CEO Compensations and Optimal Structure of Debt

Under Moral Hazard and Asymmetric Information

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Abstract:
This paper analyzes link between optimal CEO compensations and the optimal mix of private and public debt issued by a firm to resolve agency problems. We show that, absent adverse selection issues, optimal managerial compensation under moral hazard takes the form of a stock based compensation plan. The firm finances exclusively with bank loans and does not issue any public debt. However, with both types of agency problems, there is an optimal mix of private and public debt, and the optimal managerial compensation is shown to depend on growth opportunities, assets-in-place as well as the amount of public debt. Thus composition of debt is shown to influence CEO compensations under asymmetric information. While the mix of two types of debt enhances value of the firm ex-ante, ex-post it leads to inefficient restructuring.
**Introduction:**

In recent times, many corporations have resorted to a wide variety of transactions resulting in an increase in leverage and at the same time have instituted compensation schemes for the CEO and managers that link their payout to the performances of stock price. Leveraged buy outs, (LBOs) repurchase of stocks by issuing debt and employee stock ownership plans (ESOPs) are prominent examples of these twin phenomena. See Holmstrom and Kaplan (2001) for a discussion on changes in patterns of leverage and design of managerial compensations in the context of US economy over last two decades. Empirical studies also reveal that structure of debt issued by corporations is not homogeneous and debts of different kinds vary among themselves with respect to seniority, security and maturity. Such key characteristics, in general, depend on identity of holders of these debts. For example, private debt, typically owned by a bank, is senior and secured and public debt, usually held by a large number of dispersed investors, on the other hand is junior and unsecured.\(^1\) Recent empirical studies find that agency problems, arising from moral hazard and asymmetric information, influence heterogeneity in structure of a firm’s debt because choice between private and public debt not only convey information about key characteristics about a firm’s project from insiders to outsiders but also ameliorates problems associated with managerial moral hazards.\(^2\)

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\(^1\) Houston and James (1996) found that percentage of firms with public debt outstanding (along with bank debt) has increased from 35% to 46% between 1985 and 1990. In their sample, 66% of firms have multiple banking relationships and one-third of the bank debt is secured. Diatragachi (2000) also provides multiple banking relationship within a firm in the context of European economy. For a more recent discussion on empirical evidence between privately placed and public debt, see Denis and Mihov (2002) and Gomes and Phillips (2004).

\(^2\) Krisnaswami, Spindt and Subramaniam (1999) document that moral hazards lead to a bias in favor of private debt. Gomes and Phillips (2004) study a large sample of firms and find that choice of issuing broader class of securities under both private and public placements, including bank and private debt, arise as a means to resolve both adverse selection and moral hazards. Denis and Mihov (2002) find that the lowest quality firms use non-bank sources for borrowing, the medium ones opt for bank loans and good firms issue public debt. Houston and James (1996) and Lummer and McConnell (1989) earlier also made the same point that issues of informational asymmetry exerts impact on a firm’s choice of issuance of debt between private and public lenders.
However, the choice between issuance of private and public debt is not the only instrument available to a firm for mitigating agency costs. A firm can also motivate the CEO or the manager to work hard via appropriately designed compensation schemes. Contingent compensation schemes that links managerial/CEO remunerations to movements in price of the stock, can directly induce them to exert efforts that are value enhancing and could align interests of insiders and outsiders. A huge numbers of empirical studies examining relationship between CEO compensations and performance of firms and movements of price of stock document that incentive-based compensation schemes are widely used in practice.3

So far, the literature on the choice of private placement and public issuance of debt and incentive based managerial/CEO compensations, as instruments for mitigating agency problems, had developed on a stand alone basis, without any connection between them. The purpose of this paper is to explore links between optimal composition of private and public debt and design of optimal CEO/managerial compensations under both moral hazard (effort is unobserved) and adverse selection when the key characteristics of a firm’s project are not observed by outside investors. A firm has the option to make a choice between issuance of both private and public debt and at the same time, it can devise managerial compensations schemes in an optimal manner. In such contexts, we pose the following research questions: (a) Should a firm use instruments of CEO compensations and exercise its choice between private and public debt simultaneously in order to curb agency costs? (b) In the event a firm employs both, how is this optimal mix of private and public debt and optimal managerial compensation schemes related to each other? That is, are they substitutes or compliments or bear no relationship? (c) How are both instrument affected by basic characteristics of a firms (such as growth opportunities, risk inherent in projects etc.) which are the source of

3 Much of this literature originated from the seminal work of Jensen and Murphy (1990) that examined whether compensations based on stock-price aligns shareholders' and CEO interests. Consequently, Hall and Lieberman (1998), Milbourne (2003), Li Jin (2002) discuss various aspects of CEO compensations such as option related instruments, reputation, diversification of portfolio etc. on performance of firm.
informational asymmetry? (d) Does a firm’s optimal choice of composition of debt and managerial compensations ex-ante, always lead to efficient outcome, ex-post?

Our primary conclusions are: (a) If a firm encounters only managerial-cum-CEO moral hazards in efforts but does not face informational asymmetry about projects, then it issues only private debt (bank) and does not borrow at all from arms-length lenders such public debt holders. The optimal managerial compensations schemes under moral hazard take the form of endowing the manager with a stock based compensation plan that resembles stock appreciation rights. Hence, there is no link between structure of financing and design of remunerations. (b) On the other hand, in the presence of both types of agency problems, a firm will use an optimal mix of both types of debt, thus giving rise to heterogeneity of structure of debt. The nature of optimal managerial compensations will also differ significantly in comparison to the scenario that involves moral hazard only. Hence, a firm will use both instruments only when it confronts twin agency problems of managerial moral hazard in efforts and adverse selections in external financing of its projects. (c) Under moral hazard, managerial compensations is shown to depend solely on firms’ characteristics such as assets-in-place, NPV of its projects etc. but not on the structure or amount of outside financing. On the other hand, incentive schemes for managers depend on both, whenever a firm faces adverse selection and moral hazards. The larger the magnitude of public debt, the higher the CEO/managerial compensations. That is, under the second scenario, composition of debt financing also enters in the CEO compensation schemes in addition to non-financing aspects. (d) The amount of public debt as well as managerial compensations will depend positively on the growth opportunity of the projects but negatively on the value of assets-in-place. (e) The ex-ante optimal mix of private and public debt might lead to ex-post inefficient continuation decision where a firm may forgo projects with positive NPV.
The contribution of our paper to existing literature is two-fold: (1) The existing literature on managerial compensation primarily deals with its relationship to factors such as value of the stock, threat of takeovers etc, but not much on its link with respect to composition of the structure of a firm’s debt. We show how contingent payment to CEO/management is linked to composition of bank debt and public debt and discuss their consequent effects on incentives and value of firm. Hence, we offer a comprehensive analysis that links compensation schemes of CEOs to optimal debt structure and examine their implications on value of the firm ex-ante and frequency of successful restructuring, ex-post. (2) Second, we offer a number of additional testable hypotheses that shed light into determinants of a firm’s choice of financing and nature of its CEO compensations. For example, our results concur with the current evidence by Gomes and Phillips (2004), Denis and Milhov (2002) who find that in absence of asymmetric information, firms tend to borrow from private sources. In addition, our results imply managerial compensations will be tied to the assets-in-place and value of new projects and anything else from a firm’s assets side that ultimately influence the price of stock. In a similar way, the current empirical literature suggests that firms with severe asymmetric information will tend to use public debt. While our results corroborate this view and in addition, we offer the testable hypothesis that managerial compensations are also tied up to the amount of public debt that a firm already held as liabilities.

The intuitive reason of our result is as follows: If the managerial moral hazard is the only issue that confronts a firm, then issuing of public debt, ex-ante, is inefficient because of the higher risk of liquidation that results from its inflexible nature of timing of payments. A direct mechanism where the manager is offered a compensation scheme that pays him off only in the most favorable state of nature is sufficient to resolve the incentive problems associated with undertaking of efforts. On the other hand, if a firm has a profitable project but
outside investors are uninformed, the firm has to signal the quality of the project to outside financiers. We show that the optimal signalling mechanism is to make the payment to the CEO/management of the firm contingent on the state of nature and on the size of the issue, which includes amount of the public debt to be refinanced. Such a signalling mechanism has two beneficial effects. (1) It lowers costs of outside financing due to the signalling effect enables the investors to perfectly infer the quality of the project. (2) It creates incentive effects for the management that increases the value of the firm. Hence, a firm could use bank debt to reap informational advantage associated with it, and also issue public debt for its incentive and strategic uses, creating room for both types of debt in its capital structure.

We discuss these issues in a dynamic framework where a firm is exposed to twin agency problems of managerial moral hazard and asymmetric information in which insiders (including banks, shareholders and manager) observe key characteristics about profitability of a firm’s project but outside investors (such as public debt holders and other arms-length claim holders) can not observe such key indictors. The first type of agency problem results from separation of ownership and control between managers and the other parties who hold stakes in the firm and is modelled as managerial moral hazard in which efforts need to be elicited by optimal compensation schemes and the mix of private and public debt. The second type of agency problems arise because some parties (banks as informed lenders, dominant shareholders and manager) possess valuable information about project characteristics due to their closer proximity with the firm and is modelled as adverse selection and the informed parties could resolve this problem by an appropriate method of signalling by using the twin instruments of managerial compensations and optimal mix of debt.

The following trade-off appears all throughout in our paper while we analyze the choice between private and public debt and managerial compensations. The lists of gains are as follows: The monitoring role of banks reduces informational asymmetry associated with
outside financing and, thus, interest costs. Renegotiation of bank debt also leads to an ex-post efficient continuation decision of a firm. On the other hand, public debt, due to its rigid payment structure, offers incentives to managers to work hard that augments value of the firm. Of course, additional managerial effort benefits the shareholders from realization of an increased value of the firm.

However, all these various instruments that produce information and elicit effort for the benefit of a firm are not without costs. Banks gather valuable information which they might use in order to expropriate surplus from the firm’s profitable ventures. Rigidity of the time structure of payment of public debt impose discipline on a firm’s manager but its inflexible nature may force a firm into bankruptcy even in a situation where cash flow problems are temporary, and continuation is economically efficient. Finally, eliciting efforts from manager via compensation schemes is costly because the managers have to be given “rents” due to moral hazard and limited liability. We present a model below that incorporates these trade-offs in order to examine the optimal composition of private and public debt and managerial/CEO compensations and to find inter-relationship between these variables. We make a short review of the literature to highlight differences between our paper and the existing literature on the composition of debt and CEO compensations.

**Review of the related literature:**

There is already a distinct body of literature on the choice of public vs. private debt and emphasis is on bargaining power of private lenders and their role in alleviating problems associated with moral hazard and asymmetric information. The production of information via close monitoring is beneficial but it leads to the informational monopoly of banks. This reduces the borrower’s surplus from the project. Various models emphasize different aspects of the benefits and costs associated with revelation of information. Sharpe (1990) considers a
model where he investigates the role of contingent contracts in curbing informational monopoly of lenders. Diamond (1991) developed a model where borrowers acquire their reputation in the early phase of their lives by allowing themselves to be closely monitored making by banks. Later on, they save on the costs of monitoring by issuing public debt. Chemmanur and Fulgheri (1994) focus on reputation acquisition from the point of view of banks. Rajan (1992) presents a model where borrowing from a bank involves a trade-off between the benefits associated with flexibility of loan terms in the event of recontracting and the costs that the borrower incurs when banks, by taking advantage of informational monopoly, extract a larger surplus from the entrepreneur in the event of renegotiations. Although ex-post rents captured by banks are reflected in the lower face value of bank debt, they nevertheless, distort the entrepreneur’s effort incentives. The public debt holders, being dispersed in nature, do not claim any surplus from the entrepreneur. However, the public debt is more expensive because of the ex-post possibility of default. An entrepreneur cum borrower takes into account the costs and benefits associated with both types of debt. Rajan (1992) shows that borrowers with smaller bargaining power vis-à-vis banks will opt for public debt and that the others will opt for bank debt.

The huge literature on CEO compensations primarily discusses the pay-for-performance sensitivity of managers with respect to power of incentive based compensations. Following the seminal work of Jensen and Murphy (1990), various authors have focused on different aspects that affect CEO’s performances with respect to stock holdings. Hall and Liebman (1998) extend the pay performance scheme to executive options, Li (2002) has dealt with trading restrictions and Milbourn (2003) had emphasized on building of reputations. John and John (1993) focus on the relationship between bank debt, managerial incentives to take risky projects and structure of their compensations. See Murphy (1998) for a detailed account of this literature that captures the incentive aspects of CEO compensations with respect to
variables that affect the price of stock either directly or indirectly via mechanisms described above.

As stated in the introduction, since these two literature, both showing how a firm could effectively employ both instruments to curb agency costs, developed independently, our task is to link them via common themes of asymmetric information and moral hazard in order to gain further insights on how corporations use both instruments to curb agency costs.

The paper is organized as follows: In order to separate out impact of each type of agency problem, we will introduce a model of managerial moral hazard without adverse selection issues to derive optimal compensation schemes and structure of debt and then we will combine both moral hazard and adverse selection to examine the impact of both on the optimal design of compensation package of the manager and the choice between private and public debt. The section 1 will illustrate the basic model. In section 2, we analyze the model with managerial moral hazard and in section 3, we analyze the link between optimal compensation package of the manager and choice between private and public debt. The final section of the paper offers concluding comments.

Section 1: Outline of the basic Model:

We develop a two-period (periods 0 and 1) framework to capture interactions between the optimal design of management compensation in period 1 and composition of private and public debt issued by a firm in period 0. In period 0, the firm has a project that requires a fixed amount of capital (represented by \( k \)) to be operational. The firm also needs to hire a manager to run this project. At the beginning of period 0, the firm could borrow the entire amount of investment (\( k \)) by issuing either private or public debt or some combination of the two. Let \( k \) represent the amount of capital raised by issuing public debt at the (gross) rate of interest \( R_p \). The amount raised from incurring private debt is then (\( k - k \)), the interest on
which is denoted by $R_a$. Although a multiple number of banks contribute to fund the project, we assume that a single bank (the lead bank) undertakes the most pivotal role in collection of key information regarding the firm and the project, on behalf of other banks which also, along with the lead bank, contribute to funding of the project. Hence, the source of the entire private debt is a coalition of banks, represented by lead bank, while there are numerous and dispersed bondholders who hold the public debt.

The outcome of the project (we label it as project 0), realized by the end of period 0, is stochastic: it generates a strictly positive return $X_0$ with probability $q$, and zero otherwise. We assume that $X_0$ is high enough for the repayment of all liabilities of the firm. In the second period (at time period 1), a new project, sequel to the first period is developed. If the first project is successful, then shareholders retain full ownership over the assets of the firm and we also assume that this project can be funded from the surplus generated from earlier project.

On the other hand, if the project of the first period meets failures so that debt obligations are unpaid, then the lead bank and shareholders of the firm jointly take charge of the firm and makes the following decisions: whether to continue with the new project or to liquidate the firm. In the event of liquidation, proceeds from the sale of the firm’s assets are distributed among stakeholders according to some priority rule, exogenous to the model. On the other hand, if the lead bank and shareholders decide to continue with the new project, then (a) the lead bank roll over its existing debt and also need to finance investment required for the new project and repay outstanding public debt incurred by the firm at period 0. (b) The manager is also retained for running the firm due to firm-specific skill acquired by him due to association with the firm from the past. Hence, in the event of continuation, the firm-
bank coalition has to design incentive-based compensation package for the manager. At the end of period 1, cash flow from the sequel project is realized and all the relevant parties are paid according to contracts written earlier if the second project yields a positive cash flow and then the firm is shut down. The figure 1 sketches this timeline.

It must be noted at this point that we will introduce the dual agency problems of the manager/CEO on the one hand and the similar problem between outside investors and shareholder-bank coalition on the other hand, in period 1. In the first period, (period 0) all parties have symmetric (although imperfect) information. This is done due to following reasons. First, the role of bank as an information collection agent can be relevant only with course of time. Being associated with a firm for some time enables a bank to learn about the profitability of projects on which it will decide whether to continue with the new project or to liquidate the firm’s assets. Since continuation of the new project requires refinancing of the old debts of public debt holders, rolling over its own debt and raising new finance for projects, it is realistic that such informed decision takes place only after an elapse of a period. In short, although the bank is associated with the firm from period 0, key decisions of rolling over past debt and raising funds from outside investors and renegotiation of the old debt contracts take place at period 1 and it is natural we introduce agency problems between insiders (share holders and lead bank) and outsiders (public debt holders, other participating banks and outside investors) at this point when the project 1 is just in place. Secondly, managerial moral hazard and its alleviation via financial contracts can be relevant only when the firm is seeking funds from outside investors and that also take place in period 1 of our

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4 Since this is not a model of financial distress per se, outstanding public debts are simply refinanced and we have abstracted away other mechanisms of restructuring such as exchange offers. Manager of the original firm is still retained in the event of continuation for the same reason. We have modeled arrival of new projects together with the possibility of non repayment of earlier loans by the firm to capture greater bargaining power of the bank and concomitant exercise of its information monopoly if that event occurs. The empirical literature suggests that banks wield greater bargaining power in times of financial difficulties of the firm and they exercise information monopoly when the firm can not go outside for meeting its finance requirement and get stuck with the bank because the latter, being an inside investor, acquires information about ongoing projects.
model. Finally, we also must note that since both inflexible time structure of payments to public debt holders and stock price based compensation to management generate incentive effects, our research question on their inter-relationship, is thus built in this time line because both the composition of public and private debt and design of management compensations are endogenous to the model.

Since both managerial moral hazard in efforts, asymmetric information between insiders and outsiders about key characteristics of the project and renegotiation of bank debt take place in period 1, we outline ingredients of characteristics of project at period 1 in detail. The return from the continuation of the firm’s project at period 1 yields a stochastic return that depend on the “type” of this new project that is developed and also on effort expended by manager. We assume that the management possesses two discrete and indivisible units of the managerial input, and that the net cash flow is increasing in the amount of the managerial input.

The effort assumes a binary value of either high level ($e > 0$) or low level ($e = 0$). The type, on the other hand is represented by the probability distribution $\{p_0, p_1, p_2 : t, e\}$ over the discrete support of the vector of non-negative yields $\{y_0, y_1, y_2 + \Delta\}$ for $e > 0$ and $\{y_0, y_1, y_2\}$ for $e = 0$, where $y_2 > y_1 > y_0$. Without any loss of generality, we assume that $y_0 = 0$. Throughout our analysis, $y_2$ will be taken to represent a level of return that is high enough to satisfy all dues at the end of period 1. $y_1$ will represent a low but strictly positive yield – one where the firm is unable to repay all its creditors in full but large enough to pay for outside financings. The project also requires an investment of $I$. The firm will finance this investment from its retained earning in the earlier period if the project at time 0 which arms-length investors do not possess. Our analysis is robust to exogenous shift of power from the firm to bank.
is successful. On the other hand, in case of a failure of the project at period 0, it has to raise finance from outside if the firm survives as an ongoing entity.

In this model, $t$ is a parameter that affects the probability distribution of the returns in the various states of nature. For the sake of expositional simplicity, we assume that $t$ affects the probability of the highest return $y_2$ and the medium return in a multiplicative way so that the likelihood of occurrence of $y_2 + \Delta$ is $t(p_2 + e)$ and the probability of $y_1$ and $y_0$ are $tp_1$ and $1 - t(p_2 + e + p_1)$, respectively. Similarly, for zero level of effort, the respective probabilities are $tp_2$, $tp_1$ and $1 - tp_2 - tp_1$ and the corresponding cash flows for low level effort are $y_2$, $y_1$ and $y_0$. We assume that $t$ is distributed between $[l, r]$ with a probability distribution function $G(t)$ and the corresponding density function as $g(t)$ In the absence of asymmetric information, all parties have the knowledge of distribution of $t$ and with asymmetric information, it is the firm-bank coalition and the manager observe its realization but outside investors lack such information.

In our formulation, $\Delta$ is intended to capture incentive effects and its implementation reflects frictions that arise from the agency problem between a firm’s stakeholders and the manager. As we will discuss below that since managerial effort is unobserved by the shareholders and the manager is protected by limited liability, shareholders have to design appropriate incentive scheme so that managers undertake higher levels of effort. On the other hand, $t$ will be the source of information asymmetry that creates the agency problem between current owners of the firm and outside investors. With no agency problem between insiders and outsiders, $t$ is observed by everyone and under imperfect information, it is observed only by the informed lender (bank) and the manager but not by outside investors. Hence, the firm has to signal outside investors about the type of the project via compensation schemes. As stated in the introduction, in order to understand the impact of optimal composition of debt on
the optimal managerial compensation, we first, analyze managerial moral hazard in the absence of asymmetric information leading to adverse selection and then we discuss both to see how their combined effects influence mix of debt and managerial compensation at the optimum.

Section 2: Managerial Moral hazard:

In order to analyze the interactions between design of optimal management compensation package at time period 1 and composition of debt chosen at period 0, we work backwards. That is, we first analyze the compensation scheme at a given mix of public and private debt and then we close the model by taking into account the effects of composition of the debt on the optimal compensation package of the manager. Hence, we begin at the node in period 1, where a firms’ project has failed in period 1 and the bank is in charge of making the decision regarding continuation of the firm or liquidation of its current assets. Since, in the continuation decision in period 1, net expected surplus from the project to banks has to exceed its pay-off from liquidation, we need to elaborate the nature of the sequel project at period 1 and is done below:

(a) Continuation/Liquidation Decision:
At the end of period 0, it is known whether the firm has failed or succeeded in the initial project and the expected value of the sequel project (project 1 at period 1) is also observed by firm and the bank. In the event of failure of the first project, firm has defaulted on loans so that in case of continuation, bank debt will be renegotiated. We endow the bank with bargaining power in the renegotiation stage so that they can extract surplus from the shareholders. Such a bargaining power of the bank can be attributed to its monopoly on information acquired as an informed lender. With a profitable project at hand, banks can roll
over its past loan and help the firm raise outside finance which leads to an efficient continuation decision. However, this very act of production of information from close monitoring of firm’s activities grant banks access to privileged information which, they can use in order to expropriate surplus from the firm’s profitable ventures. This is a very likely scenario under the circumstance where a firm might have profitable projects in the immediate future and needs outside financing to initiate them but currently has a cash crunch and had been unable to meet its past dues to its creditors, including banks. Banks, can then, take advantage of temporary cash flow problem of the firm and could use its exclusive information regarding the profitability of the project to renegotiate earlier loan contract and replace it with a new one that skims off the expected surplus from the project5.

The bank will continue with the project if its expected pay-off from the project exceeds the same if the firm gets liquidated. Let $\alpha$ be the bank’s share of the expected surplus as well as from the liquidation value of the project6, then, expected pay-off to the bank in the continuation phase is the gross pay-off of the project minus payments to entrepreneur/manager and outside financers. Hence, continuation with the new project is profitable if

$$\alpha[t_y(v_2 - w - F) + t_y(v_1 - F)] \geq \alpha L \Rightarrow \text{there exists a critical value of } (t = t^*) \text{ such that the bank will liquidate the project below it and will continue if the realized value of } t \text{ exceeds } t^*$$

and

$$t^* = \frac{z + L}{[P_2y_2 + P_1y_1 - w]}$$

where,

$$z = R_p k + I = \text{amount of external financing}.$$

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5 See Rajan (1992) for theoretical arguments on the nature of “information monopoly” of banks and Houston and James (1996) for empirical evidence. Needless to say, that information acquired by inside lenders is often very soft in nature so that it can not be communicated to outsiders without costs. This gives banks an edge which they could exploit with the arrival of profitable opportunities within a firm and when firm does not have enough internal resources to initiate the project.
\[ F = \frac{R_e k + I}{t(p_2 + p_1)} \]

Promised amount to outside investors

\[ L = \text{liquidation value of the firm at period 1.} \]

\[ I = \text{Investment in the project – internal financing.} \]

\[ w = \text{Managerial compensations in the state of nature where cash flow is} \ (y_2). \text{ Hence, it is a stock-based compensation plan.} \]

Clearly, the decisions to reorganize would partly depend on NPV of the new projects, amount of past debt needs to be refinanced and compensation offered to the manager of the firm.

(b) Managerial Compensations and composition of debt under moral hazard:

Since neither shareholders nor bank can run the firm’s project by themselves, and retains the manager of the firm, it has to decide on the compensation plans of the manager of the firm, which, in turn, will also depend on the level of effort that manager exerts. Since the effort is unobserved, compensation has to be incentive compatible and it should be jointly profitable for all parties (entrepreneur/manager and bank) as a whole. At the zero level effort, the firm-bank coalition pays minimum stake to the manager, say, \( w^* \), to retain him in the firm. On the other hand, if the firm-bank coalition wants to elicit higher level of effort from the manager, it must be jointly feasible for both the firm and the manager. Next, we investigate the following questions key to our paper. (1) What is the nature of optimal compensation package for the CEO under moral hazard but no adverse selection? and (2) How is such compensation scheme linked to the firm’s composition of private and public debt?

The propositions 1 and 2 below answer these questions.

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6 The equal amount of share in both liquidation and continuation is just for simplicity and the assumption is made just to save on extra notations.
**Proposition 1:** The compensation scheme of the manager at time 1, is given by the following:

\[ w_1 = w^* \text{ for } t^* \leq t \leq t_1^* \]

\[ w_2 = \Delta + \frac{e}{(p_2 + e)} y_2 + \frac{p_2}{(p_2 + e)} w^* \text{ for } t_1^* \leq t \leq \bar{t} \]

**Proof of proposition 1:**

For the bank, higher level of effort from the manager is profitable if

\[ t(p_2 + e)[y_2 + \Delta - w - F] + t p_1[y_1 - F] \geq t p_2[y_2 - w^*-F] + t p_1[y_1 - F] \]  

(2)

For the manager, high effort is profitable if, the equity stakes offered to him is such that

\[ t(p_2 + e)w - C \geq t p_2 w^* \]  

(3)

Using (3) in (2), we get the critical value of \( t \) such that firm will prefer the CEO to exert a higher level of effort if the realized (\( t \)) exceeds the critical value, given by,

\[ t_1^* = \frac{C}{(p_2 + e)\Delta + ey_2} \]

and plugging the value of the \( t_1^* \) in (3) and writing it as an equality will give us the compensation scheme elaborated in the proposition 1.7

**Proposition 2:** The firm will issue only private (bank) debt and will not find it optimal to issue public debt at time 0 in the presence of only managerial moral hazard but no informational asymmetry between the firm-bank coalition and outside investors from whom the former raises funds at period 1.

The proof is relegated to appendix A and here we discuss intuitions and the empirical implications of these results. The proposition 1 suggests that managerial compensation under

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7 If the project in period 0 succeeds, then also compensation package of the manager is exactly the same as given in proposition 1.
pure moral hazard but no informational asymmetry would resemble stock option or stock appreciation rights. Only managers of highly profitable firm would be able to exercise the option and granting this option is also costly from the shareholders’ point of view due to limited liability which prevents punishing the manager in the bad state. The upshot of the proposition 2 is that firm will rely on a single source of funding which is bank debt. An important empirical implication is that firms which do not face the problem of asymmetric information about the key characteristics of its project with outsiders, is less likely to issue public debt as an incentive-augmenting mechanism. That is, the shareholders of such firms can directly motivate the manager to work hard by offering contingent compensation plan and not with the commitment effect that accompanies public debt. On the other hand, for financing of projects, these firms depend on bank loans due to its flexibilities and embedded options of renegotiation in times of temporary financial difficulties. The next section of the paper analyzes how composition of debt and managerial compensation scheme are influenced by both the presence moral hazard between managers and other parties and asymmetric information between insiders and outsiders regarding the profitability of projects.

**Section 3: Managerial Moral Hazard and Asymmetric Information about key project characteristics.**

We now consider the case where, at the beginning of period 1, the entrepreneur/manager and the lead bank observe the type of the second project but all other creditors remain uninformed. The justification for such a case hinges on the fact that although a coalition of banks could fund the project, it is the lead bank that takes the charge of collection and production of information regarding a particular firm. Following the failure of project 0, if the lead bank decides on continuation, it offers a compensation scheme to the management, and refinances the pre-existing public debt and raises fund for the investment in
the new project, based on its private information. Since a higher realization of \( t \) implies a lower risk associated with a project, costs of outside financing, corresponding to a higher \( t \) would be lower. Hence, if the outside investors, including other participating banks, do not observe value of \( t \), the lead bank, therefore, has the incentive to reduce the cost of refinancing by misrepresenting the degree of risk associated with their period 1 projects. Consequently, unless offsetting costs exist, such a bank observing a low \( t \) would attempt to profit by emulating the decisions of a bank that observes a high \( t \). Such misrepresentation will be absent if the decisions of a bank that relies on external funds for refinancing constitute an observable signal that credibly distinguishes each realization of \( t \) to uninformed investors. We demonstrate that, in the Separating Equilibrium of the present game, banks that decide on continuation will, indeed, choose the level of managerial compensation in a manner that appropriately reflects the true project quality. In such a situation, the managerial compensation will be strictly increasing in the observed value of \( t \).

We derive the specific nature of managerial compensation that credibly signals the degree of risk associated with the new venture in the next proposition. Intuition suggests that such a compensation scheme is output contingent in order to avoid the moral hazard problem associated with the exertion of managerial effort. In fact, since there are only two alternative levels of managerial effort (either high or low), a little reflection makes it clear that it is adequate to consider only two classes of yield-contingent offers from the bank.\(^8\)

\(^8\) This is also an optimal signalling mechanism because in traditional signalling models, either it is costless for the firm to convey information (like cheap talk models) or it incurs costs in the form of payment of dividends etc. However, in our framework, signalling is value-enhancing because it offers incentives for the manager to exert extra effort that increases expected NPV of projects. We omit proof of optimal signalling mechanism for the sake brevity but could be obtained from the authors upon request.
**Proposition 3:** In the PBSE of the game between the bank, management and the outside investors, given continuation in period 1, the compensation awarded to management is represented by

\[ w_1(t) = \frac{z}{p_2} \left[ \frac{1}{t^*} - \frac{1}{t} \right] + w^* \text{ for } t^* \leq t \leq t_1^* \text{ and } y = y_2 \]

and for \( t_1^* \leq t \leq \tilde{t} \), and \( y = y_2 + \Delta \), the compensation is

\[ w_2(t) = z \left[ \frac{1}{p_2 t^*} - \frac{1}{(p_2 + e)t} \right] + w^* . \]

Where, \( t^* = \frac{L + z}{p_2 (y_2 - w^*)} \) and \( t_1^* = \frac{C}{e[ w^* + \frac{z}{p_2 t^*}]}. \)

**Proof:** See the appendix.

The proposition 3 highlights the nature of optimal compensation in the presence of both managerial moral hazard and asymmetric information between outsiders and insiders. First, the compensation is contingent on \( t \) and is increasing in \( t \). Second, managerial compensation also jumps monotonically when output is increased from \( y_2 \) to \( y_2 + \Delta \). Finally, such compensation scheme also a fraction of the amount of funds that need to be raised from the market, \( \left( \frac{z}{L + z} \right) \) including the amount of public debt that need to be refinanced. Hence, the key difference between managerial compensation contracts under the presence of moral hazard and that of under he presence of both moral hazard and asymmetric information is that while the compensation schemes and structure of debt are independent but adding asymmetric information makes the contingent compensation scheme dependent on the amount of outside financing, including public debt issued at time 0. A closer look at the proposition 3 reveals that there are two components in managerial compensation. (a) Pure signalling effect in the range of \( t^* \leq t \leq t_1^* \) and \( y = y_2 \) and (b) Signalling and incentive
effects in the region of \( t_1^* \leq t \leq \bar{t} \), and \( y = y_2 + \Delta \). The signalling effect is purely redistributive in the sense that larger managerial compensation is fully offset with a higher interest rate charged by bank and with no change in the value of the firm. On the other hand, when compensations incorporate incentive elements, the extra effort of the manager is value enhancing. However, issuing public debt has its costs also and firms make their optimal choice of mix of public and private debt by taking benefits and costs into account. However, issuing public debt has also its costs and firms at date 0 take into account benefits and costs of issuing public debt and the proposition 4 below summarizes the result on optimal choice of mixture of debt.

**Composition of Debt:**

Since the compensation of the manager at period 1, depends among other things on the fraction of public debt issued at date 0, the question is: To what extent it has a bearing on the optimal composition of debt? The fact that manager is receiving some rent due to the presence of public debt is not the cause of issuing public debt because such gains in an universal risk-neutral world will be exactly offset by the rise in interest costs of bank loans. In other words, if banks anticipate conceding some information rent to manager at time 1 that will be appropriately adjusted in the rise of interest rate ex-ante. A closer look at the proposition 3 reveals that there are two components in managerial compensation. (a) Pure signalling effect in the range of \( t^* \leq t \leq t_1^* \) and \( y = y_2 + \Delta \) and (b) Signalling and incentive effects in the region of \( t_1^* \leq t \leq \bar{t} \), and \( y = y_2 + \Delta \). The signal effect is purely redistributive in the sense that larger managerial compensation is offset with a higher interest rate with no change in the value of the firm. On the other hand, when compensations incorporate incentive elements, the extra effort of the manager is value enhancing. Hence, it is the second element that leads an entrepreneur to issue both public and private debt.
Proposition 4: With asymmetric information and managerial moral hazard, the incentive effects of the managerial compensations induce the firm to choose a mixture of public debt and private debt at time $t = 0$.

Although the proof is done in appendix, we report here the first-order condition to analyze various trade-offs that arise when firm encounters both asymmetric information and moral hazard.

\[
[t_1^* \{(p_2 + e)\Delta + p_2\Delta_2\} - C]g(t_1^*) \left. \left| \frac{\delta t_i}{\delta k} \right| \right\} = [(R_p k) + \int \hat{t} p_2 w_{1i}(t) \frac{\delta w_i}{\delta k} g(t) dt] = 0 \quad (4)
\]

The first term captures the benefit of public debt through its effect on optimal managerial compensations. To see this clearly, we could see from the proposition 3 that an immediate consequence of dependence of $w_j(t)$ on $(z)$ is that an increased $(z)$ leads to smaller gap between contingent compensations $[w_2(t) - w_1(t)]$, so that managers could be induced to undertake higher level of effort with a smaller realization of $(t)$, and is captured by $\frac{\delta t_i}{\delta k}$ and its co-efficient $[t_1^* \{(p_2 + e)\Delta + p_2\Delta_2\} - C]g(t_1^*)$ is the expected increment in the cash flow to the firm due to implementation of higher level of effort. In short, the marginal benefit of an increased public debt is its effects on eliciting higher managerial effort via increment in managerial compensations that both alleviate moral hazard in efforts and asymmetric information in outside financing that augments value of the firm. The other two terms are the increment in cost associated with public debt. The second term is the opportunity cost of issuing public debt at date 0 which needs to be refinanced if unpaid and the last term is the expected signalling cost at the margin in the form of higher compensation costs to CEO as a higher level of public debt financing increases their pay-off. (This follows from the direct dependence of $w_j(t)$ on $z$ illustrated in the proposition 3).
A closer inspection of the equation (4) reveals that as \( k \to 0 \), the first term is positive and the last two terms vanish. Hence, the marginal benefit of issuing public debt is positive. Again, since the marginal benefits increase at a decreasing rate and marginal costs increase at an increasing rate there exists a \( k \) such that for a particular level of public debt, (say \( k \geq \bar{k} \)) the equation (4) is negative. If the initial investment requirement \( \bar{k} \) is large enough so that \( \bar{k} \geq \tilde{k} \), there exists an optimal \( k^* \) such that \( 0 < k^* < \bar{k} \) and thus the firm issues both private and public debt in equilibrium.

The next sets of propositions illustrate how such compositions of debt vary with respect to the expected NPV of the project and the consequence of optimal debt structure on efficient continuation decisions.

**Proposition 5:** The optimal amount of public debt increases with \( \Delta \) but decreases with \( L \).

**Proof:** It follows straight from the differentiation of the first-order condition, given by 4.

**Proposition 6:** The critical value of \( t^* \) is higher than under symmetric information implying that some projects with positive NPV at date 1 will not be undertaken and thus there will be an inefficient liquidation of assets.

**Proof:** It follows from the comparison of \( t^* \) derived under moral hazard where the firm does not issue public debt and under both moral hazard and adverse selection. The cut-off value is given by, \( t^* = \frac{L + z}{p_2(y_2 - w^*) + p_1y_1} \). Since the amount of public debt issued under moral hazard (\( z \)) is zero, it follows that issuing public debt, while ex-ante optimal, may lead to an inefficient outcome because projects with positive NPV will not be undertaken due to the presence of debt overhang.
Conclusion:

The design of managerial compensation schemes and the mix of privately placed debt and public debt are two effective instruments for curbing agency problems. In this paper, we discuss the scenarios where a firm would use either one or both instruments. In particular, we show that a firm uses optimal compensation schemes to resolve problems associated with moral hazard, and relies exclusively on private debt in the absence of adverse selection problems. On the other hand, use of both instruments is optimal when a firm encounters the twin problems of moral hazard with respect to the choice of managerial effort and adverse selection associated with the financing of projects.

While the conclusions of our paper agree with broader empirical findings between private placement and the issue of public debt, we tend to offer additional testable implications that link managerial compensation with the optimal structure of firm debt. Major empirical implications are (a) For an established firm, source of financing is bank debt and managerial compensations take the form of stock appreciation rights. (b) if a firm’s quality of project is better (indexed by $t$), it will issue more public debt in its capital structure and will tie managerial compensations to the amount of public debt. (c) MBOs (Management buyout) will involve more public debt than Leveraged buyouts (LBO). In our future work, we plan to conduct empirical tests of these additional results to find their consistency with the existing empirical work.
Appendix: A

Proof of the proposition 2:

The maturity value of the loan on public debt must satisfy the following equation.

\[ R_p k [q + (1 - q)(1 - G(t_1))] = k \]  \hspace{1cm} (1A)

The maturity value of the bank debt is determined by the following equation.

\[
q R_b (\bar{k} - k) + \alpha (1 - q) \left[ \{G(t^*)L + \int_{t_1}^{t} t(p_1 y_1 + p_2 y_2) - t(p_1 + p_2)F - tp_2 w_1 \} g(t) dt \right] \\
\int_{t_1}^{\bar{t}} t \{(p_2 + e) y_2 + p_1 y_1\} - \{(p_2 + e) + p_1\} F - t(p_2 + e)w_2(t) \} g(t) dt = \bar{k} - k
\]  \hspace{1cm} (2A)

The shareholders’ expected pay-off at time 0:

\[
E\pi = q[X_0 - R_p k - R_b (\bar{k} - k) + Ey - C] + (1 - \alpha)(1 - q) \left[ \{G(t^*)L + \int_{t_1}^{t} t(p_1 y_1 + p_2 y_2) - t(p_1 + p_2)F - tp_2 w_1 \} g(t) dt \right] \\
+ \int_{t_1}^{\bar{t}} t \{(p_2 + e) y_2 + p_1 y_1\} - \{(p_2 + e) + p_1\} F - t(p_2 + e)w_2(t) \} g(t) dt
\]  \hspace{1cm} (3A)

where, \(t_1^* = \frac{C}{(p_2 + e)\Delta + ey_2}\) and \(t^* = \frac{z + L}{[p_2 y_2 + p_1 y_1 - w]}\)

Using (1A) and (2A) in (3A), we get:

\[
E\pi = q(X_0 - \bar{k} + Ey - C) + (1 - q)[G(t^*)L + \int_{t_1}^{t} (p_1 y_1 + p_2 y_2) + \int_{t_1}^{\bar{t}} (p_2 + e)(y_2 + \Delta + p_1 y_1 - C)] g(t) dt - [(I + w^*)(1 - G(t^*))]
\]  \hspace{1cm} (4A)

\[
\frac{\partial E\pi}{\partial k} = (1 - q)[L - t^* (p_1 y_1 + p_2 y_2 - w^*) + I)] g(t^*) R_p = -(1 - q)[R_p k] < 0
\]  \hspace{1cm} (5A)
Proof of Proposition 3:

Let the expected pay-off function of the bank in the continuation stage be:

\[ u = u[t, F(t'), w(t')] = t(p_2 + e)[y_2 - F(t') - w(t')] + tp_1[y_1 - F(t')] \]  \hspace{1cm} (1A')

where \( y_j = \) cash flow from the project \( j = 1, 2 \).

\( F(t) = \) Maturity value of the loan that bank of type \( t \) raises from the market (or from other banks) in order to refinance the junior debt incurred by the entrepreneur at date 0 and new outside financing for project at time period 1 and \( w(t) = \) managerial compensation that a bank of type \( t \) firm. The incentive compatibility condition requires that

\[ \frac{\delta u}{\delta t}[t, F(t'), w(t')]_{t'=t} = 0 \implies -t[(p_1 + e + p_2) \frac{\delta F(t)}{\delta t} + (p_2 + e) \frac{\delta w(t)}{\delta t}] = 0. \]

Hence,

\[ \frac{\delta w(t)}{\delta t} = -\frac{(p_1 + p_2 + e)}{p_2 + e} \frac{\delta F(t)}{\delta t} \]  \hspace{1cm} (2A')

The equation (2 A') has a natural interpretation. If a bank asks for a lower refinancing costs, (higher probability of success) [i.e., smaller \( F(t) \)] due to a higher realization of \( t \), then it must be offering a higher compensation to the entrepreneur so as to convey its private information to the market adjusted for any changes in cash flow that accompany projects that claim to have a greater success rate.

The face value of the loan in a competitive financial market must satisfy the following relationship:

\[ t(p_1 + e + p_2)F(t) = R_kk + I - M = z. \]  \hspace{1cm} (3 A')

\( M = \) The amount of cash that already bank has and can use for retiring debt.

Hence, \( z = \) The total amount of fund that the bank needs to raise from outside markets.

For equilibrium to be separating, each announced \( t \) will be entitled to pay a unique \( F(t) \).

Hence,

\[ F(t) + t \frac{\delta F}{\delta t} = 0 \]  \hspace{1cm} (4 A')

Using (3 A') in (4 A'), we get:
\[
\frac{\delta F}{\delta t} = -\frac{F(t)}{t} = -\frac{z}{t^2(p_1 + e + p_2)} \quad \text{(5 A')}
\]

Finally, using incentive compatibility condition (2A) generates the following:

\[
\frac{\delta w}{\delta t} = \frac{z}{t^2(p_2 + e)} \quad \text{(6 A')}
\]

The equation (6A) is a simple first-order differential equation that gives the incentive compatible schedule of compensation for each \(t\). The solution to (6A) is given by:

\[
w(t) = -\frac{z}{t(p_2 + e)} + A \quad \text{(7 A')}
\]

Where \(A\) is a constant of integration and can be found from the boundary condition:

\[-\frac{z}{t^* (p_2 + e)} + A = w^* \]

\[w^*(t^*) = \text{minimum compensation that a bank pays to the manager to run the firm. i.e., the lowest type (the bank which does not gain from reorganization) does not need to signal to the financial market. We can find the value of the constant by using (7 A') and the boundary condition and is given by:} \]

\[A = \frac{z}{t^* (p_2 + e)} \quad \text{Now (7 A') can be written as:} \]

\[w(t) = \frac{z}{(p_2 + e)} \left[ \frac{1}{t^*} - \frac{1}{t} \right] w^*. \quad \text{(8 A')}
\]

Let us suppose that here are two levels of effort: high and low. We normalize the low level of effort to be equal to zero. Hence, we represent effort levels as \( (e_h = e) \) and \( (e_l = 0) \) and subscripts \((h)\) and \((l)\) stand for high and low respectively. The high level effort also costs the entrepreneur \((C)\) which the bank must reimburse in order to motivate him to exert effort.

From (9A), we can write the contingent payment to entrepreneur [contingent on realization \((t)\) and effort levels \((e)\)] as:
\[ w_1(t) = \frac{z}{p_2} \left[ \frac{1}{t^*} - \frac{1}{t} \right] + w^* \quad (9 \text{ A/}) \]

and

\[ w_2(t) = z \left[ \frac{1}{t^* p_2} - \frac{1}{t(p_2 + e)} \right] + w^* \quad (10 \text{ A/}) \]

where \((t^*)\) satisfies the following equation:

\[ t^* = \frac{L + z}{p_2(y_2 - w^*) + p_1 y_1} \]

Since eliciting high effort is costly, it is feasible only when the firm value rises significantly.

That is, the value of \((t)\) should be large enough so both bank and the entrepreneur find profitable to switch from a low effort intensive contingent payment to a high effort one.

For the CEO, this condition must be such that

\[ t(p_2 + e)w_2(t) - t p_2 w_1(t) \geq C \]

which, from \(9 \text{ A/}\) and \(10 \text{ A/}\), reduces to

\[ t^*_1 = \frac{C}{e[w^* + \frac{z}{p_2 t^*}]} \quad (11 \text{ A/}). \]

On the other hand, for the firm-bank, combination, the condition is:

\[ t(p_2 + e)(y_2 + \Delta - F(t) - w_2(t)) + t p_2[y_1 - F(t)] \geq t p_2[y_2 - F(t) - w_1(t)] + t p_1[y_1 - F(t)] \quad \text{and} \]

this becomes

\[ t(e y_2 + (p_2 + e)\Delta) \geq C. \quad (12 \text{ A/}) \]

**Observation:** If \((11 \text{ A/})\) is satisfied with equality, \((12 \text{ A/})\) will hold strict inequality.

**Proof:** Plugging the value of \(t^*_1\) from \((11 \text{ A/})\) into \((12 \text{ A/})\), we get

\[ \frac{z}{L + z} \leq 1 + \frac{(p_2 + e)\Delta}{e(y_2 - w^*)} \quad \text{and the inequality is strict for} \quad z > 0 \]
Appendix: B

Proof of the proposition 4:
The maturity value of the loan on public debt must satisfy the following equation.
\[ R_p k[q + (1 - q)\{(p_1 + p_2)(1 - G(t^*)) + e(1 - G(t^*)\} = k \] \hspace{1cm} (1B)

The maturity value of the bank debt is determined by the following equation.
\[ qR_b(\bar{k} - k) + (1 - q)[G(t^*)L + \int_{\tilde{t}}^{t} t(p_1y_1 + p_2y_2) - t(p_1 + p_2)F - tp_2w_1]g(t)dt \]
\[ \int_{\tilde{t}}^{t} t\{(p_2 + e)y_2 + p_1y_1\} - \{(p_2 + e) + p_1\}F - t(p_2 + e)w_2(t)g(t)dt = \bar{k} - k \] \hspace{1cm} (2B)

The entrepreneur's expected pay-off
\[ E\pi = q[X_0 - R_p k - R_b(\bar{k} - k) + Ey] + (1 - q)[\int_{\tilde{t}}^{t} p_2w_1(t) + \int_{\tilde{t}}^{t} (p_2 + e)w_2(t) - C]g(t)dt \] \hspace{1cm} (3B)

Using (1B) and (2B) in (3B), we get:
\[ E\pi = q(X_0 - \bar{k} + Ey - C) + (1 - q)G(t^*)L + \int_{\tilde{t}}^{t} [(p_1y_1 + p_2y_2) - p_2w_1(t) - I] + \int_{\tilde{t}}^{t} (p_2 + e)\Delta + p_1\Delta - C]g(t)dt \] \hspace{1cm} (4B)

Note: \[ t^* = \frac{L + z}{p_2(y_2 - w^*) + p_1y_1} \] and \[ \tilde{t}_1^* = \frac{C}{e^w + \frac{z}{p_2t^*}} = \frac{C}{e^w + \frac{z}{L + z(y_2 - w^*)}} \]
The first order condition is:

$$\frac{\partial E \pi}{\partial k} = \left[ t_i^* \{(p_2 + e)\Delta + p_2 \Delta_2\} - C \right] g(t_1^*) \left| \frac{\partial \pi}{\partial k} \right| - \left[ (R_p k) \frac{\partial \pi}{\partial k} + t \int p_2 w_k(t) \frac{\partial \pi}{\partial k} g(t) dt \right] = 0$$

and

$$\frac{\partial \pi}{\partial k} = - \frac{C \left[ \frac{L}{L + z} \right]^2}{e \left[ w^* + \frac{z}{p_2 t^*} \right]^2} < 0$$

$$\frac{\partial E \pi}{\partial k} = 0 \Rightarrow g(t_1^*) n_i^* \left[ (p_2 + e) \Delta + cy_2 - C \right] \frac{L}{(L + z)} \frac{(y_2 - w^*)}{e \left[ w^* + \frac{z}{L + z} (y_2 - w^*) \right]} - R_p kg(t^*) \frac{1}{p_2 (y_2 - w^*)} = 0$$

\((5B)\)
References


Fig. 1 (drawn for $e = 0$)