

Colonnello, Stefano; Curatola, Giuliano; Ngoc Giang Hoang

Working Paper

Direct and indirect risk-taking incentives of inside debt

IWH Discussion Papers, No. 20/2016

Provided in Cooperation with:

Halle Institute for Economic Research (IWH) – Member of the Leibniz Association

Suggested Citation: Colonnello, Stefano; Curatola, Giuliano; Ngoc Giang Hoang (2016) : Direct and indirect risk-taking incentives of inside debt, IWH Discussion Papers, No. 20/2016, Leibniz-Institut für Wirtschaftsforschung Halle (IWH), Halle (Saale), <https://nbn-resolving.de/urn:nbn:de:gbv:3:2-57815>

This Version is available at:

<https://hdl.handle.net/10419/142256>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Discussion Papers

No. 20

June 2016



Direct and Indirect Risk-taking Incentives of Inside Debt

Stefano Colonnello, Giuliano Curatola, Ngoc Giang Hoang

Authors

Stefano Colonnello

Corresponding author

Otto-von-Guericke University Magdeburg and
Halle Institute for Economic Research (IWH) –
Member of the Leibniz Association
Department of Financial Markets
E-mail: Stefano.Colonnello@iwh-halle.de
Tel +49 345 7753 773

Giuliano Curatola

Goethe University Frankfurt, Faculty of
Economics and Business Administration,
House of Finance
E-mail: curatola@safe.uni-frankfurt.de

Ngoc Giang Hoang

Independent

The responsibility for discussion papers lies solely with the individual authors. The views expressed herein do not necessarily represent those of the IWH. The papers represent preliminary work and are circulated to encourage discussion with the authors. Citation of the discussion papers should account for their provisional character; a revised version may be available directly from the authors.

Comments and suggestions on the methods and results presented are welcome.

IWH Discussion Papers are indexed in RePEc-EconPapers and in ECONIS.

Editor

Halle Institute for Economic Research (IWH) –
Member of the Leibniz Association

Address: Kleine Maerkerstrasse 8
D-06108 Halle (Saale), Germany
Postal Address: P.O. Box 11 03 61
D-06017 Halle (Saale), Germany

Tel +49 345 7753 60
Fax +49 345 7753 820

www.iwh-halle.de
ISSN 2194-2188

Direct and Indirect Risk-taking Incentives of Inside Debt*

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 (CDS) contracts, we provide evidence supportive of the model's predictions.

Keywords: inside debt, credit spreads, risk-taking

JEL Classification: G32, G34

* A previous version of the paper circulated under the title "Executive Compensation Structure and Credit Spreads". We would like to thank Laurent Bach, Pascal Busch, Pierre Collin-Dufresne, Michel Dubois, Matthias Efung, Rüdiger Fahlenbrach, Harald Hau, Nataliya Klimenko, Jules Munier, Erwan Morellec, Kjell G. Nyborg, Jean Charles Rochet, René M. Stulz, Anders B. Trolle, Philip Valta, Toni Whited, Qunzi Zhang, and seminar participants at the International Paris Finance Meeting, the Annual Swiss Doctoral Workshop, the SFI Ph.D. Financial Intermediation and Stability Workshop, the University of Zurich, and the 21st Annual Meeting of the German Finance Association (DGF) & 13th Symposium on Finance, Banking, and Insurance for insightful discussions and comments. Giulia Fantini provided valuable research assistance. We are grateful to Jan Benjamin Junge for sharing data and code. We gratefully acknowledge financial support from the Center of Excellence SAFE, funded by the State of Hessen initiative for research LOEWE.

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.

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 being probably 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 (salary, bonus, equity awards, inside debt etc.), each providing different risk-taking incentives. We argue that not only the *direct* risk-taking incentives of inside debt need to be considered, but also their interactions with other compensation components. 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 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

¹Since our model does not distinguish between the different determinants of the recovery rate in

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 secured, absorbs the fluctuations of the 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 of this trade-off, our model predicts a positive and concave relation between the credit spread and CEO ownership. Such a relation becomes stronger as the seniority of inside debt increases.

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 period 2006-2011. It is worth noting that we do not aim at providing causal evidence. Our empirical approach, indeed, 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 show that salary is positively correlated with CDS spreads, our proxy for credit spreads. We 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 ([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 subject to a high risk of forfeiture in bankruptcy. 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 2006-2008 using a measure of inside debt seniority based on the relative duration of executive pensions and loans. Our analysis, being based on marked-based credit spreads, allows us to study firms' cost of public debt at any time point in time. Then, we also demonstrate that the relation between CEO ownership and CDS spreads is generally positive and concave. This relation, as conjectured, is weaker in the presence of low-seniority inside debt.

default, we will use the terms "secured inside debt" and "high-seniority inside debt" interchangeably. Similarly, we will use the terms "unsecured inside debt" and "low-seniority inside debt" interchangeably.

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. More precisely, when inside debt is high, the positive relation between the credit spread and CEO ownership is stronger in bad times. For low inside debt, instead, the negative relation between the credit spread and CEO ownership is predicted not to vary substantially across different states of the world. We provide evidence compatible with these time-series implications. Furthermore, our model 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. Such a region endogenously arises only when the ratio of low-seniority inside debt to ownership is sufficiently high. Also in this case, we provide evidence consistent with our model by studying default risk, as proxied by the Altman's Z-score. Finally, though not solving the firm's optimal leverage problem, we discuss the possible implications of our model for the CEO's choice of leverage. We expect a U-shaped relation between high-seniority inside debt and leverage to arise. Such a relation is arguably weaker for low-seniority inside debt, whereas an inverted U-shaped relation possibly holds for CEO ownership. We empirically confirm these patterns by examining market leverage.

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 two components only, 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.² On the empirical side, several studies provide evidence pointing to a mitigating role of inside debt for 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

²Some recent theoretical studies examine the impact deferred compensation on the alleviation of excessive risk-taking ([Leisen, 2013](#); [Inderst and Pfeil, 2013](#); [Feess and Wohlschlegel, 2012](#)).

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,³ 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 compensation structure in its entirety, as the interactions between different compensation components, especially when inside debt is large and unsecured, may result in the unintended effect of encouraging risk-shifting.

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 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.

³Most 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

$$\frac{dM_t}{M_t} = -r dt - \alpha dZ_t, \quad M_0 = 1, \quad (1)$$

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

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

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

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 a part of its asset with debt by issuing a zero-coupon bond at discounted price B_0 for a payment of face value F at time T , then current regulation allows for the interest expense, $F - B_0$, to be deducted from the corporate taxable income.

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

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

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

$$X_b = F + \frac{\tau}{1 - \tau} B_0. \quad (3)$$

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

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

2.3 Valuation of stock and bond

2.3.1 Stock

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

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

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

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

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

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

2.3.2 Bond

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

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

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

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

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

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

we arrive at a fixed point problem since the second term in the right-hand side itself depends on X_b . In Appendix A we prove that rational expectation equilibrium conditions ensure that this fixed point 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 compensation which the manager receives in full or in part depending on whether the firm is solvent at the terminal date.

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

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

where

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

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

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

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

paper, we refer to parameter θ as the effective seniority or risk of forfeiture of inside debt, where a higher effective seniority implies a lower risk of forfeiture and vice versa.⁶

Suppose 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 CEO's utility function has constant relative risk-aversion γ with respect to wealth:

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

Notice that $U(\pi_T)$ is globally concave in π_T but not necessarily so in X_T . In particular, for any given value of the bankruptcy threshold X_b , it is possible to show that when $X_T \geq X_b$, $U(X_T)$ is strictly concave in X_T , while when $X_T < X_b$, $U(X_T)$ it can be either convex or concave depending on the 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, 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 the bankruptcy threshold X_b (see Appendix A). This assumption simplifies the mathematical analysis of the model and also allows a direct comparison of our results with those of [Carlson and Lazrak \(2010\)](#). 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 that, once appointed to the position, has full discretion over the choice of firm risk, σ , which he/she dynamically and continuously controls along the life of the asset. It is worth noting that we do not model the optimal choice of managerial 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

⁶In this setup, we have implicitly assumed that the source of payment for inside debt is kept in a separate account and the terminal asset value X_T is to be shared between shareholders and bondholders only. The balance of this inside debt account, however, is sensitive to both the occurrence and the severity of bankruptcy event, as well as the effective seniority of inside debt in bankruptcy (governed by parameter θ). This specification retains most of realistic features of inside debt while making the problem more tractable and easier to solve.

perfectly observable along the horizon. A similar optimal policy, with separation of the state space into three regions, is also obtained by [Basak and Shapiro \(2005\)](#), but in a different context.⁷ Throughout this paper, we impose rational expectation conditions so that shareholders, bondholders, and the manager correctly anticipate optimal choices of each other and reflect that in the valuation of corporate securities. 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:

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

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

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

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.

⁷[Basak and Shapiro \(2005\)](#) 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 case of default, the agent incurs fixed and variable costs proportional to the amount of debt left unpaid. Our approach differs for several reasons. First, unlike [Basak and Shapiro \(2005\)](#), we assume separation between ownership and control, which allows us to study the relation between compensation packages and managerial risk-taking behavior. Second, we consider the tax benefit of debt and therefore the default threshold is endogenous in our model. Third, since the agent/borrower of [Basak and Shapiro \(2005\)](#) incurs bankruptcy costs, optimal terminal wealth in the default region cannot be zero. By contrast, in our model, optimal terminal wealth is zero when default occurs, thus producing important differences in terms of risk-taking incentives.

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

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

where \hat{X}_b is a constant that depends on the contract's parameters and $y\bar{M}$, yM^* and yM^{**} (all defined in Appendix A) are thresholds of the state-price density that divide the state space into the three regions relevant for the manager. X_b^* is the unique solution of the non-linear equation:

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

Proof. See Appendix A. □

To gain further insights on 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 of the world and zero otherwise. The intuition for this result is the following: 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 time.

The presence of inside debt modifies the manager's payoff in bad times and, thus, changes the optimal choice of risk. While a manager with zero inside debt chooses to stay above the bankruptcy threshold in very good states and to default in bad states, 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 only chooses to default when the situation further deteriorates (i.e., when the state-price density M_T is sufficiently large).⁸

In other words, 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 quite high and the manager may have an incentive to accept default more often and to increase 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

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

(see the proof of Proposition 1 in conjunction with Lemma A.1). 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 has to be 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 the managerial compensation may not produce the intended result of lowering the probability of firm’s default if the seniority is not low enough.

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

Proposition 2. *Given the optimal terminal value of firm’s assets, the current value of assets is given by*

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

⁸Since 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 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, $N(\cdot)$ and $\phi(\cdot)$ 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 firm's risk determines the probability of default and, thus, the payoff of bondholders⁹

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

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 :

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

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

⁹Note that in our current setup, similar to [Carlson and Lazrak \(2010\)](#), the manager also optimally chooses zero liquidation value in bankruptcy so the dead-weight cost δ does not matter. Therefore the impact of inside debt on credit spreads and related variables will be seen through its impact on default probability, but not on recovery value. An extended model where the manager's utility is not universally convex in the default area will result in a positive recovery value in bankruptcy. Inside debt may play a role in determining the liquidation value in such case as well (see [Edmans and Liu, 2011](#)).

free rate r :

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

2.7 Empirical implications

2.7.1 Calibration parameters

For model parameters, we set the risk-free rate at $r = 1.65\%$ per year, which is the simple average of (annualized) U.S. 3 month T-bill rates for the period 2002 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%.¹⁰ 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 about 30%. Finally, we consider a moderately risk-averse manager with $\gamma = 0.6$. The analysis about the optimal policy is done for an arbitrary time $t = 1$.¹¹ To capture the variation in aggregate conditions, we let the state-price density M vary between 0.7 in good times and 1.5 in bad times, respectively below and above 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 equity ownership. Salary and inside debt are divided by total assets, consistent with the normalization of $X_0 = 1.0$. Equity ownership accounts also for option holdings. We consider the interquartile range as range of variation. Salary (inside debt) can vary from 0.006% (0.010%) to 0.025% (0.141%) of total assets. Equity ownership can vary from 0.273% to 1.186%. We let the effective seniority θ vary such that we obtain recovery rates ranging from 1% to 70%, consistent with the observed seniority of inside debt.

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 the state-price

¹⁰This data is provided by Aswath Damodaran at New York University, available for download at <http://people.stern.nyu.edu/adamodar/>.

¹¹The particular value of t is not important for the analysis, although as t gets closer to the terminal date T , all effects discuss below become less significant.

density $M = 1$, which corresponds to its initial value. The case of salary (Panel A) is clear and intuitive: Both optimal volatility of firm's assets and credit spreads increase with salary (to draw the figure we keep inside debt and CEO ownership constant at their median values). This result depends on the insurance effect of salary and is consistent with [Carlson and Lazrak \(2010\)](#).

The role of inside debt (Panel B) depends on its seniority: Asset volatility and the credit spread are decreasing in unsecured inside debt (to draw the figure we keep salary and CEO ownership constant at their median values). However, when the seniority of inside debt increases, asset volatility and the credit spread become less sensitive to changes in inside debt. Indeed, only secured inside debt is effective in aligning the incentive of the manager with those of bondholders, because it exposes managers and bondholders to the same risk. In contrast, secured inside debt tends to act as salary.¹² The relation between 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 may be much lower than contractual seniority, thus, dampening the risk-reducing role of inside debt.

Panel C depicts the relation between CEO ownership, asset volatility and credit spreads for the median level of inside debt. We observe that this relation is not monotone: Asset volatility and credit spreads increase with CEO ownership initially and then level off, depending on the value on inside debt seniority. To understand this result, it is useful to first recall the relation between asset volatility and CEO ownership when a risk-averse manager is only paid with salary and equity (see, e.g., [Carlson and Lazrak, 2010](#)). In this case, asset volatility and credit spreads decrease with CEO ownership. As a result, an increase in the CEO ownership produces two counteracting forces. On the one hand, the firm's equity is a call option on the value of firm assets. Therefore, the manager has the incentive to increase asset volatility to increase the value of equity and, in turn, the expected value of his/her compensation. However, the higher asset volatility, the higher is the volatility of manager's compensation. A risk-averse manager will trade-off the two opposite effects generated by ownership. The introduction of inside debt reduces the volatility of manager's compensation and, thus, reduces utility losses caused by higher

¹²We even find that, for an arbitrary high recovery rate (99%), asset volatility and credit spread are both increasing in inside debt. We do not report this case in the figures because we do not observe a recovery rate of 99% in our sample, but results are available upon request.

asset volatility. As a result, for low values of equity ownership the manager can increase asset volatility in reaction to higher fraction of equity compensation and the more so the higher is the recovery rate of inside debt. When CEO ownership is high, increasing asset volatility would be particularly penalizing in term of utility for the CEO, thus, inducing a more prudent behavior.

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 throughout 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 stabilizing 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, the negative relation between the credit spread and CEO ownership debt, 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. Since 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.

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

$$\ln(\text{Credit spread})_{i,t} = \beta_1 \cdot \text{Salary}_{i,t} + \beta_2 \cdot \text{Inside debt}_{i,t} + \beta_3 \cdot \text{Ownership}_{i,t} + \theta \cdot \text{Controls}_{i,t} + v_j + \nu_t + \epsilon_{i,t}, \quad (9)$$

where the subscripts i , j , and t indicate firm, industry, and fiscal year, respectively. $\text{Credit spread}_{i,t}$ is the firm’s CDS spread. We take the natural logarithm to alleviate skewness in CDS spreads. $\text{Salary}_{i,t}$ and $\text{Inside debt}_{i,t}$ are normalized by the firm’s total assets, similarly to our model parameters A and D in the comparative statics analysis. Even though option holdings are not modeled in our theoretical framework, we measure $\text{Ownership}_{i,t}$, the empirical counterpart of p , as the effective ownership based on shares and options held by the CEO. $\text{Controls}_{i,t}$ 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 v_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:

$$\begin{aligned} \ln(\text{Credit spread})_{i,t} = & \beta_1 \cdot \text{Salary}_{i,t} + \beta_2 \cdot \text{Inside debt (protected)}_{i,t} + \\ & \beta_3 \cdot \text{Inside debt (non-protected)}_{i,t} + \beta_4 \cdot \text{Ownership}_{i,t} + \\ & \beta_5 \cdot \text{Ownership}_{i,t} \times \text{Low seniority}_{i,t} + \\ & \theta \cdot \text{Controls}_{i,t} + v_j + \nu_t + \epsilon_{i,t}. \end{aligned} \quad (10)$$

$Low\ seniority_{i,t}$ 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 Hypotheses 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. Hypotheses 3 suggests that the positive relation between credit spreads and ownership should be weaker in the presence of a higher fraction of 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 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. Even though the measurement of asset risk is controversial and an in-depth analysis of asset risk goes beyond the scope of this paper, we provide some 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 modify both asset risk and leverage. In this supplementary battery of tests, hence, we 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, as the new enhanced disclosure requirements of the U.S. Securities and Exchange Commission (SEC) about executive pensions and deferred compensation were first enforced for 2006 fiscal year-end. We obtain CEO compensation data from Standard and Poor’s Execucomp, accounting 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 such 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 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 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

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 such phenomenon has been recorded so far.

¹⁴On a certain day we might have multiple CDS spreads for a given firm, because of CDS trading with more than one documentation clause, i.e. the definition of the credit event. In these cases we take the average spread for that date. In other words, we do not put any restriction about the documentation clause.

¹⁵We 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.

¹⁶Although 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.

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 and vega, thanks to the enhanced SEC disclosure requirements introduced in 2006. This is important because in a period of widespread stock price declines such as 2007-2009, the one-year approximation method might deliver severely biased estimates, as it neglects underwater options ([Core and Guay, 2002](#)).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 (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 us finding evidence supportive of 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 \(2014\)](#).

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

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

Macroeconomic conditions. In our time-series tests, we focus on changes in CEO incentives across different states of the world. To this end, we focus on changes in macroeconomic conditions. Indeed, in our model, aggregate risk is the only explicitly modeled source of risk and drives both the pricing kernel and firm value. We use the three-month moving average of the Chicago Fed National Activity Index (CFNAI). We classify a period as in a bad macroeconomic state if the CFNAI is negative, i.e., below-average growth. Finally, 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*. Such a 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 substantial fraction of the median CEO firm-specific wealth: Roughly 15% and 5%, respectively. Figure 6 also shows that the distribution of seniority is concentrated around 0%. Because of this, 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

¹⁹Table 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. Such an 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

variables are winsorized at the 1st and 99th percentile. Detailed definitions of the variables are given in Table A.2. All dollar amounts are expressed in 2010 dollars.

3.3 Main results

Table 3 presents results about our cross-sectional hypotheses. We estimate equation (9), which relates CDS spreads to 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”, namely 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 include also selected firm characteristics (size, debt-equity ratio, and profitability). In column 4, we allow for a quadratic relation between CDS spreads and ownership by including *Squared CEO ownership*. In column 5, we estimate the same specification but using demeaned *CEO ownership* to allow for an easier interpretation of the quadratic relation.

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 aligning managerial interests with those of bondholders. The positive and statistically significant coefficient on CEO ownership is consistent with Hypothesis 3. Interestingly, *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. Such a trade-off can explain the observed concave relation.

These results are also economically important. As CDS spreads are log-transformed,

debt holdings are zero, we address potential concerns about this assumption.

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

the estimated coefficients should be interpreted as semi-elasticities. Based on the estimates in column 3, thus, a one-standard-deviation increase in *Salary-to-assets* is associated with a 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 Hypotheses 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 set of control variables and fixed effects and also allow for 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 includes also 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 and the more so the higher is the recovery rate of inside debt. 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 so when also equity incentives are low. To ensure that we capture a meaningful interaction between these different forms of compensation, below we examine it 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 implica-

tions. 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 to 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. Both in the presence of 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 only available at 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*. In order not to have CEOs 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*.²¹

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.²²

²¹We obtain qualitative similar results using quintiles and terciles (unreported).

²²Given the rich set of fixed effects, we choose not to include other control variable to avoid issues

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 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.²³

3.4.2 Default risk

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

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

with “bad controls”.

²³In columns 2 and 4, *CFNAI slowdown* is absorbed by quarter fixed effects.

Empirically, in line with our calibration exercise, we proxy for D , θ , and p by 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.

By 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 only include 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).²⁴ 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., $D(1 + \theta p)^{-1}$.

3.4.3 Asset risk

We investigate how cross-sectional variation in asset risk is related to CEO firm-specific wealth structure. As pointed out 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 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, a higher leverage would increase the value of equity through tax benefits and therefore

²⁴In this case, we control also for the market debt-equity ratio, because the measure proposed by MacKie-Mason (1990) does not include it.

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 with salary and equity only. 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 two compensation components only and therefore the impact of compensation on the optimal manager’s choices can be summarized by one variable only, namely the cash-to-equity ratio. By contrast, in our model the manager is rewarded with three compensation components, namely cash, equity and inside debt, and therefore it does not exist a 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 discuss intuitively 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 implications for leverage choices similar to salary. 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 than for secured inside debt. When 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. Yet, 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 measuring CDS spreads in the quarter following the fiscal year end. In columns 3 and 4, we check if our results are sensitive to the way unobserved firm heterogeneity is accounted for by 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 about 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 rewarded with salary, equity and inside debt. We use our model to understand the joint role played by different compensation components in shaping risk-taking incentives and credit spreads. The model predicts that the common belief that inside debt lowers credit spreads may not always hold. Indeed, we find that only when inside debt is subject to substantial losses in case of default, the CEO optimally takes on less risk, thus decreasing both the probability of default and the credit spreads. Second, the standard result that in the presence of a risk-averse managers, higher CEO ownership is always associated with lower credit spreads may fail to hold in the presence of inside debt. Equity ownership is negatively related to credit spreads only when inside debt holdings are low. Otherwise equity ownership is positively related to credit spreads, especially in bad aggregate states, when bondholders would arguably desire a more prudent behavior. We empirically test

our predictions using a comprehensive sample of U.S. public firms with traded CDS contracts over the period 2006-2011. We confirm the model predictions concerning the joint effect of inside debt and equity incentives on CDS spreads.

We extend existing models studying managerial compensation and risk-taking by including inside debt and modeling its seniority in bankruptcy. Our theoretical framework helps to rationalize the observed dynamics of credit spreads. However, our model does not account for a relevant component of managerial compensation, namely 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 question is the following: Given the complex interactions among different components of compensation, what would be the optimal contract from the shareholders' (or bondholders') point of view? We leave these questions for future research.

References

- Anantharaman, D., Fang, V.W., Gong, G., 2014. Inside debt and the design of corporate debt contracts. *Management Science* 60, 1260–1280.
- Angrist, J.D., Pischke, J.S., Mostly harmless econometrics: An empiricist's companion, Princeton University Press, NJ, 2009.
- Basak, S., Shapiro, A., 2005. A model of credit risk, optimal policies, and asset prices. *Journal of Business* 78, 1215–1266.
- Bebchuk, L.A., Jackson, R.J., 2005. Executive pensions. *Journal of Corporation Law* 30, 823–855.
- Bharath, S.T., Shumway, T., 2008. Forecasting default with the Merton distance to default model. *Review of Financial Studies* 21, 1339–1369.
- Blanco, R., Brennan, S., Marsh, I.W., 2005. An empirical analysis of the dynamic relation between investment-grade bonds and credit default swaps. *Journal of Finance* 60, 2255–2281.
- Bolton, P., Mehran, H., Shapiro, J.D., 2010. Executive compensation and risk-taking. *Review of Finance* 65, 1123–1161.
- Calcagno, R., Renneboog, L., 2007. The incentive to give incentives: On the relative seniority of debt claims and managerial compensation. *Journal of Banking & Finance* 31, 1795 – 1815.
- Carlson, M., Lazrak, A., 2010. Leverage choice and credit spreads when managers risk shift. *Journal of Finance* 65, 3323–2362.
- Carpenter, J.N., 2000. Does option compensation increase managerial risk appetite? *Journal of Finance* 55, 2301–2331.
- Cassell, C.A., Huang, S.X., Sanchez, J.M., Stuart, M.D., 2012. Seeking safety: The relation between CEO inside debt holdings and the riskiness of firm investment and financial policies. *Journal of Financial Economics* 103, 588–610.
- Core, J., Guay, W., 2002. Estimating the value of employee stock option portfolios and their sensitivities to price and volatility. *Journal of Accounting Research* 40, 613–630.

- Cristy, M., 2010. The bankrupt's guide to employee benefits: Terminating retirement plans in bankruptcy. *Journal of Pension Benefits*.
- Edmans, A., Liu, Q., 2011. Inside debt. *Review of Finance* 15, 75–102.
- Feess, E., Wohlschlegel, A., 2012. Mandatory deferral of banker compensation and misallocation of risky projects. Available at SSRN: <http://ssrn.com/abstract=2118560>.
- Gerakos, J., 2007. CEO pensions: disclosure, managerial power, and optimal contracting. Available at SSRN: <http://ssrn.com/abstract=982180>.
- Halford, J., Qiu, M., 2012. Inside debt and debt incentives: Evidence from the 2008 financial crisis. Available at SSRN: <http://ssrn.com/abstract=2005205>.
- Hall, B.J., Knox, T.A., 2004. Underwater options and the dynamics of executive pay-to-performance sensitivities. *Journal of Accounting Research* 42, 365–412.
- Henderson, M. T., 2007. Paying CEOs in bankruptcy: Executive compensation when agency costs are low. *Northwestern University Law Review* 101. Available at SSRN: <http://ssrn.com/abstract=927081>.
- Himmelberg, C.P., Hubbard, G., 2000. Incentive pay and the market for CEOs: An analysis of pay-for-performance sensitivity. Available at SSRN: <http://ssrn.com/abstract=236089>.
- Hoang, G.N., 2013. Inside debt and corporate failure. Available at SSRN: <http://ssrn.com/abstract=2351718>.
- Inderst, R., Pfeil, S., 2013. Securitization and compensation in financial institutions. *Review of Finance* 17, 1323–1364.
- Jackson, R.J., Honigsberg, C., 2014. The hidden nature of executive retirement pay. *Virginia Law Review* 100, 479–1819.
- Jensen, M.C., Meckling, J.H., 1976. Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics* 3. Available at SSRN: <http://ssrn.com/abstract=94043>.
- Kahle, K.M., Stulz, R.M., 2013. Access to capital, investment, and the financial crisis. *Journal of Financial Economics* 110, 280–299.

- Leisen, D.P.J., 2013. Does bonus deferral reduce risk taking? Available at SSRN: <http://ssrn.com/abstract=1662555>.
- MacKie-Mason, J.K., 1990. Do taxes affect corporate financing decisions? *Journal of Finance* 45, 1471–1493.
- Ortiz-Molina, H., 2007. Executive compensation and capital structure: The effects of convertible debt and straight debt on CEO pay. *Journal of Accounting and Economics* 43, 69–93.
- Phan, H.V., 2014. Inside debt and mergers and acquisitions. *Journal of Financial and Quantitative Analysis* 49, 1365–1401.
- Reid, C.D., CEO SERPs: Are they related to firm risk and who approves them? PhD dissertation, University of Tennessee 2011.
- Stulz, R.M., Winter 2010. Credit default swaps and the credit crisis. *Journal of Economic Perspectives* 24, 73–92.
- Sundaram, R.K., Yermack, D., 2007. Pay me later: Inside debt and its role in managerial compensation. *Journal of Finance* 62, 1551–1588.
- Wei, C., Yermack, D., 2011. Investor reactions to CEOs’ inside debt incentives. *Review of Financial Studies* 24, 3813–3840.

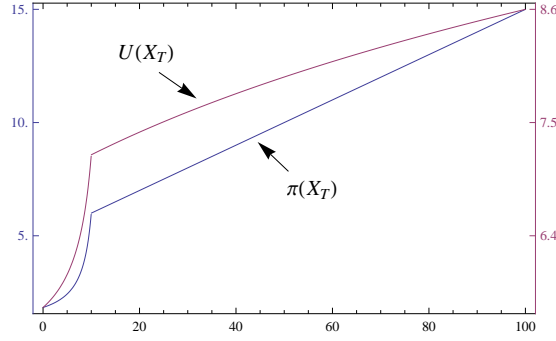


Figure 1: CEO payoff diagram and utility function

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 $\gamma = .8$.

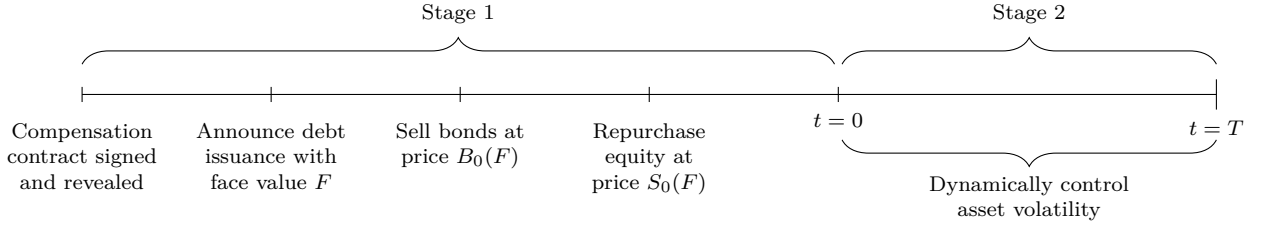


Figure 2: Timing of the model

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 *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 \(2010\)](#).

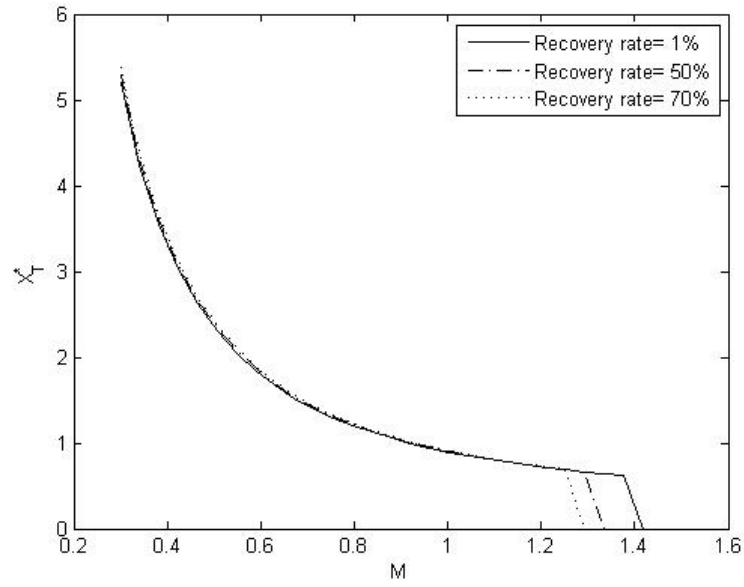
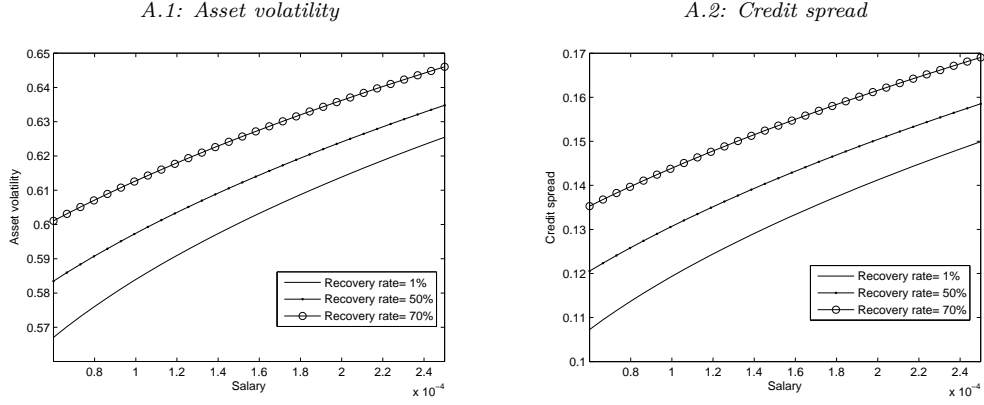


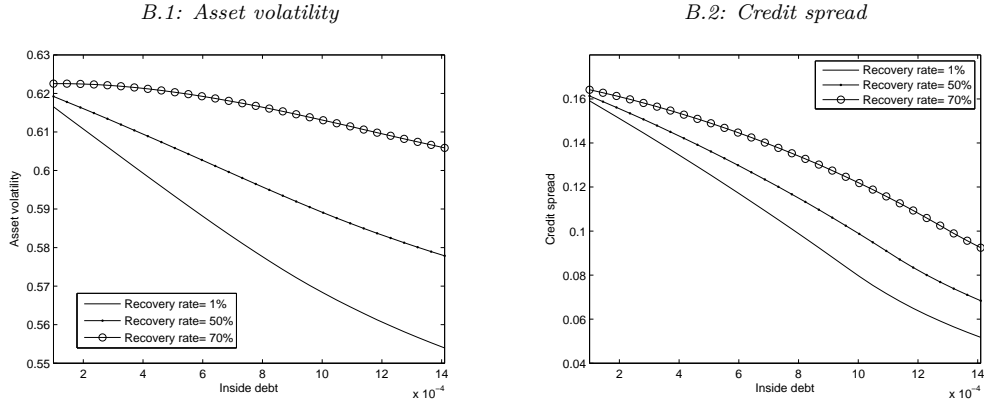
Figure 3: Optimal terminal asset value

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



Panel B: Inside debt



Panel C: CEO ownership

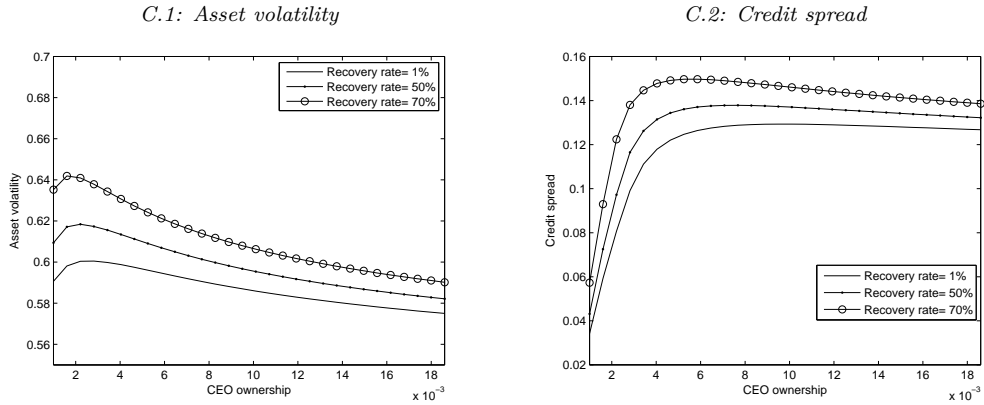
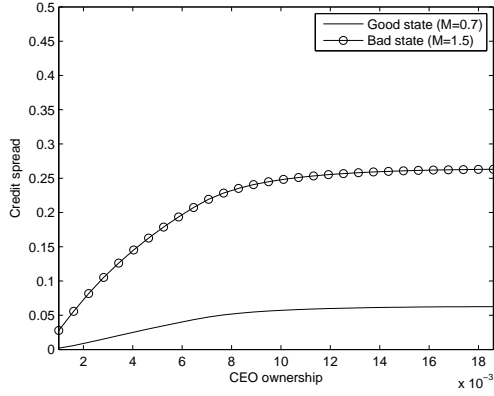


Figure 4: Asset volatility, credit spread, and CEO firm-specific wealth-structure

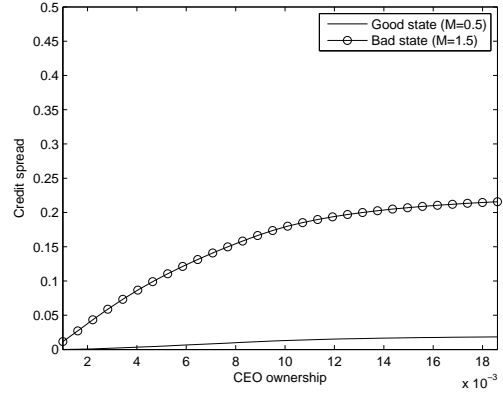
This figure plots optimal choices of asset volatility and associated credit spreads for different levels of salary (Panel A), inside debt (Panel B), and CEO ownership (Panel C). For each graph, compensation components that are not varying are held fixed at their median levels reported in Table 1. Other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

Panel A: High inside debt

A.1: High seniority

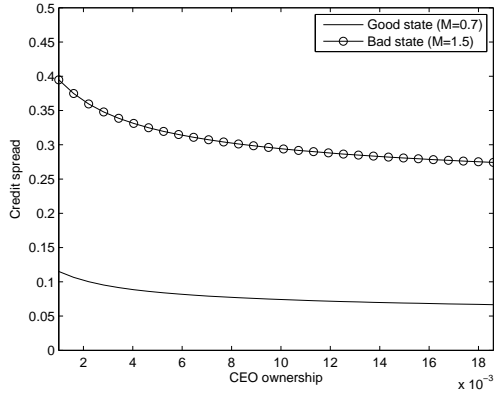


A.2: Low seniority



Panel B: Low inside debt

B.1: High seniority



B.2: Low seniority

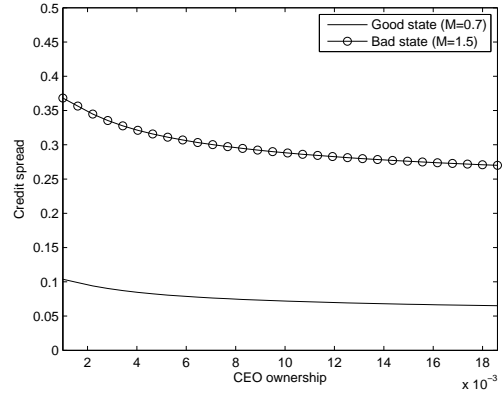


Figure 5: Credit spread and CEO ownership across aggregate states of the world

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.

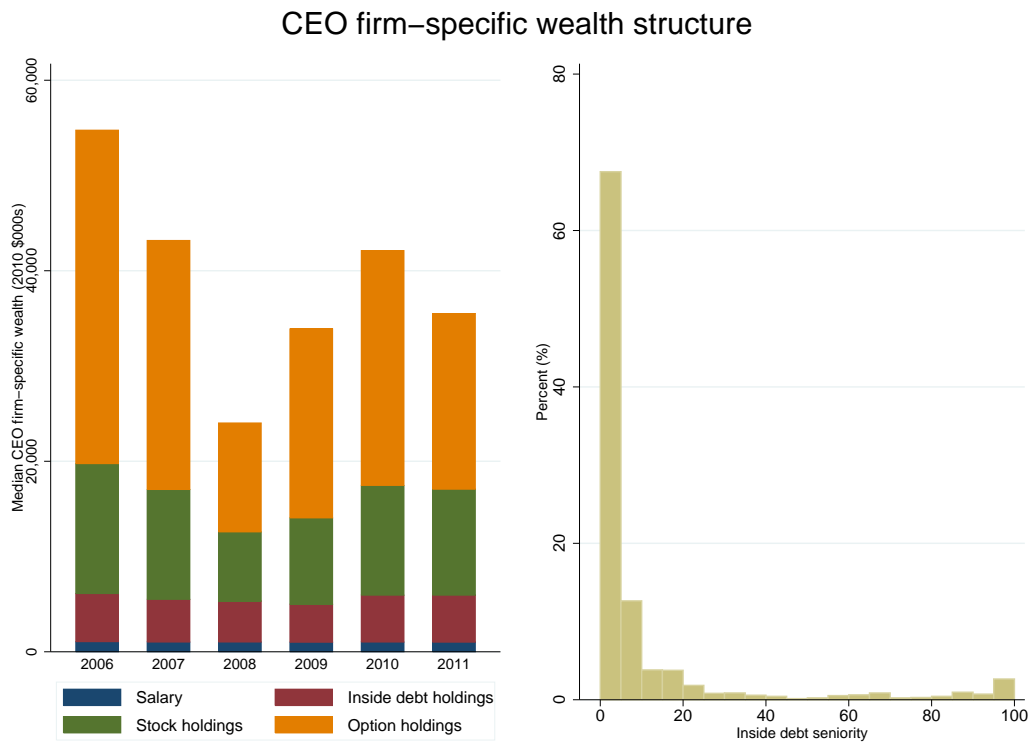


Figure 6: CEO firm-specific wealth level and composition: 2006-2011

This figure reports the level and composition of CEO firm-specific wealth over the period 2006-2011 for Execucomp firms with traded CDSs (608 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.

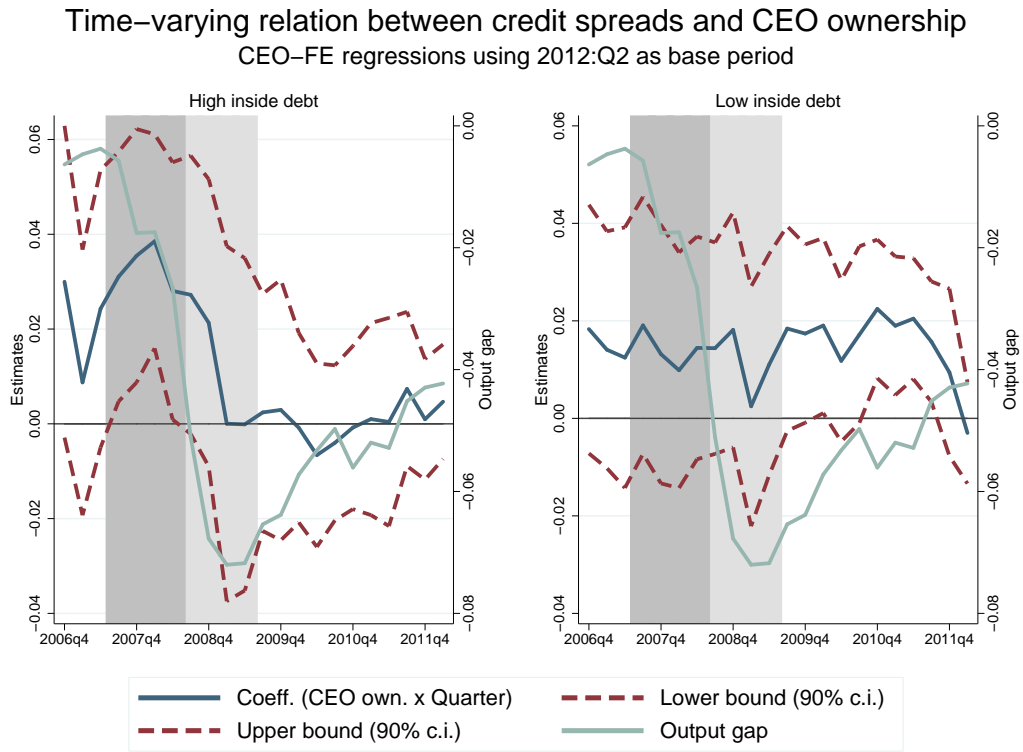


Figure 7: Credit spreads and CEO ownership across aggregate states of the world

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.

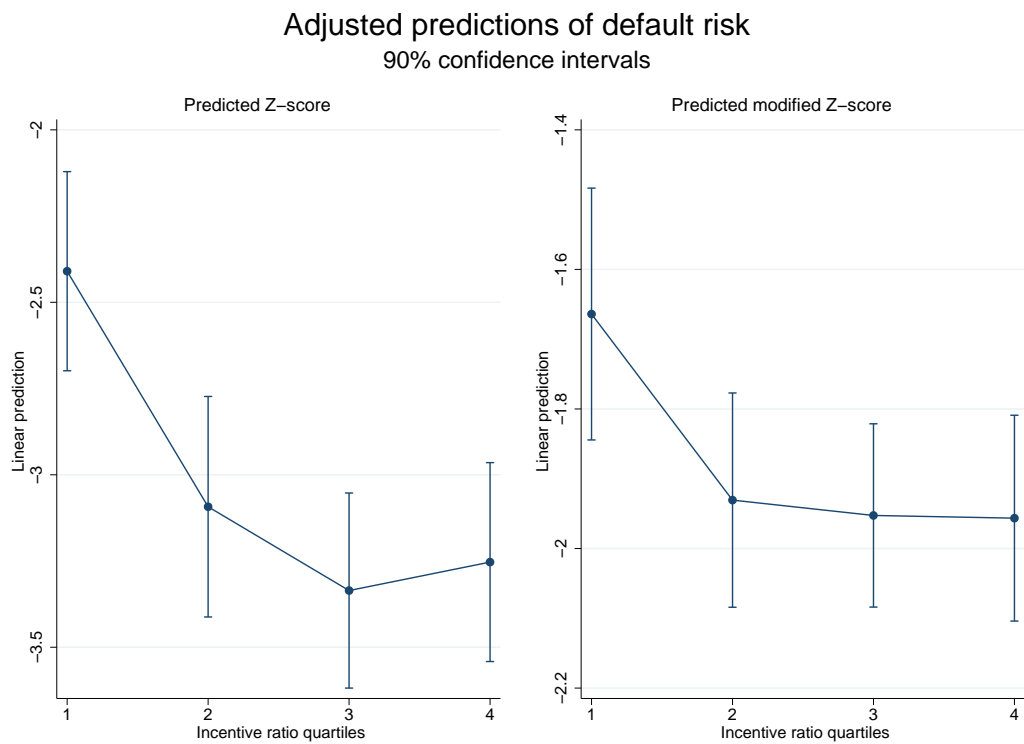


Figure 8: Default risk and the incentive ratio

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 purpose. Information is based on our sample reported in Table 2, where all variables are winsorized at the 1st and the 99th 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.2 for variable definitions.

	Mean	Std.Dev.	Q1	Med.	Q3	Obs.
<i>Outcome variables</i>						
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
<i>CEO firm-specific wealth structure</i>						
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
<i>CEO characteristics</i>						
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
<i>Firm characteristics</i>						
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
<i>Macroeconomics conditions</i>						
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-transformed 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.2](#) for variable definitions.

	Log of CDS spread (<i>t</i>)				
	(1)	(2)	(3)	(4)	(5)
Salary-to-assets	23.171*** (9.87)	20.374*** (8.60)	5.064** (2.02)	4.409* (1.74)	4.409* (1.74)
Inside debt-to-assets	-0.855*** (-3.97)	-0.658*** (-3.22)	-0.342** (-2.17)	-0.372** (-2.41)	-0.372** (-2.41)
CEO ownership	0.022** (2.36)	0.025*** (2.69)	0.021** (2.40)	0.075*** (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 (-0.77)	-0.002 (-0.46)	-0.004 (-0.86)	-0.004 (-0.86)
CEO age		-0.015** (-2.30)	-0.008* (-1.76)	-0.008* (-1.74)	-0.008* (-1.74)
CEO turnover		0.235*** (3.63)	0.027 (0.48)	0.032 (0.57)	0.032 (0.57)
Size			-0.204*** (-6.26)	-0.201*** (-6.25)	-0.201*** (-6.25)
Market D/E			0.336*** (14.14)	0.336*** (14.38)	0.336*** (14.38)
Profitability			-2.832*** (-9.06)	-2.803*** (-9.00)	-2.803*** (-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-transformed 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.2 for variable definitions.

	Log of CDS spread (<i>t</i>)				
	(1)	(2)	(3)	(4)	(5)
Salary-to-assets	21.717*** (9.29)	20.752*** (8.58)	18.257*** (7.42)	4.470* (1.80)	4.470* (1.80)
Inside debt-to-assets (prot.)	0.219 (0.13)	0.120 (0.07)	0.316 (0.19)	-0.664 (-0.61)	-0.664 (-0.61)
Inside debt-to-assets (non-prot.)	-0.777*** (-3.48)	-0.828*** (-3.72)	-0.634*** (-3.02)	-0.276* (-1.77)	-0.276* (-1.77)
CEO ownership	0.038*** (3.82)	0.103*** (3.45)	0.106*** (3.22)	0.087*** (4.03)	
CEO ownership × Low sen.	-0.041** (-2.32)	-0.039** (-2.21)	-0.029* (-1.85)	-0.040*** (-3.23)	
Sq. CEO ownership		-0.003** (-2.39)	-0.003** (-2.35)	-0.002** (-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*** (3.89)	0.345*** (3.79)	0.284*** (3.24)	0.181*** (2.92)	0.120** (2.10)
CEO tenure			-0.008 (-1.17)	-0.004 (-0.76)	-0.004 (-0.76)
CEO age			-0.015** (-2.29)	-0.008* (-1.77)	-0.008* (-1.77)
CEO turnover			0.243*** (3.76)	0.032 (0.59)	0.032 (0.59)
Size				-0.187*** (-5.84)	-0.187*** (-5.84)
Market D/E				0.337*** (14.53)	0.337*** (14.53)
Profitability				-2.807*** (-9.12)	-2.807*** (-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-transformed 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.2 for variable definitions.

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

(Continued)

Table 5: – *Continued*

CEO ownership \times 2011Q1	0.001 (0.08)		0.019** (2.21)	
CEO ownership \times 2011Q2	0.000 (0.03)		0.020*** (2.73)	
CEO ownership \times 2011Q3	0.007 (0.75)		0.016** (2.11)	
CEO ownership \times 2011Q4	0.001 (0.13)		0.009 (0.91)	
CEO ownership \times 2012Q1	0.005 (0.64)		-0.003 (-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-transformed 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.2](#) for variable definitions.

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

	Market leverage ($t + 1$)					
	(1)	(2)	(3)	(4)	(5)	(6)
Inside debt-to-assets (prot., cent.)	-0.766 (-1.36)	-0.674 (-1.33)				
Sq. inside debt-to-assets (prot., cent.)	6.510* (1.93)	5.202* (1.69)				
Inside debt-to-assets (non-prot., cent.)			-0.086 (-1.41)	-0.087 (-1.56)		
Sq. inside debt-to-assets (non-prot., cent.)			0.052 (0.50)	0.043 (0.49)		
CEO ownership (cent.)					0.013*** (2.65)	0.008* (1.86)
Sq. CEO ownership (cent.)					-0.001** (-2.57)	-0.000 (-1.62)
Size		-0.023*** (-4.32)		-0.026*** (-4.64)		-0.022*** (-3.86)
Profitability		-0.448*** (-5.22)		-0.436*** (-5.14)		-0.449*** (-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-transformed 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.2 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.) \times 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.) \times 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

In this appendix, we establish several properties of the utility function and of the maximization problem that are necessary to prove the propositions of the paper.

Take any given value $X_b \geq 0$. We begin by stating some preliminary results that we need to determine the solution to the manager's maximization problem.

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

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

Given the convex-concave shape of the utility function, to solve the manager's problem we first have to determine all the points of local maximum. We then evaluate the manager's value function at all the points of local maximum and compare these values to find the global maximum. The comparison is based on the properties of the value function established in Lemmas 2 – 5 below.

Denote by $V(X_T, M_T)$ the objective function of our maximization problem:

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

where y is a positive constant.

Lemma 2. *Define $f(yM_T) = V(\bar{X}, yM_T) - V(X_b, yM_T)$, for $yM_T < \frac{p(1-\tau)}{(A+D)^\gamma}$ and $\bar{X} > X_b$. Thus,*

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

and therefore f is monotonically decreasing in yM_T for $yM_T \in (0, \frac{p(1-\tau)}{(A+D)^\gamma})$. Moreover, it is straightforward to show that under current model assumptions (in particular, $\gamma \in (0, 1)$, $\tau \in [0, 1]$, and $p \geq 0$), $\lim_{\{yM_T \rightarrow 0\}} f(yM_T) = +\infty$ and $\lim_{\{yM_T \rightarrow y\bar{M}\}} f(yM_T) = 0$.

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

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

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 $\theta < D/(p(1-\tau))$.

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

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

Notice that the first term in the right-hand side is decreasing in X_b for $X_b \geq 0$ iff

$$\gamma(\theta + X_b)D\theta - 2A(\theta + X_b)^2 - 2(\theta + X_b)D\theta < 0$$

which is true because we consider the case $\gamma < 1$. As a result the maximum value of $\frac{\left(A + \frac{D\theta}{\theta + X_b} \right)^{-\gamma}}{(\theta + X_b)^2}$ is achieved at $X_b = 0$ and is given by

$$\frac{(A+D)^{-\gamma}}{\theta^2}.$$

Therefore, a necessary and sufficient condition for the existence of a positive \hat{X}_b such that $z'(X_b) > 0$ for any $X_b \in [0, \hat{X}_b]$ and negative otherwise is

$$\begin{aligned} \frac{(A+D)^{-\gamma}}{\theta^2} &> \frac{p(1-\tau)(A+D)^{-\gamma}}{D\theta} \\ \Leftrightarrow \theta &< \frac{D}{p(1-\tau)}. \end{aligned}$$

□

Lemma 4. Let $g(yM_T) = V(\bar{X}, yM_T) - V(0, yM_T)$, for $yM_T < y\bar{M}$ and $\bar{X} > X_b$. Then, g is monotonically decreasing in yM_T for $yM_T \in (0, y\bar{M})$. Moreover

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

where $z(X_b)$ is defined as in Lemma 3. The results of Lemma 3 also imply that i) $z_2 \geq 0$ when $X_b \leq \hat{X}_b$ and therefore $g \geq 0$ for all $yM_T \in (0, y\bar{M})$; ii) When $X_b > \hat{X}_b$, $z_2 < 0$ and therefore g changes sign over the interval $yM_T \in (0, y\bar{M})$. Moreover, when $X_b > \hat{X}_b$ 1) there exists a unique threshold $yM^* \in (0, y\bar{M})$ such that $g = 0$, such that $g > 0$ for $yM_T < yM^*$ and $g < 0$ for $yM_T > yM^*$; 2) yM^* is decreasing in X_b .

Proof. The shape of the function g is given by

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

which is clearly negative when $yM_T < y\bar{M}$. The sign of z_2 follows directly from Lemma 3. To prove 1) it is enough to note that g is a monotonic decreasing function of yM_T and, when $X_b > \hat{X}_b$, changes sign over the interval $yM_T \in (0, y\bar{M})$. Therefore it must exist a unique $yM^* \in (0, y\bar{M})$ such that $g = 0$, that is

$$\left(\frac{(1-\gamma)(A+D) + \gamma \left(\frac{p(1-\tau)}{yM^*} \right)^{\frac{1}{\gamma}}}{p(1-\gamma)(1-\tau)} - X_b \right) yM^* = \frac{\left(A + \frac{D\theta}{X_b + \theta} \right)^{1-\gamma}}{1-\gamma}. \quad (\text{A.2})$$

In order to show that yM^* is decreasing in X_b , we first assume, by contradiction, that there exist two pairs of values $\{(X_b, yM^*); (X'_b, yM'^*)\}$ solving equation (A.2) such that

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

Substituting these values into (A.2) and subtracting the two equations, we obtain:

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

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

Lemma 5. Define $h(yM_T) = V(X_b, yM_T) - V(0, yM_T)$ for $yM_T \geq y\bar{M}$. Then: i) $h'(yM_T) = -X_b < 0$; ii) $h(yM_T) \leq h(y\bar{M})$; iii) when $X_b > \hat{X}_b$, $h(y\bar{M}) < 0$; iv) when $X_b \leq \hat{X}_b$, $h(y\bar{M}) \geq 0$ and there exists a unique $yM^{**} \geq y\bar{M}$ such that $h \geq 0$ for $yM_T \leq yM^{**}$, and $h < 0$ otherwise; v) yM^{**} is decreasing in X_b .

Proof. We first observe that $\frac{\partial h}{\partial (yM)} = -X_b < 0$ which implies that h is monotonically decreasing in yM_T for any $X_b > 0$, and therefore $yM_T \geq y\bar{M}$, implies

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

It is then straightforward to verify that when $X_b > \hat{X}_b$, $h(y\bar{M}) < 0$ for any $yM_T \geq y\bar{M}$. When $X_b \leq \hat{X}_b$, $h(y\bar{M}) \geq 0$, and the fact that h is monotonically decreasing in yM_T implies 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.

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,

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

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

We are now ready to compute the optimal terminal value of cash flows.

A.2 Optimal terminal asset value

Proof of Proposition 1. Consider the Legendre-Fenchel transform of the original problem:

$$U^*(M_T) = \max_{X_T \geq 0} [U(X_T) - yM_T X_T], \quad (\text{A.3})$$

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

Since $U(X_T)$ is convex for $X_T \in [0, X_b]$, concave for $X_T > X_b$, and $yM_T X_T$ is linear in X_T , we know that function $V(X_T, M_T) = U(X_T) - yM_T X_T$ is also convex and concave over the same intervals. Therefore we have at most three candidates for optimality: 0, X_b and

$$\bar{X} = X_b + \frac{\left[\frac{p(1-\tau)}{yM_T} \right]^{1/\gamma} - (A + D)}{p(1 - \tau)} \quad (\text{A.4})$$

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

$$yM_T < \frac{p(1 - \tau)}{(A + D)^\gamma} := y\bar{M}. \quad (\text{A.5})$$

Therefore we can state our first 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 $\{0, X_b\}$. Then we need to compare the value functions associated with the local maximizers to determine the global maximizer of the manager's utility function. Given our previous result, 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 value functions associated to 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 value functions associated to 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 any $yM_T \geq y\bar{M}$. 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 $yM^{**} \geq y\bar{M}$ 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.5) 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 equation (A.2) 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 Lemma 5) such that the optimal solution is \bar{X} for $yM_T < y\bar{M}$, X_b for $yM_T \in [y\bar{M}, yM^{**}]$, and 0 for $yM_T > yM^{**}$.

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

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

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 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

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

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,

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

and

$$\lim_{X_b \rightarrow +\infty} \chi(X_b) = +\infty.$$

These facts together imply that there exists a unique value $X_b^* \in [F, \infty)$ such that $\chi(X_b^*) = 0$. \square

A.3 Optimal dynamic risk-taking

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

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

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

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

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

$$\begin{aligned} X_t = \mathbb{E}_t \left[\frac{M_T}{M_t} X_T^* \right] &= \mathbb{1}_{\{X_b^* > \hat{X}_b\}} \mathbb{E}_t \left[\frac{M_T}{M_t} \bar{X} \mathbb{1}_{\{M_T \leq M^*\}} \right] \\ &\quad + \mathbb{1}_{\{X_b^* \leq \hat{X}_b\}} \mathbb{E}_t \left[\frac{M_T}{M_t} \left(\bar{X} \mathbb{1}_{\{M_T \leq \bar{M}\}} + X_b^* \mathbb{1}_{\{\bar{M} \leq M_T \leq M^{**}\}} \right) \right]. \end{aligned} \quad (\text{A.6})$$

Consider first the case $X_b^* > \hat{X}_b$. Given the value of \bar{X} in equation (A.4) and previous results, we have:

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

where

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

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

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

where

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

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

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 the actual information provided in SEC filings. We start 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 twenty companies provide a rather complete description of inside debt funding and lump-sum options. To capture in a complete as possible way 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](#)).²⁵ 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.²⁶ Detailed definitions of the variables used in this appendix are given in Table A.2.

Panel A of Table A.1 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 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 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.

²⁵We acknowledge that this might pose self-selection bias issues.

²⁶These 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.

Panel B of Table [A.1](#) reports summary statistics about the variables used to estimate this ratio. Interestingly, CEO debt-like compensation has a lower duration than the outside loans (debt maturity), as *Duration ratio* exhibits a mean of 0.18.

Panel C of Table [A.1](#) 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. Knowing 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.2](#).

Table A.1: 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.2 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.1: – *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.2: Definition of variables

Variable	Definition
CDS spread	Average of daily five-year U.S. dollar denominated CDS spreads over the last fiscal year from Markit. We consider only CDS on unsecured debt (tier=snrfor). We do not put any restriction on the documentation clause.
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 $-3.3 \times (\text{pi}/\text{at}) - (\text{saleq}/\text{at}) - 1.4 \times (\text{re}/\text{at}) - 1.2 \times (\text{act}-\text{lct})/\text{at} - 0.6 \times (\text{prcc.f} \cdot \text{csho})/\text{lt}$ in Compustat.
Modified Z-score	MacKie-Mason (1990) modified Altman's Z-score defined as $-3.3 \times (\text{pi}/\text{at}) - (\text{sale}/\text{at}) - 1.4 \times (\text{re}/\text{at}) - 1.2 \times (\text{act}-\text{lct})/\text{at}$ in Compustat.
Market leverage	Market leverage defined as $(\text{dlc}+\text{dltt})/(\text{prcc.f} \times \text{csho} + \text{at} - \text{ceq})$ 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 missing values to zero.
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 and vega, thanks to the enhanced SEC disclosure requirements introduced in 2006. As in Ortiz-Molina (2007) , we assume that CEOs with missing data about options have zero options.
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 , nonqual , non-tax , nontax , exec , excess , equaliz , and restor .
Low seniority	Indicator equal to one if <i>Inside debt seniority</i> is zero.
Incentive ratio	Incentive measure defined as the ratio of <i>Inside debt-to-assets</i> to the product of <i>Inside debt seniority</i> and <i>CEO ownership</i> .
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. 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.
Size	Natural logarithm of real sales (sale) in Compustat.
Market D/E	Debt-to-equity ratio defined as $\text{dlc}+\text{dltt}/(\text{prcc.f} \times \text{csho})$ in Compustat.
Profitability	Profitability defined as $(\text{ib}+\text{dp})/\text{at}(\text{t}-1)$ 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.

(Continued)

Table A.2: – *Continued*

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 <i>CEO retirement age</i> and <i>CEO age</i> .
Time-to-death	Difference between CEO life expectancy (based on life tables by the Center for Disease Control’s National Vital Statistics Reports) and <i>CEO age</i> .
CEO after-retirement horizon	Difference between <i>Time-to-death</i> and <i>Time-to-retirement</i> , 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 <code>pbarr</code> 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 $(dd1+d1c+2\times dd2+3\times dd3+4\times dd4+5\times dd5+(d1tt-dd2-dd3-dd4-dd5)\times 10)/(d1tt+d1c)$ 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 <i>Duration (inside debt)/Debt maturity</i> . We also compute it separately for non-qualified pension plans and deferred compensation plans.

Halle Institute for Economic Research –
Member of the Leibniz Association

Kleine Maerkerstrasse 8
D-06108 Halle (Saale), Germany

Postal Address: P.O. Box 11 03 61
D-06017 Halle (Saale), Germany

Tel +49 345 7753 60
Fax +49 345 7753 820

www.iwh-halle.de

ISSN 2194-2188