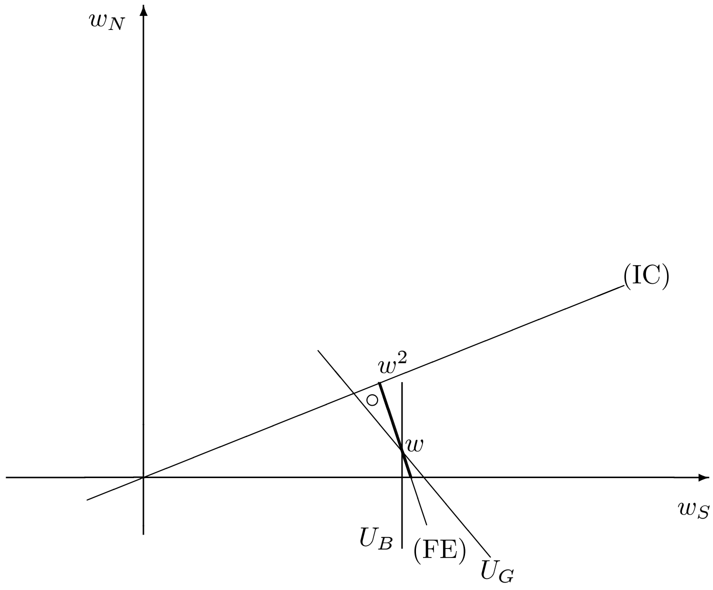

Figure 7

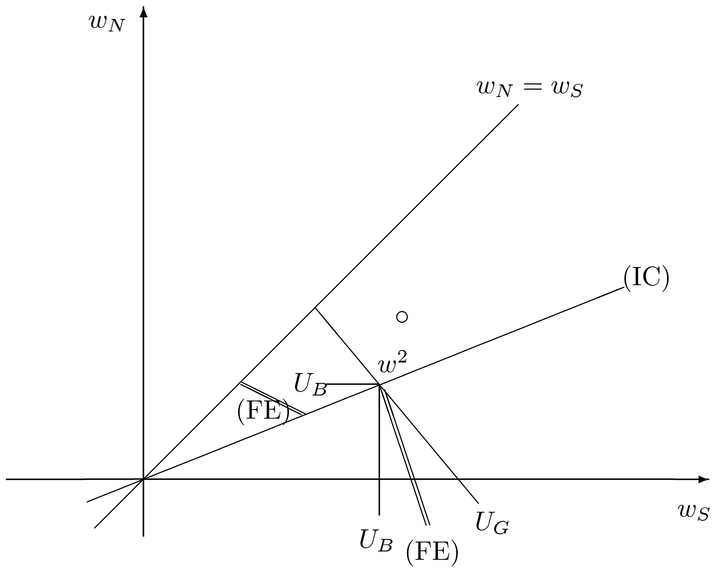

Figure 8

Table 1

Pay-Performance Sensitivities

		Profits gross of salary payments		Profits net of salary payments	
α	β	Period 1	Period 2	Period 1	Period 2
1	1	0.0292	0.1154	−0.0016	0.0850
3	1.5	0.0228	0.1483	−0.0014	0.1260
1.5	3	0.0126	0.0844	−0.0034	0.0672
3	3	0.0173	0.1190	−0.0008	0.0974

Table 2

OLS coefficients for specification (2) (salaries vs. profits gross of salary payments; average of two periods)

α	β	γ_1	γ_2	$\gamma_1 + 0.5\gamma_2$	$\gamma_1 + \gamma_2$
1	1	0.1245	−0.1251	0.0620	−0.0006
3	1.5	0.1145	−0.0769	0.0761	0.0376
1.5	3	0.1009	−0.1075	0.0472	−0.0066
3	3	0.1153	−0.1050	0.0628	0.0103