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Negative Hedging: Performance Sensitive Debt and CEOs' Equity Incentives (CRI 2009-014)

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Keywords
performance sensitive debt, equity compensation

Comments

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By

Alexei Tchistyi, David Yermack, and Hayong Yun*

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JEL classifications: G30; G34
Keywords: Performance sensitive debt; equity compensation

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We examine the relation between CEOs' equity incentives and their use of performance-sensitive debt contracts. These contracts require higher or lower interest payments when the borrower's performance deteriorates or improves, thereby increasing expected costs of financial distress while making a firm riskier to the benefit of option holders. We find that managers whose compensation is more sensitive to stock volatility choose steeper and more convex performance pricing schedules, while those with high delta incentives choose flatter, less convex pricing schedules. Performance pricing contracts therefore seem to provide a channel for managers to increase firms' financial risk to gain private benefits.

I. Introduction

Performance pricing in commercial debt contracts links the borrower's interest payments to a measure of financial performance, such as its current credit rating or balance sheet ratios. A typical performance sensitive debt (PSD) contract charges lower interest rates in times of good performance and higher interest during poor performance.

Some practitioners caution that performance pricing may exacerbate the costs of financial distress.[1] Consistent with these concerns, Manso, Strulovici, and Tchistyi (2009) demonstrate that in a setting with bankruptcy costs and tax benefits, PSD obligations are less efficient than fixed-rate loans of the same market value, because PSD contracts precipitate default, increase bankruptcy costs, and reduce firm value. Moreover, the inefficiency of PSD is greater when the slope of performance pricing is steeper. This finding suggests that the existence of PSD obligations should be explained by other market frictions, and recent research illuminates some possibilities. Manso, Strulovici, and Tchistyi (2009) demonstrate that PSD can be used as a signaling or screening device in a setting with asymmetric information. Tchistyi (2009) shows that it is optimal to issue PSD in a dynamic setting with moral hazard. Asquith, Beatty, and Weber (2005) suggest that PSD can reduce contracting costs.

In this paper we develop and test a further theory, that PSD contracts enable executives to transfer value to themselves at the expense of shareholders. In particular, our paper tests whether the existence and strength of PSD contract terms are related to managers' incentives from ownership and compensation.[2] Performance pricing increases the volatility of the firm's net cash

[1] For example, see "Credit ratings can harm your wealth," *Investment Adviser*, December 9, 2002.

[2] PSD may also enable a firm to raise funds in the presence of financing constraints that prevent it from issuing straight debt. According to this hypothesis, PSD contracts could create value by enabling investment in more profitable projects when a firm is constrained (Froot, Scharfstein, and Stein (1993)). However, the firms in our sample are large public companies with relatively good access to external markets, and we were unable to find significant evidence of this effect.

flow and consequently the volatility of equity returns. This creates a potential conflict of interest between the firm's managers and shareholders, in which managers may enter into debt contracts that reduce share values. This could occur because higher stock volatility due to performance pricing increases the value of stock options held by management, but it also may reduce the value of the firm because of the higher expected costs of financial distress. As a result, equity value could decline, if we assume that banks that agree to performance sensitive loans negotiate pricing schedules that leave them no worse off than the alternative of issuing fixed rate debt. Indeed, Figure 1 shows that CEOs are more likely to choose PSD contracts after they receive large stock option awards. We illustrate this conflict of interest, which we call "negative hedging" by the manager, with a model in section III, and provide further details of this figure in section V.

Our hypotheses about option-holding managers seeking PSD contracts differ from a similar conflict of interest between managers and shareholders, in which option-holding managers increase firm leverage in order to raise equity volatility. This leverage effect, documented empirically by Berger, Ofek, and Yermack (1997), occurs when management substitutes debt for equity in the capital structure, thereby raising returns to equity holders in all positive future states of the world while reducing them in adverse future states. The effect of a PSD contract is more subtle. PSD contracts redistribute the gains to equity holders across certain future states, increasing returns to equity when the firm performs very well, while reducing them when performance lies in a middle range. Figure 2 illustrates these differences by showing payoffs to equity holders under three hypothetical capital structures: an all equity firm, a levered firm with straight debt only, and a levered firm with PSD.

We develop a model of firms' financing choices between straight debt and PSD, in a representative company with a risk-averse CEO who holds both stock and options. While

choosing PSD over straight debt increases the CEO's option values due to higher stock volatility, the CEO also experiences a loss in expected utility due to larger expected bankruptcy costs and the increased stock volatility itself. In the model, we first show analytical results for our main hypotheses under the assumptions of a risk-neutral CEO and a uniform distribution of expected future firm values. We find that CEOs' preferences for PSD over straight debt (and preferences for steeper PSD over flatter PSD) decrease with the value of stock owned by the CEO (i.e., when the sensitivity of the CEO's wealth to stock price increases), and increase with the value of options owned (i.e., when the sensitivity of the CEO's wealth to stock volatility increases). Using numerical simulations, we show that model predictions made from simple assumptions hold under more general assumptions that incorporate lognormal firm values and CEOs with power utility functions.

To test the hypotheses implied by our model, we merge a large sample of commercial bank debt contracts with data about the equity ownership of the borrowing firms' CEOs. For each CEO in our sample, we calculate the delta, or sensitivity of stock and option values to changes in stock price, as well as the vega, or sensitivity of option values to changes in stock volatility. We predict that managers with significant vega incentives from option holdings are likely to choose debt with a PSD feature and, within the subset of PSD contracts, should prefer steeper performance pricing schedules, since steep pricing schedules imply rapid appreciation of their option holdings when risk increases. Conversely, managers with higher deltas from stock and options are likely to disfavor PSD contracts and, when PSD is used, to prefer arrangements with flatter slopes, because these managers should be more concerned about their exposure to the higher expected distress costs associated with PSD contracts.

The results of our analysis, based on Tobit regression estimations, support our hypotheses. Using a sample of 4,451 loan contracts (1,236 PSD and 3,215 straight debt) negotiated by 1,359 U.S. companies from 1994 to 2002, we find that firms whose CEOs exhibit high deltas from their stock and option holdings tend to have flatter performance pricing schedules; one standard deviation increase from the mean in delta corresponds to a 39% decrease in the slope of the performance pricing schedule. Conversely, we find that CEOs with high vegas from option inventories tend to have steeper performance pricing schedules: after controlling for heterogeneity in borrowers' characteristics and loan characteristics, a one standard deviation increase from the mean of log (1+vega) corresponds to a 17% increase in the performance pricing schedule's slope.

We examine the relationship between CEOs' incentives and the PSD slope more closely in two different ways. We look at the "interest-increasing" and "interest-decreasing" segments of the PSD slope, those that lie at credit ratings just below and just above the firm's rating at the time of contracting. We find a stronger relationship between CEOs' delta incentives and the interest-increasing slope, implying that CEOs with high ownership are more concerned with avoiding expected costs of financial distress than with reaping the benefits of high rewards for performance improvements. We also examine the convexity, rather than the slope, of the PSD pricing schedule, and we find that both local and overall convexity are positively associated with CEOs' vega incentives and negatively related to their delta incentives.

Our analysis of how executive compensation influences the choice between straight debt and PSD contributes to the literature by identifying a novel channel of managerial opportunism. While share repurchases and leverage increases raise volatility by changing net cash flows to equity holders, using PSD contracts in place of straight debt increases stock volatility by

redistributing net cash flows contingently across certain states of the future. Hence, leverage choice and PSD choice can lead to different future cash flow consequences, and these two choices have different impacts upon the incentives of a CEO who derives private benefits from free cash flows (Jensen (1986)). In addition, PSD's relative lack of transparency makes it an attractive device for managers who wish to increase stock volatility. PSD is widely issued, but its incentive effects are more complex than those of straight or convertible debt and it is difficult to value.[3] More visible strategies for risk taking, such as undertaking risky investment projects or adding leverage to the capital structure, are easy for investors to observe and are often restricted by covenants on existing debt. Identifying how managers with equity-based compensation may benefit from PSD can therefore increase investors' awareness of the potential costs of PSD and improve investor protection.

This paper proceeds as follows. Section II reviews the literature. Section III presents our hypotheses. Section IV presents institutional facts about PSD contracts and describes the data. Section V contains the basic analysis of the effects of managers' deltas and vegas upon the terms of PSD contracts. Section VI contains our conclusions.

II. Review of the literature

Despite PSD's growing importance, research into its role in corporate lending has been limited. Bhanot and Mello (2006), Tchistyi (2006), and Manso, Strulovici, and Tchistyi (2009) provide theoretical models of PSD from an optimal dynamic contracting perspective. Bhanot and Mello (2006) is closely related to our work. While those authors study the effect of PSD on

[3] Stanford finance professor Darrell Duffie has stated in the news media that PSD contracts "have caused some head-scratching in terms of how to price them," *The New York Times*, January 29, 2002.

asset substitution, which is the change in volatility due to moral hazard after a debt contract is in place, our study emphasizes the role of a PSD contract itself as a source of increased risk.

The empirical literature on PSD begins with Beatty and Weber (2003), who study the role of PSD as part of earnings management, and continues with a large-sample study by Asquith, Beatty, and Weber (2005). The authors partition their sample of PSD contracts into two groups: interest-decreasing loans, in which low-credit borrowers negotiate a schedule of interest reductions contingent upon improved performance, and interest-increasing loans, which stipulate rising interest rates should performance deteriorate. The authors conjecture that different economic motives lead to these different forms of PSD and verify their hypotheses using variables related to historical default rates, return volatilities, and measures of credit rating precision and information asymmetry. Our study extends these findings by providing evidence for the variation of specific contractual terms of PSD (the slope and convexity of the pricing schedule) rather than the simple binary choice between straight debt and PSD. We also relate these choices to the sensitivities of the CEO contracts.

Other empirical studies on topics related to PSD include Hillion and Vermaelen (2004), which studies the stock price reaction to death spiral convertibles, and Lando and Mortensen (2005) which studies the pricing of step-up bonds.

Our paper is also related to the literature that links executive compensation and firms' financial policies. Prior studies note that equity-based compensation such as stock options may or may not encourage CEOs to take more risk. A notable recent theory paper in this literature is Lewellen (2006). Extending prior theoretical work on risk aversion and executive compensation (Carpenter (2000) and Ross (2004)), Lewellen (2006) shows that option grants do not necessarily

encourage managers to increase leverage, because increased volatility imposes costs on risk-averse managers.

A number of empirical papers have found that increases in CEOs' equity-based incentives are associated with greater financial risk in the areas of investment policies (Coles, Daniel, and Naveen (2006)), risk-increasing acquisitions (Agrawal and Mandelker (1987) and Datta, Iskandar-Datta, and Raman (2001)), less corporate hedging (Tufano (1996), and Knopf, Nam, and Thornton (2002)), increases in stock volatility (DeFusco, Johnson, and Zorn (1990), Guay (1999), and Cohen, Hall, and Viceira (2000)), larger firm-specific risk (Jin (2002)), and increases in cash flow volatility (Rajgopal and Shevlin (2002)). Mehran (1992), and Berger, Ofek, and Yermack (1997) show that option grants encourage entrenched managers to increase leverage. Datta, Iskandar-Datta, and Raman (2005) show a negative relationship between CEOs with stock ownership and corporate debt maturity, implying that large stock ownership reduces manager-shareholder conflicts and leads managers to voluntarily subject themselves to more monitoring from short-term debt. A somewhat contrasting result appears in Babenko (2009), which shows a decrease in stock and option grants after share repurchases, because repurchases increase pay-performance sensitivity and therefore act as a substitute for new equity compensation.

III. Hypothesis development

A. Model setup

We consider a firm that needs to raise capital D at time $t = 0$ to invest in its projects and chooses to raise the capital in the form of debt. We assume that the firm can choose from a set of linear PSD loans:

$$C(v) = c_0 - c_1 v, \tag{1}$$

where v is the value of the firm and $C(v)$ is the total (principal and interest) promised debt payment at time $t = 1$, and parameters c_0 and c_1 are nonnegative constants ($c_0 \geq 0, c_1 \geq 0$).[4] We note that straight debt is a special case of a linear PSD ($c_1 = 0$).[5]

The firm is in default when $C(v) > v$, i.e., $v < V_D(c_0, c_1) \equiv \frac{c_0}{1+c_1}$ (default boundary). We assume that a deadweight bankruptcy cost equals fraction γ of the firm's value. The firm is liquidated at $t = 1$, and its value v at time $t = 1$ is distributed according to p.d.f. $f(v)$.

Assuming that the market is competitive and risk-neutral, the market value of the debt is a function of the PSD parameters and is given by:

$$D(c_0, c_1) = \frac{1}{1+r_f}\left\{\int_0^{V_D}(1-\gamma)vf(v)dv + \int_{V_D}^{\infty}(c_0 - c_1 v)\, f(v)dv\right\} \tag{2}$$

where r_f is the risk-free rate, and V_D denotes function $V_D(c_0, c_1)$. We impose the following restriction on the parameters c_0 and c_1:

$$\frac{1}{1+r_f}\left\{\int_0^{V_D}(1-\gamma)vf(v)dv + \int_{V_D}^{\infty}(c_0 - c_1 v)\, f(v)dv\right\} = D_0 \tag{3}$$

$$\frac{dD(c_0,c_1)}{dc_0} = \frac{1}{1+r_f}\left\{\int_{V_D}^{\infty} f(v)dv - \frac{\gamma}{1+c_1}V_D f(V_D)\right\} > 0 \tag{4}$$

Equation (3) says that the amount D_0 that the firm borrows at time zero is fixed, no matter what PSD is chosen. Equation (4) says that the firm is not extremely overleveraged, in the sense that

[4] For simplicity, we allow debt payment *C(v)* to be negative when *v* is sufficiently large. However, our results still hold if we assume that the PSD is non-negative: max $\{0, c_0 - c_1 v\}$.

[5] We acknowledge that choices of capital structure can also be driven by managerial incentives (see, for example, Lewellen (2006)). However, in the main model, we do not consider the possibility of equity financing, as it would divert attention from our main focus. Later in this section we consider the effect of leverage on a manager's incentives. We show that, in addition to changes in stock volatility, changes in leverage are associated with changes in free cash flows, from which managers may derive private benefits. This contrasts with PSD choices, which increase stock volatility by redistributing net cash flows, and leave total expected free cash flows unchanged. We also point out that adjusting performance pricing provisions can be done more easily than changing leverage. Leverage is easily observable by shareholders, who may question a manager's decision to change it, while performance pricing schedule adjustments are more likely to go unnoticed.

an increase in the debt payment does not lead to a reduction of the debt value. From now on, we will assume that D_0 is sufficiently low so that equation (4) is satisfied.

The manager with utility function $U(W)$ holds n shares of the firm and m stock options with the strike price K expiring on date $t = 1$. In addition, he will be paid wage w_1 and has outside wealth of w_0. Let N be the number of shares outstanding. Assuming $m<<N$, the stock price at $t = 1$ is given by

$$S_1(v) = \frac{max\{v - C(v), 0\}}{N} \tag{5}$$

The call option pays

$$G_1(v) = max\{S_1(v) - K, 0\} = \begin{cases} 0 & if\ v \leq V_K \\ \frac{v - C(v)}{N} - K & if\ v > V_K \end{cases} \tag{6}$$

where $V_K = \frac{c_0 + NK}{1 + c_1}$ (option exercise boundary). Hence, the manager's wealth at time $t = 1$ is given by

$$W_1(v) = w_0 + w_1 + nS_1(v) + mG_1(v) \tag{7}$$

At time zero the manager chooses PSD that maximizes his expected utility:

$$\max_{c_0 \geq 0,\, c_1 \geq 0} \int_0^\infty U\big(W_1(v)\big) f(v) dv \tag{8}$$

subject to equation (3).

At $t = 0$, the stock price is equal to

$$S_0 = \frac{1}{N(1 + r_f)} \left\{ \int_{V_D}^\infty (v - (c_0 - c_1 v))\, f(v) dv \right\}. \tag{9}$$

The sum of the equity value and the PSD value at $t = 0$ is equal to expected present value of the firm minus the expected losses resulting from the bankruptcy BC:

$$S_0 + D_0 = \frac{1}{1 + r_f} \int_0^\infty v\, f(v) dv - BC, \tag{10}$$

where the bankruptcy cost is given by

$$BC = \frac{1}{1+r_f}\left\{\int_0^{V_D} \gamma v f(v) dv\right\}. \tag{11}$$

The value of the call option at $t = 0$ is equal to

$$G_0 = \frac{1}{(1+r_f)}\left\{\int_{V_K}^{\infty} \left(\frac{(1+c_1)v - c_0}{N} - K\right) f(v) dv\right\} \tag{12}$$

B. Comparative statics

Using the model, we can examine how optimal PSD contracts change for various parameters of interest. For our empirical tests, we are mainly interested in how a CEO's equity incentives are related to optimal PSD contract choices (c_0, c_1).

We can regard c_0 as a function of c_1, which is implicitly defined by (3). The following lemma shows how the PSD intercept c_0 and default boundary V_D on the PSD slope c_1.

Lemma 1: (1) PSD intercept c_0 increases with PSD slope c_1: $\frac{dc_0(c_1)}{dc_1} \geq 0$,

(2) Default boundary V_D increases with PSD slope c_1: $\frac{dV_{D(c_0(c_1),c_1)}}{dc_1} \geq 0$.

Detailed proofs of the lemmas and propositions of this section are shown in the Appendix.

The first point of Lemma 1 follows from equation (3), which requires that the market value of the PSD at time $t = 1$ remains fixed. The second point follows the first one, noting that larger fixed repayment (c_0) will lead to more repayment in low v regions and make default more likely. Overall, Lemma 1 is consistent with findings of Manso, Strulovici, and Tchistyi (2009) who analyze PSD in a dynamic setting with an endogenous default boundary.

The next proposition demonstrates that while PSD slope c_1 negatively affects bankruptcy costs and the stock value, it increases the option value.

Proposition 1: (1) Expected bankruptcy cost *BC* increases with PSD slope $\left(\frac{dBC}{dc_1} \leq 0\right)$,

(2) Equity value S_0 decreases with PSD slope c_1 $\left(\frac{dS_0}{dc_1} \leq 0\right)$,

(3) Option value G_0 increases with PSD slope c_1 $\left(\frac{dG_0}{dc_1} > 0\right)$, if $\gamma < \gamma^*$, where

$$\gamma^* = \frac{(1+c_1)P(v \geq V_D)P(v \geq V_K)(E[v|v \geq V_K] - E[v|v \geq V_D])}{V_D f(V_D) \int_{V_K}^{\infty} (v - V_D) f(v) dv}.$$

Expected bankruptcy cost increases with c_1, because default boundary V_D increases with c_1. A steeper PSD slope leads to a lower stock value because of higher bankruptcy costs, while it leads to a higher option value due to the convexity of option payoffs. Overall, Lemma 1 and the first two points of Proposition 1 are consistent with findings of Manso, Strulovici, and Tchistyi (2009) who analyze PSD in a dynamic setting with an endogenous default boundary. The last point of Proposition 1 is a new result. From now on we will assume that $\gamma < \gamma^*$ so that $\frac{dG_0}{dc_1} > 0$.

Based on the results of Proposition 1, we can develop our main hypotheses that (1) a CEO with high delta compensation package (large stock ownership) will choose a flatter PSD contract, and (2) a CEO with high vega compensation package (large option grants) will choose a steeper PSD contract.

Indeed, a risk-neutral CEO maximizes his expected wealth $w_0 + w_1 + nS_0(v) + mG_0(v)$. When a CEO holds more shares, he cares more about the negative impact of the PSD slope on the stock and prefers flatter PSD slopes. When a CEO holds more options, he cares more about the positive impact of the PSD slope on options and prefers steeper PSD slopes. A risk-averse CEO will be less willing to choose PSD. However, it is straightforward to show that if either the CEO's risk aversion is low or the number of options owned by the CEO is high, then the CEO

will still prefer PSD over straight debt, although the optimal PSD slope c_1 will be smaller than that for the risk-neutral CEO.

To illustrate further the model's predictions, we consider a numerical example with power utility $U(W) = \frac{W^{1-\rho}}{1-\rho}$. For parameter values related to executive compensation characteristics, we chose values that are representative of the ExecuComp database: total outstanding number of shares (N) of 5 billion, CEO's number of equity shares (n) of 5 million, CEO's number of option shares (m) of 10 million, CEO's initial wealth (w_0) of $50 million, and strike price of $1. We chose a risk-free rate of 1.57%, which is the recent yield of a 1-month Treasury bill, fractional bankruptcy cost (γ) of 10%, and coefficient of risk aversion (ρ) of 2. Finally we assume that ν follows a lognormal distribution.

The outcomes of our numerical simulations, showing comparative statics of the optimal PSD intercept (c_0) and slope (c_1) with respect to a range of important variables, are shown in Figures 3a through 3d.

The main hypotheses of our paper concern the relationship between a CEO's equity incentives and the firm's debt financing choice. Figure 3a shows that CEOs' preferences for PSD decline as they hold more shares in their own firms. A higher PSD slope increases expected bankruptcy costs, which makes the stock less valuable. In contrast, Figure 3b shows that CEOs' preferences for a steep PSD slope increase as they hold more options, because of the option values' increase in volatility induced by the PSD contract. Also, the optimal PSD intercept (c_0) mimics the trend of the optimal PSD slope (c_1), which is consistent with the predictions of Lemma 1 ($\frac{dc_0}{dc_1} \geq 0$). Together, the results in Figures 3a and 3b imply that the choice of a PSD contract should be a decreasing function of a CEO's overall delta, or the sensitivity of his wealth

to changes in the stock price, and an increasing function of the vega, or the sensitivity of his wealth to changes in stock volatility.

Figures 3c and 3d show that a CEO's choice of a PSD slope decreases with higher fractional bankruptcy costs and a greater risk-aversion coefficient, respectively. The reason for these results lies in the tendency of PSD to increase stock volatility.

C. Further extensions: leverage and free cash flows

The model described above can be extended to explore the effect of changes in leverage on managerial incentives. Prior research by Jensen (1986) notes that managers may divert firms' free cash flow for their own private benefit, and reducing free cash flows by increasing leverage can mitigate such problems. In order to incorporate the free cash flow effect of leverage, consider a firm whose risk-neutral manager can raise λD_0 from debt and $(1-\lambda)D_0$ from equity. Also, we assume that fraction $1-\varphi$ of the free cash flow $v - C(v)$ is returned to the shareholders and fraction $(1-\theta)\varphi(v - C(v))$ of the free cash flow is diverted by the CEO for his own private benefit.[6] The diversion of free cash flow incurs a deadweight cost of $\theta\varphi(v - C(v))$.

In this case, the competitive lending condition for the creditors becomes

$$\lambda D_0 = \frac{1}{1+r_f}\left\{\int_0^{V_D}(1-\gamma)vf(v)dv + \int_{V_D}^{\infty}(c_0 - c_1 v)\, f(v)dv\right\} \tag{13}$$

and for the fair return of new equity, holders require

$$(1-\lambda)D_0 = N_{new}\frac{1}{1+r_f}E[S_1(v)], \tag{14}$$

where $s(v)$ is the price per share of the firm's equity after new equity issuance,

[6] To emphasize the effect of free cash flow in the Jensen (1986) sense, we consider $v - C(v)$ as free cash flow. This implicitly assumes that all of the residual value in excess of debt repayment is stored in cash or liquid assets.

$$S_1(v) = max\left\{\frac{(1-\varphi)(v-C(v))}{N+N_{new}}, 0\right\} = \begin{cases} 0 & if\ v \leq V_D \\ \frac{(1-\varphi)(v-C(v))}{N+N_{new}} & if\ v \geq V_D \end{cases}. \tag{15}$$

The value of an option becomes

$$G_1(v) = max\{S_1(v) - K, 0\} = \begin{cases} 0 & if\ v \leq V_K \\ \frac{(1-\varphi)(v-C(v))}{N+N_{new}} - K & if\ v \geq V_K \end{cases} \tag{16}$$

Hence, the manager's wealth becomes

$$W_1(v) = w_0 + w_1 + nS_1(v) + mG_1(v) + (1-\theta)\varphi(v - C(v)). \tag{17}$$

The manager's expected value of private benefit (PB) becomes

$$PB = (1-\theta)\varphi \int_{V_D}^{\infty} \big(v - C(v)\big) f(v) dv. \tag{18}$$

The following proposition shows that the manager's private benefit is decreasing in leverage (and λ) while keeping its PSD slope (c_1) fixed.

Proposition 2: For a fixed PSD slope (c_1), private benefit is decreasing in the fraction of funds raised by debt (λ).

Proposition 2 highlights one of the key differences between changing leverage and changing PSD slope from the managerial incentive viewpoint. Steeper PSD slopes increase stock volatility by redistributing net cash flows while leaving total expected free cash flow unchanged. In contrast, higher leverage increases stock volatility, as noted in prior studies (e.g., Lewellen (2006), and Babenko (2009)), but it also reduces total expected free cash flow, from which managers may extract private benefits. Hence, a manager who seeks to obtain private benefits by increasing stock volatility will generally do better by holding leverage fixed and increasing the PSD slope, rather than the alternative of simply increasing leverage.

IV. Data description

We obtain data about PSD contracts from the Dealscan database, which contains detailed information on more than 100,000 loans, high-yield bonds, and private placements, mostly to larger borrowers. From 1994 to the present, Dealscan reports information about PSD features when they appear in debt contracts, including the PSD pricing grid. A pricing grid is essentially a step function schedule of interest payments contingent upon some aspect of the borrower's future performance or financial health, such as its debt rating.

Table 1 shows three loans from Nortel Networks Inc., illustrating how typical PSD contracts are described in performance pricing grids. These loans were 364-day facilities borrowed from syndicates of banks during 2001 and 2002, a period during which the company's credit rating was in decline. On July 31, 2001, Nortel's S&P senior debt rating was A, which subsequently fell to BBB- on December 20, 2001, and then to "not-rated" on April 8, 2002. The loan amounts ranged from $660 million to $1.22 billion.

Performance grids for the three loan contracts appear at the bottom of Table 1 and in Figure 4. Performance spreads are measured in basis points over LIBOR and are contingent upon the borrower's credit rating. The first contract specified future credit rating contingencies below the borrower's current credit rating, while the last contract specified future credit rating contingencies higher than current borrower's credit rating. The former is called an interest-increasing PSD contract, and the latter is referred to as an interest-decreasing PSD contract. The performance grid of the first contract, when Nortel was A-rated, ranged from A to BBB-, while the performance grids when Nortel was BBB- or NR rated ranged from BBB+ to BB. Thus, the performance grids specified detailed pricing schedules near a borrower's current credit rating, while leaving ranges far from the current rating as a flat schedule. Finally, the number of pricing

steps was smaller when Nortel had high credit quality (A rated) compared to when it had poor credit quality (BBB- and NR).

According to Asquith, Beatty, and Weber (2005), Dealscan reports five major types of financial measures found among the universe of PSD contracts: debt-to-EBITDA ratio (used in 53.3% of contracts), debt ratings (24.9%), interest coverage ratio (8.4%), fixed charge ratio (4.8%), and leverage (8.6%). Among these possible variables, we examine those using the senior debt rating as a measure of a borrower's performance.[7] This choice allows us to compare performance spreads across firms at different times. Also, the senior debt rating may be subject to less manipulation by managers than other PSD criteria. Beatty and Weber (2003) show that managers with PSD contracts tend to influence accounting information when performance measures are directly based on accounting figures. To achieve standardization of contract formats within the subsample we study, we narrow our observations to contracts issued between 1994 and 2002, by companies outside the financial industry (SIC codes 60–69), with LIBOR-based spreads, and without multiple performance criteria.

The riskiness of a PSD contract is measured by the slope of its performance pricing schedule. A steep slope indicates low interest payments when a firm performs well and high interest payments when a firm performs poorly. A flat slope, in contrast, indicates an ordinary fixed-rate debt contract, where constant interest payments are charged regardless of how a firm performs. Measuring the slope is complicated by the possibility that it might change over different ranges of the performance measure; the example presented earlier in this section shows exactly this situation, for a company whose pricing schedule is flatter at extreme levels of performance than in the middle range.

[7] PSD contracts based upon credit rating generally use the higher of the senior debt ratings maintained by Moody's and Standard & Poor's for the issuing company at any given time. Pricing grids for these contracts are generally expressed using the S&P notation (e.g., BBB instead of Baa).

We adopt two measures of the slope of a PSD contract, the "average slope" and the "local slope." An "average slope" is the mean PSD slope over all credit rating contingencies, and it measures a CEO's appetite for risk over a long horizon. A "local slope" is the PSD slope only for credit rating segments adjacent to the firm's actual credit rating at the time of contract inception, and it measures a CEO's appetite for risk in the short term. To calculate average slope, we find the change in interest rates over each credit rating increment specified in a given PSD contract. We then divide each incremental change by the market-wide difference in yields over the same increment at the time the contract was negotiated, using corporate bond yield data obtained from Moody's.[8] Under this scaling, a contract will exhibit a slope of one if it calls for a change in interest rates mirroring the profile of prevailing market yields. The slope will exceed one if it is steeper than the market yield profile and will be less than one if it is flatter. Fixed rate debt will have a slope of 0. After calculating market-adjusted slopes for all rating increments individually, we take their mean value for each contract, over the range bounded by the upper and lower limits of credit ratings for which interest changes are specified (these upper and lower limits vary from one contract to another).

Our calculation of local slope is quite similar. Again we calculate the change in interest rates called for by the PSD contract over each rating increment and scale that change by the prevailing market-wide slope for each increment. While the average slope calculation uses data for all increments specified under the contract, local slope is calculated as the average over the rating increments immediately above and immediately below the company's rating at the time of contract negotiation. Local slope is therefore:

[8] Our market-wide data are based upon the Moody's end-of-month value weighted average yield for long-term corporate bonds in each ratings class, according to data from the Citigroup YieldBook. We thank Chenyang Wei for assistance in obtaining this data.

$$LocalSlope = \frac{1}{2}\left(\frac{Spread(i-1) - Spread(i)}{Moody(i-1) - Moody(i)} + \frac{Spread(i) - Spread(i+1)}{Moody(i) - Moody(i+1)}\right) \tag{19}$$

where *Spread*(*n*) is the firm's interest cost above LIBOR at any rating *n*, *Moody* (*n*) is the market value-weighted average yield within rating class *n*, and *i* is the firm's rating at the time of contract negotiation. About 20% of our PSD contracts (281 observations out of 1,236) are written with the company's current credit rating as a "corner point" of the pricing schedule—meaning the changes in interest rates are specified only in one direction, exclusively above or exclusively below its current rating. For these observations we calculate local slope using only the single rating increment adjacent to its current rating. Figure 5 provides a graphical illustration of the calculation of local slope; intuitively, the slope of a PSD contract equals the change in spread (basis points above LIBOR) for each unit change in market spread at the firm's current credit rating.

To measure the convexity of a performance pricing profile *r*, we let CR_l and CR_h denote the lowest and the highest credit ratings used in the performance pricing schedule and $N(CR)$ denote the number of credit rating notches between CR and CR_h. We define the linear extrapolation of performance pricing schedule *r* as follows:

$$r_L(CR) = r(CR_h) + \frac{r(CR_l) - r(CR_h)}{N(CR_l)} N(CR). \tag{20}$$

We define the convexity of performance pricing profile *r* as the greatest deviation from the linear extrapolation:

$$x_r = sign\big(r_L(CR) - r(CR)\big) \cdot \max_{CR \in [CR_h, CR_l]} |r_L(CR) - r(CR)|, \tag{21}$$

where $sign(a)$ is 1 if $a \geq 0$ and is -1 if $a < 0$. Figure 5 shows conceptually how we measure convexity. The large majority of our PSD contracts exhibit convexity according to this definition, although many contracts have inflection points between convex and concave segments, and our

definition classifies a minority of 120 observations, or about 9% of our PSD sample, as concave. In our calculations of convexity we assign negative values to the concave observations, so that concavity is essentially treated as "negative convexity." We calculate values of overall convexity and local convexity based on the same approach as used for average slope and local slope.

We merge our sample of debt contracts from Dealscan with borrowers' financial statement data from Compustat using a matching algorithm.[9] We gather variables measuring firm size (natural log of total assets), leverage (short-term plus long-term debt over total assets), market-to-book ratio, cash flow (EBITDA), and the time series volatility of cash flow (the standard deviation of EBITDA over the four years prior to the loan year, standardized by the mean value over the same period).

We obtain information on managerial compensation and ownership from the ExecuComp database. Following Guay (1999) and Core and Guay (1999, 2002), we use the sensitivity of a CEO's stock and option values to changes in stock price (delta) and the sensitivity of a CEO's stock and option values to changes in stock return volatility (vega) as measures for incentives provided by managerial compensation and ownership. Based on these measures, Coles, Daniel, and Naveen (2006) find that higher vega leads to more risk-taking activities by management, such as lower investment in property, plant, and equipment; higher book leverage; and market leverage. In contrast, higher delta leads to less risky financial policies such as a decrease in leverage and an increase in capital expenditures.[10]

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[9] The process involves using text extracts to match firm names as they appear on each database. After the automated matching process, we inspect each paired observation for errors due to pathologies of the algorithm. We thank Charles Himmelberg for providing a conversion table and helpful advice.

[10] In this paper, we assume that PSD contracts are issued after compensation contracts are already made. There is a concern that compensation contracts may change in response to PSD contracts. We address this endogeneity issue by conducting a two-stage least squares Tobit regression, where delta and vega are endogenous variables. Also,

We follow the procedure described by Core and Guay (2002) for constructing delta and vega, and we use these statistics as proxies for managerial incentives. We match each PSD contract with the CEO's prior year-end delta and vega for each issuing company. The CEO's delta is obtained by weighting each CEO's delta for shares owned and delta for options owned by the number of shares and options held by that CEO. The delta for stock is one by definition, and the delta for stock option holdings is based on the derivative of the Black-Scholes formula with respect to stock price. To take account of the size of the CEO's equity position relative to the total capitalization of the firm, we divide the delta of each CEO by the firm's total shares outstanding plus the CEO's options. The approach, following the functional form used by Yermack's (1995) study of delta incentives from CEO options, gives the value gain realized by each CEO for a $1.00 increase in the firm's equity value. Since the vega for stock is very close to zero,[11] we only need to evaluate vega for option holdings, which is provided by the derivative of the Black-Scholes formula with respect to volatility. Due to the skewness of *vega*'s distribution, we generally use the functional form log(1+*vega*) in our regression estimations.

After discarding financial firms and companies without adequate data availability, we have a sample of 1,236 PSD contracts for 425 firms. Together with 3,215 non-PSD contracts for

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delta and vega are likely to change as the stock price changes, and the true value of delta and vega may differ from our measure, which uses annual closing stock price. If these discrepancies between actual and annualized sensitivities occur randomly, we expect the measurement errors to cancel out on average over the whole sample.

[11] In theory, a stock's vega may not be 0. Our assumption is based on Guay's (1999) empirical finding that vegas of stocks are very small relative to those of options, and can be approximated as 0: In Table 2 of Guay (1999), the mean executive option vega is 0.167 (standard deviation 0.105), while mean of stock's vega is 0.005 (standard deviation 0.016). The PSD issuers in our sample are mostly investment grade firms. Hence, stock convexity for PSD issuers should not be of great concern.

934 firms, our whole sample consists of 4,451 contracts for 1,359 firms who compete in 57 different primary two-digit SIC industries.[12] Table 2 presents summary statistics.

Comparing CEO incentives in firms with and without PSD contracts, we find little difference in delta but a significant difference in log(1+vega): The mean CEO delta is 0.023 for the PSD loan sample, while that of the non-PSD loan sample is 0.024. The vega, in contrast, is larger for the PSD sample than the non-PSD sample, with the difference significant at the 1% level.

Since the firms in our sample are public companies with bank relationships, they tend to be large. The median market capitalization for the PSD sample is $3.1 billion, while that of the non-PSD sample is $2.5 billion. The median value of total assets is $4.2 billion for firms with PSD contracts and is $3.3 billion for firms without PSD contracts, which is substantially larger than the average for the entire Compustat population. Firms with PSD contracts have lower market-to-book ratios and cash flow (EBITDA) than those without PSD contracts. PSD borrowers are somewhat older than straight debt borrowers. Figure 6 shows that both PSD and non-PSD issuers in our sample generally have high credit quality, but the distribution is somewhat tighter for PSD, with straight debt accounting for most of the observations with very high and very low ratings.[13] We do not find noticeable industry differences in our samples of PSD and non-PSD contracts. Table 3 presents the five highest and lowest industries for PSD use, ranked according to the ratio of PSD contracts over all debt contracts in our sample. Industries are arranged according to the 48 Fama-French SIC groups.

[12] Approximately 30% of our sample has useable PSD contracts because we only use those based on credit rating. In our Dealscan data source, 44% of the contracts have PSD features, suggesting that PSD contracts are almost as popular as straight debt.

[13] A certain number of observations are nonrated in both the PSD and non-PSD samples and are not used in Figure 6. It is possible for a nonrated bond to have a PSD pricing schedule based upon its credit rating, and this happens 72 times in our sample. In these cases the loan contract generally treats nonrated status as equivalent to having the lowest possible credit rating.

Loan characteristics of PSD contracts and ordinary debt contracts also exhibit noticeable differences. Loan amounts for PSD contracts are larger than those for the ordinary debt contracts, and the numbers of lenders involved in PSD contracts are significantly larger than those involved in ordinary debt contracts. This is consistent with Asquith, Beatty, and Weber (2005), who find that performance pricing is used to reduce renegotiation costs, which can become prohibitively high when many lenders are involved. PSD contracts have shorter maturity than ordinary debt contracts.

Our summary statistics for the average slope and local slope of PSD contracts indicate mean values of approximately 0.28 and 0.31, respectively. Our measure of overall convexity exhibits mean and median values just below 0.20, indicating that pricing schedules tend to be bowed toward the origin at a maximal deviation of about 20% below the linear projection between a schedule's endpoints. However, most PSD contracts exhibit very little convexity near the debt rating at the time of contract inception, as the mean value for local convexity is just 0.02 and the median value for local convexity is 0.

In Table 4 we show the sample correlations between average slope, local slope, overall convexity, local convexity, and a fifth variable equal to the number of individual rating steps specified in each PSD contract. These five quantities are used as dependent variables in our regression analysis below. We show correlations both for the entire sample, including fixed-rate debt with no pricing schedule, and for the subsample of PSD contracts only. In the upper panel, we see strong correlations among most of the dependent variables within the overall sample, due to the majority of zero-valued observations for all four of them. For example, the correlation between average slope and local slope is 0.823, and all correlations are significant at least at the 5% level.

Within the subsample of PSD contracts, sample correlations have much more modest magnitudes, the largest being the correlation of 0.526 between average slope and local slope. The two convexity measures exhibit weakly negative correlations with both average slope and local slope.

V. Analysis of PSD contract terms

In this section, we examine the impact of CEOs' equity incentives on firms' choices of PSD contract parameters. We expect CEOs with high values of vega to prefer more risky PSD contracts, and CEOs with high values of delta to prefer less risky contracts.

Figure 1 provides preliminary evidence that CEO incentives play an important role in the decision to issue PSD instead of straight debt. The figure shows PSD issuance frequencies for a subsample of 248 CEOs who received very large stock option awards, which we define as more than 1% of the company's outstanding shares. We display the probability that the firm's next debt issue following a large CEO option award is PSD, with the data shown separately depending upon whether the last debt issue prior to the option award was PSD or straight debt. For comparison purposes, data are also shown in the same format for our remaining sample of 4,203 pairs of debt contracts issued in sequence by individual firms, with no large CEO stock option award occurring between each contract pair. The figure shows that while prior PSD issuers continue to exhibit a preference for PSD in their next debt contracts, a large CEO option award leads to a markedly greater likelihood of PSD issuance regardless of the characteristics of the prior issue. Among the group of prior straight debt issuers, for instance, the probability that the next debt issue is PSD is about 40% following the receipt of a large option award by the CEO,

and about 25% otherwise. The difference is somewhat less dramatic for prior PSD issuers but is statistically significant at the 5% level in both cases.

A. Slope

We begin by using the slope of the PSD performance pricing schedule as our measure of the risk of a PSD contract. Because the straight-debt contracts in our sample exhibit zero slope by definition, we employ a Tobit regression specification:

$$Slope_i = \max(Slope_i^*, 0)$$

$$Slope_i^* = \alpha + \alpha_{Industry} + \alpha_{Year} + \beta_1 \cdot Delta_i + \beta_2 \cdot Vega_i + X_i \cdot \gamma + \varepsilon_i \qquad (22)$$

$$\varepsilon_i \sim N(0, \sigma^2)$$

$Slope_i$ is the dependent variable (the slope of PSD contract), $Delta_i$ is the delta of a CEO's equity grants normalized by shares outstanding, $Vega_i$ is the vega of a CEO's equity grants specified as log(1+vega), X_i are control variables, $\alpha_{Industry}$ are two-digit SIC dummy variables, α_{Year} are year dummy variables, and ε_i is the error term. We draw independent variables from prior literature on CEO compensation (e.g., Core and Guay (1999)) and on capital structure (e.g., Barclay and Smith (1995)) to control for heterogeneity in borrowers' characteristics and loan characteristics. These control variables in our models include firm size, leverage, market-to-book ratio, return on assets (based upon EBITDA), the time series volatility of EBITDA (the standard deviation over the prior 4 years, scaled by the mean over the prior 4 years), and an indicator variable for whether the firm's senior debt is rated by either Moody's or Standard & Poor's. To control for heterogeneity in loan characteristics, we use loan amount (scaled by total assets) and the log of maturity, as well as the log of the total number of PSD contracts for each firm reported in Dealscan, whether or not these contracts meet the data criteria for inclusion on

our sample. These control variables account for differences in borrowing capacity, investment opportunities and activities, uncertainty in borrowers' performance, and basic loan conditions. To account for the clustering of PSD contracts within firms and the heteroskedasticity of the error terms (ε), we cluster all standard errors at the firm level.

As suggested by Coles, Daniel, and Naveen (2006), a CEO's incentive structure (e.g., delta and vega) and aspects of the firm's capital structure (e.g., leverage and PSD choice) are determined simultaneously by many of the same economic forces. For example, firms with growth opportunities may benefit from motivating a risk-averse CEO to invest in high risk projects. These firms may offer a high vega compensation package, and the CEO in turn may seek out further risky growth opportunities. As a result, the causality of the CEO's incentive structure and the firm's risk profile may run on both directions. To deal with this possibility, Coles, Daniel, and Naveen (2006) employ a simultaneous equations model. Since the dependent variable of our paper is censored at zero (i.e., PSD slope), we employ a simultaneous equations model in a Tobit framework (i.e., 2SLS Tobit). While this model is not widely used in prior corporate finance research, it has been well developed in the labor economics literature to study female labor force participation (see, e.g., Connelly (1992) and Smith and Blundell (1986)).

For nearly all of our models, Wald tests indicate that the null hypothesis of exogeneity for delta and vega is rejected, so we adopt the two-stage least squares approach in our regressions throughout the paper. To implement this model, we need separate independent variables for the first-stage OLS models of CEOs' delta and vega incentives. We estimate the delta model with the dependent variables equal to the log of cash compensation (salary plus bonus), one-year earnings growth, return to shareholders, the Gompers-Ishii-Metrick (2003) governance index, firm size (log of total assets), years of tenure as CEO, year dummy variables, and two-digit

industry dummy variables. For the vega model, the independent variables are the log of cash compensation, return to shareholders, the governance index, the market-to-book ratio, and two-digit industry dummies. Prior studies such as Coles, Daniel, and Naveen (2006) find these variables to be influential on executive compensation characteristics (e.g., delta and vega), and hence, they are likely to be good candidates as instruments for our test. The null hypotheses of weak instruments based on F-tests proposed by Staiger and Stock (1997) are strongly rejected for both delta (F-stats = 59.26) and vega (F-stats = 12.34), which further confirms the validity of our instruments.[14]

As a measure for the goodness of the fit of the Tobit model, we adopt:

$$R^2_{DECOMPOSITION} = \frac{\frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2}{\frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2 + \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2} \tag{23}$$

where $\hat{y}_i$ is the value predicted by a maximum likelihood estimation, y_i is the actual value observed in the data, and $\bar{y}$ is the sample mean.[15]

The first two columns of Table 5 show parameter estimates for our two-stage least squares Tobit with the dependent variables equal to the average and local slopes of the performance pricing function. As shown in the table, we find that a CEO's delta has a negative impact on firms' choices of PSD slopes (significant for average slope but not local slope), whereas vega has a significantly positive impact that is similar for both dependent variables.

[14] We also assume that these instruments are independent from the second-stage residuals. Unfortunately, we are unable to find formal tests for this assumption. However, given that the second-stage dependent variables are not directly linked to CEO compensation, it seems to be a reasonable assumption.

[15] In nonlinear regression, there is no well-behaved counterpart to the R^2 from linear regression. One of the shortcomings of the above fit measure is that it does not relate to the proportion of variation explained; it only ranges from 0 to 1 because of a mechanical normalization. For further discussion on fit measures for nonlinear regressions, we refer the reader to the modeling guide of LIMDEP software, which we use for the estimation of our Tobit model (Greene (2002)).

These estimates are consistent with our moral hazard hypothesis that CEOs with high delta prefer flatter PSD contracts to mitigate the expected costs of financial distress, while CEOs with high vega prefer steeper PSD contracts because they increase the riskiness of the firm and volatility of stock returns.

To assess the economic significance of the estimated coefficients for the CEO delta and vega variables, we evaluate the impact of a one standard deviation change in each variable upon the average slope. Based on the descriptive statistics from Table 2, a one standard deviation increase in the CEO's delta, which is 0.046, corresponds to a decrease of 0.1 in the average slope of the pricing schedule, according to estimates in the left column of Table 5. Compared to the median value of 0.254, this change implies a reduction in magnitude of about 39%. In terms of credit spreads, an average fixed rate loan in our sample has 60 b.p. and the median difference between the maximum and minimum spread in a PSD grid is 50 b.p. That is, relative to a fixed rate loan, a typical PSD contract in our sample charges 35 b.p. more at the highest credit rating of the PSD contract, and 85 b.p. at the lowest credit rating. For a one standard deviation change in delta, the average slope decreases to 15.4% (i.e., 0.254-0.1), and the difference between the minimum and maximum spreads decreases to 30 b.p. That is, relative to a fixed rate loan, a typical PSD contract in our sample has 45 b.p. at the highest credit rating of the PSD contract, and 75 b.p. at the lowest credit rating of the PSD contract. For an average firm with high cash flow, this change in credit spread may be insignificant. However, for firms approaching financial distress, cash flows are often close to zero or negative, and such increase in spread at low credit rating will impose substantial extra burden on these firms. For the log(1+vega) variable, a one standard deviation change in the vega variable implies a change in the PSD slope of about 17%. All of these results about the importance of delta and vega are robust to various

combinations of subsets of control variables specified in Equation (22), as well as to tests on delta and vega alone by themselves without the other.

Analyzing estimates for other control variables in Table 5, we see that firms with smaller size, lower leverage, and higher cash flow (EBITDA) choose steeper PSD contracts. These results are broadly consistent with certain theories in corporate finance about optimizing behavior of the borrowers and lenders. For example, firms with high leverage may negotiate less risky PSD contracts to reduce agency costs of debt related to asset substitution. Firms with higher cash flow likely face lower expected costs of financial distress and therefore bear fewer implicit costs from steeper-sloped PSD contracts.

Our results in the first two columns of Table 5 indicate a connection between the slope of PSD contracts and the structure of CEOs' equity incentives. To understand this link in greater detail, we investigate the PSD slope in both directions starting from the firm's credit rating at the time of contract inception. If a firm's credit quality worsens, it moves into the "interest-increasing" range of the PSD pricing schedule and must pay greater coupon rates. In the other direction, if credit quality improves, the firm may move into the "interest-decreasing" PSD range and pay lower rates. In our sample of 1,236 PSD contracts, approximately 14% are strictly interest increasing, specifying rate changes only in the direction of credit deterioration, and another 6% are strictly interest decreasing. However, the overwhelming majority of 80% of contracts exhibit both interest-increasing and interest-decreasing slope components. In the third and fourth columns of Table 5, we present regression results in which the dependent variable equals the slope of each of these pieces; for example, for the interest-increasing contracts, the dependent variable equals the actual PSD slope at all credit ratings below the current rating, and zero at all ratings above it.

Estimates in the third and fourth columns of Table 5 indicate that the relation between the managers' delta and the PSD slope is negative over both the interest-increasing and interest-decreasing segments, but the magnitude is far stronger for the interest-increasing segment and is only significant in this direction. We conclude that delta incentives cause managers to have greater concern over avoiding the costs of financial distress than with the possibility of reducing the firm's credit costs in times of good performance. This pattern recalls the "asymmetric benchmarking" of CEO compensation incentives documented by Garvey and Milbourn (2006). CEOs' vega incentives are estimated as positive in both directions but without statistical significance.

In further estimations that are untabulated to save space, we investigate whether PSD slopes are associated with variables that proxy for expected bankruptcy costs and CEO risk aversion. We use the ratio of property, plant, and equipment (PPE) over total assets as our proxy for bankruptcy costs, since debt recovery rates in chapter 11 would likely be correlated with asset tangibility. For CEO risk aversion, we use an estimate of total CEO wealth equal to cash compensation plus the value of stock and option holdings, since risk aversion declines as a function of wealth for most people. We find that, as predicted by our model, both of these variables have positive estimates when added to the regressions in Table 5. However, only the CEO wealth variable is consistently significant; the PPE/total assets variable has estimates with marginal significance only in certain specifications, such as a dummy variable for firms in the top quintile. Because the large majority of firms in our sample are quite far from financial distress, our data may lack sufficient cross-sectional variation in order to test the hypothesis related to expected bankruptcy costs.

B. Convexity

Having identified significant relations between PSD contract slopes and CEO incentives, we examine whether similar patterns exist for the convexity of PSD contracts. Convexity provides an alternative measure of PSD contract riskiness, since convex pricing schedules accelerate the rate of increase in interest payments and thereby accelerate the rate of financial burden as the firm approaches states of low cash flow. Such convexity will increase the likelihood of financial distress, but it will also benefit CEOs with option-based risk incentives by providing very large rewards for improvements in firm performance. Following similar arguments used in the previous section, we expect CEOs with high delta to prefer flat PSD contracts that avoid deterioration of firm value due to increased expected bankruptcy costs, while high vega CEOs should prefer riskier PSD contracts with convex performance pricing schedules.

We estimate least squares regressions to test associations between convexity and CEO incentive variables; the least squares framework is used instead of Tobit since a minority of PSD contracts—those with concave schedules—are treated as having negative values for convexity. As dependent variables, we use both overall and local measures of convexity; these are estimated over the entire contract performance range and the rating segments immediately adjacent to the rating at contract inception, respectively.

Results of the estimations appear in Table 6. Similar to our earlier findings about PSD slopes, we find significantly negative parameter estimates for the CEO delta variable in both models and significant positive estimates for vega in one out of two. These results buttress our earlier evidence that managers with risk-taking incentives arising from option holdings use PSD contracts as a risk-shifting device, while managers with high ownership incentives from shares and options tend to do the opposite.

C. Impact of corporate governance

The main theme of this paper is that PSDs can be used by CEOs to capture private gains at the expense of shareholders. We therefore conjecture that firms with more entrenched managers will choose steeper-sloped PSD schedules and also prefer PSD over straight debt. In this section, we test this hypothesis by relating PSD slopes to corporate governance.

Anti-takeover provisions such as poison pills facilitate the entrenchment of corporate managers by shielding them from the threat of takeover. We therefore augment our prior regression models with an indicator variable that equals one if a firm has a poison pill and zero otherwise. As shown in Table 7, parameter estimates for the poison pill indicator are positive and statistically significant, implying that entrenched managers do elect debt contracts with steeper PSD slopes. Parameter estimates for the main delta and log(1+vega) variables are similar to those presented earlier in Table 5. We repeat this analysis using other measures of CEO entrenchment, such as indicators for a staggered board, the fraction of shares held by insiders, and Bebchuk, Cohen, and Ferrell's (2009) entrenchment index. Results, which are untabulated to save space, are qualitatively similar with consistent indication that more entrenched CEOs prefer steeper PSD schedules.

VI. Conclusions

This paper explores the effect of CEO equity incentives on the structure of performance sensitive debt contracts. PSD contracts require larger interest payments during a downturn in a borrower's performance but lower interest during states of performance improvement. This pattern tends to increase firm risk and lower overall equity value by exacerbating the expected

costs of financial distress. However, option holders would generally benefit from PSD contracts, since that pattern of payoffs to an optionee has a convex relation to overall equity value.

We estimate relations between a large sample of PSD schedules and the structure of CEOs' delta and vega incentives from their personal holdings of shares and options. We find that CEOs with high vega incentives from their option holdings tend to choose steeper and more convex performance pricing schedules than those with low vegas. These effects accord with our hypotheses about how the risk-taking incentives from personal option holdings should influence managers' choices when negotiating PSD schedules. Moreover, we find the opposite result for CEOs with high delta incentives, suggesting that they negotiate flatter and less steep PSD contracts in order to reduce the expected costs of financial distress. Our results are robust to controls for corporate governance, expected bankruptcy costs, and managerial risk aversion, all of which also exhibit significant associations with patterns of PSD contract design.

Appendix

Proof of Lemma 1.

(1) Differentiating (3) and taking into account that $V_D = \frac{c_0}{1+c_1}$ gives

$$\frac{dc_0}{dc_1} = \frac{\int_{V_D}^{\infty} vf(v)dv - \frac{\gamma}{1+c_1}V_D^2 f(V_D)}{\int_{V_D}^{\infty} f(v)dv - \frac{\gamma}{1+c_1}V_D f(V_D)} > 0 \tag{A1}$$

The denominator is positive because of equation (4). The numerator is positive because

$$\int_{V_D}^{\infty} vf(v)dv - \frac{\gamma}{1+c_1}V_D^2 f(V_D) = V_D\left(\int_{V_D}^{\infty} \frac{v}{V_D} f(v)dv - \frac{\gamma}{1+c_1}V_D f(V_D)\right)$$

$$> V_D\left(\int_{V_D}^{\infty} f(v)dv - \frac{\gamma}{1+c_1}V_D f(V_D)\right) > 0$$

(2) Differentiating $V_D \equiv \frac{c_0}{1+c_1}$ with respect to c_1 and taking into account (A1) gives

$$\frac{dV_D}{dc_1} = \frac{\int_{V_D}^{\infty}(v-V_D)f(v)dv}{(1+c_1)\int_{V_D}^{\infty} f(v)dv - \gamma V_D f(V_D)} > 0 \tag{A2}$$

Again, the denominator is positive because of equation (3).

Proof of Proposition 1.

(1) $BC = \frac{1}{1+r_f}\left\{\int_0^{V_D} \gamma v f(v)dv\right\}$ is increasing in c_1 because V_D is increasing in c_1.

(2) Because *BC* is increasing in c_1 and D_0 is fixed, it follows from (10) that S_1 is decreasing in c_1.

(3) Differentiating (12) with respect to c_1 and taking into account (A2) and the fact that $V_K = \frac{c_0+NK}{1+c_1} = V_D + \frac{NK}{1+c_1}$ gives

$$\frac{dG_0}{dc_1} = \frac{(1+c_1)P(v \geq V_D)P(v \geq V_K)(E[v|v \geq V_K] - E[v|v \geq V_D]) - \gamma V_D f(V_D)\int_{V_K}^{\infty}(v-V_D)f(v)dv}{N(1+r_f)\big((1+c_1)P(v \geq V_D) - \gamma V_D f(V_D)\big)}$$

where

$$P(v \geq V) = \int_V^\infty f(v)dv$$

and

$$E[v|v \geq V] = \frac{\int_V^\infty vf(v)dv}{\int_V^\infty f(v)dv}$$

The denominator is positive because of (1). Thus, $\frac{dG_0}{dc_1} > 0$ when

$$\gamma < \gamma^* = \frac{(1+c_1)P(v \geq V_D)P(v \geq V_K)(E[v|v \geq V_K] - E[v|v \geq V_D])}{V_D f(V_D) \int_{V_K}^\infty (v - V_D) f(v)dv}$$

Proof of Proposition 2.

For a fixed c_1, taking derivatives of c_0 with respect to λ in the competitive lending condition (Equation 13) yields,

$$\frac{dc_0}{d\lambda} = D_0 \left(\frac{1}{1+r_f} \left\{ \int_{V_D}^\infty f(v)dv - \frac{\gamma}{1+c_1} V_D f(V_D) \right\} \right)^{-1} > 0.$$

$\frac{dc_0}{d\lambda}$ is positive because of (4). In addition, since $\frac{dV_D}{dc_0} > 0$,

$$\frac{dV_D}{d\lambda} = \left(\frac{dV_D}{dc_0}\right)\left(\frac{dc_0}{d\lambda}\right) > 0.$$

Thus, $PB = (1-\theta)\varphi \int_{V_D}^\infty (v - (c_0 - c_1 v))\, f(v)dv$ is decreasing in λ.

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Table 1
Examples of performance pricing grids
Data for Nortel Networks Inc.'s syndicated 364-day facilities issued on July 31, 2001, December 20, 2001, and April 8, 2002, as reported by Dealscan. Each loan's pricing was tied to Nortel's long-term senior unsecured rating by Standard & Poor's. Nortel's S&P senior debt rating was A on July 31, 2001, BBB- on December 20, 2001, and Not Rated on April 8, 2002. The performance grids show spreads measured by basis points over LIBOR, contingent upon the company's S&P rating.

Loan characteristics	Contract 1	Contract 2	Contract 3
Date	July 31, 2001	December 20, 2001	April 8, 2002
Type	364-day facility	364-day facility	364-day facility
Amount	$1,220 million	$660 million	$1,175 million
Lenders in syndicate	10	11	25
Lead bank	Chase Manhattan & Credit Suisse	JPMorgan Chase & Credit Suisse	JP Morgan Chase
Senior	Yes	Yes	Yes
Secured	No	Yes	N/A
Covenant (million)	$3,500 (Net worth)	$1,880 (Tangible net worth)	N/A
Company's S&P senior debt rating	A	BBB-	NR
Performance grid (basis points over LIBOR)			
Greater than A	45	-	-
Greater than A-	55	-	-
Greater than BBB+	77.5	77.5	77.5
Greater than BBB	100	100	100
Greater than BBB-	120	120	120
Greater than BB+	-	150	150
Greater than BB	-	162.5	162.5
Less than BB	-	175	175

Table 2
Summary statistics
Descriptive statistics for a sample of performance sensitive debt (PSD) and regular debt contracts. Data are drawn for observations representing the intersection of the Dealscan, Compustat, and ExecuComp databases between 1994 and 2002, from all industries except the financial industry (SIC 6000-6999). The PSD sample includes only contracts for which the performance measure is based exclusively on the company's senior S&P debt rating. The delta and vega variables for each company's CEO are based upon holdings of stock and options. Leverage equals total debt / total assets. Volatility of sales is the time series standard deviation of annual sales over the four years prior to the loan year, divided by the time series mean value. The slope and convexity of the PSD loan pricing schedules are based on changes in the interest spread for different rating intervals, as described more completely in the text. The PSD sample includes 1,236 contracts negotiated by 425 individual firms, while the non-PSD sample includes 3,215 contracts from 934 firms.

	PSD contracts			Non-PSD contracts			Difference in means	
CEO incentives	Median	Mean	Std. Dev.	Median	Mean	Std. Dev.	Difference	t-statistic
Delta	0.0072	0.0227	0.0457	0.0080	0.0243	0.0515	(0.0015)	-0.92
log(1+Vega)	15.9	14.8	4.3	15.6	14.3	4.6	0.5	3.23
Cash compensation (000)	1275	1582	1162	1090	1498	1569	84	1.72
Years tenure in office	5	7.7	7.5	5	7.3	6.8	0.4	1.83
Borrower characteristics								
Market capitalization (mm)	3105	6714	10225	2490	12184	36809	(5470)	-5.15
Firm age (years)	30.0	33.5	21.0	29.0	33.3	22.4	0.1	0.14
Total assets (mm)	4200	8944	15115	3348	12765	41904	(3821)	-3.13
Leverage	0.33	0.33	0.13	0.32	0.32	0.20	0.01	1.64
Market-to-book ratio	1.38	1.66	0.95	1.39	1.76	1.21	(0.10)	-2.65
PP&E (mm)	1402	3495	5186	1118	3925	7530	(430)	-1.85
Cash flow (EBITDA, mm)	271	445	1156	203	620	2063	(175)	-2.82
Volatility of cash flow	0.309	0.506	2.104	0.309	0.557	10.918	(0.051)	-0.16
Senior debt rating at loan date	BBB+			BB+				
Loan characteristics								
Amount (mm)	400	677	865	200	471	851	206	7.20
Maturity (months)	36	36.3	23.1	30	40.7	40.1	(4.4)	-3.67
Number of lenders	14	16.1	11.0	5	8.6	9.6	7.5	22.44
Steps in pricing schedule	5	5.1	1.1					
Average slope	0.254	0.283	0.154					
Local slope	0.282	0.313	0.230					
Overall convexity	0.195	0.185	0.178					
Local convexity	0.000	0.023	0.2423					

Table 3
PSD issuance frequency by industry: Highest and lowest
Performance sensitive debt issuance frequency in various industries, according to observations from the Dealscan database between 1994 and 2002, from all industries except the financial industry (SIC 6000-6999). The table shows the fraction of PSD contracts in the five industries with the highest and lowest PSD frequencies, as well as the frequency for the overall sample. Industries are sorted into 48 groups according to the Fama-French SIC code mapping. Industries with fewer than 50 observations are not shown in the table.

Industry	Debt contracts in sample	PSD frequency
Printing and publishing	84	46.4%
Construction materials	148	45.3%
Apparel	97	42.3%
Consumer goods	90	37.8%
Chemicals	217	34.1%
. . .		
ENTIRE SAMPLE	4,451	27.8%
. . .		
Health care	44	25%
Automobiles and trucks	131	16.0%
Restaurants and lodging	79	13.9%
Pharmaceuticals	95	11.6%
Computers	144	8.6%

Table 4
Correlations among dependent variables
Sample correlations among key dependent variables. The top panel shows Pearson correlations for the entire sample of 4,451 debt contracts, and the bottom panel shows correlations for the subsample of 1,236 performance sensitive debt (PSD) contracts. Data are drawn from the intersection of observations in the Dealscan, Compustat, and ExecuComp databases between 1994 and 2002, from all industries except the financial industry (SIC 6000-6999). The slope and convexity of the PSD loan pricing schedules are based on changes in interest spreads for different rating intervals, as described more completely in the text.

All observations	Average slope	Local slope	Overall convexity
Local slope	0.823***		
Overall convexity	0.488***	0.487***	
Local convexity	0.068***	-0.038**	0.183***

PSD observations	Average slope	Local slope	Overall convexity
Local slope	0.526***		
Overall convexity	-0.174***	-0.029	
Local convexity	-0.001	-0.153***	0.173***

Significant at 1% (***), 5% (**) and 10% (*) levels

Table 5
Slopes of PSD contracts and CEOs' equity incentives
Regression models for slopes of PSD contract pricing schedules. The sample includes 4,451 debt contracts issued by 1,359 firms between 1994 and 2002, both with and without PSD contract features. The average slope of a pricing schedule equals the mean of the ratio of the differential interest cost over each credit rating interval covered by a PSD contract, divided by the differential Moody's value-weighted average interest cost over the same interval at the time of the contract negotiation. Local slope is the average slope measured over the two rating intervals immediately adjacent to the firm's rating; if performance pricing is defined only in one direction, local slope is calculated only for the single adjacent interval. The slope of straight debt is zero. For columns 3 and 4, the average slope dependent variable, which is defined more completely in the text, is decomposed into two segments. In the third column, the dependent variable equals the average slope at all credit ratings below the firm's rating at the time of contract inception (the "interest increasing" range), and zero at all higher ratings. In the fourth column, the dependent variable equals the average slope at all credit ratings above the firm's current rating (the "interest decreasing" range) and zero otherwise. Key explanatory variables are the sensitivity of CEO stock and option values to stock price (delta), and the sensitivity of CEO option values to stock price volatility (vega). Standard errors clustered at the firm level are shown in parentheses. Estimates use a two-stage least squares Tobit framework described more fully in the text.

Dependent variable:	Average slope x 10^2	Local slope x 10^2	Slope of interest increasing segment x 10^2	Slope of interest decreasing segment x 10^2
Delta	-217.224	-161.355	-228.140	-76.813
	(85.375)**	(125.331)	(79.623)***	(83.395)
Log (1+vega)	1.026	1.216	0.887	0.461
	(0.565)*	(0.711)*	(0.521)*	(0.544)
Firm size (log of assets)	-3.976	-4.221	-4.760	-2.784
	(1.166)***	(1.498)***	(1.090)***	(1.104)**
Leverage (total debt / total assets)	-33.398	-46.703	-36.708	-27.229
	(7.159)***	(10.015)***	(7.147)***	(6.949)***
Market-to-book ratio	-0.711	0.138	-0.172	-1.979
	(0.869)	(1.121)	(0.841)	(0.967)**
EBITDA / total assets	27.146	30.641	25.737	26.155
	(10.355)***	(12.998)**	(10.176)**	(9.241)***
EBITDA time series volatility	-0.023	-0.020	-0.002	-0.023
	(0.071)	(0.094)	(0.055)	(0.065)
Sr. debt rated by S&P or Moody's	31.988	39.818	172.140	22.644
(indicator)	(3.284)***	(4.582)***	(9.386)***	(3.222)***
Loan amount / total assets	0.186	0.348	-0.0145	-0.090
	(0.979)	(1.347)	(0.824)	(0.768)
Log of Maturity (months)	0.281	0.498	0.238	0.409
	(0.955)	(1.211)	(0.898)	(0.893)
Log of Number of PSD contracts	38.677	47.062	34.778	31.436
	(1.778)***	(2.803)***	(1.725)***	(2.064)***
Year & 2-digit SIC indicators	Yes	Yes	Yes	Yes
Pseudo-R^2	0.445	0.461	0.478	0.470
Observations	4,451	4,451	4,451	4,451

Significant at 1% (***), 5% (**) and 10% (*) levels.

Table 6
Global and local convexity of PSD contracts
Two-stage least squares regression estimates of the global and local convexity of pricing schedules of performance sensitive debt contracts. The sample includes 4,451 debt contracts issued by 1,359 firms between 1994 and 2002, both with and without PSD contract features. Convexity is calculated based on the most extreme departure of the pricing schedule slope from the linear projection of the schedule between the upper and lower limits of credit ratings for which performance pricing is contracted. Concave pricing schedules, about eight percent of the sample, are assigned negative values for convexity. Global convexity is measured over the entire range of credit ratings for which performance pricing is specified, while local convexity is measured over the two rating intervals immediately adjacent to the firm's rating; if performance pricing is defined only in one direction, local convexity is calculated only for the single adjacent interval. For non-PSD (straight) debt, the majority of the sample, convexity always equals zero by construction. Key explanatory variables are the sensitivity of CEO stock and option values to stock price (delta), and the sensitivity of CEO option values to stock price volatility (vega). Standard errors clustered at the firm level are shown in parentheses.

Dependent variable:	Global convexity x 10^2	Local convexity x 10^2
Delta	-43.078	-59.480
	(22.991)*	(25.713)**
Log (1+vega)	0.267	0.060
	(0.144)*	(0.151)
Firm size (log of assets)	-0.606	-0.096
	(0.336)*	(0.390)
Leverage (total debt / total assets)	-7.731	-3.626
	(1.435)***	(1.484)**
Market-to-book ratio	0.350	0.078
	(0.162)**	(0.188)
EBITDA / total assets	-1.505	0.812
	(1.416)	(1.146)
EBITDA time series volatility	-0.006	-0.004
	(0.013)	(0.014)
Sr. debt rated by S&P or Moody's (indicator)	3.428	1.349
	(0.577)***	(0.637)**
Loan amount / total assets	0.161	0.110
	(0.317)	(0.190)
Log of Maturity (months)	0.442	0.205
	(0.242)*	(0.236)
Log of Number of PSD contracts / firm	6.342	6.188
	(0.540)***	(0.770)***
Year & 2-digit SIC indicators	Yes	Yes
Adjusted R^2	0.143	0.144
Observations	4,451	4,451

Significant at 1% (***), 5% (**) and 10% (*) levels.

Table 7
The impact of corporate governance on PSD slopes

Regression models for slopes of PSD contract pricing schedules. The sample includes 4,451 debt contracts issued by 1,359 firms between 1994 and 2002, both with and without PSD contract features. The average slope of the pricing schedule equals the mean of the ratio of the differential interest cost over each credit rating interval covered by a PSD contract, divided by the differential Moody's value-weighted average interest cost over the same interval at the time of contract negotiation. Local slope is the average slope measured over the two rating intervals immediately adjacent to the firm's rating; if performance pricing is defined only in one direction, local slope is calculated only for the single adjacent interval. The slope of straight debt is zero. For columns 3 and 4, the average slope dependent variable, which is defined more completely in the text, is decomposed into two segments. In the third column, the dependent variable equals the average slope at all credit ratings below the firm's rating at the time of contract inception (the "interest increasing" range), and zero at all higher ratings. In the fourth column, the dependent variable equals the average slope at all credit ratings above the firm's current rating (the "interest decreasing" range) and zero otherwise. Key explanatory variables are the indicator for poison pill, sensitivity of CEO stock and option values to stock price (delta), and the sensitivity of CEO option values to stock price volatility (vega). Standard errors clustered at the firm level are shown in parentheses. Estimates use a two stage least squares Tobit framework described more fully in the text. Estimates use a two-stage least squares Tobit framework described more fully in the text.

Dependent variable:	Average slope x 10^2	Local slope x 10^2	Slope of interest increasing segment x 10^2	Slope of interest decreasing segment x 10^2
Poison pill (indicator)	0.007	0.007	0.006	0.007
	(0.003)**	(0.004)*	(0.003)*	(0.003)**
Delta	-212.286	-156.462	-223.895	-71.781
	(84.706)**	(124.751)	(79.643)***	(82.627)
Log (1+vega)	1.002	1.193	0.860	0.439
	(0.560)*	(0.708)*	(0.518)*	(0.540)
Firm size (log of assets)	-3.902	-4.146	-4.693	-2.717
	(1.159)***	(1.492)***	(1.089)***	(1.095)**
Leverage (total debt / total assets)	-33.036	-46.365	-36.359	-26.922
	(7.120)***	(9.981)***	(7.113)***	(6.904)***
Market-to-book ratio	-0.673	0.176	-0.149	-1.946
	(0.862)	(1.116)	(0.839)	(0.956)**
EBITDA / total assets	26.165	29.829	24.905	25.335
	(10.038)***	(12.756)**	(9.940)**	(8.974)***
EBITDA time series volatility	-0.023	-0.020	-0.003	-0.024
	(0.071)	(0.094)	(0.055)	(0.065)
Sr. debt rated by S&P or Moody's	32.034	39.902	171.716	22.718
(indicator)	(3.270)***	(4.576)***	(9.382)***	(3.213)***
Loan amount / total assets	0.203	0.367	-0.003	-0.070
	(0.977)	(1.346)	(0.823)	(0.768)
Log of Maturity (months)	0.291	0.512	0.266	0.416
	(0.952)	(1.208)	(0.897)	(0.892)
Log of Number of PSD contracts	38.737	47.133	34.833	31.508
	(1.778)***	(2.799)***	(1.736)***	(2.059)***
Year & 2-digit SIC indicators	Yes	Yes	Yes	Yes
Pseudo-R^2	0.445	0.461	0.479	0.470
Observations	4,451	4,451	4,451	4,451

Significant at 1% (***), 5% (**) and 10% (*) levels.

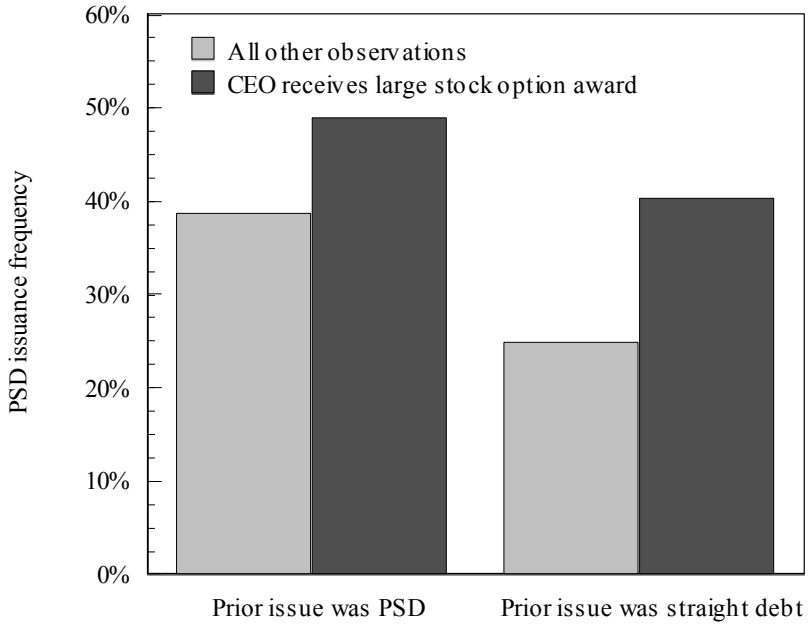


Figure 1
PSD issuance frequencies and large CEO stock option awards
The figure shows performance sensitive debt issuance frequencies for subsamples partitioned according to whether the company's prior debt issue in the Dealscan database was PSD or straight debt. Within each subsample, PSD frequencies are shown separately based on whether the CEO received a large stock option award between the prior and subsequent debt issues, with a large option award defined as greater than 1.0% of shares outstanding. The overall sample includes 248 observations associated with large CEO option awards, and 4,203 observations with no large awards. In both subsamples, the difference between the two bars shown is statistically significant at the 5% level.

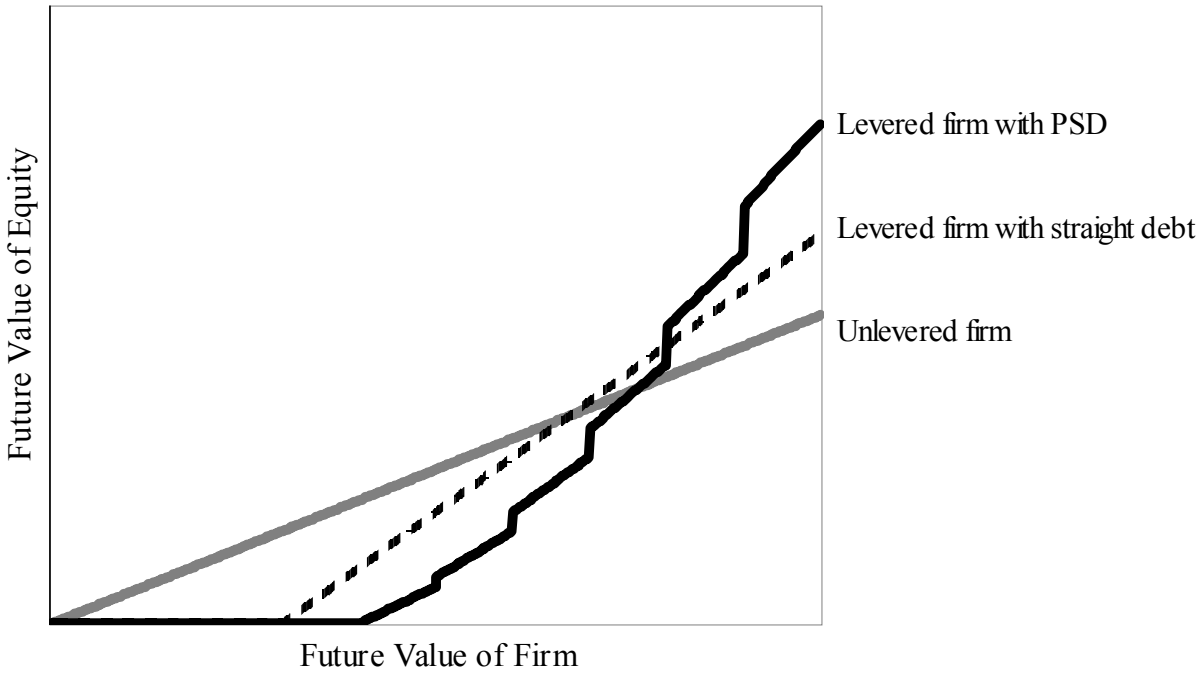
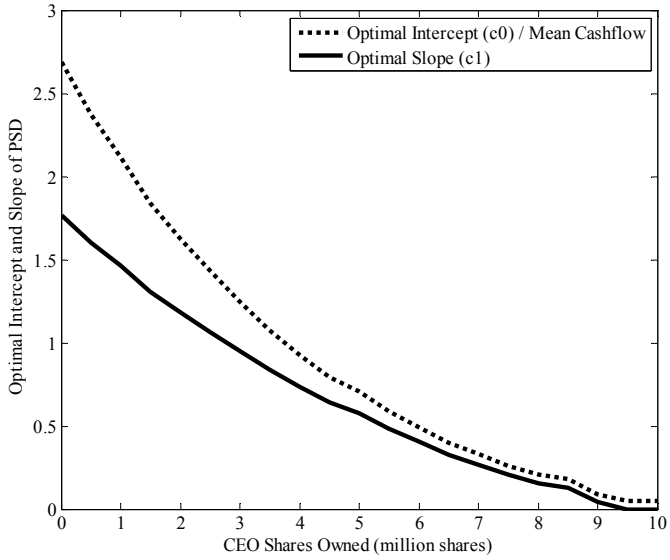
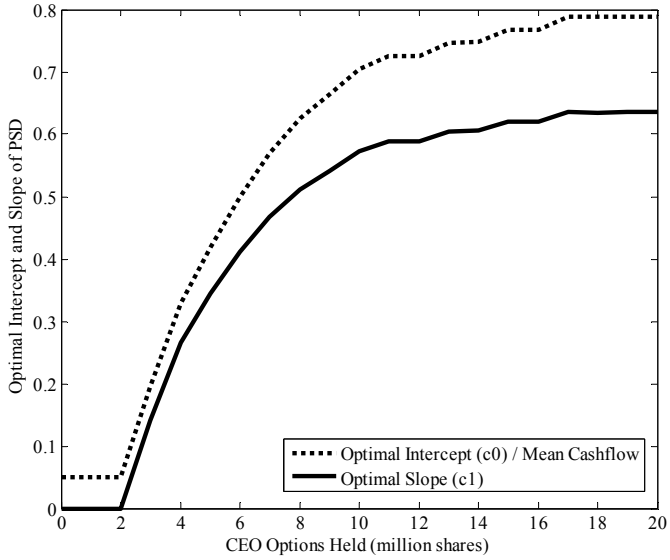


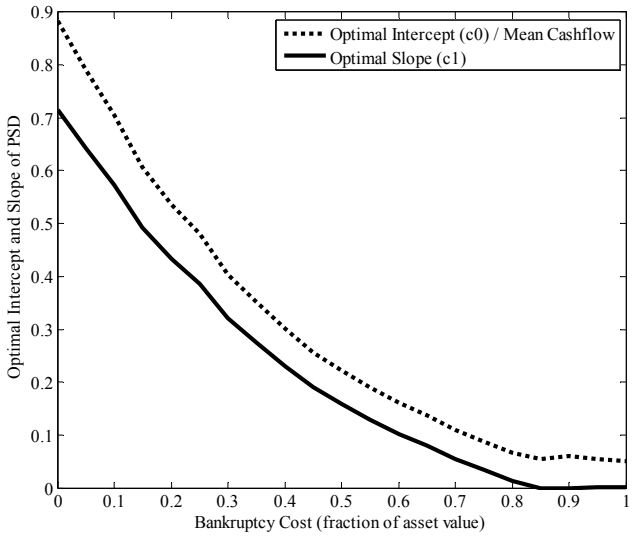
Figure 2
Value of equity claim under different capital structures
The figure shows the value of an equity claim under three different stylized capital structures for a hypothetical firm. In all three cases, the equity claim has an identical ex ante dollar value. The solid grey line shows that under an unlevered, all-equity capital structure, the equity holder receives a constant fraction of future firm value. The dotted line shows the future value of equity under a classical levered capital structure in which the firm issues straight debt and uses the proceeds to eliminate equity held by other investors. With straight debt, if the firm performs poorly, equity receives nothing, but when the firm performs well the equity holder receives a greater fraction of firm value than she would in an all-equity firm, as the slope of the dotted line exceeds the slope of the solid grey line. The dark, segmented line shows the future value of equity under a levered capital structure in which the firm issues performance sensitive debt and uses the proceeds to eliminate outside equity. With PSD, the cost of debt rises as firm performance deteriorates, and default occurs at a higher firm value. The different segments of the PSD schedule reflect periodic increases in interest cost as firm performance deteriorates; these higher interest costs reduce the value of the equity claim. At very high levels of performance, the value of an equity claim exceeds the value that would be realized in an ordinary levered capital structure without PSD.



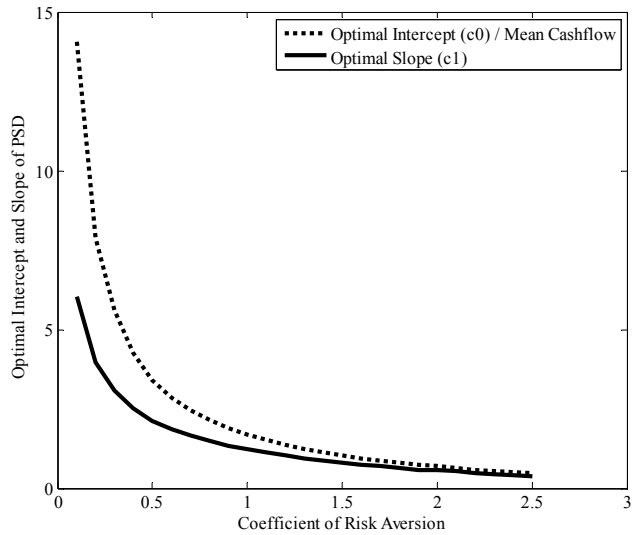
(3a) Optimal PSD vs. CEO shares owned



(3b) Optimal PSD vs. CEO options held



(3c) Optimal PSD vs. bankruptcy cost



(3d) Optimal PSD vs. CEO risk aversion

Figures 3a through 3d
Comparative statics of PSD slope

The figures show the optimal intercept (c_0) and slope (c_1) of a PSD contract with respect to the CEO's stock ownership (3a), stock option holdings (3b), the firm's fractional bankruptcy cost (3c), and the CEO's risk-aversion parameter (3d). The figures are generated by numerical simulations based upon the model described in section II. Simulations use the following assumptions: CEO equity holdings (n) of 5 million shares, CEO option holdings (m) of 10 million shares, total outstanding number of shares (N) of 5 billion, CEO initial wealth (w_0) of \$50 million, option strike price of \$1, risk free rate of 1.57%, fractional bankruptcy cost (γ) of 10%, and coefficient of risk-aversion (ρ) of 2.

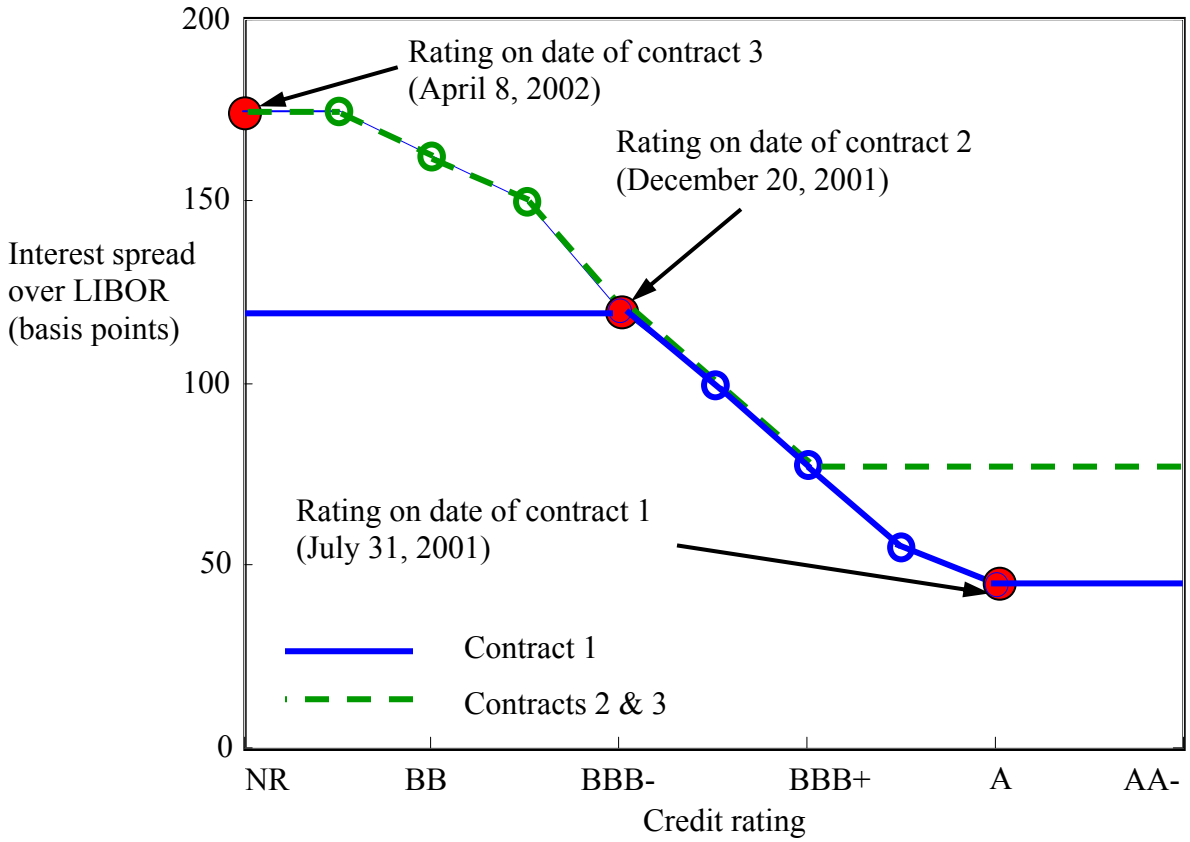


Figure 4
Examples of performance pricing grids
The figure shows examples of pricing grids in performance sensitive debt contracts negotiated by Nortel Networks Inc., according to data from Loan Pricing Corp.'s Dealscan database. The solid line with circles shows interest rates for a 364-day credit facility negotiated on July 31, 2001, contingent upon the company's future credit rating. The dashed line shows the pricing schedule for similar loans to the same company on December 20, 2001, and April 8, 2002. Nortel's S&P senior debt rating was A on July 31, 2001, BBB- on December 20, 2001, and NR on April 8, 2002.

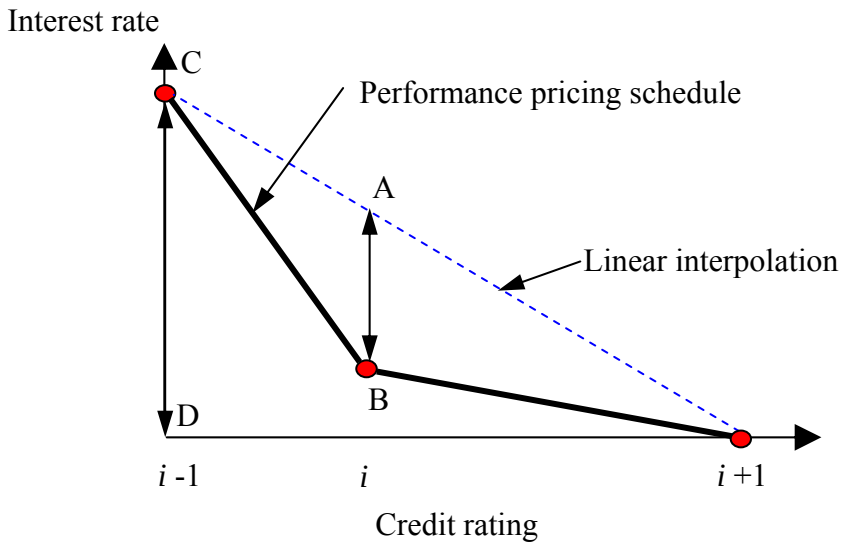


Figure 5
Slope and convexity of a performance pricing profile
The figure shows a hypothetical performance pricing profile for a firm that has credit rating *i* and negotiates a performance sensitive debt contract calling for higher interest payments if the credit rating deteriorates and lower interest payments if it improves. The figure shows how the interest rate might change above and below the firm's current rating. If $i - 1$ and $i + 1$ represent the credit ratings immediately adjacent to current rating, then our definition of local slope is:

$$\frac{1}{2}\left(\frac{Spread(i) - Spread(i-1)}{Moody(i) - Moody(i-1)} + \frac{Spread(i+1) - Spread(i)}{Moody(i+1) - Moody(i)}\right)$$

Where *Spread*(*n*) is the interest charged at credit rating *n*, measured as basis points above LIBOR, and *Moody*(*n*) is the value-weighted average yield for long-term corporate bonds of credit rating *n* during the month in which the contract is negotiated. Our definition of average slope is analogous, except it is measured using the mean ratios for all rating segments between the upper and lower limits of credit ratings specified in each contract. Our definition of overall convexity, which is described more fully in the text, is based upon the maximum deviation of a pricing profile from linearity and is therefore similar to the ratio:

$$\frac{A - B}{\|C - D\|}$$

Convexity therefore equals zero for perfectly linear pricing schedules and takes a negative value for concave schedules.

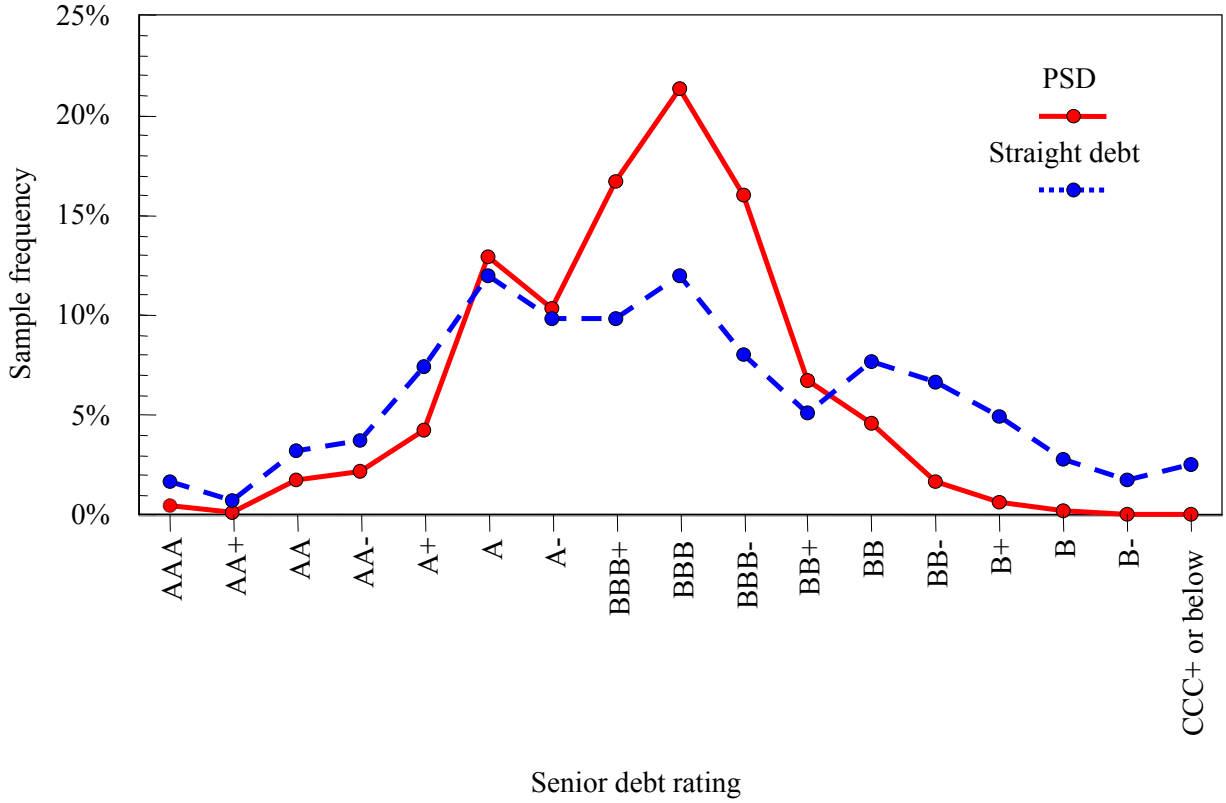


Figure 6
Credit quality of PSD and straight debt issuers
The figure shows the frequency distribution of senior debt ratings at the time of contract inception for samples of 1,303 performance sensitive debt contracts and 2,666 straight debt contracts. The PSD and straight debt samples analyzed in the paper are somewhat larger, but the figure does not include debt issues by companies that are not rated by S&P or Moody's.