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Direct and Indirect Risk-Taking Incentives of Inside Debt

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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 has direct and indirect effects on managerial risk-taking incentives. First, inside debt exerts his expected 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. Additionally, inside debt may also have indirect effects, which distort the risk-taking incentives provided by equity compensation. 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.

Direct and Indirect Risk-Taking Incentives of Inside Debt*

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Abstract

We develop a model of managerial compensation structure and asset risk choice. The model provides predictions about the relation between credit spreads and different compensation components. First, we show that credit spreads are decreasing in inside debt only if it is unsecured. Second, the relation between credit spreads and equity incentives varies depending on the features of inside debt. We show that credit spreads are increasing in equity incentives. This relation becomes stronger as the seniority of inside debt increases. Using a sample of U.S. public firms with traded credit default swap contracts, we provide evidence supportive of the model's predictions.

JEL Classification: G32, G34

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1 Introduction

The recent finance literature has devoted considerable attention to inside debt, that is, managerial pensions and deferred compensation plans whose payment is promised for a future date, normally the retirement date. The pioneering works of Bebchuk and Jackson (2005) and Sundaram and Yermack (2007) illustrate that inside debt is prevalent, constitutes a significant part of executive compensation, and mitigates default risk. Moreover, several studies analyze the implications of inside debt for corporate policies and managerial risk-taking incentives in particular (e.g., Wei and Yermack, 2011; Cassell, Huang, Sanchez, and Stuart, 2012; Phan, 2014). The general view is that inside debt is an efficient tool to align the incentives of managers to those of bondholders, thereby reducing risk-taking and corporate default.

However, the ability of inside debt to align the incentives of managers and bondholders depends on several factors, with the seniority of inside debt in bankruptcy probably being the most important (e.g., Anantharaman, Fang, and Gong, 2014; Jackson and Honigsberg, 2014). If CEOs are able to withdraw their inside debt before retirement, they are insured against default risk. As a result, these CEOs are not subject to the risk of losing their inside debt if the company defaults, and the previously described incentive-alignment effect may vanish. Moreover, managerial compensation is comprised of different components (e.g., salary, equity awards and inside debt), each providing different risk-taking incentives. We argue that not only the *direct* risk-taking incentives of inside debt but also their interactions with other compensation components need to be considered. These are what we call the *indirect* risk-taking incentives of inside debt. We show that indirect incentives are also important in shaping managerial risk decisions. To the best of our knowledge, we are the first to develop and test a theoretical model that accounts for all these considerations.

We build on the framework of Carlson and Lazrak (2010) and 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 of varying seniority. The firm in our model is levered, which allows us to derive several cross-sectional implications about the credit spread. First, our model predicts that the volatility of a firm's assets (chosen by the manager) and thus the credit spread are increasing in salary. This result depends on the insurance effect of salary. Second, we show that the role of inside debt crucially depends on its seniority. Only unsecured inside debt is effective in aligning the incentives of managers to those of bondholders, which translates into a lower credit spread.[1] Third, inside debt plays an important role in shaping the risk-taking incentives of CEO ownership. In the absence of inside debt, the optimal asset volatility chosen by a risk-averse CEO decreases with CEO ownership. This is so because a risk-averse CEO tries to offset the higher variation in his/her wealth induced by higher ownership by decreasing asset volatility. However, inside debt, especially when large and relatively secured, absorbs the fluctuations of a manager's wealth and may induce the manager to take on more risk in reaction to an increase in his/her ownership. As a result, our model predicts a positive and concave relation between the credit spread and CEO ownership. This relation becomes stronger as the seniority of inside debt increases, as long as it is not made absolutely secured.

We test these cross-sectional predictions about credit spreads on a sample of U.S. public firms with traded credit default swap (CDS) contracts during the 2006-2011 period. It is worth noting at the outset that we do not aim at providing causal evidence. Rather, our empirical approach aims at testing the unique correlation patterns predicted by the model. To this end, we pay particular attention to linking the model variables to their empirical counterparts. We find that our model provides a realistic description of the relation between credit spreads and CEO compensation structure.

We first show that salary is positively correlated with CDS spreads, our proxy for credit spreads. This result is in line with Carlson and Lazrak (2010). We next illustrate that a negative relation between inside debt and CDS spreads exists, which is consistent with Wei and Yermack (2011) and the extant empirical evidence indicating a negative relation between inside debt and managerial risk-taking (e.g., Cassell, Huang, Sanchez, and Stuart, 2012). Our result supports the argument that inside debt encourages managerial conservatism and that bondholders value this incentive mechanism. To test the additional implications of our model, 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 associated with significantly lower CDS spreads only if it is highly unsecured. This result confirms and extends the evidence provided by Anantharaman, Fang, and Gong (2014), whose analysis is based on private loan spreads at origination over the 2006-2008 period using a measure of inside debt seniority based on the relative duration of executive pensions and loans. Our analysis extends the result to market-based credit spreads and allows us to study a firm's cost of public debt at any point in time.

[1] Because our model does not distinguish between the different determinants of the recovery rate in default, we will use the terms "secured inside debt" ("unsecured inside debt") and "high-seniority inside debt" ("low-seniority inside debt") interchangeably.

We proceed to demonstrate that the relation between CEO ownership and CDS spreads is generally positive and concave. This relation is weaker in the presence of low-seniority inside debt. In further tests, we explore the economic mechanism at work in greater detail. Our model delivers time-series predictions on the state-dependent relation between CEO ownership and credit spreads for different levels of inside debt. In particular, the model predicts that when inside debt is high, the relation between the credit spread and CEO ownership is generally positive and stronger in bad times; when inside debt is low, this relation is negative and does not vary substantially across different states of the world. We provide evidence compatible with these time-series implications.

Our model also suggests that inside debt may favor managerial conservatism through the formation of an extended region on the state price density over which the CEO chooses not to default, while a CEO with zero inside debt would have chosen otherwise. Such a behavior endogenously arises only when the ratio of unsecured inside debt to CEO ownership is sufficiently high. Intuitively, when inside debt is large relative to CEO ownership and inside debt is unsecured in bankruptcy, it is in the best interest of the manager to implement policies that keep the firm afloat rather than gambling for resurrection, a likely behavior for managers whose wealth depends more on equity ownership. Here too, we provide evidence consistent with our model by studying the relation between inside debt and default risk as proxied by the Altman's Z-score.

Our analysis contributes to the strand of theoretical and empirical research studying the role of inside debt. The theoretical literature on managerial risk-taking usually considers a manager with a compensation contract that consists of only two components, one of which is typically a fixed component unrelated to the firm's performance (i.e., salary). Carpenter (2000) considers a manager paid with options and salary. Carlson and Lazrak (2010) assume that the manager is paid with salary and equity. In the spirit of Jensen and Meckling (1976), Edmans and Liu (2011) consider a manager rewarded with inside debt and equity. Bolton, Mehran, and Shapiro (2010) analyze a managerial compensation scheme based on the firm's stock price and CDS spread. Some recent theoretical studies examine how deferred compensation can help alleviate excessive risk-taking (Inderst and Pfeil, 2013; Leisen, 2013; Feess and Wohlschlegel, 2012).

On the empirical side, several studies provide evidence for a mitigating role of inside debt in managerial risk-taking. For instance, Sundaram and Yermack (2007) illustrate that CEOs with high inside debt are more conservative. Consistently, Wei and Yermack (2011) find that firms experience a rise in bond prices coupled with a fall in equity prices when large inside debt holdings are disclosed. Cassell, Huang, Sanchez, and Stuart (2012) show that inside debt holdings are positively related to managerial conservatism. Hoang (2013) finds that on average inside debt is associated with much lower default risk. Some authors, however, suggest that inside debt may not have an unambiguously risk-reducing role. Anantharaman, Fang, and Gong (2014) stress that inside debt is effective at reducing the cost of private loans only when subject to forfeiture in bankruptcy. Similarly, Jackson and Honigsberg (2014) document that executives often receive inside debt payments before retirement, thus reducing their exposure to default risk. We develop and test a model in which salary, equity compensation and inside debt of different seniority interact to shape managerial incentives. In this way, we can study not only the direct risk-taking incentives of inside debt but also its indirect incentives. Our empirical evidence confirms the importance of indirect inside debt incentives for equity-debt conflicts.

This paper also contributes to the ongoing debate about executive compensation reform in the aftermath of the global crisis. It provides empirical support for various recent initiatives by academic scholars and regulators on both sides of the Atlantic and around the globe,[2] the majority of whom encourage financial institutions and corporations to employ more deferred compensation to prevent excessive risk-taking and avoid endangering the stability of the global financial system, as experienced in the 2007-2009 financial and economic crisis. Importantly, this paper also highlights that it would be inadequate to focus solely on inside debt. The design and implementation of these proposals should consider the compensation structure in its entirety, as the interactions between different compensation components, especially when inside debt is large and secured, may result in the unintended effect of encouraging risk-taking.

The remainder of the paper is organized as follows. Section 2 presents the model and its implications. Section 3 tests the predictions of the model. Section 4 concludes.

2 Model

We build on the model of Carlson and Lazrak (2010) to study the asset risk choice of a risk-averse 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] Most notably, the "Principles for sound compensation practices and their implementation standards" by the Financial Stability Board, the discussion of "Aligning incentives at systemically important financial institutions" by Squam Lake Group, and the proposal on "Incentive-based compensation arrangements" by the Board of Governors of the Federal Reserve System and related regulatory agencies.

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 assets in place with terminal value X_T, $T > 0$, which is used to pay taxes and bankruptcy costs (if any) and then shared among bondholders and shareholders. We assume that all risks in the model are systematic so that the firm value dynamics is driven by the same Brownian motion that governs the dynamics of the pricing kernel. In particular, the firm's asset value dynamics is 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 volatility of the firm's assets, which is chosen by the manager. 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 on 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 relation 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 the individual level. If the firm finances part of its assets with debt by issuing a zero-coupon bond at discounted price B_0 for a payment of face value F at time T, then the current regulation allows the interest expense, $F - B_0$, to be deducted from the corporate taxable income.

The solvent state is defined 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 that there exists a dead-weight bankruptcy cost of rate δ. Letting 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

Letting 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

Denoting 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, we arrive at a fixed point problem

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

because the second term on the right-hand side itself depends on X_b. In Appendix A, we prove that rational expectation equilibrium conditions ensure that this problem always admits a unique solution.

2.4 Managerial compensation and utility

We define a 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, 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 the case of insolvency, $k < 1$ and 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 ($\theta \to \infty$).[3] 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 situations, although inside debt is junior to corporate debt in bankruptcy, an entrenched self-interested manager can still divert away cash flows to recover part of his/her inside debt at the expense of bondholders.[4] Throughout this paper, we refer to parameter θ as the effective seniority or risk of forfeiture of inside debt,

[3] Secured deferred compensation 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 his/her deferred compensation benefits. See, e.g., Sundaram and Yermack (2007), Wei and Yermack (2011).

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

where a higher effective seniority implies a lower risk of forfeiture and vice versa.[5]

Supposing that the manager starts with zero initial wealth, his/her terminal wealth is equal to the value of his/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 the CEO's utility function has constant relative risk-aversion γ with respect to wealth:

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

Note that $U(\pi_T)$ is globally concave in π_T but not necessarily so in X_T. In particular, for any given value of 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 $X_T < X_b$, it can be either convex or concave depending on risk-aversion coefficient γ and the combination of compensation contract terms (A, p, D, θ). We restrict our attention to the case where $\gamma < 1$. Under this assumption, the managerial utility function is convex for $0 \leq X_T < X_b$ and concave for $X_T \geq X_b$, irrespective of the combination of contract parameters and bankruptcy threshold X_b (see Appendix A). This assumption simplifies the mathematical analysis of the model while it is unlikely to have consequential impacts on the qualitative interpretation of our results. Figure 1 provides a sample diagram of the CEO terminal payoff and his/her associated utility function in our setting.

2.5 Manager's problem

We consider a manager who, once appointed to the position, has full discretion over the choice of firm risk, σ, which he/she dynamically and continuously controls throughout the life of the firm's assets. It is worth noting that we do not model the optimal choice of managerial compensation 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. Throughout this paper, we impose rational expectation conditions so that shareholders, bondholders, and the manager correctly

[5] In this setup, we have implicitly assumed that the source of payment for inside debt is kept separate from the terminal asset value. 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. This specification balances the trade-off between retaining realistic features of inside debt and keeping the problem mathematically tractable.

anticipate each other's optimal choices and reflect that in the valuation of corporate securities. Figure 2 presents the sequence of decisions made in the model.

2.6 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 the results of this analysis in all possible scenarios.

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

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

where: $\hat{X}_b$ (defined in Appendix A) is a non-negative constant whose value depends on the compensation contract parameters; $y\bar{M}, yM^*$ and yM^{**} (defined in Appendix A) are thresholds of the state-price density, scaled by the Lagrangian multiplier y, that divide the state space into three regions, each of which corresponds to a different optimal choice of the terminal asset value; X_b^*, the bankruptcy threshold, is the unique solution of the *non-linear equation:*

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

Proof. See Appendix *A*. □

To gain further insights into the optimal value of firm assets, it is instructive to recall the optimal terminal asset value when the manager is paid only with salary and equity (i.e., $D = 0$), as in Carlson and Lazrak (2010). In that case, X_T^* reduces to

$$X_T^* = \begin{cases} X_b^* + \frac{1}{p(1-\tau)}\left(\left[\frac{p(1-\tau)}{yM_T}\right]^{1/\gamma} - A\right) & \text{if } yM_T \leq yM^* \\ 0 & \text{otherwise.} \end{cases}$$

The formula shows that a manager with zero inside debt divides the state space into two regions and chooses an optimal terminal asset value above the bankruptcy threshold only in very good states and zero otherwise. The intuition for this result is as follows: The performance-dependent component of compensation (equity awards) makes the manager's utility s-shaped around the default threshold, thus inducing risk-seeking behavior in bad times. As a result, the manager is willing to accept a low cash flow in bad times (thus accepting default) in exchange for a higher cash flow in good times.

The presence of inside debt modifies the manager's payoff structure and therefore changes the optimal choice of terminal asset value. While a manager with zero inside debt chooses to stay above the bankruptcy threshold in very good states and to default otherwise, the manager with positive inside debt divides state space into three regions and chooses to stay above the bankruptcy threshold in very good states, to stay exactly at the bankruptcy threshold in intermediate states, and to default only when the situation further deteriorates (i.e., when the state-price density M_T is sufficiently large).[6,7]

[6]A similar optimal policy, with separation of the state space into three regions, is also obtained by Basak and Shapiro (2005) in a different context. The authors study the optimal portfolio of an agent who has a debt contract in place and decides how to allocate his/her wealth between a risky and a risk-free asset. Default occurs if the agent cannot repay the face value of the debt, in which case he/she incurs some bankruptcy cost proportional to the amount of debt left unpaid. Our context differs in that we assume the separation between ownership and control and study the relation between executive compensation and managerial risk-taking behavior. Moreover, the default threshold in our model is not exogenously fixed at a level proportional to the face value of debt but rather, arises endogenously from the interaction between creditors, shareholders and the manager under a rational expectation framework.

[7]Since the expected value of X_T^* is fixed at X_0, this policy implies that in comparison with a manager with zero inside debt, a manager with positive and unsecured inside debt necessarily trades off terminal asset values in intermediate states for higher values in the tails.

The presence of inside debt in the compensation package makes the manager more reluctant to default, resulting in an extended "no-default" region. This region, however, arises only when the default threshold is sufficiently low (i.e., $X_b^* \leq \hat{X}_b$) to overcome the incentive of gambling-for-resurrection strategies. In fact, for a high default threshold, the probability of default becomes high, and the manager may have an incentive to accept default more often and to increase the firm's risk in an effort to bring the final value of cash flow above the default threshold. Naturally, the desire to undertake gambling for resurrection strategies or, instead, to prevent default depends on the contract parameters. In Appendix A, we show that the extended no-default region arises only if

$$\frac{D}{\theta(1-\tau)} > p. \tag{8}$$

(See the proof of Proposition 1 in conjunction with Lemma 3). Condition (8) says that the beneficial effect of inside debt arises only if inside debt is sizable (i.e., D is sufficiently large) and, more importantly, unsecured (i.e., θ is low). Intuitively, when inside debt is bankruptcy proof, it provides the manager with an insurance in case of default and thus induces more risk-taking. This intuition is contained in Figure 3, where we plot the manager's optimal terminal wealth for different levels of inside debt seniority. We observe that a manager paid with high-seniority inside debt decides to default more often than a manager paid with low-seniority inside debt, thus emphasizing the insurance effect of high-seniority inside debt. This result suggests that deferring managerial compensation may not produce the intended effect of lowering the probability of corporate default if the effective seniority of deferred compensation is not kept sufficiently low.

Using the optimal terminal value of assets determined above, we can compute the current value of the firm's assets and optimal risk choice as follows:

Proposition 2. *Given the optimal terminal value of firm's assets, the current value of assets 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 optimal choice of risk, 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, $i = \{1, ..., 5\}$, Γ, Ψ are defined as in Appendix A.

Proof. See Appendix A. □

The level of the firm's risk determines the probability of default and, thus, the payoff of bondholders:[8]

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

The value of corporate bond at any time $t \in [0, T)$ is then computed as the expected value of the payoff B_T^* discounted using the state price density M:

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

Finally, we compute the continuously compounded bond yield, R_t:

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

and define the credit spread (ρ_t) as the difference between the bond yield and the risk free rate, r:

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

[8] 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 and 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).

2.7 *Empirical implications*

2.7.1 *Calibration parameters*

For the 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 to 2012. The market price of risk α is set equal to 0.33, consistent with a 7% market risk premium and an annualized market volatility of 21%.[9] Corporate income tax rate is fixed at $\tau = 33\%$, the average effective tax rate levied on U.S. corporations. The manager's horizon is $T = 5$ years, which matches the median CEO tenure of our sample. For firm-specific variables, we normalize initial asset value X_0 to 1.0 and set the face value of debt $F = 0.3$, in line with the observed book leverage of approximately 30%. Finally, we consider a moderately risk-averse manager with $\gamma = 0.6$. The analysis of the optimal policy is conducted for arbitrary time $t = 1$.[10] To capture the variation in aggregate conditions, we let state-price density M vary between 0.7 in good times and 1.5 in bad times below and above, respectively, the default threshold for any recovery rate in Figure 3.

For compensation variables, we calibrate the model using values from our sample (to be discussed in more detail in the empirical part). Table 1 reports the empirically relevant range of salary, inside debt, and CEO ownership. Salary and inside debt are divided by total assets, consistent with the normalization of $X_0 = 1$. CEO ownership includes both stock and option holdings. We consider the interquartile range as range of variation for comparative statics analysis. In particular, salary and inside debt can vary from 0.006% to 0.025% and from 0.010% to 0.141% of total assets, respectively. CEO ownership can vary from 0.273% to 1.186%. We let effective seniority θ vary such that we obtain recovery rates ranging from 1% to 70%, consistent with the observed seniority of inside debt.[11]

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

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

[11] Recall that the definition of recovery rate of inside debt in bankruptcy is $k(\theta, X_b, X_T) = \theta / (\theta + (X_b - X_T)^+)$ where $(X_b - X_T)^+$ can be approximated by the creditors' loss in bankruptcy. Empirically, the long-term average loss for U.S. senior unsecured bondholders is 57% of the face value (See "Default, Transition, and Recovery. U.S. Recovery Study: Recent Post-Bankruptcy Recovery Levels Disappoint Senior Unsecured Bondholders," by Standard & Poor's Ratings Services. Consulted on May 25, 2013 at http://www.standardandpoors.com/spf/upload/Ratings_US/US_Recovery_Study_Recent_Post_Bankruptcy_Recovery_Levels.pdf). This implies that for an average level of debt $F = 0.3$, the empirical average of $(X_b - X_T)^+$ is 0.17. Using this number in the formula of k, we can form a map between θ and the recovery rate of inside debt in bankruptcy.

2.7.2 Comparative statics analysis

In Figure 4, we analyze the relation of the different compensation components with the optimal volatility choice and the credit spread for an intermediate level of state-price density $M = 1$, which corresponds to its initial value. The case of salary (Panel A) is clear and intuitive: Both the optimal volatility of a firm's assets and credit spreads increase with salary. This result, similarly to Carlson and Lazrak (2010), stems from the insurance effect of salary. Because salary is paid independently of the firm's performance, it serves as an insurance buffer for managerial risk-taking. The larger this buffer, the higher the incentive for risk-taking and hence the higher the credit spread.

The role of inside debt (Panel B) depends critically on its seniority. Asset volatility and the credit spread decrease sharply with inside debt when it is unsecured. For higher levels of seniority of inside debt, however, this relation is remarkably weakened. Indeed, only unsecured inside debt is effective in aligning the incentive of the manager with those of bondholders, because it exposes the manager and bondholders to the same risk. In contrast, secured inside debt tends to act as salary, hence a buffer for risk-taking.[12] This relation between inside debt seniority and optimal asset volatility (and the credit spread) raises an additional concern related to the distinction between contractual seniority and effective seniority. Jackson and Honigsberg (2014) show that most of the managers are able to withdraw their pension plans before retirement. This implies that the effective seniority of inside debt may be much higher than its contractual seniority, thus, dampening the risk-reducing role of inside debt.

Panel C depicts the relation among CEO ownership, asset volatility and credit spreads for the median level of inside debt. We observe that these relations are not monotone: Asset volatility and credit spreads increase with CEO ownership initially and then level off. This is so because an increase in the CEO ownership produces two counteracting effects on the manager's wealth. On the one hand, given that the firm's equity is a call option on the value of the firm's assets, the manager has the incentive to raise asset volatility in order to increase the value of equity and, in turn, the expected value of his/her final wealth. On the other hand, the higher the asset volatility, the higher the volatility of the manager's wealth. A risk-neutral manager will ignore the latter effect, but a risk-averse manager will trade off the two opposite effects generated by equity

[12] As a theoretical exercise, we find that for an arbitrarily high level of recovery rate (99%), asset volatility and credit spread are both increasing in inside debt. We do not report this case in the figure because recovery rates beyond 70% are outside of the empirically relevant range of parameters in our sample, but this result is available upon request.

ownership. Carlson and Lazrak (2010) show that when a risk-averse manager is paid only with salary and equity (no inside debt), the effect of ownership on the volatility of the manager's wealth dominates, and as a result, asset volatility and credit spreads decrease with CEO ownership. The introduction of inside debt changes the effect of equity ownership on the fluctuations of the manager's wealth. Given that inside debt can still be received even in case of default, it helps stabilize the manager's wealth and reduces utility losses caused by higher asset volatility. As a result, for low values of equity ownership, the manager can increase asset volatility in reaction to higher equity ownership. This effect becomes more pronounced as the recovery rate of inside debt increases. When CEO ownership is high, however, increasing asset volatility is particularly harmful in terms of utility for a risk-averse manager, thus inducing more prudent behavior, which translates into the leveling off of the relation between equity ownership and asset volatility and the relation between equity ownership and credit spreads.

To shed more light on the economic mechanism behind our cross-sectional implications on the credit spread and CEO ownership, it is useful to look at how such a relation changes over time for different inside debt levels (Figure 5). In other words, we analyze this relation as aggregate conditions evolve. For high inside debt (Panel A), credit spreads are increasing in CEO ownership, while they are decreasing for low inside debt (Panel B). High inside debt helps stabilize the manager's compensation especially in bad aggregate states by decreasing the utility losses induced by asset volatility, thus rendering the manager less reluctant to take on risk when rewarded with higher fractions of the firm's equity. In the presence of low inside debt, the negative relation between the credit spread and CEO ownership, instead, does not appear to vary substantially across different aggregate states.

In conclusion, our model delivers three testable cross-sectional hypotheses.

Hypothesis 1:
The credit spread is increasing in salary.

Hypothesis 2:
The credit spread is decreasing in inside debt. This relation is weakened as the effective seniority of inside debt in bankruptcy increases.

Hypothesis 3:
The credit spread is increasing in equity ownership. This relation is weakened as the effective seniority of inside debt in bankruptcy decreases.

3 Empirical analysis

3.1 Empirical approach

We now empirically examine the relation between credit spreads and CEO compensation structure. Because the flow and stock compensation components in our model coincide, we use the term CEO firm-specific wealth structure rather than compensation structure throughout the empirical analysis.

It should be stressed at the outset that we do not aim at establishing causality. Rather, our goal is to analyze the model's prediction about endogenous patterns in credit spreads and CEO firm-specific wealth structure in the data. To test our cross-sectional hypotheses, we estimate the following panel regression:

$$\begin{aligned} \ln(\mathit{Credit\ spread})_{i,t} =& \beta_1 \cdot \mathit{Salary}_{i,t} + \beta_2 \cdot \mathit{Inside\ debt}_{i,t} + \beta_3 \cdot \mathit{Ownership}_{i,t} + \\ & \theta \cdot \mathit{Controls}_{i,t} + \upsilon_j + \nu_t + \epsilon_{i,t}, \end{aligned} \tag{9}$$

where subscripts i, j, and t indicate firm, industry, and fiscal year, respectively. $\mathit{Credit\ spread}_{i,t}$ is the firm's CDS spread. We take the natural logarithm to alleviate skewness in CDS spreads. $\mathit{Salary}_{i,t}$ and $\mathit{Inside\ debt}_{i,t}$ are normalized by the firm's total assets, similarly to our model parameters A and D in the comparative statics analysis. Although option holdings are not modeled in our theoretical framework, we measure $\mathit{Ownership}_{i,t}$, the empirical counterpart of p, as the effective ownership based on shares and options held by the CEO. $\mathit{Controls}_{i,t}$ include CEO characteristics (age, tenure, and a turnover indicator) and firm characteristics (size, debt-equity ratio, and profitability). Because our main hypotheses are cross-sectional, we omit firm fixed effects. However, we include industry fixed effects υ_j to mitigate concerns about omitted variables. Furthermore, we include fiscal year fixed effects ν_t to control for aggregate shocks. Standard errors are clustered at the firm level.

The parameters of interest in equation (9) are β_1, β_2, and β_3. Based on Hypothesis 1, we expect β_1, which measures the association between credit spreads and salary, to be positive. Hypothesis 2 and 3 predict a negative (positive) unconditional relation between credit spreads and inside debt (ownership). Hence, we expect β_2 and β_3 to be negative and positive, respectively.

Whereas Hypothesis 1 holds unchanged throughout the cross-section, Hypothesis 2 and Hypothesis 3 predict that the role of inside debt and ownership depends on in inside debt seniority. Thus, to better test the economic channel suggested by the model, we augment specification (9) to account for cross-sectional variation in seniority:

$$\begin{aligned}\ln(Credit\ spread)_{i,t} = &\beta_1 \cdot Salary_{i,t} + \beta_2 \cdot Inside\ debt\ (protected)_{i,t} + \\ &\beta_3 \cdot Inside\ debt\ (non\text{-}protected)_{i,t} + \beta_4 \cdot Ownership_{i,t} + \\ &\beta_5 \cdot Ownership_{i,t} \times Low\ seniority_{i,t} + \\ &\theta \cdot Controls_{i,t} + \upsilon_j + \nu_t + \epsilon_{i,t}. \end{aligned} \tag{10}$$

$Low\ seniority_{i,t}$ is an indicator variable equal to one if inside debt seniority is low. $Controls_{i,t}$, in this case, also include $Low\ seniority_{i,t}$.

Given the expected unconditional relations described above, the parameters of interest in equation (10) are β_3 and β_5. According to Hypothesis 2, inside debt is associated with reduced risk-taking only when non-protected in bankruptcy (negative β_3), while no significant relation should be found for protected inside debt. Hypothesis 3 suggests that the positive relation between credit spreads and ownership should be weaker in the presence of a higher fraction of non-protected inside debt (negative β_5).

In additional tests, we explore in greater detail the economic mechanism behind our main hypotheses. First, to better understand inside debt's indirect role in shaping risk-taking incentives of equity holdings, we examine the time-series implications of the state-dependent relations in the model. In particular, we study how the relation between credit spreads and ownership changes throughout the business cycle. Second, in line with condition (8), we analyze how the mix of equity incentives and inside debt of different seniorities relates to default risk. Third, we extend our analysis to asset risk. Within our theoretical framework, asset risk serves as the economic channel linking CEO firm-specific wealth structure and credit spreads. Although the measurement of asset risk is controversial and an in-depth analysis of asset risk goes beyond the scope of this paper, we provide suggestive evidence in this respect. Finally, we analyze leverage choices. In our baseline tests, we test predictions derived under the assumption that the manager cannot change the firm's leverage. However, for a CEO it may be rational to take into account both asset risk and leverage. In this supplementary battery of tests, we thus look at how leverage ratios correlate with CEO firm-specific wealth structure.

3.2 Data

We consider a sample of U.S. public firms having CDS contracts traded in the period from 2006 to 2011. Our sample begins in 2006 because the new enhanced disclosure requirements of the U.S. Securities and Exchange Commission (SEC) about executive pensions and deferred compensation were first enforced for the 2006 fiscal year end. We obtain CEO compensation data from Standard and Poor's Execucomp, accounting and daily stock return data from the CRSP-Compustat merged database, 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, subsidiaries and firm-years with negative assets or sales. We also exclude firm-years with missing assets, sales, number of outstanding shares, and stock price at fiscal year end. Finally, we obtain CDS data from Markit.

Using these data sources, we compute the following variables.

Credit spreads. To measure credit spreads, our primary dependent variable, we rely on CDS spreads rather than on bond credit spreads.[13] 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.[14] By measuring CDS spreads over the last fiscal quarter, whereas CEOs' compensation packages are generally set in the first two fiscal quarters (see, e.g., Hall and Knox, 2004), we ensure that the former fully reflect this information.

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.[15] To measure incentives from cash compensation, we focus on salary, given that bonus is tied to the firm performance, and thus cannot be regarded as safe.[16] In

[13] 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 this phenomenon has been recorded so far.

[14] On a certain day, we may 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 on the documentation clause.

[15] 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.

[16] Although executive salary can be contractually junior to debt in bankruptcy, in many jurisdictions (including the U.S.), the law permits that executive salary is preserved during the restructuring process. Empirical studies further document that when creditors take control of distressed firms, they do revise executive salaries but there is no significant evidence for a downward adjustment; rather, an average firm even increases slightly executive salaries relative to pre-distress levels (see, e.g., Calcagno and Renneboog, 2007; Henderson, 2007). Taken together, these evidences suggest that unlike discretionary bonus, managerial salary remains relatively safe even when a company is in distress.

line with the comparative statics results above, we scale salary by total assets (*Salary-to-assets*). It is useful to note that our model features a one-period horizon in which all compensation components are paid at the end, while in reality salary is paid in annual installments. One may thus suggest that it is necessary to look at the present value of future salaries. However, CEO salary is generally not bound to the firm, so this distinction is arguably inconsequential for our empirical design.

To capture the incentives provided by inside debt holdings, we rely on the sum of the present value of all pension plans and the aggregate balance of deferred compensation plans at fiscal year-end.[17] As for salary, we scale inside debt holdings by total assets to maintain consistency with our model (*Inside debt-to-assets*).

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 ownership*). 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, 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).[18] Because we do not explicitly introduce option holdings in the model, we also repeat our tests using a measure of CEO ownership based on shares alone (*CEO stock ownership*).

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. 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 between inside debt protected and non-protected in bankruptcy, thus obtaining *Inside debt-to-assets (protected)* and *Inside debt-to-assets*

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

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

(non-protected), respectively. There are good reasons to believe that our seniority measure underestimates effective seniority in bankruptcy, given that a fraction of non-qualified plans might be funded (see, e.g., Cristy, 2010; Reid, 2011). Below, however, we argue that this should bias against our finding evidence to support our model predictions. In Appendix B.1, using hand-collected data from SEC DEF 14A forms for a random sample of firms, we also validate our seniority measure against the inside-debt-relative-duration measure of seniority proposed by Anantharaman, Fang, and Gong (2014).

Macroeconomic conditions. In our tests, we focus on changes in CEO incentives across different states of the world. To this end, we focus on changes in macroeconomic conditions in our model, aggregate risk is the only explicitly modeled source of risk, and it drives both the pricing kernel and firm value. We use the three-month moving average of the Chicago Fed National Activity Index (CFNAI) and classify a period as being in a bad macroeconomic state if the CFNAI is negative, i.e., below-average growth. Finally, for robustness, we also use the output gap.

Other variables. In additional cross-sectional tests of the economic mechanism, we use default risk, asset risk, and leverage as outcome variables. To proxy for default risk, we use both the Altman's Z-score and the modified Altman's Z-score by MacKie-Mason (1990). In default risk tests, our main explanatory variable is the so-called *Incentive ratio*. This ratio summarizes a CEO's mix of equity incentives and inside debt of different seniorities and directly builds on the condition for the presence of an extended no-default region (8). We use the naïve asset volatility measure by Bharath and Shumway (2008) as a proxy for asset risk. Furthermore, we measure leverage as the ratio of total debt to the market value of assets. Finally, in our regressions, we also include a set of control variables, such as size, the market debt/equity ratio, profitability, CEO age and tenure, and an indicator variable equal to one in years in which a CEO turnover is observed.

Table 2 reports the descriptive statistics for all variables. The final sample features 508 unique firms for 2,398 firm-year observations. The average CDS spread is 232.579 basis points, and the average market debt/equity is 72.15%. The mean *Salary-to-assets* ratio is 0.019%, the mean *CEO effective ownership* is 1.525%, and the mean *Inside debt-to-assets* is 0.118%, with a mean seniority of 10.43%. The low values of *Salary-to-assets* and *Inside debt-to-assets* relative to *CEO ownership* should be interpreted in the light of the scaling by total assets. Indeed, Figure 6 shows that salary and inside debt holdings represent a sizable fraction of the median CEO firm-specific wealth, approximately 15%

and 5%, respectively. Figure 6 also shows that the distribution of seniority is concentrated around 0%. Consistently, we distinguish between CEOs with low and high seniority inside debt by means of the indicator variable *Low seniority*, which is equal to one when the fraction of ERISA-qualified plans to total inside debt holdings is zero and zero otherwise.[19] All variables are winsorized at the 1st and 99th percentiles. Detailed definitions of the variables are given in Table A.II. All dollar amounts are expressed in 2010 dollars.

3.3 Main results

Table 3 presents the results of our cross-sectional tests. We estimate equation (9), which relates CDS spreads to the CEO firm-specific wealth structure. In column 1, we include only year fixed effects besides firm-specific wealth structure variables to reduce concerns that our results might be influenced by "bad controls", i.e., control variables that are potentially outcome variable themselves and may generate selection bias (Angrist and Pischke, 2009). For the same reason, we opt for a parsimonious set of control variables. In column 2, we control for Fama-French 17 industry fixed effects and CEO characteristics (age, tenure, and a turnover indicator).[20] In column 3, we also include selected firm characteristics (size, debt-equity ratio, and profitability). In column 4, we allow a quadratic relation between CDS spreads and CEO ownership by including *Squared CEO ownership*. In column 5, we estimate the same specification but use demeaned *CEO ownership*.[21]

Consistent with Hypothesis 1, *Salary-to-assets* exhibits a positive and statistically significant coefficient in each specification, similarly to Carlson and Lazrak (2010). The intuition behind this result is that fixed pay is akin to an insurance, which induces a reduction in CEO risk aversion. Table 3 also provides insights into the relation of CDS spreads to inside debt and ownership unconditional on inside debt seniority. In line with Hypothesis 2, the coefficient associated with *Inside debt-to-assets* is negative and statistically significant. Economically, indeed, inside debt helps align managerial interests with those of bondholders. The positive and statistically significant coefficient

[19] Table 2 shows that *Low seniority* has a higher number of available observations than *Inside debt seniority* (2,398 vs. 2,072). This is because when inside debt holdings (the denominator of *Inside debt seniority*) are zero and *Inside debt seniority* is missing, we assume *Low seniority* to be equal to zero. This assumption allows us to exploit cross-sectional variation stemming from CEOs that are not awarded inside debt. In additional tests based on the *Incentive ratio*, which is set to missing when inside debt holdings are zero, we address potential concerns about this assumption.

[20] We choose a coarse industry classification because the sample of CDS-traded Execucomp firms is relatively small. In the robustness tests below, we use a finer industry classification.

[21] By demeaning *CEO ownership*, we allow an easier interpretation of the linear and quadratic terms as slope and curvature, respectively.

on CEO ownership is consistent with Hypothesis 3. Notably, *Squared CEO ownership* enters with a significantly negative coefficient. In other words, the relation between CDS spreads and ownership is concave, as depicted in Panel C of Figure 4. In our model, CEO ownership generates two counteracting forces. Equity incentives give the CEO a call option on the firm's assets, whose value is increasing in volatility. At the same time, the risk-averse CEO dislikes this increase in compensation's volatility. As argued above, such a trade-off can explain the observed concave relation.

These results are also economically important. As CDS spreads are log-transformed, the estimated coefficients should be interpreted as semi-elasticities. Thus, based on the estimates in column 3, a one-standard-deviation increase in *Salary-to-assets* is associated with an 8.9% increase in CDS spreads. A one-standard-deviation increase in *Inside debt-to-assets* is associated with a 6.0% decrease in CDS spreads. Finally, a one-standard-deviation in *CEO ownership* is associated with a 7.4% increase in CDS spreads.

Table 4 examines Hypothesis 2 and Hypothesis 3 in greater detail by taking into account inside debt seniority. To this end, we estimate equation (10), which distinguishes between protected and non-protected inside debt and interacts ownership with the indicator *Low seniority*. The reported specifications include different sets of control variables and fixed effects and also allow a quadratic relation between CDS spreads and ownership. As predicted by Hypothesis 2, we find that only non-protected inside debt is associated with significantly lower CDS spreads. The intuition for this result is that only risky inside debt is able to align CEOs to debt holders. It is also worth noting that our measure of inside debt seniority is downward biased. However, this should make our finding stronger. Our non-protected inside debt supposedly also includes pension plans with relatively high effective seniority. This fact, in turn, biases against us finding a negative and significant effect of low seniority inside debt on CDS spreads.

In line with Hypothesis 3, we find that the positive relation between CDS spreads and CEO ownership is significantly lower in the presence of low-seniority inside debt. Again, we illustrate that this relation is concave. To better understand the economic rationale behind this result, it should be stressed that inside debt reduces the volatility of CEO firm-specific wealth and thus reduces a risk-averse CEO's utility losses due to the higher volatility. Hence, for low values of ownership, managerial risk-taking is increasing in ownership. This relation is more pronounced when the recovery rate of inside debt is high. Interestingly, *Low seniority* exhibits a positive and significant coefficient. This finding is still compatible with our model's predictions, given that the indicator variable *Low seniority* can be equal to one irrespective of the level of *Inside debt-to-assets*. However, it suggests that even firms awarding low-seniority but small-in-magnitude inside debt holdings to their CEOs tend to be characterized by higher credit spreads, especially when equity incentives are also low. To ensure that we capture a meaningful interaction between these different forms of compensation, we examine it below throughout the business cycle conditioning on the level and seniority of inside debt. Moreover, we look at the *Incentive ratio*, a comprehensive measure of the mix of equity incentives and inside debt of different seniorities.

All in all, these baseline findings provide evidence consistent with our model implications. In the next section, we explore the economic mechanism put forward by the model in greater detail.

3.4 Economic mechanism

3.4.1 Credit spreads and CEO ownership along the business cycle

We now study how the relation between credit spreads and CEO ownership changes with macroeconomic conditions for different levels and seniorities of inside debt. This analysis helps us pin down the mechanism behind the concave relation described above. In particular, we test the time-series implications delivered by our model, which are depicted in Figure 5. In short, we expect credit spreads to be increasing in CEO ownership in the presence of high inside debt. This relation should be more pronounced in bad aggregate states. By contrast, we expect to observe a negative relation between credit spreads and CEO ownership in the presence of low inside debt. In this case, however, the relation should be stable across different aggregate states. In the presence of both high and low inside debt incentives, these implications remain unchanged irrespective of inside debt seniority.

Given that our sample period is relatively short (2006-2011), we rely on quarterly data (2006Q4-2012Q2) for these tests to exploit more precise variation in the business cycle. However, executive compensation data are available only at an annual frequency, so we use the previously available observation until a new observation is available. As we are interested in time-series variation, we estimate CEO fixed effect regressions. We consider CEO (rather than firm) fixed effect regressions to avoid confounding effects due to CEO turnovers. Moreover, these tests require us to classify CEOs based on the level of inside debt incentives. We define the "High inside debt" ("Low inside debt") subsample as the top (bottom) quartile of *Inside debt-to-assets*. To prevent CEOs from moving across inside debt classes during their tenure, we compute each CEO's average *Inside* *debt-to-assets*. Then, we assign him/her to the top or bottom quartile based on average *Inside debt-to-assets*.[22]

Table 5 reports the estimates of CEO fixed effects regressions of CDS spreads on CEO ownership. Columns 1 and 2 present coefficient estimates for the "High inside debt" subsample. Columns 3 and 4 present coefficient estimates for the "Low inside debt" subsample. In columns 1 and 3, we interact *CEO ownership* with quarter fixed effects.[23] We consider 2012Q2, the last quarter for which we have available CDS spreads, as the base level. Hence, we use a relatively good aggregate state as our benchmark. In the presence of high inside debt, we find a positive but insignificant relation in 2012Q2, which matches the flat pattern in good times in Panel A of Figure 5. The base-level relation, instead, is significantly negative for low inside debt, consistent with Panel B of Figure 5. We are especially interested, however, in how this relation evolves with aggregate conditions. To facilitate the interpretation of the estimated coefficients of interactions with quarter fixed effects, we plot them along with 90% confidence intervals in Figure 7. As expected, we observe that changes in the base-level relation are positive during the last financial crisis (dark and light gray shaded area) in the presence of high inside debt. The estimated coefficients for interactions are significantly positive only during the pre-Lehman Brothers bankruptcy part of the crisis (2007Q2-2008Q2, dark grey area), as defined by Kahle and Stulz (2013). The estimated changes in the relation between CDS spreads and CEO ownership exhibit a 0.6845 correlation (p-value of 0.0004) with *Output gap*, which is also plotted in Figure 7. By contrast, as predicted, the changes in the relation do not appear to be clearly related to aggregate conditions in the presence of low inside debt. The correlation with *Output gap*, in this case, is only 0.0008 (p-value of 0.9971). These findings are supported by the specifications reported in columns 2 and 4, where we interact *CEO ownership* with the *CFNAI slowdown* indicator. The interaction coefficient is significantly positive for the "High inside debt" subsample, whereas it is statistically indistinguishable from zero for the "Low inside debt" subsample.[24]

3.4.2 Default risk

We now illustrate how default risk relates to the CEO firm-specific wealth structure. Our model offers insights into the CEO's choice to default. A risk-averse CEO will be

[22]We obtain qualitatively similar results using quintiles and terciles (unreported).

[23]Given the rich set of fixed effects, we choose not to include other control variable to avoid issues with "bad controls".

[24]In columns 2 and 4, *CFNAI slowdown* is absorbed by quarter fixed effects.

more reluctant to default when he/she is awarded large enough inside debt with low seniority. This implication is illustrated by inequality (8), which defines the condition under which an extended no-default region arises. The same condition allows us to derive a comprehensive measure of a CEO's mix of equity incentives and inside debt of different seniorities:

$$Incentive\ ratio = \frac{D}{\theta p}.$$

Empirically, in line with our calibration exercise, we proxy for D, θ, and p using *Inside debt-to-assets*, *Inside debt seniority*, and *CEO ownership*. For higher values of the *Incentive ratio*, an extended no-default region is more likely to emerge.

Using the Altman's Z-score, we investigate the relation between default risk and the *Incentive ratio*. Given that the latter is arguably measured noisily, we estimate a regression of the Altman's Z-score on *Incentive ratio* quartile indicator variables, which includes size and CEO characteristics as control variables (unreported, but available upon request). We omit profitability and the market debt-equity ratio because they are components of the Altman's Z-score. The focus is on cross-sectional variation. Therefore, we include only industry and year fixed effects. In Figure 8 (left panel), we plot the predicted Altman's Z-score for different *Incentive ratio* quartiles. We observe that default risk is substantially higher for the bottom quartile, which is compatible with the existence of the extended no-default region. A similar result holds if we use the modified Altman's Z-score by MacKie-Mason (1990) as the proxy for default risk (right panel).[25] In unreported tests, we observe similar patterns when using lagged regressors and when using a modified *Incentive ratio* that allows us to include firm-years for which inside debt seniority is zero, i.e., using $D(1+\theta p)^{-1}$ in place of $D(\theta p)^{-1}$.

3.4.3 Asset risk

We investigate how cross-sectional variation in asset risk is related to the CEO firm-specific wealth structure. As noted above, asset risk-taking links CEO compensation to credit spreads in our model. Table 6 reports regressions of the naïve asset volatility measure by Bharath and Shumway (2008). Columns 1 and 2 present estimates of regressions in the spirit of specification (9). Columns 3 and 4 present estimates of regressions in the spirit of specification (10). We observe that asset volatility generally exhibits patterns similar to those of CDS spreads. However, we do not find clear evidence of the inverted

[25] In this case, we alsos control for the market debt-equity ratio because the measure proposed by MacKie-Mason (1990) does not include it.

U-shaped relation between asset volatility and CEO ownership depicted in Panel C of Figure 4.

3.4.4 Leverage choice

So far, we have assumed that the manager cannot change the firm's leverage. However, higher leverage would increase the value of equity through tax benefits and therefore would also increase the manager's wealth. The CEO may thus have the incentive to modify both the firm's leverage and asset volatility.

Carlson and Lazrak (2010) study the optimal leverage choice of a manager rewarded only with salary and equity. They show that the optimal leverage is a U-shaped function of the salary-to-equity ratio. Intuitively, the cash component of managerial compensation acts as an insurance that reduces managerial risk aversion. Therefore, when the salary-to-equity ratio is high, the cost of increasing leverage is low and optimal leverage is increasing in such a ratio. By contrast, when the ratio is low, the manager optimally chooses lower asset volatility that gradually increases as the salary-to-equity ratio increases. The higher volatility reduces the benefits of leverage, and therefore, optimal leverage is decreasing in the cash-to-equity ratio for low levels of this ratio. The leverage problem in their model is tractable because their manager is rewarded with only two compensation components, and therefore, the impact of compensation on the optimal manager's choices can be summarized by only one variable, i.e., the cash-to-equity ratio. By contrast, in our model the manager is rewarded with three compensation components, i.e., cash, equity and inside debt. Hence, there is no unique variable summarizing the impact of managerial compensation. Ideally, we would have to solve the optimal leverage problem for any values of salary, equity ownership and inside debt (and inside debt seniority), which would make the optimal leverage problem intractable. However, we can still intuitively discuss the manager's optimal leverage choice in our model.

First, secured inside debt is akin to salary. Hence, we expect secured inside debt to have similar implications for leverage choices. Our model should produce a U-shaped relation between secured inside debt and optimal leverage choice. For unsecured inside debt, however, the cost of increasing leverage is higher it is than for secured inside debt. When the seniority of inside debt is low, the manager is concerned with the risk of losing inside debt if the company defaults and gradually decreases asset volatility as inside debt increases. In other words, when seniority is low, we expect to see a less pronounced U-shaped relation between inside debt and optimal leverage.

Second, we expect the cash-to-equity ratio to have exactly the same effect in our model as in Carlson and Lazrak (2010). The only difference is that we do not summarize incentives with a unique ratio and analyze the impact of salary and equity separately. As a result, we expect that in our setting, there exists the same U-shaped relation between salary and optimal leverage but an inverted U-shaped relation between CEO ownership and optimal leverage.

Table 7 presents estimates of regressions of market leverage on the protected and non-protected components of inside debt and on CEO ownership. We analyze the different components of CEO firm-specific wealth structure separately. Because leverage is a stickier variable than CDS spreads and asset volatility, we lag all the explanatory variables. Again, we focus on cross-sectional variation. As conjectured above, in columns 1 through 4, we observe a U-shaped relation between market leverage and *Inside debt-to-assets (protected)* (significantly positive quadratic term), whereas such a relation is less pronounced for *Inside debt-to-assets (protected)* (insignificantly positive quadratic term). The evidence for CEO ownership points to the predicted inverted U-shaped relation. However, the relation becomes negative only for very high levels of CEO ownership.

3.5 Robustness

Table 8 presents several robustness tests of our main results on CDS spreads and CEO firm-specific wealth structure. In columns 1 and 2, we repeat the baseline analysis but measure CDS spreads in the quarter following the fiscal year end. In columns 3 and 4, we check whether our results are sensitive to the way unobserved firm heterogeneity is accounted for using the Fama-French 30 industry classification to define industry fixed effects. In columns 5 and 6, we repeat our tests using a measure of CEO ownership based on shares alone, *CEO stock ownership*. All the results related to our cross-sectional hypotheses remain robust, except for columns 4 and 5, where *Inside debt (non-protected)* exhibits large negative but statistically insignificant coefficients (0.112 and 0.124 p-values, respectively).

4 Conclusion

We propose a model to study the risk-taking incentives of a manager whose compensation consists of salary, equity and inside debt. We use our model to understand the joint role played by different compensation components in shaping managerial risk-taking incentives and credit spreads. First, the model predicts that inside debt reduces risk-taking and lowers credit spreads only when it is subject to substantial losses in bankruptcy. Second, the standard result that, for a risk-averse manager, higher CEO ownership is always associated with lower credit spreads may fail to hold in the presence of inside debt. In fact, equity ownership is negatively related to credit spreads only when inside debt is low; when inside debt is high, equity ownership is positively related to credit spreads, especially in bad aggregate states when bondholders would desire more prudent behavior. We empirically test and confirm our model predictions using a comprehensive sample of U.S. public firms with traded CDS contracts over the 2006-2011 period.

We extend existing literature studying managerial compensation and risk-taking by including inside debt and modeling its seniority in bankruptcy. Our theoretical framework helps rationalize the observed dynamics of credit spreads. However, our model does not account for another relevant component of managerial compensation, i.e., stock options. Studying the risk-taking incentives stemming from the interactions of stock options with the three compensation we model in this paper could be a fruitful area for future research. Moreover, an important open and challenging question is, given the complex interactions among different components of compensation, what would be the optimal contract from the securityholders' point of view? We leave these questions for future research.

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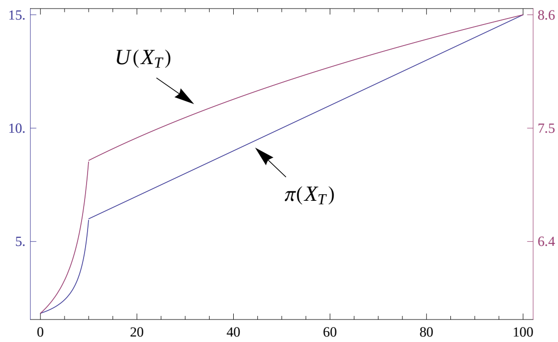


Figure 1: CEO payoff diagram and utility function
This is a sample graph of CEO's payoff $\pi_T(X_T)$ and his/her associated utility $U(\pi_T(X_T))$ with $A = 1, p = .1, D = 5, \theta = 2, X_b = 10$, and $\gamma = .8$.

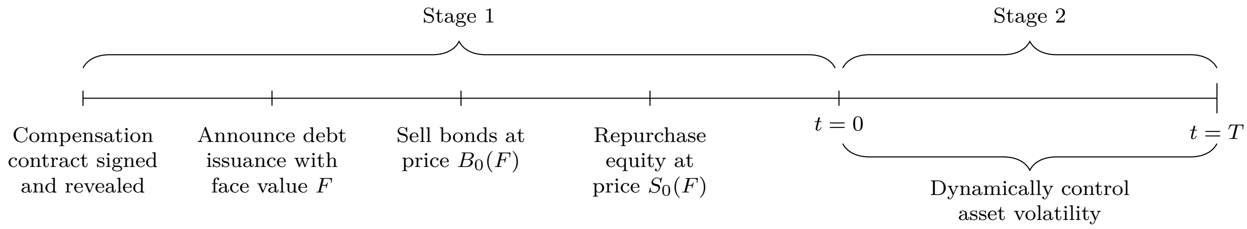


Figure 2: Timing of the model
Beginning at stage 1, shareholders and the manager agree on a compensation contract and reveal all contract details publicly. Shareholders make decision about leverage by announcing the issuance of a zero-coupon bond with face value F and maturity at time T, sell the bond 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 a *pro rata* basis (i.e., with the same fraction as his/her ownership holding immediately before the redemption), so that his/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).

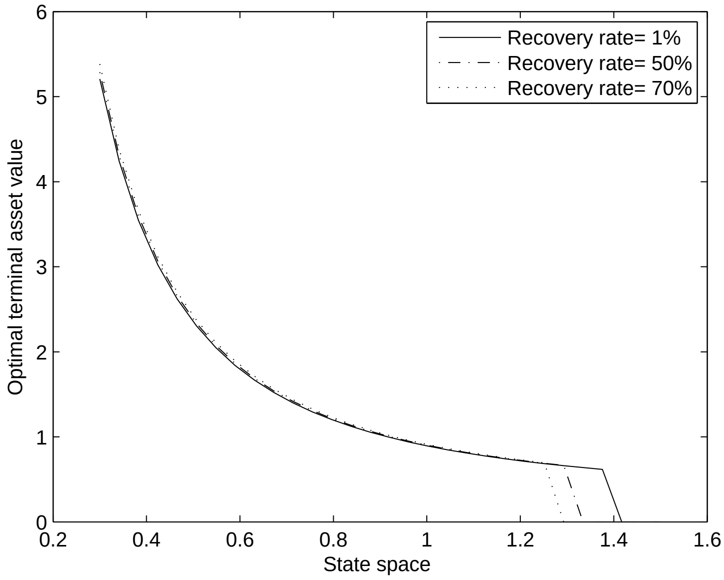
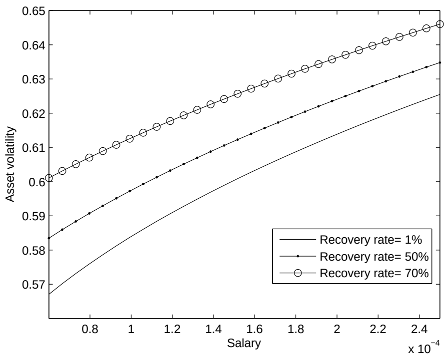


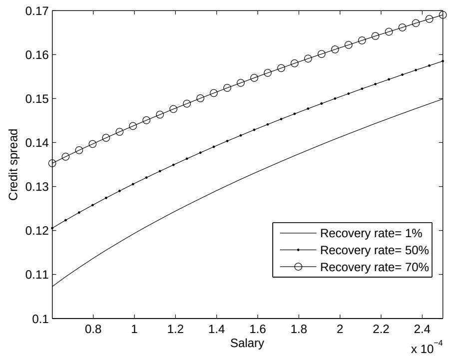
Figure 3: Optimal terminal asset value
This figure plots optimal choices of terminal asset value for different recovery rates of inside debt. Salary, inside debt, and CEO ownership are fixed at their median levels reported in Table 1. Other parameters are discussed in Section 2.7.1.

Panel A: Salary

A.1: Asset volatility

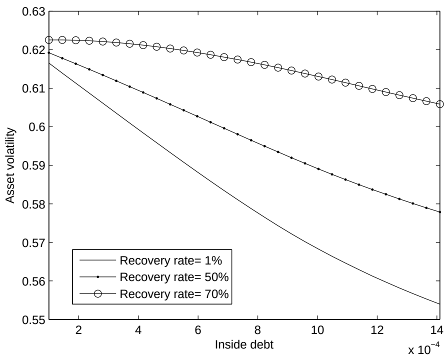


A.2: Credit spread

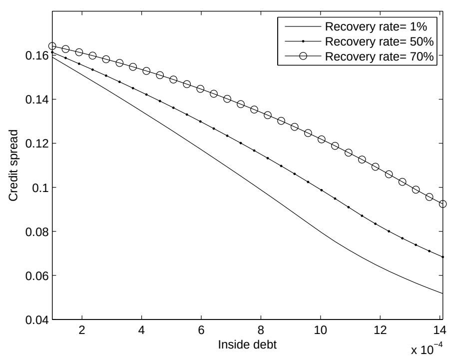


Panel B: Inside debt

B.1: Asset volatility

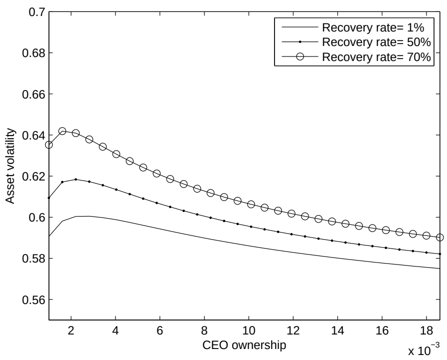


B.2: Credit spread



Panel C: CEO ownership

C.1: Asset volatility



C.2: Credit spread

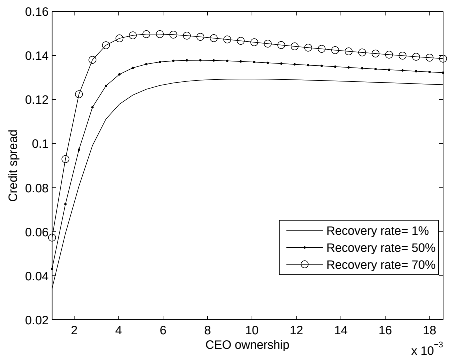


Figure 4: Asset volatility, credit spread, and CEO firm-specific wealth-structure
This figure plots optimal choices of asset volatility and associated credit spreads for different levels of salary (Panel A), inside debt (Panel B), and CEO ownership (Panel C). For each graph, compensation components that are not varying are held fixed at their median levels reported in Table 1. Other parameters are discussed in Section 2.7.1.

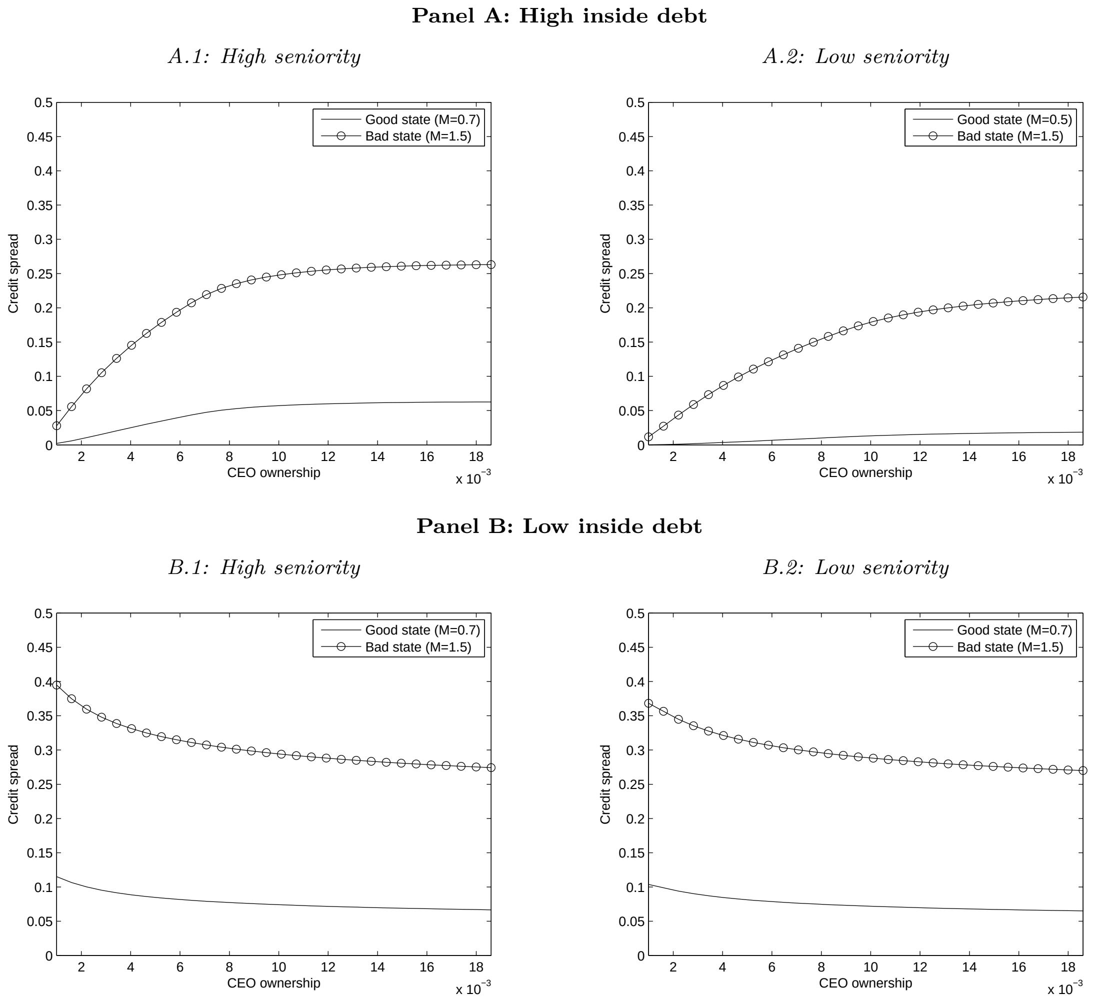


Figure 5: Credit spread and CEO ownership across aggregate states of the world
This figure plots the relation between credit spreads and CEO ownership across different aggregate states of the world in the presence of high inside debt holdings (Panel A) and low inside debt holdings (Panel B). In each panel, the graph on the left (right) depicts the case with high-seniority (low-seniority) inside debt. Compensation components that are not varying are held fixed at their median levels reported in Table 1. Other parameters are discussed in Section 2.7.1.

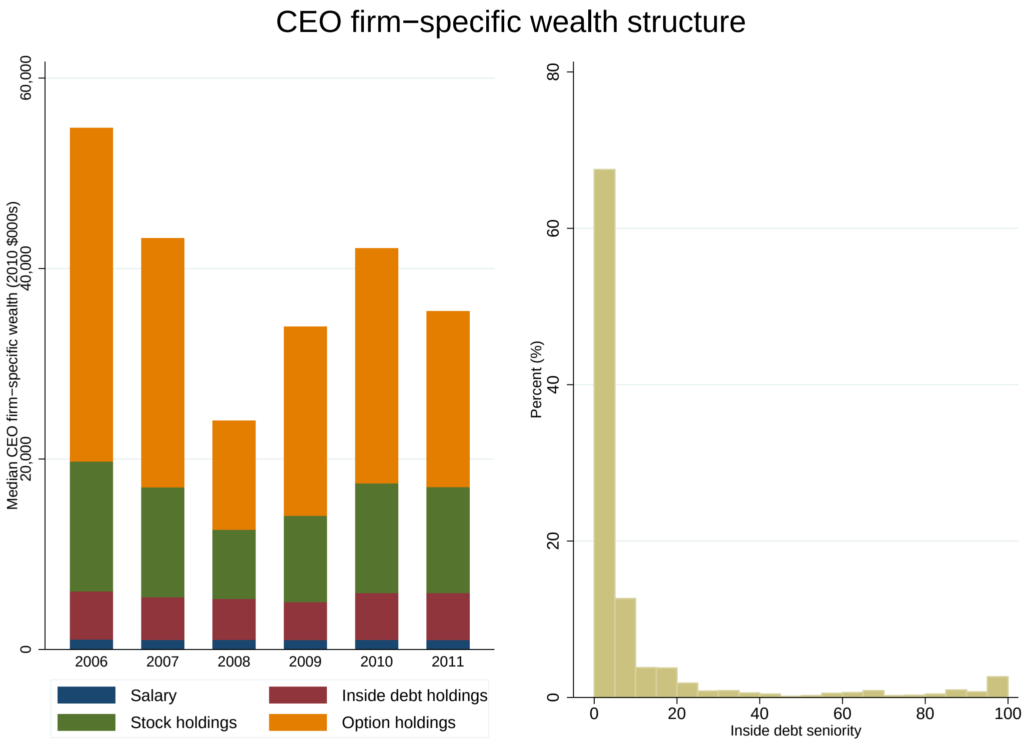


Figure 6: CEO firm-specific wealth level and composition: 2006-2011
This figure reports the level and composition of CEO firm-specific wealth over the period of 2006-2011 for Execucomp firms with traded CDSs (508 firms). The graph on the left depicts the median level and composition of firm-specific wealth in our sample. The graph on the right depicts the distribution of our measure of inside debt seniority, i.e., the fraction of ERISA-qualified pension plans to total inside debt holdings.

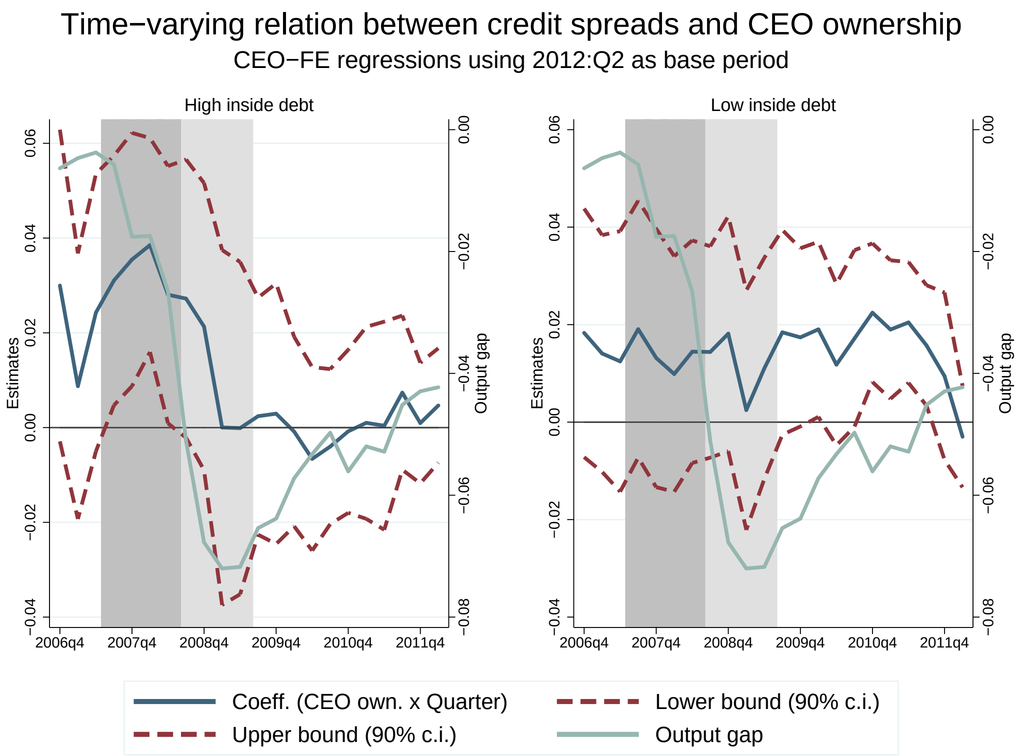


Figure 7: Credit spreads and CEO ownership across aggregate states of the world
This figure plots estimated coefficients of interactions of CEO ownership with quarter fixed effects from columns 1 and 3 in Table 5. Along the point estimates, also 90% confidence intervals are plotted. The graph on the left (right) shows the case of top (bottom) quartile of *Inside debt-to-assets*. Shaded areas represent different phases of the 2007-2009 crisis: i) In dark grey the pre-Lehman Brothers bankruptcy part of the crisis (2007Q2-2008Q2), as defined by Kahle and Stulz (2013), ii) in light grey the second part of the recession as defined by NBER (until 2009Q2). Also the output gap is reported.

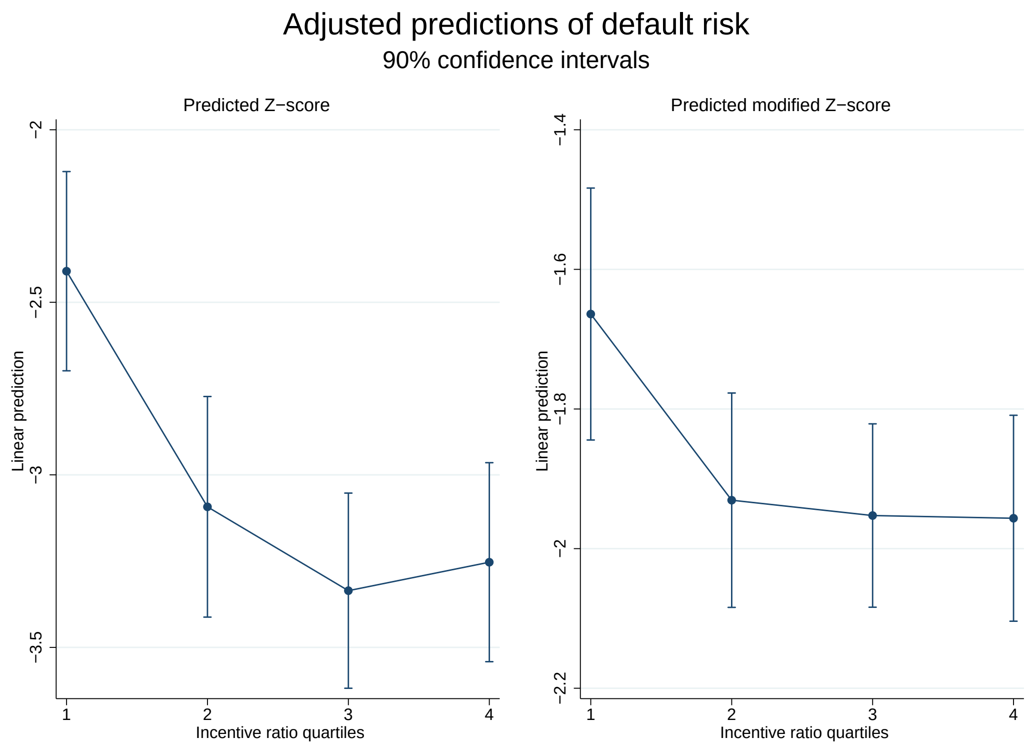


Figure 8: Default risk and the incentive ratio
This figure plots the predicted Altman's Z-score (left graph) and the MacKie-Mason (1990) modified Altman's Z-score (right graph) for different *Incentive ratio* quartiles. These predictions are based on regressions of the Altman's Z-score on *Incentive ratio* quartile indicator variables, size, CEO characteristics (age, tenure, and a turnover indicator), Fama-French 17 industry fixed effects, and year fixed effects. In the case of the MacKie-Mason (1990) modified Altman's Z-score, also the market debt-equity ratio is included among the control variables.

Table 1: Empirically relevant range of compensation variables
This table reports the empirically relevant range of salary, inside debt, and CEO ownership compensation for calibration purposes. Information is based on our sample reported in Table 2, where all variables are winsorized at the 1^{st} and the 99^{th} percentile and level variables like salary and inside debt are scaled by total assets, consistently with the normalization of $X_0 = 1.0$ in the model.

	Quartile 1	Median	Quartile 3
Salary-to-assets	0.006%	0.013%	0.025%
Inside debt-to-assets	0.010%	0.049%	0.141%
CEO ownership	0.273%	0.603%	1.186%

Table 2: Summary statistics
This table reports summary statistics of all variables employed in the paper. The sample includes 508 U.S. firms over the period 2006-2011 with 5-year maturity CDS contracts traded, excluding financial institutions and utilities. We obtain executive compensation data from Execucomp, accounting and stock market data from the CRSP-Compustat merged database, and CDS market data from Markit. All dollar amounts are in 2010 constant dollars. Refer to Table A.II for variable definitions.

	Mean	Std.Dev.	Q1	Med.	Q3	Obs.
Outcome variables						
CDS spread (bp)	232.579	343.162	52.691	111.976	271.698	2316
Asset volatility	0.354	0.159	0.242	0.317	0.429	2398
Z-score	-2.943	2.596	-3.902	-2.702	-1.801	2282
Modified Z-score	-1.686	1.843	-2.415	-1.755	-1.088	2282
Market leverage	0.211	0.145	0.106	0.179	0.281	2398
CEO firm-specific wealth structure						
Salary-to-assets %	0.019	0.017	0.006	0.013	0.025	2398
Inside debt-to-assets %	0.118	0.183	0.010	0.049	0.141	2398
Inside debt-to-assets (prot.) %	0.009	0.026	0.000	0.000	0.005	2398
Inside debt-to-assets (non-prot.) %	0.107	0.175	0.006	0.041	0.128	2398
CEO ownership %	1.525	3.379	0.273	0.603	1.186	2398
CEO stock ownership %	1.000	3.242	0.057	0.160	0.406	2398
Inside debt seniority %	10.426	22.512	0.000	2.069	7.225	2072
Low seniority	0.334	0.472	0.000	0.000	1.000	2398
Incentive ratio	0.170	0.413	0.007	0.034	0.115	1272
CEO characteristics						
CEO tenure	6.274	6.084	2.000	5.000	8.000	2398
CEO age	55.882	6.138	52.000	56.000	60.000	2398
CEO turnover	0.101	0.301	0.000	0.000	0.000	2398
Firm characteristics						
Size	8.871	1.119	8.045	8.782	9.699	2398
Market D/E	0.721	1.293	0.156	0.314	0.652	2398
Profitability	0.090	0.094	0.056	0.096	0.138	2376
Macroeconomics conditions						
NBER recession	0.340	0.474	0.000	0.000	1.000	2398
CFNAI slowdown	0.851	0.356	1.000	1.000	1.000	2398
Output gap	-0.042	0.024	-0.064	-0.050	-0.018	2398

Table 3: CDS spreads and CEO firm-specific wealth structure
This table reports panel regressions that use log-tranformed 5-year CDS spreads as dependent variable over the period 2006-2011. Column 1 analyzes the relation between CDS spreads and CEO firm-specific wealth structure as measured by *Salary-to-assets*, *Inside debt-to-assets*, and *CEO ownership*. Column 2 controls for Fama-French 17 industry fixed effects and CEO characteristics (age, tenure, and a turnover indicator). Column 3 controls also for selected firm characteristics (size, debt-equity ratio, and profitability). Column 4 includes a quadratic term, *Squared CEO ownership*. Column 5 uses demeaned measures of CEO ownership. All specifications include year fixed effects. 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.II for variable definitions.

	Log of CDS spread (t)				
	(1)	(2)	(3)	(4)	(5)
Salary-to-assets	23.171***	20.374***	5.064**	4.409*	4.409*
	(9.87)	(8.60)	(2.02)	(1.74)	(1.74)
Inside debt-to-assets	-0.855***	-0.658***	-0.342**	-0.372**	-0.372**
	(-3.97)	(-3.22)	(-2.17)	(-2.41)	(-2.41)
CEO ownership	0.022**	0.025***	0.021**	0.075***	
	(2.36)	(2.69)	(2.40)	(3.21)	
Sq. CEO ownership				-0.003**	
				(-2.29)	
CEO ownership (cent.)					0.066***
					(3.33)
Sq. CEO ownership (cent.)					-0.003**
					(-2.29)
CEO tenure		-0.005	-0.002	-0.004	-0.004
		(-0.77)	(-0.46)	(-0.86)	(-0.86)
CEO age		-0.015**	-0.008*	-0.008*	-0.008*
		(-2.30)	(-1.76)	(-1.74)	(-1.74)
CEO turnover		0.235***	0.027	0.032	0.032
		(3.63)	(0.48)	(0.57)	(0.57)
Size			-0.204***	-0.201***	-0.201***
			(-6.26)	(-6.25)	(-6.25)
Market D/E			0.336***	0.336***	0.336***
			(14.14)	(14.38)	(14.38)
Profitability			-2.832***	-2.803***	-2.803***
			(-9.06)	(-9.00)	(-9.00)
Year F.E.	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	Yes	Yes	Yes	Yes
Observations	2280	2251	2238	2238	2238
Adjusted R^2	0.23	0.31	0.57	0.58	0.58

Table 4: CDS spreads and CEO firm-specific wealth structure: The role of inside debt seniority
This table reports panel regressions that use log-tranformed 5-year CDS spreads as dependent variable over the period 2006-2011. Column 1 analyzes the relation between CDS spreads and CEO firm-specific wealth structure, taking into account the level of protection of inside debt in bankruptcy. The explanatory variables include *Salary-to-assets*, *Inside debt-to-assets (protected)*, *Inside debt-to-assets (non-protected)*, *CEO ownership*, and the interaction between *CEO ownership* and *Low seniority*, an indicator variable equal to one when the CEO's fraction of ERISA-qualified plans to total inside debt holdings is zero and zero otherwise. Column 2 includes a quadratic term, *Squared CEO ownership*. Column 3 controls for Fama-French 17 industry fixed effects and CEO characteristics (age, tenure, and a turnover indicator). Column 4 controls also for selected firm characteristics (size, debt-equity ratio, and profitability). Column 5 uses demeaned measures of CEO ownership. All specifications include year fixed effects. 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.II for variable definitions.

	Log of CDS spread (t)				
	(1)	(2)	(3)	(4)	(5)
Salary-to-assets	21.717***	20.752***	18.257***	4.470*	4.470*
	(9.29)	(8.58)	(7.42)	(1.80)	(1.80)
Inside debt-to-assets (prot.)	0.219	0.120	0.316	-0.664	-0.664
	(0.13)	(0.07)	(0.19)	(-0.61)	(-0.61)
Inside debt-to-assets (non-prot.)	-0.777***	-0.828***	-0.634***	-0.276*	-0.276*
	(-3.48)	(-3.72)	(-3.02)	(-1.77)	(-1.77)
CEO ownership	0.038***	0.103***	0.106***	0.087***	
	(3.82)	(3.45)	(3.22)	(4.03)	
CEO ownership × Low sen.	-0.041**	-0.039**	-0.029*	-0.040***	
	(-2.32)	(-2.21)	(-1.85)	(-3.23)	
Sq. CEO ownership		-0.003**	-0.003**	-0.002**	
		(-2.39)	(-2.35)	(-2.35)	
CEO ownership (cent.)					0.079***
					(4.23)
CEO ownership (cent.) × Low sen.					-0.040***
					(-3.23)
Sq. CEO ownership (cent.)					-0.002**
					(-2.35)
Low sen.	0.357***	0.345***	0.284***	0.181***	0.120**
	(3.89)	(3.79)	(3.24)	(2.92)	(2.10)
CEO tenure			-0.008	-0.004	-0.004
			(-1.17)	(-0.76)	(-0.76)
CEO age			-0.015**	-0.008*	-0.008*
			(-2.29)	(-1.77)	(-1.77)
CEO turnover			0.243***	0.032	0.032
			(3.76)	(0.59)	(0.59)
Size				-0.187***	-0.187***
				(-5.84)	(-5.84)
Market D/E				0.337***	0.337***
				(14.53)	(14.53)
Profitability				-2.807***	-2.807***
				(-9.12)	(-9.12)
Year F.E.	Yes	Yes	Yes	Yes	Yes
Industry F.E.	No	No	Yes	Yes	Yes
Observations	2280	2280	2251	2238	2238
Adjusted R^2	0.25	0.26	0.32	0.58	0.58

Table 5: Time-varying relation between credit spreads and CEO ownership

This table reports quarterly panel regressions that use log-tranformed 5-year CDS spreads as dependent variable over the period 2006Q4-2012Q2. Column 1 analyzes the relation between CDS spreads and CEO ownership. Columns 1 and 2 present coefficient estimates for the "High inside debt" subsample. Columns 3 and 4 present coefficient estimates for the "Low inside debt" subsample. The "High inside debt" ("Low inside debt") subsample is defined as the top (bottom) quartile of *Inside debt-to-assets*, based on the average *Inside debt-to-assets* of each CEO over his/her tenure. Columns 1 and 3 interact *CEO ownership* with quarter fixed effects. The period 2012Q2 is used as the base level. Columns 2 and 4 interact *CEO ownership* with *CFNAI slowdown*, an indicator variable equal to one if the CFNAI is negative. All specifications include CEO fixed effects and year fixed effects. The *t*-statistics are calculated with robust standard errors clustered by CEO. Significance at the 10%, 5%, and 1% levels are indicated by *, **, ***, respectively. Refer to Table A.II for variable definitions.

	High inside debt		Low inside debt	
	(1)	(2)	(3)	(4)
CEO ownership	0.002	0.001	-0.026*	-0.011
	(0.16)	(0.22)	(-1.74)	(-1.28)
CEO ownership × CFNAI slowdown		0.011***		0.000
		(3.65)		(0.04)
CEO ownership × 2006Q4	0.030		0.018	
	(1.51)		(1.19)	
CEO ownership × 2007Q1	0.009		0.014	
	(0.52)		(0.96)	
CEO ownership × 2007Q2	0.024		0.012	
	(1.37)		(0.77)	
CEO ownership × 2007Q3	0.031*		0.019	
	(1.95)		(1.20)	
CEO ownership × 2007Q4	0.035**		0.013	
	(2.20)		(0.82)	
CEO ownership × 2008Q1	0.039***		0.010	
	(2.82)		(0.68)	
CEO ownership × 2008Q2	0.028*		0.014	
	(1.71)		(1.05)	
CEO ownership × 2008Q3	0.027		0.014	
	(1.53)		(1.10)	
CEO ownership × 2008Q4	0.021		0.018	
	(1.16)		(1.24)	
CEO ownership × 2009Q1	0.000		0.002	
	(0.00)		(0.17)	
CEO ownership × 2009Q2	-0.000		0.011	
	(-0.01)		(0.80)	
CEO ownership × 2009Q3	0.002		0.018	
	(0.16)		(1.45)	
CEO ownership × 2009Q4	0.003		0.017	
	(0.18)		(1.57)	
CEO ownership × 2010Q1	-0.001		0.019*	
	(-0.07)		(1.75)	
CEO ownership × 2010Q2	-0.007		0.012	
	(-0.56)		(1.18)	
CEO ownership × 2010Q3	-0.004		0.017	
	(-0.41)		(1.56)	
CEO ownership × 2010Q4	-0.001		0.022***	
	(-0.08)		(2.61)	

(Continued)

Table 5: – *Continued*

CEO ownership × 2011Q1	0.001		0.019**	
	(0.08)		(2.21)	
CEO ownership × 2011Q2	0.000		0.020***	
	(0.03)		(2.73)	
CEO ownership × 2011Q3	0.007		0.016**	
	(0.75)		(2.11)	
CEO ownership × 2011Q4	0.001		0.009	
	(0.13)		(0.91)	
CEO ownership × 2012Q1	0.005		-0.003	
	(0.64)		(-0.48)	
CEO F.E.	Yes	Yes	Yes	Yes
Quarter F.E.	Yes	Yes	Yes	Yes
Observations	2317	2317	2347	2347
Adjusted R^2	0.48	0.48	0.34	0.35

Table 6: Asset risk and CEO firm-specific wealth structure
This table reports panel regressions that use the log-tranformed asset volatility measure by Bharath and Shumway (2008) as dependent variable over the period 2006-2011. Columns 1 and 2 analyze the relation between CDS spreads and CEO firm-specific wealth structure as measured by *Salary-to-assets*, *Inside debt-to-assets*, and *CEO ownership*. Columns 3 and 4 take into account the level of protection of inside debt in bankruptcy by including also the following explanatory variables: *Inside debt-to-assets (protected)*, *Inside debt-to-assets (non-protected)*, and the interaction between *CEO ownership* and *Low seniority*, an indicator variable equal to one when the CEO's fraction of ERISA-qualified plans to total inside debt holdings is zero and zero otherwise. Odd-numbered columns control for CEO characteristics (age, tenure, and a turnover indicator). Even-numbered columns control also for selected firm characteristics (size, debt-equity ratio, and profitability). All specifications include *Squared CEO ownership* and use demeaned measures of CEO ownership. All specifications include Fama-French 17 industry fixed effects and year fixed effects. 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.II for variable definitions.

	Log of asset volatility (t)			
	(1)	(2)	(3)	(4)
Salary-to-assets	5.822***	3.644***	5.641***	3.628***
	(10.10)	(4.76)	(9.71)	(4.79)
Inside debt-to-assets	-0.199***	-0.169***		
	(-4.34)	(-3.86)		
Inside debt-to-assets (prot.)			-0.457	-0.503
			(-1.34)	(-1.58)
Inside debt-to-assets (non-prot.)			-0.168***	-0.137***
			(-3.47)	(-2.97)
CEO ownership (cent.)	0.017***	0.015**	0.020***	0.018***
	(2.68)	(2.45)	(3.20)	(2.92)
Sq. CEO ownership (cent.)	-0.001*	-0.001	-0.001	-0.000
	(-1.75)	(-1.46)	(-1.53)	(-1.28)
CEO ownership (cent.) × Low sen.			-0.010**	-0.009**
			(-2.38)	(-2.06)
Low sen.			0.036*	0.028
			(1.77)	(1.40)
CEO tenure	-0.002	-0.002	-0.002	-0.001
	(-1.11)	(-0.95)	(-1.04)	(-0.91)
CEO age	-0.001	-0.001	-0.001	-0.001
	(-0.89)	(-0.84)	(-0.82)	(-0.80)
CEO turnover	0.040**	0.034*	0.041**	0.035*
	(2.19)	(1.87)	(2.24)	(1.90)
Size		-0.041***		-0.038***
		(-3.45)		(-3.22)
Market D/E		-0.003		-0.003
		(-0.50)		(-0.47)
Profitability		-0.474***		-0.478***
		(-4.91)		(-5.05)
Year F.E.	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes
Observations	2366	2344	2366	2344
Adjusted R^2	0.56	0.59	0.57	0.59

Table 7: Leverage choice
This table reports panel regressions that use market leverage as dependent variable over the period 2006-2011. Columns 1 and 2 analyze the quadratic relation between market leverage and inside debt protected in bankruptcy, *Inside debt-to-assets (protected)*. Columns 3 and 4 analyze the quadratic relation between market leverage and inside debt non-protected in bankruptcy, *Inside debt-to-assets (non-protected)*. Columns 5 and 6 analyze the quadratic relation between market leverage and *CEO ownership*. Even-numbered columns control also for selected firm characteristics (size and profitability). The explanatory variables are lagged in all specifications. All specifications include Fama-French 17 industry fixed effects and year fixed effects. 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.II for variable definitions.

	Market leverage ($t+1$)					
	(1)	(2)	(3)	(4)	(5)	(6)
Inside debt-to-assets (prot., cent.)	-0.766	-0.674				
	(-1.36)	(-1.33)				
Sq. inside debt-to-assets (prot., cent.)	6.510*	5.202*				
	(1.93)	(1.69)				
Inside debt-to-assets (non-prot., cent.)			-0.086	-0.087		
			(-1.41)	(-1.56)		
Sq. inside debt-to-assets (non-prot., cent.)			0.052	0.043		
			(0.50)	(0.49)		
CEO ownership (cent.)					0.013***	0.008*
					(2.65)	(1.86)
Sq. CEO ownership (cent.)					-0.001**	-0.000
					(-2.57)	(-1.62)
Size		-0.023***		-0.026***		-0.022***
		(-4.32)		(-4.64)		(-3.86)
Profitability		-0.448***		-0.436***		-0.449***
		(-5.22)		(-5.14)		(-5.24)
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1843	1826	1843	1826	1843	1826
Adjusted R^2	0.13	0.25	0.13	0.26	0.14	0.25

Table 8: CDS spreads and CEO firm-specific wealth structure: Robustness

This table reports panel regressions that use log-tranformed 5-year CDS spreads as dependent variable over the period 2006-2011. Columns 1 and 2 use CDS spreads in the quarter following the fiscal year end as dependent variable. Columns 3 and 4 use Fama-French 30 industry fixed effects. Columns 5 and 6 use a measure of CEO ownership based on shares alone, (*CEO stock ownership*). Odd-numbered columns analyze the relation between CDS spreads and CEO firm-specific wealth structure as measured by *Salary-to-assets*, *Inside debt-to-assets*, and *CEO ownership*. Even-numbered take into account the level of protection of inside debt in bankruptcy by including also the following explanatory variables: *Inside debt-to-assets (protected)*, *Inside debt-to-assets (non-protected)*, and the interaction between *CEO ownership* and *Low seniority*, an indicator variable equal to one when the CEO's fraction of ERISA-qualified plans to total inside debt holdings is zero and zero otherwise. All specifications include *Squared CEO ownership* and use demeaned measures of CEO ownership. All specifications include Fama-French 17 industry fixed effects, except columns 3 and 4. All specifications control for year fixed effects, CEO characteristics (age, tenure, and a turnover indicator), and selected firm characteristics (size, debt-equity ratio, and profitability). 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.II for variable definitions.

	Log of CDS spread $(t+1)$		Log of CDS spread (t)			
	(1)	(2)	(3)	(4)	(5)	(6)
Salary-to-assets	4.869*	4.884*	4.154	4.277*	4.933*	4.936**
	(1.88)	(1.93)	(1.60)	(1.68)	(1.95)	(2.00)
Inside debt-to-assets (prot.)	-0.858	-0.669	-0.849	-0.324	-0.897	-0.532
	(-0.83)	(-0.60)	(-0.77)	(-0.28)	(-0.87)	(-0.49)
Inside debt-to-assets (non-prot.)	-0.354**	-0.296**	-0.274**	-0.213	-0.306*	-0.241
	(-2.39)	(-2.02)	(-2.03)	(-1.59)	(-1.93)	(-1.54)
CEO ownership (cent.)	0.066***	0.081***	0.072***	0.082***		
	(3.32)	(4.21)	(3.66)	(4.37)		
CEO ownership (cent.) × Low sen.		-0.040***		-0.031**		
		(-3.34)		(-2.45)		
Sq. CEO ownership (cent.)	-0.003**	-0.003***	-0.003***	-0.003***		
	(-2.51)	(-2.72)	(-2.82)	(-2.82)		
CEO stock ownership (cent.)					0.060***	0.073***
					(2.69)	(3.55)
CEO stock ownership (cent.) × Low sen.						-0.046***
						(-3.66)
Sq. CEO stock ownership (cent.)					-0.002*	-0.002*
					(-1.81)	(-1.76)
Low sen.		0.090		0.158***		0.122**
		(1.59)		(2.79)		(2.14)
Year F.E.	Yes	Yes	Yes	Yes	Yes	Yes
Industry F.E.	Yes	Yes	No	No	Yes	Yes
FF30-industry F.E.	No	No	Yes	Yes	No	No
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2189	2189	2249	2249	2238	2238
Adjusted R^2	0.58	0.59	0.59	0.60	0.57	0.58

Appendix for
"Direct and Indirect Risk-Taking Incentives of Inside Debt"

A Proofs

A.1 Properties of the managerial utility function

Let the managerial utility function be defined as in section 2. The following lemma presents general properties of U with respect to X_T for all possible combinations of model parameters (A, p, D) and θ.

Lemma 1. *For a given value $X_b \geq 0$, denote by $U_1(X_T)$ the branch of the utility function defined for $X_T < X_b$ and by $U_2(X_T)$ the complementary branch defined for $X_T \geq X_b$. Then, U_2 is concave. U_1 is convex if $\gamma \leq 2$ or $\{\gamma > 2$ and $D \leq \frac{2A}{\gamma-2}\}$ and concave 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. The proof is straightforward from calculating the second-order derivatives of $U_1(X_T)$, $U_2(X_T)$ and then solving for the inequalities $U_1''(X_T) \geq 0$ and $U_2''(X_T) \geq 0$. □

A.2 Optimal terminal asset value

Consider the Legendre-Fenchel transform of the manager's static problem 7 in subsection 2.6:

$$\max_{X_T \geq 0} \left[U(X_T) - yM_T X_T\right], \tag{A.1}$$

where $y \geq 0$ is the Lagrangian multiplier associated with the budget constraint $E[M_T X_T] \leq X_0$.

Letting $V(X_T, M_T) = U(X_T) - yM_T X_T$, then in explicit form:

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

At this stage, we just take bankruptcy threshold X_b as a given non-negative constant; later we will show that there exists a unique value of X_b that is internally consistent with the manager's optimal policy. It follows from Lemma 1 that under the assumption $\gamma < 1$, $U(X_T)$ is convex for $X_T \in [0, X_b]$ and concave for $X_T > X_b$, and so is $V(X_T, M_T)$ because $yM_T X_T$ is a linear term.

Given this mixed convex-concave shape of the objective function, we solve the manager's problem by first determining all local maximizers and then evaluating the objective function at each of these local maximizers to find the global maximum. There are at most three candidates: 0, X_b and

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

which is the local maximizer of the concave part of the objective function and is obtained by solving the equation $\partial V/\partial X_T = 0$ for the concave part. By definition, $\bar{X} > X_b$ and therefore $\bar{X}$ is a local maximizer only when

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

The comparison of the objective function at these local maximizers is based on the intermediate results established in Lemmas 2 – 5 below.

Lemma 2. *Let $f(yM_T) = V(\bar{X}, yM_T) - V(X_b, yM_T)$, where $\bar{X}$ is given as in equation A.2 and $yM_T \in (0, y\bar{M})$. Then, $f(yM_T)$ is strictly positive.*

Proof. Given the definition of f and the domain restriction $yM_T \in (0, y\bar{M})$, it follows that

$$\frac{\partial f}{\partial (yM)} = -\frac{1}{p(1-\tau)}\left(\left[\frac{p(1-\tau)}{yM_T}\right]^{1/\gamma} - (A+D)\right) < 0$$

and therefore f is monotonically decreasing in yM_T for $yM_T \in (0, y\bar{M})$. Moreover, 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 every $yM_T \in (0, y\bar{M})$. □

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

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 (which implies $\hat{X}_b = 0$); or (ii) z increases from 0 to some positive maximum value and decreases to $-\infty$ thereafter (which implies that 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 with respect to X_b. Straightforward computations yield

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

Notice that the expression in the square brackets of the right-hand side is decreasing in X_b for $X_b \geq 0$. Under the assumption $\gamma < 1$, it then follows that

$$\frac{\partial z}{\partial X_b} \leq \left.\frac{\partial z}{\partial X_b}\right|_{X_b=0} = \frac{1-\gamma}{(A+D)^\gamma}\left[\frac{D}{\theta} - p(1-\tau)\right]$$

It follows that a necessary and sufficient condition for case (ii) to prevail, i.e., there exists a value $\hat{X}_b > 0$ such that $z(X_b) \geq 0$ for every $X_b \in [0, \hat{X}_b]$ and negative otherwise, is $D/\theta - p(1-\tau) > 0$

or equivalently,

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

□

Lemma 4. *Let* $g(yM_T) = V(\bar{X}, yM_T) - V(0, yM_T)$*, where* $\bar{X}$ *is given as in equation A.2 and* $yM_T \in (0, y\bar{M})$*. Let* $\hat{X}_b$ *be defined as in Lemma 3. Then, when* $X_b \leq \hat{X}_b$*,* $g \geq 0$ *for all* $yM_T \in (0, y\bar{M})$*. When* $X_b > \hat{X}_b$*, there exists a unique threshold* $yM^* \in (0, y\bar{M})$ *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 $g > 0$ *for* $yM_T \in (0, yM^*)$ *and* $g < 0$ *for* $yM_T \in (yM^*, y\bar{M})$*. Moreover,* yM^* *is decreasing in* X_b*.*

Proof. We first observe that g is monotonically decreasing in yM_T for $yM_T \in (0, y\bar{M})$ since

$$\frac{\partial g}{\partial (yM)} = -X_b - \frac{1}{p(1-\tau)}\left[\left(\frac{p(1-\tau)}{yM_T}\right)^{\frac{1}{\gamma}} - (A+D)\right] < 0.$$

Next, straightforward computations show that

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

where $z(X_b)$ is defined as in Lemma 3. Together, this implies that g decreases monotonically from $+\infty$ to $\bar{g}$ as yM_T goes from 0 to $y\bar{M}$. When $X_b \leq \hat{X}_b$, $\bar{g} \geq 0$ (cf. Lemma 3), implying that $g \geq 0$ for all $yM_T \in (0, y\bar{M})$. When $X_b > \hat{X}_b$, $\bar{g} < 0$ (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 $yM_T > yM^*$. yM^* is obtained by solving the equation $g(yM_T) = 0$ which is given in equation (A.5). 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) such that

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

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 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. ☐

Lemma 5. *Define $h(yM_T) = V(X_b, yM_T) - V(0, yM_T)$, where $yM_T \geq y\bar{M}$. Let $\hat{X}_b$ be defined as in Lemma 3. Then, when $X_b > \hat{X}_b$, $h(y\bar{M}) < 0$ for every $yM_T \geq y\bar{M}$. When $X_b \leq \hat{X}_b$, there exists a unique value $yM^{**} \geq y\bar{M}$ defined as*

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

such that $h \geq 0$ for $yM_T \in (y\bar{M}, yM^{**})$ and $h < 0$ for $yM_T > yM^{**}$. Moreover, yM^{**} is decreasing in X_b.

Proof. We first observe that $\partial h/\partial(yM) = -X_b$. This means that for any $X_b > 0$, h is monotonically decreasing in yM_T. For every $yM_T \geq y\bar{M}$, it holds that

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

It is then straightforward to verify that when $X_b > \hat{X}_b$, $h(y\bar{M}) < 0$, implying that $h < 0$ for every $yM_T \geq y\bar{M}$. 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. yM^{**} is obtained by solving the equation $h(yM_T) = 0$ which is given in (A.6). 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,

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

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 $X_b > 0$. ☐

Proof of Proposition 1. We are now ready to compute the optimal policy of the manager. We first state our preliminary result concerning the local maximizers of the manager's utility function: when $yM < y\bar{M}$, local maximizers are $\{0, X_b, \bar{X}\}$; when $yM \geq y\bar{M}$, local maximizers are $\{0, X_b\}$. We then need to compare the objective function at each of these local maximizers to determine the global maximizer of the manager's utility function. Given our previous results, we have to consider two cases: $yM < y\bar{M}$ and $yM \geq y\bar{M}$.

Case 1: $yM < y\bar{M}$. In this case we have to compare the objective function evaluated at the maximizers $\{0, X_b, \bar{X}\}$. We compare first X_b and $\bar{X}$. Clearly $\bar{X}$ is preferred to X_b if $f(yM_T) = V(\bar{X}, yM_T) - V(X_b, yM_T) > 0$. Given the result of Lemma 2 we know that $f(yM_T) > 0$ for all $yM_T < y\bar{M}$ and therefore we conclude that $\bar{X}$ is preferred to X_b. Then, we have to compare $\bar{X}$ and 0. Clearly, $\bar{X}$ is preferred to 0 if $g(yM_T) = V(\bar{X}, yM_T) - V(0, yM_T) > 0$.

From Lemma 4 we know that when $X_b \leq \hat{X}_b$ (where $\hat{X}_b$ is defined in Lemma 3), then $g \geq 0$ for all $yM_T \in (0, y\bar{M})$ and therefore, $\bar{X}$ is preferred to 0 over the same interval of yM_T. When instead $X_b > \hat{X}_b$, there exists a unique $yM^* \in (0, y\bar{M})$ such that $g > 0$ for $yM_T < yM^*$ and $g < 0$ for $yM_T > yM^*$. As a result, $\bar{X}$ is preferred to 0 for $yM_T < yM^*$ and 0 is preferred to $\bar{X}$ for $yM_T > yM^*$. At $yM_T = yM^*$, the manager is indifferent between 0 and $\bar{X}$.

Case 2: $yM \geq y\bar{M}$. In this case we have to compare the objective function evaluated at the maximizers $\{0, X_b\}$. X_b is preferred to 0 if $h(yM_T) = V(X_b, yM_T) - V(0, yM_T) > 0$. From Lemma 5 we know that when $X_b > \hat{X}_b$, then $h < 0$ for every $yM_T \geq y\bar{M}$. Thus, in this case, 0 is preferred to X_b over the whole interval $(y\bar{M}, \infty)$. Instead when $X_b \leq \hat{X}_b$ there exists a unique value $yM^{**} \geq y\bar{M}$ such that $h \geq 0$ for $yM_T \leq yM^{**}$, and $h < 0$ otherwise. Therefore, in this case, X_b is preferred to 0 for $yM_T \in [y\bar{M}, yM^{**})$ and 0 is preferred to X_b for $yM_T > yM^{**}$; at $yM_T = yM^{**}$, the manager is indifferent between X_b and 0.

Putting together results of Case 1 and Case 2, we can summarize the optimal choice of terminal asset value, denoted by X_T^*, 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 (*A*.5) 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 in (*A*.6) 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 $yM_T > yM^{**}$.

To complete the proof it remains to show that there exists a unique value of bankruptcy threshold X_b solving the equation

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

where

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

with X_T replaced by X_T^*. Since X_T^* can take only one of three values $\{\bar{X}, X_b, 0\}$ and $\bar{X} \geq X_b$ the only case where $X_T^* < X_b$ is when $X_T^* = 0$. The previous equation thus reduces to

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

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

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

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

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

and that $\lim_{\{X_b \to +\infty\}} \chi(X_b) = +\infty$. These facts together imply that there exists a unique value $X_b^* \in [F, \infty)$ such that $\chi(X_b^*) = 0$.

□

A.3 Optimal dynamic risk-taking

Before calculating the optimal volatility of the firm's assets, we have to compute the expected value of future cash flow. To this purpose, we state here the following useful results. 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 $\mu_Y = \mathbb{E}[\ln(Y)]$, $\nu_Y^2 = Var(\ln(Y))$, $N(x)$ 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

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

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

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

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

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

Thus,

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

where

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

Proof of Proposition 2. The current value of firm's assets X_t, $t \in [0, T)$ is given by

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

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

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

where

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

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

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

where

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

Putting together all computations, we obtain the asset value X_t as in the Proposition. The optimal volatility then follows by applying the Ito's on X_t and comparing coefficients with equation (2). □

B Data appendix

B.1 Validation of the text-based measure of inside debt seniority

In this section, we validate the text-based measure of inside debt seniority used in this paper against actual information provided in SEC filings. We start by identifying a random sample of 20 companies with inside debt using data available for at least three consecutive fiscal years. For each of these firms, we read through their DEF 14A forms and collect information about compensation agreements. These 20 companies provide a rather complete description of inside debt funding and lump-sum options. To capture as comprehensively as possible the descriptive information in SEC filings, we follow Anantharaman, Fang, and Gong (2014). Namely, we collect information about the presence of qualified and non-qualified pension plans, deferred compensation plans and lump-sum options related to non-qualified pension plans and deferred compensation, as well as information about the use of trusts such as rabbi and secular trusts. Regarding the latter variables, i.e., rabbi and secular trusts, it is worth noting that disclosure about the use of these trusts is not compulsory (see, e.g., Gerakos, 2007).[26] Furthermore, we hand-collect data about the CEO normal retirement age, which we assume to be 65 when missing. We compute each CEO's time-to-death based on the Center for Disease Control's National Vital Statistics Reports.[27] Detailed definitions of the variables used in this appendix are given in Table A.II.

Panel A of Table A.I reports information on several features of inside debt such as qualified and non-qualified pension plans and deferred compensation. These results suggests that all the CEOs in our random sample receive deferred compensation plans as part of their remuneration, and in 84% of cases they are allowed to withdraw such plans as a lump-sum. Furthermore, 91% of CEOs are granted non-qualified pension plans, i.e., SERPs, that in 85% of cases admit lump-sums options. Only 22% of the sample disclosed the use of trusts, and only 11 firm-years provide detailed information about the type of trusts. Finally, data shows that 72% of the CEOs are awarded ERISA-qualified pension plans, i.e., rank-and-file plans.

To validate our text-based measure of inside debt's protection in bankruptcy, first, we check

[26] We acknowledge that this might pose self-selection bias issues.

[27] These data are available only from 2001 to 2009, thus we assume that the life tables for 2010-2011 are the same as in 2009, given the high persistence of demographic series.

that the text-based algorithm correctly classifies qualified and non-qualified pension plans, finding an extremely low error rate. Second, we estimate the duration of inside debt following Anantharaman, Fang, and Gong (2014), but relative to firms' debt maturity rather than to loans' maturity. We combine retirement age, current non-qualified pension plan balances and discount rates, and published life expectancy tables to estimate the Macaulay duration for each non-qualified pension plan, which reflects the weighted average time-to-maturity of non-qualified pension plan projected cash flows. With regards to non-qualified pension plans with lump-sum options, we compute the duration assuming that the entire non-qualified pension plan balance is paid one year after retirement. A similar assumption is made about deferred compensation. Moreover, for those companies with both non-qualified pension plans and deferred compensation, we compute the overall duration of debt-like claims by weighting the duration of non-qualified pension plans and deferred compensation by their accrued balances. Finally, we build a variable equal to the ratio of inside debt duration and debt maturity, and examine how this indicator (*Duration ratio*) correlates with our text-based measure of inside debt seniority. Panel B of Table A.I reports summary statistics about the variables used to estimate this ratio. Interestingly, CEO debt-like compensation has a lower duration than the outside debt (debt maturity), as *Duration ratio* exhibits a mean of 0.18.

Panel C of Table A.I shows that our inside debt seniority measure exhibits a negative and statistically significant correlation both with the duration of inside debt and its duration relative to firm's debt. Given that *Duration ratio*, as proposed by Anantharaman, Fang, and Gong (2014), is supposedly negatively correlated with actual inside debt seniority, we can argue that our text-based measure is indeed a good proxy. Though we recognize that *Duration ratio* is probably a less noisy estimate of seniority, our text-based measure can be computed very easily, without any need to hand-collect data. We thus believe that it might be useful for future research on inside debt.

B.2 Definitions of variables

See Table A.II.

Table A.I: Validation of the text-based measure of inside debt seniority

This table reports the validation of our text-based measure of inside debt seniority against information disclosed in SEC DEF 14A forms. We hand-collect data on inside debt's features and funding in bankruptcy for a random sample of 20 firms with data available for at least three consecutive fiscal years. Panel A reports information on several features of inside debt holdings. All of the variables are indicators equal to one if the CEO's compensation package features the given provision. Only for *Non-qualified pension plan with trust* the dummy variable assumes value equal to one whe the DEF 14A discloses in the presence of a secular trust and zero in the presence a rabbi trust. Panel B reports summary statistics of all variables employed in the validation analysis. Panel C reports the correlation matrix between several inside debt duration measures and our text-based measure of inside debt seniority. Significance at the 10%, 5%, and 1% levels are indicated by *, **, ***, respectively. Refer to Table A.II for variable definitions.

Panel A: Inside debt's characteristics

	= 1	= 0
Pension plan	101	5
Qualified pension plan	76	30
Non-qualified pension plan	96	10
Non-qualified pension plan with trust	23	83
Non-qualified pension plan with trust [=1 (Secular) =0 (Rabbi)]	5	6
Non-qualified pension plan with lump-sum option	90	16
Non-qualified pension plan trusts and lump-sum option	11	95
Deferred compensation plan	106	0
Deferred compensation with lump-sum option	89	17

Panel B: Summary statistics

	Obs.	Mean	Std. Dev.	Min.	Max.
CEO age	106	55.30	5.24	40.00	69.00
Time-to-retirement (years)	106	9.71	5.15	0	25.00
Time-to-death (years)	106	25.40	4.55	14.85	37.77
CEO after-retirement horizon (years)	106	3.15	5.14	1.00	17.11
Inside debt holdings (thousands)	106	14,649.91	16,134.14	33.53	81,128.84
Pension value (thousands)	106	9,615.01	10,526.16	-	40,112.54
Pension value (non-protected) (thousands)	106	8,729.38	10,220.26	0	39,511.87
Deferred compensation (thousands)	106	4,874.42	8,713.60	0	46,635.11
Debt maturity (years)	102	6.65	1.58	1.28	10.00
Duration non-qualified plans	79	0.90	0.29	0.43	1.86
Duration deferred compensation	70	2.88	3.53	0	17.68
Duration (inside debt)	91	1.14	0.65	0	2.83
Duration ratio (non-qualified pension plan)	77	0.15	0.07	0.06	0.43
Duration ratio (deferred compensation)	68	0.44	0.52	0	2.57
Duration ratio	89	0.18	0.12	0	0.54
Text-based inside debt seniority	86	0.15	0.27	0	1.00

(Continued)

Table A.I: – *Continued*

Panel C: Correlation matrix	1	2	3	4	5	6	7
1 Duration (non-qualified plans)	1						
2 Duration (deferred compensation)	-0.157	1					
3 Duration (inside debt)	0.479***	0.537***	1				
4 Duration ratio (non-qualified plans)	0.608***	-0.248	0.263*	1			
5 Duration ratio (deferred compensation)	-0.151	0.979***	0.552***	-0.119	1		
6 Duration ratio	0.408***	0.361**	0.862***	0.701***	0.468***	1	
7 Text-based measure of inside debt seniority	-0.0941	-0.239	-0.423***	0.18	-0.23	-0.284*	1

Table A.II: Definition of variables

Variable	Definition
CDS spread	Average of daily five-year U.S. dollar denominated CDS spreads over the last quarter of the fiscal year from Markit. We consider only CDS on unsecured debt (`tier=snrfor`). We do not put any restriction on the documentation clause.
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 fiscal year.
Z-score	Altman's Z-score defined as `−3.3 × (pi/at) − (saleq/at) − 1.4 × (re/at) − 1.2×(act−lct)/at) − 0.6×(prcc_f× csho)/lt)` in Compustat.
Modified Z-score	MacKie-Mason (1990) modified Altman's Z-score defined as `−3.3 × (pi/at) − (sale/at) − 1.4 × (re/at) − 1.2×(act−lct)/at)` in Compustat.
Market leverage	Market leverage defined as `(dlc+dltt)/(prcc_f×csho+at−ceq)` in Compustat.
Salary-to-assets	Salary component defined as `salary` from Execucomp scaled by total assets (`at`) in Compustat.
Inside debt-to-assets	Inside debt component defined as the sum of `defer_balance` and `pension_value` from Execucomp scaled by total assets (`at`) from Compustat. We set inside debt holdings to zero when missing.
Inside debt-to-assets (protected)	ERISA-qualified pension plans scaled by total assets (`at`) in Compustat.
Inside debt-to-assets (non-protected)	Inside debt holdings that are not ERISA-qualified pension plans scaled by total assets (`at`) in Compustat.
CEO ownership	CEO 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, 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.
CEO stock ownership	CEO ownership non-adjusted for CEO's option portfolio delta.
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`.
Low seniority	Indicator equal to one if *Inside debt seniority* is zero.
Incentive ratio	Incentive measure defined as the ratio of *Inside debt-to-assets* to the product of *Inside debt seniority* and *CEO ownership*.
CEO tenure	Number of years since the executive was appointed as CEO based on `becameceo` in Execucomp. 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.
CEO turnover	Indicator equal to one if the CEO changes in the current fiscal year.
Size	Natural logarithm of real sales (`sale`) in Compustat.
Market D/E	Debt-to-equity ratio defined as `dlc+dltt/(prcc_f×csho)` in Compustat.
Profitability	Profitability defined as `(ib+dp)/at(t−1)` in Compustat.
NBER recession	Indicator equal to one if a period belongs to a recession period according to the National Bureau of Economic Research (NBER) from FRED.
CFNAI slowdown	Indicator equal to one if a period is characterized by negative CFNAI (from FRED), i.e., below-average growth.
Output gap	Output gap defined as the difference between real actual GDP and real potential GDP scaled by real potential GDP.
CEO retirement age	CEO normal retirement age collected from SEC DEF 14A forms. If missing, it is assumed to be equal to 65.
Time-to-retirement	Difference between *CEO retirement age* and *CEO age*.

(Continued)

Table A.II: – *Continued*

Time-to-death	Difference between CEO life expectancy (based on life tables by the Center for Disease Control's National Vital Statistics Reports) and *CEO age*.
CEO after-retirement horizon	Difference between *Time-to-death* and *Time-to-retirement*, except for SERPs with lump-sum options and for ODC plans, for which we assume that the entire amount is paid one year after retirement, in line with Anantharaman, Fang, and Gong (2014).
Pension discount rate	Pension discount rate defined as `pbarr` from Compustat.
Duration (inside debt)	Macaulay duration of CEO inside debt holdings computed following Anantharaman, Fang, and Gong (2014). We also compute it separately for non-qualified pension plans and deferred compensation plans.
Debt maturity	Firm's debt maturity defined as (dd1+dlc+2×dd2+3×dd3+4×dd4+5×dd5+(dltt−dd2−dd3−dd4−dd5)×10)/(dltt+dlc) from Compustat. We assume an average maturity of 10 years for debt maturing in more than five years.
Duration ratio	Duration of inside debt relative to firm's debt maturity defined as *Duration* (*inside debt*)/*Debt maturity*. We also compute it separately for non-qualified pension plans and deferred compensation plans.

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