Inside Debt and Managerial Risk Taking

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Abstract

We investigate the effects of inside debt compensation on firm risk taking in a principal-agent framework. The model allows for a costly effort and asset volatility choices by the manager. Corporate shareholders select the firm's capital structure to maximize the *ex ante* firm value by rationally anticipating managerial choices *ex post*. We find that inside debt compensation is less efficient than a combination of a fixed wage and equity in reducing the firm's risk, because of favorable seniority structure. In particular, debt compensation can reduce managerial risk taking only when the cost of changing risk is low. Furthermore, even though debt compensation can improve managerial effort and reduce *managerial* risk taking, it does not necessarily decrease the firm's *overall* risk, given the equityholders' capital structure and operating scale choices. In general, fixed wage that are less senior than firm's outside debt is most efficient at encouraging managerial effort and reducing firm risk.

Keywords: CEO risk taking, inside debt, leverage, principal-agent problem

JEL codes: G32, G34, J33

1 Introduction

Executive compensation raised much controversy in the aftermath of the 2007-08 financial crisis. Compensation reforms, such as Dodd-Frank Executive Compensation Reform Act in the US and Remuneration Code in the UK, have been gradually implemented to restrict excessive pay and to limit excessive risk taking. Although they are well intended, it is far too early to say whether these reforms are capable of reducing the risk-taking behavior.[1] A general approach adopted by these reforms to limit pay and risk taking is to introduce debt-like features into the compensation package. For example, both the Dodd-Frank Act and the UK Remuneration Code include clawback policies, which involves deferring CEOs' compensation over a long period of time.[2] Deferred salary is essentially a debt instrument contingent on the firm's asset value, as its payoff is similar to the firm's debt.

The standard theory proposed by Jensen and Meckling (1976) suggests that rewarding debt compensation can reduce corporate risk taking in a simple owner-bondholder setup. The question is whether this claim remains true in a more realistic framework where pay package, managerial decisions and firm policies are simultaneously determined. In this paper, we explore such a problem by investigating effects of debt compensation on the behavior of a manager as well as on that of equityholders. We find that rewarding debt compensation to managers can reduce managerial risk taking but this does not necessarily imply lowering the risk of the firm's equity.

[1] Historically, some well-intended reforms caused the exactly opposite effect. For example, Perry and Zenner (2001) and Murphy (2013) argue that the one million-dollar deductibility rule (i.e. US Internal Revenue Code Section 162(m)) leads to higher CEO compensation, even though the rule was intended to reduce CEO pay.

[2] In the US, section 954 of the Dodd-Frank Act requires companies to adopt clawback policies for compensation awarded in preceding 3 years. The rules are expected to be effective in 2017. In the UK, based on Bank of England's Prudential Regulation Authority, Rule 15.17 and 15.20 on remuneration structure, 'a material risk taker who performs a senior management function', must have their variable remuneration deferred not less than 7 years and subject to clawback for a period of at least 7 years. The deferral rules are in effect on 1 January 2016.

Specifically, we develop a numerical principal-agent model in which capital structure, compensation package and managerial actions are endogenously determined. We consider a risk-averse manager whose compensation consists of two components. The first is the firm's stock, which represents equity incentives awarded to the manager; the second is either a fixed wage or a fraction of the firm's debt. The presence of the second component allows for a direct comparative analysis of the effects of inside debt.

Given the remuneration package offered by the firm's shareholders, the manager chooses the level of effort and volatility to maximize the expected utility of her terminal wealth. Her actions have a direct effect on the company value: the effort choice influences the mean of the firm's return, whereas the volatility choice translates into the likelihood of more extreme value realizations. The manager incurs a cost of exerting different actions and the cost of managerial action is increasing and convex in both effort and the size of volatility adjustment. Unlike prior contributions to the literature on risk shifting, we allow for a strictly positive cost of *both an increase* and a reduction of volatility. Without a managerial action, the firm's volatility stays at its benchmark ("normal") level. We label the manager's volatility choice as the degree of managerial risk taking, to reflect the fact that the firm's risk level is directly controlled by her.

Shareholders can affect the risk of the firm by choosing the firm's capital structure given that this choice is inherently associated with selecting the scale of firm's operations. Hence, the firm's total risk is the outcome of both the manager's and shareholders' risk choices. In addition to the capital structure, shareholders determine the manager's compensation contract, which provides an additional channel through which managerial risk taking is influenced. The model is solved by maximizing the shareholders' objective function, which equals the expected value of equity net of any payments to the manager.

Our framework introduces two major extensions to the standard principal-agent model. The first one is the inclusion of the managerial risk choice. As shareholders can also change risk by adjusting the firm's capital structure, we effectively investigate risk-taking choices made by the manager and shareholders. Another extension is the inclusion of risky debt. Since the level of debt is endogenously determined, the compensation plan also has an impact on the firm's cost of debt. The additional interaction between the compensation and capital structure allows for a detailed examination of the effects of inside debt compensation on managerial choices.

By relaxing some of the assumptions commonly made in the extant literature, the model generates a number of novel economic results and insights. Firstly, a combination of inside debt and equity compensation can encourage more managerial effort than a combination of fixed wage and equity, however, it only occurs when the manager is highly skilled. Although counter-intuitive, it is easy to understand by looking at compensation payoffs at default. When a firm fails, payoff of inside debt is always positive and proportionate to the firm's residual value, whereas payoff of fixed wage can be zero and in some cases does not vary with residual value. At default, this structure creates a strong incentives for the manager, who receives inside debt, to exert high effort and collect a large payoff. Since the manager is very skilled and her effort choice has large impact on firm value, it is possible to revive an already bankrupted firm. Fixed wage on the other hand may encourage the manager to not work, for higher effort does not necessarily lead to higher payoff.

The result is consistent with Edmans and Liu (2011) who find that debt compensation can improve managerial effort. To achieve this result, they assume that managerial effort has a significant impact on the firm's value upon bankruptcy. This is similar to our highly skilled manager scenario.

Secondly, debt compensation reduces managerial risk taking only in one special case, that is, when the cost of changing volatility is relatively low. This result may be viewed as rather reassuring, assuming that compensation reforms are targeted mainly at large banks, which have a relatively low cost of changing risk (volatility). Even then, although debt compensation may under certain parameter scenarios limit managerial risk taking, it may fail to reduce the institution's total risk. This is due to our third result that debt compensation can make the firm more vulnerable to failure because shareholders choose a debt level that offsets the manager's effort and risk choice.

Thirdly, debt compensation leads to higher overall firm risk in most usual scenarios. Even though inside debt can improve managerial effort and limit managerial risk taking under certain scenarios, endogenously chosen leverage always makes firm more risky. While debt compensation makes the manager behave like a debtholder and reduces manager-debtholder agency cost, whether it can improve firm's default risk depends largely on its seniority structure. i.e. how it is paid in the event of bankruptcy. In our model, debt compensation increases firm's default risk because its payoff is partially protected. Jensen and Meckling (1976) argue that using inside debt can reduce asset substitution problem, but their original analysis does not consider the implication of introducing a third party – the manager. As in our analysis, rewarding this third party with debt could worsen the asset substitution problem if she is not subject to the full consequence of the firm's bankruptcy.

Our conclusions are consistent with several effects documented in the executive compensation literature. Unsecured debt compensation reduces various measures of firm risk, e.g. Cassell et al. (2012), Bennett et al. (2015), Caliskan and Doukas (2015); inside debt reduces shareholders return e.g. Srivastav et al. (2014); the relationship between the level of debt and the magnitude of the shareholder-bondholder agency cost, e.g. Ortiz-Molina (2007) and Brockman et al. (2010); and the role of capital structure in curbing managerial actions, e.g. Jensen (1986).

The remainder of the paper is organized as follows. Section 2 outlines the model, whereas section 3 discusses solution methodology and the base-case parameter values. Numerical results are discussed in section 4, which is followed by section 5 containing empirical implications. Section 6 concludes the paper.

2 The model

In the model, the manager maximizes her expected terminal utility by choosing the optimal effort and volatility. Unlike in most standard principal-agent models, where the level of effort, a, is the only managerial choice variable, the manager can also influence the company's volatility, v. This can be achieved by choosing a particular operational policy. Managerial effort increases the firm's asset value and is privately costly to the manager. Volatility choice is costly to implement as well so changing the firm's risk results in a negative utility to the manager. Volatility is assumed to have a positive impact on the firm's expected asset value, which can be interpreted as a risk premium.[3] The manager's choice variables are not verifiable, so any compensation package, which is designed to maximize shareholders' value and chosen by them, must be based on managerial incentive compatibility.

Shareholders choose the firm's capital structure, L, and the compensation package.[4] A higher dollar amount of debt is associated with a bigger scale of firm's operations. Managerial compensation consists of two components, the first is an incentive pay, $C \in [0, 1]$, which is a fraction of the firm's total equity. This is equivalent to paying the manager with the firm's stock. The second is a non-incentive pay, $D_z, z \in \{e, d\}$, which could either be a fixed wage, D_e, or debt compensation, D_d, depending on the considered scenario. When the non-incentive pay is the fixed wage ($D_z = D_e$), we recover a standard equity pay model similar to Cadenillas et al. (2004) and Palmon et al. (2008) as a special case, where the manager is compensated with equity and a fixed wage. When the non-incentive pay is D_d, the manager is compensated with equity and debt as in Edmans and Liu (2011). We use this setup to compare the effects of debt compensation against a conventional equity compensation model.

There are two periods in our model: t_0 and t_1. At t_1, the firm's levered asset value, X_1,

[3]This assumption is made to ensure that both shareholders and the manager have incentives to increase risk.
[4]We use capital structure and leverage interchangeably throughout the paper.

is a function of managerial effort, a. The firm's (outside) equity value then equals

$$S^z(X_1) = (1 - C)(X_1 - L - D_z)^+. \tag{1}$$

The firm's outside equity value at maturity, $S(X_1)$, is the firm's asset value net of debt and compensation to the manager. The firm's levered asset value at t_1 equals

$$X_1 = (X_0 + B_0) \exp\left\{ \left[r + a + \alpha(\sigma + v) \right] T + (\sigma + v)\epsilon\sqrt{T} \right\}, \tag{2}$$

where $T = t_1 - t_0$ is the time interval between the two periods, ϵ is a random variable which takes value either 1 or -1, and $a \in (0, +\infty)$ is the manager's effort choice. There is no coefficient in front of a to proxy the manager's skill. As we discuss later skills are modeled in the manager's cost function. Effort increases the firm's expected asset value. Parameter $v \in (-\overline{\sigma}, \infty)$ reflects the manager's volatility choice. When volatility is being reduced, v takes a negative value. Volatility level σ is the firm's normal risk if there is no managerial action to change the firm's volatility. $\overline{\sigma} > 0$ represents the maximum amount by which volatility can be reduced. We impose the strict inequality $\overline{\sigma} < \sigma$, which reflects the fact that there are physical limitations by how much the manager can reduce risk. X_0 is the firm's unlevered asset value at t_0, B_0 is debt value at t_0, r is the risk-free interest rate, and α is a positive constant that measures the effect of risk on the expected return. Cadenillas et al. (2004) interpret α as the slope of the Capital Market Line, which depends on characteristics of the firm. We adopt the same interpretation here. Random variable ϵ follows a binomial distribution:

$$\epsilon = \begin{cases} 1 & \text{with probability} \quad p \\ -1 & \text{with probability} \quad 1 - p \end{cases}, \tag{3}$$

where p is given by

$$p = \frac{1 - e^{-(\sigma+v)\sqrt{T}}}{e^{(\sigma+v)\sqrt{T}} - e^{-(\sigma+v)\sqrt{T}}}. \tag{4}$$

Probability p is set so that $E[X_1]$ is always equal to $(X_0 + B_0) \exp\Big\{\big[r + a + \alpha(\sigma + v)\big]T\Big\}$.[5] In this setting, the manager's volatility choice affects the firm value as well as the probability of each state, so there are feedback effects between managerial choices and the compensation package. Prior contributions assume either of the two for tractability. For example, John and John (1993) assume that the managerial action only affects the probability of each state.[6] In contrast, Edmans and Liu (2011) assume it only affects the value in each state. Since in our framework the solution is obtained numerically, we can explicitly introduce managerial action feedback effects.

2.1 Manager's problem

The manager is risk averse and has a power utility function $u(x)$

$$u(x) = \frac{x^{1-\gamma}}{1-\gamma} \quad , \tag{5}$$

where γ is the coefficient of relative risk aversion. Utility is additively separable in income and action. In addition to effort, we introduce volatility adjustment as a choice variable. Function $h(a, v)$ denotes the manager's cost function or disutility, with

$$h(a, v) = A_1 a^\theta + A_2 |v|^\beta \tag{6}$$

[5] p is chosen to eliminate the bias associated with using the exponential function so that volatility only contributes to expected return through α. For this reason, p is also independent of riskless rate r.

[6] In John and John (1993), the value in each state is constant but probability of each state is controlled by the manager.

$A_1 > 0$ and $\theta > 0$ are exogenous parameters that determine cost of effort, both can be interpreted as managerial skill. A low value of A_1 or high value of θ indicates the manager has high skills because effort is less costly for her to implement. $A_2 > 0$ and $\beta > 1$ determine cost of volatility. Since it is costly to increase and decrease volatility, the absolute value is used to make sure the volatility cost is always positive.

The cost is increasing and convex in both effort and volatility. When the manager does not take any action to change risk (i.e., $v = 0$), the risk of the firm value is simply σ. The lowest value v could take is $-\overline{\sigma}$ (recall that $\overline{\sigma} < \sigma$). This is a rather practical assumption as it is not possible to reduce certain risks. The cost function is similar to the linear case of Guo and Ou-Yang (2006).[7]

It is costly to increase (positive value of v) and decrease (negative value of v) volatility. This volatility choice has a similar effect to hedging. For example, Bettis et al. (2001) assume that firms can change volatility by costly hedging. There is always a cost involved when the manager varies the firm's basic risk level. This assumption is particularly relevant for the financial industry because most financial firms spend large sums to manage their risk. The manager incurs the volatility cost because altering the firm's risk level requires effortful action. Identifying the right risky project to invest is a process that requires skills. Engaging in hedging strategies is also costly because the manager incurs a cost maintaining such a hedging program. In this sense, the volatility cost is very similar to the effort cost.

Guo and Ou-Yang (2006) consider a similar setup, but they only allow for the case where it is costly to reduce risk. We argue that volatility cost is increasing on both sides, that is, when either increasing or reducing risk. In addition to linear contracts in their paper, we

[7]We could also consider a family of Cobb-Douglas-type cost functions $h(a, v) = ka^\theta v^\beta$. However, interdependence between a and v would result in the manager choosing either a or v equal to zero, which would result in the value of the cost function being always equal to zero as well. In such a case, the manager could then set the level of the other decision variable to infinity, which would make the maximization problem unsolvable. Guo and Ou-Yang (2006) avoid this problem by assuming that the level of output risk is infinite when managerial effort variable is set to zero.

also consider the convexity of stock compensation.

Consequently, given the manager's utility and cost function, her objective function is given by

$$\max_{a,v} E\Big\{u\big[M^z(X_1)\big] - h(a,v)\Big\}, \tag{7}$$

where $M^z(X_1)$ is the manager's wealth at t_1. When the manager is compensated with equity and a fixed wage only,

$$M^e(X_1) = \begin{cases} W & \text{if} \quad X_1 \in [0, L] \\ W + X_1 - L & \text{if} \quad X_1 \in (L, L + D_e] \\ W + C(X_1 - L - D_e) + D_e & \text{if} \quad X_1 \in (L + D_e, +\infty) \end{cases} \tag{8}$$

where $W > 0$ is a constant representing the manager's personal wealth, which is independent of her compensation. This is a practical and also a technical assumption, as managers usually have positive external wealth. A zero personal wealth gives the utility level of negative infinite in some states, which would make the problem unsolvable. X_1 is the firm's levered asset value defined in equation (2). The manager's actions have a direct impact on her compensation through effort and volatility choices. In the first case, the firm asset value is lower than the face value of the debt. The firm liquidates and the manager receives nothing. Shareholders' value is also zero, whereas debtholders receive the residual value of $X_1 < L$.

The second case occurs when the firm asset value is higher than debt value but is insufficient to pay manager's fixed wage D_e. Hence, the firm is liquidated and the manager receives $X_1 - L$. Within the third range, when firm value is large enough, both manager's fixed wage D_e and stock grant C can be paid. In the event of liquidation, we therefore assume the following residual claim structure: debtholders have the highest seniority over the residual claim, the manager of the firm following next (fixed wage), with shareholders following last. Note that the manager is an employee of the firm but not a debtholder as in the second considered case.[8] This difference affects the manager's payoff at bankruptcy and indirectly affect debtholders and shareholders behaviors. We call this scenario the fixed wage case, as the manager does not receive any debt compensation.

When the manager is only compensated with equity and debt,

$$M^d(X_1) = \begin{cases} W + \frac{D_d}{D_d+L} bX_1 & \text{if} \quad X_1 \in [0, L + D_d] \\ W + C(X_1 - L - D_d) + D_d & \text{if} \quad X_1 \in (L + D_d, +\infty) \end{cases} \tag{9}$$

where $b \in (0, 1)$ in the first range represents fractional value associated with firm default, during which a fraction $1-b$ of the firm's asset value is lost. In this case, the firm asset value is not enough to pay back debt. The firm goes bankrupt and the manager's debt compensation is shared with the firm's debtholders. Therefore, the manager receives a fraction $\frac{D_d}{D_d+L}$ of all the firm's residual value. In the second range, the firm has enough value for both the manager and debtholders. The manager receives equity as well as debt compensation. We call this scenario the inside debt case, as the manager's compensation partly consists of inside debt. Under this scenario, the manager and debtholders essentially has equal rights on the firm's residual value. This is important because debtholders no longer has priority on the firm's residual value, instead the residual value is shared between debtholder and the manager.

[8] Although employees with unpaid wages and dismissed following insolvency are usually treated as preferential creditors, the amount that they can recover is limited and in most cases negligible for a company's CEO. For example, under the UK Employment Rights (Increase of Limits) Order 2014, arrears of pay up to £464 a week for a maximum of eight weeks (resulting in a total of £3,712) are recoverable. This is negligible in comparison with a CEO's total fixed wage. See also Grant (2001), p. 129, as well as Kabir et al. (2013) in the pension liability context.

2.2 Shareholders' problem

Shareholders make compensation and leverage decisions,[9] and their objective is to maximize the firm's outside equity value net any debt and compensation to the manager,

$$\max_{D_z, C, L} E\Big[S^z(X_1)\Big], \tag{10}$$

where $S^z(X_1)$ is given by,

$$S^z(X_1) = \begin{cases} 0 & \text{if} \quad X_1 \in [0, L + D_z] \\ (1 - C)(X_1 - L - D_z) & \text{if} \quad X_1 \in (L + D_z, +\infty) \end{cases} \tag{11}$$

$S^z(X_1)$ is the equity value given the firm's asset value X_1. The first range represents the case where the firm asset value is lower than the combined face value of the debt and the manager's non-incentive pay, D_z. The firm asset value is not enough to pay back the manager and the debtholders, so shareholders receive a zero payoff. The second range corresponds to the case where firm asset value is large enough for both the manager's non-incentive pay D_z and debt repayment L. The respective payoffs of the manager, shareholders and bondholders are summarized in Table 1.

[Please insert Table 1 about here.]

Shareholders' problem is solved subject to the following conditions,

$$E\Big\{u\big[M^z(X_1)\big] - h(a, v)\Big\} \geq u(H_0) \tag{12}$$

[9] As discussed previously, shareholders can always indirectly influence the firm's capital structure by buying and selling the firm's shares. Other studies also assume leverage is controlled by shareholders, for example Stulz (1990) and Cadenillas et al. (2004).

$$(a, v) \in \arg\max_{a,v} E\Big\{u\big[M^z(X_1)\big] - h(a, v)\Big\}, \tag{13}$$

These are the basic participation and incentive compatibility constraints (see Holmström (1979)). Participation constraint (12) represents the minimum expected utility level at which the manager is willing to work for the firm. Here H_0 is a certainty equivalent that represents the manager's external opportunities.[10] Condition (13) is the incentive compatibility constraint which ensures that the manager maximizes her utility, given shareholders' choices. This constraint is essential to the problem since shareholders cannot observe (hence enforce) the manager's actions.

The timeline of decisions is the following: at the beginning of t_0 shareholders determine the levels of decision variables (D_z, C, L) to maximize the firm's equity value. In determining these levels, shareholders anticipate the effect of their choices on manager's actions (and their expected utility). After observing the capital structure and compensation package chosen by shareholders, the manager optimally chooses her effort and volatility to maximize the expected terminal utility. If the manager's expected utility is higher than her reservation utility H_0, she accepts the offer. The game ends at t_1 when the firm liquidates and shareholders pay off the manager and debtholders.[11]

2.3 Debtholders' claims

Since debt in our setup is generally risky, the firm has a positive probability of default. We outline here the valuation method for the firm's debt obligation. At maturity (t_1), the

[10]In a general equilibrium model H_0 would be determined by the competitive market.

[11]Liquidation here means that the firm dissolves and firm's assets are distributed to each party in the model according to the previously outlined residual claim structure.

(outside value of the) debt B_1^z is given by

$$B_1^e = \begin{cases} bX_1 & \text{if} \quad X_1 \in [0, L] \\ L & \text{if} \quad X_1 \in (L, +\infty) \end{cases} \tag{14}$$

and

$$B_1^d = \begin{cases} \frac{L}{D_d+L} bX_1 & \text{if} \quad X_1 \in [0, L + D_d] \\ L & \text{if} \quad X_1 \in (L + D_d, +\infty) \end{cases} \tag{15}$$

where L is face value of the risky debt, held by outside debtholders. As outlined above, b is a proportional bankruptcy cost representing a deadweight loss in the event of firm default. Since debtholders have high priority on the firm's residual claim, debtholders always receive a non-zero cash flow.

It is worth noting that debtholders are fully aware of the manager's compensation contract. They know that the manager's compensation consists of equity and a fixed wage or debt, they are aware of the seniority structure in the event of bankruptcy. They correctly incorporate all these information into the initial debt price. At t_0, the outside debt value is simply discounted expected value of B_1^z,

$$B_0 = e^{-rT} E[B_1^z(X_1, L)] \tag{16}$$

where $B_1^z(X_1, L)$ indicates dependence on both X_1 and L. Since there is no interest payment, B_0 can be interpreted as the initial price of a zero-coupon bond.[12]

[12]As there is no tax advantage associated with debt financing, the amount of (outside) debt is chosen to effectively trade-off benefits of the firm's debt-financed growth with the associated bankruptcy costs.

3 Solution methodology

The problem does not admit a closed-form solution and we obtain our results numerically. Since the model involves two parties that make choices, the problem is solved in two stages. In the second stage, we solve the problem for the manager. The solution of the manager's problem is then used to solve shareholders' problem in the first stage.

In the second stage of the problem the manager observes the compensation contract and firm leverage. If the contract offers the expected utility higher than $u(H_0)$, the manager accepts it and (privately) optimally chooses the levels of a and v.

In the first stage, shareholders choose compensation contract (D_z, C) and the firm leverage L. Shareholders correctly anticipate the second stage managerial effort and volatility choice. It is not optimal for the shareholders to choose contract variables that provide the manager with utility of less than $u(H_0)$, in which case the manager does not take the job. It is, however, optimal to choose a combination of C and D_z which corresponds to reservation utility, $u(H_0)$. In that case, the cost of employing the manager is minimized. The manager herself is indifferent between contract packages as all combinations provide her with the reservation utility. The solution seeking procedure then follows: for a given leverage L, combinations of C and D_z are sought to maximize the shareholders' outside equity value, while maintaining the utility provided to the manager at $u(H_0)$. For each combination of C and D_z, the second stage problem (equation (7)) must be solved and shareholder value calculated using equation (11). This procedure is then repeated for all leverage choices L. The optimal leverage, L^* and the corresponding optimal C^* and D_z^*, are then chosen as those that maximize the (outside) equity value.

Essentially, the solution search procedure plots the manager's participation constraint in the shareholders' value space. The optimal solution is merely the point on the participation constraint that maximizes the shareholders' expected value.

The proposed numerical approach is a consequence of the fact that principal-agent models are generally difficult to solve analytically. Closed-form solutions are rare and numerical methods are computationally intensive but necessary. Previous contributions obtained solutions only to some special cases of the principal-agent model. For example, Grossman and Hart (1983), Innes (1990) and Prescott (2004) only solve the problem for linear contracts. Su and Judd (2007) and Armstrong et al. (2007) include convex contracts in their problem but they do not consider endogenous leverage, unlike our model.

3.1 Base case parameters

In choosing appropriate parameters for our numerical results and make comparisons possible we follows Cadenillas et al. (2004) and Guo and Ou-Yang (2006). We normalize the firm's initial unlevered asset value, X_0, at 100 which is done in Cadenillas et al. (2004). We choose the effort coefficients A_1 and A_2 to be 0.5 and 2 which is close to values used in Figure 11 of Guo and Ou-Yang (2006). Effort and volatility cost parameters, θ and β are both set to 2, which is used in Figure 12 of Guo and Ou-Yang (2006). Time is chosen to be $T = 1$. The interest rate, r, is set to 0.03. The firm's benchmark volatility level, σ, is set to 0.3 which is approximately the median volatility in the sample of executive stock option issues in Carpenter (1998). The manager's coefficient of risk aversion, γ, is assumed to be 4, following Kahl et al. (2003). The manager's reservation wage, H_0, and personal wealth, W, are both set at 10. Bankruptcy deadweight loss, $1 - b$, is set to 0.2, which means 20% of the firm's asset value is destroyed in the event of default. This is consistent with empirical evidence where bankruptcy cost is estimated to be between 10% and 20%, e.g Andrade and Kaplan (1998) and Hennessy and Whited (2007).

4 Optimal solution and risk taking

The primary question the paper attempts to answer is whether debt compensation reduces managerial risk taking as well as the firm's total risk, given that the firm's total risk is determined by both the manager's and shareholders' choices. Recall that there are two ways of changing equity risk. The first is via the manager's volatility choice, v, and this risk is implied by the firm's and the manager's characteristics. We call this managerial risk taking, as the manager can shift this risk by changing the firm's operating strategy or adopting certain type of hedging strategy. The second source of risk is the firm's debt level, L. Higher leverage means that the equity value depends more heavily on the manager's action choices. As a consequence, it magnifies managerial risk taking and makes the firm more risky. Since shareholders control the firm's leverage choice, they can indirectly moderate the manager's action choices.

Optimal solutions of both the fixed wage and inside debt cases are presented in Table 2. We report results for a range of exogenous parameters. The difference between the two cases is the design of compensation package. Essentially, we are comparing the same manager's risk-taking choice by rewarding her with different compensation packages, that is, with equity combined with either a fixed wage or inside debt.

4.1 Debt compensation and managerial effort

The optimal solutions suggest that debt compensation makes the manager behave more like a debtholder most of the time. As Table 2 shows, the manager exerts less effort across almost every exogenous parameters when rewarded with inside debt. For example, at $A_1 = 0.1$, optimal effort is 100.34×10^{-4} and 1.53×10^{-4} for fixed wage and inside debt cases, respectively. Consistent with conventional wisdom, equity and fixed wage is a very effective tool to induce effort, because it aligns the manager's objective with shareholders' value maximization.

However, there are exceptions. At $\theta = 5$ and 6, optimal effort is higher under the inside debt case. Debt and equity compensation actually encourages more effort than fixed wage and equity. Assuming large effort impact on firm's default value (which is equivalent to a high value of θ in our model), Edmans and Liu (2011) find a similar result. It is very simple to see the rationale: The manager is compensated even when the firm fails as equation (9) shows that the manager's payoff is a linear function of the firm's residual value, bX_1. Since cost of effort is low at high value of θ, she can exert large effort to revive the bankrupted firm and also to earn a large payoff. Fixed wage has a similar impact on the manager's effort, but it does not scale up her payoff at firm failure. As equation (8) shows that the manager's fixed wage does not vary with firm residual value bX_1, and can equal to zero in the worst case. Effectively, inside debt turned a highly skilled manager into a shareholder during firm default.

[Please insert Table 2 about here.]

4.2 Debt compensation and managerial risk taking

In almost every reported case, debt compensation leads to higher managerial risk taking. As shown in Table 2, for most parameter values, the fixed wage case (i.e., with no debt compensation) has lower volatility value. For example, for $\gamma = 3$, the volatility choices in the fixed wage and inside debt cases are $v = -46.91 \times 10^{-4}$ and $v = -5.59 \times 10^{-4}$, respectively.[13] Even when the firm's normal level of volatility is low (small value of σ), debt compensation still leads to higher managerial risk taking. For example, for $\sigma = 0.2$, the

[13]Optimal effort and risk aversion is negatively related, as shown in Table 2, optimal effort, a, equals 0.129 at $\gamma = 2$ and decreases to $a = 0.000$ at $\gamma = 7$. This is expected and in line with previous studies. External wealth, W, can approximate the manager's risk aversion. But the manager uses effort choices to prevent non-negative wealth, that is why optimal effort choices, a, is positively related to W, as shown in Table 2.

volatility choices are -3.83×10^{-4} and -0.16×10^{-4} for the fixed wage and inside debt case, respectively. While in both cases managerial risk taking is negative, suggesting that the optimal volatility choices are to reduce the firm's risk, risk reduction is usually much higher in the fixed wage case. In another words, debt compensation lowers the risk-reducing incentives. The result also applies to parameters A_1, A_2, W and θ where volatility choice is lower under the fixed wage case. The only exceptions occurs at $T = 5$ where inside debt case leads to a slightly lower volatility choice. As we discuss later, this is due mainly to low cost of adjusting volatility.[14] In all above cases, the absolute scale of volatility change is very small, both of the order of 10^{-4}. This is because volatility cost is relatively high, as a result, the manager uses mainly effort (for the former case, the choice levels are $a = 202.15 \times 10^{-4}$ and 14.78×10^{-4}, respectively) to improve her utility. The magnitude of volatility changes could be large when the cost of adjusting volatility is low. For example, at $\beta = 10$, volatility choices for the fixed wage and inside debt cases are 0.1096 and 0.1095, respectively. The magnitude is almost five hundred times that of the base case choices.

Cost of adjusting volatility is also affected by the parameter γ, where another case of large volatility choices is observed: $\gamma = 2$ as shown in Table 2, where the parameters are $a = 0.129$ and $v = -0.027$. This is hundred times more than the base case choices. Interestingly, in this scenario the solutions to the fixed wage and inside debt cases start converging. It is simply optimal to compensate the manager predominantly with equity. Since both the effort and volatility costs are low, equity induces large effort and volatility choices, which leads to high firm values. In the limit, it is optimal not to award any fixed wage or debt at all because equity is most effective in improving firm value. Therefore, both cases will have exactly the

[14] High value of T is equivalent to low cost of adjusting volatility. This is because large T increases impact of effort and volatility in equation (2), but does not increases their respective cost in equation (6). Relatively, the cost of adjusting volatility is lower than in other cases.

same solutions.[15]

The only case where debt compensation actually reduces risk taking is at high value of β, i.e. when the volatility cost is low. The reason for this is that debt compensation reduces the manager's marginal utility, so she implements less effort and avoids large adjustments to the risk level. This is because both actions lead to a higher utility cost. When volatility cost is high, the manager optimally reduces volatility (e.g. negative value of v). Debt compensation in this case, makes the manager reduce volatility less than in the contract with a fixed wage and equity. When the volatility cost is low, debt makes the manager increase volatility in both cases but the increase is smaller (i.e., associated with a positive but lower v) in the inside debt case than when manager is compensated with a combination of equity and a fixed wage. Consequently, the inside debt case is associated with a lower volatility choice. In other words, debt compensation can only reduce managerial risk taking when the firm's cost of adjusting volatility is low. However, the difference in volatility choices is very small between the two cases (for example, when $\beta = 6$, the fixed wage case has $v = 217.23 \times 10^{-4}$, and the inside debt case has $v = 216.57 \times 10^{-4}$). Even though a fixed wage and debt compensation have different payoffs at firm bankruptcy, impact of debt compensation is limited because chances of firm failure are very small. Value maximizing shareholders always choose optimal leverage so the firm has a very small chance of failure. This result raises the question whether compensation design can have any significant effect on the manager's risk-taking behavior.

4.3 Debt compensation and total firm risk

Does debt compensation reduce the firm's risk as a whole? A priori, it is not obvious whether paying the manager with debt makes shareholders take less risk via their leverage choice. To measure the firm's total riskiness taking into account both managerial and shareholders'

[15] Empirically, our model therefore predicts that actual (optimal) compensation packages associated with a low cost of adjusting the riskiness of corporate strategy indeed do not have a fixed wage or inside debt component.

risk taking, we calculate distance-to-default (DtD) based on each set of optimal solutions. This measure is a widely accepted indicator of default likelihood. Following Sundaram and Yermack (2007), we define DtD as the number of standard deviation decreases in a firm's asset value that it would take for the firm to default. Formally,

$$\text{DtD} = \frac{E[X_1] - L}{E[X_1](\sigma + v)\sqrt{T}} \tag{17}$$

where $E[X_1]$ is firm's expected asset value and L is the face value of firm's debt. As shown in Table 3, the inside debt case typically has lower DtD statistics (see last two columns of Table 3, for example, at $\gamma = 3$, DtD is 0.9531 and 0.9438 for the fixed wage and inside debt cases, respectively) and, hence, a higher probability of default. In the fixed wage case, the manager implements higher effort which increases the firm's expected asset value and reduces default likelihood. In the inside debt case, managerial effort is substantially lower which impacts the firm value as well as the default probability. In other words, debt compensation are likely to make firm more risky and more prone to failure. The reason for this result is that debt compensation protects the manager against firm failure more than cash compensation does (cf. the seniority structure) so that she implements less effort when rewarded with debt.

There are three cases where debt compensation lead to lower default probability. They occurs when cost of effort is low (e.g. low value of A_1), cost of volatility is high (e.g. high value of A_2), and length of contract is high (e.g. high value of T). For example, at $A_1 = 0.1$, DtD for fixed wage and inside debt are 0.9473 and 0.9485. Inside debt has slightly higher DtD hence lower default probability. In each of these cases, optimal leverage is considerably lower in the inside debt case. Although the fixed wage case encourages higher optimal effort and increases the firm's asset value, it also affords the firm to take higher leverage. The extra leverage raises firm's default probability, and it also outweigh the value increasing effect of effort. So default probability is higher in the fixed wage case.

Although firm's overall riskiness can be lower in the inside debt case. The differences between the two cases are rather small for most parameter values. Similar to the optimal solution presented in Table 2, this is because the manager's payoffs (both fixed wage and debt compensation) are not solvency-contingent. Even though the payoffs (from fixed wage and debt compensation) are different at firm default, given the fact that default has a small probability of occurring, firm default is not likely to significantly affect the manager's optimal choice. This in turn leads to small difference in firm's total risk. As discussed previously, the result suggests that debt compensation is not very effective at reducing firm's total risk.

Debt compensation also makes the manager behave more like debtholders which exacerbates the shareholders-manager conflict. Although the shareholders-manager agency cost is not explicitly modeled, it is obvious that shareholders choose leverage to offset the manager's debtholder-like behavior. In fact, debt compensation intensifies the asset substitution problem and increases the shareholders-manager agency cost. As shareholders' returns are almost always lower in the inside debt case. Table 4 shows shareholders' return, μ_S. It is usually lower in the inside debt case. For example, at $\alpha = 0.06$, μ_S equals to 0.0025 and -0.0004 for fixed wage and inside debt cases, respectively. This phenomenon has been well documented in the empirical literature, e.g. Ortiz-Molina (2007) and Brockman et al. (2010).

However, there are exceptions. The first such exception occurs for high values of θ, where the manager has a very low cost of exerting effort. Shareholders' return, μ_S, is actually higher under the inside debt case. For example, at $\theta = 6$, μ_S equals to 0.7163 under the inside debt case, compared to the lower value of 0.5332 under the fixed wage case. This result suggests that debt compensation encourages the manager to behave like a shareholder. As evident from Table 2, optimal effort indeed is higher under the inside debt case when $\theta = 6$. Shareholders, who anticipated the manager's large effort choices, increase firm's optimal leverage and raise their returns. This result is similar to that of Edmans and Liu (2011) who assume effort has large impact on the firm's residual value, so inside debt actually encourages managerial effort.

Even though inside debt can lead to higher effort and higher shareholders' return when cost of effort is low, it does not reduce the firm's overall risk at all. As Table 3 shows, when $\theta = 5$ and 6, fixed wage case still generates higher DtD values (1.0799 and 1.1536) than inside debt case (1.0000 and 1.0280). Debt compensation in this special case merely affords shareholders with more leverage.

[Please insert Table 3 about here.]

4.4 Managerial effort and firm total risk

To isolate the effect of managerial effort on firm's total risk, Table 3 also reports DtDs while holding the effort level at zero. It appears that debt has little effect on risk taking, as both cases have exactly the same DtDs (for example, at $\beta = 4$, the no effort DtDs equals 0.9492 for both fixed wage and inside debt cases). The reason for this result is simple: since shareholders choose the manager's compensation package, and managerial effort is set to zero. Both cases would generate identical return for the shareholders. The compensation package acts merely as a substitutional tool for the firm's leverage. This result is similar to the well known mechanism that leverage is a substitute of equity incentives (e.g. Jensen (1986), Stulz (1990) and Gao (2010)) for disciplining managers.

The key mechanism here is the feedback effect of effort on leverage. When effort is non-zero, as in Table 2, optimal leverage differs between the two cases because higher effort choices afford the firm to take on more debt. However, when effort is set to zero, such feedback effect is removed and both cases generate the same optimal leverage. In short, the firm's DtD is mostly improved by managerial effort, which increases the firm's asset value as well as shareholders' return. Without managerial effort, either compensation packages would have the same impact on firm's total risk.

4.5 Leverage and managerial risk taking

In addition to presenting optimal individual choices of shareholders and the manager, we also report the firm's DtDs while holding leverage exogenous. As shown in Table 3, when leverage is fixed at 100, both cases are associated with an identical default probability. The result is also discussed in Edmans and Liu (2011), who argue that if default is unlikely, fixed wage and inside debt would be indifferent. Because at an acceptable leverage level firm bankruptcy will never occur. In this case, debt and fixed wage cases have exactly the same payoffs (for example, at $\sigma = 0.1$, DtDs for both fixed wage and inside debt cases are 1.7161, as shown in Table 3), which means that compensating the manager with a combination of equity and either debt or a fixed wage will lead to the same outcomes. Debt and fixed wage have different payoffs only in the event of bankruptcy. Therefore, only if leverage is sufficiently high, so that bankruptcy is very likely, debt compensation has a potential of having any advantage over a fixed wage and equity.

4.6 Is debt compensation a solution?

A number of reforms have been proposed across the globe following the financial crisis. Dodd-Frank Executive Compensation Reform Act in the US and Remuneration Code in the UK are two examples. Both reforms require that bonuses should be deferred to a greater extent, which suggests that compensation should have more debt-like features. In support of these reforms, empirical studies find evidence that firms with higher proportion of debt compensation are likely to have lower risk. For example, Sundaram and Yermack (2007) and Wei and Yermack (2011) show that higher CEO pension assets are associated with lower firm default probability, and investors rationally price managerial debt compensation into firms' CDS spread. Bennett et al. (2015) find that higher proportion of inside debt is associated with lower bank default risk.

However, is debt compensation the right solution to our compensation problem? While compensation reforms are partly driven by the hypothesis 'bonuses caused the crisis', is more debt-like compensation likely to alleviate the problem? Based on our model solutions, the most effective tool of reducing risk is to control firm leverage. As the first 2 columns in Table 3 shows, firms with fixed leverage have far lower default probabilities. Managerial effort, on the other hand, can help improve firm value. In practice, relying on effort to reduce risk could be ineffective, as Fahlenbrach and Stulz (2011) show that bank CEOs did not make any superior returns during the recent crisis, which implies that CEOs may have no effort input to firms' return. When effort is universally zero, our model shows that rewarding equity with either inside debt or a fixed wage would have almost an identical effect on firm risk.

In short, debt compensation appears to have less scope for reducing risk than it was envisaged. When volatility cost is low, debt compensation reduces managerial risk taking. But the combined effects of leverage and debt compensation can make the firm more vulnerable to default. Debt compensation can make the manager's objective more aligned with debtholders or shareholders depending on the manager's skills. As Table 4 shows, debtholders' returns are the same across the two cases, but shareholders' returns can be lower or higher when the manager is rewarded with inside debt. For example, at $\gamma = 3$, shareholders' return, μ_S, is lower under the inside debt case. It equals to 0.0463 when awarded with fixed wage and -0.0073 when awarded with inside debt. At $\theta = 5$, shareholders' return is higher under the inside debt case. It equals to 0.3143 and 0.3711 for fixed wage and inside debt cases. However, debtholders' return, μ_D, equals to 0.03 all the time.

[Please insert Table 4 about here.]

The above results clearly indicate that debt compensation does not always lead to a more risk-averse behavior. Debt compensation causes higher default risk, because the seniority structure (equation 9) treats the manager and debtholders equally. It partially protects the manager's compensation at the expense of the debtholders. In fact, due to the seniority structure, the manager's compensation never goes to zero. This creates a disincentive for the manager to not exert effort, and also limits the firm's capacity to borrow. Hence reduces shareholders value and increases default risk. In the extreme case of a highly skilled manager ($\theta = 5$ and 6), effort is large but leverage becomes so high that inside debt still increases default risk. Therefore, a compensation reform that matches executive remuneration with company's debt must make sure the seniority structure are properly specified – the manager's claim must come after the debtholders'. The new clawback provisions proposed in the UK and US implicitly put debtholders claim before the manager's, it should reduce default risk of those reform-affected firms.

5 Empirical implications

Our results show that fixed wage and equity are more effective at reducing managerial risk taking than debt compensation. As not all firms award debt to their CEOs, a study that looks at firms with and without inside debt can be undertaken to test such a hypothesis. When designing such a study, one would have to find a way of distinguishing between the two types of risk taking: managerial and that resulting from shareholders decision. In principle, one could attempt to proxy managerial risk taking by manager's strategic choices and implementation of operational policies. However, these proxies may also capture the firm's total risk, since firm total risk is a function of managerial risk-taking and shareholders leverage choice. Shareholders can in many ways influence the manager's risk choice. For example, Coles et al. (2006) use leverage, R&D, and operational policies to proxy firms' total risk. It would be interesting to design a new proxy to capture managerial risk-taking independent of shareholders' risk choices. This will allow testing of this prediction.

The main criticism of inside debt is that it reduces shareholders return and limit firm's growth. For example, Liu et al. (2014) find that inside debt encourages firms to hold excessive amount of cash that limits firms' growth prospect. Srivastav et al. (2014) find inside debt reduces dividend and stock buyback. Our model shows that, when the manager is highly skilled, inside debt can increase shareholders return. Because the manager can significantly increases the firm's residual value, essentially turning inside debt into equity when the firm is close to bankruptcy. It would be interesting to revisit those studies with an additional measure of managerial skill/talent, where we expect to observe a higher shareholders return for firms with skilled manager. Edmans and Liu (2011) make a similar assumption that effort has a large impact on a firm's residual value, hence we also expect to see inside debt increases shareholders returns when the manager has large influence on a firm's residual value. Though testing this prediction would require not only managerial skill/talent, but also the manager's human capital and negotiation power at bankruptcy.

Our final result shows that inside debt compensation increases the firm default probability, because the seniority structure of inside debt partially protects the manager from being punished for firm failure. Anantharaman et al. (2014)extensively test the seniority structure of different components of inside debt. They find that seniority structures is the main determinant for reducing default risk, and only inside debt that are truly unprotected can reduce a firm's default risk. The result suggests that even fixed wage can be more effective at reducing risk if structured to be less senior than the firm's outside debt. This provides direct support to the compensation reform implemented in the UK and US, where regulated financial institution are mandatory to implement clawback provisions for compensation made to their CEOs.

6 Conclusions

We develop a computational principal-agent model with managerial actions, compensation package and firm leverage. To analyze effects of debt compensation on managerial actions and firm policy, we implement the model based on equity, fixed wage and debt compensation. Our analysis compares the effects of compensating managers with equity and a fixed wage or inside debt. The main result is that even though debt can improve managerial effort and limit managerial risk taking in certain circumstances, the firm's total risk can still increase. As our numerical results show, this result is due to the fact that debt compensation can increase or reduce the shareholder-manager conflict. The manager's objective can be more aligned with debtholders, or shareholders, when debt compensation is awarded, depending on the skills of the manager. However, it does not resolve the fundamental conflict between debtholders and shareholders.

Jensen and Meckling (1976) suggest that rewarding debt can reduce risk taking, but their results assume that the manager is also the single shareholder of the firm. In that case, debt compensation always reduces risk taking because the owner shareholder's incentives are aligned with debtholders. In our argument, awarding debt to the manager will increase firm risk if inside debt is more senior than the firm's outside debt. In that case, not only the manager behaves like a debtholer which reduces shareholders' return, but also make the firm more risky.

Without considering seniority structure, using debt as a form of compensation has hardly any benefit. In the extreme case of a highly skilled manager, inside debt can encourage higher effort and increase shareholders' return, but it still leads to higher firm risk. One easy solution is to reward the manager with unprotected fixed wage, which is very similar to compensation that are subject to clawback provisions, not only increases managerial effort but also reduce the firm's risk. As clawback provisions are implemented in the new reform, we expected to see financial institutions becomes gradually safer.

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Table 1: **Payoffs of the manager, shareholders and debtholders** – The table reports payoffs to the manager, shareholders and debtholders. The payoffs of the manager, shareholders and bondholders sum up to the firm's total asset value, X_1 when the firm survives; or bX_1 when the firm fails. In the fixed wage case, the manager is compensated with equity, C and a fixed wage, D_e. In the inside debt case, the manager is compensated with equity, C and debt, D_d.

Firm asset value, X_1	$[0, L]$	$(L, L + D_z]$	$(L + D_z, +\infty)$
		The fixed wage case	
The manager's payoff, $M^e(X_1)$	0	$X_1 - L$	$C(X_1 - L - D_e) + D_e$
Shareholders' payoff, $S^e(X_1)$	0	0	$(1 - C)(X_1 - L - D_e)$
Bondholders' payoff, B_1^e	bX_1	L	L
Total	bX_1	X_1	X_1
		The inside debt case	
The manager's payoff, $M^d(X_1)$	$\frac{D_d}{D_d+L} bX_1$	$\frac{D_d}{D_d+L} bX_1$	$C(X_1 - L - D_d) + D_d$
Shareholders' payoff, $S^d(X_1)$	0	0	$(1 - C)(X_1 - L - D_d)$
Bondholders' payoff, B_1^d	$\frac{L}{D_d+L} bX_1$	$\frac{L}{D_d+L} bX_1$	L
Total	bX_1	bX_1	X_1

Table 2: **Optimal choices of equityholders and the manager** – The table reports optimal solutions of the problem. The base case has the following parameter values: firm initial asset value, $X_0 = 100$, effort and volatility cost parameters, $A_1 = 0.5$ and $A_2 = 2$, fraction of firm value destroyed in the event of bankruptcy, $b = 0.8$, manager's initial wealth, $W = 10$, reservation wage, $H_0 = 10$, time variable, T, firm volatility without managerial action, $\sigma = 0.3$, maximum volatility that can be reduced, $\overline{\sigma} = 0.2$, reservation wage, $H_0 = 10$. Under the inside debt case, the manager is given equity and debt and each optimal solution is composed of: managerial effort choice, a, volatility choice, v, equity, C, debt compensation, D_d, and firm leverage, L. Under the fixed wage case, the manager receives equity, C, and a fixed wage, D_e. In addition to the optimal choice variables, expected equity value, $E[S^z(X_1)]$ and initial debt price, B_0, are also reported. Managerial risk taking is represented by volatility choice, v, and shareholders' risk taking is represented by leverage choice, L.

Case	Fixed wage case							Inside debt case						
Optimal Solutions	$E[S^e(X_1)]$	a 10^{-4}	v 10^{-4}	C 10^{-2}	D_e	B_0	L	$E[S^d E(X_1)]$	a 10^{-4}	v 10^{-4}	C 10^{-2}	D_d	B_0	L
Base Case	99.03	10.75	-2.53	0.37	9.76	266.50	274.62	98.75	0.60	-0.16	0.27	9.75	265.20	273.27
γ														
2	147.02	1291.26	-271.92	15.10	0.00	343.47	353.93	147.02	1291.26	-271.92	15.10	0.00	343.47	353.93
3	104.73	202.15	-46.91	1.79	10.74	290.82	299.68	99.27	14.78	-5.59	0.86	9.23	269.40	277.60
5	98.74	0.53	-0.13	0.17	9.84	264.82	272.88	98.72	0.01	-0.01	0.16	9.84	264.74	272.80
6	98.72	0.03	-0.01	0.16	9.84	264.74	272.80	98.72	0.01	-0.01	0.17	9.84	264.74	272.80
7	98.72	0.00	0.00	0.00	10.23	264.74	272.80	98.72	0.00	0.00	0.17	9.84	264.74	272.80
T														
0.25	93.31	4.95	-2.35	0.14	9.91	563.68	567.92	93.26	0.09	-0.06	0.14	9.88	562.96	567.20
0.50	95.36	7.20	-2.44	0.21	9.87	389.00	394.88	95.24	0.27	-0.11	0.19	9.82	388.13	394.00
3	112.97	21.14	-2.75	0.73	9.68	143.96	157.52	111.71	2.03	-1.44	0.38	9.61	141.73	155.07
5	127.80	29.16	-2.86	0.90	9.83	107.82	125.26	125.11	3.85	-3.11	0.52	9.47	105.25	122.29
θ														
3	108.16	262.81	-2.42	1.39	10.50	294.39	303.36	101.97	80.23	0.59	0.46	9.60	274.77	283.14
4	117.25	564.86	-0.78	0.01	17.01	308.83	318.24	115.26	365.60	1.50	1.20	9.00	314.67	324.25
5	136.91	934.90	-0.52	7.93	5.96	337.15	347.42	144.94	963.80	-0.45	7.88	6.92	404.14	416.45
6	170.43	1508.23	-0.88	9.07	4.33	377.36	388.85	204.68	1645.76	-0.57	11.55	6.01	562.96	580.10
β														
4	98.89	0.01	-3.15	0.02	9.82	265.16	273.24	98.76	0.99	1.00	0.18	9.82	264.82	272.88
6	98.78	0.03	217.23	0.12	9.88	243.31	250.72	98.78	0.03	216.57	0.13	9.88	243.39	250.80
8	98.89	0.02	612.91	0.11	9.89	211.17	217.60	98.89	0.02	612.88	0.11	9.89	211.17	217.60

Table 2 (continued)

10	99.02	0.02	1096.08	0.11	9.90	180.43	185.92	99.02	0.02	1094.93	0.11	9.89	180.50	186.00
A_1														
0.1	100.34	55.12	-2.58	0.87	9.75	271.61	279.88	98.78	1.53	-0.15	0.32	9.70	265.48	273.56
0.25	99.36	21.79	-2.56	0.52	9.73	267.88	276.04	98.77	1.13	-0.15	0.24	9.77	265.16	273.24
1	98.86	5.33	-2.51	0.29	9.80	265.79	273.88	98.72	0.03	-0.12	0.26	9.76	265.09	273.16
2	98.78	2.65	-2.50	0.24	9.82	265.40	273.48	98.72	0.02	0.01	0.22	9.79	264.93	273.00
A_2														
0.5	98.96	10.46	-9.88	0.28	9.90	266.72	274.84	98.75	0.78	-0.80	0.28	9.74	265.32	273.40
1	99.01	10.50	-4.86	0.28	9.86	266.33	274.44	98.75	0.76	-1.73	0.23	9.78	265.24	273.32
3	99.04	10.79	-1.69	0.38	9.75	266.48	274.60	98.75	0.62	-0.11	0.17	9.83	264.85	272.92
5	99.04	10.81	-1.27	0.39	9.74	266.48	274.60	98.75	0.69	-0.09	0.27	9.74	265.20	273.28
σ														
0.1	96.66	0.14	0.00	0.31	9.70	599.15	617.40	96.66	0.14	0.00	0.31	9.70	599.15	617.40
0.2	99.10	16.32	-3.83	0.53	9.77	428.16	441.20	98.49	0.62	-0.16	0.29	9.72	423.58	436.48
0.4	99.18	7.93	-1.87	0.28	9.79	186.87	192.56	99.02	0.59	-0.16	0.25	9.76	186.40	192.08
0.5	99.40	6.25	-1.48	0.25	9.80	139.63	143.88	99.29	0.52	-0.14	0.23	9.78	139.39	143.64
W														
1	101.62	99.06	-23.31	0.69	10.45	276.27	284.68	99.28	15.11	-7.21	0.36	9.70	267.73	275.88
5	99.67	33.63	-7.92	0.51	9.90	269.12	277.32	98.82	2.87	-3.46	0.31	9.73	265.86	273.96
20	98.79	2.11	-0.50	0.37	9.67	265.71	273.80	98.73	0.08	-0.03	0.42	9.60	265.71	273.80
30	98.75	0.67	-0.16	0.45	9.58	265.86	273.96	98.73	0.00	0.00	0.42	9.59	265.71	273.80
α														
0.06	100.25	10.97	-2.56	0.41	9.73	270.06	278.28	99.96	0.61	-0.16	0.33	9.68	268.81	277.00
0.09	104.08	11.66	-2.63	0.53	9.62	281.20	289.76	103.75	0.64	-0.16	0.42	9.59	279.72	288.24
0.12	108.19	12.39	-2.69	0.63	9.52	293.07	302.00	107.82	0.68	-0.16	0.54	9.46	291.52	300.40
0.15	112.60	13.18	-2.76	0.73	9.43	305.81	315.12	112.17	0.71	-0.15	0.60	9.38	303.94	313.20

Table 3: **Distance-to-Default** – The table reports Distance-to-Default (DtD) based on optimal solutions from Table 2. DtD consistent with Sundaram and Yermack (2007) as $\text{DtD} = \frac{E[X_1]-L}{E[X_1](\sigma+v)\sqrt{T}}$. The first two columns are based on solutions where leverage is exogenous and fixed at 100. The second two columns are based on solutions where effort, a, is set to 0. The last two columns are based on optimal solutions reported in Table 2. All parameters are given in Table 2.

Specification	Fixed leverage		No effort		Optimal	
Case	Fixed wage	Debt	Fixed wage	Debt	Fixed wage	Debt
γ						
3	1.7165	1.7165	0.9488	0.9488	0.9531	0.9438
4	1.7161	1.7161	0.9493	0.9493	0.9490	0.9490
5	1.7161	1.7161	0.9499	0.9499	0.9499	0.9499
6	1.7161	1.7161	0.9499	0.9499	0.9499	0.9499
7	1.7161	1.7161	0.9505	0.9505	0.9499	0.9499
T						
0.25	3.3953	3.3953	1.0899	1.0899	1.0909	1.0899
0.50	2.4137	2.4137	1.0290	1.0290	1.0294	1.0284
3	0.9944	0.9944	0.7843	0.7843	0.8464	0.8468
5	0.7663	0.7663	0.6913	0.6913	0.7843	0.7836
θ						
3	1.7470	1.7470	1.0010	1.0010	0.9996	0.9970
4	1.7902	1.7902	1.0010	1.0010	1.0420	0.9848
5	1.8605	1.8605	1.0010	1.0010	1.0799	1.0000
6	1.9357	1.9357	1.0010	1.0010	1.1536	1.0280
β						
4	1.7050	1.7050	0.9492	0.9492	0.9574	0.9497
6	1.6015	1.6015	0.9406	0.9406	0.9525	0.9405
8	1.4289	1.4289	0.9231	0.9231	0.9231	0.9231
10	1.2632	1.2632	0.9024	0.9024	0.9024	0.9024
A_1						
0.1	1.7161	1.7161	0.9494	0.9494	0.9473	0.9485
0.25	1.7161	1.7161	0.9494	0.9494	0.9482	0.9492
1	1.7161	1.7161	0.9494	0.9494	0.9494	0.9491
2	1.7161	1.7161	0.9494	0.9494	0.9497	0.9494
A_2						
0.5	1.7161	1.7161	0.9494	0.9494	0.9506	0.9489
1	1.7161	1.7161	0.9494	0.9494	0.9500	0.9494
3	1.7161	1.7161	0.9494	0.9494	0.9487	0.9498
5	1.7161	1.7161	0.9494	0.9494	0.9486	0.9490
σ						
0.1	1.7161	1.7161	1.4959	1.4959	1.4732	1.4732
0.2	1.7161	1.7161	0.9961	0.9961	0.9956	0.9955
0.4	1.7161	1.7161	0.9056	0.9056	0.9054	0.9052
0.5	1.7161	1.7161	0.8646	0.8646	0.8644	0.8643

Table 3 (continued)

W						
1	1.7162	1.7162	0.9504	0.9504	0.9532	0.9484
5	1.7161	1.7161	0.9499	0.9499	0.9497	0.9489
20	1.7161	1.7161	0.9485	0.9485	0.9482	0.9476
30	1.7161	1.7161	0.9475	0.9475	0.9475	0.9475
α						
0.06	1.7161	1.7161	0.9403	0.9403	0.9476	0.9473
0.09	1.7161	1.7161	0.9151	0.9151	0.9435	0.9434
0.12	1.7161	1.7161	0.8882	0.8882	0.9396	0.9393
0.15	1.7161	1.7161	0.8630	0.8630	0.9359	0.9358

Table 4: **Shareholder and debtholder returns** – This table reports debtholders returns (μ_D) and shareholders returns (μ_S) based on optimal solution in Table 2. Parameter values are those of the base case. Debtholders returns are computed as $\mu_D = \frac{\log(L)-\log(B_0)}{T}$, where L is face value of debt. B_0 is initial price of debt. Similarly, shareholder returns are computed as $\mu_S = \frac{\log\{E[S^z(X_1)]\}-\log(X_0)}{T}$, where value of $E[S^z(X_1)]$ are those reported in Table 2.

Case	Fixed wage case		Inside debt case	
Returns	μ_D	μ_S	μ_D	μ_S
γ				
3	0.0300	0.0462	0.0300	-0.0073
4	0.0300	-0.0098	0.0300	-0.0126
5	0.0300	-0.0127	0.0300	-0.0129
6	0.0300	-0.0129	0.0300	-0.0129
7	0.0300	-0.0129	0.0300	-0.0129
T				
0.25	0.1200	-0.0448	0.1200	-0.0499
0.50	0.0600	-0.0245	0.0600	-0.0245
3	0.0100	-0.0037	0.0100	-0.0037
5	0.0060	-0.0020	0.0060	-0.0020
θ				
3	0.0300	0.0784	0.0300	0.0195
4	0.0300	0.1591	0.0300	0.1420
5	0.0300	0.3142	0.0300	0.3711
6	0.0300	0.5332	0.0300	0.7163
β				
4	0.0300	-0.0112	0.0300	-0.0125
6	0.0300	-0.0123	0.0300	-0.0123
8	0.0300	-0.0112	0.0300	-0.0112
10	0.0300	-0.0098	0.0300	-0.0098
A_1				
0.1	0.0300	0.0034	0.0300	-0.0123
0.25	0.0300	-0.0064	0.0300	-0.0124
1	0.0300	-0.0114	0.0300	-0.0128
2	0.0300	-0.0123	0.0300	-0.0128
A_2				
0.5	0.0300	-0.0105	0.0300	-0.0126
1	0.0300	-0.0100	0.0300	-0.0126
3	0.0300	-0.0097	0.0300	-0.0126
5	0.0300	-0.0096	0.0300	-0.0126
σ				
0.1	0.0300	-0.0340	0.0300	-0.0340
0.2	0.0300	-0.0090	0.0300	-0.0152
0.4	0.0300	-0.0082	0.0300	-0.0099
0.5	0.0300	-0.0060	0.0300	-0.0071

Table 4 (continued)

W				
1	0.0300	0.0161	0.0300	-0.0073
5	0.0300	-0.0033	0.0300	-0.0119
20	0.0300	-0.0122	0.0300	-0.0128
30	0.0300	-0.0126	0.0300	-0.0128
α				
0.06	0.0300	0.0025	0.0300	-0.0004
0.09	0.0300	0.0400	0.0300	0.0368
0.12	0.0300	0.0787	0.0300	0.0753
0.15	0.0300	0.1186	0.0300	0.1149