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Executive Compensation Structure and Credit Spreads

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Non-Technical Summary

In the aftermath of the recent financial crisis there has been increasing debate over the role of managerial compensation. Analysts and critics argue that many compensation packages may have generated excessive risk taking and contributed to the rapid spread of the crisis. In this paper we analyse the risk taking incentives of a manager whose compensation package consists of salary, equity awards and inside debt. Salary is the fixed component of pay, independent of performances. Equity compensation increases with stock prices and, thus, depends on performance. Inside debt consists of pensions and deferred compensation plans, whose payment is delayed until the retirement date. For tax-deferral benefits, inside debt is often unsecured, unfunded, and subject to a substantial risk of forfeiture in bankruptcy.

Traditionally, theorists and practitioners are in favour of inside debt as a tool to reduce risk-taking incentives and, in turn, the risk of corporate defaults. We show that inside debt exerts this beneficial effect only if its risk of forfeiture in bankruptcy is high. We also derive conditions under which inside debt increases managerial risk-taking incentives and accelerates the process towards bankruptcy. For instance, a large and unsecured inside debt tends to distort the risk-taking incentives of equity compensation and generates a situation in which higher equity ownership leads to higher credit spreads. Using a sample of US listed companies with traded credit default swap contracts we find evidence supportive of our predictions. These findings contribute to the recent regulatory initiatives in the US and the EU oriented towards reforming the structure of managerial compensation.

Executive Compensation Structure and Credit Spreads*

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Abstract

We develop a model of managerial compensation structure and asset risk choice. The model provides predictions about how inside debt features affect the relation between credit spreads and compensation components. First, inside debt reduces credit spreads only if it is unsecured. Second, inside debt exerts important indirect effects on the role of equity incentives: When inside debt is large and unsecured, equity incentives increase credit spreads; When inside debt is small or secured, this effect is weakened or reversed. We test our model on a sample of U.S. public firms with traded CDS contracts, finding evidence supportive of our predictions. To alleviate endogeneity concerns, we also show that our results are robust to using an instrumental variable approach.

JEL Classification: G32, G34, J32, J33, M52

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1 Introduction

Executive compensation consists of three main components: Salary, equity compensation, and inside debt. Salary is fixed and paid independently of performance,[1] and equity compensation is a variable part whose payoff is increasing in stock price. Both of these components are rationalized in the standard principal-agent framework (see, e.g., Hölmstrom, 1979). Inside debt consists of managerial pension and deferred compensation plans whose payment is delayed until a future date, normally the retirement date. For tax exemption purposes, these plans are often unsecured and unfunded and subject to forfeiture in bankruptcy.[2]

Given the significant difference in the payoff schedules of these compensation components, it is important to understand both the effect of each component and the combined effect of compensation structure on managerial risk-taking incentives. In this paper, we study the asset risk choice of a risk-averse manager whose compensation consists not only of salary and equity awards but also of inside debt. Our model delivers three main implications. First, there exists a positive relation between salary and credit spreads. Second, inside debt reduces credit spreads only if its effective seniority in bankruptcy is low. This relation is weakened or reversed as the effective seniority increases. Third, higher equity ownership leads to higher credit spreads only if managerial inside debt is large and unsecured. When inside debt is secured or small, this relation is weakened or reversed. Overall, inside debt, which is *per se* important, also exerts consequential *indirect effects* on the role of equity incentives, namely the main compensation component.

We test our model predictions on a sample of U.S. public firms during the period 2006-2011 and provide evidence in line with our model's predictions. We find that CEO's projected salary is positively correlated with CDS spreads as suggested by our model. We illustrate that a negative relation between inside debt and CDS spreads exists, consistently with Wei and Yermack (2011) and the extant empirical evidence of a negative relation between inside debt and managerial risk-taking (see, e.g., Wei and Yermack,

[1]Although in some jurisdictions, including the U.S. one, executive salary may be contractually junior to debt in bankruptcy, the law permits that executive salary is preserved during the restructuring process. Empirical evidence also shows that, although salary is often revised when creditors take control, the average firm even slightly increases salary level from the pre-distress level (see, e.g., Calcagno and Renneboog, 2007; Henderson, 2007).

[2]For a discussion about institutional features of executive pensions and deferred compensation, see Bebchuk and Jackson (2005), Sundaram and Yermack (2007), Wei and Yermack (2011), and Cadman and Vincent (2011).

2011; Cassell, Huang, Sanchez, and Stuart, 2012; Phan, Forthcoming; Hoang, 2013). Our result therefore supports the argument that inside debt provides incentives for managerial conservatism and that debt holders value this incentive mechanism. Moreover, we develop a direct and easy-to-replicate text-based measure of inside debt seniority. Using such a measure, we provide evidence that inside debt is effective at reducing credit spreads only if large and exposed to a high risk of forfeiture in bankruptcy. This finding extends the work of Anantharaman, Fang, and Gong (2014), who document a similar effect for private loan spreads, using a measure of inside debt seniority based on the relative duration of executive pensions and loans. The strong negative effect of unsecured inside debt on credit spreads is particularly interesting, as our sample period is characterized by the 2007 to 2009 recession. In other words, inside debt seems to limit risk-taking when managerial risk-shifting behavior is more likely to be observed.

We also show that the relation between equity incentives and CDS spreads is generally positive. This relation, however, stems from CEO-years characterized by large and unsecured inside debt holdings, consistently with our hypothesis. By contrast, managerial stock holdings do not exert a significant effect on CDS spreads when inside debt holdings are small or secured. These findings corroborate the results of Dittman, Norden, and Zhu (2013), who provide evidence of a positive impact of new CEO restricted stock grants on CDS spreads in an event study framework.

Finally, to support the causal interpretation of our results, we adopt an instrumental variable approach. In particular, we instrument unsecured inside debt using median inside debt incentives at the industry-level, and personal state income taxes in the U.S. states that attract the highest number of retiree migrants. The first instrument is meant to capture exogenous variation stemming from benchmarking practices in executive compensation design (see, e.g., Bizjack, Lemmon, and Naveen, 2008). The second instrument exploits exogenous variation in state taxation, building on the intuition that tax-planning reasons play a key role in CEOs' deferred compensation and pension choices. The persistence of our results after controlling for endogeneity supports the conjecture that CEOs receiving larger unsecured inside debt incentives implement less risky policies.

Our analysis contributes to the strand of theoretical and empirical research studying the role of inside debt. The analysis of inside debt has emerged only recently following pioneer works of Bebchuk and Jackson (2005), Sundaram and Yermack (2007), Wei and Yermack (2011), Edmans and Liu (2011), who document that inside debt is prevalent, constitutes a significant part of executive compensation, and has consequential impacts on corporate policies. To the best of our knowledge, we are the first to develop a framework in which salary, equity compensation and inside debt interact to shape managerial incentives. Our findings suggest that executive compensation plays a non-trivial role in determining firms' default risk and credit spreads, arising from the interaction between competing incentives coming from different compensation components. This adds to some recent developments in the literature discussing the proposal to defer executive compensation to alleviate excessive risk-taking.[3]

The remainder of the paper is organized as follows. Section 2 presents key components of the theoretical model. Section 3 discusses the solution and model implications in forms of testable hypotheses that relate executive compensation with credit spreads. Section 4 tests the predictions of the model. Section 5 concludes.

2 Model

We extend the model of Carlson and Lazrak (2010) to study the asset risk choice of a manager whose compensation consists not only of fixed salary and equity awards but also of deferred compensation and pension plans. This model allows us to examine theoretically the joint effect of salary, equity compensation, and inside debt on managerial risk-taking incentives and credit spreads.

2.1 Asset value dynamics

We work in a partial equilibrium framework with complete markets. The pricing kernel dynamics is given by

$$\frac{dM_t}{M_t} = -rdt - \alpha dZ_t, \quad M_0 = 1, \tag{1}$$

where $r > 0$ is the instantaneous risk-free rate, $\alpha > 0$ is the market price of risk, and Z is a standard Brownian motion.

The firm has an asset in place with terminal pre-tax value X_T that is used to pay taxes, bankruptcy costs (if any), and finally shared among bondholders and shareholders. We assume for simplicity that all risks in the model are systematic so that the firm value dynamics are driven by the same Brownian motion that governs the dynamics of the

[3]See Leisen (2013), Inderst and Pfeil (2012), Feess and Wohlschlegel (2012), Anantharaman, Fang, and Gong (2014).

pricing kernel. In particular, the firm's asset value dynamics are given by

$$\frac{dX_t}{X_t} = (r + \alpha\sigma_t)dt + \sigma_t dZ_t, \quad X_0 > 0, \tag{2}$$

where σ_t is the instantaneous choice of firm risk over which the manager has full discretion. The process $\{\sigma_t : t \geq 0\}$ is adapted to the filtration generated by the Brownian trajectory and is perfectly observable. In this setting, X_0 is fixed exogenously, implying that the manager has no influence on the unconditional expectation of the terminal asset value but only its dispersion. Although this setup does not allow us to study the effort choice (an action that can alter the unconditional expected asset value), it permits us to focus on the relationship between compensation structure and security valuation purely via the channel of risk-taking incentives.

2.2 Taxes, borrowing, and bankruptcy

Let τ be the corporate tax rate and assume that there is no tax at individual level. If the firm finances a part of its asset with debt by issuing a zero-coupon bond at discounted price B_0 for a payment of face value F at time T, then current regulation allows for the interest expense, $F - B_0$, to be deducted from the corporate taxable income.

Following Carlson and Lazrak (2010), we define the solvent state as when the firm's terminal asset value X_T, net of taxes, is sufficient to service its promised payment of debt to bondholders. This implies that the firm is solvent if and only if

$$X_T - \tau\left[X_T - (F - B_0)\right] \geq F.$$

Rearranging terms and denoting by X_b the bankruptcy threshold so that the firm is solvent if and only if $X_T \geq X_b$, we obtain

$$X_b = F + \frac{\tau}{1-\tau} B_0. \tag{3}$$

In case of bankruptcy ($X_T < X_b$), we assume that taxes are levied on the full value X_T and there exists a dead-weight bankruptcy cost of rate δ. Let C_T denote the cash flow available for distribution between bondholders and shareholders at time T, we have:

$$C_T = \begin{cases} (1-\tau)X_T + \tau(F - B_0) & \text{if } X_T \geq X_b, \\ (1-\delta)(1-\tau)X_T & \text{if } X_T < X_b. \end{cases} \tag{4}$$

2.3 Valuation of stock and bond

2.3.1 Stock

Let S_T denote the payoff to shareholders at time T, we have

$$S_T = \begin{cases} C_T - F & \text{if } X_T \geq X_b, \\ 0 & \text{if } X_T < X_b. \end{cases}$$

Substituting for the definition of C_T in (4), we can rewrite

$$S_T = (1-\tau)(X_T - X_b)^+.$$

Using the pricing kernel specified in (1), the equity price at time $t \in [0, T)$ is given by

$$S_t = \mathbb{E}_t\left[\frac{M_T}{M_t} S_T\right] = (1-\tau)\mathbb{E}_t\left[\frac{M_T}{M_t}(X_T - X_b)^+\right].$$

2.3.2 Bond

Denote by B_T the payoff to bondholders at time T, we have:

$$B_T = \begin{cases} F & \text{if } X_T \geq X_b, \\ (1-\delta)(1-\tau)X_T & \text{if } X_T < X_b. \end{cases}$$

Given the pricing kernel specified in (1), the bond price at time $t \in [0, T)$ is defined analogously as

$$B_t = \mathbb{E}_t\left[\frac{M_T}{M_t} B_T\right].$$

Substituting $B_0 = \mathbb{E}[M_T B_T]$ into the equation defining bankruptcy threshold

$$X_b = F + \frac{\tau}{1-\tau}\mathbb{E}[M_T B_T],$$

we arrive at a fixed point problem since the second term in the right-hand side itself depends on X_b. We prove below that in our current setting, rational expectation equilibrium conditions ensure that this fixed point problem always admits a unique solution.

2.4 Managerial compensation and utility

We define managerial compensation contract by a vector (A, p, D), where A is the fixed salary, p is the number of shares owned by the manager (expressed as a fraction of total firm outstanding shares), and D is the value of inside debt compensation which the manager receives in full or in part depending on whether the firm is solvent at the terminal date.

Under a piecewise linear compensation structure, we define π_T, the total compensation value at time T, as

$$\pi_T = A + pS_T + k(X_T, X_b, \theta)D, \tag{5}$$

where

$$k(X_T, X_b, \theta) = \frac{\theta}{\theta + (X_b - X_T)^+}, \quad \theta > 0, \tag{6}$$

is the recovery rate of inside debt in bankruptcy. When the firm is solvent, $k = 1$, and inside debt is paid in full. In case of insolvency, k is increasing in X_T, reflecting the intuition that the recovery value of inside debt is increasing in the salvage value of bondholders. For any given value of X_b and X_T, parameter θ captures the riskiness of the deferred compensation, ranging from almost surely unsecured ($\theta \to 0$) to almost surely secured ($\theta \to \infty$).[4] Apart from reflecting the contractual seniority of inside debt in bankruptcy, parameter θ can also reflect managerial control over the effectiveness of such contractual terms. In some situation, although inside debt is junior to corporate debt in bankruptcy, an entrenched self-interested manager can still divert away cash flows to recover parts of her inside debt at the expense of bondholders.[5] Throughout this paper, we refer to parameter θ as the effective seniority or risk of forfeiture of inside debt, where a higher effective seniority implies a lower risk of forfeiture and vice versa.[6]

[4] Secured deferred compensation is special and corresponds to the case of qualified deferred compensation plans (e.g., plans under 401(k)) or non-qualified deferred compensation plans put in a "secular" trust. A significant amount of deferred compensation, however, is unsecured and when bankruptcy happens, the manager can at best recoup only a fraction of her deferred compensation benefits. See, e.g., Sundaram and Yermack (2007), Wei and Yermack (2011).

[5] See, e.g., Bebchuk and Jackson (2005), Calcagno and Renneboog (2007), Gerakos (2007).

[6] In this setup, we have implicitly assumed that the source of payment for inside debt is kept in a

Suppose that the manager starts with zero initial wealth, her terminal wealth is equal to the value of her compensation at time T:

$$\pi_T = A + p(1-\tau)(X_T - X_b)^+ + k(X_T, X_b, \theta)D.$$

We further assume that CEO's utility function has constant relative risk-aversion γ with respect to wealth:

$$U(\pi_T) = \frac{\pi_T^{1-\gamma}}{1-\gamma}.$$

Notice that $U(\pi_T)$ is globally concave in π_T but not necessarily so in X_T. In particular, for any given value of the bankruptcy threshold X_b, it is possible to show that when $X_T \geq X_b$, $U(X_T)$ is strictly concave in X_T, while when $X_T < X_b$, $U(X_T)$ can alternate between convex and concave depending on the risk-aversion coefficient γ and the combination of compensation contract terms (A, p, D, θ). In this paper, we restrict our attention to the case where $\gamma < 1$. Under this assumption, managerial utility function has an unique shape with a convex part for $0 \leq X_T < X_b$ and a concave part for $X_T \geq X_b$, irrespective of the combination of contract parameters and the bankruptcy threshold X_b (see Appendix A). This assumption greatly simplifies the mathematical analysis of the model, although, admittedly, it may rule out interesting behavior patterns by strongly risk-averse managers. Fig. 1 provides a sample diagram of the CEO terminal payoff and her associated utility function in our setting.

2.5 Manager's problem

We consider a manager that, once appointed to the position, has full discretion over the choice of firm risk, σ, which she dynamically and continuously controls along the life of the asset. It is worth noting that we do not model the optimal choice of managerial com-

separate account and the terminal asset value X_T is to be shared between shareholders and bondholders only. The balance of this inside debt account, however, is sensitive to both the occurrence and the severity of bankruptcy event, as well as the effective seniority of inside debt in bankruptcy (governed by parameter θ.) This specification retains most of realistic features of inside debt while making the problem more tractable and easier to solve. An alternative justification for our modeling approach is that inside debt is consequential for managerial risk-taking incentives, but has a marginal direct effect in bankruptcy. Because of this, inside debt, D, does not enter directly the bankruptcy threshold (3), but affects it indirectly through the bond price, B_0. Such an interpretation also matches the data: Fig. 10 and Panel A of Table 2 show that, while inside debt makes up for roughly 10% of CEO firm-specific wealth (with important consequences for her risk-taking incentives), the ratio of inside debt to firm assets is typically zero.

pensation contract, (A, p, D), and leverage, F, which are set by risk-neutral shareholders at time 0 (the initial date) and taken as given by the manager. Shareholders' decisions are announced publicly and the manager's choices of firm risk are perfectly observable along the horizon. A similar optimal policy, with separation of the state space into three regions, is also obtained by Basak and Shapiro (2005), but in a different context.[7] Throughout this paper, we impose rational expectation conditions so that shareholders, bondholders, and the manager correctly anticipate optimal choices of each other and reflect that in the valuation of corporate securities. Fig. 2 presents the sequence of decisions made in the model.

3 Solution and model implications

3.1 Optimal terminal asset value and risk-taking dynamics

The utility maximization problem of the manager, taking as given a compensation contract (A, p, D) and debt of face value F, is:

$$\max_{\{\sigma_t : t \geq 0\}} \mathbb{E}\left[U(A + p(1-\tau)(X_T - X_b)^+ + k(X_T, X_b, \theta)D)\right]$$
$$\text{s.t. } \{X_t : t \geq 0\} \text{ defined in (2) and } X_b \text{ defined in (3).}$$

As standard in the asset pricing literature, we solve this problem in two steps. First, we solve the static problem

$$\max_{\{X_T \geq 0\}} \mathbb{E}\left[U(A + p(1-\tau)(X_T - X_b)^+ + k(X_T, X_b, \theta)D)\right]$$
$$\text{s.t. } \mathbb{E}\left[M_T X_T\right] \leq X_0 \text{ and } X_b \text{ defined in (3),} \tag{7}$$

to obtain the manager's optimal choice of terminal asset value X_T^*, and then, using Ito's lemma, we derive the dynamic optimal choice of asset volatility. Proposition 1 summarizes

[7] Basak and Shapiro (2005) study the optimal portfolio of an agent who has a debt contract in place and decides how to allocate her wealth between a risky and a risk-free asset. Default occurs if the agent cannot repay the face value of the debt. In case of default, the agent incurs fixed and variable costs proportional to the amount of debt left unpaid. Our approach differs for several reasons. First, unlike Basak and Shapiro (2005), we assume separation between ownership and control, which allows us to study the relation between compensation packages and managerial risk-taking behavior. Second, we consider the tax benefit of debt and therefore the default threshold is endogenous in our model. Third, since the agent/borrower of Basak and Shapiro (2005) incurs bankruptcy costs, optimal terminal wealth in the default region cannot be zero. By contrast, in our model, optimal terminal wealth is zero when default occurs, thus producing important differences in terms of risk-taking incentives.

the result of this analysis.

Proposition 1 *The optimal terminal asset value X_T^* is given by:*

$$X_T^* = \begin{cases} X_b^* + \frac{1}{p(1-\tau)}\left(\left(\frac{p(1-\tau)}{yM_T}\right)^{1/\gamma} - (A+D)\right) & \text{if } \{(X_b^* \leq \hat{X}_b) \wedge (yM_T \leq y\bar{M})\} \\ & \text{or } \{(X_b^* > \hat{X}_b) \wedge (yM_T \leq yM^*)\}, \\ X_b^* & \text{if } \{(X_b^* \leq \hat{X}_b) \wedge (y\bar{M} \leq yM_T \leq yM^{**})\}, \\ 0 & \text{otherwise,} \end{cases}$$

where $\hat{X}_b, y\bar{M}, yM^*, yM^{**}$ are defined as in Lemmas 2-5 of Appendix A and X_b^* is the unique solution of the non-linear equation:

$$X_b - F\left(1 + \frac{\tau}{1-\tau}\mathbb{E}\left[M_T\left(\mathbb{1}_{\{X_b > \hat{X}_b\}}\mathbb{1}_{\{yM_T \leq yM^*\}} + \mathbb{1}_{\{X_b \leq \hat{X}_b\}}\mathbb{1}_{\{yM_T \leq yM^{**}\}}\right)\right]\right) = 0.$$

For any time $t \in [0, T)$, the present value of firm asset is given by

$$X_t = \begin{cases} e^{-r(T-t)}\left(X_b^* - \frac{A+D}{p(1-\tau)}\right)N(d_1) + e^{-\Gamma(T-t)}\Psi(y, M_t)N(d_2) & \text{if } X_b^* > \hat{X}_b \\ e^{-r(T-t)}\left(X_b^* N(d_5) - \frac{A+D}{p(1-\tau)}N(d_3)\right) + e^{-\Gamma(T-t)}\Psi(y, M_t)N(d_4) & \text{if } X_b^* \leq \hat{X}_b. \end{cases}$$

The associated dynamic optimal choice of risk-taking σ_t^* in case $X_b^* > \hat{X}_b$ is given by

$$\sigma_t^* = \left(X_b^* - \frac{A+D}{p(1-\tau)}\right)\frac{e^{-r(T-t)}\phi(d_1)}{X_t\sqrt{T-t}} + \frac{e^{-\Gamma(T-t)}\Psi(y, M_t)}{X_t}\left(\frac{\alpha N(d_2)}{\gamma} + \frac{\phi(d_2)}{\sqrt{T-t}}\right)$$

and in case $X_b^* \leq \hat{X}_b$ is given by

$$\sigma_t^* = \left(X_b^*\phi(d_5) - \frac{A+D}{p(1-\tau)}\phi(d_3)\right)\frac{e^{-r(T-t)}}{X_t\sqrt{T-t}} + \frac{e^{-\Gamma(T-t)}\Psi(y, M_t)}{X_t}\left(\frac{\alpha N(d_4)}{\gamma} + \frac{\phi(d_4)}{\sqrt{T-t}}\right).$$

In these equations, $N(.)$ and $\phi(.)$ are standard normal cumulative and density functions, respectively, and $d_{i,i=1..5}, \Gamma, \Psi$ are defined as in Appendix A.

Proof. See Appendix A. ■

Fig. 3 compares the difference in optimal choices of terminal asset value and risk-taking dynamics when the manager has zero and positive inside debt. Concerning the optimal choice of terminal asset value, the left panel of Fig. 3 suggests that a manager with zero inside debt divides the state space into two regions and pursues a bang-bang policy by choosing to stay above bankruptcy threshold in very good states and zero otherwise. By contrast, a manager with positive and unsecured inside debt divides state space into three regions and chooses to stay above the bankruptcy threshold in very good states, to stay exactly at bankruptcy threshold for an extended range of intermediate states, and only chooses to default (i.e. zero terminal asset value) when the situation further deteriorates (this part happens when M_T is sufficiently large, not shown in Fig. 3.)[8] An immediate implication of this policy is that the presence of unsecured inside debt in the compensation makes corporate defaults less likely, since the threshold of the state price above which the manager chooses to default has been shifted farther to the right relative to the case of zero inside debt.[9]

Concerning risk-taking dynamics, we observe from the right panel of Fig. 3 that a manager having positive and unsecured inside debt chooses to take more risk in good states and less risk in bad states than a manager without inside debt. For any given level of salary, the key trade-off facing a manager with positive inside debt when deciding how much risk to take is the balance between her utility gains and losses from equity and inside debt compensation. Note that, for a risk-neutral manager, gains and losses of utility boil down to changes in the expected values of stock price and inside debt. For a risk-averse manager, changes in variance and higher order moments also matter. However, given our assumption that the risk-aversion coefficient $\gamma < 1$, the impact of higher order moments is likely to be small and the trade-off between utility gains and losses from risk-taking may be driven mainly by gains and losses in expected values. In good states, the probability of default is negligible and the manager is more willing to take risk because she benefits from an increase in stock price without suffering a large expected loss on inside debt. Instead, in bad states, default is likely and the manager becomes more conservative because expected losses on inside debt are large and cannot be compensated by an increase in stock price. For a manager without inside debt, such trade-off vanishes

[8]Since the expected value of X_T^* is fixed at X_0, this policy implies that in comparison with a manager without inside debt holding, a manager with positive and unsecured inside debt holdings necessarily trades off terminal asset values in intermediate states for higher values in the tails. We observe from the figure that as $M_T \in (0.5, 1.4)$, the terminal asset value of inside debt firm is lower than that of zero inside debt firms; however, outside this region, terminal asset value of inside debt firm is higher.

[9]In unreported numerical analysis, we observe that the threshold of state price at which the manager chooses to default is increasing in the value of inside debt D and decreasing in its effective seniority, implying that awarding the manager with larger inside debt and at the same time, make that inside debt unsecured helps reduce the occurrence of corporate default.

and cash flow volatility monotonically increases when economic conditions deteriorate.

It is worth noting that the result discussed above relies on the existence of an intermediate region in the state space where the manager chooses to stay exactly at the bankruptcy threshold X_b^*. This intermediate region, however, arises only if $\theta < D/(p(1-\tau))$ (cf. Lemma 3 in Appendix A), implying that the result holds only if inside debt compensation is strictly positive *and* relatively unsecured. When inside debt is bankruptcy-proof, its impact on risk-taking incentives and corporate default may be reversed. We will get back to this point in Section 3.3.

3.2 Security valuation

3.2.1 Stock valuation

Given $S_T^* = (1-\tau)(X_T^* - X_b^*)^+$ and the pricing equation $S_t = \mathbb{E}_t\left[\frac{M_T}{M_t} S_T^*\right]$, the stock price at any time $t \in [0, T)$ is

$$S_t = \begin{cases} (1-\tau)\left(-\frac{A+D}{p(1-\tau)} e^{-r(T-t)} N(d_1) + \Psi(y, M_t) e^{-\Gamma(T-t)} N(d_2)\right) & \text{if } X_b^* > \hat{X}_b \\ (1-\tau)\left(-\frac{A+D}{p(1-\tau)} e^{-r(T-t)} N(d_3) + \Psi(y, M_t) e^{-\Gamma(T-t)} N(d_4)\right) & \text{if } X_b^* \leq \hat{X}_b. \end{cases}$$

Associated stock volatility in case $X_b^* > \hat{X}_b$ is given by

$$\sigma_t^S = \frac{1-\tau}{S_t}\left(-\frac{A+D}{p(1-\tau)} \frac{e^{-r(T-t)}\phi(d_1)}{\sqrt{T-t}} + e^{-\Gamma(T-t)}\Psi(y, M_t)\left(\frac{\alpha N(d_2)}{\gamma} + \frac{\phi(d_2)}{\sqrt{T-t}}\right)\right),$$

and in case $X_b^* \leq \hat{X}_b$ is given by

$$\sigma_t^S = \frac{1-\tau}{S_t'}\left(-\frac{A+D}{p(1-\tau)} \frac{e^{-r(T-t)}\phi(d_3)}{\sqrt{T-t}} + e^{-\Gamma(T-t)}\Psi(y, M_t)\left(\frac{\alpha N(d_4)}{\gamma} + \frac{\phi(d_4)}{\sqrt{T-t}}\right)\right),$$

where S_t and S_t' are the value of S_t defined for $X_b^* > \hat{X}_b$ and $X_b^* \leq \hat{X}_b$, respectively.

3.2.2 Bond valuation and credit spread

Using the optimal choice of terminal asset value X_T^* given in Proposition 1, the terminal payoff of the bond can be computed as:[10]

$$B_T^* = \begin{cases} F & \text{if } \{(X_b^* > \hat{X}_b) \wedge (yM_T \leq yM^*)\} \text{ or } \{(X_b^* \leq \hat{X}_b) \wedge (yM_T \leq yM^{**})\} \\ 0 & \text{otherwise.} \end{cases}$$

Valuation of the bond at any time $t \in [0, T)$ is given by:

$$B_t = \mathbb{E}_t \left[\frac{M_T}{M_t} B_T^* \right] = F \left(\mathbb{1}_{\{X_b^* > \hat{X}_b\}} \mathbb{E}_t \left[\frac{M_T}{M_t} \mathbb{1}_{\{M_T \leq M^*\}} \right] + \mathbb{1}_{\{X_b^* \leq \hat{X}_b\}} \mathbb{E}_t \left[\frac{M_T}{M_t} \mathbb{1}_{\{M_T \leq M^{**}\}} \right] \right)$$

or equivalently,

$$B_t = \begin{cases} Fe^{-r(T-t)} N(d_1) & \text{if } X_b^* > \hat{X}_b \\ Fe^{-r(T-t)} N(d_5) & \text{if } X_b^* \leq \hat{X}_b. \end{cases}$$

The volatility of the bond value is given by:

$$\sigma_t^B = \begin{cases} \frac{1}{\sqrt{T-t}} \left[\phi(d_1)/N(d_1) \right] & \text{if } X_b^* > \hat{X}_b \\ \frac{1}{\sqrt{T-t}} \left[\phi(d_5)/N(d_5) \right] & \text{if } X_b^* \leq \hat{X}_b. \end{cases}$$

The continuously compounded bond yield is defined as

$$R_t \equiv \frac{\ln(F) - \ln(B_t)}{T-t} = \begin{cases} r - \frac{1}{T-t} \ln(N(d_1)) & \text{if } X_b^* > \hat{X}_b \\ r - \frac{1}{T-t} \ln(N(d_5)) & \text{if } X_b^* \leq \hat{X}_b, \end{cases}$$

and the corresponding credit spread follows:

$$\rho_t \equiv R_t - r = \begin{cases} -\frac{1}{T-t} \ln(N(d_1)) & \text{if } X_b^* > \hat{X}_b \\ -\frac{1}{T-t} \ln(N(d_5)) & \text{if } X_b^* \leq \hat{X}_b. \end{cases}$$

[10]Note that in our current setup, similar to Carlson and Lazrak (2010), the manager also optimally chooses zero liquidation value in bankruptcy so the dead-weight cost δ does not matter. Therefore the impact of inside debt on credit spreads and related variables will be seen through its impact on default probability, but not on recovery value. An extended model where the manager's utility is not universally convex in the default area will result in a positive recovery value in bankruptcy. Inside debt may play a role in determining the liquidation value in such case as well. See Edmans and Liu (2011).

3.3 *Empirical implications for risk-taking and credit spreads*

3.3.1 *Calibration parameters*

For model parameters, we set the risk-free rate at $r = 1.65\%$ per year, which is the simple average of (annualized) U.S. 3 month T-bill rates for the period 2002-2012. The market price of risk α is set equal to .33, consistent with a market risk-premium 7% per year and an annualized market volatility of 21%.[11] Corporate income tax rate is fixed at $\tau = 30\%$, the average effective tax rate levied on U.S. corporations. The maturity of debt $T = 5$ is the median maturity of long-term debt reported in Barclay and Smith (1995). For firm-specific variables, we normalize initial asset value X_0 to 1.0 and set the face value of debt $F = .3$, consistent with a median book-leverage of 30%. Given the empirical range of book-leverage between 0 and 60%, F varies between 0 and .6 in all simulations that involve changes in F. Finally, we select the risk-aversion coefficient $\gamma = .9$ so that stock volatility of a typical firm (one with median leverage, median compensation structure and in average states) matches empirical patterns of stock volatility. The analysis about the optimal policy across the state space is done for an arbitrary time $t = .25$.[12]

For compensation variables, we calibrate the model using empirical estimates from our sample. Table 1 reports the empirically relevant range of salary, equity ownership, and inside debt compensation based on our sample (to be discussed in more details in the empirical part), where all variables are winsorized at the 5^{th} and the 95^{th} percentile and level variables like salary and inside debt are divided by the median asset value, consistent with the normalization of $X_0 = 1.0$. Since our model features a one-period horizon in which all compensation components are paid one time at the end while in reality, salary is paid in annual installments, we multiply average annual salary by 6, the average tenure of CEOs in years (Kaplan and Minton, 2012), to arrive at an estimate for salary received over the entire horizon. This is the value reported in Table 1.

For the effective seniority of inside debt in bankruptcy θ, we recall the definition of recovery rate of inside debt in bankruptcy $k(\theta, X_b, X_T) = \theta / \left(\theta + (X_b - X_T)^+\right)$ and note that the value $(X_b - X_T)^+$ can be approximated by the creditors' loss in bankruptcy. Empirically, the long-term average loss for U.S. senior unsecured bondholders is 57% of

[11] This data is provided by Aswath Damodaran at New York University, available for download at http://people.stern.nyu.edu/adamodar/.

[12] The particular value of t is not important for the analysis, although as t gets closer to the terminal date T, all effects discuss below become less significant.

the face value,[13] implying that for an average level of debt $F = .3$, the empirical average of $(X_b - X_T)^+$ is .17. Using this number in the formula of k, we can form a map between θ and the recovery rate of inside debt in bankruptcy. It turns out that as θ varies in the interval $[.0017, 17]$, the recovery rate of inside debt varies between 1% and 99%. We will use this as the relevant range of θ in our comparative analysis.

3.3.2 Comparative statics analysis

3.3.2.1 Credit spreads and salary

In order to study the effect of salary on managerial risk-taking incentives and credit spreads, we hold model parameters and other parts of executive compensation fixed at their median levels, and let salary increase over its empirical relevant range reported in Table 1. Fig. 4 plots the optimal asset risk choice and associated credit spread across state space in this case.

We observe that as salary increases (moving from the solid line to star-marked line and circle-marked line in Fig. 4), the manager takes more risk uniformly across states and this pushes up credit spreads. The economic intuition behind this result rests on the fact that salary is a fixed and pre-committed payment, insensitive to default probability. Therefore, in the context of a risk-averse manager, higher salary provides the manager with more insurance to take risk, for which she benefits from the gain in equity compensation value. This is the same as the result derived by Carlson and Lazrak (2010) for the case where managers have no inside debt.[14]

3.3.2.2 Credit spreads and inside debt

We now let inside debt increase while holding salary and equity compensation fixed at their median levels. We consider two separate cases: When the effective seniority of inside debt in bankruptcy is low and when it is high. Fig. 6 plots optimal asset risk choices and credit spreads across the state space in these cases.

[13]Source: "Default, Transition, and Recovery. U.S. Recovery Study: Recent Post-Bankruptcy Recovery Levels Disappoint Senior Unsecured Bondholders," by Standard & Poor's Ratings Services. Report dated August 6, 2012; accessed at http://www.standardandpoors.com/spf/upload/Ratings_US/US_Recovery_Study_Recent_Post_Bankruptcy_Recovery_Levels.pdf on May 25, 2013.

[14]In further numerical analysis presented in Appendix A, we confirm that the positive relationship between salary and credit spreads remains intact for various levels of corporate debt, equity compensation, inside debt, and inside debt effective seniority in bankruptcy. Fig. 5 provides a representative plot of credit spread as a function of salary.

Consider first the case when the effective seniority of inside debt in bankruptcy is low, implying that a large part of inside debt is forfeited in bankruptcy. The left picture of Fig. 6-Panel A shows that, relative to a manager without inside debt (solid line), a manager with positive inside debt takes typically the same risk in good times, but much less risk in bad times. This behavior benefits bondholders and uniformly pushes down credit spreads as observed in the right plot of the same panel. The intuition behind this result was discussed in detail in Section 3.1. As we switch to Fig. 6-Panel B where the effective seniority is high (implying a low risk of forfeiture), the effect is reversed: Higher inside debt leads to higher risk-taking across the state space and this pushes up credit spreads as seen in the right plot of the same panel. This result is intuitive, because when inside debt is bankruptcy-proof, its payoff structure becomes similar to that of salary and this adds more to the insurance for risk-taking.[15]

The above discussion leads to the testable prediction that, all else equal, managers with larger unsecured inside debt choose the same level of asset volatility as managers without inside debt in good times, but much lower asset volatility in bad times, leading to lower credit spreads. This relation is weakened or reversed when the effective seniority of inside debt increases. To the extent that a large fraction of inside debt in reality is non-qualified deferred compensation subject to forfeiture in bankruptcy, this prediction is consistent with the empirical evidence documented in Wei and Yermack (2011). This is also consistent with the evidence in Anantharaman, Fang, and Gong (2014), who analyze the effect contractual terms of inside debt on private loans spreads, and find that when inside debt is characterized by high seniority (as proxied by the relative duration of CEO's pensions plans to loans), it loses its power in inducing managerial conservatism.

Note that the effective seniority of inside debt as described in our paper extends beyond the contractual seniority of inside debt. For example, if one believes that a powerful manager can always find ways to shield her inside debt balance in bankruptcy irrespective of its contractual design, one may well expect that the negative relationship between inside debt and credit spreads is weakened or reversed in a sample with more powerful managers or less effective corporate governance mechanisms.

[15] In Appendix A, we present our additional numerical analysis, which confirms that the negative (positive) relationship between inside debt and credit spread when θ is low (high) remains intact for different levels of salary, equity compensation, and corporate debt. For intermediate levels of θ, this relationship is not monotone but inverse U-shape where credit spread increases in inside debt up to a certain level and decreases thereafter. Fig. 7 illustrates the point.

3.3.2.3 Credit spreads and equity incentives

We now hold fixed salary and inside debt compensation and increase managerial stock ownership. Fig. 8 plots credit spread as a function of equity ownership for different levels of inside debt and its effective seniority in bankruptcy. From this figure, we observe a remarkable difference in the way equity compensation affects credit spreads when taking into account the presence of inside debt and its risk of forfeiture. In the left panel, we find that when inside debt is not forfeited in bankruptcy, credit spread is always monotonically decreasing in equity ownership irrespective of the level of inside debt. This relation extends to the case where inside debt is unsecured but the balance is rather small, as seen in the solid line and star-marked line of the right panel.

However, when inside debt is unsecured and the balance grows larger (moving down from the circle-marked line to the dashed line in the right panel), credit spread becomes increasing in equity ownership. At the extremes, for firms having inside debt close to the top sample percentile (the dashed line), credit spread can become monotonically increasing in the entire empirical range of equity ownership. Taken together, the numerical analysis suggests that when the expected loss of inside debt in bankruptcy is negligible (that is, when it is secured or the balance is small), credit spread is decreasing monotonically in equity ownership. When the expected loss from inside debt is sufficiently large, credit spread can become increasing in equity ownership.

In order to explain this result, we look at the risk-taking behavior of the manager. Fig. 9 plots the optimal risk-taking dynamics across state space for four combinations of inside debt size and effective seniority. We observe that when inside debt is small or secured, the patterns of risk-taking across the state space are broadly similar: Higher equity ownership (moving from the solid line to star-marked line and circle-marked line) induces the manager to take less risk uniformly across states, causing the credit spread to decrease in equity ownership as observed in Fig. 8. The intuition behind this result rests on the fact that the manager is risk-averse and wishes to reduce the variance of her terminal payoff (apart from the concern for other higher-order moments.) When the manager is awarded more equity incentives, the risk exposure of her compensation increases, and she naturally acts more conservatively to offset such utility loss. *A priori*, higher equity awards also lead to an increase in the expected value of terminal compensation, so it is not always obvious that this is detrimental to the manager's utility. However, within empirically-relevant ranges of equity awards and risk-aversion coefficient, the utility gain from such increase in equity awards is generally dominated by the utility loss resulting from the increase in the variance of terminal payoff. We thus have that a risk-averse manager chooses to take less risk as her equity ownership increases.

In the bottom-left picture of Fig. 9 we observe a remarkably different risk-taking behavior: When inside debt is large and unsecured, increasing equity awards induces the manager to take less risk in good times and more risk in bad times, a signal of risk-shifting behavior that harms bondholders, leading to the increasing slope in credit spread as a function of equity ownership. Also this relation can be explained using the balance of utility gains and losses. Suppose that the current state is good and a manager with an already large inside debt holding now receives more equity awards. The additional equity awards magnify the manager's exposure to risk and immediately cause a utility loss. In deciding whether to take more risk, the manager may gain from a rise in expected value of stock but will suffer a loss that comes from the reduction in expected value of inside debt (due to higher probability of default) and the utility loss from higher variance of terminal payoff. When inside debt balance is large, this double loss may well exceed the gain from stocks and causes the manager to behave more conservatively. Suppose now that the current state is bad, so that the probability of default becomes higher. In such case, the manager cannot afford to be more conservative, because there is a fair chance that she ends up in bankruptcy and loses her inside debt balance. Her natural action then is to take more risk to have a higher chance of getting out of bankruptcy and gain from both her inside debt and equity compensation. This incentive is magnified by the size of stock compensation, causing the credit spread to increase in equity ownership when inside debt balance is large and unsecured.

Overall, the discussion in this section leads to the following testable empirical hypotheses.

Hypothesis 1 *Credit spread is increasing in salary.*

Hypothesis 2 *Credit spread is decreasing in unsecured inside debt. This relation is weakened or reversed as the effective seniority of inside debt in bankruptcy increases.*

Hypothesis 3 *Credit spread is increasing in equity ownership if inside debt is large* and *unsecured. This relation is weakened or reversed if inside debt is small* or *secured.*

4 Empirical analysis

In this section we empirically test the impact of executive compensation structure on credit spreads using a comprehensive sample of U.S. public firms. Since flow and stock compensation components in our model coincide, we use the term CEO's firm-specific wealth structure rather than compensation structure throughout this section.

4.1 Data

We consider a sample of U.S. public firms having CDS contracts traded in the 2006-2011 period. Our sample begins in 2006, as new SEC's enhanced disclosure requirements about executive pensions and deferred compensation were first enforced for 2006 fiscal year-end. We obtain CEO compensation data from Standard and Poor's Execucomp, accounting data from Standard and Poor's Compustat, stock returns data from Center for Research in Security Prices (CRSP), and macroeconomic data from St. Louis Federal Reserve Bank's Federal Reserve Economic Data (FRED). We require each firm to have traded ordinary shares (CRSP share code 10 or 11.) We exclude financial institutions, utilities, and firm-years with negative or missing assets or sales. We use corporate governance data from IRRC for 2006, and from Riskmetrics for the 2007-2011 period. We merge firms from Compustat, IRRC and Riskmetrics following the procedure described in Cashman, Gillan, and Jun (2012). Finally, we obtain CDS data from Markit. Further details about the matching of Markit and Compustat firms are provided in Appendix B.1.

Using these data sources, we compute the following variables.

Credit spreads. To measure credit spreads, our dependent variable, we rely on CDS spreads rather than bond credit spreads.[16] Following Wei and Yermack (2011), we consider five-year CDS contracts written on unsecured debt denominated in U.S. dollars. We calculate a CDS spread for each firm-year by averaging daily observations over the last fiscal quarter.[17]

[16]Blanco, Brennan, and Marsh (2005) provide evidence that "CDSs are a cleaner indicator than bond spreads." Although one might be concerned that CDS spreads are an upward-biased measure of credit spreads during the 2007-2009 financial crisis because the market was less liquid and prone to manipulation by short-sellers in this period, Stulz (2010) argues that no evidence of such phenomenon has been recorded so far.

[17]On a certain day we might have multiple CDS spreads for a given firm, because of CDS trading with more than one documentation clause, i.e. the definition of the credit event. In these cases we take the average spread for that date. In other words, we do not put any restriction about the documentation clause.

CEO firm-specific wealth structure. Consistently with the model presented above, we are interested in the composition of the CEO's wealth tied to the firm rather than flow compensation.[18] We capture the incentives provided by inside debt by means of two measures widely used in the literature. The first, theoretically motivated by Jensen and Meckling (1976) and Edmans and Liu (2011), is the *CEO relative D/E ratio*:

$$CEO\ relative\ D/E\ ratio = \frac{\mathrm{D}_{\mathrm{CEO}}/\mathrm{E}_{\mathrm{CEO}}}{\mathrm{D}_{\mathrm{Firm}}/\mathrm{E}_{\mathrm{Firm}}},$$

where $\mathrm{D}_{\mathrm{CEO}}$ ($\mathrm{E}_{\mathrm{CEO}}$) is the CEO's inside debt (equity) holdings, and $\mathrm{D}_{\mathrm{Firm}}$ ($\mathrm{E}_{\mathrm{Firm}}$) is the firm's total debt (equity), respectively. The CEO's inside debt holdings, $\mathrm{D}_{\mathrm{CEO}}$, are given by the sum of the present value of all pension plans and the aggregate balance of deferred compensation plans at fiscal year-end.[19] We proxy for a CEO's equity holdings, $\mathrm{E}_{\mathrm{CEO}}$, using the fiscal year-end dollar value of both stock and option incentives (see below for a detailed discussion). Finally, $\mathrm{D}_{\mathrm{Firm}}$ is estimated as the sum of long term debt and debt in current liabilities, whereas $\mathrm{E}_{\mathrm{CEO}}$ is the firm's market value of equity at fiscal year-end.

Our second measure of inside debt incentives, used for robustness purposes, is the *CEO relative incentive ratio*, which proxies for "the marginal change in the CEO's inside debt over the marginal change in his inside equity holdings, given a unit change in the overall value of the firm, scaled by the ratio of the marginal change in the firm's external debt over the marginal change in its external equity, given the same unit change in the overall value of the firm" (Wei and Yermack, 2011). We estimate such measure following Cassell, Huang, Sanchez, and Stuart (2012):

$$CEO\ relative\ incentive\ ratio = \frac{\Delta\mathrm{D}_{\mathrm{CEO}}/\Delta\mathrm{E}_{\mathrm{CEO}}}{\Delta\mathrm{D}_{\mathrm{Firm}}/\Delta\mathrm{E}_{\mathrm{Firm}}},$$

where $\Delta\mathrm{E}_{\mathrm{CEO}}$ is the CEO's total delta, i.e., the sum of the number of shares held by the CEO (assumed to have a delta of one) and the number of options held by the CEO times their Black-Scholes delta. $\Delta\mathrm{E}_{\mathrm{Firm}}$, the firm's total delta, is computed similarly, based on Compustat's data on outstanding options at the firm-level. $\Delta\mathrm{D}_{\mathrm{CEO}}$ and $\Delta\mathrm{D}_{\mathrm{Firm}}$ are assumed to be equal to $\mathrm{D}_{\mathrm{CEO}}$ and $\mathrm{D}_{\mathrm{Firm}}$, respectively.

[18] We identify CEOs modifying the Execucomp indicator `ceoann` using the variables `becameceo` and `leftofc`, because `ceoann`, as pointed out by Himmelberg and Hubbard (2000), is often missing in the first year the CEO enters the sample.

[19] We set inside debt holdings to zero when both these data items are missing in Execucomp in line with Halford and Qiu (2012).

With respect to cash compensation, we focus on salary, as bonus is tied to the firm performance, and thus cannot be regarded as safe. Since our model features a one-period horizon in which all compensation components are paid one time at the end, while in reality salary is paid in annual installments, we perform a projection of salary for the entire managerial decision horizon. In our tests, in line with Carlson and Lazrak (2010), we divide this projection by the value of CEO's stock and option holdings, to obtain a normalized measure of salary, *PV expected salary-to-stock ratio*. We estimate CEO's wealth from salary compensation multiplying current salary by the CEO's "expected decision horizon", which is computed similarly to Antia, Pantzalis, and Park (2010) and Cassell, Huang, Sanchez, and Stuart (2012). We depart from these studies in two respects. First, whereas Antia, Pantzalis, and Park (2010) simply compute their measure benchmarking individual CEO's tenure and age to the industry-year unconditional medians, we compute these medians restricting the sample to CEOs actually displaced in a given industry-year to better proxy for the number of years the CEO expects to stay in office. Second, our measure of CEO's expected decision horizon, as the one by Antia, Pantzalis, and Park (2010), exhibits negative values for roughly half of the CEOs. To deal with this, Cassell, Huang, Sanchez, and Stuart (2012) set the former to one if negative. This amounts to collapsing half of the total variation in the decision horizon to just one value. To work around this issue, we obtain a normalized CEO's expected decision horizon mapping its raw estimate to the industry-year span of tenure at turnover by means of the empirical cumulative distribution function of the decision horizon. Then we simply multiply this normalized measure by the current salary to get our estimate of the present value of expected future salary payments.

In line with our model, we measure equity incentives as the effective ownership at fiscal year-end based on shares and options held by the CEO, *CEO effective ownership*, in line, for instance, with Jensen and Murphy (1990). Even though option holdings are not modeled in our theoretical framework, we always include in our regressions the CEO's vega as a control variable, given the importance of executive stock options in shaping managerial risk-taking incentives. As we study the 2006-2011 period, we use the full-information method, as opposed to the one-year approximation method by Core and Guay (2002), to compute the CEO's option portfolio delta and vega, thanks to the enhanced SEC disclosure requirements introduced in 2006. This is important because in a period of widespread stock price declines such as 2007-2009, the one-year approximation method might deliver severely biased estimates, as it neglects underwater options (Core and Guay, 2002).[20]

Inside debt seniority. Given the importance of inside debt's risk of forfeiture in bankruptcy for our predictions, we develop a novel easy-to-compute measure of seniority. In particular, we perform a text-based classification of pensions into ERISA-qualified plans and non-qualified plans, such as Supplemental Executive Pension Plans (SERPs), Supplemental Key Employee Retirement Plans (SKERPs), Supplemental Senior Officer Retirement Plans (SSORPs), restoration plans, benefit equalization plans, and excess plans. We assume that only ERISA plans are funded, while non-qualified plans and deferred compensation plans are deemed as unfunded (see, e.g., Anantharaman, Fang, and Gong, 2014; Cristy, 2010; Wei and Yermack, 2011). Hence we measure seniority as the ratio of ERISA-qualified plans to total inside debt holdings. Similarly, we are able to compute our main measure of inside debt described above distinguishing inside debt protected and non-protected in bankruptcy, obtaining *CEO relative D/E ratio (protected)* and *CEO relative D/E ratio (non-protected)*, respectively. We do not perform any validation of our seniority measure against actual hand-collected data, but there are good reasons to believe that this measure underestimates the effective seniority of inside debt in bankruptcy, given that some fraction of non-qualified plans might be funded (see, e.g., Cristy, 2010; Reid, 2011). Below, however, we argue that this should bias against us finding evidence supportive of our model's predictions.

Other variables. In our credit spreads regressions we also include a set of control variables in line with the literature (see, e.g., Carlson and Lazrak, 2010; Cassell, Huang, Sanchez, and Stuart, 2012), such as the market debt/equity ratio, the monthly Sharpe ratio, the firm-level marginal tax rate before interest deductions from Blouin, Core, and Guay (2010),[21] sales, ROA, the stock return over the last fiscal year, the book-to-market ratio, a dividend indicator equal to one if a firm pays dividends in a given year, a distress indicator equal to one if a firm belongs to the top decile of the modified Z-score by MacKie-Mason (1990), an indicator equal to one if the CEO has been appointed during the current year, the corporate governance E-index by Bebchuck, Cohen, and Ferrell

[20] As in Ortiz-Molina (2007), we assume that CEOs with missing data about options have zero options.

[21] Our results are robust to using the John Graham's simulated tax rates before financing, for which we replace missing values with the tax rates predicted by the procedure of Graham and Mills (2008). We are grateful to John Graham for providing us with data.

(2009),[22] and CEO age. Importantly, we always include the distress indicator to control for idiosyncratic risk, which arguably affects CDS spreads, but it is not explicitly taken into account in our model.

Table 2 reports the descriptive statistics for all variables. The final sample features 504 unique firms for 2,183 firm-year observations. The average CDS spread is 237.3 basis points, the average market debt/equity is 88.1%, and average sales are $17,529 billion. The mean *PV expected salary-to-stock ratio* is 0.371 with a mean CEO's expected horizon of 4.3 years, the mean *CEO effective ownership* is 0.016, and the mean *CEO relative D/E ratio* is 1.598 with a mean seniority of 10.8%. Most of the variation of inside debt seniority is in the top quartile. For instance, the ninth decile is 30%. This is the reason why we choose the third quartile as our threshold to distinguish between low and high seniority inside debt in the subsequent analysis.

All the variables are winsorized at the 1st and 99th percentile. Detailed definitions of the variables are given in Table A.1. All dollar amounts are expressed in 2011 dollars.

4.2 Empirical approach

In our empirical tests we focus on credit spreads rather than on risk-taking. Indeed, risk-taking within our theoretical framework serves as the economic channel through which CEO firm-specific wealth structure affects credit spreads. However, performing an empirical analysis directly on risk-taking goes beyond the scope of this paper, as the measurement of asset risk is highly controversial.[23]

We test our hypotheses by means of panel regressions of CDS spreads on the components of CEO firm-specific wealth and the set of control variables presented above. Our baseline specification is in line with Carlson and Lazrak (2010). We measure CDS spreads over the last fiscal quarter, while CEOs' compensation packages are generally set in the first two fiscal quarters (see, e.g., Hall and Knox, 2004), so that the former fully reflect such information. However, as a robustness check, we also always estimate a specification with all the independent variables lagged with respect to CDS spreads.

[22] We use the E-index instead of the G-index by Gompers, Ishii, and Metrick (2003) because it is available even after 2006.

[23] Cassell, Huang, Sanchez, and Stuart (2012) use several measures such as equity volatility, R&D expenses, working capital and segment diversification. Many papers rely on the model of Merton (1974) to extract asset volatility from equity volatility. A model-free market measure of asset risk is proposed by Choi (Forthcoming).

We use the logarithmic transformation of highly skewed variables.[24] To take care of the omitted variables problem, all the regressions in their baseline form include industry fixed effects at the two-digit SIC code level, and year fixed effects. To deal with endogeneity from reverse causality in tests of Hypothesis 2, we also instrument inside debt incentives with personal income tax rates and lagged industry median inside debt (see below for a discussion of the identification strategy). In testing Hypothesis 3, it is necessary to classify firms according to the level and seniority of inside debt, hence selection bias is a major challenge. As a consequence, alongside the sample of firm-years with large or secured inside debt, we form a matched sample of control firm-years based on observable firm characteristics, industry, and fiscal year. The *t*-statistics are calculated with Huber-White robust standard errors clustered at the firm-level as recommended by Petersen (2009).

4.3 Results

Panel A of Table 3 tests Hypothesis 1 and provides preliminary evidence concerning Hypotheses 2 and 3. Columns 1 and 2 focus on the contemporaneous specification measuring inside debt through *CEO relative D/E ratio* and *CEO relative incentive ratio*, respectively. Columns 3 and 4 repeat the same analysis for the specification with lagged regressors. In line with Hypothesis 1, the coefficient of *PV expected salary-to-stock* is positive and significant at the 1% level in each of these cases. The coefficient associated with inside debt is negative and significant at 1% level. This is consistent with Hypothesis 2, which predicts that inside debt exerts a negative effect on credit spreads only if unsecured, as Table 2 shows that inside debt seniority is rather low over our sample. With respect to Hypothesis 3, our findings are less clear-cut, which comes as no surprise given that such hypothesis predicts different effects depending on the level and seniority of inside debt. However, stock holdings exhibit an overall positive and significant coefficient broadly in line with Hypothesis 3 and the low seniority of inside debt in our sample.

The coefficient of the present value of expected future salary payments to equity in-

[24] If a highly skewed variable can be equal to zero or even negative, such as *CEO relative D/E ratio* and *CEO effective ownership*, we apply the corrected transformation $\ln(1 + x)$, in order not to lose any observation. The only exception to this rule is vega, for which we use a plain logarithmic transformation even though it can be equal to zero. This amounts to excluding the 115 CEO-year observations without option incentives. These observations are indeed outliers: Among them, for instance, there are Warren Buffet and Steve Jobs.

centives ratio is relatively small in terms of economic significance. Based on the coefficient estimate in column 1, a 10% change in *PV expected salary-to-stock ratio* (evaluated at mean) would lead to a 0.71% increase in the CDS spread. The intuition behind these results, as discussed in Carlson and Lazrak (2010), is that a risk-averse manager obtains an insurance effect from fixed pay, which induces her to implement risk-seeking policies.

Panel B of Table 3 studies the effect of inside debt on CDS spreads, distinguishing between its protected and non-protected component. Columns 1 and 2 report the estimated coefficients for the contemporaneous specification measuring inside debt through *CEO relative D/E ratio* and *CEO relative incentive ratio*, respectively, both decomposed in their two components. Columns 3 and 4 repeat the same analysis for the specification with lagged regressors. Consistently with Hypothesis 2, the non-protected component of inside debt displays a negative and significant coefficient, whereas the protected component exerts no significant effect on CDS spreads. Based on the −0.176 coefficient estimate in column 1, a 10% increase in *CEO relative D/E ratio* (evaluated at mean) translates into with a 1.01% drop in CDS spreads. This effect, while larger than the one of expected salary, is still relatively small, but, as we show in Section 4.3.1, it becomes economically sizable once endogeneity is taken into account. Our finding extends the evidence provided by Anantharaman, Fang, and Gong (2014), who also illustrate that inside debt is effective at reducing spreads only if characterized by low seniority.[25] The intuition for this result is that only risky inside debt is able to align CEOs to debt holders, while high seniority pension plans, being *de facto* riskless, do not have this effect. It is also worthwhile noticing that our measure of inside debt seniority is downward biased. However, this makes our finding stronger. In fact, our non-protected inside debt supposedly includes also pension plans with relatively high effective seniority. This fact biases against us finding a negative and significant effect of low seniority inside debt on CDS spreads.

In Panel C of Table 3, we examine the effect of equity incentives on CDS spreads. To test Hypothesis 3, we interact *CEO effective ownership* with an indicator variable equal to one if a firm-year belongs to the top quartile of inside debt seniority or to the bottom quartile inside debt in levels (excluding observations with inside debt equal to zero).[26] In columns 1 and 2, *CEO effective ownership* exhibits a positive and significant coefficient

[25] Anantharaman, Fang, and Gong (2014) restrict their analysis to a sample of private loan contracts, whereas our result is applicable to the full sample of Execucomp firms.

[26] We exclude firm-years with zero inside debt in computing this indicator variable, because, as pointed out by Hoang (2013), the effect of inside debt is arguably discontinuous at zero.

at the 1% level when inside debt is large and unsecured, while its effect on CDS spreads is slightly negative and statistically indistinguishable from zero when inside debt is small or unsecured. This result matches Hypothesis 3. In columns 3 and 4, we focus separately on the top quartile of inside debt seniority and the bottom quartile of inside debt in levels, respectively. In columns 5 and 6, we estimate a lagged specification. In each of these cases, our findings are in line with Hypothesis 3.[27]

To better understand the economic rationale behind the results in Panel C, consider a risk-averse manager holding a combination of equity incentives and unsecured debt. In deciding to whether to take more risk, she trades off the utility gain from increased expected payoff against the utility loss from increased payoff variance. In a period of widespread stock price declines (such as our sample period and the bad states in the bottom-left picture of Fig. 9), her position amounts to holding an out-of-the-money call, so the utility gain from increased asset risk prevails and the manager will gamble more on firm's survival as his equity stake in the firm increases.

These baseline findings provide suggestive evidence that is consistent with our model's implications. However, reverse causality and selection bias are an issue in our tests. Thus, in the next section we try to alleviate such concerns.

4.3.1 Endogeneity and selection bias

Default risk and compensation structure are endogenous. Hence, to address the endogeneity issue, we rely on an instrumental variable approach. We re-estimate the regressions in Panel A and Panel B of Table 3 instrumenting inside debt. In particular, we use two instrumental variables together. Our first variable is the lagged *Median industry CEO relative D/E ratio*, computed year-by-year for each two-digit SIC code industry. We choose this instrument because of the widespread practice of benchmarking compensation packages to peer groups in the same industry (see, e.g., Bizjack, Lemmon, and Naveen, 2008). Hence, while we expect median inside debt in the industry to positively correlate with that of individual firms, we do not see any compelling reason for it to directly affect a firm's credit spread, so that the exclusion condition is arguably satisfied.

Our second instrumental variable is the mean wages tax rate for the highest tax bracket in the top ten states by inflow of retiree migrants, computed year-by-year. Tax-

[27]In unreported tests, we find that these results are robust to using alternative thresholds for inside debt seniority and level.

planning reasons play an important role in determining compensation packages. As income from inside debt is taxed at withdrawal, we argue that expected income taxation after retirement substantially affects the size of CEOs' deferred compensation and pension plans. Rather than using the current taxation regime in the state where the firm is located to proxy for future taxes, we look at the ten U.S. states attracting the most retiree migrants as of 2000 (top ten host states) according to Haas, Bradley, Longino, Stoller, and Serow (2006), such as Florida, California, and Texas. Indeed, later-life migration to Sun Belt states is an important and extensively studied phenomenon in the U.S. mainly involving affluent retirees, such as our CEOs (see, e.g. Serow, 2003). We expect the mean tax rate in these states to positively correlate with inside debt, the economic rationale being that CEOs anticipate that a current low tax rate will probably translate into a higher tax rate in the next few years, given the observed mean-reverting behavior of state tax rates, thus reducing the value of their pensions. Fig. 11 visualizes the mean tax rate in our top ten host states for the period of 1977-2012, illustrating that it is indeed stationary around the secular increasing trend in state taxation. Kim and Lu (2011) document the same behavior for federal personal tax rates. Deviations from the trend are relatively short-lived, so they are probably most important for CEOs close to retirement: We indeed verify that the correlation between inside debt and the mean tax rate in the top ten states is highest for CEOs aged between 60 and 65 years. Moreover, unlike taxation in the headquarters' state, the mean tax rate in the top ten host states does not reflect local economic conditions affecting also firms' credit spreads, and is thus more likely to satisfy the exclusion condition. Finally, though variation in the mean tax rate is admittedly small, it is of magnitude comparable to most of the state corporate tax changes exploited by Heider and Ljungqvist (2014), who found them to be consequential for firms' leverage choices.[28]

Panel A of Table 4 presents the two-stage least squares results for the baseline specification in Panel A of Table 3. These panel regressions do not include year fixed effects, as there is no cross-sectional variation in *Mean wage tax rate (top 10 host states)*. We still control for macroeconomic conditions by means of the Chicago Fed National Activity Index. Column 1 (column 3) reports the first-stage results for *CEO relative D/E ratio*

[28]It is well-known that Compustat reports only the current and not the historical headquarters of firms in the database. To overcome this drawback, we make use of CRSP's information on firm historical headquarters available starting from 2007 in the table COMPHIST

(*CEO relative incentive ratio*). Our instrument variables satisfy the relevance condition, and display the conjectured coefficient signs. The Angrist-Pischke test of excluded instruments exhibits a close to 10 F-statistic, reducing concerns about weak identification. In column 2 (column 4), we estimate the second-stage regression for *CEO relative D/E ratio* (*CEO relative incentive ratio*). The Hansen's J test does not reject the null hypothesis that our instruments are valid. As above, inside debt incentives have a negative and significant effect on CDS spreads, and *PV expected salary-to-stock* carries a positive and significant coefficient. Interestingly, once we account for endogeneity, the economic effect of compensation structure becomes substantially larger. Based on the coefficient estimates in column 2, a 10% increase in *CEO relative D/E ratio* leads to a 18.59% (44 basis points) decrease in CDS spreads, while a 10% increase in *PV expected salary-to-stock* translates into a 2.65% (6 basis points) increase in CDS spreads.

In Panel B of Table 4, we re-estimate with two-stage least squares the specification in Panel B of Table 3. As contributions to ERISA-qualified plans (protected in bankruptcy) are largely non-discretionary, making the relation between CDS spreads and secured inside debt less plagued by endogeneity, we instrument only *CEO relative D/E ratio (non-protected)* and *CEO relative incentive ratio (non-protected)* with the same variables as above. In line with Hypothesis 2, columns 2 and 4 illustrate that only the non-protected component of inside debt is effective at reducing risk-taking. Moreover, protected inside debt incentives display now a sizeable positive coefficient.

The specifications in Panel C of Table 3 rely on an interaction term between equity incentives and an indicator variable equal to one if inside debt is small or secured. The use of interactions helps to better dissect the underlying economic mechanism, making our tests of Hypothesis 3 less prone to endogeneity (Rajan and Zingales, 1998). Still, classifying firms according to the level and seniority of inside debt may induce a selection bias. To deal with this issue, we match firm-years with large or secured inside debt ("treated" observations) to similar firm-years. Using the procedure proposed by Abadie and Imbens (2002), we require exact matching on two-digit SIC code industry and year, and minimize the matching error on a vector of continuous covariates including sales, ROA, book-to-market ratio, and debt-to-equity ratio.[29] Each treated firm-year is matched to one control firm-year, allowing for replacement.

Panel A of Table 5 presents the results of the matching. We are able to match 76.6% of

[29]We use the Stata routine `nnmatch` developed by Abadie, Drukker, Herr, and Imbebs (2004).

treated firm-years and each matched control firm-year is used up to three times. Before matching, treated firm-years are characterized by significantly lower ROA, and higher book-to-market ratio and debt-to-equity ratio. All the differences turn insignificant after matching, except the debt-to-equity ratio. In the latter case, however, the difference becomes economically small. Interestingly, treated and matched firms are not significantly different in terms of CEO's vega and total annual compensation, so that they mainly differ in terms of compensation structure.

In Panel B of Table 5, we re-estimate the regressions in Panel C of Table 3 over the treated and matched sample. Each matched observation is weighted by the number of times it is used. It is worth noting that we do not perform a difference-in-differences analysis, as it is not straightforward to identify events relevant for this purpose. Columns 1 and 2 report the results for the contemporaneous and lagged specification, respectively. In both cases, *CEO effective ownership* displays a positive and significant coefficient at the 1% level when inside debt is large and unsecured, which becomes statistically indistinguishable from zero when inside debt is small or unsecured.

4.3.2 Robustness checks

In this section we perform several robustness tests that we present in Table 6. In Panel A, we repeat the baseline analysis controlling for additional corporate governance characteristics, such as an indicator variable equal to one if a CEO is in her first year of tenure, the E-index and CEO's age. Columns 1 and 2 focus of Hypothesis 1, columns 3 and 4 on Hypothesis 2, and columns 5 and 6 on Hypothesis 3. Our findings are in line with the analysis above. Panel B re-estimates the regressions used above to tests our hypotheses excluding firm-years with zero inside debt holdings. Again, our results hold. In Panel C, to check if our results are sensitive to the way unobserved firm heterogeneity is accounted for, we carry out the same tests both without industry fixed effects and with industry fixed effects at the four-digit SIC code-level. Also in this case, coefficient estimates match our hypotheses. We obtain similar results (untabulated) for specifications with lagged regressors.

In unreported regressions, we also show that our results are robust to using firm-year clustered standard errors and alternative thresholds of inside debt seniority and level.

5 Conclusion

The corporate governance literature has long stressed the importance of different components of managerial firm-specific wealth, namely fixed salary, equity incentives, and inside debt, as important determinants of managerial risk-taking. We consider different components of CEO's firm-specific wealth jointly, rather than on a stand-alone basis, and analyze their effect on the CEO's risk-taking incentives and the firm's credit spreads. Our theoretical model provides several novel predictions. First, the common belief that inside debt lowers credit spreads holds true only under certain conditions. Indeed, we find that only when inside debt is relatively unsecured, i.e. junior to corporate debt in bankruptcy, the CEO chooses higher asset volatility in good times and lower asset volatility in bad times, thus decreasing both the probability of default and the credit spreads. Second, the standard result that in the context of a risk-averse manager, higher stock ownership is always associated with lower credit spreads may fail to hold in the presence of inside debt. In particular, we find that equity ownership increases credit spreads only when inside debt is large and unsecured. In other words, inside debt exerts an indirect effect on CEO's risk-taking through equity incentives.

We then empirically test our predictions using a comprehensive sample of U.S. public firms with traded CDS contracts over the period 2006-2011. We confirm the model predictions concerning the joint effect of inside debt and equity incentives on CDS spreads. Our findings are robust to taking into account endogeneity and selection bias.

These results suggest that different components of CEO compensation should be considered jointly in order to correctly understand the CEO's risk-taking incentive and corporate credit spreads. We believe that further empirical and theoretical research addressing the consequences of the interaction among executive compensation components is needed.

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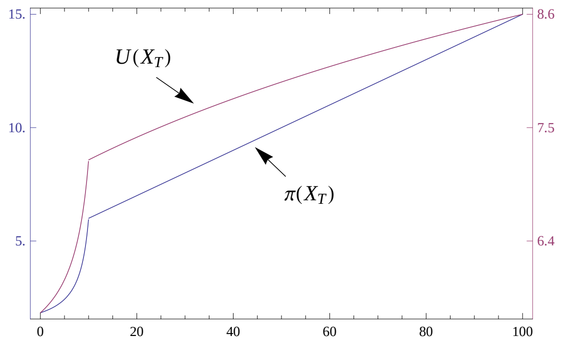


Figure 1: CEO payoff diagram and utility function
This is a sample graph of CEO's payoff $\pi_T(X_T)$ and her associated utility $U(\pi_T(X_T))$ with $A = 1, p = .1, D = 5, \theta = 2, X_b = 10$, and $\gamma = .8$.

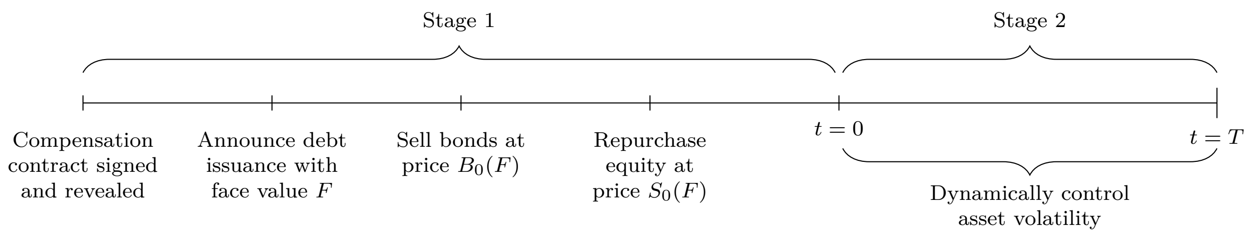


Figure 2: Timing of the model
Beginning at stage 1, shareholders and the manager agree on a compensation contract and reveal all contract details publicly. Shareholders make decision about leverage by announcing the issuance of a zero-coupon bond with face value F and maturity at time T; sell the bond at fair price B_0; and use the proceed to redeem a part of outstanding shares. For computational convenience, we assume that the manager is asked to participate in the redemption on *pro rata* basis (i.e. with the same fraction as her ownership holding immediately before the redemption) so that her equity ownership remains the same as specified in the compensation contract after the redemption. All these actions happen at time 0. From time 0 to T, the manager dynamically adjusts firm risk σ_t at will. At time T, terminal firm value X_T is realized and all contracts settled. Parts of this figure were adapted from Carlson and Lazrak (2010).

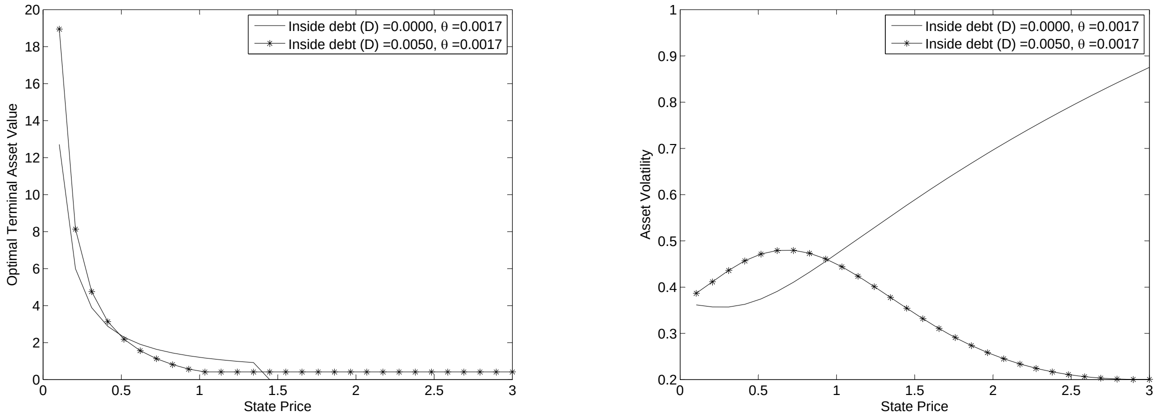


Figure 3: Optimal terminal asset value and risk-taking dynamics
This figure plots optimal choices of terminal asset value and associated risk-taking dynamics of a manager with zero inside debt holding (solid line) and a manager with positive inside debt holding (star-marked line) across state space. Salary and equity ownership holdings are fixed at their median levels reported in Table 1 of Section 3.3.1. Inside debt seniority θ is set at low level, implying that a large fraction of inside debt balance will be forfeited in bankruptcy. Model parameters are discussed in Section 3.3.1 of the text.

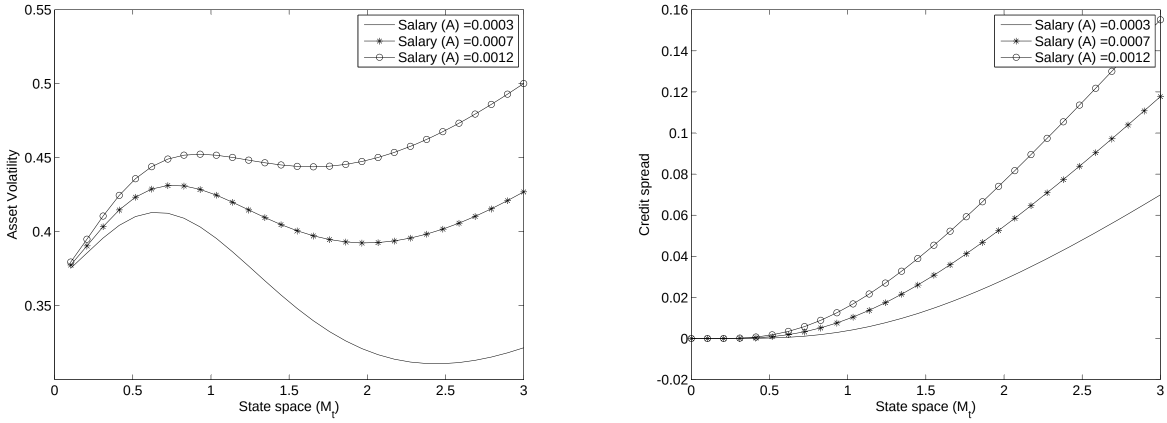


Figure 4: Risk-taking dynamics and credit spread as salary increases
These pictures plot optimal asset risk choices and corresponding credit spreads across state space. Moving from the solid line to star-marked line and circle-marked line, salary increases steadily while other compensation components are kept constant at their median levels reported in Table 1. $\theta = .0017$, implying an expected inside debt recovery rate of 1%. Model parameters are described in Section 3.3.1 of the text.

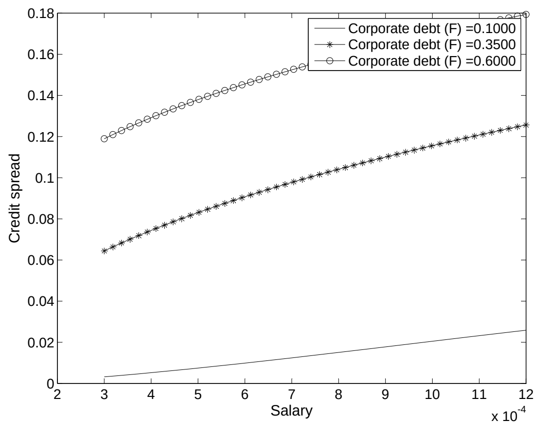
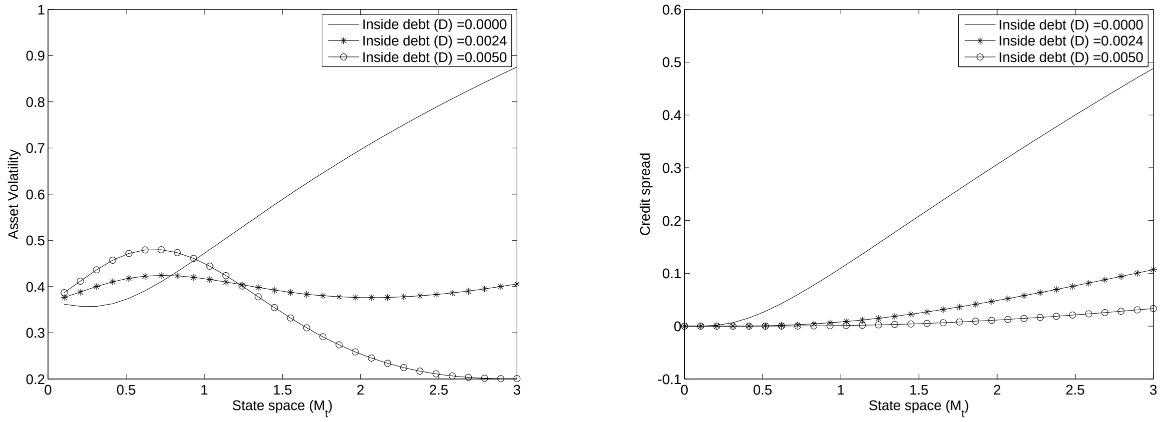


Figure 5: Credit spread as a function of salary
This picture plot credit spread as a function of salary for different levels of corporate debt. Other compensation components are kept constant at their median levels reported in Table 1. $\theta = .0017$, implying an expected inside debt recovery rate of 1%. Model parameters are described in Section 3.3.1 of the text.

Panel A: $\theta = .0017$, implying a very high risk of forfeiture for inside debt.



Panel B: $\theta = 16.83$, implying a very low risk of forfeiture for inside debt.

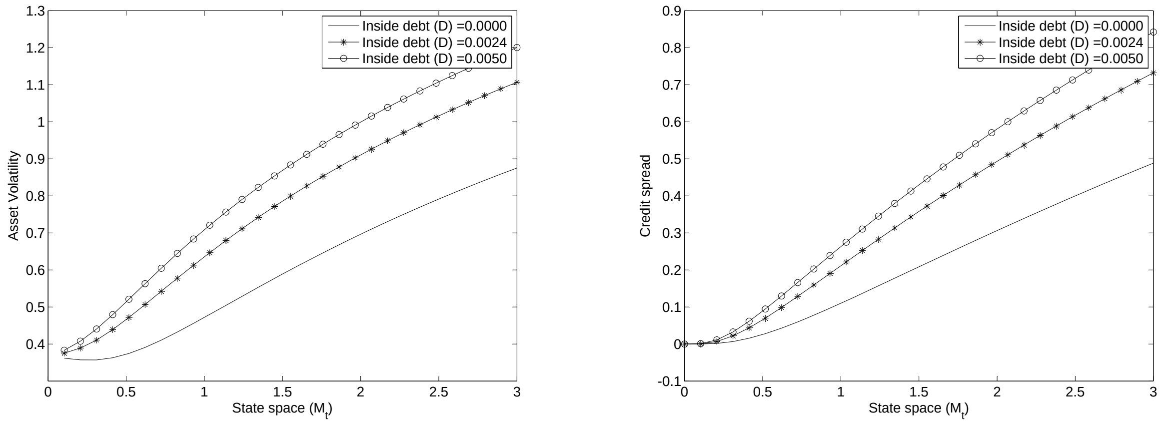


Figure 6: Risk-taking dynamics and credit spread as inside debt holdings increase
These pictures plot optimal asset risk choices and corresponding credit spreads across state space for two cases: (i) when the effective seniority of inside debt in bankruptcy is low (Panel A) and (ii) when the effective seniority of inside debt in bankruptcy is high (Panel B). Moving from the solid line to star-marked line and circle-marked line, inside debt increases steadily while other compensation components are kept constant at their median levels reported in Table 1. Model parameters are described in Section 3.3.1 of the text.

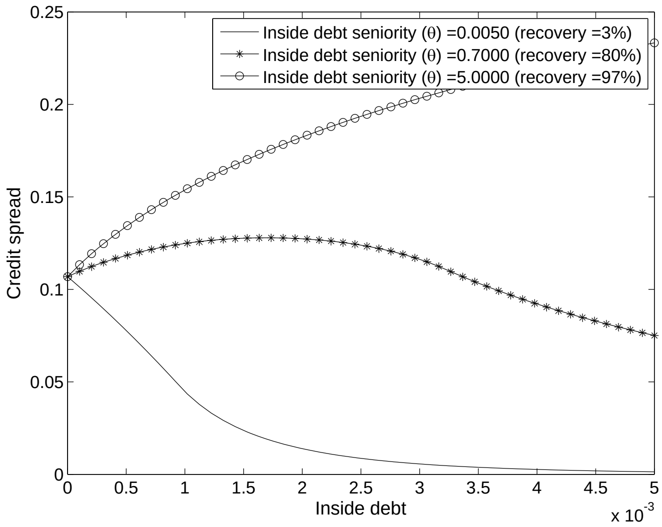


Figure 7: Credit spread as a function of inside debt holdings
This picture plot credit spread as a function of inside debt for different levels of effective seniority of inside debt in bankruptcy. Other compensation components are kept constant at their median levels reported in Table 1. Model parameters are described in Section 3.3.1 of the text.

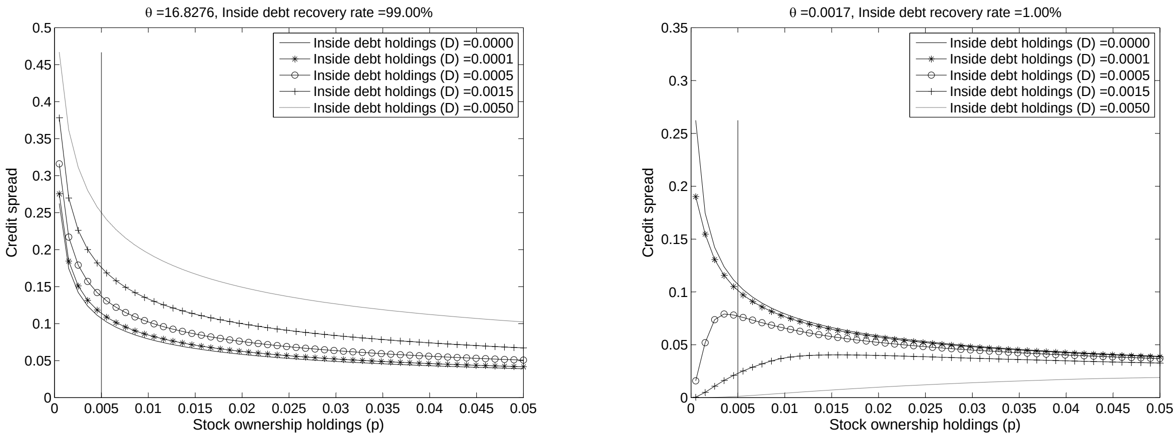


Figure 8: Credit spread as a function of equity ownership
This figure plots credit spread as a function of equity ownership holdings for different values of inside debt. The left panel corresponds to the case where effective seniority of inside debt in bankruptcy is high (low risk of forfeiture) and the right panel corresponds to the case where effective seniority of inside debt in bankruptcy is low (high risk of forfeiture.) The solid vertical line marks the sample median value of equity ownership. Other compensation components are kept constant at their median levels reported in Table 1. Model parameters are described in Section 3.3.1 of the text.

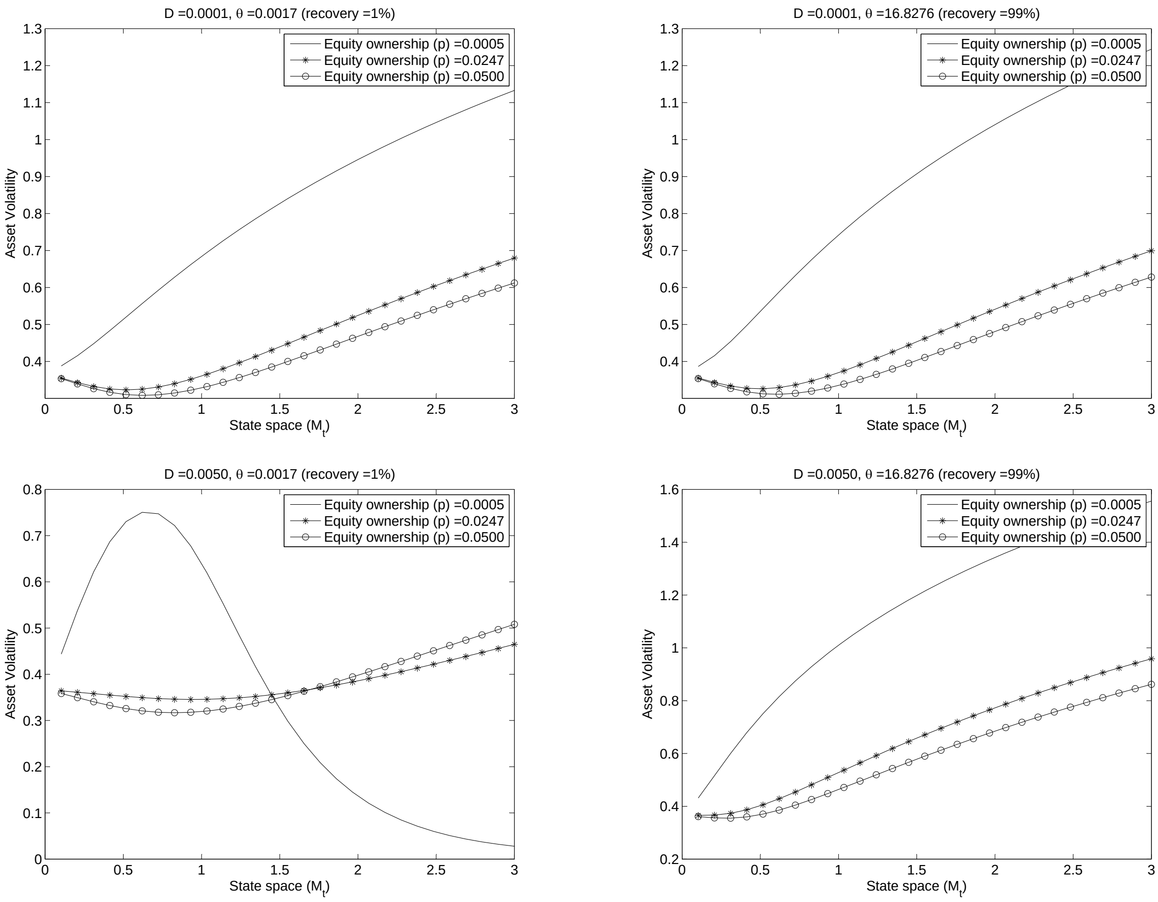


Figure 9: Risk-taking dynamics as equity ownership increases
This figure plots optimal choices of asset volatility for different levels of equity ownership holding. Top-left picture corresponds to the case when both inside debt holding and its effective seniority are low; top-right picture corresponds to the case when inside debt holding is low and its effective seniority is high; bottom-left picture correponds to the case when inside debt holding is high and its effective seniority is low; and bottom-right picture corresponds to the case when both inside debt holding and its effective seniority are high. Salary is fixed at its median level reported in Table 1. Model parameters are discussed in Section 3.3.1 of the text.

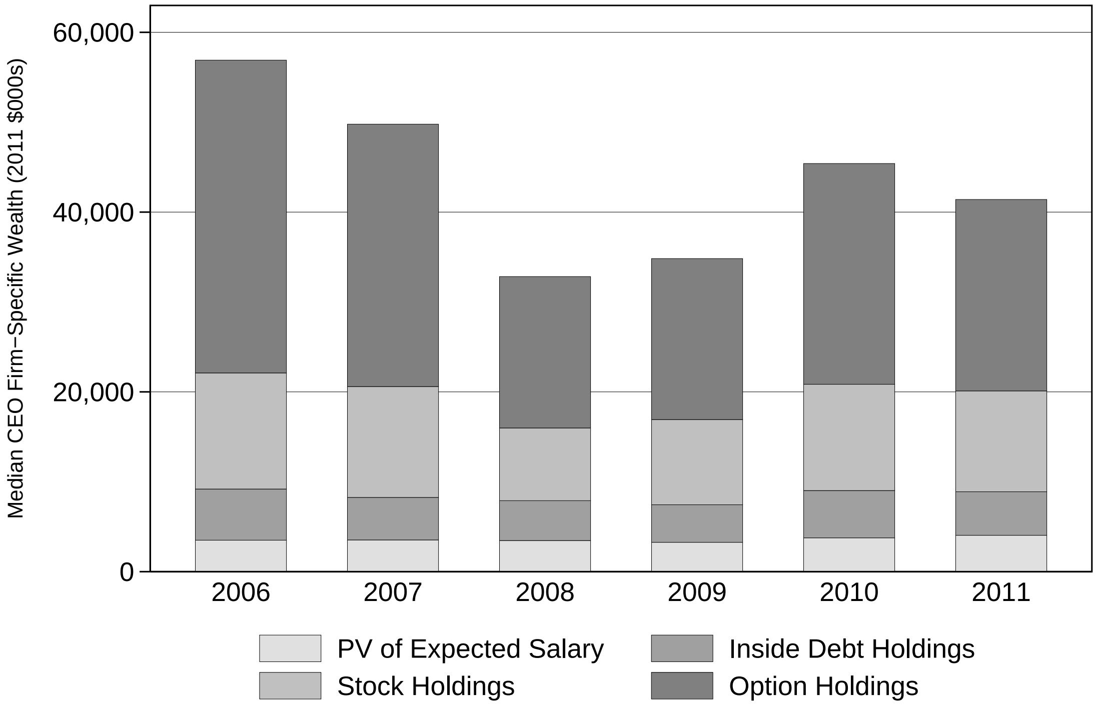


Figure 10: Median CEO firm-specific wealth level and composition: 2006-2011
This figure reports the median level and composition of CEO firm-specific wealth over the period 2006-2011 for the sample of Markit CDS firms reported in Execucomp (650 firms).

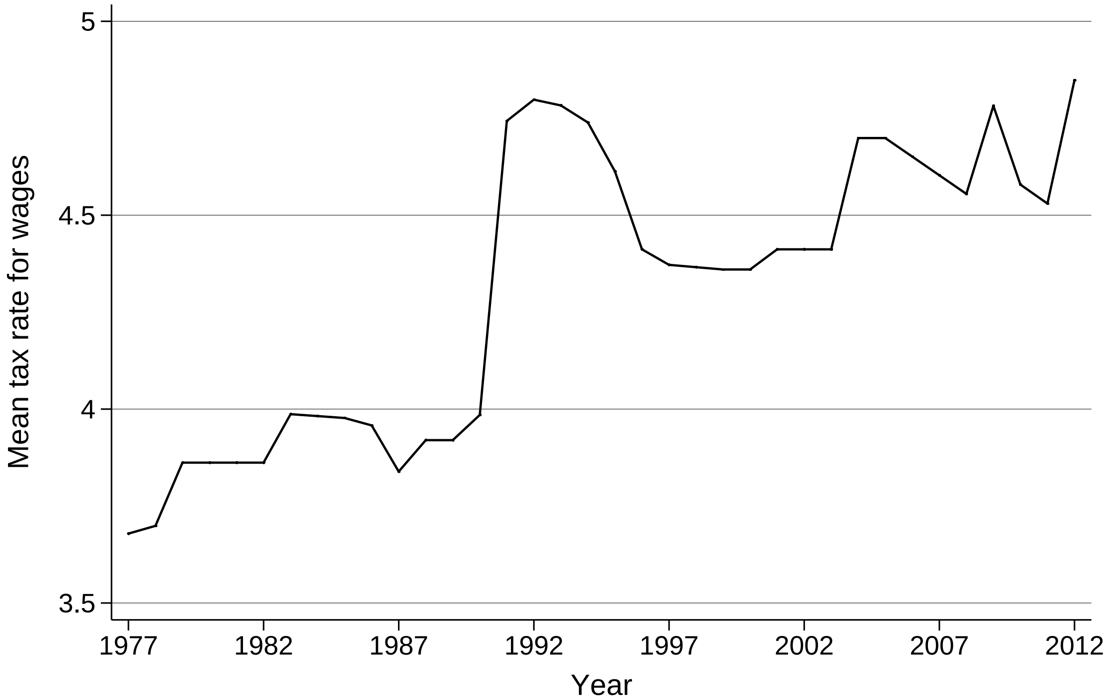


Figure 11: Mean state tax rates for wages in top ten states by inflow of retiree migrants: 1977-2012
This figure reports the mean state tax rate for wages in the highest tax bracket across the top ten states by inflow of retiree migrants according to Haas, Bradley, Longino, Stoller, and Serow (2006).

Table 1: Empirically relevant range of compensation variables
This table reports the empirically relevant range of salary, equity ownership, and inside debt compensation for calibration purpose. Information is based on our sample reported in Table 2, where all variables are winsorized at the 5^{th} and the 95^{th} percentile and level variables like salary and inside debt are scaled by the median asset value, consistently with the normalization of $X_0 = 1.0$ in the model. Since our model features a one-period horizon in which all compensation components are paid one time at the end while in reality, salary is paid in annual installments, we multiply average annual salary by 6, the average tenure of CEOs in years (Kaplan and Minton, 2012), to arrive at an estimate for salary received over the entire horizon.

	Min.	Median	Max.
PV of exp. salary	0.0003	0.0006	0.0012
Equity ownership	0.0005	0.0050	0.0500
Inside debt	0.0000	0.0005	0.0050

Table 2: Summary statistics
This table reports summary statistics of all variables employed in the paper. The sample includes 504 U.S. firms over the period of 2006-2011 with 5-year maturity CDS contracts trading, excluding financial institutions and utilities. We obtain accounting data from Compustat, stock market data from CRSP, executive compensation data from Execucomp, governance data from IRRC (2006)/Riskmetrics (2007-2011), and CDS market data from Markit. All dollar amounts are in 2011 constant dollars. Refer to Table A.1 for variable definitions.

	Mean	Std. Dev.	Q1	Med.	Q3	Obs.
Firm characteristics						
CDS spread (bp)	237.254	412.859	52.424	109.706	269.496	2307
Asset volatility	0.252	0.136	0.161	0.211	0.302	2325
D/E ratio	0.881	3.542	0.155	0.311	0.646	2325
Sharpe ratio	0.103	0.151	0.005	0.101	0.206	2323
Marginal tax rate	0.325	0.058	0.334	0.345	0.350	2307
Sales (billions)	17.529	35.510	3.242	6.783	16.641	2325
Total assets (billions)	18.941	34.177	3.778	7.749	18.612	2325
ROA	0.040	0.088	0.016	0.052	0.085	2325
Stock return	0.104	0.726	-0.192	0.054	0.284	2321
Book-to-market ratio	0.690	0.227	0.517	0.686	0.857	2325
Dividend indicator	0.683	0.466	0.000	1.000	1.000	2325
Z-score distress indicator	0.095	0.293	0.000	0.000	0.000	2325
E-index	2.669	1.519	1.000	3.000	4.000	2142
CEO compensation and characteristics						
PV exp. salary-to-stock ratio	0.371	1.317	0.036	0.096	0.247	2304
CEO relative D/E ratio	1.598	6.981	0.050	0.353	1.145	2278
CEO relative D/E ratio (non-prot.)	1.404	6.090	0.034	0.295	1.016	2278
CEO relative D/E ratio (prot.)	0.145	0.642	0.000	0.004	0.047	2278
CEO relative incentive ratio	1.516	6.719	0.053	0.368	1.184	2250
CEO relative incentive ratio (non-prot.)	1.336	5.939	0.036	0.304	1.040	2250
CEO relative incentive ratio (prot.)	0.120	0.429	0.000	0.004	0.049	2250
Effective CEO ownership	0.016	0.041	0.003	0.006	0.012	2325
Inside debt seniority	0.108	0.227	0.000	0.022	0.077	1998
CEO decision hor. (years)	4.300	3.320	2.207	3.489	5.364	2325
Salary (thousands)	1096.559	402.642	873.029	1046.225	1268.531	2325
Bonus (thousands)	370.468	1818.299	0.000	0.000	0.000	2325
PV exp. salary (thousands)	4573.773	3660.572	2244.595	3580.590	5663.536	2325
PV exp. cash comp. (thousands)	5876.469	6763.512	2453.904	3970.100	6528.177	2325
Inside debt holdings (thousands)	10647.487	16585.812	585.168	4776.715	13273.216	2325
Inside debt holdings/total assets	0.001	0.002	0.000	0.000	0.001	2325
Stock and option holdings (thousands)	151560.265	553282.888	16273.784	39513.352	92616.398	2325
CEO vega	247.991	303.208	49.043	147.512	320.870	2325
New CEO	0.053	0.225	0.000	0.000	0.000	2325
CEO age (years)	55.654	6.206	52.000	56.000	60.000	2325
CEO tenure (years)	6.247	6.109	2.000	5.000	8.000	2325

Table 3: CDS spreads and CEO firm-specific wealth structure

This table reports panel regressions of CDS spreads on several measures of CEO firm-specific wealth structure and firm characteristics over the period of 2006-2011. Panel A examines the general relation between CDS spreads and CEO firm-specific wealth structure. Columns 1 and 2 estimate a contemporaneous specification, whereas columns 3 and 4 consider lagged independent variables. Odd-numbered (even-numbered) columns use *CEO relative D/E ratio* (*CEO relative incentive ratio*) as a measure of incentives provided by inside debt. Panel B focuses on the relation between CDS spreads and selected features of inside debt incentives, distinguishing between the protected and non-protected in bankruptcy component of inside debt. Columns 1 and 2 estimate a contemporaneous specification, whereas columns 3 and 4 consider lagged independent variables. Odd-numbered (even-numbered) columns use the protected and non-protected component of *CEO relative D/E ratio* (*CEO relative incentive ratio*) as measures of incentives provided by inside debt. The unreported control variables are the same as in Panel A. Panel C focuses on the relation between CDS spreads and the interaction between equity incentives and inside debt features. Columns 1 through 4 estimate a contemporaneous specification, whereas columns 5 and 6 consider lagged independent variables. Columns 1, 2, 5 and 6 interact *CEO effective ownership* with an indicator equal to one if inside debt incentives are secured (top quartile of seniority) or small (bottom quartile of *CEO relative D/E ratio* (columns 1 and 5) or *CEO relative incentive ratio* (columns 2 and 6)). Column 3 interact *CEO effective ownership* with an indicator equal to one if inside debt incentives are secured (top quartile of seniority). Column 4 interact *CEO effective ownership* with an indicator equal to one if inside debt incentives are small (bottom quartile of *CEO relative D/E ratio*). The unreported control variables are the same as in Panel A. The t-statistics are calculated with robust standard errors clustered by firm. Significance at the 10%, 5%, and 1% levels are indicated by *, **, ***, respectively. Refer to Table A.1 for variable definitions.

Panel A: CDS spreads and salary

	Log of CDS spread (t)		Log of CDS spread ($t+1$)	
	(1)	(2)	(3)	(4)
Log of PV exp. salary-to-stock	0.0708***	0.0696***	0.0786***	0.0770***
	(3.49)	(3.40)	(3.30)	(3.20)
Log of CEO relative D/E ratio	-0.190***		-0.130***	
	(-5.33)		(-3.32)	
Log of CEO relative incentive ratio		-0.197***		-0.141***
		(-5.49)		(-3.58)
Log of effective CEO ownership	1.571	1.580	2.130*	2.107*
	(1.53)	(1.56)	(1.90)	(1.89)
Log of CEO vega	-0.0473***	-0.0621***	-0.0383**	-0.0494***
	(-2.99)	(-4.12)	(-2.36)	(-2.88)
D/E ratio	0.0387***	0.0373***	0.0595*	0.0584
	(4.20)	(4.09)	(1.67)	(1.64)
Sharpe ratio	-0.0855	-0.120	-0.00894	-0.0317
	(-0.40)	(-0.56)	(-0.04)	(-0.14)
Marginal tax rate	-1.563***	-1.511**	-1.019*	-0.996*
	(-2.65)	(-2.57)	(-1.77)	(-1.73)
Log of sales	-0.141***	-0.134***	-0.104***	-0.0992***
	(-5.38)	(-5.12)	(-3.75)	(-3.54)
Log of ROA	-1.018***	-1.007***	-0.980***	-0.966***
	(-3.04)	(-3.02)	(-3.03)	(-3.00)

(Continued)

Table 3: – *Continued*

Log of stock return	-0.0249	-0.0274	0.117***	0.116***
	(-0.55)	(-0.60)	(2.81)	(2.80)
Log of book-to-market	0.777***	0.746***	0.824***	0.801***
	(8.27)	(8.05)	(8.65)	(8.43)
Dividend ind.	-0.532***	-0.525***	-0.521***	-0.517***
	(-8.67)	(-8.57)	(-7.58)	(-7.50)
Distress ind.	0.166	0.160	0.216*	0.215*
	(1.55)	(1.49)	(1.92)	(1.90)
Industry F.E.	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes
Observations	2183	2166	1717	1705
Adjusted R^2	0.68	0.68	0.59	0.59

(Continued)

Table 3: – *Continued*

Panel B: CDS spreads and inside debt (protected vs. non-protected)				
	Log of CDS spread (t)		Log of CDS spread ($t+1$)	
	(1)	(2)	(3)	(4)
Log of PV exp. salary-to-stock	0.0699***	0.0687***	0.0773***	0.0759***
	(3.44)	(3.36)	(3.22)	(3.15)
Log of CEO relative D/E ratio (non-prot.)	-0.176***		-0.130***	
	(-4.11)		(-2.64)	
Log of CEO relative D/E ratio (prot.)	-0.103		-0.0224	
	(-0.80)		(-0.15)	
Log of CEO relative incentive ratio (non-prot.)		-0.184***		-0.141***
		(-4.26)		(-2.85)
Log of CEO relative incentive ratio (prot.)		-0.116		-0.0419
		(-0.82)		(-0.25)
Log of effective CEO ownership	1.575	1.582	2.118*	2.095*
	(1.53)	(1.56)	(1.88)	(1.88)
Control variables	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes
Observations	2183	2166	1717	1705
Adjusted R^2	0.68	0.68	0.59	0.59

(Continued)

Table 3: – *Continued*

Panel C: CDS spreads and equity ownership						
	Log of CDS spread (t)				Log of CDS spread ($t+1$)	
	(1)	(2)	(3)	(4)	(5)	(6)
Log of PV exp. salary-to-stock	0.0730***	0.0717***	0.0715***	0.0749***	0.0781***	0.0767***
	(3.75)	(3.65)	(3.57)	(3.87)	(3.37)	(3.27)
Log of CEO relative D/E ratio	-0.189***		-0.188***	-0.172***	-0.128***	
	(-5.37)		(-5.30)	(-4.91)	(-3.29)	
Log of CEO relative incentive ratio		-0.197***				-0.139***
		(-5.55)				(-3.56)
Log of effective CEO ownership	3.612***	3.608***	1.881*	3.785***	4.491***	4.455***
	(5.04)	(5.09)	(1.87)	(5.42)	(6.79)	(6.69)
High sen. OR Low CEO rel. D/E ratio	0.0443				0.0709	
	(0.82)				(1.19)	
Log of eff. CEO own. × High sen. OR Low CEO rel. D/E ratio	-3.856***				-4.807***	
	(-4.09)				(-4.96)	
High sen. OR Low CEO rel. inc. ratio		0.0481				0.0713
		(0.88)				(1.19)
Log of eff. CEO own. × High sen. OR Low CEO rel. inc. ratio		-3.845***				-4.784***
		(-4.11)				(-4.94)
High seniority			-0.0126			
			(-0.21)			
Log of eff. CEO own. × High seniority			-2.620**			
			(-2.00)			
Low CEO rel. D/E ratio				0.208**		
				(2.45)		
Log of eff. CEO own. × Low CEO rel. D/E ratio				-4.788***		
				(-4.86)		
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2183	2166	2183	2183	1717	1705
Adjusted R^2	0.68	0.68	0.68	0.68	0.59	0.59

Table 4: CDS spreads and inside debt incentives: Two-stage least squares estimation
This table estimates with two-stage least squares panel regressions of CDS spreads on several measures of CEO firm-specific wealth structure and firm characteristics over the period of 2006-2011. Panel A (B) re-estimates the contemporaneous specifications in Panel A (B) of Table 3 instrumenting inside debt incentives. Inside debt incentives are instrumented with two variables: (i) the lagged *Median industry CEO relative D/E ratio*, computed year-by-year for each two-digit SIC code industry; (ii) the *Mean wages tax rate (top 10 host states)*, defined as the year-by-year average tax rate on wages for the highest tax bracket in the top ten states by inflow of retiree migrants according to Haas, Bradley, Longino, Stoller, and Serow (2006). Odd-numbered columns report the results of the first-stage estimation. Even-numbered columns report the results of the second-stage estimation. Columns 1 and 2 use *CEO relative D/E ratio* as measure of inside debt, whereas columns 3 and 4 use *CEO relative incentive ratio* as measure of inside debt. All the regressions include the same control variables as in Panel A of Table 3. The t-statistics are calculated with robust standard errors clustered by firm. Significance at the 10%, 5%, and 1% levels are indicated by *, **, ***, respectively. Refer to Table A.1 for variable definitions.

Panel A: CDS spreads and inside debt

	Log of CDS spread (t)			
	(1) 1st stage	(2) 2nd stage	(3) 1st stage	(4) 2nd stage
Mean wage tax rate (top 10 host states)	0.263** (2.38)		0.293*** (2.65)	
Median industry CEO rel. D/E ratio (lagged)	0.00916*** (3.33)		0.00954*** (3.33)	
Log of PV exp. salary-to-stock	0.0655*** (3.91)	0.265*** (2.83)	0.0657*** (3.87)	0.249*** (3.00)
Log of CEO rel. D/E ratio (predicted)		-3.023** (-2.46)		
Log of CEO rel. inc. ratio (predicted)				-2.803*** (-2.68)
Log of effective CEO ownership	-0.939* (-1.78)	-1.066 (-0.50)	-0.985* (-1.89)	-0.943 (-0.49)
CFNAI index	-0.00812 (-0.89)	0.0506 (1.60)	-0.00892 (-0.99)	0.0488* (1.66)
Control variables	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes
Year F.E.	No	No	No	No
Observations	1714	1714	1699	1699
F-stat A-P test of excl. instr.		8.590		9.382
Hansen J-test p-value		0.205		0.201

(Continued)

Table 4: – *Continued*

Panel B: CDS spreads and inside debt seniority				
	Log of CDS spread (t)			
	(1) 1st stage	(2) 2nd stage	(3) 1st stage	(4) 2nd stage
Mean wage tax rate (top 10 host states)	0.263** (2.38)		0.293*** (2.65)	
Median industry CEO rel. D/E ratio (lagged)	0.00916*** (3.33)		0.00954*** (3.33)	
Log of PV exp. salary-to-stock	0.0655*** (3.91)	0.184*** (2.83)	0.0657*** (3.87)	0.182*** (2.87)
Log of CEO rel. D/E ratio (non-prot., predicted)		-3.116** (-2.33)		
Log of CEO rel. D/E ratio (prot.)		2.192 (1.53)		
Log of CEO rel. inc. ratio (non-prot., predicted)				-2.966** (-2.42)
Log of CEO rel. inc. (prot.)				2.117 (1.53)
Log of effective CEO ownership	-0.939* (-1.78)	-1.575 (-0.74)	-0.985* (-1.89)	-1.519 (-0.74)
CFNAI index	-0.00812 (-0.89)	0.0740*** (2.92)	-0.00892 (-0.99)	0.0761*** (3.17)
Control variables	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes
Year F.E.	No	No	No	No
Observations	1714	1714	1699	1699
F-stat A-P test of excl. instr.		16.04		17.61
Hansen J-test p-value		0.199		0.190

Table 5: : CDS spreads and equity ownership: Matched control sample

This table examines the relation between CDS spreads and the interaction between equity incentives and inside debt features, using a matched control sample of firm-years. We match firm-years belonging to top quartile of inside debt seniority or bottom quartile of inside debt in levels ("treated" observations) to similar firm-years. Using the `nnmatch` Stata routine developed by Abadie, Drukker, Herr, and Imbebs (2004), we require exact matching on two-digit SIC code industry and year, and minimize the matching error on a vector of continuous covariates including sales, ROA, book-to-market ratio, and debt-to-equity ratio. Each treated firm-year is matched to one control firm-year, allowing for replacement. Panel A presents means of selected variables of treated and control firms before and after the matching. Differences in means are assessed using standard t-tests and Wilcoxon rank-sum tests. Panel B re-estimates the baseline specification in Panel C of Table 3 over the treated and matched control sample, using *CEO relative D/E ratio* as measure of inside debt incentives. Column 1 reports results for the contemporaneous regression, whereas column 2 considers lagged independent variable. Each matched observation is weighted by the number of times it is used. All the regressions include the same control variables as in Panel A of Table 3. The t-statistics are calculated with robust standard errors clustered by firm. Significance at the 10%, 5%, and 1% levels are indicated by *, **, ***, respectively. Refer to Table A.1 for variable definitions.

Panel A: Summary statistics

	Pre-match				Post-match			
	Treated	Control	p-value	Wilcoxon p-value	Treated	Control	p-value	Wilcoxon p-value
Log of sales	2.034	2.049	0.786	0.394	2.056	2.026	0.682	0.811
Log of ROA	0.021	0.041	0.000***	0.000***	0.030	0.035	0.446	0.163
Log of book-to-market	-0.375	-0.452	0.000***	0.000***	-0.381	-0.399	0.379	0.291
D/E ratio	1.299	0.679	0.000***	0.000***	0.992	0.747	0.233	0.001***
Log of total compensation	8.882	8.920	0.284	0.109	8.887	8.899	0.819	0.452
Log of CEO vega	4.655	4.759	0.197	0.079*	4.763	4.668	0.382	0.282
CEO age	55.623	55.728	0.708	0.256	55.781	55.400	0.358	0.721

(Continued)

Table 5: – *Continued*

Panel B: Regressions on the matched sample		
	Log CDS spread (t)	Log CDS spread ($t+1$)
	(1)	(2)
Log of PV exp. salary-to-stock	0.0769**	0.0712**
	(2.24)	(1.99)
Log of CEO relative D/E ratio	-0.182***	-0.146***
	(-4.04)	(-2.93)
Log of effective CEO ownership	4.288***	4.496***
	(4.33)	(4.63)
High sen. OR Low CEO rel. D/E ratio	0.166***	0.149**
	(2.78)	(2.32)
Log of eff. CEO own. × High sen. OR Low CEO rel. D/E ratio	-4.445***	-4.943***
	(-4.31)	(-4.68)
Control variables	Yes	Yes
Industry F.E.	Yes	Yes
Year F.E.	Yes	Yes
Observations	982	798
Adjusted R^2	0.69	0.61
Treated	499	402
Control	483	396
Control (unique obs.)	426	350

Table 6: Robustness checks
This table reports panel regressions of CDS spreads on several measures of CEO firm-specific wealth structure and firm characteristics over the period of 2006-2011. Panel A re-estimates the contemporaneous regressions of Table 3 including additional corporate governance control variables. Panel B re-estimates the contemporaneous regressions of Table 3 excluding firm-years with zero inside debt incentives. Panel C re-estimates the contemporaneous regressions of Table 3 without industry fixed effects (odd-numbered columns) and with industry fixed effects at the four-digit SIC code-level (even-numbered columns). All the regressions include the same control variables as in Panel A of Table 3. The t-statistics are calculated with robust standard errors clustered by firm. Significance at the 10%, 5%, and 1% levels are indicated by *, **, ***, respectively. Refer to Table A.1 for variable definitions.

Panel A: Additional control variables						
	Log of CDS spread (t)					
	(1)	(2)	(3)	(4)	(5)	(6)
Log of PV exp. salary-to-stock	0.0628*** (2.88)	0.0620*** (2.83)	0.0628*** (2.88)	0.0620*** (2.83)	0.0697*** (3.12)	0.0688*** (3.07)
Log of CEO rel. D/E ratio	-0.182*** (-5.05)		-0.182*** (-5.05)		-0.181*** (-5.06)	
Log of CEO rel. incentive ratio		-0.189*** (-5.19)		-0.189*** (-5.19)		-0.188*** (-5.22)
Log of effective CEO ownership	0.200 (0.23)	0.264 (0.31)	0.200 (0.23)	0.264 (0.31)	2.854* (1.93)	2.935** (1.98)
Log of CEO rel. D/E ratio (non-prot.)						
Log of CEO rel. D/E ratio (prot.)						
Log of CEO rel. inc. ratio (non-prot.)						
Log of CEO rel. inc. ratio (prot.)						
High sen. OR Low CEO rel. D/E ratio					0.0699 (1.27)	
Log eff. own. × H. sen. OR L. r. D/E					-3.494** (-2.32)	
High sen. OR Low CEO rel. inc. ratio						0.0756 (1.37)
Log eff. own. × H. sen. OR L. r. i.						-3.536** (-2.34)
New CEO	-0.131** (-2.06)	-0.139** (-2.17)	-0.131** (-2.06)	-0.139** (-2.17)	-0.130** (-2.03)	-0.138** (-2.14)
E-index	-0.0398** (-2.05)	-0.0408** (-2.12)	-0.0398** (-2.05)	-0.0408** (-2.12)	-0.0402** (-2.08)	-0.0412** (-2.14)
Log of CEO age	0.224 (0.90)	0.208 (0.83)	0.224 (0.90)	0.208 (0.83)	0.246 (1.00)	0.231 (0.93)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2019	2006	2019	2006	2019	2006
Adjusted R^2	0.68	0.68	0.68	0.68	0.68	0.68

(Continued)

Table 6: – *Continued*

Panel B: Excluding firm-years with zero inside debt						
	Log of CDS spread (t)					
	(1)	(2)	(3)	(4)	(5)	(6)
Log of PV exp. salary-to-stock	0.0628***	0.0609***	0.0619***	0.0600***	0.0765***	0.0748***
	(2.80)	(2.68)	(2.75)	(2.65)	(3.29)	(3.19)
Log of CEO rel. D/E ratio	-0.188***				-0.183***	
	(-5.21)				(-5.15)	
Log of CEO rel. inc. ratio		-0.196***				-0.192***
		(-5.41)				(-5.37)
Log of effective CEO ownership	0.312	0.338	0.327	0.349	5.810***	5.951***
	(0.39)	(0.42)	(0.41)	(0.43)	(2.79)	(2.79)
Log of CEO rel. D/E ratio (non-prot.)			-0.175***			
			(-4.03)			
Log of CEO rel. D/E ratio (prot.)			-0.0953			
			(-0.74)			
Log of CEO rel. inc. ratio (non-prot.)				-0.184***		
				(-4.21)		
Log of CEO rel. inc. ratio (prot.)				-0.109		
				(-0.77)		
High sen. OR Low CEO rel. D/E ratio					0.0633	
					(1.08)	
Log eff. own. × H. sen. OR L. r. D/E					-5.933***	
					(-2.93)	
High sen. OR Low CEO rel. inc. ratio						0.0654
						(1.12)
Log eff. own. × H. sen. OR L. r. i.						-6.061***
						(-2.93)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1924	1912	1924	1912	1924	1912
Adjusted R^2	0.68	0.68	0.68	0.68	0.68	0.68

(Continued)

Table 6: – *Continued*

Panel C: Unobserved firm heterogeneity						
	Log of CDS spread (t)					
	(1)	(2)	(3)	(4)	(5)	(6)
Log of PV exp. salary-to-stock	0.0957***	0.0633***	0.0945***	0.0626***	0.0973***	0.0649***
	(4.86)	(3.35)	(4.78)	(3.29)	(5.06)	(3.42)
Log of CEO rel. D/E ratio	-0.225***	-0.169***			-0.226***	-0.170***
	(-5.93)	(-5.11)			(-6.01)	(-5.18)
Log of effective CEO ownership	2.837***	1.827***	2.844***	1.831***	4.466***	3.152***
	(3.41)	(2.78)	(3.42)	(2.78)	(5.20)	(3.08)
Log of CEO rel. D/E ratio (non-prot.)			-0.208***	-0.160***		
			(-4.78)	(-3.93)		
Log of CEO rel. D/E ratio (prot.)			-0.123	-0.0802		
			(-1.05)	(-0.76)		
High sen. OR Low CEO rel. D/E ratio					0.0269	0.0494
					(0.50)	(0.96)
Log eff. own. × H. sen. OR L. r. D/E					-3.098***	-2.683**
					(-2.93)	(-2.48)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	No	No	No	No	No
SIC4 Industry F.E.	No	Yes	No	Yes	No	Yes
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2183	2183	2183	2183	2183	2183
Adjusted R^2	0.64	0.75	0.64	0.75	0.64	0.75

A Appendix

A.1 *Properties of managerial utility function*

For any given value of X_b, denote by $U_1(X_T)$ the left branch of $U(X_T)$ where $X_T \in [0, X_b]$ and $U_2(X_T)$ the right branch of $U(X_T)$ where $X_T \in [X_b, \infty)$. We first state a result that characterizes all possible shapes of the utility function in the entire domain of X_T.

Lemma 1 *$U_2(X_T)$ is globally concave in $[X_b, \infty)$. $U_1(X_T)$ is globally convex in $[0, X_b]$ if $\gamma \leq 2$ or $\{\gamma > 2$ and $D \leq \frac{2A}{\gamma-2}\}$; globally concave in $[0, X_b]$ if $\{\gamma > 2$, $D > \frac{2A}{\gamma-2}$, and $\theta > \frac{2AX_b}{D(\gamma-2)-2A}\}$. In case $\{\gamma > 2$, $D > \frac{2A}{\gamma-2}$, and $\theta \leq \frac{2AX_b}{D(\gamma-2)-2A}\}$, there exists a reflection point $X_f = X_b - \theta\left(\frac{D(\gamma-2)}{2A} - 1\right) < X_b$ such that $U_1(X_T)$ is convex in the interval $0 \leq X_T \leq X_f$ and concave in the interval $X_f \leq X_T \leq X_b$.*

Proof. Straightforward from computing second-order derivatives of $U_1(X_T)$, $U_2(X_T)$ and solving for inequalities $U_1''(X_T) \geq 0$ and $U_2''(X_T) \geq 0$. ■

A.2 *Proof of Proposition 1*

A.2.1 *Optimal terminal asset value*

We begin by taking $X_b \geq 0$ as given and consider the Legendre-Fenchel transform of the original problem:

$$U^*(M_T) = \max_{X_T \geq 0} \left[U(X_T) - yM_TX_T\right], \tag{A.1}$$

where $y \geq 0$ denotes the Lagrangian multiplier associated with the budget constraint $E[M_TX_T] \leq X_0$ in problem (7). The role of y will become clear shortly; for the moment, suffice it to consider yM_T as a composite positive variable.

Denote by $V(X_T, M_T)$ the objective function in the Legendre-Fenchel transformation (A.1). In explicit form, $V(X_T, M_T)$ is given by

$$V(X_T, M_T) = \begin{cases} \frac{1}{1-\gamma}\left(A + p(1-\tau)(X_T - X_b) + D\right)^{1-\gamma} - yM_TX_T & \text{if } X_T > X_b, \\ \frac{1}{1-\gamma}\left(A + \frac{D\theta}{X_b - X_T + \theta}\right)^{1-\gamma} - yM_TX_T & \text{if } 0 \leq X_T \leq X_b. \end{cases}$$

Since $U(X_T)$ is convex for $X_T \in [0, X_b]$, concave for $X_T > X_b$, and yM_TX_T is linear in X_T, we know that $V(X_T, M_T)$ is also convex and concave over the same intervals. This suggests that we have at most three candidates for optimality: 0, X_b, and a value

$\bar{X}$ obtained by solving the first-order condition of the concave part. Straightforward computations yield:

$$\bar{X} = X_b + \frac{\left[\frac{p(1-\tau)}{yM_T}\right]^{1/\gamma} - (A+D)}{p(1-\tau)}. \tag{A.2}$$

The condition $\bar{X} > X_b$ (domain restriction of the concave part) implies that $\bar{X}$ is a candidate of optimality if and only if

$$yM_T < \frac{p(1-\tau)}{(A+D)^{\gamma}} := y\bar{M}. \tag{A.3}$$

The threshold $y\bar{M}$ is a cut-off level of the state price such that as long as $yM < y\bar{M}$, candidates for optimality consist of $\{0, X_b, \bar{X}\}$ and if $yM \geq y\bar{M}$, candidates for optimality consist of only $\{0, X_b\}$. In what follows, we use the notation $a \succ (\succeq)\ b$ to mean *a is strictly (weakly) preferred to b* and $a \simeq b$ to mean *a is equivalent to b* in terms of managerial utility. We now compare values of V at these candidates to characterize the solution of the problem.

Case 1: $yM < y\bar{M}$ and feasible candidates are $\{0, X_b, \bar{X}\}$

The following lemma states the first result of the comparison:

Lemma 2 *If $\bar{X}$ is a candidate of optimality, it dominates X_b.*

Proof. Define $f(yM_T) = V(\bar{X}, yM_T) - V(X_b, yM_T)$, where $yM_T < y\bar{M}$ and $\bar{X} > X_b$. We first observe that f is monotonically decreasing in yM_T for $yM_T \in (0, y\bar{M})$, since

$$f'(yM_T) = -\frac{\left[\frac{p(1-\tau)}{yM_T}\right]^{1/\gamma} - (A+D)}{p(1-\tau)} < 0 \text{ when } yM_T < y\bar{M}.$$

Next, it is straightforward to show that under current model assumptions (in particular, $\gamma \in (0,1)$, $\tau \in [0,1]$, and $p \geq 0$), $\lim_{\{yM_T \to 0\}} f(yM_T) = +\infty$ and $\lim_{\{yM_T \to y\bar{M}\}} f(yM_T) = 0$. This implies that $f(yM_T) > 0$ for all $yM_T < y\bar{M}$, or equivalently, $\bar{X}$ dominates X_b whenever it is a candidate of optimality. ∎

Before comparing $\bar{X}$ and 0, we begin with an intermediate result:

Lemma 3 *Let $\hat{X}_b = max\ \{X_b \geq 0 : z(X_b) = 0\}$ where $z(X_b)$ is given by*

$$z(X_b) = (A+D)^{-\gamma}\left(A + D - p(1-\gamma)(1-\tau)X_b\right) - \left(A + \frac{D\theta}{\theta + X_b}\right)^{1-\gamma}. \tag{A.4}$$

Then, $z(X_b) \geq 0$ for every $X_b \in [0, \hat{X}_b]$ and $z(X_b) < 0$ otherwise. Moreover, $\hat{X}_b > 0$ if and only if $\theta < D/(p(1-\tau))$.

Proof. Given the definition of $z(X_b)$ we first observe that for every $\theta > 0$, z is strictly concave in X_b, $z(0) = 0$, and $\lim_{\{X_b \to \infty\}} = -\infty$. This implies that we have at most 2 possibilities: either (i) z is monotonically decreasing and lies entirely below 0 (in which case, $\hat{X}_b = 0$); or (ii) z increases from 0 to some positive maximum value and decreases to $-\infty$ thereafter (in which case, z reaches zero at some value $\hat{X}_b > 0$.) The first part of the lemma thus follows. Consider now the first derivative of z. Straightforward computations show that

$$sign[z'(X_b)] = sign\left[\frac{\left(A + \frac{D\theta}{\theta + X_b}\right)^{-\gamma}}{(\theta + X_b)^2} - \frac{p(1-\tau)(A+D)^{-\gamma}}{D\theta}\right].$$

Notice that the first term in the right-hand side is decreasing in X_b for $X_b \geq 0$. We then know that

$$\frac{\left(A + \frac{D\theta}{\theta + X_b}\right)^{-\gamma}}{(\theta + X_b)^2} - \frac{p(1-\tau)(A+D)^{-\gamma}}{D\theta} \leq \frac{(A+D)^{-\gamma}}{\theta^2} - \frac{p(1-\tau)(A+D)^{-\gamma}}{D\theta},$$

and the necessary and sufficient condition for $z'(X_b) > 0$ for *some* value of X_b (i.e. case (ii) prevails) is given by:

$$\theta < \frac{D}{p(1-\tau)}.$$

This concludes the proof. ■

We now turn to the comparison between $\bar{X}$ and 0. The following lemma summarizes the result of this comparison:

Lemma 4 *If contract parameters (A, p, D) and the bankruptcy threshold X_b are such that $X_b \leq \hat{X}_b$, where $\hat{X}_b$ is defined as in Lemma 2, then $\bar{X} \succeq 0$ for every $yM < y\bar{M}$. Otherwise (i.e. if $X_b > \hat{X}_b$), there exists a unique threshold $0 < yM^* < y\bar{M}$ solving the equation*

$$\left(\frac{(1-\gamma)(A+D) + \gamma\left(\frac{p(1-\tau)}{yM}\right)^{\frac{1}{\gamma}}}{p(1-\gamma)(1-\tau)} - X_b\right) yM = \frac{\left(A + \frac{D\theta}{X_b + \theta}\right)^{1-\gamma}}{1-\gamma} \tag{A.5}$$

such that $\bar{X} \succ 0$ for $yM_T \in (0, yM^*)$ and $0 \succ \bar{X}$ for $yM_T \in (yM^*, y\bar{M})$; at $yM_T = yM^*$, $\bar{X}$ and 0 are indifferent. Moreover, yM^* is decreasing in X_b.

Proof. Define $g(yM_T) = V(\bar{X}, yM_T) - V(0, yM_T)$, where $yM_T < y\bar{M}$ and $\bar{X} > X_b$. We first observe that g is monotonically decreasing in yM_T for $yM_T \in (0, y\bar{M})$, since

$$g'(yM_T) = -X_b - \frac{\left(\frac{p(1-\tau)}{yM_T}\right)^{\frac{1}{\gamma}} - (A+D)}{p(1-\tau)} < 0 \text{ when } yM_T < y\bar{M}.$$

Next, straightforward computations show that

$$z_1 = \lim_{\{yM_T \to 0\}} g(yM_T) = +\infty \quad \text{and} \quad z_2 = \lim_{\{yM_T \to y\bar{M}\}} g(yM_T) = z(X_b)/(1-\gamma),$$

where $z(X_b)$ is defined as in Lemma 2. Together, this implies that g decreases monotonically from $+\infty$ to z_2 as yM_T goes from 0 to $y\bar{M}$. When $X_b \leq \hat{X}_b$, $z_2 \geq 0$ (cf. Lemma 2), implying that $g \geq 0$ for all $yM_T \in (0, y\bar{M})$ and equivalently, $\bar{X}$ is (weakly) preferred to 0 over the same interval of yM_T. When $X_b > \hat{X}_b$, $z_2 < 0$ (cf. Lemma 3), implying that g changes sign and there exists a unique value $yM^* \in (0, y\bar{M})$ such that $g > 0$ for $yM_T < yM^*$ and $g < 0$ for $yM_T > yM^*$. Equivalently, $\bar{X}$ is preferred to 0 for $yM_T < yM^*$ and 0 is preferred to $\bar{X}$ for $yM_T > yM^*$; at $yM_T = yM^*$, 0 and $\bar{X}$ are indifferent. yM^* is obtained by solving the equation $g(yM_T) = 0$ which is given in equation (A.5).

In order to show that yM^* is decreasing in X_b, we first assume, by contradiction, that there exist two pairs of values $\{(X_b, yM^*); (X'_b, yM'^*)\}$ solving equation (A.5) and satisfying

$$X_b < X'_b \quad \text{and} \quad yM^* < yM'^*.$$

Substituting these values into (A.5) and subtracting the two equations, we obtain:

$$\left(\frac{\gamma\left(\frac{p(1-\tau)}{yM^*}\right)^{\frac{1}{\gamma}} - \gamma\left(\frac{p(1-\tau)}{yM'^*}\right)^{\frac{1}{\gamma}}}{p(1-\tau)(1-\gamma)} + (X'_b - X_b)\right)(yM^* - yM'^*) = \frac{\left(A + \frac{D\theta}{X_b+\theta}\right)^{1-\gamma} - \left(A + \frac{D\theta}{X'_b+\theta}\right)^{1-\gamma}}{1-\gamma}$$

Hypothetical assumptions $X_b < X'_b$ and $yM^* < yM'^*$ together imply that the left-hand side of this equation is negative while the right-hand side is positive, hence an impossible equality. It is thus necessary that when $X_b < X'_b$, $yM^* > yM'^*$, or equivalently, yM^* is decreasing in X_b. This concludes the proof. ■

CASE 2: $yM_T \geq y\bar{M}$ AND FEASIBLE CANDIDATES ARE $\{0, X_b\}$

The following lemma characterizes the comparison in this case:

Lemma 5 *Let $\hat{X}_b$ be defined as in Lemma 3. Then, if $X_b > \hat{X}_b$, 0 is preferred to X_b for every $yM_T \geq y\bar{M}$; otherwise (i.e. if $X_b \leq \hat{X}_b$), there exists a unique threshold $yM^{**} > y\bar{M}$ defined by*

$$yM^{**} = \frac{(A+D)^{1-\gamma} - \left(A + \frac{D\theta}{\theta+X_b}\right)^{1-\gamma}}{(1-\gamma)X_b} \tag{A.6}$$

such that $X_b \succ 0$ for $y\bar{M} \leq yM_T < yM^{**}$ and $0 \succ X_b$ for $yM_T > yM^{**}$; at $yM_T = yM^{**}$, X_b and 0 are indifferent. Moreover, yM^{**} is decreasing in X_b.

Proof. Define $h(yM_T) = V(X_b, yM_T) - V(0, yM_T)$ where $yM_T \geq y\bar{M}$. We first observe that when $X_b = 0$, X_b and 0 are of course equivalent; moreover, since $h'(yM_T) = -X_b < 0$, h is linear and monotonically decreasing in yM_T for any $X_b > 0$, . Given $yM_T \geq y\bar{M}$, it holds that

$$h(yM_T) \leq h(y\bar{M}) = \frac{(A+c)^{1-\gamma} - \left(A + \frac{c\theta}{\theta+X_b}\right)^{1-\gamma} - (A+c)^{-\gamma}p(1-\gamma)(1-\tau)X_b}{1-\gamma}.$$

It is then straightforward to verify that when $X_b > \hat{X}_b$, $h(y\bar{M}) < 0$, implying that h lies entirely below 0 for every $yM_T \geq y\bar{M}$. This in turn implies that 0 is preferred to X_b over the whole interval $(y\bar{M}, \infty)$. When $X_b \leq \hat{X}_b$, $h(y\bar{M}) \geq 0$, and the fact that h is monotonically decreasing in yM_T together imply that there exists a unique value $yM^{**} \geq y\bar{M}$ such that $h \geq 0$ for $yM_T \leq yM^{**}$, and $h < 0$ otherwise. Equivalently, X_b is (weakly) preferred to 0 for $yM_T \in [y\bar{M}, yM^{**}]$ and 0 is preferred to X_b for $yM_T > yM^{**}$; at $yM_T = yM^{**}$, X_b and 0 are indifferent. yM^{**} is obtained by solving the equation $h(yM_T) = 0$ which is given in (A.6).

In order to show that yM^{**} is decreasing in X_b, we first observe that $\partial yM^{**}/\partial X_b = m(X_b)/X_b^2$ where

$$m(X_b) = \frac{D\theta X_b \left(A + \frac{D\theta}{\theta+X_b}\right)^{-\gamma}}{(\theta+X_b)^2} + \frac{\left(A + \frac{D\theta}{\theta+X_b}\right)^{1-\gamma}}{1-\gamma} - \frac{(A+D)^{1-\gamma}}{1-\gamma}.$$

In addition,

$$sign\left[m'(X_b)\right] = sign\left[-2A\left(\theta+X_b\right) - c\theta(2-\gamma)\right] < 0 \text{ when } \gamma < 1$$

and $\lim_{\{X_b \to 0\}} m(X_b) = 0$. These facts together imply that $m(X_b) < 0$, or equivalently, $\partial yM^{**}/\partial X_b < 0$ and yM^{**} is decreasing in X_b, for all $X_b > 0$. This concludes the proof. ■

Together, previous lemmas allow us to characterize the optimal choice of terminal asset value, denoted by X_T^*, in all possible scenarios as follows: *for any contract parameters* (A, p, D, θ), *let* $y\bar{M}$ *be defined as in (A.3) and let* $\hat{X}_b$ *be defined as in Lemma 3. If* $X_b > \hat{X}_b$, *there exists a unique threshold* yM^* *defined as in Lemma 4 such that the optimal solution is* $\bar{X}$ *for* $yM_T < yM^*$ *and* 0 *otherwise. If* $X_b \leq \hat{X}_b$, *there exists a unique threshold* yM^{**} *defined as in Lemma 5 such that the optimal solution is* $\bar{X}$ *for* $yM_T < y\bar{M}$, X_b *for* $yM_T \in [y\bar{M}, yM^{**}]$, *and* 0 *for* $yM_T > yM^{**}$. This result is obtained taking as given an arbitrary value of X_b. One pending final step to complete the proof is to show that there exists a unique value of bankruptcy threshold X_b solving equation (3) with X_T replaced by X_T^*, the optimal choice of terminal asset value stated in the proposition. Since X_T^* can take only one of three values $\{\bar{X}, X_b, 0\}$ and $\bar{X} \geq X_b$ so the only case where $X_T^* < X_b$ is when $X_T^* = 0$. Equation (3) thus reduces to

$$X_b = F\left(1 + \frac{\tau}{1-\tau}\mathbb{E}\left[M_T \mathbb{1}_{\left\{X_T^* \geq X_b\right\}}\right]\right).$$

Let $h(X_b) = X_b - F\left(1 + \frac{\tau}{1-\tau}\mathbb{E}\left[M_T \mathbb{1}_{\left\{X_T^* \geq X_b\right\}}\right]\right)$, we need to show that the equation $h(X_b) = 0$ always admits a unique solution in the interval $[F, \infty)$. We first observe that $h(X_b)$ can be rewritten as

$$X_b - F\left(1 + \frac{\tau}{1-\tau}E\left[M_T\left(\mathbb{1}_{\left\{X_b > \hat{X}_b\right\}}\mathbb{1}_{\{yM_T \leq yM^*\}} + \mathbb{1}_{\left\{X_b \leq \hat{X}_b\right\}}\mathbb{1}_{\{yM_T \leq yM^{**}\}}\right)\right]\right).$$

The fact that yM^* and yM^{**} are decreasing in X_b (cf. Lemma 4 and Lemma 5) then implies that for every value of $\hat{X}_b$, the function $h(X_b)$ is piecewise monotonically increasing in the entire domain of X_b. Next, observe that $h(X_b)$ is continuous,

$$h(F) = -\frac{\tau}{1-\tau}F\mathbb{E}\left[M_T \mathbb{1}_{\left\{X_T^* \geq X_b\right\}}\right] < 0,$$

and

$$\lim_{X_b \to +\infty} h(X_b) = +\infty > 0.$$

These facts together imply that there always exists a unique value $X_b^* \in [F, \infty)$ such that $h(X_b^*) = 0$. This conclude the first part of proof. ■

A.2.2 Optimal dynamic risk-taking

Before calculating the asset value at any time t explicitly, we recall a few intermediate computations which will later become useful. If Y is a log-normally distributed random variable, then, for any given value $c \geq 0$ we have

$$\mathbb{E}\left[Y\mathbb{1}_{\{Y\leq c\}}\right] = e^{\mu_Y + \frac{1}{2}\nu_Y^2} N(\bar{d}(c)),$$

where $\mu_Y = \mathbb{E}\left[\ln(Y)\right]$, $\nu_Y^2 = Var(\ln(Y))$, $N(x)$ is the cumulative standard normal distribution function evaluated at x and

$$\bar{d}(c) = \frac{ln(c) - \mu_Y - \nu_Y^2}{\nu_Y}.$$

Given the process of pricing kernel specified in (1), we have $M_t = e^{-\left(r+\frac{\alpha^2}{2}\right)t - \alpha Z_t}$. Let $Y_1 = M_T/M_t$, thus, Y_1 is log-normally distributed and

$$\mathbb{E}_t\left[\ln(Y_1)\right] = -\left(r + \frac{\alpha^2}{2}\right)(T-t) \quad \text{and} \quad Var_t(\ln(Y_1)) = (\alpha\sqrt{T-t})^2.$$

Therefore, for any arbitrary threshold M^{th}, we have:

$$\mathbb{E}_t\left[\frac{M_T}{M_t}\mathbb{1}_{\left\{M_T \leq M^{th}\right\}}\right] = \mathbb{E}_t\left[Y_1\mathbb{1}_{\left\{Y_1 \leq M^{th}/M_t\right\}}\right] = e^{-r(T-t)}N(d(M^{th})),$$

where

$$d(M^{th}) = \frac{ln\left(\frac{M^{th}}{M_t}\right) + \left(r - \frac{\alpha^2}{2}\right)(T-t)}{\alpha\sqrt{T-t}}.$$

Next, let $Y_2 = (M_T/M_t)^{1-\frac{1}{\gamma}}$. Y_2 is log-normally distributed with

$$\mathbb{E}_t\left[\ln(Y_2)\right] = -(1-\frac{1}{\gamma})\left(r + \frac{\alpha^2}{2}\right)(T-t) \quad \text{and} \quad Var_t(\ln(Y_2)) = \left((1-\frac{1}{\gamma})\alpha\sqrt{T-t}\right)^2.$$

Thus,

$$\mathbb{E}_t\left[\left(\frac{M_T}{M_t}\right)^{1-\frac{1}{\gamma}}\mathbb{1}_{\{M_T\le M^{th}\}}\right]=\mathbb{E}_t\left[Y_2\mathbb{1}_{\left\{Y_2\le\left(\frac{M^{th}}{M_t}\right)^{1-\frac{1}{\gamma}}\right\}}\right]=e^{-(1-\frac{1}{\gamma})\left(r+\frac{\alpha^2}{2\gamma}\right)(T-t)}N(d'(M^{th})),$$

where

$$d'(M^{th})=d(M^{th})+\frac{\alpha\sqrt{T-t}}{\gamma}.$$

We now turn to the computation of asset value X_t, $t\in[0,T)$. The pricing formula allows us to write

$$\begin{aligned}X_t=\mathbb{E}_t\left[\frac{M_T}{M_t}X_T^*\right]&=\mathbb{1}_{\{X_b^*>\hat{X}_b\}}\mathbb{E}_t\left[\frac{M_T}{M_t}\bar{X}\mathbb{1}_{\{M_T\le M^*\}}\right]\\&+\mathbb{1}_{\{X_b^*\le\hat{X}_b\}}\mathbb{E}_t\left[\frac{M_T}{M_t}\left(\bar{X}\mathbb{1}_{\{M_T\le\bar{M}\}}+X_b^*\mathbb{1}_{\{\bar{M}\le M_T\le M^{**}\}}\right)\right].\end{aligned}\qquad\text{(A.7)}$$

Consider first the case $X_b^*>\hat{X}_b$. Given the value of $\bar{X}$ in equation (A.2) and previous results, we have:

$$\begin{aligned}\mathbb{E}_t\left[\frac{M_T}{M_t}\bar{X}\mathbb{1}_{\{M_T\le M^*\}}\right]&=\mathbb{E}_t\left[\frac{M_T}{M_t}\left(X_b^*+\frac{\left[\frac{p(1-\tau)}{yM_T}\right]^{\frac{1}{\gamma}}-(A+D)}{p(1-\tau)}\right)\mathbb{1}_{\{M_T\le M^*\}}\right]\\&=\left(X_b^*-\frac{A+D}{p(1-\tau)}\right)\mathbb{E}_t\left[\frac{M_T}{M_t}\mathbb{1}_{\{M_T\le M^*\}}\right]+\Psi(y,M_t)\mathbb{E}_t\left[\left(\frac{M_T}{M_t}\right)^{1-\frac{1}{\gamma}}\mathbb{1}_{\{M_T\le M^*\}}\right]\\&=\left(X_b^*-\frac{A+D}{p(1-\tau)}\right)e^{-r(T-t)}N(d_1)+e^{-\Gamma(T-t)}\Psi(y,M_t)N(d_2),\end{aligned}$$

where

$$\begin{aligned}&\Psi(y,M_t)=\frac{(p(1-\tau))^{\frac{1}{\gamma}-1}}{y^{\frac{1}{\gamma}}M_t^{\frac{1}{\gamma}}}\quad\text{and}\quad\Gamma=(1-1/\gamma)\left(r+\frac{\alpha^2}{2\gamma}\right),\\&d_1=d(M^*)=\frac{ln\left(\frac{M^*}{M_t}\right)+\left(r-\frac{\alpha^2}{2}\right)(T-t)}{\alpha\sqrt{T-t}},\\&d_2=d'(M^*)=d_1+\frac{\alpha\sqrt{T-t}}{\gamma}.\end{aligned}$$

Similarly, for the case $X_b^* \leq \hat{X}_b$, we have:

$$
\begin{aligned}
&\mathbb{E}_t\left[\frac{M_T}{M_t}\left(\left(\left(X_b^* + \frac{\left[\frac{p(1-\tau)}{yM_T}\right]^{1/\gamma} - (A+D)}{p(1-\tau)}\right)\mathbb{1}_{\left\{M_T\leq\bar{M}\right\}} + X_b^*\mathbb{1}_{\left\{\bar{M}\leq M_T\leq M^{**}\right\}}\right)\right)\right] \\
&= -\frac{A+D}{p(1-\tau)}\mathbb{E}_t\left[\frac{M_T}{M_t}\mathbb{1}_{\left\{M_T\leq\bar{M}\right\}}\right] + \Psi(y, M_t)\mathbb{E}_t\left[\left(\frac{M_T}{M_t}\right)^{1-\frac{1}{\gamma}}\mathbb{1}_{\left\{M_T\leq\bar{M}\right\}}\right] + X_b^*\mathbb{E}_t\left[\frac{M_T}{M_t}\mathbb{1}_{\{M_T\leq M^{**}\}}\right] \\
&= \left(X_b^* N(d_5) - \frac{A+D}{p(1-\tau)}N(d_3)\right)e^{-r(T-t)} + e^{-\Gamma(T-t)}\Psi(y, M_t)N(d_4),
\end{aligned}
$$

where

$$
\begin{aligned}
d_3 = d(\bar{M}) &= \frac{ln\left(\frac{\bar{M}}{M_t}\right) + \left(r - \frac{\alpha^2}{2}\right)(T-t)}{\alpha\sqrt{T-t}}, \\
d_4 = d'(\bar{M}) &= d_3 + \frac{\alpha\sqrt{T-t}}{\gamma}, \\
d_5 = d(M^{**}) &= \frac{ln\left(\frac{M^{**}}{M_t}\right) + \left(r - \frac{\alpha^2}{2}\right)(T-t)}{\alpha\sqrt{T-t}}.
\end{aligned}
$$

Putting together all computations, we obtain the asset value X_t as in the proposition. A standard application of Ito's lemma then gives us the associated optimal choice of volatility accordingly. This concludes the second part of proof. ■

A.3 Additional comparative statics analysis

A.3.1 Salary

See Fig. A.1.

A.3.2 Inside debt

See Fig. A.2.

A.3.3 Equity ownership

See Fig. A.3 and Fig. A.4.

B Data appendix

B.1 Matching procedure of Compustat and Markit

We match the U.S. entities in Markit to Compustat firms. We assign to each unique combination of Markit company name, ticker and REDCODE ever traded according to Markit, a Compustat GVKEY and ticker. To do so, we follow the procedure here reported.

1. We match firms automatically using company name and ticker, company name alone, and ticker alone.

2. We check the accuracy of each of these automatic matches searching for the firm in Capital IQ.

3. We try to hand-match all the unmatched firms using the Compustat's Code Lookup tool, checking the company tree and changes of company name on Capital IQ.

4. For each of the automatically matched and unmatched firms we check if a non-traded parent company (as reported in Capital IQ) exists. If so, we match the Markit entity with the parent's GVKEY.[30]

B.2 Definitions of variables

See Table A.1.

[30]When we match a Markit entity with the parent, we always check that the subsidiary was already owned by the parent by the time CDS began trading, looking at the "M&A/private placements"sheet of Capital IQ. If this condition is not met, we stick to the matching with the subsidiary; The same applies when the parent company is a non-U.S. firm. Moreover, if the parent is a Markit-matched firm we also check that its start trading date is prior to the subsidiary's start date. If not, we check, looking at the Capital IQ "M&A/private placements"sheet, if it is the case to match the parent's GVKEY with the subsidiary's start date. A good example is that of Meritor Inc. (start CDS trading: March 2011), parent of ArvinMeritor Inc. (start CDS trading: January 2011), which has always been owned by Meritor Inc.: In this case it is clear that the parent has had CDSs trading through its subsidiary since 2001, therefore we match the parent's GVKEY with the subsidiary's start trading date. In general, however, we prefer to match the parent's GVKEY to the parent's start date, because we think it is more significant for corporate governance choices to understand when the parent itself began to have CDSs trading. An ambiguous case, for instance, is that of AT&T and AT&T Wireless Services.

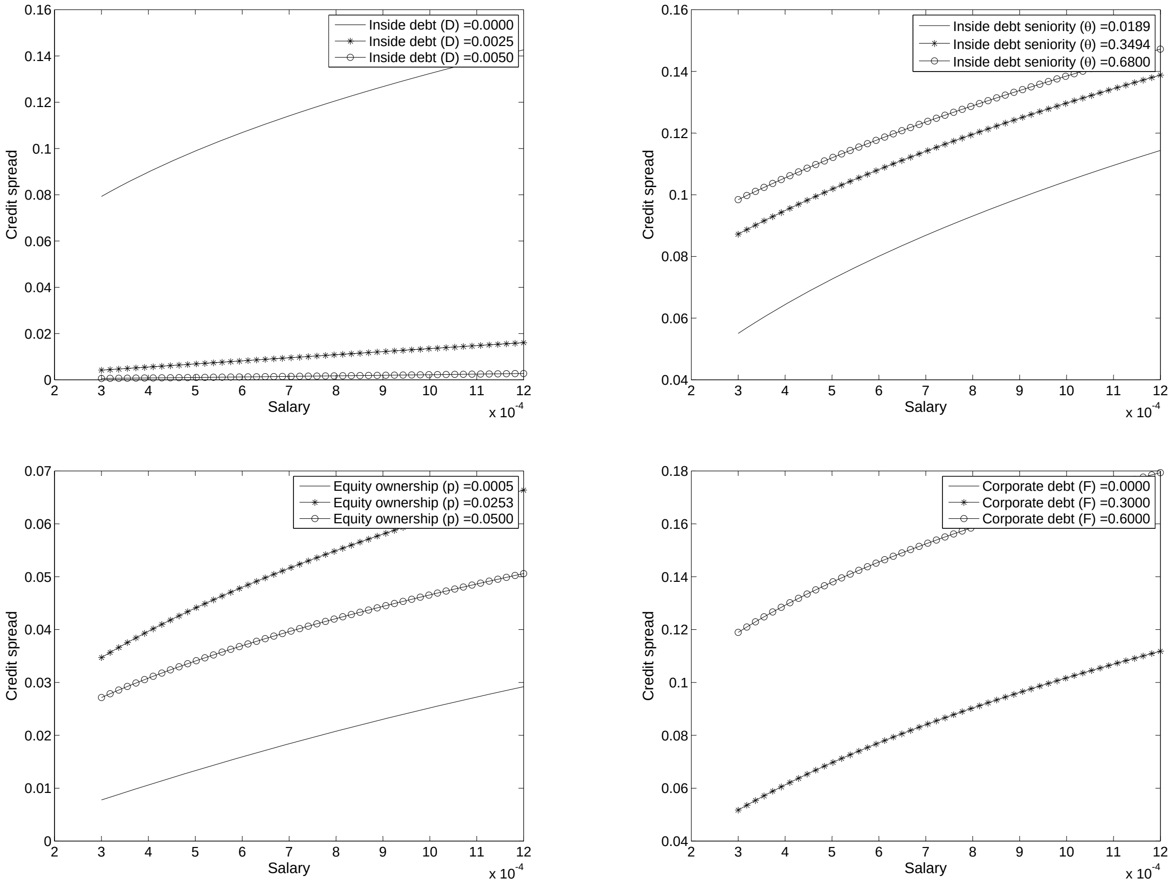


Figure A.1: Credit spread as a function of salary
This figure plots credit spread as a function of salary for different levels of inside debt (top-left panel), inside debt effective seniority (top-right panel), equity ownership holding (bottom-left panel) and corporate debt (bottom-right panel). It serves to illustrate that the positive relationship between credit spread and salary holds unambiguously as other compensation components and corporate debt change. In each panel, compensation terms that do not vary are kept at their median levels reported in Table 1. Model parameters are discussed in Section 3.3.1 of the text.

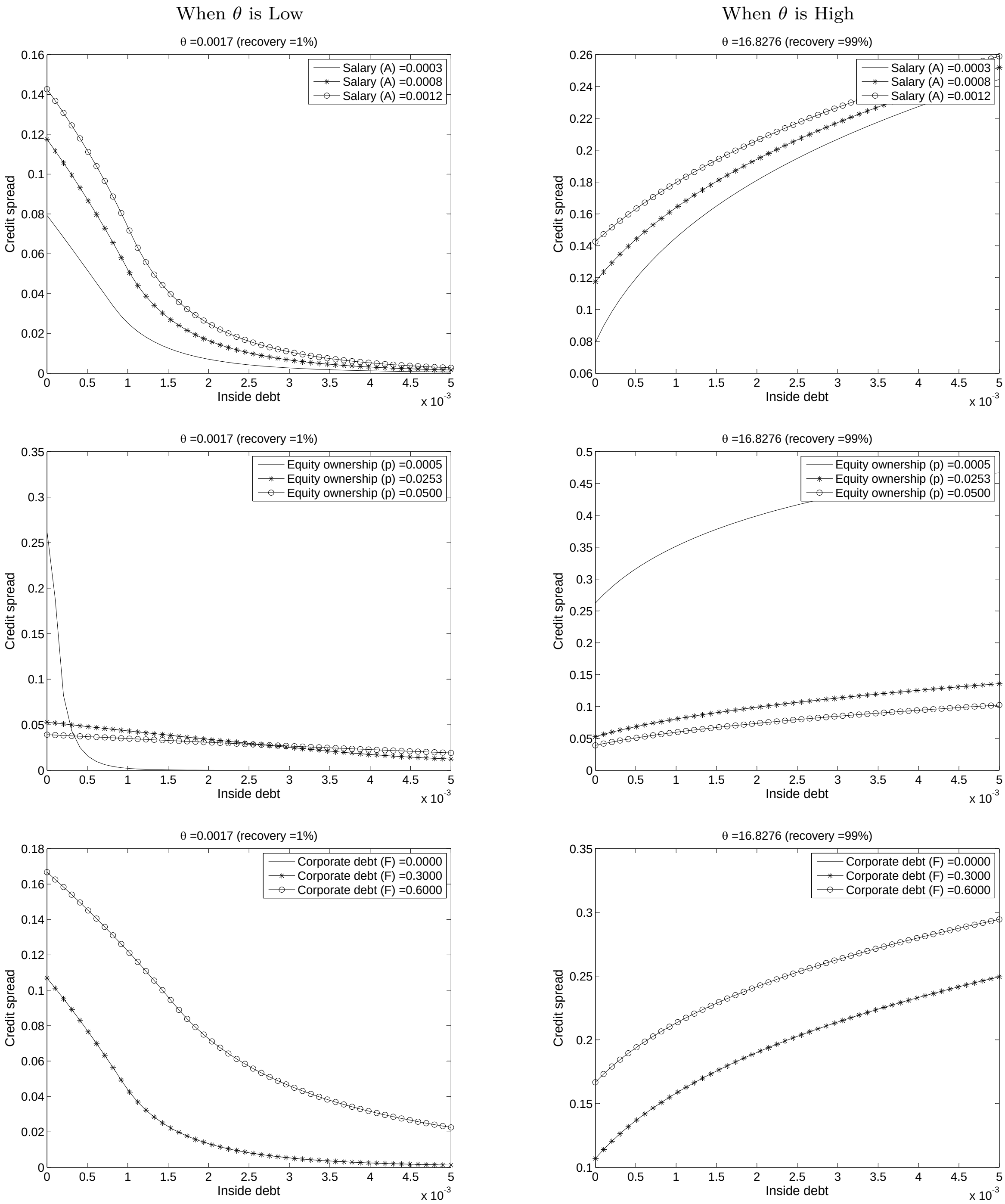


Figure A.2: Credit spread as a dunction of inside debt holdings for different levels of inside debt seniority This figure plots credit spread as a function of inside debt for different levels of salary (top panels), equity ownership holding (middle panels), and corporate debt (bottom panels). It serves to illustrate that when the effective seniority of inside debt in bankruptcy is low (high), the negative (positive) relationship between credit spread and inside debt holds unambiguously for various levels of salary, equity ownership holding, and corporate debt. In each panel, compensation terms that do not change are kept at their median levels reported in Table 1. Model parameters are discussed in Section 3.3.1 of the text.

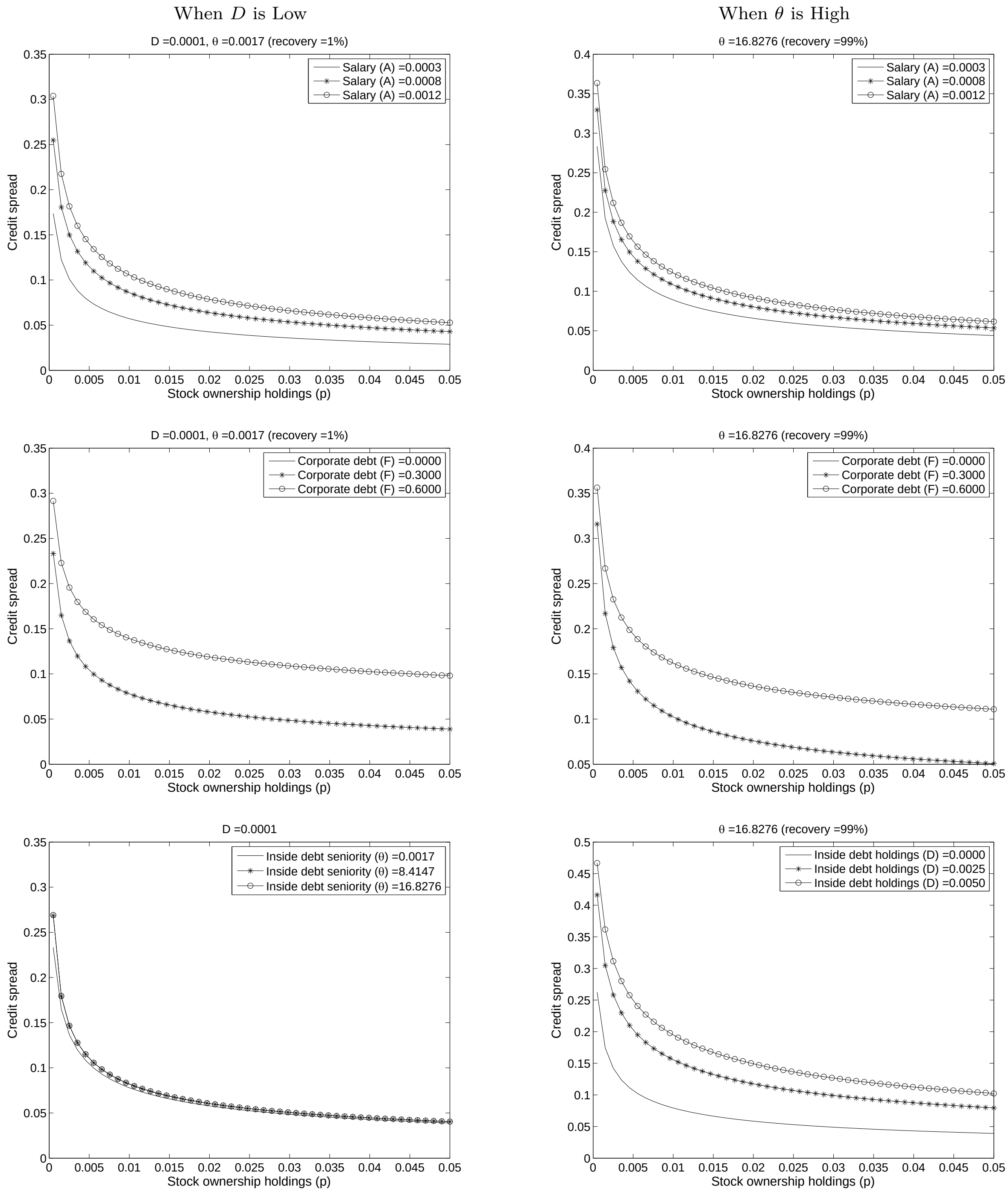


Figure A.3: Credit spread as a function of equity ownership for different levels of inside debt seniority This figure plots credit spread as a function of equity ownership for different levels of salary, corporate debt, and inside debt holding or inside debt effective seniorty in bankruptcy. It serves to illustrate that the negative relationship between credit spread and equity ownership when D is low or θ is high holds unambiguously when corporate debt and other compensation terms change. In each panel, compensation components that do not vary are kept at their median levels reported in Table 1. Model parameters are discussed in Section 3.3.1 of the text.

When D is High and θ is Low

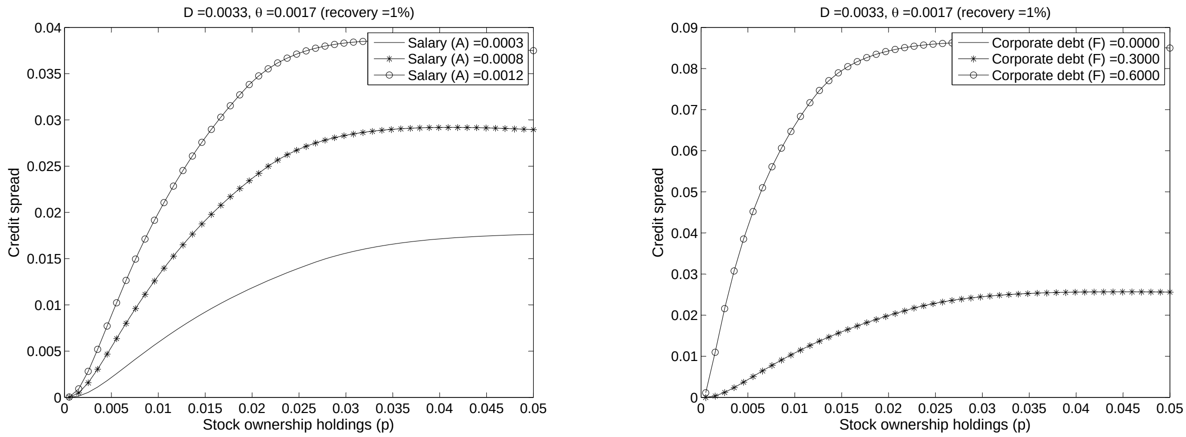


Figure A.4: Credit spread as a function of equity ownership for different levels of inside debt and inside debt seniority

This figure plots credit spread as a function of equity ownership for different levels of salary (left panel) and corporate debt (right panel) when inside debt holding is large *and* inside debt effective seniority in bankruptcy is low. It serves to illustrate that when this is the case, the positive relationship between credit spread and equity ownership holds unambiguously for various levels of salary and corporate debt. In each panel, compensation terms that do not change are kept at their median levels reported in Table 1. Model parameters are discussed in Section 3.3.1 of the text.

Table A.1: : Definition of variables

Variable	Definition
CDS spread	Average of daily five-year U.S. dollar denominated CDS spreads over the last fiscal year from Markit. We consider only CDS on unsecured debt (`tier=snrfor`). We do not put any restriction on the documentation clause.
Salary	Salary defined as `salary` from Execucomp.
Bonus	Bonus defined as `bonus` from Execucomp.
CEO decision horizon	First, we compute the raw expected decision horizon of CEO i in year t, DH, as $DH_{i,t} = \left(Med.\,Tenure_{Ind,t} - Tenure_{i,t}\right) + \left(Med.\,Age_{Ind,t} - Age_{i,t}\right)$, where $Med.\,Tenure_{Ind,t}$ and $Med.\,Age_{Ind,t}$ are the industry-year CEOs' median tenure and age at turnover, respectively. When these conditional medians are missing (a few cases indeed), we replace them with the median CEOs' tenure and age at turnover over the given year, *i.e.* not conditioning by industry. In line with Cassell, Huang, Sanchez, and Stuart (2012), we use two-digit SIC code industries. Second, we normalize CEO's expected decision horizon, $\overline{DH}$, as $\overline{DH}_{i,t} = 1 + Med.\,Tenure_{Ind,t} \times \text{CDF}(DH_{i,t})$, where CDF(.) is the empirical cumulative distribution function of the raw estimate of the decision horizon.
PV expected salary	Present value of expected future salary payments defined as the product of current salary and CEO's decision horizon.
PV. exp. cash	Present value of expected future cash payments defined as the product of the sum of current salary and bonus, and CEO's decision horizon.
CEO effective ownership	CEO's stock ownership adjusted for CEO's option portfolio delta. As we work on the 2006-2011 period, we use the full-information method - as opposed to the one-year approximation method by Core and Guay (2002) - to compute the CEOs' option portfolio delta and vega, thanks to the enhanced SEC disclosure requirements introduced in 2006. As in Ortiz-Molina (2007), we assume that CEOs with missing data about options have zero options.
Stock and option holdings	CEO's stock and option holdings at fiscal year-end defined as (`shrown_excl_opts`+Total option delta) × `prcc_f` in Execucomp and Compustat. We set missing values to zero.
Inside debt holdings	Inside debt holdings defined as the sum of `defer_balance` and `pension_value` from Execucomp. We set missing values to zero.
Inside debt seniority	Inside debt seniority defined as the ratio of ERISA-qualified pension plans to total inside debt holdings. We deem deferred compensation as unfunded. We identify non-qualified pension plans, such as Supplemental Executive Pension Plans (SERPs), Supplemental Key Employee Retirement Plans (SKERPs), Supplemental Senior Officer Retirement Plans (SSORPs), restoration plans, benefit equalization plans, and excess plans, searching for the following words in the Execucomp field `pension_name`: `suppl`, `serp`, `srp`, `skerp`, `erps`, `ssorp`, `non-qual`, `non qual`, `nonqual`, `non-tax`, `nontax`, `exec`, `excess`, `equaliz`, and `restor`.
Option holdings vega	We follow the definition of Brockman, Martin, and Unlu (2010), but we do need to resort to the approximation method by Core and Guay (2002), as from 2006 full disclosure about past underwater option grants is required.
PV expected salary-to-stock ratio	Similarly to Carlson and Lazrak (2010), it is defined as the ratio of *PV expected salary* to *Stock and option holdings*.
Total compensation	Total annual compensation defined as `tdc1` from Execucomp.
CEO relative D/E ratio	Defined as in Cassell, Huang, Sanchez, and Stuart (2012).
CEO relative incentive ratio	Defined as in Wei and Yermack (2011) and Cassell, Huang, Sanchez, and Stuart (2012).
Asset volatility	Standard deviation of asset returns defined as in the naïve approach by Bharath and Shumway (2008). We measure equity volatility as the annualized standard deviation of stock returns over the last quarter of the fiscal year.
D/E ratio	Debt-to-equity ratio defined as `dlc`+`dltt`/(`prcc_f`×`csho`) in Compustat.
Sharpe ratio	Sharpe ratio defined as in Carlson and Lazrak (2010).
Tax rate	Marginal tax rate before interest deductions from Blouin, Core, and Guay (2010) available in Compustat.
Sales	Net sales defined as `sales` from Execucomp.
Total assets	Total assets defined as `at` from Execucomp.
ROA	Return on assets defined as `roa` from Execucomp.
Stock return	Stock return over the fiscal year defined as `trs1yr` from Execucomp.
Book-to-market ratio	Book-to-market ratio defined as `at`/(`at`−`ceq`+`prcc_f`×`csho`) in Compustat.
Dividend indicator	Indicator equal to one if a firm pays dividends in a given year.

(Continued)

Table A.1: – *Continued*

Distress indicator	Indicator equal to one if a firm is in the top decile of the modified Z-score by MacKie-Mason (1990) in a given year.
Mean wage tax rate (top 10 host states)	Mean state personal wages tax rate for the highest tax bracket in the top ten states by inflow of retiree migrants according to Haas, Bradley, Longino, Stoller, and Serow (2006), computed year-by-year. State tax rates for individuals in the highest tax bracket are from the TAXSIM model and can be downloaded here: http://www.nber.org/~taxsim/state-rates/. Feenberg and Coutts (2012) describe the TAXSIM model. The relevant U.S. states are Arizona, California, Florida, Georgia, Nevada, New Jersey, North Carolina, Pennsylvania, Texas, and Virginia.
Median industry CEO relative D/E	Median industry *CEO relative D/E ratio*, computed year-by-year for each two-digit SIC code industry.
New CEO	Indicator equal to one if the CEO has been appointed in the current fiscal year. The Execucomp indicator variable `ceoann` does not identify a CEO for each firm-year. Indeed, as pointed out by Himmelberg and Hubbard (2000), it is often missing in the first year the firm enters the sample. Because of this, we construct an indicator for CEOs using Execucomp variables `becameceo` and `leftofc` that allows us to detect some additional CEOs.
CEO age	CEO's age defined as `age` in Execucomp. If missing, we replace it with `page`−(Current year− `year`). If missing, we replace it with the CEOs' median age.
E-index	Entrenchment index defined as in Bebchuck, Cohen, and Ferrell (2009), using IRRC (2000-2006) and Riskmetrics (2007-2011) data.
CFNAI index	Three-month moving average Chicago Fed National Activity Index (CFNAI) from FRED, St. Louis Federal Reserve Bank. We reverse the CFNAI to make it positively correlated with NBER recessions.

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