Optimal Priority Structure, Capital Structure, and Investment

Dirk Hackbarth
University of Illinois at Urbana-Champaign
College of Business
515 East Gregory Dr., MC-520
Champaign, IL 61820
(217) 333-7343
dhackbar@illinois.edu

David C. Mauer
University of Texas at Dallas
School of Management
800 West Campbell Rd., SM31
Richardson, TX 75080
(972) 883-5844
dmauer@utdallas.edu

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Abstract

We examine the role of debt priority structure in resolving stockholder-bondholder conflicts over investment policy. In a dynamic model where the firm can issue multiple classes of debt, we show that the firm may under- or overinvest in future growth options. We show that when debt priority is endogenized along with capital structure there is an interior optimal priority structure which virtually eliminates equityholders' suboptimal investment incentives and fully exploits the debt capacity of future growth options. The optimal priority structure allocates priority to initial debt to mitigate suboptimal investment incentives and yet preserves priority for subsequent debt issues to maximize future debt capacity. A key implication of our analysis is that priority structure is a critical and heretofore unrecognized financial contracting device that helps to resolve stockholder-bondholder conflicts over investment policy. Several additional results have implications for empirical research in corporate finance.

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1. Introduction

Researchers in corporate finance have long been interested in the question of how financial structure influences and in turn is influenced by investment policy. As originally argued by Myers (1977), when the firm has risky debt outstanding and when managers act to maximize equity value rather than total firm value, managers have an incentive to underinvest in future growth options. The reason is that risky debt may capture enough of the benefit from the exercise of these options that the net present value accruing to equityholders is negative. As emphasized by Jensen and Meckling (1976), there are also circumstances under which managers may have an incentive to overinvest in future growth options. Since the loss in firm value attributable to these suboptimal investment incentives constitutes a significant component of the agency costs of debt, an important question is how financial contracts have evolved to control conflicts of interest between stockholders and bondholders.

In this paper, we examine how capital structure and debt priority structure interact with corporate investment policy in a dynamic model where self-interested equityholders may choose a suboptimal growth option exercise strategy. Extending Leland's (1994) model to investment, the novel feature of our model is the explicit recognition that the existing capital structure of the firm influences future investment decisions through two channels. First, there is the standard stockholder-bondholder conflict attributable to the existing capital structure over the timing of the investment decision. Second, there is the largely ignored role played by how future investment is financed, which is the key focus of our analysis. Recognizing that future investment may be financed with a combination of equity and debt has important consequences for the existing capital structure, the nature of the investment conflict, and ultimately for the dynamic evolution of financial contracts. In particular, an interesting and novel feature of this feedback from future to current financing decisions is the critical role that debt priority structure plays in resolving stockholder-bondholder conflicts.

In our model the firm has assets-in-place and a growth option to expand its operations, the timing of which is endogenously determined by management to maximize the market value of equity (second-best policy) or the market value of debt and equity (first-best policy). The firm chooses its initial capital structure and the debt-equity mix used to finance the cost of exercising the growth option by trading off tax benefits of debt against expected default costs triggered by an endogenous default decision of equityholders as in Leland (1994). Since the firm can have multiple debt issues outstanding after the growth option is exercised, it must also choose a priority rule for its debts in case of post-investment default. Our analysis allows for equal priority (*pari passu*), me-first for initial debt, me-first for additional debt issued to finance the growth option, and an optimal allocation of priority. The latter case allows the firm to choose any priority (in default) that together with dynamic financing decisions jointly optimize firm value.

We find that priority structure plays a critical and heretofore unrecognized role in helping to resolve stockholder-bondholder conflicts over investment policy. To see this role, it is important to understand how debt influences the firm's investment policy. In a standard Myers (1977) framework where the firm is constrained to only finance the growth option with equity, it is well known that equityholders will underinvest in the growth option by delaying its exercise relative to a first-best firm value-maximizing exercise policy. We show, however, that this all-equity financing constraint is suboptimal, since an unconstrained firm will *optimally* finance the cost of exercising the growth option with debt. Interestingly, under an equal priority (*pari passu*) scheme for the initial pre-investment debt and the additional debt used to finance the growth option, we find that equityholders' investment incentive shifts from underinvestment to overinvestment.[1] Thus, although it is optimal for the firm to use debt to finance the cost of exercising the growth option, in equilibrium, the firm continues to bear significant agency costs of debt since equityholders now choose to overinvest (i.e., invest too soon) in the growth option. Investment distortions cannot be resolved under either a me-first rule for initial debt or a me-first rule for additional debt.[2] Importantly, we show that when debt priority is endogenized along with capital structure there is an *interior* optimal priority structure which virtually eliminates equityholders' incentive to overinvest in the growth option. This optimal priority structure allocates just enough priority to initial debt to discourage equityholders from diluting their claim with additional debt and yet preserves priority for additional debt to enhance the proceeds from the additional debt issue. In this sense, we establish the novel result that the optimal choice of *debt structure* can nearly create first-best investment incentives for an equity value-maximizing manager.

Our analysis highlights the role of priority structure in an optimal financial contract designed to mitigate stockholder-bondholder conflicts.[3] On the one hand, we show that capital structure can be used to completely eliminate underinvestment incentives when new debt can be issued at the time of investment. However, this financial contracting solution is suboptimal since it does not fully exploit the incremental debt capacity of the growth option. On the other hand, equityholders' anticipation of that additional debt capacity induces suboptimal overinvestment incentives. We show, however, that the optimal allocation of priority among the firm's debts can

[1] Note that this implies that there is a unique capital structure (i.e., initial time zero debt issue and additional debt issue when the growth option is exercised) at which the equityholders' investment strategy equals the firm value-maximizing investment strategy and there are no agency costs of debt. We illustrate this novel "zero agency cost" solution in our analysis of the unconstrained model in Section 4.1.
[2] Indeed, we show that a me-first rule for initial debt (i.e., complete protection from dilution caused by the additional debt issue) leads right back to underinvestment, while a me-first rule for additional debt simply magnifies equityholders' incentive to overinvest.
[3] For excellent reviews of the financial contracting approach to corporate finance, see e.g., Hart (1995) and Roberts and Sufi (2009).

eliminate overinvestment incentives. Thus, optimal capital structure and optimal priority structure can together eliminate *both* under- and overinvestment incentives and hence fully exploit the debt capacity of the firm's growth option.[4]

We also find that highly levered firms will *spread* priority across debt classes. Thus, in our model, as the initial debt level increases and therefore the implied credit rating of the firm deteriorates, the firm will spread out priority by shifting priority to future debt issues. This implication of our model is consistent with the recent empirical results of Rauh and Sufi (2009) who find that firms spread priority among multiple tiers of debt as credit quality weakens.

Our analysis has implications for the conservative debt policy puzzle. As first studied by Graham (2000), a large proportion of firms appear to be underleveraged in that they are far from fully exploiting debt tax deductions and yet have low ex ante costs of financial distress. We show that debt conservatism is consistent with a setting where the firm has the flexibility to issue debt in the future. Specifically, we find that having the option to issue debt in the future dramatically decreases the optimal leverage today. Goldstein, Ju, and Leland (2001) and Strebulaev (2007) find similar results in models where the firm has the option to recapitalize in the future (i.e., buy back all outstanding debt and issue a new higher amount of debt). Unlike these models, however, debt conservatism is a feature of our model because the debt capacity of future growth options has a downward influence on the current level of debt. Thus, the interaction between financing and investment decisions in a dynamic setting may give the appearance of debt conservatism. Importantly, we find this result even when there is *no* agency conflict over the timing of the investment decision.

[4] Similarly, Hackbarth, Hennessy, and Leland (2007) show that placing bank debt senior in the firm's debt priority structure fully exploits interest tax shield benefits in a trade-off model with multiple classes of debt but without investment.

We uncover several new and interesting implications for the relation between leverage and Tobin's *Q* and leverage and credit spreads. We establish that market leverage ratios are decreasing in Tobin's *Q* and book leverage ratios are increasing in Tobin's *Q*. These relations are important, because they hold regardless of whether there is a stockholder-bondholder conflict over the exercise of future growth options. The implications for empirical work are many. First, documenting an inverse relation between market leverage and the market-to-book ratio – the standard proxy for Tobin's *Q* – may not be evidence of agency costs of debt. Indeed, our analysis shows that there should be an inverse relation between market leverage and the market-to-book ratio with or without agency costs of debt. Second, the debt capacity of growth options may not be negative. In contrast with Barclay, Morellec, and Smith (2006), who argue that there should be a negative relation between book leverage and growth options, we find a positive relation between book leverage and Tobin's *Q* even when there are agency conflicts over the exercise of the firm's future growth options. Third, our model illustrates that the relation between leverage and growth opportunities depends on whether the empiricist is using a book or a market leverage measure. Consistent with our model's predictions, Fama and French (2002), Chen and Zhao (2006), and Frank and Goyal (2009) find that book leverage is positively related to the market-to-book ratio. Chen and Zhao (2006) further establish that credit spreads decrease in the market-to-book ratio, a result which we find in our model using Tobin's *Q*, and which helps to explain why leverage and *Q* can be positively related.

Lastly, the analysis has implications for the empirical measurement of agency costs of debt. We find that an alternative indicator of agency costs is the time elapsed between intermittent investments. The analysis suggests that a hazard model of the probability of investment, such as Whited (2006), could be a fruitful avenue for tests of agency conflicts.

Our paper is related to a growing literature that examines dynamic investment and financing decisions in continuous-time models.[5] The papers closest yet complementary to ours are Lobanov and Strebulaev (2007) and Sundaresan and Wang (2007). Similar to our analysis, these papers show how growth option exercise decisions and financing decisions interact in dynamic models. Unlike our analysis, however, Lobanov and Strebulaev (2007) do not study debt structure, while Sundaresan and Wang (2007) find debt structure is economically *not* important when the firm may endogenously adjust leverage in response to investment distortions. A key difference between our analysis and the Sundaresan and Wang analysis is that they exogenously specify either a me-first priority rule for earlier debt issues or a *pari passu* (equal) priority rule for all debt issues. In contrast, we find that when overall financial structure is endogenous, debt priority structure plays an important role in mitigating if not completely eliminating investment distortions.[6]

The remainder of the paper is organized as follows. Section 2 presents the general model. Section 3 analyzes the constrained version of the model, in which the growth option is fully equity financed. We relax this standard assumption in Section 4 by considering debt and equity financing of the growth option. In addition, the firm can select between equal priority and me-first rules as well as a jointly optimal capital and priority structure choice in this section. Section 5 concludes and several technical developments are relegated to the Appendix.

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[5] For example, see Brennan and Schwartz (1984), Mello and Parsons (1992), Mauer and Triantis (1994), Mauer and Ott (2000), Childs, Mauer, and Ott (2005), Lobanov and Strebulaev (2007), Strebulaev (2007), Sundaresan and Wang (2007), Titman and Tsyplakov (2007), Hackbarth (2008), Tserlukevich (2008), and Tsyplakov (2008).

[6] Earlier work by Smith and Warner (1979), Stulz and Johnson (1985), and Berkovitch and Kim (1990) examine how debt priority structure influences investment incentives. Smith and Warner (1979) argue that secured debt may limit the firm's ability to engage in asset substitution, while Stulz and Johnson (1985) argue that secured debt can mitigate underinvestment problems. Berkovitch and Kim (1990) examine how exogenously-specified priority rules influence a firm's decision to make an investment when the firm has debt outstanding and the investment is all debt

2. Model

2.1 Basic Assumptions

Consider a firm with assets-in-place and a growth option. Assets-in-place generate uncertain earnings before interest and tax (EBIT) of $(X(t))_{t\geq 0}$, which is described by

$$dX(t) = \mu X(t)dt + \sigma X(t)dZ(t), \qquad X(0) = X_0 > 0, \tag{1}$$

where μ is the constant drift rate per unit time under the risk-neutral measure, σ is the constant volatility per unit time, and $(Z(t))_{t\geq 0}$ is a standard Wiener process under the risk-neutral measure. A risk-free security yields a constant r per unit time with $\mu < r$.

The firm may exercise the growth option by paying an investment expenditure of $I > 0$. Immediately upon exercise, EBIT increases from X to ΠX, where $\Pi > 1$. Although we assume that the exercise of the growth option is irreversible, the firm has the flexibility to exercise the option at any time. We assume that the manager chooses the exercise policy of the growth option to maximize the market value of equity. Given that the firm uses equity and debt financing (discussed below), equity value maximization may not coincide with firm value maximization. For comparison, we therefore consider the case where the manager chooses the growth option exercise policy that maximizes total firm value.

The firm is initially capitalized with (a single class of) debt and equity financing. Following Leland (1994), we assume that this initial debt issue has infinite maturity and has a coupon payment of C_0. The firm may issue additional debt when it finances the cost, I, of exercising the growth option. We assume that this additional debt issue also has infinite maturity,

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financed. Barclay and Smith (1995) and Julio, Kim, and Weisbach (2008) empirically document that a firm's debt priority structure is related to firm characteristics that predict agency conflicts (e.g., growth opportunities).

and has a coupon payment of C_s. The optimal debt coupon initially, C_0^*, and when the growth option is exercised, C_s^*, are jointly determined to maximize the initial value of the firm. This optimization is driven by a tradeoff between bankruptcy costs, interest tax shields, and investment benefits. Notably, the tradeoff will indirectly be influenced also by the contractual specification of priority structure.[7]

Assuming corporate taxes are paid at a constant rate τ with full loss offset provisions, outside bankruptcy the firm earns interest tax shields of τC_0 and $\tau(C_0 + C_s)$ before and after exercise of the growth option, respectively. The decision to default on debt coupon payments is chosen endogenously to maximize the market value of equity before and after investment (see e.g. Leland (1994)). In the event of default, equityholders receive nothing (i.e., there are no deviations from absolute priority), and bondholders assume ownership of the firm's assets net of bankruptcy costs.[8] Bankruptcy costs include the loss of interest tax shields, the loss of the growth option (assuming it has not already been exercised), and the fraction α $(0 \leq \alpha < 1)$ of the value of assets-in-place. Prior to the exercise of the growth option, initial debtholders receive 100% of this net asset value. After the exercise of the growth option, however, this net asset value is distributed to the initial and additional debts according to a contractually specified priority rule

[7] Our analysis links the timing of the additional debt issue to the timing of the exercise of the growth option, thereby not allowing the firm to choose separately when to issue additional debt. First, an important issue is whether this linkage of debt financing and growth option investment exercise induces the investment distortions which we attribute to the agency costs of debt. The answer is no, because investment distortions are identified by comparing first- and second-best decisions with the *same* financing and investment options, so that the potential influence of leverage benefits is the same. Second, and perhaps most importantly, this exogenously imposed linkage is actually optimal, since the firm in our model would not *optimally* choose to issue debt before or after the growth option is exercised (see Appendix C). On the one hand, the firm would not issue additional debt before the option is exercised, because maximum additional debt capacity is achieved at investment when cash flow expands from X to ΠX. On the other hand, it is suboptimal to delay issuing additional debt after the growth option is exercised as long as the firm's debt capacity changes substantially at the time of the investment, so that the post-investment restructuring option is far enough in the money that it is optimally exercised immediately.

[8] Franks and Torous (1994) document that violations of absolute priority are more pronounced in distressed exchanges than in formal bankruptcy reorganizations (i.e., Chapter 11). More recently, Bharath, Panchapagesan, and Werner (2007) find a sharp decline in the incidence of absolute priority violations in the U.S.

enforced by the bankruptcy court. We assume initially equal priority (*pari passu*) in bankruptcy, and subsequently analyze me-first rules and the case where capital structure and priority structure are jointly optimized.

In what follows, we first derive security and firm values before and after exercise of the growth option—subscripts l and h are used for the (on average) *l*ow and *h*igh regions of earnings before and after investment. Using these valuation results, we then derive the first- and second-best growth option exercise policies that maximize firm and equity value, respectively. Some of the technical details of the model derivation are in the Appendix.

2.2 Security and Firm Values After Investment

Given that after investment the firm's EBIT is increased by the multiplier Π and the firm has two debt issues outstanding, the cash flow to equity is $(\Pi X - C)(1-\tau)$ per unit time, where $C = C_0 + C_s$. For $X > X_{dh}$, the value of equity is equal to

$$E_h(X,C) = (1-\tau)\left[\left(\frac{\Pi X}{r-\mu} - \frac{C}{r}\right) - \left(\frac{\Pi X_{dh}}{r-\mu} - \frac{C}{r}\right)\left(\frac{X}{X_{dh}}\right)^a\right], \tag{2}$$

where $X_{dh} \in (0, X_0)$ denotes the default threshold, the ratio $(X / X_{dh})^a$ is the value of a contingent claim paying \$1 if EBIT hits X_{dh} the first time from above, and $a < 0$ is the negative root of the quadratic equation $x(x-1)\sigma^2/2 + x\mu - r = 0$. Since default is determined endogenously to maximize the market value of equity, equity value in (2) must satisfy a smooth-pasting condition at the default threshold, $\partial E_h / \partial X\big|_{X = X_{dh}} = 0$. Using this condition we may determine that

$$X_{dh} = \frac{a(r-\mu)C}{r(a-1)\Pi}. \tag{3}$$

The market values of the initial debt issue and the additional debt issued to finance the investment in the growth option are, for $X > X_{dh}$, given by

$$D_h(X, C_0) = \frac{C_0}{r}\left[1 - \left(\frac{X}{X_{dh}}\right)^a\right] + \beta_0 L_h(X_{dh})\left(\frac{X}{X_{dh}}\right)^a, \tag{4}$$

and

$$D_h(X, C_s) = \frac{C_s}{r}\left[1 - \left(\frac{X}{X_{dh}}\right)^a\right] + \beta_s L_h(X_{dh})\left(\frac{X}{X_{dh}}\right)^a, \tag{5}$$

respectively, where $L_h(X_{dh}) = (1-\alpha)\Pi U X_{dh}$ with $U = (1-\tau)/(r-\mu)$ is the liquidation value of assets in bankruptcy (i.e., when $X = X_{dh}$), and where $\beta_0 = C_0/C$ and $\beta_s = 1-\beta_0 = C_s/C$. Note that the coupon weights, β_0 and β_s, apportion $L_h(X_{dh})$ among the debts according to our base case assumption of equal priority (*pari passu*).

Summing (2), (4) and (5), we may compute firm value after investment as

$$V_h(X, C) = \Pi U X + \frac{\tau C}{r}\left[1 - \left(\frac{X}{X_{dh}}\right)^a\right] - \alpha \Pi U X_{dh}\left(\frac{X}{X_{dh}}\right)^a, \tag{6}$$

which is the sum of unlevered value (i.e., the value of assets-in-place) and expected tax shield value (based on a total coupon of $C = C_0 + C_s$), minus expected bankruptcy costs. We will find it useful in subsequent sections to define an optimal capital structure for the firm after the growth option is exercised. Thus, maximizing (6) with respect to *C*, we find that

$$C^*(X) = \Pi U X \frac{r(a-1)}{a(1-\tau)}\left[1 - a\left(1 + (1-\tau)\frac{\alpha}{\tau}\right)\right]^{1/a}. \tag{7}$$

Note that $C^*(X)$ describes the optimal total capital structure of the firm at an arbitrary level of X after investment.

2.3 Security and Firm Values before Investment

The general solutions for the market values of equity and debt prior to investment in the growth option are

$$E_l(X, C_0) = (1-\tau)\left(\frac{X}{r-\mu} - \frac{C_0}{r}\right) + E_1 X^a + E_2 X^z, \tag{8}$$

and

$$D_l(X, C_0) = \frac{C_0}{r} + D_1 X^a + D_2 X^z, \tag{9}$$

where E_1, E_2, D_1, and D_2 are constants to be determined by boundary conditions, and where $z > 1$ is the positive root of the quadratic equation $x(x-1)\sigma^2/2 + x\mu - r = 0$.

Denoting X_{dl} as the default threshold and X_s as the investment threshold, $E_l(X, C_0)$ must satisfy the following default (10) and investment (11) boundary conditions:

$$E_l(X_{dl}, C_0) = 0, \tag{10}$$

and

$$E_l(X_s, C_0) = E_h(X_s, C) - \left[I - D_h(X_s, C_s)\right]. \tag{11}$$

Note that the term in square brackets on the right-hand-side of (11) is the amount of equity financing used to invest in the growth option.[9] Substituting (2), (5), and (8) into (10) and (11), we may determine that

$$E_l(X,C_0) \;=\; (1-\tau)\left[\left(\frac{X}{r-\mu}-\frac{C_0}{r}\right)-\left(\frac{X_{dl}}{r-\mu}-\frac{C_0}{r}\right)\Delta(X)\right]+$$

$$(1-\tau)\left[\frac{(\Pi-1)X_s}{r-\mu}-\frac{I-D_h(X_s,C_s)}{1-\tau}-\frac{C_s}{r}-\frac{C}{r}\left(\frac{1}{a-1}\right)\left(\frac{X_s}{X_{dh}}\right)^a\right]\Sigma(X), \qquad (12)$$

where

$$\Delta(X)=\frac{X^zX_s^a-X^aX_s^z}{X_{dl}^zX_s^a-X_{dl}^aX_s^z} \quad \text{and} \quad \Sigma(X)=\frac{X_{dl}^zX^a-X_{dl}^aX^z}{X_{dl}^zX_s^a-X_{dl}^aX_s^z}.$$

We may interpret (12) as follows. Denoting T_{dl} as the (random) first passage time to default (i.e., $T_{dl}=\inf\{t:X(t)\le X_{dl}\}$) and T_s as the (random) first passage time to investment (i.e., $T_s=\inf\{t:X(t)\ge X_s\}$), it can be shown (see Appendix A) that $\Delta(X)=\mathrm{E}[e^{-rT_{dl}}\mid T_{dl}<T_s]$ and $\Sigma(X)=\mathrm{E}[e^{-rT_s}\mid T_s<T_{dl}]$, where $\mathrm{E}[\cdot\mid\cdot]$ denotes conditional expectation. In words, $\Delta(X)$ is the present value of \$1 contingent on X *first* reaching the default threshold X_{dl} from above, and $\Sigma(X)$ is the present value of \$1 contingent on X *first* reaching the investment threshold X_s from below. Thus, the first line of (12) is the pre-investment value of assets-in-place less the present value of after-tax coupon payments, minus this net value to equity in default multiplied by the default state price, $\Delta(X)$. The second line of (12) captures the incremental value to equity resulting from investing in the growth option and issuing additional debt to help finance the

[9] Note that if the term in square brackets is negative, equityholders receive a debt-financed dividend in addition to the fully debt-financed investment cost at the time of investment. As we will see below, whether $I<D_h(X_s,C_s)$ or not is endogenously determined as a result of optimizing the joint choice of capital structure C_0 and C_s (and debt structure) subject to the relevant boundary conditions for default and investment.

investment expenditure, all multiplied by the investment state price, $\Sigma(X)$. As expected, if $X = X_{dl}$, $\Delta(X_{dl}) = 1$, $\Sigma(X_{dl}) = 0$, and $E_l(X, C_0) = 0$; and if $X = X_s$, $\Delta(X_s) = 0$, $\Sigma(X_s) = 1$, and $E_l(X_s, C_0) = E_h(X_s, C) - [I - D_h(X_s, C_s)]$.

The constants in $D_l(X, C_0)$ are identified using, respectively, the default boundary condition at X_{dl} and the value-matching boundary condition at X_s:

$$D_l(X_{dl}, C_0) = L_l(X_{dl}), \tag{13}$$

and

$$D_l(X_s, C_0) = D_h(X_s, C_0), \tag{14}$$

where $L_l(X_{dl}) = (1-\alpha)UX_{dl}$. Substitution of (4) and (9) into (13) and (14) gives

$$D_l(X, C_0) = \frac{C_0}{r}\left[1 - \Delta(X) - \left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\right] + L_l(X_{dl})\Delta(X) + \beta_0 L_h(X_{dh})\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X), \tag{15}$$

where it is clear in (15) that initial time zero debt receives the full liquidation value of the firm if the firm is bankrupt before T_s (i.e., $L_l(X_{dl})$), and receives the fraction β_0 of the liquidation value of the firm if the firm is bankrupt after T_s (i.e., $\beta_0 L_h(X_{dh})$). Thus, $D_l(X, C_0)$ is a weighted average of discounted coupon payments, pre-investment liquidation proceeds, and post-investment liquidation proceeds.

Summing $E_l(X, C_0)$ and $D_l(X, C_0)$, total firm value can be written as

$$V_l(X, C_0) \; = \; UX + (1-\tau)\left(\frac{(\Pi - 1)X_s}{r - \mu} - \frac{I}{1-\tau}\right)\Sigma(X) + \frac{\tau C_0}{r}\left[1 - \Delta(X) - \left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\right]$$

$$+\frac{\tau C_s}{r}\left[1-\left(\frac{X_s}{X_{dh}}\right)^a\right]\Sigma(X)-\alpha\left[UX_{dl}\Delta(X)+\Pi UX_{dh}\left(\frac{X_s}{X_{dh}}\right)^a\Sigma(X)\right]. \quad (16)$$

In (16), the first term is the value of assets-in-place, the second term is the *levered* value of the growth option, the next two terms are, respectively, the tax shield values of the time zero debt issue and the time T_s debt issue, and the final term is the expected value of bankruptcy costs. Observe that the *levered* value of the growth option in (16) is worth less than the *unlevered* value of the growth option. Formally, as $\Sigma(X)<(X/X_s)^z$ for $X_{dl}>0$, we have

$$(1-\tau)\left(\frac{(\Pi-1)X_s}{r-\mu}-\frac{I}{1-\tau}\right)\Sigma(X) < (1-\tau)\left(\frac{(\Pi-1)X_s}{r-\mu}-\frac{I}{1-\tau}\right)\left(\frac{X}{X_s}\right)^z,$$

where the right-hand since of the inequality is the *unlevered* value of the growth option. Hence, this inequality reveals an additional (implicit) cost of issuing debt at time zero.

2.4 Optimal Policies

We now determine the optimal value of X at which the firm invests in the growth option, X_s. As noted above, we assume that the manager chooses the growth option exercise policy to maximize the market value of equity. Since this policy may not maximize total firm value, we refer to this critical value of X as the second-best investment trigger. We must also solve for the pre-investment endogenous default threshold, X_{dl}, that maximizes the market value of equity. Thus, we require that the market value of equity, $E_l(X, C_0)$, satisfies the following smooth-pasting conditions at X_s and X_{dl}:[10]

$$\left.\frac{\partial E_l(X, C_0)}{\partial X}\right|_{X=X_s} = \left.\frac{\partial E_h(X, C)}{\partial X}\right|_{X=X_s} + \left.\frac{\partial D_h(X, C_s)}{\partial X}\right|_{X=X_s}, \tag{17}$$

and

$$\left.\frac{\partial E_l(X, C_0)}{\partial X}\right|_{X=X_{dl}} = 0. \tag{18}$$

Substituting (2), (5), and (12) into (17), we find that

$$X_s = \frac{r-\mu}{1-\Theta}\left[\frac{\Lambda}{\Pi-1}\left(\frac{X_{dl}}{r-\mu} - \frac{C_0}{r}\right) - \frac{\Theta}{\Pi-1}\left(\frac{C_s}{r} + \frac{I - D_h(X_s, C_s)}{1-\tau}\right)\right.$$
$$\left. + \left\{\frac{a 1_{C_s>0}}{\Pi-1}\left(\frac{C_s}{r(1-\tau)} - \frac{a(1-\alpha)\beta_s}{a-1}\frac{C}{r}\right) + \frac{a-\Theta}{\Pi-1}\frac{C}{r}\frac{1}{a-1}\right\}\left(\frac{X_s}{X_{dh}}\right)^a\right], \tag{19}$$

where $1_{C_s>0}$ is an indicator function that is equal to 1 when $C_s > 0$ and zero otherwise, and Λ and Θ are the elasticities of $\Delta(X)$ and $\Sigma(X)$ with respect to the investment threshold:

$$\Lambda = \frac{\partial \Delta(X)}{\partial X_s}\frac{X_s}{\Delta(X)} = \frac{(a-z)X_s^{a+z}}{X_{dl}^z X_s^a - X_{dl}^a X_s^z} > 0 \quad \text{and} \quad \Theta = -\frac{\partial \Sigma(X)}{\partial X_s}\frac{X_s}{\Sigma(X)} = \frac{aX_s^a X_{dl}^z - zX_{dl}^a X_s^z}{X_{dl}^z X_s^a - X_{dl}^a X_s^z} > 0$$

Similarly, substituting (12) into (18), we find that

$$X_{dl} = \frac{r-\mu}{1+\Omega}\left[\Omega\frac{C_0}{r} - \Gamma\left(\frac{(\Pi-1)X_s}{r-\mu} - \frac{C_s}{r} - \frac{I - D_h(X_s, C_s)}{1-\tau} - \frac{C}{r}\left(\frac{1}{a-1}\right)\left(\frac{X_s}{X_{dh}}\right)^a\right)\right], \tag{20}$$

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[10] The second term on the right-hand-side of (17) is the change in value of the debt proceeds from issuing additional

where Ω and Γ are the elasticities of $\Delta(X)$ and $\Sigma(X)$ with respect to the default threshold:

$$\Omega = \frac{\partial \Delta(X)}{\partial X_{dl}} \frac{X_{dl}}{\Delta(X)} = \frac{aX_{dl}^{a} X_{s}^{z} - zX_{s}^{a} X_{dl}^{z}}{X_{dl}^{z} X_{s}^{a} - X_{dl}^{a} X_{s}^{z}} > 0 \quad \text{and} \quad \Gamma = -\frac{\partial \Sigma(X)}{\partial X_{dl}} \frac{X_{dl}}{\Sigma(X)} = \frac{(a-z)X_{dl}^{a+z}}{X_{dl}^{z} X_{s}^{a} - X_{dl}^{a} X_{s}^{z}} > 0$$

Although the expressions for X_s and X_{dl} are complicated, it is interesting to note that they not only reflect the time zero capital structure (i.e., C_0), but also the post-investment capital structure (i.e., $C = C_0 + C_s$), and through $D_h(X_s, C_s)$, priority structure (i.e., $\beta_s = 1 - \beta_0$). Our analysis in subsequent sections will examine these linkages.

For comparison, we compute the first-best investment trigger which maximizes total firm value. Thus, we solve for the investment threshold that satisfies the following smooth-pasting optimality condition:

$$\left. \frac{\partial V_l(X, C_0)}{\partial X} \right|_{X = X_s} = \left. \frac{\partial V_h(X, C)}{\partial X} \right|_{X = X_s} . \tag{21}$$

Substituting (6) and (16) into (21), we find that

$$X_s = \frac{1/U}{1-\Theta} \left[\frac{\Lambda}{\Pi - 1} \left(\frac{\tau C_0}{r} - \frac{\tau C_s}{r} \left(\frac{X_{dl}}{X_{dh}} \right)^{a} + \alpha U X_{dl} \right) + \frac{\Theta}{\Pi - 1} \left(\frac{\tau C_s}{r} - I \right) \right.$$

$$\left. + \frac{a - \Theta}{\Pi - 1} \left(\frac{\tau C_0}{r} + \alpha \Pi U X_{dh} \right) \left(\frac{X_s}{X_{dh}} \right)^{a} \right]. \tag{22}$$

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debt to finance the exercise of the growth option, evaluated at $X = X_s$.

Note that although the default threshold for this first-best case is analytically identical to that in (20), since the expressions for the first- and second-best investment triggers in (22) and (19) are different, and therefore the capital structure, priority structure, and post investment default thresholds are likely to be different, we anticipate that the pre-investment default thresholds will be different.

3. All-Equity Financing of the Growth Option

We assume initially that the firm faces a constraint which requires that the growth option is all equity financed, and establish the well known Myers (1977) result that levered equityholders will underinvest in the growth option. Although this analysis is intended to set the stage for our subsequent analysis, we establish several new results for the relation between leverage ratios, credit spreads, and Tobin's *Q*, and the measurement of the agency cost of debt.

To implement the analysis, we set $C_s = 0$ and thereby constrain the solution of the model to the case where the investment expenditure, *I*, required to exercise the growth option is all-equity financed. Since analytic comparison of optimal policies is inconvenient and largely sterile, we solve the model numerically using the following base case parameter values: the initial pre-tax cash flow, X_0, is 20, the investment option payoff factor, Π, is 2.0, the cost of exercising the growth option, *I*, is 200, the volatility of cash flows, σ, is 25% per year, the drift rate of cash flows, μ, is 1% per year, the risk-free rate, *r*, is 6% per year, the corporate tax rate, τ, is 15%, and proportional bankruptcy costs, α, are 25% of the value of assets-in-place at the time of bankruptcy.[11]

[11] Note that for these parameters the NPV of exercising the growth option immediately is positive, i.e., NPV = $[(1 - \tau)(\Pi - 1)X_0]/(r - \mu) - I = 140$. Since NPV is increasing in *X* and since the investment threshold X_s is at least equal to X_0, the pure unlevered value of the investment when the growth option is exercised will be positive. Thus, regardless

For these parameter values, the second-best equity value-maximizing growth option exercise threshold is $X_s = 29.52$, and the first-best firm value-maximizing growth option exercise threshold is $X_s = 24.68$.[12] The higher second-best threshold indicates underinvestment in the growth option as the expected present value of investment is less under the second-best policy. As originally elucidated by Myers (1977), the economic intuition for why equityholders underinvest is that they pay all of the cost of exercising the growth option but share the benefits with risky debt. Thus, in our dynamic model, equityholders limit the benefit accruing to risky debt by waiting to exercise at a higher investment threshold where default risk is lower.

Figure 1 graphs market and book leverage ratios as a function of Tobin's *Q* for the first-best (solid line) and second-best (dashed line) investment policies. Panels A and B plot market and book leverage ratios at the optimal coupon, C_0^*, and Panels C and D plot market and book leverage ratios at a fixed coupon, C_0^{exog}.[13] Book leverage, *BL*, is computed as the market value of debt, $D_l(X_0, C_0)$, divided by the value of assets-in-place, $V_a = ((1-\tau)X_0)/(r-\mu)$, and market leverage, *ML*, is the market value of debt divided by total firm value, $V_l(X_0, C_0)$. Tobin's *Q* is computed as the ratio of total firm value to the value of assets-in-place. The graphs vary *Q* by varying $\Pi > 1$.[14]

Holding debt constant (C_0^{exog}), Panel C illustrates that first- and second-best market leverage ratios are decreasing in *Q*, and Panel D illustrates that first- and second-best book

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of the leverage benefits from exercising the growth option and financing the investment cost with debt, the investment benefits will always be positive.

[12] These policies assume the debt coupon is fixed at $C_0^{exog} = 18.48$. As discussed below (see Table 1), this coupon is the average of the first-best optimal coupon and the second-best optimal coupon for the base-case parameters.

[13] Whether under a first- or second-best investment policy, the optimal coupon is chosen to maximize total firm value, i.e., $C_0^* = \arg\max V_l(X_0, C_0)$. Thus, in Panels A and B the optimal coupon is changing as *Q* varies.

[14] We could alternatively vary *Q* by varying *I*.

leverage ratios are increasing in Q. A similar pattern emerges in Panels A and B when we allow debt to endogenously adjust (C_0^*) as Q is varied, albeit with one difference. Focusing first on book leverage in Panel B, we see that both first- and second-best book leverage ratios are increasing in Q. Thus, in contrast with the conclusions of Barclay, Morellec, and Smith (2006), who argue for and find empirical evidence of a negative relation between book leverage and growth options, our model predicts a positive relation with (second-best) or without (first-best) agency conflicts. Evidence consistent with our model's prediction is reported in Fama and French (2002) and Frank and Goyal (2009) who find that book leverage is reliably positively related to the market-to-book asset ratio, and in Chen and Zhao (2006) who find that book leverage is positively related to the market-to-book asset ratio for all firms except those with the highest market-to-book ratios.[15] Finally, note that although Panel B (and Panel D) illustrates that the incremental debt capacity of growth options is always positive, the wedge between the first- and second-best leverage ratios widens as Q increases. This indicates that the agency cost of debt *is* increasing in Q.

The positive relation between book leverage and Tobin's Q in Panel B is reversed for market leverage in Panel A. Thus, note in Panel A that the second-best market leverage ratio (dashed line) is monotonically decreasing in Tobin's Q. Unexpectedly, however, observe that the first-best market leverage ratio graph is first decreasing and then increasing in Q. This U-shaped pattern has an important implication for empirical tests of capital structure theory. In particular, it shows that market leverage and Q can be negatively related in a standard bankruptcy cost and interest tax shield trade-off model of capital structure with *no* stockholder-bondholder agency

[15] Interestingly, for their whole sample Chen and Zhao (2006) find that book (and market) leverage is negatively related to the market-to-book ratio – presumably because of the negative relation for high market-to-book firms. This could explain why Barclay, Morellec, and Smith (2006) and earlier authors (e.g., Rajan and Zingales (1995) and Johnson (2003)) find a negative relation.

conflict. This is important because almost without question it has been assumed in the literature that documenting an inverse relation between market (and book) leverage and Q (typically proxied by the market-to-book ratio) is *prima facie* evidence of agency costs of debt.[16] Perhaps equally important, the U-shaped graph illustrates that first-best market leverage (like first- and second-best book leverage) can also increase in Q. This result is consistent with the empirical analysis in Chen and Zhao (2006), who find that market leverage is typically increasing in the market-to-book ratio. Our analysis shows that their result can be explained in a dynamic trade-off model of capital structure.[17]

The U-shaped relation between market leverage and Q for the first-best case can be explained as follows. Note that the relation between market leverage and Q reflects the relation between debt capacity today and the present value of future growth opportunities. Thus, when the present value of growth opportunities contributes little to firm value (i.e., low Q), increases in Q have a relatively small influence on debt capacity, and therefore market leverage is decreasing in Q. Past some point, however, the relative importance of growth opportunities for firm value is large enough that the enhanced debt capacity results in market leverage increasing in Q. In addition, as Π increases (or I decreases) the growth option will be exercised sooner, and therefore the immediately realizable debt capacity increases. These factors drive the U-shaped relation between market leverage and Q under first-best. In comparison, the market leverage for the second-best case is always monotonically decreasing in Q, because the debt capacity

[16] See Chen and Zhao (2006) for a statement of this thesis and for additional citations to the voluminous capital structure literature that makes this assumption.

[17] The bottom of the U in Panel A occurs at a Q ratio of about 1.34, but this point (after which the market leverage ratio starts to increase) depends on the parameter inputs. For example, if we double the cost of investment from $I = 200$ to $I = 400$, the minimum point occurs at a Q ratio of about 1.63. These Q ratios are close to the median market-to-book ratios for nonfinancial firms on Compustat. For example, over the period 1980 to 2007, the median market-to-book ratio of all nonfinancial firms on Compustat is 1.37.

enhancement effect of higher growth option value is offset by the greater agency cost of debt as Q increases.

Figure 2 graphs the first-best (solid line) and second-best (dashed line) credit spread of debt as a function of Q for exogenous leverage, C_0^{exog}, and for endogenous leverage, C_0^*. The credit spread is computed as $CSP = [C_0 / D_l(X_0, C_0)] - r$, using C_0^{exog} in Panel A and C_0^* in Panel B. Observe for endogenous leverage that first-best credit spreads are always greater than or equal to second-best credit spreads. Only when leverage is exogenous do we find that the second-best credit spread exceeds the first-best credit spread. The reason is that optimal leverage is higher under first-best than under second-best, and this higher leverage produces a larger first-best credit spread.[18] The upshot is that one cannot measure agency costs as the difference between second-best and first-best credit spreads (see, e.g., Titman, Tompaidis, and Tsyplakov (2004)) when debt policy is endogenous.

Interestingly, Figure 2 also illustrates that regardless of whether debt is endogenous or exogenous, first- and second-best credit spreads are decreasing in Q. This helps explain why optimal leverage can be increasing in Q, despite there being greater agency conflicts in high growth option firms. Indeed, Chen and Zhao (2006) find empirically an inverse relation between credit spreads and growth opportunities and use this relation to motivate their finding that book and market leverage tends to be increasing in the market-to-book ratio.

Table 1 reports comparative static results for exogenous debt policy (Panel A) and endogenous debt policy (Panel B) for variations of parameter values around the base case values

[18] Note the irony in this result. Although the agency conflict dampens the firm's appetite for leverage in the second-best outcome by raising the cost of debt financing (i.e., the credit spread), the resulting lower optimal leverage in comparison to the case without the agency conflict results in a strictly lower equilibrium credit spread. As far as we know, this result has never been discussed in the literature, although it is clearly present in other models (e.g., Childs, Mauer, and Ott (2005)).

discussed above. In the table we report first- and second-best outcomes for the debt coupon, C_0^{exog} in Panel A and C_0^* in Panel B, the endogenous default thresholds before and after exercise of the investment option, X_{dl} and X_{dh}, the investment threshold, X_s, the time zero book and market leverage ratios, BL and ML, the market-to-book value ratio, Q, total firm value, V_l, the expected time to investment (in years) conditional on no default, $\mathrm{E}[T_s \mid T_s < T_{dl}]$, the probability of investment prior to default, π_s, the credit spread of debt (in basis points), $CSP = [C_0^{exog} / D_l(X_0, C_0^{exog})] - r$ in Panel A and $CSP = [C_0^* / D_l(X_0, C_0^*)] - r$ in Panel B, and the agency cost of debt (in %), $AC = (V_l^{FB} - V_l^{SB}) / V_l^{FB}$.[19]

Several of the comparative static results are different when debt is exogenous versus when debt is endogenous. For exogenous debt, agency costs (i.e., the difference between first- and second-best firm values) are increasing in bankruptcy costs (α) and decreasing in the tax rate (τ) and the drift of cash flows (μ). These directional effects are reversed when debt is endogenous. In particular, optimal leverage is decreasing in bankruptcy costs, and this decreases agency costs. Similarly, an increase in the corporate tax rate or the drift of cash flows enhances optimal leverage and this in turn drives up agency costs.[20]

Interestingly, observe that greater volatility of cash flows consistently decreases agency costs. This counter intuitive result is driven by three factors. First, holding leverage constant, more volatility increases the value of the firm's growth option, which enhances firm value and

[19] Recall that $C_0^{exog} = 18.48$ is the average of the first-best optimal coupon (20.09) and second-best optimal coupon (16.86) for the base case in Panel B. Appendix A discusses the computation of $\mathrm{E}[T_s \mid T_s < T_{dl}]$ and π_s.

[20] Note that reported agency costs (AC) in Table 1 are modest (e.g., about 0.5% of first-best firm value for each of the base cases in Panels A and B). This partly reflects our choice of numerical inputs, which are chosen to illustrate a variety of comparative static results. In unreported simulations, agency costs range from 1% to 2% of first-best firm value when leverage is exogenous (Panel A), and range from 0.5% to 1% of first-best firm value at optimal leverage ratios (Panel B).

lowers the default risk of debt. This mitigates equityholders' incentive to underinvest and thereby reduces agency costs. Second, allowing the firm to endogenously adjust debt in response to higher volatility, we can see that optimal leverage is decreasing in volatility, which also reduces agency costs. Third, as volatility increases the firm optimally waits for a higher cash flow level (X_s) before exercising the investment option, which reduces the benefit that debtholders receive upon investment and hence mitigates the agency conflict. The delay in exercise also reduces the present value today of any future investment distortion. Thus, and perhaps surprisingly, higher cash flow uncertainty implies in equilibrium lower agency costs.

Finally, note that an increase in the growth option's cash flow multiplier (Π) or a decrease in the cost of exercising the growth option (*I*) increases agency costs. Either effect enhances the value of the firm's growth option, which encourages the firm to both increase leverage and exercise the option sooner. This magnifies the agency conflict and brings the distortion in investment policy closer to time zero, which results in larger agency costs.

Since equityholders choose to delay investment relative to the investment timing that maximizes total firm value, notice in Table 1 that the expected time to investment, $\mathrm{E}[T_s \mid T_s < T_{dl}]$, is longer and the probability that investment ever takes place, π_s, is lower under the second-best policy than under the first best policy. Further note that the timing difference is always (weakly) increasing in the agency cost of debt regardless of whether debt policy is exogenous (Panel A) or endogenous (Panel B). This suggests that a potentially fruitful avenue for empirically testing the impact of agency conflicts on investment policy is to estimate hazard models of the probability of investment as function of the time since the last investment to test whether firm characteristics which proxy for agency conflicts influence a firm's investment hazard.[21]

4. Debt and Equity Financing of the Growth Option

We first illustrate how financial contracting can eliminate equityholder underinvestment incentives when a portion of the cost of investing in the growth option is financed with an additional debt issue. We show, however, that this zero agency cost solution is not optimal, since the firm will optimally choose to issue more debt than that which eliminates underinvestment incentives. Indeed, we show that the unconstrained joint choice of initial debt and additional debt used to finance the growth option results in equityholders choosing to overinvest in the growth option. Crucially, we relax the assumption of equal priority (*pari passu*). In particular, we examine how the allocation of seniority among the firm's multiple debt issues (e.g., via me-first covenants) influences the exercise policy of the growth option and hence firm value. Lastly, we study the jointly optimal choice of capital structure and debt structure as well as equityholders' optimal contracting response to sub-optimally high initial leverage (i.e., jointly optimal choice of additional debt and debt priority).

4.1 Using Financial Contracting to Resolve Debt Overhang

Panels A-C in Table 2 report, respectively, results for the base-case all-equity financed growth option (Panel A), and two financial contracting solutions to the debt overhang problem (Panels B and C). As discussed below, the financial contracting solutions involve debt financing of the growth option. Both solutions maintain the base-case assumption that the debt issued at

[21] Whited (2006) uses a hazard model to study the influence of financing constraints on the timing of investment.

time zero (C_0) and at time T_s (C_s) have equal priority in bankruptcy. All numerical results reported in Table 2 use Table 1 base case parameter values (i.e., $X_0 = 20$, $\Pi = 2.0$, $I = 200$, $\tau = 15\%$, $\alpha = 25\%$, $r = 6\%$, $\mu = 1\%$, and $\sigma = 25\%$).

In Panel B, we fix C_0 at the all-equity second-best solution value of 16.86 in Panel A, and solve for C_s that motivates equityholders to invest at the all-equity first-best investment threshold, $X_s^{FB} = 24.12$. Equityholders underinvest in the growth option because they pay the full cost of investment and yet share the benefits with risky debt (i.e., the investment promotes the claim of risky time zero debt). The interesting question then is how much of the investment cost must be financed with debt so that the benefit to original debtholders is exactly offset by the dilution of the value of their claim. As seen in Panel B, the answer is $C_s = 20.05$, so that the firm issues new debt of $D_h(X_s^{FB}, C_s) = 266.82$ allowing it to cover the investment cost of $I = 200$ and distribute a debt-financed dividend of 66.82.

What are the welfare implications of the solution in Panel B? In comparison to the all-equity second-best case in Panel A, we see that initial debt value is smaller (218.21 versus 234.58), equity value is larger (306.97 versus 280.46), and overall firm value is larger (525.17 versus 515.04). The net gain in firm value, 1.97%, reflects two factors. First, the resolution of the investment timing conflict; and second, the present value of the net tax benefit associated with the new debt issue used to finance the growth option. Indeed, note that the overall firm value in Panel B (525.17) exceeds the first-best firm value in Panel A (517.50). The reason is that the all-equity financed growth option solution in Panel A is suboptimal because the growth option enhances the debt capacity of the firm.

Panel C presents an alternative solution for the resolution of the debt overhang problem. As seen there, we allow the firm to optimize over C_0 and C_s, while imposing the constraint that the firm invests at the firm-best all-equity investment threshold, $X_s^{FB} = 24.12$. In comparison to the solution in Panel B, the interesting aspect of this solution is that the firm *optimally* chooses a smaller time zero coupon (10.95 versus 16.86) and a larger time T_s coupon (23.03 versus 20.05). As expected, the additional financial flexibility (i.e., optimizing over C_0 and C_s) enhances firm value; Panel C firm value, 526.55, exceeds Panel B firm value, 525.17.

Panel D of Table 2 reports the unconstrained solution where we allow the joint optimal choice of C_0 and C_s and do not force equityholders to choose the first-best all-equity investment threshold.[22] The panel reports the first-best case where the growth option investment threshold is chosen to maximize total firm value and the second-best case where the growth option investment threshold is chosen to maximize equity value.

First note that the solutions in Panel D continue to have the important Panel C property that having the option to issue debt in the future *decreases* the optimal amount of debt today. For example, compare the first-best solution in Panel A where the firm is constrained to a static (one-shot) debt policy to the first-best solution in Panel D where the firm may dynamically adjust its debt policy when it invests in the growth option. In Panel A we see $C_0^* = 20.09$ which gives a market (book) leverage ratio of 0.54 (0.82). In comparison, in Panel D we see $C_0^* = 11.43$ which gives a dramatically smaller market (book) leverage ratio of 0.30 (0.46). The *same* effect can be observed for the second-best solutions in Panels A and D. This result is similar to a result in

[22] Note that this unconstrained solution continues to assume that the two debt issues have equal priority in bankruptcy. We examine jointly optimal capital structure and debt (priority) structure in the next section. Appendix B discusses the solution technique for the joint optimal choice of C_0 and C_s.

Goldstein, Ju, and Leland (2001) and Strebulaev (2007) where the firm's initial leverage choice is smaller when it has the option to recapitalize in the future. Thus, like the models in Goldstein, Ju, and Leland (2001) and Strebulaev (2007), our model can explain why firms appear to have overly conservative capital structures, even when there is a sizable net tax advantage to debt financing.[23] Unlike their models, however, this implication in our model is *not* driven by costly recapitalization, but rather by the interaction between financing and investment decisions. Specifically, our model shows that the debt capacity of future growth options has a downward influence on the current level of debt. Note that this effect is not driven by an agency conflict over the exercise timing of the growth option, since the lower initial debt choice occurs in both first- and second-best solutions.

Perhaps the most striking result in Panel D, however, is that equityholders now overinvest in the growth option. Thus, observe that the first-best investment threshold is larger than the second-best investment threshold ($X_s^{FB} = 26.51 > X_s^{SB} = 23.80$). This more aggressive investment policy results because the debt financing of the growth option transfers wealth from initial debtholders to equityholders. Since equityholders exercise the option too soon, the amount of new debt that the growth option can support is considerably less for the second-best solution than the first-best solution (19.62 versus 25.90). Paradoxically, however, this damage to the debt capacity of the growth option actually enhances the firm's initial debt capacity. In particular, note in Panel D that the initial coupon choice (and therefore initial market and book leverage ratios) is larger under the second-best solution than under the first-best solution.[24] The reason is that the higher cash flows that the firm earns after exercising the growth option (i.e., $\Pi X, \Pi > 1$) benefit the initial debtholders and therefore earlier exercise under equity value-maximization

[23] For example, see Graham (2000).

enhances time zero debt capacity. Despite this apparent benefit, note that firm value is lower under equity value-maximization (525.93) than under firm value-maximization (527.59). The implied agency cost of debt, however, is small (i.e., AC = [527.59 − 525.93)/527.59] × 100 = 0.32%).

Using Monte Carlo simulation, Parrino and Weisbach (1999) also find that agency costs of debt are small, which they argue suggests that for most firms stockholder-bondholder conflicts are not important determinants of capital structure. Our analysis suggests, however, that relatively low agency costs are attributable to an equilibrium feedback effect; that is, once the firm's optimization endogenously reflects bankruptcy costs, interest tax shields, and investment benefits, the remaining/residual agency problem is small because it has been "optimally minimized" by financial contracting.

Table 3 reports comparative static results when the growth option is debt financed for parameter variations parallel to those in Table 1. Panel A reports results when C_0 is exogenously fixed and C_s is optimally chosen to maximize firm value (i.e., C_0^{exog} and C_s^*), and Panel B reports results when C_0 and C_s are jointly chosen to maximize firm value (i.e., C_0^* and C_s^*). Note that the fixed coupon of the initial debt issue in Panel A, $C_0^{exog} = 12.56$, is the average of the first-best optimal initial debt coupon (12.77) and second-best optimal initial debt coupon (12.36) for the base case in Panel B. The base case parameter values are identical to those used to construct Tables 1 and 2, except that we use I = 300 in Table 3 to avoid uninteresting solutions where the firm chooses to immediately invest in the growth option.[25]

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[24] This result is reversed in the comparative static results reported in Table 3 where we use a higher value of I.

[25] To ensure interesting solutions where the firm does not invest immediately, we increase I from 200 to 300. Note that at this larger I the investment benefits from exercising the growth option (i.e., benefits not including leverage benefits) will continue to be positive, since the NPV of investment is already positive at X_0. That is, using the NPV formula in footnote 11, we find the NPV = 40 at X_0 when I = 300.

Whether time 0 debt is exogenous (Panel A) or endogenous (Panel B), the directional effects of model parameters on agency costs are the same. Furthermore, with few exceptions (discussed below), the directional influence of parameter variation on agency costs is the same as that in Table 1 where the growth option is constrained to be all equity financed. We therefore focus our discussion on the results when time 0 debt is endogenous and only on key results.

There are five key results in Table 3. First, note that equityholders always invest sooner than first best (i.e., $X_s^{SB} < X_s^{FB}$) when the growth option is debt financed. This incentive to overinvest significantly reduces debt capacity. Indeed, the second key result illustrated in the table is that both time 0 and time T_s coupon choices are lower under the second-best exercise policy than under the first-best exercise policy. Thus, the stockholder-bondholder conflict over the exercise policy of the growth option has a significant influence on dynamic financing decisions. Third, observe that under the first- *and* second-best solutions, the option to use debt to finance the cost of exercising the growth option significantly lowers the optimal initial amount of debt. Indeed, the option to issue additional debt in the future produces empirically reasonable time 0 leverage ratios and credit spreads even under risk-neutrality (e.g., the second-best base case market leverage ratio is 0.35 and the credit spread is 135 basis points). Fourth, note that the reported agency costs in the Table are quite small. As noted above, this simply reflects the fact that when the growth option is financed with a firm value-maximizing choice of debt, differences between first- and second-best firm values in equilibrium *should be* small.

Finally, the influence of cash flow volatility (σ) and growth option value (Π / I) on model outcomes reported in Table 3 are noteworthy. In contrast to the all-equity financing case in Table 1, an increase in volatility increases agency costs, decreases time 0 optimal debt, and increases the optimal amount of debt issued when the firm exercises the growth option. These effects are all driven by the influence of volatility on the timing of the exercise of the growth option. As seen in Panel B (or Panel A), an increase in volatility encourage both first- and second-best decision makers to delay the exercise of the growth option. This hurts time zero debt capacity, enhances the additional debt capacity of the growth option (because the firm waits for a higher cash flow level before exercising the option), and results in a small increase in measured agency costs. A similar effect can be observed as Π decreases or as I increases, since the firm must wait for a higher cash flow level before exercising the growth option.[26]

We also examine the relations between firm leverage and Tobin's *Q* and credit spreads and Tobin's *Q* (not reported) for this augmented model where the firm can issue debt to finance the growth option. The relations are similar to those reported in Figures 1 and 2 for the case where the growth option is all-equity financed, however, first- and second-best market leverage ratios are now both monotonically decreasing in *Q* (i.e., the first-best market leverage ratio is no longer U-shaped in *Q*). One of the most long-standing and widely accepted views in corporate finance has been that a negative *Q*-leverage relation is driven by stockholder-bondholder conflicts over investment policy. However, to the best of our knowledge, this is the first paper to show that there is a negative relation between market leverage and Tobin's *Q* with or without stockholder-bondholder conflict. The upshot is that one cannot use evidence of a negative relation between market leverage and *Q* to argue for the existence of agency costs of debt.

4.2 Optimal Priority Structure

To this point, we have assumed that the debt issues outstanding after the growth option is exercised (i.e., the initial time zero debt issue and the additional debt issued to finance the investment in the growth option) have equal priority in bankruptcy. As such, note in the initial

[26] Note, however, that there is a small decrease in agency costs as I increases.

debt value $D_h(X,C_0)$ in (4) and the additional debt value $D_h(X,C_s)$ in (5) that the liquidation proceeds of the firm's assets in bankruptcy, $L_h(X_{dh})$, is allocated in proportion to the respective debts' coupon payments. Thus, in bankruptcy the initial debt receives $\beta_0 L_h(X_{dh})$ and the additional debt receives $\beta_s L_h(X_{dh})$, where $\beta_0 = C_0/(C_0+C_s)$ and $\beta_s = 1-\beta_0$. Although seemingly innocuous, this equal priority rule may not be optimal. Our objective here is to examine the jointly optimal choice of capital structure and debt structure to understand how the allocation of seniority among the firm's debt issues (e.g., via me-first covenants) influences the exercise policy of the growth option and hence firm value.

We examine three alternatives to equal priority: (i) a me-first covenant for initial debt, (ii) a me-first covenant for the additional debt issued to finance the growth option, and (iii) optimal priority structure. Under (i) and (ii) the senior debt value and junior debt value, respectively, are equal to

$$D_h(X,C_i) = \frac{C_i}{r}\left[1-\left(\frac{X}{X_{dh}}\right)^a\right] + R_i(X_{dh})\left(\frac{X}{X_{dh}}\right)^a, \tag{23}$$

and

$$D_h(X,C_j) = \frac{C_j}{r}\left[1-\left(\frac{X}{X_{dh}}\right)^a\right] + \left[L_h(X_{dh}) - R_i(X_{dh})\right]\left(\frac{X}{X_{dh}}\right)^a, \tag{24}$$

where i = 0 and j = s under (i) and i = s and j = 0 under (ii), and where the recovery in bankruptcy for senior debt i is

$$R_i(X_{dh}) = \min\left\{L_h(X_{dh}), \theta\frac{C_i}{r}\right\}, \quad \text{for} \quad 0<\theta\le 1,$$

and where the recovery for junior debt j can be written as

$$L_h(X_{dh}) - R_i(X_{dh}) = \max\left\{L_h(X_{dh}) - \theta\frac{C_i}{r}, 0\right\}.$$

Note that θ is a measure of the "strength" of the protection in bankruptcy afforded by the me-first covenant, since as θ approaches 1 the debt with the me-first covenant receives the minimum of the total liquidation proceeds of the firm or its value as risk-free debt (i.e., C/r). In contrast with the me-first cases, we solve under (iii) for the optimal priority structure by treating β_0 as an endogenous parameter and then maximize firm value over priority structure, β_0 and $\beta_s = 1 - \beta_0$, and capital structure, C_0 and C_s.[27]

Table 4 reports first- and second-best results for equal priority (Panel A), me-first for time 0 debt (Panel B), me-first for time T_s debt (Panel C), and optimal priority (Panel D). All priority cases are at the corresponding optimal capital structure (C_0^* and C_s^*). For the equal priority case in Panel A, we report $\beta_0 = C_0^*/(C_0^* + C_s^*)$, which determines how the liquidation value of the firm in bankruptcy, $L_h(X_{dh})$, is allocated between time 0 debt (β_0) and time T_s debt ($\beta_s = 1 - \beta_0$). In the me-first priority cases in Panels B and C, for θ = 0.25, 0.50, 0.75, and 1.00 we report γ_0, which is the proportion of the firm's liquidation proceeds in bankruptcy going to time 0 debt. Thus, in Panel B where time 0 debt has a me-first covenant, $\gamma_0 = R_0(X_{dh})/L_h(X_{dh})$, and in Panel C where time T_s debt has a me-first covenant, $\gamma_0 = [L_h(X_{dh}) - R_s(X_{dh})]/L_h(X_{dh})$. For comparison, Panels B and C also report the priority weighting if priority were determined by an equal priority rule, $\beta_0 = C_0^*/(C_0^* + C_s^*)$. Finally, Panel D reports model outcomes for optimal priority, β_0^*, and again for comparison, the equal priority weighting $\beta_0 = C_0^*/(C_0^* + C_s^*)$. All computations assume $X_0 = 20$, $\Pi = 2.0$, $I = 200$, $\tau = 15\%$, $\alpha = 25\%$, $r = 6\%$, $\mu = 1\%$, and $\sigma = 25\%$.

The table reveals that priority structure plays the deciding role in balancing equityholders' incentives to underinvest and overinvest in the growth option. Thus, observe in Panel A that with equal priority (and at the optimal capital structure) equityholders significantly overinvest in the growth option (i.e., the second-best investment threshold, 23.80, is less than the first-best investment threshold, 26.51). However, observe in Panel B that when time 0 debt has a me-first covenant that equityholders' investment threshold is an *increasing* function of θ, and observe in Panel C that when time T_s debt has a me-first covenant that equityholders' investment threshold is a *decreasing* function of θ.[28] This illustrates that the firm can use priority structure to eliminate equityholders' overinvestment incentive by shifting priority to time 0 debt, which moderates the dilution of their claim when the growth option is financed at time T_s with additional debt. Interestingly, however, note in Panel B that when θ exceeds about 0.60 that overinvestment shifts to underinvestment with the second-best investment trigger exceeding the first-best investment trigger. This suggests that there is an *interior* optimal debt structure which balances equityholders' overinvestment and underinvestment incentives. Indeed, as shown in Panel D, observe that the joint optimal capital structure and debt priority structure is where $\beta_0^* = 0.59$.[29] In comparison, observe that a suboptimal equal priority structure would (at the second-best optimal coupons in Panel D of $C_0^* = 11.22$ and $C_s^* = 25.97$) shift too much priority to time T_s debt (i.e., $\beta_0 = 0.30$).

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[27] See Appendix B for details of this joint optimization.

[28] Recall that θ is a measure of the strength of the protection in bankruptcy afforded by the me-first covenant.

[29] It is interesting to note that at this equilibrium debt structure equityholders invest a little earlier than first-best (i.e., 26.40 < 26.55) and therefore residual agency costs are not quite zero (i.e., $AC = 0.03$).

Although the first-best solutions are really only useful as idealized benchmarks, it is nonetheless interesting to note in Table 4 that the optimal debt structure when there are no stockholder-bondholder conflicts is a me-first covenant for time T_s debt. This solution, however, has virtually no influence on overall firm value. In particular, the increase in first-best firm value from its low point of 527.43 (me-first covenant for time 0 debt in Panel B) to the optimal debt structure value of 527.69 in Panel D is only 0.05%. In comparison, debt structure has a more significant impact on second-best firm value. In particular, the increase in second-best firm value from its low of 520.77 (me-first covenant for time T_s debt in Panel C) to the optimal debt structure value of 527.51 in Panel D is 1.29%. Thus, it appears that the benefit of optimizing priority structure jointly with capital structure is nontrivial.

Lastly, Panel E reports model outcomes where we fix the coupon for time 0 debt and optimize over priority and time T_s capital structure. Notice that relative to the cases in the other panels, the exogenous specification for C_0 is such that the firm is initially overleveraged relative to what the firm would optimally choose. These cases are interesting because they illustrate what happens to optimal priority structure as a financial contracting tool in situations where the firm has excessive leverage. These might include situations where a firm has undergone a leveraged buyout, a leveraged recapitalization, or a pro-active leverage increase as studied by Denis and McKean (2009). Notice in the second-best solutions that the firm's response to excessive leverage is to spread out priority by shifting priority from time 0 to time T_s debt. Thus, as one can see in Panel E, as C_0 increases, the optimal fraction of liquidating firm value in bankruptcy going to time 0 debt (β_0^*) decreases.[30] The reason is intuitive. As C_0 increases, the debt capacity of the growth option is sharply reduced. The firm therefore shifts greater amounts of priority to the debt issued to finance the exercise of the growth option in an effort to prop up the market value of, and therefore proceeds from, the additional debt issue. Importantly, this implication is consistent with the recent empirical results of Rauh and Sufi (2009) who find that firms spread priority among multiple tiers of debt as credit quality weakens.

The analysis thus reveals that priority structure is generally an important ingredient of the firm's overall financial (i.e., capital and debt) structure. As we observed in Table 2, although capital structure can be used to completely eliminate underinvestment incentives, this financial contracting solution is suboptimal since it does not fully exploit the incremental debt capacity of the growth option. Paradoxically, however, exploiting that debt capacity induces suboptimal overinvestment incentives. The key result in Table 4 is that the joint choice of capital structure and debt priority structure can virtually eliminate overinvestment incentives and fully exploit the debt capacity of the growth option. In other words, a key implication is that priority structure is a critical and heretofore unrecognized financial contracting device that helps resolve stockholder-bondholder conflicts over investment policy.

5. Conclusions

We examine interactions between investment and financing decisions in a dynamic framework akin to Leland (1994) where equityholders choose the optimal growth option exercise policy and the firm's debt structure decisions are driven by endogenous bankruptcy, agency costs, interest tax shields, and investment benefits arising from the debt capacity of growth options. Myers (1977) underinvestment and Jensen and Meckling (1976) overinvestment incentives arise endogenously in the model and are driven by the firm's initial capital structure

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[30] However, note that relative to the optimal debt structure in Panel D ($\beta_0^* = 0.59$, $C_0^* = 11.22$, and $C_s^* = 25.97$),

and by the debt-equity mix used to finance the investment in the growth option. We document that debt priority structure plays a critical financial contracting role in mitigating stockholder-bondholder conflict over investment policy. Indeed, we show that the jointly optimal choice of dynamic capital structure and debt priority structure can virtually implement the first-best investment policy. We also establish that the firm will optimally spread out priority among its multiple debt claims as leverage is increased and credit quality deteriorates, which is consistent with empirical evidence (see, e.g., Rauh and Sufi (2009)).

Several additional results have important implications for empirical research in corporate finance. The analysis predicts that market leverage ratios will be negatively related to Tobin's *Q*, while book leverage ratios will be positively related to Tobin's *Q*. Importantly, these relations are *not* driven by agency conflicts, and so one cannot use the empirical relations between either book or market leverage and measures of growth opportunities as reliable tests for the existence of agency conflicts arising from growth opportunities. The analysis also provides an explanation for the debt conservatism puzzle, because the option to use debt to finance future growth options significantly lowers the optimal amount of debt that the firm will choose to finance its current assets-in-place under first- and second-best policies. Lastly, the analysis illustrates that credit spreads are generally unreliable indicators of agency costs of debt. Our analysis suggests that tests for the existence of agency costs could employ duration analysis which focuses on the time elapsed between intermittent investments.

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the firm in Panel E first increases β_0^* as C_0 is pushed above $C_0^* = 11.22$.

Appendix A. Two-Sided Hitting Claims, Probabilities, and First Passage Times

We present results for the values of Arrow-Debreu securities (hitting claims) that pay \$1 contingent on the firm's EBIT process, *X*, first reaching either the default boundary, X_{dl}, or the growth option investment exercise boundary, X_s. These hitting claim values are used in the text to compute debt and equity values prior to investment. Using the fact that these claim values are simply Laplace transforms of the first passage time density function of *X*, we then compute probabilities and expected first passage times for default and investment.

Applying standard arguments, the two-sided hitting claim that pays \$1 contingent on *X* touching the level X_{dl} the first time from above *prior* to having ever reached X_s from below, and the two sided hitting claim that pays \$1 contingent on *X* touching the level X_s from below *prior* to having ever reached X_{dl} from above are, respectively, given by

$$\Delta(X) = \mathrm{E}[e^{-rT_{dl}} \,|\, T_{dl} < T_s] = \frac{X^z X_s^a - X^a X_s^z}{X_{dl}^z X_s^a - X_{dl}^a X_s^z}, \tag{A.1}$$

and

$$\Sigma(X) = \mathrm{E}[e^{-rT_s} \,|\, T_s < T_{dl}] = \frac{X_{dl}^z X^a - X_{dl}^a X^z}{X_{dl}^z X_s^a - X_{dl}^a X_s^z}, \tag{A.2}$$

where $\mathrm{E}[\cdot|\cdot]$ denotes conditional expectation, T_{dl} and T_s denote the (random) default and investment times, and $a < 0$ ($z > 1$) is the negative (positive) root of the quadratic equation $x(x-1)\sigma^2/2 + x\mu - r = 0$; that is,

$$a = -\frac{\mu - \sigma^2/2}{\sigma^2} - \sqrt{\left(\frac{\mu - \sigma^2/2}{\sigma^2}\right)^2 + \frac{2r}{\sigma^2}}, \tag{A.3}$$

and

$$z = -\frac{\mu - \sigma^2/2}{\sigma^2} + \sqrt{\left(\frac{\mu - \sigma^2/2}{\sigma^2}\right)^2 + \frac{2r}{\sigma^2}}\,. \tag{A.4}$$

To simplify the derivations of the subsequent probabilities and expected first passage times, let $\lambda = -(\mu - \sigma^2/2)$ and rearrange (A.1) and (A.2):

$$\Delta(X) = \left(\frac{X}{X_{dl}}\right)^{\lambda/\sigma^2} \frac{\left(\frac{X_s}{X}\right)^{\sqrt{(\lambda/\sigma^2)^2 + 2r\sigma^2}} - \left(\frac{X_s}{X}\right)^{-\sqrt{(\lambda/\sigma^2)^2 + 2r\sigma^2}}}{\left(\frac{X_s}{X_{dl}}\right)^{\sqrt{(\lambda/\sigma^2)^2 + 2r\sigma^2}} - \left(\frac{X_s}{X_{dl}}\right)^{-\sqrt{(\lambda/\sigma^2)^2 + 2r\sigma^2}}}\,, \tag{A.5}$$

and

$$\Sigma(X) = \left(\frac{X}{X_s}\right)^{\lambda/\sigma^2} \frac{\left(\frac{X_{dl}}{X}\right)^{\sqrt{(\lambda/\sigma^2)^2 + 2r\sigma^2}} - \left(\frac{X_{dl}}{X}\right)^{-\sqrt{(\lambda/\sigma^2)^2 + 2r\sigma^2}}}{\left(\frac{X_{dl}}{X_s}\right)^{\sqrt{(\lambda/\sigma^2)^2 + 2r\sigma^2}} - \left(\frac{X_{dl}}{X_s}\right)^{-\sqrt{(\lambda/\sigma^2)^2 + 2r\sigma^2}}}\,. \tag{A.6}$$

Using (A.5), we can compute the probability of default to occur before investment as

$$\pi_{dl}(X) = \lim_{r \downarrow 0} \Delta(X) = \lim_{r \downarrow 0} \mathrm{E}[e^{-rT_{dl}} \mid T_{dl} < T_s] = \frac{X_s^{2\lambda/\sigma^2} - X^{2\lambda/\sigma^2}}{X_s^{2\lambda/\sigma^2} - X_{dl}^{2\lambda/\sigma^2}}\,. \tag{A.7}$$

Similarly, using (A.6), we can compute the probability of investment to occur before default as

$$\pi_s(X) = \lim_{r \downarrow 0} \Sigma(X) = \lim_{r \downarrow 0} \mathrm{E}[e^{-rT_s} \mid T_s < T_{dl}] = \frac{X^{2\lambda/\sigma^2} - X_{dl}^{2\lambda/\sigma^2}}{X_s^{2\lambda/\sigma^2} - X_{dl}^{2\lambda/\sigma^2}} \tag{A.8}$$

Note that these (conditional) default and investment probabilities are simply the limits of the corresponding Laplace transform – which is the corresponding hitting claim value – as r goes to zero. Further note that $\pi_s(X) = 1 - \pi_{dl}(X)$.

Let us denote the (random) first exit time of X from the interval (X_{dl}, X_s) by the minimum of the stopping times of hitting either the lower or the upper threshold: $T_e = \min\{T_{dl}, T_s\}$. Then the value of the corresponding two-sided exit claim follows directly from (A.1) and (A.2):

$$\mathrm{E}[e^{-rT_e}] = \mathrm{E}[e^{-rT_{dl}} \mid T_{dl} < T_s] + \mathrm{E}[e^{-rT_s} \mid T_s < T_{dl}], \tag{A.9}$$

which is a Laplace transform with a lower threshold $X_{dl} < X$ and an upper threshold $X_s > X$:

$$\mathcal{L}(r; X, X_{dl}, X_s) = \int_o^\infty e^{-rt} g(t; X, X_{dl}, X_s)\, dt, \tag{A.10}$$

where $g(t; X, X_{dl}, X_s)$ is the two-sided passage time density, which is not known analytically. However, the expected two-sided exit time $\mathrm{E}[T_e] = \mathcal{L}'(0; X, X_{dl}, X_s)$ can be written as follows:

$$\mathrm{E}[T_e] = \mathrm{E}[T_{dl} \mid T_{dl} < T_s] + \mathrm{E}[T_s \mid T_s < T_{dl}], \tag{A.11}$$

which we can evaluate since (A.11) involves the expressions in (A.5) and (A.6), that is,

$$\mathrm{E}[T_e] = \lim_{r \downarrow 0} \frac{\partial \mathrm{E}[e^{-rT_e}]}{\partial r} = \lim_{r \downarrow 0} \frac{\partial \mathrm{E}[e^{-rT_{dl}} \mid T_{dl} < T_s]}{\partial r} + \lim_{r \downarrow 0} \frac{\partial \mathrm{E}[e^{-rT_s} \mid T_s < T_{dl}]}{\partial r}. \tag{A.12}$$

Hence differentiating (A.5) and (A.6) with respect to r, taking the limit as r goes to zero, and substituting the result into (A.12), we may compute $E[T_e]$ for $\lambda \neq 0$:

$$\frac{\left[1+\left(\frac{X_s}{X}\right)^{2\lambda/\sigma^2}\right]\left[\left(\frac{X_s}{X_{dl}}\right)^{2\lambda/\sigma^2}-1\right]\ln\left(\frac{X_s}{X}\right)-\left[\left(\frac{X_s}{X}\right)^{2\lambda/\sigma^2}-1\right]\left[1+\left(\frac{X_s}{X_{dl}}\right)^{2\lambda/\sigma^2}\right]\ln\left(\frac{X_s}{X_{dl}}\right)}{\lambda\left(\frac{X_{dl}}{X}\right)^{2\lambda/\sigma^2}\left[1-\left(\frac{X_s}{X_{dl}}\right)^{2\lambda/\sigma^2}\right]}+$$

$$\frac{\left[1+\left(\frac{X_{dl}}{X}\right)^{2\lambda/\sigma^2}\right]\left[\left(\frac{X_{dl}}{X_s}\right)^{2\lambda/\sigma^2}-1\right]\ln\left(\frac{X_{dl}}{X}\right)-\left[\left(\frac{X_{dl}}{X}\right)^{2\lambda/\sigma^2}-1\right]\left[1+\left(\frac{X_{dl}}{X_s}\right)^{2\lambda/\sigma^2}\right]\ln\left(\frac{X_{dl}}{X_s}\right)}{\lambda\left(\frac{X_s}{X}\right)^{2\lambda/\sigma^2}\left[1-\left(\frac{X_{dl}}{X_s}\right)^{2\lambda/\sigma^2}\right]} \quad \text{(A.13)}$$

As indicated by (A.11) and (A.12), the first term in (A.13) is the expected time until investment conditional on no prior default, $\mathrm{E}[T_s \mid T_s < T_{dl}]$, while the second term in (A.13) is the expected time until default conditional on no prior investment, $\mathrm{E}[T_{dl} \mid T_{dl} < T_s]$. After tedious algebra, the expected exit time of X from the interval (X_{dl}, X_s) simplifies to

$$\mathrm{E}[T_e] = \frac{1}{\lambda}\left[\ln\left(\frac{X}{X_{dl}}\right)\right] + \frac{1}{\lambda}\left[\ln\left(\frac{X_s}{X_{dl}}\right)\right]\left[1-\pi_{dl}(X)\right]. \quad \text{(A.14)}$$

The two-sided expected passage time has a surprisingly straightforward interpretation, since it is a convex combination of two one-sided expected passage times. The first term in (A.14) is the standard one-sided expected passage time for the firm's cash flows to drop from X to X_{dl}, provided there is no upper boundary. The second term in (A.14) contains the standard one-sided expected passage time for the firm's cash flows to rise from X_{dl} to X_s, provided there is no lower boundary. Multiplying the latter by the no-default probability and adding the result to the standard one-sided expected passage time for default yields the two-sided passage time for the firm's cash flows to exit from the interval (X_{dl}, X_s) to either side the first time.

Appendix B. Optimal Capital and Debt Priority Structure

To solve for the optimal capital structure, we must find the debt coupons $\{C_0^*, C_s^*\}$ that jointly maximize firm value. For an arbitrary priority rule $\beta_0 \in [0,1]$, this involves finding the time zero debt coupon, C_0, and time T_s debt coupon, C_s, that maximize the initial firm value, $V_l(X_0, C_0, C_s; \beta_0)$, in equation (16) of the text. An alternative solution technique, which is isomorphic and more efficient is to first maximize post-investment firm value, $V_h(X, C; \beta_0)$, in equation (6) of the text with respect to the total coupon payment, $C = C_0 + C_s$. Thus,

$$C^*(X) = \underset{C=C_0+C_s}{\arg\max}\ V_h(X, C; \beta_0)\ , \tag{B.1}$$

which gives

$$C^*(X) = \Pi U X \frac{r(a-1)}{a(1-\tau)}\left[1 - a\left(1 + (1-\tau)\frac{\alpha}{\tau}\right)\right]^{1/a} . \tag{B.2}$$

Since $C^*(X)$ holds at $X = X_s$, we may define the time T_s debt issue coupon as the difference $C_s(X_s) = C^*(X_s) - C_0$ and then perform the optimization:

$$C_0^* = \underset{C_0}{\arg\max}\ \ V_l(X_0, C_0, C_s(X_s); \beta_0)\,. \tag{B.3}$$

Given C_0^*, we may then compute C_s^* as $C_s^*(X_s) = C^*(X_s) - C_0^*$.

Note that this procedure effectively reduces a two dimensional optimization problem to a one dimensional optimization problem. Of course, this more efficient procedure produces exactly the same solution for the optimal capital structure $\{C_0^*, C_s^*\}$ as the more general problem:

$$\{C_0^*, C_s^*\} \in \underset{C_0, C_s}{\arg\max}\ V_l(X_0, C_0, C_s). \tag{B.4}$$

Note also that we could equivalently define $C_0(X_0) = C^*(X_s) - C_s$ and then optimize V_l with respect to C_s. The solution, C_s^*, then gives $C_0^*(X_0) = C^*(X_s) - C_s^*$.

When we jointly optimize over both capital and debt priority structure, $\{C_0^*, C_s^*, \beta_0^*\}$, we solve the three dimensional optimization problem:

$$\{C_0^*, C_s^*, \beta_0^*\} \in \underset{C_0, C_s, \beta_0}{\arg\max}\ V_l(X_0, C_0, C_s; \beta_0), \tag{B.5}$$

where $\beta_s^* = 1 - \beta_0^*$. Note that the problem in (B.5) explicitly recognizes the interaction between priority structure and capital structure.

Appendix C. Optimality of Joint Financing and Investment Decisions

To verify whether it is optimal to combine financing and investment decisions at time T_s, this appendix examines two alternative cases in which the additional debt C_s can be issued before or after investment (but not at the same time). Thus we examines the cases where (i) the firm issues additional debt *before* it exercises the growth option, and (ii) the firm issues additional debt *after* it exercises the growth option. Assuming policy thresholds are well defined for cases (i) and (ii), we can compute time zero firm values, debt values, and equity values under each case to determine whether (i) or (ii) dominates the current simultaneous solution. In particular, we compare time zero firm value V_l of the "unconstrained model" in Section 4 (with simultaneous financing and investment decisions) to the corresponding firm values in cases (i) and (ii) in which "leverage benefits" are *not* reaped by exercising the growth option (i.e., exercising the growth option only provides "investment benefits").

We derive firm and security values in three regions. Thus, for case (i), let *l*, *m*, and *h* denote the (on average) *low*, *median*, and *high* regions of earnings before investment and restructuring, after restructuring but before investment, and after restructuring and investment, respectively. Note that for case (ii), regions *l* and *h* are the same as in case (i), but region *m* corresponds to the region after investment but before restructuring. Let X_f denote the additional debt threshold and X_s denote the growth option exercise threshold. As in the text, the initial time zero debt issue has coupon C_0, the additional debt issue has coupon C_s, and where convenient we denote the total coupon (after the additional debt issue) as $C = C_0 + C_s$. We study the base case of equal priority (*pari passu*) where $\beta_0 = C_0 / C$ and $\beta_s = 1 - \beta_0 = C_s / C$. Finally, recall that the characteristic roots (a and z) solve $x(x-1)\sigma^2 / 2 + x\mu - r = 0$ and hence satisfy $a < 0$ and $z > 1$.

Case (i): $\boldsymbol{X_0 < X_f < X_s}$

Working backward from region *h* to region *m* to region *l* yields the following solutions.

Region *h*: $\boldsymbol{X \geq X_s > X_f}$

The equity value, $E_h(X,C)$, debt values, $D_h(X,C_0)$ and $D_h(X,C_s)$, and overall firm value, $V_h(X,C)$, for this region are identical to those in equations (2), (4), (5), and (6) of the text, respectively, and so are not reproduced here.

Region m: $X_f \leq X < X_s$

The general solutions for the equity, debt, and overall firm value for this region are

$$E_m(X,C) = (1-\tau)\left(\frac{X}{r-\mu} - \frac{C}{r}\right) + E_1 X^a + E_2 X^z, \tag{C.1}$$

$$D_m(X,C_0) = \frac{C_0}{r} + D_1 X^a + D_2 X^z, \tag{C.2}$$

$$D_m(X,C_s) = \frac{C_s}{r} + D_3 X^a + D_4 X^z, \tag{C.3}$$

$$V_m(X,C) = \frac{(1-\tau)X}{r-\mu} + \frac{\tau C}{r} + V_1 X^a + V_2 X^z, \tag{C.4}$$

The constants (E_1, E_2, D_1, D_2, D_3, D_4, V_1, V_2) in (C.1)-(C.4) are identified with the boundary conditions:

$$E_m(X_{dm},C) = 0, \tag{C.5}$$

$$E_m(X_s,C) = E_h(X_s,C) - I, \tag{C.6}$$

$$D_m(X_{dm},C_0) = \beta_0 L_m(X_{dm}), \tag{C.7}$$

$$D_m(X_s,C_0) = D_h(X_s,C_0), \tag{C.8}$$

$$D_m(X_{dm},C_s) = \beta_s L_m(X_{dm}), \tag{C.9}$$

$$D_m(X_s,C_s) = D_h(X_s,C_s), \tag{C.10}$$

$$V_m(X_{dm},C) = L_m(X_{dm}), \tag{C.11}$$

$$V_m(X_s, C) = V_h(X_s, C) - I \,, \tag{C.12}$$

where $L_m(X_{dm}) = (1-\alpha)UX_{dm}$ and X_{dm} denotes the endogenous default threshold in region *m*. Substituting (C.1)-(C.4) into (C.5)-(C.12) we obtain the following closed-form solutions:

$$E_m(X, C) = (1-\tau)\left[\left(\frac{X}{r-\mu} - \frac{C}{r}\right) - \left(\frac{X_{dm}}{r-\mu} - \frac{C}{r}\right)\Delta(X) + \left(\frac{(\Pi-1)X_s}{r-\mu} - \frac{C}{r}\left(\frac{1}{a-1}\right)\left(\frac{X_s}{X_{dh}}\right)^a\right)\Sigma(X)\right], \tag{C.13}$$

$$D_m(X, C_0) = \frac{C_0}{r}\left[1 - \Delta(X) - \left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\right] + \beta_0 L_m(X_{dm})\Delta(X) + \beta_0 L_h(X_{dh})\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\,, \tag{C.14}$$

$$D_m(X, C_s) = \frac{C_s}{r}\left[1 - \Delta(X) - \left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\right] + \beta_s L_m(X_{dm})\Delta(X) + \beta_s L_h(X_{dh})\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\,, \tag{C.15}$$

$$\begin{aligned} V_m(X, C) \;=\; & UX + (1-\tau)\left(\frac{(\Pi-1)X_s}{r-\mu} - \frac{I}{1-\tau}\right)\Sigma(X) + \frac{\tau C_0}{r}\left[1 - \Delta(X) - \left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\right] \\ & + \frac{\tau C_s}{r}\left[1 - \left(\frac{X_s}{X_{dh}}\right)^a\right]\Sigma(X) - \alpha\left[UX_{dl}\Delta(X) + \Pi U X_{dh}\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\right], \end{aligned} \tag{C.16}$$

where

$$\Delta(X) = \frac{X^z X_s^a - X^a X_s^z}{X_{dm}^z X_s^a - X_{dm}^a X_s^z}\,, \quad \text{and} \quad \Sigma(X) = \frac{X_{dm}^z X^a - X_{dm}^a X^z}{X_{dm}^z X_s^a - X_{dm}^a X_s^z}\,.$$

Region *l*: $X_0 \leq X < X_f$

The general solutions for equity, debt, and overall firm value for this region are

$$E_l(X, C_0) = (1-\tau)\left(\frac{X}{r-\mu} - \frac{C_0}{r}\right) + E_3 X^a + E_4 X^z\,, \tag{C.17}$$

$$D_l(X, C_0) = \frac{C_0}{r} + D_5 X^a + D_6 X^z, \tag{C.18}$$

$$V_l(X, C_0) = \frac{(1-\tau)X}{r-\mu} + \frac{\tau C_0}{r} + V_3 X^a + V_4 X^z. \tag{C.19}$$

The constants (E_3, E_4, D_5, D_6, V_3, V_4) in (C.17)-(C.19) are identified with the boundary conditions:

$$E_l(X_{dl}, C_0) = 0, \tag{C.20}$$

$$E_l(X_f, C_0) = E_m(X_f, C) + D_m(X_f, C_s), \tag{C.21}$$

$$D_l(X_{dl}, C_0) = L_l(X_{dl}), \tag{C.22}$$

$$D_l(X_f, C_0) = D_m(X_f, C_0), \tag{C.23}$$

$$V_l(X_{dl}, C_0) = L_l(X_{dl}), \tag{C.24}$$

$$V_l(X_f, C_0) = V_m(X_f, C_0), \tag{C.25}$$

where $L_l(X_{dl}) = (1-\alpha)UX_{dl}$ and X_{dl} denotes the endogenous default threshold in region *l*. Substituting (C.17)-(C.19) into (C.20)-(C.25) we obtain the following closed-form solutions:

$$\begin{aligned} E_l(X, C_0) \;=\; & (1-\tau)\left[\left(\frac{X}{r-\mu} - \frac{C_0}{r}\right) - \left(\frac{X_{dl}}{r-\mu} - \frac{C_0}{r}\right)\widetilde{\Delta}(X)\right] + (1-\tau)\left[\frac{D_m(X_f, C_s)}{1-\tau} - \frac{C_s}{r}\right. \\ & \left. - \left(\frac{X_{dm}}{r-\mu} - \frac{C}{r}\right)\Delta(X_f) + \left(\frac{(\Pi-1)X_s}{r-\mu} - \frac{I}{1-\tau} - \frac{C}{r}\left(\frac{1}{a-1}\right)\left(\frac{X_s}{X_{dh}}\right)^a\right)\Sigma(X_f)\right]\widetilde{\Sigma}(X), \end{aligned} \tag{C.26}$$

$$D_l(X,C_0) = \frac{C_0}{r}\left[1-\widetilde{\Delta}(X)-\Delta(X_f)\widetilde{\Sigma}(X)-\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X_f)\widetilde{\Sigma}(X)\right]$$

$$+L_l(X_{dl})\widetilde{\Delta}(X)+\beta_0 L_m(X_{dm})\Delta(X_f)\widetilde{\Sigma}(X)+\beta_0 L_h(X_{dh})\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X_f)\widetilde{\Sigma}(X), \qquad \text{(C.27)}$$

$$V_l(X,C_0) = UX+(1-\tau)\left(\frac{(\Pi-1)X_s}{r-\mu}-\frac{I}{1-\tau}\right)\Sigma(X_f)\widetilde{\Sigma}(X)$$

$$+\frac{\tau C_0}{r}\left[1-\widetilde{\Delta}(X)-\Delta(X_f)\widetilde{\Sigma}(X)-\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X_f)\widetilde{\Sigma}(X)\right]+\frac{\tau C_s}{r}\left[1-\Delta(X_f)-\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X_f)\right]\widetilde{\Sigma}(X)$$

$$-\alpha\left[UX_{dl}\widetilde{\Delta}(X)+UX_{dm}\Delta(X_f)\widetilde{\Sigma}(X)+\Pi UX_{dh}\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X_f)\widetilde{\Sigma}(X)\right], \qquad \text{(C.28)}$$

where

$$\widetilde{\Delta}(X)=\frac{X^z X_f^a - X^a X_f^z}{X_{dl}^z X_f^a - X_{dl}^a X_f^z}, \quad \text{and} \quad \widetilde{\Sigma}(X)=\frac{X_{dl}^z X^a - X_{dl}^a X^z}{X_{dl}^z X_f^a - X_{dl}^a X_f^z}.$$

To complete the solution for this case, we use smooth-pasting conditions to identify optimal policies. The smooth-pasting conditions for second-best policies under equity-value maximization are

$$\left.\frac{\partial E_l(X,C_0)}{\partial X}\right|_{X=X_{dl}}=0, \qquad \text{(C.29)}$$

$$\left.\frac{\partial E_l(X,C_0)}{\partial X}\right|_{X=X_f}=\left.\frac{\partial E_m(X,C)}{\partial X}\right|_{X=X_f}+\left.\frac{\partial D_m(X,C_s)}{\partial X}\right|_{X=X_f}, \qquad \text{(C.30)}$$

$$\left.\frac{\partial E_m(X,C)}{\partial X}\right|_{X=X_{dm}}=0, \qquad \text{(C.31)}$$

$$\left.\frac{\partial E_m(X,C)}{\partial X}\right|_{X=X_s}=\left.\frac{\partial E_h(X,C)}{\partial X}\right|_{X=X_s}. \qquad \text{(C.32)}$$

To identify first-best policies under firm value maximization, we replace (C.30) and (C.32) with

$$\left.\frac{\partial V_l(X,C_0)}{\partial X}\right|_{X=X_f} = \left.\frac{\partial V_m(X,C)}{\partial X}\right|_{X=X_f}, \tag{C.33}$$

and

$$\left.\frac{\partial V_m(X,C)}{\partial X}\right|_{X=X_s} = \left.\frac{\partial V_h(X,C)}{\partial X}\right|_{X=X_s}, \tag{C.34}$$

respectively.

Case (ii): $\boldsymbol{X_0 < X_s < X_f}$

Working backward from region *h* (same as above) to region *m* (post-investment but pre-restructuring) to region *l* (pre-investment and pre-restructuring) yields similar solutions, which are available from the authors upon request.

Numerical Solutions

Since we are unable to analytically compare cases (i) and (ii) with the simultaneous investment and financing solution in the text, we conduct for a wide range of reasonable parameter values extensive numerical experiments, which are available from the authors. Using the same procedure as outlined in Appendix B, we find that time zero firm value, V_l, is lower when $X_f < X_s$ (case (i)) or when $X_f > X_s$ (case (ii)) in comparison to the case assumed in the text where $X_f = X_s$. Indeed, we find that time zero firm value is monotonically increasing as X_f approaches X_s from below (case (i)) or from above (case (ii)). Hence, in our model, it is not optimal to exercise the additional debt issue option either before or after exercise of the growth option because this either underutilizes the growth option's debt capacity in case (i) or the expected present value of (net) tax shields available to the firm in case (ii). Overall, combining financing and investment decisions at time T_s is therefore firm-value maximizing and hence the optimal strategy at time zero.

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Table 1

First-best and second-best financing and investment decisions when the growth option is all-equity financed

The firm has assets-in-place that generate pre-tax earnings of X and an investment option that requires an investment expenditure of I and expands earning to ΠX, $\Pi > 1$. The firm is capitalized with equity and debt, but the investment expenditure is constrained to be all-equity financed. The investment decision is characterized by the earnings threshold, X_s, at which the firm exercises its investment option. The first-best exercise policy (FB) maximizes total firm value and the second-best exercise policy (SB) maximizes equity value. Panel A reports firm outcomes for various parameter inputs when the debt coupon is fixed (C_0^{exog}) and Panel B reports firm outcomes for various parameter inputs when the debt coupon is chosen to maximize total firm value (C_0^*). Note that the fixed coupon in Panel A, $C_0^{exog} = 18.48$, is the average of the first-best optimal coupon (20.09) and second-best optimal coupon (16.86) for the base case in Panel B. For the base-case and variations of base-case parameters, the table reports first- and second-best outcomes for the debt coupon, C_0^{exog} in Panel A and C_0^* in Panel B, the endogenous default thresholds before and after exercise of the investment option, X_{dl} and X_{dh}, the investment threshold, X_s, the time zero book and market leverage ratios, BL and ML, the market-to-book value ratio, Q, total firm value, V_l, the expected time to investment (in years) conditional on no default, $\mathrm{E}[T_s \mid T_s < T_{dl}]$, the probability of investment prior to default, π_s, the credit spread of debt (in basis points), $CSP = [C_0^{exog} / D_l(X_0, C_0^{exog})] - r$ in Panel A and $CSP = [C_0^* / D_l(X_0, C_0^*)] - r$ in Panel B, and the agency cost of debt (in %), $AC = (V_l^{FB} - V_l^{SB}) / V_l^{FB}$. Book leverage (*BL*) is the market value of debt divided by the value of assets-in-place, $V_a = ((1-\tau)X_0)/(r-\mu)$, where X_0 is initial (time zero) pre-tax firm cash flow, τ is the corporate tax rate, r is the risk-free rate of interest, and μ is the drift rate of cash flows. Market leverage (*ML*) is the market value of debt divided by the total time zero firm value. Market-to-book ratio (*Q*) is total time zero firm value divided by assets-in-place, V_a. The base case parameter values are as follows: the initial cash flow, X_0, is 20, the investment option payoff factor, Π, is 2.0, the cost of exercising the investment option, I, is 200, the volatility of cash flows, σ, is 25% per year, the drift rate of cash flows, μ, is 1% per year, the risk-free rate, r, is 6% per year, the corporate tax rate, τ, is 15%, and proportional bankruptcy costs, α, are 25% of the value of assets-in-place at the time of bankruptcy.

Panel A. Exogenous debt policy

		C_0^{exog}	X_{dl}	X_{dh}	X_s	BL	ML	Q	V_l	$\mathrm{E}[T_s \mid T_s < T_{dl}]$	π_s	CSP	AC (%)
FB	Base case	18.48	6.47	4.01	24.68	0.76	0.50	1.52	517.34	2.10	0.78	115.79	
SB	Base case	18.48	6.43	4.01	29.52	0.74	0.49	1.51	514.81	3.43	0.64	134.10	0.49
FB	$\alpha = 0.20$	18.48	6.46	4.01	24.77	0.76	0.50	1.53	518.73	2.13	0.77	112.41	
FB	$\alpha = 0.30$	18.48	6.47	4.01	24.60	0.76	0.50	1.52	515.96	2.07	0.78	119.19	
SB	$\alpha = 0.20$	18.48	6.43	4.01	29.52	0.75	0.49	1.52	516.27	3.43	0.64	129.85	0.47
SB	$\alpha = 0.30$	18.48	6.43	4.01	29.52	0.74	0.49	1.51	513.34	3.43	0.64	138.39	0.51
FB	$\tau = 0.12$	18.48	6.44	4.01	23.90	0.74	0.49	1.51	532.20	1.83	0.81	109.19	
FB	$\tau = 0.18$	18.48	6.49	4.01	25.53	0.78	0.51	1.53	502.70	2.37	0.75	122.43	
SB	$\tau = 0.12$	18.48	6.41	4.01	28.65	0.72	0.48	1.50	529.40	3.25	0.66	129.00	0.52
SB	$\tau = 0.18$	18.48	6.46	4.01	30.45	0.76	0.50	1.53	500.41	3.61	0.62	139.26	0.46

Table 1 Continued

		C_0^{exog}	X_{dl}	X_{dh}	X_s	BL	ML	Q	V_l	$E[T_s \mid T_s < T_{dl}]$	π_s	CSP	AC (%)
FB	$\mu = 0.008$	18.48	6.72	4.13	24.89	0.78	0.52	1.50	490.72	2.07	0.76	127.45	
FB	$\mu = 0.012$	18.48	6.21	3.89	24.49	0.74	0.48	1.54	546.19	2.14	0.79	104.81	
SB	$\mu = 0.008$	18.48	6.68	4.13	29.97	0.76	0.51	1.49	488.06	3.33	0.61	147.59	0.54
SB	$\mu = 0.012$	18.48	6.19	3.89	29.08	0.72	0.47	1.54	543.80	3.53	0.67	121.28	0.44
FB	$\sigma = 0.24$	18.48	6.69	4.12	23.87	0.77	0.51	1.52	516.81	1.92	0.81	103.73	
FB	$\sigma = 0.26$	18.48	6.25	3.90	25.50	0.75	0.49	1.52	518.03	2.25	0.75	127.69	
SB	$\sigma = 0.24$	18.48	6.65	4.12	28.71	0.75	0.50	1.51	513.98	3.45	0.66	123.87	0.55
SB	$\sigma = 0.26$	18.48	6.22	3.90	30.34	0.73	0.48	1.52	515.75	3.41	0.62	144.43	0.44
FB	$r = 0.0575$	18.48	6.27	3.92	23.79	0.76	0.49	1.54	552.66	1.83	0.81	107.78	
FB	$r = 0.0625$	18.48	6.65	4.09	25.57	0.76	0.51	1.50	485.71	2.33	0.74	123.74	
SB	$r = 0.0575$	18.48	6.24	3.92	28.79	0.74	0.48	1.54	549.66	3.36	0.66	127.75	0.54
SB	$r = 0.0625$	18.48	6.63	4.09	30.24	0.75	0.50	1.49	483.57	3.49	0.62	140.47	0.44
FB	$\Pi = 1.97$	18.48	6.52	4.07	25.57	0.75	0.50	1.50	508.63	2.37	0.75	121.64	
FB	$\Pi = 2.03$	18.48	6.41	3.95	23.84	0.77	0.50	1.55	526.30	1.82	0.81	109.64	
SB	$\Pi = 1.97$	18.48	6.49	4.07	30.35	0.74	0.50	1.49	506.42	3.58	0.62	137.67	0.44
SB	$\Pi = 2.03$	18.48	6.38	3.95	28.74	0.74	0.48	1.54	523.40	3.28	0.66	130.44	0.55
FB	$I = 195$	18.48	6.45	4.01	23.92	0.76	0.50	1.53	520.88	1.84	0.81	111.33	
FB	$I = 205$	18.48	6.48	4.01	25.44	0.76	0.50	1.51	514.00	2.35	0.75	119.79	
SB	$I = 195$	18.48	6.41	4.01	28.88	0.74	0.49	1.52	518.03	3.30	0.66	132.00	0.55
SB	$I = 205$	18.48	6.45	4.01	30.16	0.74	0.49	1.51	511.73	3.56	0.63	136.07	0.44

Panel B. Endogenous debt policy

		C_0^*	X_{dl}	X_{dh}	X_s	BL	ML	Q	V_l	$E[T_s \mid T_s < T_{dl}]$	π_s	CSP	AC (%)
FB	Base case	20.09	6.98	4.36	24.12	0.82	0.54	1.52	517.50	1.77	0.79	125.44	
SB	Base case	16.86	5.93	3.66	29.17	0.69	0.46	1.52	515.04	3.61	0.66	118.75	0.47

Table 1 Continued

		C_0^*	X_{dl}	X_{dh}	X_s	BL	ML	Q	V_l	$E[T_s \mid T_s < T_{dl}]$	π_s	CSP	AC (%)
FB	$\alpha = 0.20$	21.56	7.45	4.68	23.63	0.87	0.57	1.53	519.23	1.50	0.80	129.29	
FB	$\alpha = 0.30$	18.85	6.59	4.09	24.47	0.77	0.51	1.52	515.97	2.00	0.78	121.57	
SB	$\alpha = 0.20$	17.69	6.19	3.84	29.35	0.72	0.47	1.52	516.33	3.52	0.65	122.53	0.56
SB	$\alpha = 0.30$	16.09	5.69	3.49	29.01	0.66	0.44	1.51	513.87	3.69	0.67	115.28	0.41
FB	$\tau = 0.12$	18.09	6.32	3.93	24.01	0.73	0.48	1.51	532.20	1.91	0.80	106.99	
FB	$\tau = 0.18$	21.55	7.48	4.68	24.30	0.89	0.58	1.54	503.33	1.71	0.78	141.69	
SB	$\tau = 0.12$	15.08	5.35	3.27	27.93	0.61	0.41	1.51	530.36	3.57	0.70	98.69	0.35
SB	$\tau = 0.18$	18.38	6.43	3.99	30.43	0.76	0.50	1.53	500.41	3.63	0.62	138.30	0.58
FB	$\mu = 0.008$	18.84	6.84	4.21	24.77	0.79	0.53	1.50	490.73	2.00	0.76	129.91	
FB	$\mu = 0.012$	21.64	7.18	4.56	23.32	0.85	0.55	1.54	546.70	1.47	0.83	120.86	
SB	$\mu = 0.008$	16.06	5.90	3.59	29.42	0.68	0.46	1.50	488.59	3.60	0.64	122.84	0.44
SB	$\mu = 0.012$	17.73	5.97	3.73	28.92	0.70	0.46	1.54	543.85	3.60	0.67	114.77	0.52
FB	$\sigma = 0.24$	21.09	7.56	4.71	22.80	0.87	0.57	1.52	517.15	1.30	0.84	115.64	
FB	$\sigma = 0.26$	19.49	6.56	4.11	25.18	0.78	0.51	1.52	518.09	2.06	0.76	134.64	
SB	$\sigma = 0.24$	17.00	6.18	3.79	28.39	0.70	0.47	1.51	514.18	3.60	0.68	110.23	0.57
SB	$\sigma = 0.26$	16.73	5.70	3.53	29.96	0.68	0.45	1.52	516.01	3.59	0.64	127.44	0.40
FB	$r = 0.0575$	21.88	7.34	4.65	22.37	0.88	0.57	1.55	553.16	1.07	0.86	122.15	
FB	$r = 0.0625$	19.11	6.86	4.23	25.37	0.78	0.52	1.50	485.74	2.20	0.75	128.27	
SB	$r = 0.0575$	17.10	5.82	3.63	28.49	0.69	0.45	1.54	549.83	3.49	0.68	115.43	0.60
SB	$r = 0.0625$	16.64	6.04	3.68	29.85	0.69	0.46	1.49	483.87	3.71	0.64	121.98	0.39
FB	$\Pi = 1.97$	19.20	6.75	4.23	25.34	0.78	0.52	1.50	508.66	2.23	0.75	126.59	
FB	$\Pi = 2.03$	21.57	7.40	4.61	22.60	0.88	0.57	1.55	526.73	1.15	0.85	123.58	
SB	$\Pi = 1.97$	16.68	5.93	3.68	29.96	0.68	0.46	1.49	506.71	3.79	0.64	120.28	0.39
SB	$\Pi = 2.03$	17.04	5.94	3.64	28.43	0.70	0.45	1.54	523.58	3.42	0.68	117.11	0.60
FB	$I = 195$	21.13	7.30	4.58	22.86	0.86	0.56	1.53	521.22	1.26	0.84	124.15	
FB	$I = 205$	19.45	6.79	4.22	25.13	0.79	0.52	1.51	514.06	2.15	0.76	126.29	
SB	$I = 195$	16.94	5.94	3.68	28.55	0.69	0.46	1.52	518.24	3.45	0.67	117.51	0.57
SB	$I = 205$	16.79	5.93	3.64	29.79	0.69	0.46	1.51	511.99	3.76	0.64	119.87	0.40

Table 2

First-best and second-best investment and financing decisions when the growth option is financed with debt and equity

The firm has assets-in-place that generate pre-tax earnings of X and an investment option that requires an investment expenditure of I and expands earning to ΠX, $\Pi > 1$. The firm is capitalized with equity and debt and may finance the investment expenditure with equity and an additional debt issue. The investment decision is characterized by the earnings threshold, X_s, at which the firm exercises its investment option. The first-best exercise policy (FB) maximizes total firm value and the second-best exercise policy (SB) maximizes equity value. Panel A reports firm outcomes when the growth option is constrained to be all-equity financed. Panels B and C provide financial contracting solutions to the debt overhang problem. Panel B holds the initial debt coupon, C_0, constant at the all-equity second-best solution value of 16.86 in Panel A, and solves for the coupon of the debt issue used to finance the cost of exercising the growth option, C_s, that motivates equityholders to invest at the all-equity first-best investment threshold, $X_s^{FB} = 24.12$. Panel C optimizes firm value over C_0 and C_s, while imposing the constraint that the firm invests at the first-best all-equity investment threshold, $X_s^{FB} = 24.12$. Panel D reports the unconstrained solution where the firm optimizes over C_0 and C_s and the investment threshold is chosen to maximize firm value (first-best) or equity value (second-best). The table reports the optimal initial debt coupon, C_0^*, the endogenous default threshold before the exercise of the investment option, X_{dl}, the investment threshold, X_s, the optimal coupon of the debt issue used to finance the growth option, C_s^*, the endogenous default threshold after exercise of the investment option, X_{dh}, the initial time zero debt value, D_l, the initial debt value at $X = X_s$, D_{h0}, the market value of the debt issued to finance the cost of exercising the growth option at $X = X_s$, D_{hs}, the initial time zero book and market leverage ratio, *BL* and *ML*, the market-to-book value ratio, *Q*, total firm value, V_l, the expected time to investment (in years) conditional on no default, $E[T_s \mid T_s < T_{dl}]$, the probability of investment prior to default, π_s, and the credit spread of debt (in basis points), $CSP = [C_0^* / D_l(X_0, C_0^*)] - r$. Book leverage (*BL*) is the market value of initial time zero debt divided by the value of assets-in-place, $V_a = ((1-\tau)X_0)/(r-\mu)$, where X_0 is initial (time zero) pre-tax firm cash flow, τ is the corporate tax rate, r is the risk-free rate of interest, and μ is the drift rate of cash flows. Market leverage (*ML*) is the market value of initial time zero debt divided by the total time zero firm value. Market-to-book ratio (*Q*) is total time zero firm value divided by assets-in-place, V_a. The base case parameter values are as follows: the initial cash flow, X_0, is 20, the investment option payoff factor, Π, is 2.0, the cost of exercising the investment option, I, is 200, the volatility of cash flows, σ, is 25% per year, the drift rate of cash flows, μ, is 1% per year, the risk-free rate, r, is 6% per year, the corporate tax rate, τ, is 15%, and proportional bankruptcy costs, α, are 25% of the value of assets-in-place at the time of bankruptcy.

	C_0^*	X_{dl}	X_s	C_s^*	X_{dh}	D_l	D_{h0}	D_{hs}	*BL*	*ML*	*Q*	V_l	$E[T_s]$	π_s	*CSP*
Panel A. Constrained solution – all-equity-financed growth option[1]															
FB	20.09	6.98	24.12		4.36	276.99	300.04		0.82	0.54	1.52	517.50	1.77	0.79	125.44
SB	16.86	5.93	29.17		3.66	234.58	261.34		0.69	0.46	1.52	515.04	3.61	0.66	118.75
Panel B. Financial contracting resolves debt overhang: hold C_0 constant at SB solution; find C_s to solve $X_s = X_s^{FB} = 24.12$															
SB	16.86	5.76	24.12	20.05	8.01	218.21	224.36	266.82	0.64	0.42	1.54	525.17	2.10	0.81	172.67
Panel C. Financial contracting resolves debt overhang: optimize over C_0 and C_s subject to $X_s = X_s^{FB} = 24.12$															
SB	10.95	3.93	24.12	23.03	7.37	148.98	148.83	313.10	0.44	0.28	1.55	526.55	2.73	0.83	134.71

Table 2 Continued

	C_0^*	X_{dl}	X_s	C_s^*	X_{dh}	D_l	D_{h0}	D_{hs}	BL	ML	Q	V_l	$E[T_s]$	π_s	CSP
Panel D. Unconstrained solution – optimize over C_0, C_s, and X_s [2]															
FB	11.43	4.09	26.51	25.90	8.10	155.67	155.47	352.20	0.46	0.30	1.55	527.59	3.76	0.76	134.53
SB	13.90	4.87	23.80	19.62	7.27	186.08	189.02	266.76	0.55	0.35	1.55	525.93	2.24	0.83	147.10

[1] Agency cost of debt = 0.47%.

[2] Agency cost of debt = 0.32%.

Table 3

First-best and second-best financing and investment decisions when the growth option is financed with debt and equity

The firm has assets-in-place that generate pre-tax earnings of X and an investment option that requires an investment expenditure of I and expands earning to ΠX, $\Pi > 1$. The firm is capitalized with equity and debt and may finance the investment expenditure with equity and an additional debt issue. The investment decision is characterized by the earnings threshold, X_s, at which the firm exercises its investment option. The first-best exercise policy (FB) maximizes total firm value and the second-best exercise policy (SB) maximizes equity value. Panel A reports firm outcomes for various parameter inputs when the initial debt coupon is fixed (C_0^{exog}) and Panel B reports firm outcomes for various parameter inputs when the initial debt coupon is chosen to maximize total firm value (C_0^*). In both Panels A and B, the coupon of the additional debt used to finance the investment expenditure is chosen to maximize firm value. The optimal coupon on the additional debt issue is denoted as C_s^*. After exercise of the growth option, the initial debt issue and the additional debt issue are assumed to have equal priority in bankruptcy. Note that the fixed coupon of the initial debt issue in Panel A, $C_0^{exog} = 12.56$, is the average of the first-best optimal initial debt coupon (12.77) and second-best optimal initial debt coupon (12.36) for the base case in Panel B. For the base-case and variations of base-case parameters, the table reports first- and second-best outcomes for the initial debt coupon, C_0^{exog} in Panel A and C_0^* in Panel B, the investment threshold, X_s, the optimal additional debt coupon, C_s^*, the initial debt value, $D_l(X_0, C_0^{exog})$ in Panel A and $D_l(X_0, C_0^*)$ in Panel B, the initial debt value at the investment exercise threshold, $D_h(X_s, C_0^{exog})$ in Panel A and $D_h(X_s, C_0^*)$ in Panel B, the additional debt value at the investment exercise threshold, $D_h(X_s, C_s^*)$, the time zero pre-investment market leverage ratio, ML, total firm value, V_l, the credit spread of debt (in basis points), $CSP = [C_0^{exog} / D_l(X_0, C_0^{exog})] - r$ in Panel A and $CSP = [C_0^* / D_l(X_0, C_0^*)] - r$ in Panel B, and the agency cost of debt (in %), $AC = (V_l^{FB} - V_l^{SB}) / V_l^{FB}$. The base case parameter values are as follows: the initial cash flow, X_0, is 20, the investment option payoff factor, Π, is 2.0, the cost of exercising the investment option, I, is 300, the volatility of cash flows, σ, is 25% per year, the drift rate of cash flows, μ, is 1% per year, the risk-free rate, r, is 6% per year, the corporate tax rate, τ, is 15%, and proportional bankruptcy costs, α, are 25% of the value of assets-in-place at the time of bankruptcy.

Panel A. Exogenous initial debt policy

		C_0^{exog}	X_s	C_s^*	$D_l(X_0, C_0^{exog})$	$D_h(X_s, C_0^{exog})$	$D_h(X_s, C_s^*)$	ML	V_l	CSP	AC (%)
FB	Base case	12.56	39.37	42.89	171.55	170.80	583.18	0.35	484.74	132.29	
SB	Base case	12.56	34.89	36.58	170.60	170.80	497.34	0.35	483.41	136.35	0.28
FB	$\alpha = 0.20$	12.56	39.12	47.22	171.57	168.62	633.86	0.35	487.31	132.19	
FB	$\alpha = 0.30$	12.56	39.58	39.16	171.40	172.64	538.11	0.36	482.45	132.94	
SB	$\alpha = 0.20$	12.56	34.21	39.73	170.29	168.62	533.22	0.35	485.63	137.68	0.35
SB	$\alpha = 0.30$	12.56	35.47	33.79	170.70	172.64	464.35	0.36	481.38	135.94	0.22
FB	$\tau = 0.12$	12.56	38.44	36.88	163.12	163.81	515.74	0.33	494.38	118.05	
FB	$\tau = 0.18$	12.56	40.03	49.36	160.34	155.30	654.40	0.34	475.41	130.49	
SB	$\tau = 0.12$	12.56	34.98	32.50	162.58	163.81	454.46	0.33	493.56	120.43	0.17
SB	$\tau = 0.18$	12.56	34.85	41.46	158.90	155.30	549.75	0.34	473.66	137.11	0.37

Table 3 Continued

		C_0^{exog}	X_s	C_s^*	$D_l(X_0, C_0^{exog})$	$D_h(X_s, C_0^{exog})$	$D_h(X_s, C_s^*)$	ML	V_l	CSP	$AC\,(\%)$
FB	$\mu = 0.008$	12.56	39.91	40.17	183.65	187.23	543.52	0.40	458.87	153.51	
FB	$\mu = 0.012$	12.56	39.12	43.61	188.36	189.06	595.83	0.37	512.84	134.67	
SB	$\mu = 0.008$	12.56	35.46	34.15	182.91	187.23	462.00	0.40	457.64	156.55	0.27
SB	$\mu = 0.012$	12.56	34.39	36.67	187.37	189.06	500.95	0.37	511.30	138.56	0.30
FB	$\sigma = 0.24$	12.56	38.25	41.19	176.80	176.53	567.18	0.37	482.60	125.16	
FB	$\sigma = 0.26$	12.56	40.59	44.23	172.27	172.10	593.72	0.35	486.91	144.26	
SB	$\sigma = 0.24$	12.56	33.99	35.19	175.89	176.53	484.50	0.37	481.27	128.90	0.27
SB	$\sigma = 0.26$	12.56	35.81	37.52	171.31	172.10	503.63	0.35	485.55	148.41	0.28
FB	$r = 0.0575$	12.56	38.30	41.94	176.23	175.19	591.61	0.34	517.26	129.76	
FB	$r = 0.0625$	12.56	40.40	44.10	164.02	162.99	578.68	0.36	455.65	132.22	
SB	$r = 0.0575$	12.56	33.80	35.56	175.19	175.19	501.60	0.34	515.76	133.94	0.29
SB	$r = 0.0625$	12.56	35.97	37.89	163.14	162.99	497.21	0.36	454.47	136.27	0.26
FB	$\Pi = 1.97$	12.56	40.51	44.02	167.35	165.75	598.47	0.35	478.36	128.45	
FB	$\Pi = 2.03$	12.56	38.20	42.43	167.10	165.75	576.85	0.34	491.22	129.52	
SB	$\Pi = 1.97$	12.56	35.87	37.57	166.38	165.75	510.78	0.35	477.06	132.70	0.27
SB	$\Pi = 2.03$	12.56	33.96	36.36	166.15	165.75	494.38	0.34	489.89	133.69	0.27
FB	$I = 290$	12.56	38.08	41.30	168.73	167.74	561.55	0.35	487.86	131.16	
FB	$I = 310$	12.56	40.60	44.85	169.12	167.74	609.84	0.35	481.77	129.45	
SB	$I = 290$	12.56	33.73	35.17	167.77	167.74	478.18	0.35	486.48	135.35	0.28
SB	$I = 310$	12.56	36.05	38.44	168.18	167.74	522.61	0.35	480.50	133.55	0.26

Panel B. Endogenous initial debt policy

		C_0^*	X_s	C_s^*	$D_l(X_0, C_0^*)$	$D_h(X_s, C_0^*)$	$D_h(X_s, C_s^*)$	ML	V_l	CSP	$AC\,(\%)$
FB	Base case	12.77	39.40	42.72	173.89	173.57	580.88	0.36	484.74	134.11	
SB	Base case	12.36	34.89	36.78	168.23	168.04	500.06	0.35	483.41	134.63	0.28

Table 3 Continued

		C_0^*	X_s	C_s^*	$D_l(X_0, C_0^*)$	$D_h(X_s, C_0^*)$	$D_h(X_s, C_s^*)$	ML	V_l	CSP	$AC\,(\%)$
FB	$\alpha = 0.20$	13.59	39.24	46.39	183.33	182.39	622.67	0.38	487.38	141.16	
FB	$\alpha = 0.30$	12.02	39.52	39.61	165.16	165.24	544.41	0.34	482.47	128.00	
SB	$\alpha = 0.20$	13.03	34.21	39.25	175.76	174.95	526.80	0.36	485.64	141.56	0.36
SB	$\alpha = 0.30$	11.71	35.45	34.61	160.77	160.97	475.64	0.33	481.42	128.54	0.22
FB	$\tau = 0.12$	11.05	38.39	37.47	155.13	154.58	523.99	0.31	494.41	112.51	
FB	$\tau = 0.18$	14.31	40.46	47.42	189.61	189.64	628.74	0.40	475.90	154.50	
SB	$\tau = 0.12$	10.73	34.97	33.47	150.56	150.03	468.15	0.31	493.62	112.54	0.16
SB	$\tau = 0.18$	13.84	34.85	39.34	183.10	183.48	521.58	0.39	473.93	155.77	0.42
FB	$\mu = 0.008$	12.28	39.75	41.51	166.33	166.11	561.62	0.36	459.04	138.10	
FB	$\mu = 0.012$	13.30	39.06	44.06	182.18	181.74	601.94	0.36	512.86	130.19	
SB	$\mu = 0.008$	11.93	35.40	35.97	161.52	161.44	486.61	0.35	457.86	138.73	0.26
SB	$\mu = 0.012$	12.82	34.38	37.66	175.49	175.17	514.57	0.34	511.35	130.57	0.29
FB	$\sigma = 0.24$	12.87	38.25	41.15	177.38	177.21	566.61	0.37	482.60	125.58	
FB	$\sigma = 0.26$	12.67	40.57	44.36	170.54	170.05	595.43	0.35	486.91	142.84	
SB	$\sigma = 0.24$	12.53	33.99	35.47	172.52	172.58	488.31	0.36	481.27	126.57	0.27
SB	$\sigma = 0.26$	12.19	35.81	38.15	164.11	163.63	512.08	0.34	485.57	142.84	0.28
FB	$r = 0.0575$	12.71	38.33	41.70	179.72	179.28	588.18	0.35	517.26	132.20	
FB	$r = 0.0625$	12.82	40.45	43.77	168.42	168.20	574.38	0.37	455.66	135.98	
SB	$r = 0.0575$	12.29	33.80	35.69	173.56	173.30	503.45	0.34	515.76	132.89	0.29
SB	$r = 0.0625$	12.43	35.97	37.88	163.24	163.10	497.10	0.36	454.47	136.35	0.26
FB	$\Pi = 1.97$	12.82	40.60	43.50	174.57	174.25	591.50	0.37	478.38	134.13	
FB	$\Pi = 2.03$	12.72	38.26	41.99	173.21	172.88	570.87	0.35	491.24	134.10	
SB	$\Pi = 1.97$	12.38	35.87	37.37	168.64	168.39	508.13	0.35	477.07	134.38	0.28
SB	$\Pi = 2.03$	12.34	33.96	36.22	167.87	167.74	492.42	0.34	489.89	134.89	0.27
FB	$I = 290$	12.68	38.12	41.02	172.67	172.35	557.68	0.35	487.87	134.13	
FB	$I = 310$	12.85	40.67	44.43	175.02	174.69	604.12	0.36	481.79	134.09	
SB	$I = 290$	12.30	33.73	35.20	167.36	167.26	478.64	0.34	486.48	135.06	0.28
SB	$I = 310$	12.42	36.05	38.35	169.14	168.86	521.48	0.35	480.51	134.27	0.27

Table 4

Optimal Debt Structure – Endogenous Capital and Priority Structure

The firm has assets-in-place that generate pre-tax earnings of X and an investment option that requires an investment expenditure of I and expands earning to ΠX, $\Pi > 1$. The firm is capitalized with equity and debt and may finance the investment expenditure with equity and an additional debt issue. The investment decision is characterized by the earnings threshold, X_s, at which the firm exercises its investment option. The first-best exercise policy (FB) maximizes total firm value and the second-best exercise policy (SB) maximizes equity value. Panels A-D report, respectively, first- and second-best results for equal priority, me-first for time 0 debt, me-first for time T_s debt, and optimal priority. All priority cases are at the corresponding optimal capital structure (C_0^* and C_s^*). For the equal priority case in Panel A, we report $\beta_0 = C_0^* /(C_0^* + C_s^*)$, which determines how the liquidation value of the firm in bankruptcy, $L_h(X_{dh})$, is allocated between time 0 debt (β_0) and time T_s debt ($\beta_s = 1 - \beta_0$). In the me-first priority cases in Panels B and C , we report γ_0, which is the proportion of the firm's liquidation proceeds in bankruptcy going to time 0 debt. Thus, in Panel B where time 0 debt has a me-first covenant, $\gamma_0 = R_0(X_{dh})/L_h(X_{dh})$, and in Panel C where time T_s debt has a me-first covenant, $\gamma_0 = [L_h(X_{dh}) - R_s(X_{dh})]/L_h(X_{dh})$, where $R_i(X_{dh}) = \min[L_h(X_{dh}),(\theta)(C_i/r)]$ for i = 0, s and θ = 0.25, 0.50, 0.75, and 1.00. Note that θ is a measure of the strength of the protection in bankruptcy afforded by the me-first covenant. For comparison, Panels B and C also report the priority weighting if priority were determined by an equal priority rule, $\beta_0 = C_0^* /(C_0^* + C_s^*)$. Panel D reports model outcomes for optimal priority, β_0^*, and again for comparison, the equal priority weighting $\beta_0 = C_0^* /(C_0^* + C_s^*)$. Finally, Panel E reports model outcomes where we fix the coupon for time 0 debt and optimize over priority and time T_s capital structure. In addition to reporting β_0, γ_0, β_0^*, and θ, the table reports the optimal initial debt coupon, C_0^*, the endogenous default threshold before the exercise of the investment option, X_{dl}, the investment threshold, X_s, the optimal coupon of the debt issue used to finance the growth option, C_s^*, the endogenous default threshold after exercise of the investment option, X_{dh}, the initial time zero debt value, D_l, the initial debt value at $X = X_s$, D_{h0}, the market value of the debt issued to finance the cost of exercising the growth option at $X = X_s$, D_{hs}, the initial time zero market leverage ratio, *ML*, total firm value, V_l, the credit spread of debt (in basis points), $CSP = [C_0^* / D_l(X_0, C_0^*)] - r$, and the agency cost of debt (in %), $AC = (V_l^{FB} - V_l^{SB})/V_l^{FB}$. Market leverage (*ML*) is the market value of initial time zero debt divided by the total time zero firm value. The base case parameter values are as follows: the initial cash flow, X_0, is 20, the investment option payoff factor, Π, is 2.0, the cost of exercising the investment option, I, is 200, the volatility of cash flows, σ, is 25% per year, the drift rate of cash flows, μ, is 1% per year, the risk-free rate, r, is 6% per year, the corporate tax rate, τ, is 15%, and proportional bankruptcy costs, α, are 25% of the value of assets-in-place at the time of bankruptcy.

	β_0	γ_0	β_0^*	θ	C_0^*	X_{dl}	X_s	C_s^*	X_{dh}	D_l	D_{h0}	D_{hs}	*ML*	V_l	*CSP*	*AC* (%)
Panel A. Equal priority																
FB	0.31				11.43	4.09	26.51	25.90	8.10	155.67	155.47	352.20	0.30	527.59	134.53	
SB	0.42				13.90	4.87	23.80	19.62	7.27	186.08	189.02	266.76	0.35	525.93	147.10	0.32
Panel B. Me-first covenant for time 0 debt																
FB	0.31	0.23		0.25	11.52	4.11	26.52	25.84	8.11	154.07	152.22	355.65	0.29	527.62	147.36	
FB	0.30	0.46		0.50	11.28	4.06	26.49	26.03	8.10	158.91	162.01	345.27	0.30	527.55	109.53	
FB	0.30	0.67		0.75	11.05	4.01	26.46	26.22	8.09	163.64	171.47	335.25	0.31	527.49	75.26	
FB	0.29	0.88		1.00	10.84	3.97	26.43	26.39	8.08	168.26	180.62	325.58	0.32	527.43	44.07	
SB	0.46	0.35		0.25	15.02	5.20	23.06	17.46	7.05	195.92	198.54	243.11	0.37	524.77	166.55	0.54
SB	0.35	0.53		0.50	12.40	4.42	25.26	23.18	7.72	173.62	178.13	305.65	0.33	527.22	114.05	0.06
SB	0.27	0.62		0.75	10.45	3.81	27.04	27.63	8.26	155.21	162.22	355.59	0.29	527.42	73.57	0.01
SB	0.22	0.65		1.00	8.54	3.19	28.20	31.17	8.62	133.67	142.32	397.64	0.25	526.63	38.82	0.15

Table 4 Continued

	β_0	γ_0	β_0^*	θ	C_0^*	X_{dl}	X_s	C_s^*	X_{dh}	D_l	D_{h0}	D_{hs}	ML	V_l	CSP	AC (%)
Panel C. Me-first covenant for time T_s debt																
FB	0.30	0.48		0.25	11.32	4.08	26.49	25.99	8.10	160.17	163.77	343.53	0.30	527.55	107.00	
FB	0.31	0.00		0.50	11.77	4.16	26.55	25.63	8.12	149.10	142.06	366.43	0.28	527.69	189.31	
FB	0.31	0.00		0.75	11.77	4.16	26.55	25.63	8.12	149.10	142.06	366.43	0.28	527.69	189.31	
FB	0.31	0.00		1.00	11.77	4.16	26.55	25.63	8.12	149.10	142.06	366.43	0.28	527.69	189.31	
SB	0.31	0.48		0.25	11.10	4.00	25.06	24.20	7.66	157.21	160.05	319.87	0.30	527.20	106.13	0.07
SB	0.57	0.35		0.50	18.48	6.24	23.12	14.08	7.07	233.96	240.37	202.33	0.45	523.74	189.81	0.75
SB	0.67	0.25		0.75	21.27	7.03	22.62	10.60	6.91	260.47	268.78	164.42	0.50	521.88	216.41	1.10
SB	0.72	0.17		1.00	22.75	7.45	22.30	8.66	6.82	273.80	282.73	144.37	0.53	520.77	230.92	1.31
Panel D. Optimal priority structure																
FB	0.31		0.00		11.77	4.16	26.55	25.63	8.12	149.10	142.06	366.42	0.28	527.69	189.32	
SB	0.30		0.59		11.22	4.06	26.40	25.97	8.07	162.88	168.96	336.62	0.31	527.51	88.78	0.03
Panel E. Extreme leverage and optimal priority structure																
FB	0.40		0.00		15.00	5.13	26.60	22.47	8.13	185.19	181.06	328.34	0.35	527.26	210.00	
FB	0.54		0.00		20.00	6.57	26.14	16.82	7.99	236.83	241.41	259.20	0.45	524.92	244.50	
FB	0.72		0.00		25.00	7.97	24.64	9.70	7.53	285.71	301.77	170.09	0.55	520.63	275.02	
SB	0.40		0.65		15.00	5.24	26.33	22.09	8.05	206.81	217.58	286.70	0.39	526.88	125.30	0.07
SB	0.55		0.60		20.00	6.73	25.59	16.05	7.82	256.82	274.19	215.91	0.49	524.19	178.76	0.14
SB	0.74		0.33		25.00	8.11	23.86	8.61	7.29	298.30	318.46	138.48	0.57	519.90	238.07	0.14

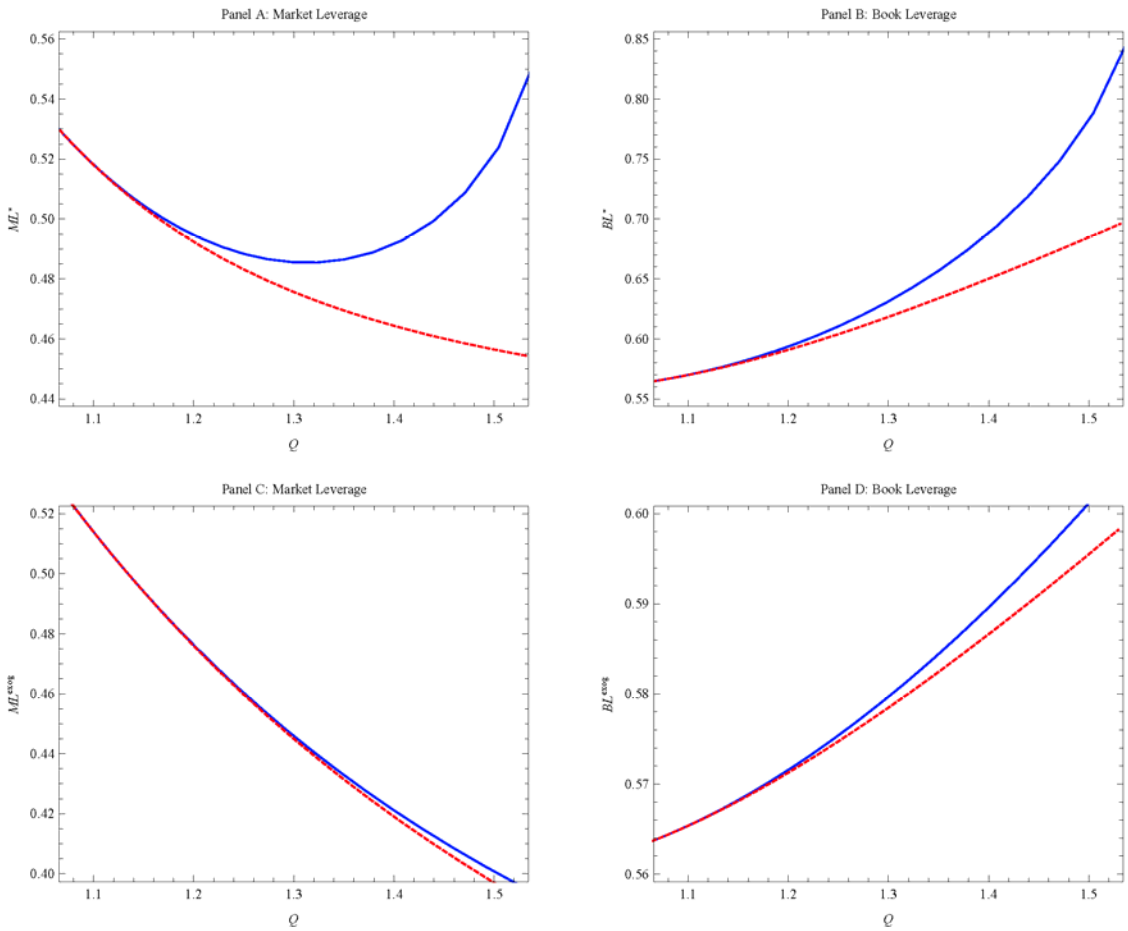

Figure 1. First- and second-best market and book leverage ratios as a function of Tobin's *Q*. Panels A and B plot market and book leverage ratios at the optimal coupon, C_0^*, as a function of Tobin's *Q*, and Panels C and D plot market and book leverage ratios at a fixed exogenously-specified coupon, C_0^{exog}, as a function of Tobin's *Q*. The solid line is the first-best market/book leverage ratio and the dashed line is the second-best market/book leverage ratio. The market leverage ratio is computed as the market value of debt divided by total firm value, the book leverage ratio is computed as the market value of debt divided by the value of assets-in-place, and Tobin's *Q* is the market value of the firm divided by the value of assets-in-place. The value of assets in place is computed as $V_a = ((1-\tau)X_0)/(r-\mu)$, where X_0 is initial (time zero) pre-tax firm cash flow, τ is the corporate tax rate, r is the risk-free rate of interest, and μ is the drift rate of cash flows. The graphs assume the initial cash flow, X_0, is 20, the cost of exercising the investment option, I, is 200, the volatility of cash flows, σ, is 25% per year, the drift rate of cash flows, μ, is 1% per year, the risk-free rate, r, is 6% per year, the corporate tax rate, τ, is 15%, and proportional bankruptcy costs, α, are 25% of the value of assets-in-place at the time of bankruptcy. Variation in *Q* is generated by varying the investment (growth) option payoff factor, Π.

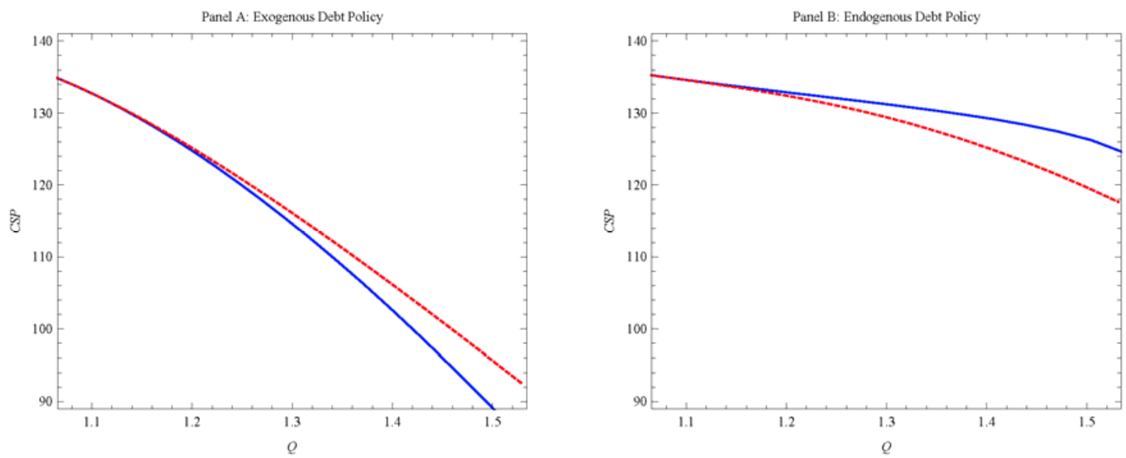

Figure 2. First- and second-best credit spreads for exogenous and endogenous debt policy as a function of Tobin's *Q*. Panel A plots credit spreads at a fixed exogenously-specified coupon, C_0^{exog}, as a function of Tobin's *Q*, and Panel B plots credit spreads at the optimal coupon, C_0^*, as a function of Tobin's *Q*. The solid line is the first-best credit spread and the dashed line is the second-best credit spread. The credit spread is computed as $CSP = [C_0 / D_l(X_0, C_0)] - r$, using C_0^{exog} in Panel A and C_0^* in Panel B. The graphs assume the initial cash flow, X_0, is 20, the cost of exercising the investment option, I, is 200, the volatility of cash flows, σ, is 25% per year, the drift rate of cash flows, μ, is 1% per year, the risk-free rate, r, is 6% per year, the corporate tax rate, τ, is 15%, and proportional bankruptcy costs, α, are 25% of the value of assets-in-place at the time of bankruptcy. Variation in *Q* is generated by varying the investment (growth) option payoff factor, Π.