Financial structure, managerial compensation and monitoring*

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Abstract

When a firm has external debt and monitoring by shareholders is essential, managerial bonuses are shown to be an optimal solution. A small managerial bonus linked to firm’s performance not only reduces moral hazard between managers and shareholders, but also between creditors and monitoring shareholders. A negative relation between corporate bond yields and managerial bonuses can be predicted. Furthermore, the model shows how higher managerial pay-performance sensitivity goes hand in hand with greater company leverage. These predictions find support in the empirical literature.

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1 Introduction

In modern companies managers and shareholders together contribute to enhance firm’s value; they are, however, in competition when sharing the firm’s revenues, not only internally, but also with outside investors (as pointed out by Jensen and Meckling, 1976).

Designing the optimal managerial compensation has to account for this double-edged competition. While a higher compensation improves managerial effort, it also reduces the amount of resources available to reward shareholders and bondholders for their effort and investment in the firm. The impact of a managerial compensation scheme on company value crucially depends on the effect on all parties’ incentives.

There exists a literature on the interplay between managerial compensation and the financial structure of a firm (see Murphy, 1999, for a review). We depart from such literature by explicitly introducing shareholders’ monitoring. There are at least two reasons for why shareholders’ monitoring is important. First, shareholders’ monitoring on managerial effort improves company value: Core et al. (1999) find evidence that governance structures with greater control on managers improve company performance, while Huson et al. (2001) show that monitoring by shareholders increases the rate of replacement of managers in response to a poor company performance. Second, although managerial effort is essential, the empirical evidence on managerial compensation is controversial: for example Jensen and Murphy (1990) document that CEO pay-performance sensitivity is only 3.25$ per 1000$ change in shareholder value, while Hall and Liebman (1998) document an important and increasing pay-performance effect on CEOs contracts. This evidence questions in some way the effectiveness of monetary incentives alone, without shareholders’ monitoring, to enhance managerial effort.

In the paper we analyze a model where managers, providing effort, are subject to moral hazard: monetary incentives and shareholders’ monitoring motivate their effort. Given that shareholders’ monitoring is unobservable to outsiders, there is an additional moral hazard between shareholders and bondholders. In a leveraged firm, this moral hazard curtails insiders effort. Our findings show that shareholders might find it optimal to pay a bonus not only to increase their managers’effort but to
show bondholders a greater commitment towards monitoring. When managers exert a greater effort, the likelihood of company default decreases; given that shareholders are residual claimants of any benefit from monitoring when the firm is solvent, their incentive to monitor increases. Even a small managerial bonus helps to restore correct incentives for insiders, creating a virtuous circle, by reducing the cost of external debt and enhancing total company value. This benefit is greater in leveraged firms. The crucial assumption for the result is that investors observe the managerial compensation. This is based on the fact that public firms in the U.S. are obliged to disclose compensation paid to managers by the S.E.C.. The result in this paper offers a rationale for why this is beneficial when firms demand external finance.

The implications of the model find empirical support in Duru et al.(2005), Core et al. (1999) and Edwards et al.(2006) concerning the relation between managerial bonuses, corporate bond yields and leverage.

The research outlined in this paper relates to the literature on managerial compensation and financial structure of the firm (John and John, 1993; Berkovitz et al., 2000; Dessi, 2001; Calcagno and Renneboog, 2007). There the focus is on asset substitution efforts of insiders, while we focus on the monitoring effort of the owner. This has different implications for optimal managerial compensation. In the literature investigating asset substitution, shareholders and managers’ interests are aligned through an increase in the pay-performance sensitivity of managerial compensation, by means of bonuses or stock-holdings. In a leveraged firm, greater pay-performance sensitivity of managerial compensation increases the cost of debt since bondholders anticipate the increased asset substitution attitude of managers; thus pay-performance sensitivity must decrease with the level of debt. Here, instead, it is shown that a greater sensitivity to company revenues improves not only managerial effort, but - most importantly - shareholders’ monitoring, reinforcing insiders’ incentives to exert extra effort. This has a positive consequence on the cost of debt. While a managerial bonus alone introduces a problem of competition for scarce resources between company insiders and outsiders, shareholders’ monitoring helps to mitigate this competition.

The idea of efficiency wages (see Shapiro and Stiglitz, 1984, and subsequent papers) is here applied to managerial compensation schemes: managers’ moral hazard is curbed through monetary incentives, but in addition shareholders monitor and punish
their managers when any shirking is detected. This paper underlines the importance of insiders’ monitoring as in the literature on shareholders’ monitoring (see for instance Huddart, 1993; Aghion and Tirole, 1997; and Burkart et al., 1997). Although we share the opinion expressed in the literature that the efforts of shareholders and managers are both essential for the project, we differ in that we believe that the efforts are complementary, and we thus focus on the case of under-provision of monitoring.

Finally we share some insights with the literature on financial structure as incentive mechanism (Dewatripont and Tirole, 1994), and on debt as an optimal incentive mechanism when insiders exert unobservable effort (Innes, 1990). In this paper, we add the interaction between managerial effort and the efforts of the owners.

The remainder of the paper is organized as follows: Section 2 describes the basic model, Section 3 analyzes the equilibrium efforts and debt rate, and Section 4 solves for the optimal managerial compensation. Section 5 analyzes the effect of changes in leverage on the optimal managerial compensation. Section 6 extends the basic model from single project to greater number of projects. The empirical predictions of the model are contained in Section 7 and concluding remarks in Section 8.

2 The setup

Consider a three-date economy \((T = 0, 1, 2)\) with three types of agents: entrepreneurs, investors and managers. Entrepreneurs, without capital, start up risky projects. Investors have capital to invest. Managers can enhance the success of the risky project. Each entrepreneur hires a manager to run a project and raises funds from investors.

Each risky project in the economy requires 1 unit of capital at date 0 and returns \(R\) at date 2 with probability \(p\). This probability depends on the combined efforts of the manager and the entrepreneur.

The manager exerts an effort \(e \in [0, 1]\) at a private cost \(E e^2\) with \(E \geq 0\). The entrepreneur has access to a monitoring technology: by monitoring with intensity \(m \in [0, 1]\), he detects with probability \(m\) misbehavior by his manager. The monitoring effort costs \(M m^2\) with \(M > 0\). Finally \(E \geq M > 0\) since running a project requires at least the same amount of time as monitoring it.\(^1\) The two costly efforts,

\(^1\) Note that assumption \(E > M\) implies that the entrepreneur could be better off by firing the
monitoring and managerial effort, cannot be observed outside the firm: given that the entrepreneur cannot observe the behavior of the manager without costs and investors cannot observe neither of the two insiders’ efforts, a double moral hazard is present in the model.

The combined impact of the effort of the manager and of the monitoring of the entrepreneur is captured by the probability of success of the project $p \in [p_L, p_H]$ with $\Delta \equiv p_H - p_L > 0$. However the specific form of the probability derives from the outcome of the strategic interaction of the manager and of the entrepreneur, as it will become clear in the next sub-section.

We assume that the minimum expected return of the risky project, when zero effort is exerted, is lower than the gross return from an alternative value preserving investment returning 1 with certainty, i.e.

$$ p_L R < 1; \quad \text{(A1)} $$

while the maximum expected return, net of the cost of effort, is greater than the alternative return

$$ p_H R - \frac{E}{2} > 1. \quad \text{(A2)} $$

The timing of the model is as follows. At the beginning of date 0, the entrepreneur sets the managerial compensation. Then the entrepreneur raises funds from perfectly competitive capital markets and at date 1 entrepreneur and manager choose, respectively, monitoring effort $m$ and managerial effort $e$. Effort choices are not observable, while returns from projects are observable to outsiders. At date 2 project returns are realized and claims are settled. Figure 1 summarizes the timing of the model.

Insert Figure 1

With this timing we assume that investors observe the managerial compensation. The model is solved backwards: equilibrium effort, monitoring and return to investors are computed for given managerial compensation. Then, entrepreneur’s optimal choice of managerial compensation is resolved.

manager and running the project by himself. In the paper we show that, although the managerial effort is more costly than the entrepreneurial effort, inducing a positive managerial effort is optimal in order to reduce the cost of external finance.
2.1 Managerial compensation

The manager, who responds to monetary incentives, is offered a managerial compensation, sum of a fixed salary and a bonus. The fixed salary is set equal to the zero outside option of the manager. The managerial bonus \( b \in [0, R] \) is by contract dependent on the observable return of the project and it is paid whenever the project succeeds. However the entrepreneur retains the option to fire the manager, when, as a result of monitoring, he detects misbehavior by the manager.\(^2\) The project’s probability of success switches to \( \phi \in [p_L, p_H] \), depending on the average ability of outside managers, when the old manager is fired and replaced by a new manager from outside.

The entrepreneur and the manager choose their efforts non-cooperatively and simultaneously. Figure 2 depicts the strategic interaction of the entrepreneur and of the manager as well as their gross revenues, for given effort choices.

From Figure 2 we derive the specific form of the probability of success of the project

\[
p = p_L + e\Delta + m(1 - e)(\phi - p_L). \tag{1}
\]

The probability of success is \( p_H \) when the manager exerts maximum effort, while \( p_L \) when the manager shirks without being detected; otherwise, the probability is \( \phi \) if the manager is fired and replaced by another one. Expression (1) shows the benefit of monitoring: monitoring improves the success probability of the project by detecting shirking and replacing the old manager with a more efficient one. This benefit is larger the greater the probability of shirking and the higher the quality of outside managers, \( \phi > p_L \).

For given managerial compensation, the expected utility of the manager is

\[
u = q b - \frac{E}{2} e^2, \tag{2}\]

where \( q = ep_H + (1 - e)(1 - m)p_L \) is the probability that the manager is rewarded the bonus. When the manager exerts effort \( e \), he earns the managerial bonus with

\(^2\)The decision to fire the manager is at the entrepreneur’s discretion. This is in line with the empirical fact that managerial contracts are riskier when compared to workers’ labor contracts. In particular there is no “good cause” clause in the managerial contract, while this is required in the worker’s contract.
probability $p_H$; if he shirks his duties and the entrepreneur does not detect him, he earns the managerial bonus with probability $p_L$; finally he is not paid the bonus when fired with probability $m(1 - e)$. Notice that the probability of pocketing the bonus for the insider manager is lower compared to the success probability of the project, that is $q - p = -m(1 - e) \phi < 0$. The reason is, the project might still succeed due to the new manager’s effort, but the old manager is not rewarded the bonus because he is fired. In this case the bonus is still paid conditional on success but to the new manager.

2.2 Financing of the firm

To derive the expected profit of the entrepreneur we need to consider the financing of the firm. To start the project, the entrepreneur with $\omega$ units of inside equity issues $D = 1 - \omega$ units of debt on perfectly competitive financial markets. For each unit, the debt claim promises to pay a face value $r$ on date 2 whenever the project is successful, due to limited liability by the entrepreneur. The expected profit of the entrepreneur (the owner or the main shareholder of the firm) can be expressed as

$$
\pi = p(R - b - rD) - \omega - \frac{M}{2}m^2,
$$

(3)

where the first term represents the expected total return from the project net of managerial bonus and repayment to debt-holders, the second term is the opportunity cost of entrepreneur’s capital and the third term is the monitoring cost. Expression (3) shows the competition for project revenues between managers and investors; a larger managerial bonus shrinks the amount of revenues to repay investors for given probability of success of the project. However, the probability of success of the project is not constant but it changes with monitoring and managerial effort.

In addition, expression (3) shows the risk of default of debt. Since the entrepreneur is subject to limited liability but invests in a risky project, debt-holders earn the promised face value $r$ only with probability $p$: greater monitoring and managerial effort lead to greater probability of honoring the debt and smaller probability of default.

\[3^3\text{This assumption guarantees that the entrepreneur will not fire the manager too often, given that the monitoring outcome is non-observable. After firing a manager, the entrepreneur hires another manager and pays him exactly the same bonus: thus he will not fire the old manager to save the bonus.}\]
Anticipating the probability of default, investors require their claim to return at least the alternative return $1$, that is

$$pr = 1.$$  \hfill (4)$$

When investors anticipate a greater probability of success, they demand a smaller face value of debt given condition (4), and this releases resources for insiders, either managers or shareholders.

### 3 Equilibrium efforts and debt rate

We now turn to the equilibrium effort choices, monitoring and managerial effort, and to the equilibrium debt rate, for a given managerial bonus $b$.

The entrepreneur and the manager choose simultaneously and non-cooperatively their efforts; then investors, anticipating the equilibrium efforts, set the debt rate at a competitive rate. We characterize the equilibrium of the game in the following Proposition:

**Proposition 1** The equilibrium in which the manager exerts effort $\hat{e}$, the entrepreneur exerts monitoring effort $\hat{m}$ and pays to investors the debt rate $\hat{r}$, is characterized by the solution to the following equations:

$$[\Delta + \hat{m} p_L] b - E\hat{e} = 0,$$  \hfill (5)$$

$$\Delta(\phi) [1 - \hat{e}] [R - b - \hat{r} D] - M\hat{m} = 0,$$  \hfill (6)$$

$$\hat{p}\hat{r} = 1.$$  \hfill (7)$$

where $\Delta(\phi) \equiv \phi - p_L$ is an increasing function in $\phi \in [p_L, p_H]$ attaining its maximum value at $\Delta \equiv \Delta(p_H)$ and where

$$\hat{p} = p_L + \hat{e}\Delta + \hat{m} [1 - \hat{e}] \Delta(\phi)$$  \hfill (8)$$

is the equilibrium probability of success of the risky project.

**Proof.** See in Appendix A.

Eq.(5) shows that, for a given bonus, the effort of the manager improves with monitoring: greater monitoring increases the probability that the manager is caught shirking and thus fired, inducing a greater managerial effort.
Eq.(6) shows that, for a given bonus and debt rate, the benefit of monitoring depends negatively upon the managerial effort due to a free-riding problem: a greater managerial effort improves the probability of success of the project without costs for the entrepreneur, while monitoring entails a positive private cost. The entrepreneur prefers the manager to exert the effort to save his private cost of monitoring.

Finally, according to eq.(7), in equilibrium investors adjust the debt rate in competitive financial markets so that the expected return from risky debt equals the alternative return 1.

Once we substitute the equilibrium efforts, monitoring and debt rate in eq.(3) the equilibrium expected profit of the entrepreneur is:

\[
\tilde{\pi}(b) = \tilde{p}(b)(R - b) - 1 - \frac{M}{2}\tilde{m}(b)^2,
\]

(9)

We now turn to the analysis of the optimal managerial compensation.

4 Optimal managerial compensation

For a given debt rate an increase in the level of the bonus has a positive impact on managerial effort, but a negative impact on monitoring. We can see this from Figure 3 where the best reply functions are drawn from equations (5) and (6):

Insert Figure 3

The Nash equilibrium is defined as the intersection between the two best reply functions. For a given debt rate, as the level of the bonus rises from 0 to \(b > 0\), the equilibrium moves from \(Q\) to \(N\), where the effort of the manager is higher, while monitoring is lower: the two efforts are substitutes since the bonus improves managerial effort, reducing the benefit of monitoring.

When we allow for a change in the debt rate, the effect of a greater managerial effort on the monitoring may vary. A greater managerial effort increases the probability of success of the project, reducing the face value of debt anticipated by investors; then the marginal benefit of monitoring rises inducing greater monitoring. The implication in term of Figure 3 is that the vertical intercept of the entrepreneur’s best reply function shifts up as a consequence of a lower debt rate. The intersection of the two functions takes place at a higher monitoring level, in point \(P\) instead of \(N\) and the two equilibrium efforts become complements.
This result derives from the effect of a larger bonus on the size of the moral hazard between entrepreneur and investors. For a given debt rate, the marginal benefit of monitoring is partially appropriated by investors, as a greater monitoring reduces the probability of default of the risky debt, investors are paid more often the face value, but this reduces the monitoring effort of the entrepreneur. The severity of this moral hazard depends on the size of the managerial bonus. A greater bonus reduces this dis-incentive to monitor.

This consideration is important when we analyze changes in the level of the managerial bonus. At date 0 the entrepreneur sets the level of the managerial bonus to maximize his expected profit in (9) by anticipating effort choices and debt rate.

It is possible to show cases where the equilibrium expected profit increases with the bonus. Due to the highly non-linear nature of the closed-form solution of the equations (5)-(7), we use numerical simulations. We compute the equilibrium expected profit for different values of the managerial bonus in the case of a project entirely financed through debt, given parameters \( p_L = 0.6, p_H = 0.9, \phi = 0.85, R = 1.65, M = 0.1 \) and \( E = 0.18 \). When the managerial bonus is \( b = 0 \) in equilibrium the manager does not exert any effort, while the entrepreneur’s monitoring effort is \( \hat{m}(0) = 0.06 \): expected profit is close to zero \( \hat{\pi}(0) = 0.014 \). If the managerial bonus is set at \( b = 0.05 \), the manager exerts effort \( \hat{e}(0.05) = 0.2 \) and the entrepreneur monitors with intensity \( \hat{m}(0.05) = 0.7 \) earning profit \( \hat{\pi}(0.05) = 0.25 > 0.014 \). The result hinges on the beneficial effect of the bonus on the cost of external finance. Investors who observe the managerial bonus anticipate its beneficial effect on the success probability of the project and demand a lower debt rate. The debt rate falls from \( \hat{r}(0) = 1.62 \) to \( \hat{r}(0.05) = 1.25 \) as the bonus rises. This reduces the share of revenues for investors and improves the entrepreneur’s incentive to monitor. As a matter of fact \( b = 0.05 \) is the optimal bonus as it maximizes the expected profits in (9).

The impact of a greater managerial bonus on the monitoring intensity in equilibrium can be separated into two effects, one negative, one positive. The negative effect derives from the direct impact on the project revenue: given the monitoring effort a higher managerial bonus implies a greater share of project return to the manager, improving manager’s effort but conversely reducing the incentive of the entrepreneur to monitor. The positive effect derives from the impact on the moral hazard be-
tween entrepreneur and investors: a greater bonus increases the effort of the manager reducing the probability of default on the debt, thus strengthening the monitoring incentive of the entrepreneur. We have shown an example where the positive effect dominates and monitoring increases.

This result is based on the observation that a larger managerial bonus has a positive impact on the probability of success of the project. We can state the following result.

**Proposition 2** There exists a threshold value $\bar{m} \in (0, 1)$ such that the probability of success with the managerial bonus is higher than without it, $\widehat{p}(b) > \widehat{p}(0)$, if the entrepreneur monitoring effort with the bonus $\hat{m}(b)$ is greater than $\bar{m}$.

**Proof.** See in Appendix A.

To conclude, investors, anticipating that with the bonus the manager exerts a higher effort and that a smaller probability of default of the project increases the monitoring effort of the entrepreneur, demand a lower interest rate. This reduces the cost of external finance and improves, in equilibrium, the expected profit. The bonus serves as an optimal commitment to increase the monitoring effort of the entrepreneur.

5 Leverage

The model shows the optimality of managerial bonuses as a way for the entrepreneur to commit to a higher level of monitoring level. This result depends on the level of debt over total assets, i.e., the firm’s leverage. Proposition 2 shows that the benefit of the managerial bonus may be important enough to achieve greater probability of success. To see when this result occurs, we conduct a comparative statistic exercise.

**Proposition 3** The threshold $\bar{m} \in (0, 1)$ decreases with the amount of debt $D$.

**Proof.** See in Appendix A.

As the level of debt increases, the moral hazard problem of the entrepreneur becomes more acute; at the equilibrium the level of monitoring decreases. This reduces the equilibrium profit. An increase in the managerial bonus increases the managerial
effort and thus ameliorates the moral hazard of the entrepreneur. This reduces the cost of external finance and increases the equilibrium expected profit.

Figure 4 shows the entrepreneur’s equilibrium expected profit, while Figure 5 the entrepreneur’s equilibrium monitoring effort, as functions of the managerial bonus for levels of debt $D = 0$ and $D = 1$.

Insert Figure 4 and Figure 5

Figure 4 shows that the expected profit with $D = 0$ is always higher than with $D = 1$ since in the first case one of the two moral hazard problems is not present. The result of the optimality of a positive level of the bonus is due to leverage, as with $D = 0$ the equilibrium expected profit is decreasing in the bonus. Given that debt is risky, debt-holders expect not to be paid the face value $rD$ whenever the project fails: expected shortfalls on debt are $rD(1 - p)$. The greater this term, the greater the moral hazard of the entrepreneur. In Figure 5 expected shortfalls for debt-holders are drawn together with the monitoring intensity of the entrepreneur. Monitoring intensity and expected shortfalls are inversely correlated when $D = 1$, implying that the optimality of the bonus depends on its effect on the moral hazard of the entrepreneur. When $D = 0$ instead expected shortfalls are zero for any level of the bonus and this effect is absent.

The optimal managerial bonus is larger in firms with greater leverage. Conversely, the larger the inside equity the smaller the moral hazard of the entrepreneur.

The same can be shown referring to Figure 3 when $D = 0$. Starting from $b = 0$, as the bonus increases to $b > 0$ the equilibrium switches from Q to N. In equilibrium the level of monitoring decreases while managerial effort improves (only substitution effect). In this case there is neither the benefit from external finance nor a role for the managerial bonus. The beneficial effect of the bonus derives from the impact on the debt rate through an upward shift of the best reply function of the entrepreneur. This proves that leverage is essential for the beneficial effect of the bonus.

6 Extension: a larger number of projects

The result on the optimal managerial bonus may depend upon the size of the firm or the degree of diversification of firm’s projects. We extend the basic model from
single project to 2 projects to see how the result in the previous section is affected by a change in the number of independent projects.

We consider two cases: case A where the degree of diversification is increased at given size of the firm and case B where an increase in the degree of diversification is associated to a greater size.\footnote{In the real world projects can be selected from more or less correlated opportunities. This choice corresponds to compare for given leverage case A (non correlated projects) with the case in the previous section (perfect correlation among projects). See for instance Hellwig (1998) for a model where this choice is analyzed in a setting without delegation.}

**Case A:** To analyze the effect of a greater diversification of projects without changing the size of the firm, we assume that the entrepreneur invests one unit of capital into 2 independent projects each one returning \( \frac{R}{2} \) with probability \( p \), 0 otherwise. The entrepreneur assigns each project to a different manager. From the financing side nothing changes as the entrepreneur with \( \omega \) units of inside equity issues \( D = 1 - \omega \) units of debt on perfectly competitive markets returning a face value \( r \) on date 2.\footnote{While in the single project case debt and outside equity are equivalent financial contracts, this is not true anymore in the 2 projects case where debt dominates outside equity as incentive contract. We use the result in Innes (1990) who shows that debt is the optimal solution when the entrepreneur exerts a non-observable and costly effort.}

The distribution of total returns from projects now is different from the model with a single project as the revenues come from the sum of two independent projects. Given total returns from projects, net of managerial bonus payments, \( Z \), the expected profit of the entrepreneur can be expressed as

\[
\pi = E \max \{ Z - rD, 0 \} - \omega - \frac{M}{2} \sum_{i=1}^{2} m_i^2, \quad i = 1, 2. 
\]

(10)

where the first term represents the expected total returns from the 2 projects net of the return to debt-holders, the second term is the opportunity cost of entrepreneur’s capital and the last term is the sum of monitoring costs. Similarly to the single project case, we characterize the symmetric equilibrium of the game with 2 projects (leaving the details in Appendix B).

Given non-linearity of the equilibrium conditions, we proceed with numerical simulations. In the same numerical example as that in Section 4, for the entrepreneur starting 2 projects instead of one, the optimal bonus when \( D = 1 \) is \( b = 0.21 \) compared to \( b = 0.05 \) in the single project case. In the case of two projects there are
two contrasting effects: on one hand firm’s revenues distribution is more concentrated around its mean, as a result of diversification, and this helps in curbing the moral hazard between debt-holders and shareholders (as shown in Cerasi and Daltung, 2000); on the other hand the agency costs inside the firm increase due to convexity of monitoring costs as shareholders have to monitor two managers instead of one.\(^6\) In this numerical example this second effect dominates the first one and, as a result, the optimal bonus is greater than in the single project case.

Case B: Let us now consider the case where the size of the firm and the degree of diversification are correlated. This implies studying the case of an entrepreneur who invests 2 units of capital into 2 independent projects each one returning \(R\) with probability \(p\), 0 otherwise. The entrepreneur assigns each project to a different manager. From the financing side the entrepreneur with \(\omega\) units of inside equity issues \(D = 2 - \omega\) units of debt on perfectly competitive markets returning per unit a face value \(r\) on date 2. The expression of the expected profit of the entrepreneur is unchanged relatively to expression (10), however the distribution of total revenues from projects changes as the return in case of success is now doubled (it is enough to substitute \(2R\) instead of \(R\) in all the expressions in Appendix B). Given that \(D = 1\), when investing into 2 projects the leverage of the firm decreases as debt is diluted on a larger base of assets. From the result in the previous section we know that the optimal managerial bonus decreases with leverage, therefore we expect the optimal bonus to be smaller in this case compared to case A. As a matter of fact in the same numerical example as that in Section 4, for the entrepreneur starting 2 projects, the optimal bonus with \(D = 1\) is \(b = 0\) in case B instead of \(b = 0.21\) in case A.

Finally it is easy to show that in both cases A and B when \(D = 0\) the optimal managerial bonus is \(b = 0\), although equilibrium expected profits are lower in the case of 2 projects due to the convexity of monitoring costs.

\(^6\)Following Laux (2001) one could show however that assigning 2 projects to the same manager and giving him a managerial contract where he is rewarded the bonus only if both projects succeed might reduce the agency costs.
7 Empirical implications

The model has numerous empirical predictions on the level of managerial compensation. This paper shares with others (e.g., John and John, 1993) the implication that managerial compensation and financial structure of the firm are to be studied together. This implication finds empirical support in Hartzell and Starcks (2003).

The model predicts that leveraged firms paying higher bonus to their managers have a lower cost of external debt. Evidence of a negative cross-sectional relation between managerial bonus and returns to bondholders is supportive of our model. Duru et al. (2005) find that larger managerial bonuses are associated with lower corporate bond yields and conclude that managerial bonuses help reduce the cost of external debt in contrast with the empirical evidence on the relation between managerial stock-holdings and bond yields (see, for instance, De Fusco et al., 1990, among others).

Another prediction of the model is that, the higher the leverage, the greater the level of managerial bonus: as the acuteness of moral hazard increases, insiders shift the greater risk of default onto creditors due to limited liability. A greater managerial bonus serves to increase insiders’ incentives. There is empirical evidence that more leveraged firms pay higher managerial bonuses to their managers. Again Duru et al. (2005) find that more leveraged firms tend to pay greater managerial bonuses to their managers. Other papers, such Mehran (1992) and Berger et al. (1997), point out that managers in more leveraged firms have greater pay-performance sensitivity compensation. Evidence in support of the model is that managers in firms owned by a small number of shareholders - i.e., closely held firms - are rewarded with lower bonuses as shareholders’ incentives to monitor are greater. Core et al. (1999) report that CEO pay-performance sensitivity is lower in firms with larger numbers of monitoring shareholders. Edwards et al. (2006) find that pay-performance sensitivity measured on managerial bonuses decreases when there are large independent shareholders. Furthermore, in management buyouts, that is in LBOs where the same management runs the company, greater leverage is accompanied by the adoption of greater pay-performance incentives for managers (see Kaplan, 1989).

Finally, a prediction of the model is that larger firms, when the increase in size is not accompanied by a greater leverage, should pay lower managerial bonuses. Al-
though not a direct test of this prediction, Jensen and Murphy (1990) report empirical
evidence that in larger firms the average sensitivity of managerial compensation to
change in shareholders wealth is 1.85\$ compared with the figure of 8.05\$ in smaller
firms. Further, Rose and Shepard (1997) show that changes in incumbent CEO comp-
ensation levels are negatively correlated with changes in the degree of corporate
diversification.

8 Conclusion

This paper analyses the optimal level of managerial bonus when firms are leveraged.
When monitoring by shareholders is essential, although subject to moral hazard,
managerial bonus provides a commitment to exert greater effort by insiders towards
external claim-holders. The model predicts greater managerial pay-performance sen-
sitivity, the greater the leverage.

Throughout the analysis we have assumed that managers are paid out of project
revenues before bondholders, namely that they are senior compared to other creditors.
In the model with a single project this assumption is neutral, while it is crucial for
the model with two projects. One possible effect of a different seniority of managerial
bonuses is that managers could be punished not only when shirking, but also when
the firm is unable to repay bondholders (see for instance John and John, 1993; and
Calcagno and Renneboog, 2007). The optimal priority of claims structure is out of
the scope of this paper and requires further investigation.

In the model with 2 projects we have assumed that each manager is assigned to
a single risky project. Laux (2001) shows that assigning more than one project to
each manager could be optimal, because it increases the set of states in which the
entrepreneur can punish the manager. The interaction between internal hierarchy
and managerial compensation is left to future research.

Finally, in this paper we have focused on managerial bonuses while ignoring other
forms of pay-performance incentives, such as stock-options or direct stock-holdings to
managers. Given our simple setup, where each manager is assigned to only one project
and project returns are dichotomic, our bonus variable can be easily re-interpreted
as managerial equity holdings. In a more general setup, we would have to distinguish
between the different forms of managerial pay-performance compensation.
A Proofs

Proof of Proposition 1: For a given debt rate $r$ and monitoring intensity $m$, the manager chooses the effort to maximize his utility in (2):

$$\frac{\partial u}{\partial e} = (\Delta + mp_L)b - Ee = 0. \quad (11)$$

For a given debt rate $r$ and managerial effort $e$ the entrepreneur chooses the monitoring intensity to maximize profit in (3), that is

$$\frac{\partial \pi}{\partial m} = \Delta(\phi)(1 - e) [R - b - rD] - Mm = 0, \quad (12)$$

The Nash equilibrium is given by the couple of efforts $(\hat{m}, \hat{e})$ solution to (12) and (11). In addition investors require their expected return to be equal to 1 as in (4). They rationally anticipate that the equilibrium effort is $\hat{e}$ and monitoring $\hat{m}$. Substituting equilibrium efforts in the investors’ rationality condition in (4) gives (7). □

Proof of Proposition 2: From equilibrium conditions in Proposition 1, substituting (7) into (6) gives

$$\Delta(\phi) \left[ R - \frac{D}{\hat{p}(b)} \right] = M \frac{\hat{m}(b)}{(1 - \hat{e}(b))} + b\Delta(\phi) \quad (13)$$

where $\hat{p}(b)$ is given by (8). When $b = 0$ the above condition collapses to

$$\Delta(\phi) \left[ R - \frac{D}{\hat{p}(0)} \right] = M\hat{m}(0) \quad (14)$$

with $\hat{p}(0) = p_L + \hat{m}(0)\Delta(\phi)$ since $\hat{e}(0) = 0$. We can compare $\hat{p}(0)$ and $\hat{p}(b)$ by using (13) and (14). It follows that $\hat{p}(b) > \hat{p}(0)$ if

$$\frac{\hat{m}(b)}{(1 - \hat{e}(b))} + b\frac{\Delta(\phi)}{M} > \hat{m}(0).$$

It is useful to define the LHS of the above disequality, after substituting (5), as a generic function of $m \in [0,1]$

$$g(m) = \frac{m}{1 - \frac{b}{E}(\Delta + mp_L)} + \frac{b}{M}\Delta(\phi).$$

When $1 - \frac{b}{E}\Delta > 0, g'(m) > 0$ and $g''(m) > 0$ for any $m$ with $g'(0) > 1$. For a small $b$, $b \leq \hat{m}(0)\frac{M}{\Delta(\phi)}$, there must exists a $\overline{m} \in [0,1]$ such that $g(\overline{m}) = \hat{m}(0)$ : then $g(m) > \hat{m}(0)$ for all $m > \overline{m}$ where $\overline{m} \equiv g^{-1}(\hat{m}(0))$. This implies that $\hat{p}(b) < \hat{p}(0)$ if $\hat{m}(b) < \overline{m}$ and $\hat{p}(b) > \hat{p}(0)$ if $\hat{m}(b) \geq \overline{m}$. For a larger $b$, $\frac{E}{\Delta} > b > \hat{m}(0)\frac{M}{\Delta(\phi)}$, $g(m) > \hat{m}(0)$ for all $m$, thus $\hat{p}(b) > \hat{p}(0)$ always. □

Proof of Proposition 3: From the proof of Proposition 2, $\overline{m}$ is defined as $\overline{m} = g^{-1}(\hat{m}(0))$. Since $g(m)$ is an increasing monotonic function, $\overline{m}$ behaves like this as well. It follows that $\overline{m}$ increases with $\hat{m}(0)$. From equation (14) it can be easily seen that $\hat{m}(0)$ decreases with $D$. □
B Profits with 2 projects

Total return on projects, net of managerial bonus payments, \( Z \), has the Binomial distribution

\[
Z = \begin{cases} 
0 & (1 - p_i)(1 - p_{-i}) \\
\frac{R}{2} - b & p_i(1 - p_{-i}) + p_{-i}(1 - p_i) \\
R - 2b & p_i p_{-i}
\end{cases}
\]

and average equal to

\[
E(Z) = (p_i + p_{-i}) \left( \frac{R}{2} - b \right),
\]

where \( p_i \) is given by (1), \( i \in \{1, 2\} \) and \( i \neq -i \). Given the probability distribution of \( Z \) expected profit in (10) can be rewritten as

\[
[R - 2b - rD] p_i p_{-i} + \max \left\{ \frac{R}{2} - b - rD, 0 \right\} [p_i(1 - p_{-i}) + p_{-i}(1 - p_i)] - \omega - \frac{M}{2} \sum_{i=1}^{2} m_i^2
\]

while debt-holders’ expected return is constrained by the condition:

\[
rp_i p_{-i} + \frac{1}{D} \min \left\{ rD, \frac{R}{2} - b \right\} [p_i(1 - p_{-i}) + p_{-i}(1 - p_i)] = 1
\]

For a given debt rate \( r \) and monitoring intensity \( m_i \), each manager chooses the effort to maximize his utility in (2):

\[
\frac{\partial u_i}{\partial e_i} = (\Delta + m_i p_L) b - E e_i = 0, \quad i = 1, 2.
\]

For a given debt rate \( r \) and managerial effort \( e_i \) the entrepreneur chooses the monitoring intensity to maximize expected profit in (16), that is

\[
\frac{\partial \pi}{\partial m_i} = \left\{ [R - 2b - rD] p_{-i} + \max \left\{ \frac{R}{2} - b - rD, 0 \right\} (1 - 2p_{-i}) \right\} \left(1 - e_i\right) \Delta(\phi) - M m_i = 0,
\]

for \( i = 1, 2 \). The symmetric Nash equilibrium is given by the solution to (18) and (19) when \( e_i = e_{-i} = \hat{e} \) and \( m_i = m_{-i} = \hat{m} \). The system of equations that defines the equilibrium, once substituting symmetric efforts into the investor rationality condition in (17), is given by

\[
\left\{ [R - 2b - \hat{r}D] \hat{p} + \max \left\{ \frac{R}{2} - b - \hat{r}D, 0 \right\} (1 - 2\hat{p}) \right\} \left(1 - \hat{e}\right) \Delta(\phi) - M \hat{m} = 0
\]

for \( i = 1, 2 \). The symmetric Nash equilibrium is given by the solution to (20) and (21) when \( e_i = e_{-i} = \hat{e} \) and \( m_i = m_{-i} = \hat{m} \). The system of equations that defines the equilibrium, once substituting symmetric efforts into the investor rationality condition in (17), is given by

\[
\left\{ [R - 2b - \hat{r}D] \hat{p} + \max \left\{ \frac{R}{2} - b - \hat{r}D, 0 \right\} (1 - 2\hat{p}) \right\} \left(1 - \hat{e}\right) \Delta(\phi) - M \hat{m} = 0
\]

and

\[
\hat{r} \hat{p}^2 + \frac{1}{D} \min \left\{ \hat{r}D, \frac{R}{2} - b \right\} 2\hat{p}(1 - \hat{p}) = 1
\]
where \( \hat{p} \) is given by (8). We have to distinguish between two cases, depending on whether \( \hat{r}D \) is above or below \( \left( \frac{R}{2} - b \right) \).

Case (a): \( \hat{r}D < \frac{R}{2} - b \). Equilibrium conditions (21) and (22) simplify to:

\[
(1 - \hat{e}) \Delta(\phi) \left[ \left( \frac{R}{2} - b \right) - \hat{r}D(1 - \hat{p}) \right] - M \hat{m} = 0, \\
\hat{r} \hat{p}(2 - \hat{p}) = 1. 
\]

(23) \hspace{1cm} (24)

Substituting (24) into (23) we derive the single equation:

\[
(1 - \hat{e}) \Delta(\phi) \left[ \left( \frac{R}{2} - b \right) - D \left( \frac{1 - \hat{p}}{\hat{p}(1 - \hat{p})} \right) \right] - M \hat{m} = 0
\]

which defines the equilibrium together with (20).

Case (b): \( \hat{r}D > \frac{R}{2} - b \). Equilibrium conditions (21) and (22) simplify to:

\[
(1 - \hat{e}) \Delta(\phi) \left[ R - 2b - \hat{r}D \right] \hat{p} - M \hat{m} = 0, \\
\hat{r} \hat{p}^2 + \frac{2}{D} \left( \frac{R}{2} - b \right) \hat{p}(1 - \hat{p}) = 1. 
\]

(25) \hspace{1cm} (26)

Substituting (26) into (25) we derive the single equation:

\[
(1 - \hat{e}) \Delta(\phi) \left[ R - 2b - \frac{D}{\hat{p}} \right] - M \hat{m} = 0
\]

which defines the equilibrium together with (20).

In both cases a) and b) the expected profit in the symmetric equilibrium can be derived from (16) and collapses to

\[
\hat{\pi}(b) = 2\hat{p}(b) \left( \frac{R}{2} - b \right) - 1 - M \hat{m}(b)^2.
\]
References


Fig. 1: Timing of the game.

<table>
<thead>
<tr>
<th>T=0</th>
<th>T=1</th>
<th>T=2</th>
</tr>
</thead>
<tbody>
<tr>
<td>entrepreneur sets</td>
<td>contract with investors</td>
<td>entrepreneurs and managers mature;</td>
</tr>
<tr>
<td>managerial compensation</td>
<td>is signed</td>
<td>choose efforts</td>
</tr>
</tbody>
</table>
Fig. 2: The game-tree represents the strategic interaction in the choices of monitoring $m$ by the entrepreneur and effort $e$ by the manager. Entrepreneur and manager choose efforts simultaneously and non-cooperatively. When the entrepreneur monitors with intensity $m$ the manager has the choice between exerting effort or shirking to save the private cost of effort. When the manager behaves he earns the bonus with probability $p_H$ otherwise, when caught shirking, he is fired. A new manager assures the probability of success $\phi \in [p_L, p_H]$ and earns the bonus when the project succeeds. When the entrepreneur does not monitor, the manager earns the bonus with probability $p_H$ when behaving, otherwise with the lowest probability $p_L$. 

Entrepreneur’s return: $p_H (R-b) \quad \phi (R-b) \quad p_H (R-b) \quad p_L (R-b)$

Manager’s return: $p_H b \quad 0 \quad p_H b \quad p_L b$
Fig. 3: The diagram represents the best reply functions of the entrepreneur and the manager with and without the bonus $b$. Without the bonus, the equilibrium is in $Q$ with monitoring $m(0)$ and zero managerial effort. For a positive level of the bonus, $b>0$, the best reply functions are given by the two dashed lines and the equilibrium is in $P$. The point $N$ is not an equilibrium as the interest rate is $r(0)$ while it has to be adjusted for the success probability at the new equilibrium efforts with the bonus $e(b)$ and $m(b)$, i.e. $r(b)<r(0)$. 
Fig.4: Firm’s equilibrium profits $\hat{\pi}$ as the bonus $b$ changes for different levels of debt, $D=0$ and $D=1$. The figure is drawn for probability of success of the project $p_H=0.9$ and $p_L=0.6$, outside manager’s probability of success $\phi=0.85$, project return $R=1.65$, monitoring cost $M=0.1$ and effort cost $E=0.18$. 
Fig. 5: Entrepreneur’s equilibrium monitoring $\hat{m}$ as the bonus $b$ changes for different levels of debt, $D=0$ and $D=1$. The figure is drawn for success probabilities of the project $p_H=0.9$ and $p_L=0.6$, outside manager’s probability of success $\phi=0.85$, project return $R=1.65$, monitoring cost $M=0.1$ and effort cost $E_e=0.18$. On the same diagram the thin dashed line represents the expected losses (shortfalls) on the face value of debt when $D=1$. 