Optimal Priority Structure, Capital Structure, and Investment

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We study the interaction between financing and investment decisions in a dynamic model, where the firm has multiple debt issues and equityholders choose the timing of investment. Jointly optimal capital and priority structures can virtually eliminate investment distortions because debt priority serves as a dynamically optimal contract. Examining the relative efficiency of priority rules observed in practice, we develop several predictions about how firms adjust their priority structure in response to changes in leverage, credit conditions, and firm fundamentals. Notably, financially unconstrained firms with few growth opportunities prefer senior debt, while financially constrained firms, with or without growth opportunities, prefer junior debt. Moreover, lower-rated firms are predicted to spread priority across debt classes. Finally, our analysis has a number of important implications for empirical capital structure research, including the relations between market leverage, book leverage, and credit spreads and Tobin's Q, the influence of firm fundamentals on the agency cost of debt, and the conservative debt policy puzzle. (*JEL* G13, G31, G32, G33)

Researchers in corporate finance have long been interested in the question of how financial structure influences and is influenced by investment policy. On the one hand, Myers (1977) argues that when a firm has outstanding risky debt, equityholders have an incentive to underinvest in future growth options. On the other hand, Jensen and Meckling (1976) argue that there are also situations in which equityholders have an incentive to overinvest in future growth options. Since the loss in firm value—attributable to these suboptimal investment incentives—is thought to be nontrivial, an important question is how financial contracts have evolved to mitigate conflicts over investment policy.

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In this article, we examine how capital structure and debt priority structure interact with investment policy. In extending Leland's (1994) model to investment, a novel modeling feature is the explicit recognition that the firm's existing capital structure influences future investment decisions through two channels: First, there is a stockholder–bondholder conflict over investment timing, and second, there is the role of how future investment is financed, which is the primary focus of our analysis. The recognition that future investment may be financed with equity and debt has consequences for the existing capital structure, the growth option exercise policy, and the dynamic evolution of financial contracts. A key feature of this analysis is the role that priority structure plays in the stockholder–bondholder conflict over investment policy.

In our model, the firm has assets-in-place and a growth option to expand its operations. The option exercise is endogenously determined to maximize the market value of equity. 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 bankruptcy costs that are triggered by an endogenous default decision.[1] Since the firm can have multiple outstanding debt issues, the firm must choose a priority rule for its debts in the event of default. We allow the firm to choose any one of three priority rules observed in practice—equal priority (*pari passu*), me-first for initial debt, or me-first for additional debt issued to finance the growth option.[2] For comparative purposes, we derive a "normative" optimal priority, which allows the firm to choose any allocation of claims in default that is jointly optimal with dynamic financing.[3]

There are several empirical facts on leverage and priority structure that we seek to explain with our model. First, we investigate whether future financing and investment decisions help explain the decision to use overly conservative leverage levels (see, e.g., Graham 2000). Second, empirical evidence on debt priority structures generally suggests that financially unconstrained firms with few growth opportunities tend to use senior debt claims, while financially constrained firms with more abundant growth opportunities tend to preserve priority for future debt issues by using junior debt.[4] Finally, Rauh and Sufi

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[1] In an extension of the model, we introduce transaction costs of issuing debt and equity to examine how market frictions influence the initial capital structure, the manner in which the growth option is financed, and, in particular, to address the question of why we observe three debt priority structures in the data.

[2] We briefly note in Section 3 how these priority structures historically evolved and the empirical evidence on the frequency with which firms use a particular type of priority structure.

[3] Our analysis focuses on how debt priority structure influences investment and financing decisions outside bankruptcy. There is a considerable amount of related work, however, that examines how debt securities with different priorities influence the costs, mode (Chapter 7 or 11), and outcome of the bankruptcy process (see, e.g., Gilson, John, and Lang 1990; Gilson, Hotchkiss, and Ruback 2000; Bris, Schwartz, and Welch 2005; Bris, Welch, and Zhu 2006; Broadie, Chernov, and Sundaresan 2007; Bris, Ravid, and Sverdlove 2008).

[4] Barclay and Smith (1995) and Julio, Kim, and Weisbach (2008) find that the use of secured debt and other high-priority debt-like instruments (e.g., leases) is more prevalent in firms that are more likely to have stockholder–bondholder agency conflicts. Nash, Netter, and Poulsen (2003) report that bond issues by high market-to-book firms are significantly less likely to have dividend restrictions and restrictions on issuance of additional debt.

(2010) report that, as a firm's credit quality deteriorates, it tends to allocate priority to future debt issues by using a greater fraction of subordinate debt in its debt structure (i.e., a "priority spreading" phenomenon).

In the absence of agency conflicts, our model predicts an optimal leverage ratio of 54%. Although much smaller than Leland's (1994) point estimate of 70%, both estimates are too high, relative to median (quasi-market) leverage ratios observed in the data.[5] However, we find that agency conflicts significantly decrease optimal leverage. In particular, if future investment is chosen to maximize equity value, and if the investment cost is all-equity-financed, then the optimal leverage ratio decreases to 46%, which illustrates that agency conflicts over investment timing imply significantly lower optimal leverage. If, however, the future investment is financed by a mixture of debt and equity, then the optimal leverage ratio is further reduced to 35%, which illustrates that the opportunity to issue additional debt in the future further decreases optimal leverage today. Finally, in the case in which the firm faces an agency conflict over the timing of investment, and over how much additional debt the firm issues to finance investment, the optimal initial leverage is only 12%. Overall, these model estimates imply that agency conflicts over the timing and financing of future investments can explain empirically observed leverage levels.

We find that priority structure plays an important role in balancing equityholders' incentives to over- and underinvest in the growth option. Without priority protection for initial debt, equityholders have an incentive to overinvest in the growth option because the additional debt used to finance its exercise dilutes initial debt. However, this incentive to dilute existing debt can be eliminated by making it senior to subsequent creditors with using a me-first covenant. Yet, protecting initial debt from dilution ensures that initial debt will benefit from the exercise of the growth option and thereby provides equityholders with an incentive to underinvest in the growth option. We show that there exists an *interior* optimal priority structure that balances this trade-off of investment incentives and virtually eliminates over- and underinvestment incentives. Moreover, we show that empirically observed priority rules produce investment outcomes and hence firm values that are quite close to those under the normative optimal priority rule.

The role played by priority structure in our model generates predictions that are largely consistent with the results from the empirical literature. Using an extension of the model that incorporates an initial startup cost—in addition

Bris, Ravid, and Sverdlove (2008) document that firms issuing senior debt are about ten times larger, are more profitable, pay more dividends, have lower leverage, and have higher credit ratings than firms that issue junior debt only. Finally, in a large recent sample of bond issues, Chava, Kumar, and Warga (2010) find that subsequent financing restrictions (e.g., restrictions on funded debt, indebtedness, liens, and senior debt issuance of parent and subsidiary firms) are significantly less likely in high market-to-book firms and are significantly more likely in firms with high leverage.

5 For example, Frank and Goyal (2009) report a mean (median) ratio of long-term debt to market value of assets of 0.20 (0.13).

to the cost of exercising the growth option—and external financing costs, we show how priority structure varies with firm characteristics. In particular, we find that firms with high external financing costs (e.g., small and financially constrained firms), and especially riskier firms with high financial distress costs, preserve priority for future debt issues by using primarily junior debt in their current debt structures. This result is consistent with evidence reported by Rauh and Sufi (2010), who find that, relative to high-credit-quality firms, low-credit-quality firms tend to use junior debt that allows for the allocation of priority to future debt issues. Our model also predicts that financially unconstrained firms with few growth opportunities should prefer debt structures that are composed of senior debt. In sharp contrast, the model predicts that financially constrained firms, with or without growth opportunities, should prefer junior debt. These predictions are consistent with the empirical evidence on priority structure.

Our analysis has a number of additional implications for capital structure research. First, the model has an interesting quantitative prediction for the relation between market leverage and Tobin's Q. In the absence of agency conflicts between stockholders and bondholders, the model predicts a U-shaped relation between market leverage and Q, with the base of the U occurring close to the median Q value of nonfinancial firms in the Compustat universe (i.e., about 1.40). Since the model predicts that leverage and Q are always negatively related when there are agency conflicts, one can test for the impact of agency conflicts on capital structure by estimating leverage-Q relations in high- and low-Q subsamples of firms. Thus, a negative (positive) leverage-Q relation for high-Q firms implies that stockholder–bondholder agency conflicts are economically important (unimportant), while a negative relation for low-Q firms is uninformative. Second, the model predicts that the credit spreads on risky debt should be decreasing in Q. Third, the analysis offers a number of predictions about the factors that influence the agency cost of debt. Of particular interest are the surprising predictions that the agency cost of debt is decreasing in bankruptcy costs and the growth option component of firm value. Finally, as noted above, our model can explain Graham (2000) debt conservatism puzzle.

Some early articles examine how debt priority affects investment incentives. Smith and Warner (1979) argue that secured debt can limit a firm's ability to engage in asset substitution, while Stulz and Johnson (1985) find that secured debt can mitigate underinvestment problems. Berkovitch and Kim (1990) report that project finance can help resolve investment incentive problems. More recently, Hackbarth, Hennessy, and Leland (2007) show that placing bank debt senior in the firm's priority structure fully exploits interest tax shield benefits in a trade-off model with multiple classes of debt but without investment. Our analysis extends this work by examining the dynamic trade-off between priority structure, capital structure, and investment incentives and yields important additional insights and empirical predictions.

Our article is also related to a growing body of literature that studies interactions between investment and financing decisions by using dynamic models.[6] The articles that are closest yet complementary to ours are Lobanov and Strebulaev (2007) and Sundaresan and Wang (2007). Similar to our analysis, these articles show how investment and financing decisions interact in dynamic models; however, unlike our analysis, Lobanov and Strebulaev (2007) do not study priority structure, and Sundaresan and Wang (2007) do not analyze how priority structure mitigates investment incentive conflicts.

The remainder of the article is organized as follows: Section 1 presents the model. Section 2 examines how current and future capital structure decisions affect equityholders' incentives to under- and overinvest in the growth option. Section 3 studies the role of debt priority structure in balancing investment incentives and the determinants of priority structure. Section 4 concludes.

1. Model

1.1 Baseline assumptions

Consider a firm with assets-in-place and a growth option. At every point in time t, assets-in-place generate earnings before interest and taxes (EBIT) of X_t, which evolve in accordance with a geometric Brownian motion with initial value $X_0 > 0$, drift μ, and volatility σ under the risk-neutral measure. In addition, a risk-free technology yields a rate r per unit time with $r > \mu$.

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

The firm is initially capitalized with (a single class of) debt and equity. This initial debt issue has infinite maturity and a coupon payment of C_0. The firm may issue additional debt to finance the investment cost, I_s. This additional debt issue also has infinite maturity and a coupon payment of C_s. The optimal coupon, C_0^*, is chosen to maximize the initial value of the firm, while the optimal coupon of the debt used to finance the growth option, C_s^*, is chosen either to maximize total firm value or the sum of equity plus new debt. These optimizations are driven by a trade-off between agency costs, bankruptcy costs,

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[6] For example, see Brennan and Schwartz (1984), Mello and Parsons (1992), Mauer and Triantis (1994), Mauer and Ott (2000), Hennessy (2004), Childs, Mauer, and Ott (2005), Lobanov and Strebulaev (2007), Strebulaev (2007), Sundaresan and Wang (2007), Titman and Tsyplakov (2007), Hackbarth (2008), Tserlukevich (2008), Tsyplakov (2008), Gorbenko and Strebulaev (2010), and Morellec and Schuerhoff (2010, 2011).

tax benefits, and investment benefits. Notably, this trade-off is also influenced by the firm's priority structure.[7]

Assuming that 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 investment. The decision to default on debt coupon payments is endogenously made to maximize the market value of equity before and after investment. In the event of default, equityholders receive nothing and bondholders assume ownership of the firm's assets net of bankruptcy costs. Bankruptcy costs include the loss of interest tax shields, the loss of the growth option (if it has not been exercised), and the fraction α of the value of assets-in-place. Prior to investment, initial debtholders receive the entire net asset value. However, after investment this net asset value is distributed to the initial and additional debt in accordance with a contractually specified priority rule that is enforced by the bankruptcy court. We assume initially equal priority (*pari passu*) in bankruptcy and subsequently analyze me-first rules and the case in which capital structure and priority structure are jointly optimized.

1.2 Additional assumptions

We extend the baseline model to allow for contracting frictions and market imperfections in order to help us better understand the debt priority structures that are observed in practice. Thus, the firm faces the transaction costs of issuing debt and external equity to finance an initial investment cost, $I_0 > 0$, at time 0.[8] Following Hennessy and Whited (2007), the cost of external equity takes the linear quadratic form: $\Lambda(x) \equiv \lambda_0 + \lambda_1\, x + \lambda_2\, x^2$, where $\lambda_i \geq 0$ for $i = 0, 1, 2$, and x denotes the value of external equity. The firm also faces proportional flotation costs $\phi > 0$ of issuing debt.

For a fraction of external equity, θ, and a coupon, C_0, the firm's initial funding condition requires that investment and transaction costs equal debt and external equity values:

$$I_0 + \Lambda(\theta E_l(X_0, C_0)) + \varphi\, D_l(X_0, C_0) = D_l(X_0, C_0) + \theta E_l(X_0, C_0), \quad (1)$$

where D_l and E_l denote initial debt and equity values. The objective is to maximize the value of inside equity, $(1 - \theta)E_l(X_0, C_0)$, with respect to C_0, subject to the funding constraint in Equation (1) that pins down θ. This optimization produces C_0 as a function of θ on the basis of a trade-off between the use of debt and (external) equity to satisfy the firm's initial

[7] Our analysis assumes that the timing of the additional debt issue coincides with the timing of the option exercise. Appendix 2 shows that joint timing is in fact optimal for economically interesting and realistic parameter choices. Moreover, Denis and McKeon (2010) establish for their sample of Compustat firms over the 1971–1999 period that proactive leverage increases are primarily motivated by investment (55%) and also by working capital (36%).

[8] These costs also apply to issuing additional debt and (possibly) external equity to finance the investment cost, I_s.

funding condition. If there are no fixed or quadratic flotation costs (i.e., $\lambda_0 = \lambda_2 = 0$), and if the proportional transaction costs on debt and equity coincide (i.e., $\lambda_1 = \phi = \phi$), then the funding condition in Equation (1) implies $(1-\theta)E_l(X_0, C_0)$=$D_l(X_0, C_0) + E_l(X_0, C_0) - I_0/(1-\phi)$, which reveals that the extended model nests the baseline model as a special case (i.e., maximizing inside equity value, $(1-\theta)E_l(X_0, C_0)$, is equivalent to maximizing total firm value, $D_l(X_0, C_0) + E_l(X_0, C_0)$).

In what follows, we present claim values before and after investment for the baseline model and point out differences from the extended model. Subscripts l and h are used for the (on average) $l$ow and $h$igh regions of earnings before and after investment. We present the exercise policies that maximize firm and equity value. (Additional details are in Appendix 1.)

1.3 Security and firm values after investment

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

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

where $X_{dh} > 0$ denotes the default threshold, the ratio $(X/X_{dh})^a$ is the value of a contingent claim that pays one dollar 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 endogenously determined to maximize the market value of equity, equity value in Equation (2) must satisfy a smooth-pasting condition at the default threshold, $\partial E_h/\partial X|_{X=X_{dh}} = 0$. Using this condition, we may determine that

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

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

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

and

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

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 in accordance with our base case assumption of equal priority (*pari passu*).

Summing Equations (2), (4), and (4), 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 tax shield value (on the basis of a total coupon of $C = C_0 + C_s$) minus bankruptcy costs.

1.4 Security and firm values before investment

Prior to investment, the firm has one outstanding debt issue and the cash flow to equity is $(1-\tau)(X - C_0)$ per unit time. For $X > X_{dl}$, the value of equity is equal to

$$\begin{aligned} E_l(X, C_0) \;=&\; (1-\tau)\left[\left(\frac{X}{r-\mu} - \frac{C_0}{r}\right) - \left(\frac{X_{dl}}{r-\mu} - \frac{C_0}{r}\right)\Delta(X)\right] \\ &+ (1-\tau)\left[\frac{(\Pi - 1)X_s}{r-\mu} - \frac{I_s - D_h(X_s, C_s)}{1-\tau} - \frac{C_s}{r} - \frac{C}{r}\right. \\ &\times \left.\left(\frac{1}{a-1}\right)\left(\frac{X_s}{X_{dh}}\right)^a\right]\Sigma(X), \end{aligned} \tag{7}$$

where $\Delta(X) = (X^z X_s^a - X^a X_s^z)/(X_{dl}^z X_s^a - X_{dl}^a X_s^z)$ is the state price for X *first* reaching the default threshold X_{dl} from above, $\Sigma(X) = (X_{dl}^z X^a - X_{dl}^a X^z)/(X_{dl}^z X_s^a - X_{dl}^a X_s^z)$ is the state price for X *first* reaching the investment threshold X_s from below, and $z > 1$ is the positive root of the quadratic equation $x(x-1)\sigma^2/2 + x\mu - r = 0$. The first term in Equation (6) is the pre-investment value of assets-in-place less the value of after-tax coupon payments minus this net value to equity in default multiplied by the default state price, $\Delta(X)$. The second term in Equation (6) captures the incremental value to equity that results from investing in the growth option and issuing additional debt to help finance the investment expenditure all multiplied by the investment state price, $\Sigma(X)$. Note that 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 $E_l(X_s, C_0) = E_h(X_s, C) - [I_s - D_h(X_s, C_s)]$.[9] The market value of the initial debt issue for $X > X_{dl}$ is equal to

[9] For the extended model, we replace $I_s - D_h(X_s, C_s)$ by $I_s - (1-\varphi)D_h(X_s, C_s) + \Lambda(I_s - (1-\varphi)D_h(X_s, C_s))1_E$ in Equation (7), where 1_E is an indicator function for equity issuance that is 1 if $I_s - (1-\varphi)D_h(X_s, C_s) > 0$ and zero otherwise.

$$D_l(X, C_0) = \frac{C_0}{r}\left[1 - \Delta(X) - \left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\right] + L_l(X_{dl})\Delta(X)$$
$$+\beta_0 L_h(X_{dh})\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X), \tag{8}$$

where it is clear in Equation (8) that time 0 debt receives the full liquidation value of the firm if the firm is bankrupt before T_s (i.e., $L_l(X_{dl}) = (1-\alpha)UX_{dl}$) 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 at time 0 can be written as

$$V_l(X, C_0) = UX + (1-\tau)\left(\frac{(\Pi - 1)X_s}{r-\mu} - \frac{I_s}{1-\tau}\right)\Sigma(X)$$
$$+\frac{\tau C_0}{r}\left[1 - \Delta(X) - \left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\right]$$
$$+\frac{\tau C_s}{r}\left[1 - \left(\frac{X_s}{X_{dh}}\right)^a\right]\Sigma(X)$$
$$-\alpha\left[UX_{dl}\Delta(X) + \Pi U X_{dh}\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\right]. \tag{9}$$

In Equation (9), 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 the tax shield values of the time 0 debt issue and the time T_s debt issue, respectively, and the final term is the value of bankruptcy costs. Observe that because of debt overhang from time 0 debt, the *levered* value of the growth option in Equation (9) 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

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

where the right-hand side of the inequality is the *unlevered* value of the growth option.

1.5 Optimal growth option exercise policies

We now determine the optimal level of X at which the firm invests in the growth option, X_s. As noted above, the growth option exercise policy maximizes the market value of equity. Since this policy may not maximize total firm value, we refer to it 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]

$$\left.\frac{\partial E_l(X,C_0)}{\partial X}\right|_{X=X_s} = \left.\frac{\partial E_h(X,C)}{\partial X}\right|_{X=X_s} + \left.\frac{\partial D_h(X,C_s)}{\partial X}\right|_{X=X_s}, \tag{10}$$

and

$$\left.\frac{\partial E_l(X,C_0)}{\partial X}\right|_{X=X_{dl}} = 0. \tag{11}$$

Substituting Equations (2), (5), and (7) into Equation (10), we find that[11]

$$\begin{aligned} X_s = \frac{r-\mu}{1-\Theta}\Bigg[& \frac{\Lambda}{\Pi-1}\left(\frac{X_{dl}}{r-\mu}-\frac{C_0}{r}\right)-\frac{\Theta}{\Pi-1}\left(\frac{C_s}{r}+\frac{I_s-D_h(X_s,C_s)}{1-\tau}\right) \\ & + \left\{\frac{a 1_{C_s>0}}{\Pi-1}\left(\frac{C_s}{r(1-\tau)}-\frac{a(1-\alpha)\beta_s}{a-1}\frac{C}{r}\right)\right. \\ & \left. + \frac{a-\Theta}{\Pi-1}\frac{C}{r}\frac{1}{a-1}\right\}\left(\frac{X_s}{X_{dh}}\right)^a\Bigg], \end{aligned} \tag{12}$$

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

$$\Lambda = \frac{\partial\Delta(X)}{\partial X_s}\frac{X_s}{\Delta(X)} = \frac{(a-z)X_s^{a+z}}{X_{dl}^z X_s^a - X_{dl}^a X_s^z} > 0$$

and

$$\Theta = -\frac{\partial\Sigma(X)}{\partial X_s}\frac{X_s}{\Sigma(X)} = \frac{aX_s^a X_{dl}^z - zX_{dl}^a X_s^z}{X_{dl}^z X_s^a - X_{dl}^a X_s^z} > 0.$$

Similarly, substituting Equation (7) into Equation (11), we find that

$$\begin{aligned} X_{dl} = \frac{r-\mu}{1+\Omega}\Bigg[\Omega\frac{C_0}{r} - \Gamma\Bigg(& \frac{(\Pi-1)X_s}{r-\mu}-\frac{C_s}{r}-\frac{I_s-D_h(X_s,C_s)}{1-\tau} \\ & -\frac{C}{r}\left(\frac{1}{a-1}\right)\left(\frac{X_s}{X_{dh}}\right)^a\Bigg)\Bigg], \end{aligned} \tag{13}$$

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10 The second term on the right-hand side of Equation (10) is the change in value of the debt proceeds from issuing additional debt to finance the exercise of the growth option, evaluated at $X = X_s$.

11 For the extended model, the smooth-pasting condition in Equation (10) becomes $\left.\frac{\partial E_l(X,C_0)}{\partial X}\right|_{X=X_s} = \left.\frac{\partial E_h(X,C)}{\partial X}\right|_{X=X_s} + (1-\varphi)\left.\frac{\partial D_h(X,C_s)}{\partial X}\right|_{X=X_s} - \left.\frac{\partial\Lambda(I_s-(1-\varphi)D_h(X,C_s))1_E}{\partial X}\right|_{X=X_s}$, where 1_E equals one if $I_s-(1-\varphi)D_h(X_s,C_s) > 0$ and zero otherwise, so we do not use Equation (12) in the extended model and replace $I_s - D_h(X_s,C_s)$ by $I_s-(1-\varphi)D_h(X_s,C_s)+\Lambda(I_s-(1-\varphi)D_h(X_s,C_s))1_E$ in Equation (13).

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

$$\Omega = \frac{\partial \Delta(X)}{\partial X_{dl}} \frac{X_{dl}}{\Delta(X)} = \frac{a X_{dl}^a X_s^z - z X_s^a X_{dl}^z}{X_{dl}^z X_s^a - X_{dl}^a X_s^z} > 0$$

and

$$\Gamma = -\frac{\partial \Sigma(X)}{\partial X_{dl}} \frac{X_{dl}}{\Sigma(X)} = \frac{(a-z) X_{dl}^{a+z}}{X_{dl}^z X_s^a - X_{dl}^a X_s^z} > 0.$$

Although the expressions for X_s and X_{dl} are complicated, it is interesting to note that they reflect the time 0 capital structure (i.e., C_0) and 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 find the critical level of X that satisfies the following smooth-pasting condition:

$$\left.\frac{\partial V_l(X, C_0)}{\partial X}\right|_{X=X_s} = \left.\frac{\partial V_h(X, C)}{\partial X}\right|_{X=X_s}. \tag{14}$$

Substituting Equations (6) and (9) into Equation (14), we find that

$$\begin{aligned} X_s = \frac{1/U}{1-\Theta} \Bigg[& \frac{\Lambda}{\Pi - 1} \left(\frac{\tau C_0}{r} - \frac{\tau C_s}{r} \left(\frac{X_{dl}}{X_{dh}} \right)^a + \alpha U X_{dl} \right) \\ & + \frac{\Theta}{\Pi - 1} \left(\frac{\tau C_s}{r} - I_s \right) \\ & + \frac{a - \Theta}{\Pi - 1} \left(\frac{\tau C_0}{r} + \alpha \Pi U X_{dh} \right) \left(\frac{X_s}{X_{dh}} \right)^a \Bigg]. \end{aligned} \tag{15}$$

Note that the default threshold for this first-best case is analytically identical to that in Equation (13), but because the expressions for the first- and second-best investment triggers in Equations (15) and (12) are different, the capital structure, priority structure, and default threshold in Equation (3) will be different. Hence, we anticipate that the pre-investment default thresholds will also be different.

1.6 Optimal capital and debt priority structure

For an arbitrary priority rule, $\beta_0 \in [0, 1]$, the optimal capital structure is described by the jointly optimal debt coupons $\{C_0^*, C_s^*\}$, which solve the joint optimization problem

$$C_0^* = \arg\max_{C_0} \; V_l(X_0, C_0, C_s^*; \beta_0), \tag{16}$$

and

$$C_s^* = \arg\max_{C_s} \{E_h(X_s, C_0^* + C_s; \beta_0) + D_h(X_s, C_s; \beta_0) + D_l(X_s, C_0; \beta_0)\}, \tag{17}$$

where the optimization in Equation (17) reflects first-best financing of the growth option because it accounts for the effect of C_s on $D_l(X_s, C_0; \beta_0)$. The solution to the joint optimization problem, after removing $D_l(X_s, C_0; \beta_0)$ in Equation (17), corresponds to second-best financing of the growth option because the choice of C_s ignores potential dilution of the initial debtholders' claim.

To jointly optimize over capital and debt priority structure, $\{C_0^*, C_s^*, \beta_0^*\}$, we replace Equation (16) with the optimization problem:

$$\{C_0^*, \beta_0^*\} = \arg\max_{C_0, \beta_0} V_l(X_0, C_0, C_s^*; \beta_0) \tag{18}$$

and jointly solve Equations (17) and (18). Notice that the problem in Equation (18) explicitly recognizes the interaction between capital structure and priority structure.

2. Financing the Growth Option

We assume initially that the firm finances the growth option with equity and obtains the well-known Myers (1977) result, which states 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. We illustrate how financial contracting can eliminate underinvestment when the growth option is financed with debt and equity, and show that the jointly optimal choice of initial debt and additional debt used to finance the growth option results in overinvestment.

2.1 Base case parameter values

Since analytic comparison of optimal policies is inconvenient and largely sterile, we numerically solve the model by using the following base case parameter values: The initial pretax cash flow, X_0, is twenty, the investment option payoff factor, Π, is 2.0, the cost of exercising the growth option, I_s, 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. For these parameters, the NPV of immediately exercising the growth option is positive (i.e., NPV $= (1-\tau)$ $(\Pi - 1)\ X_0\ /(r - \mu) - I_s = 140$) and increasing in X.[12]

2.2 All-equity financing of the growth option

Table 1 reports first- and second-best outcomes for the optimal initial debt coupon, C_0^*, the endogenous default threshold before investment, 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 investment, X_{dh}, the first passage time to investment conditional on no default prior to investment, $\bar{T}_s = \mathrm{E}[T_s|T_s < T_{dl}]$, the probability of investment conditional on no default prior to investment, Π_s, total firm value, V_l, the growth option component of firm value, V_G, the market-to-book value ratio, Q, the time 0 market leverage ratio, *MLev*, the credit spread (in basis points) of the initial debt issue at time 0, CSP_0, the credit spread of the additional debt issue at time T_s, CSP_s, and the agency cost of debt, $AC = V_l^{FB}/V_l^{SB} - 1$.[13] Panel A of Table 1 reports model outcomes when the cost of exercising the growth option is all-equity-financed.[14]

As seen in Panel A, the second-best equity value-maximizing growth option exercise threshold is $X_s = 29.17$, and the first-best firm value-maximizing growth option exercise threshold is $X_s = 24.12$. The higher second-best threshold indicates underinvestment in the growth option, since the expected present value of investment is less under the second-best policy. The economic intuition that explains why equityholders underinvest is that they pay the full cost of exercising the growth option but share the benefits with risky debt. Thus, equityholders limit the benefit that accrues to risky debt by waiting to exercise at a higher investment threshold, where default risk is lower. This delay is economically significant, as the expected time to investment, $\bar{T}_s$, is longer (3.61 years vs. 1.77 years) and the probability of investment, Π_s, is smaller (0.66 vs. 0.79) under the second-best policy than under the first-best policy. Observe that underinvestment induces a 15% reduction in the optimal leverage ratio (from 0.54 to 0.46).

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,

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12 These parameters imply a Tobin's Q of about 1.5, a fraction of firm value due to the growth option of about 29%, and a value of tax shields net of bankruptcy costs (i.e., the last three terms in Equation (9)) of around 7% of firm value.

13 Market leverage (*MLev*) is the market value of initial time 0 debt divided by the total time 0 firm value. Market-to-book ratio (Q) is total time 0 firm value divided by assets-in-place, $V_a = (1-\tau)X_0/(r-\mu)$. For the computation of $\bar{T}_s = \mathrm{E}[T_s|T_s < T_{dl}]$ and Π_s, see Appendix 1.

14 For this case, $C_s^* = 0$ and $CSP_s = 0$, so Table 1 reports "NA" for "Not Available" in these columns.

Table 1
First- and second-best investment and financing decisions

	C_0^*	X_{dl}	X_S	C_S^*	X_{dh}	$\bar{T}_S$	Π_S	V_I	V_G	Q	$MLev$	CSP_0	CSP_S	AC (%)
Panel A: Equity-financed investment														
FB	20.09	6.98	24.12	NA	4.36	1.77	0.79	517.50	147.68	1.52	0.54	125.44	NA	
SB	16.86	5.93	29.17	NA	3.66	3.61	0.66	515.04	148.74	1.51	0.46	118.75	NA	0.48
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	2.10	0.81	525.17	149.04	1.54	0.42	172.67	151.49	
Panel C1: Financial contracting resolves debt overhang: optimize over C_0 and C_s subject to $X_s = X_s^{FB} = 24.12$ with commitment to first-best financing at time T_s														
SB	10.96	3.94	24.12	23.01	7.37	2.73	0.83	526.55	150.26	1.55	0.28	134.77	135.48	
Panel C2: Financial contracting resolves debt overhang: optimize over C_0 and C_s subject to $X_s = X_s^{FB} = 24.12$ without commitment to first-best financing at time T_s														
SB	4.65	1.81	24.12	35.07	8.62	3.90	0.86	524.29	150.80	1.54	0.12	129.99	167.57	

(*continued*)

Table 1
Continued

	C_0^*	X_{dl}	X_s	C_s^*	X_{dh}	$\bar{T}_s$	Π_s	V_l	V_G	Q	$MLev$	CSP_0	CSP_s	AC (%)
Panel D1: First-best debt-equity financed investment – optimize over C_0, C_s, and X_s														
FB	11.43	4.09	26.51	25.90	8.10	3.76	0.76	527.59	151.45	1.55	0.30	134.53	135.48	
Panel D2: Second-best debt-equity financed investment with commitment to first-best financing at time T_s														
SB	13.90	4.87	23.80	19.62	7.27	2.24	0.83	525.93	149.41	1.55	0.35	147.10	135.48	0.32
Panel D3: Second-best debt-equity financed investment without commitment to first-best financing at time T_s														
SB	4.73	1.83	24.27	35.31	8.69	3.99	0.85	524.40	150.97	1.54	0.12	129.48	167.92	0.61

The firm has assets-in-place that generate pre-tax earnings of X and an investment option that requires an investment expenditure of I_s and expands EBIT 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 financed with equity. 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 C1 assumes that equityholders can commit to first-best financing of the growth option (i.e., C_s is chosen to maximize the sum of equity value, proceeds from the new debt issue, and the initial debt value), and Panel C2 assumes that equityholders cannot commit to first-best financing of the growth option (i.e., C_s is chosen to maximize equity value and the proceeds from the new debt issue). Panel D reports the 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). Panel D1 reports the first-best financing and investment outcome, Panel D2 reports the second-best investment outcome assuming equityholders can commit to first-best financing of the growth option, and Panel D3 reports the second-best investment outcome assuming equityholders cannot commit to first-best financing of the growth option. The table reports the optimal initial debt coupon, C_0^*, the endogenous default threshold before investment, 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 investment, X_{dh}, the first passage time to investment conditional on no default prior to investment, $\bar{T}_s = \mathrm{E}[T_s | T_s < T_{dl}]$, the probability of investment conditional on no default prior to investment, Π_s, total firm value, V_l, the growth option component of firm value, V_G, which is given by the second term in (9), the market-to-book value ratio, Q, the time 0 market leverage ratio, *MLev*, the credit spread (in basis points) of the initial debt issue at time 0, $CSP_0 = C_0^*/D_l(X_0, C_0^*) - r$, the credit spread of the additional debt issue at time T_s, $CSP_s = C_s^*/D_h(X_s, C_s^*) - r$, and the agency cost of debt (in %), $AC = V_l^{FB}/V_l^{SB} - 1$. Market leverage (*MLev*) is the market value of time 0 debt divided by the total time 0 firm value. Market-to-book ratio (Q) is total time 0 firm value divided by assets-in-place, $V_a = (1-\tau)X_0/(r-\mu)$, where X_0 is initial (time 0) 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 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_s, 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.

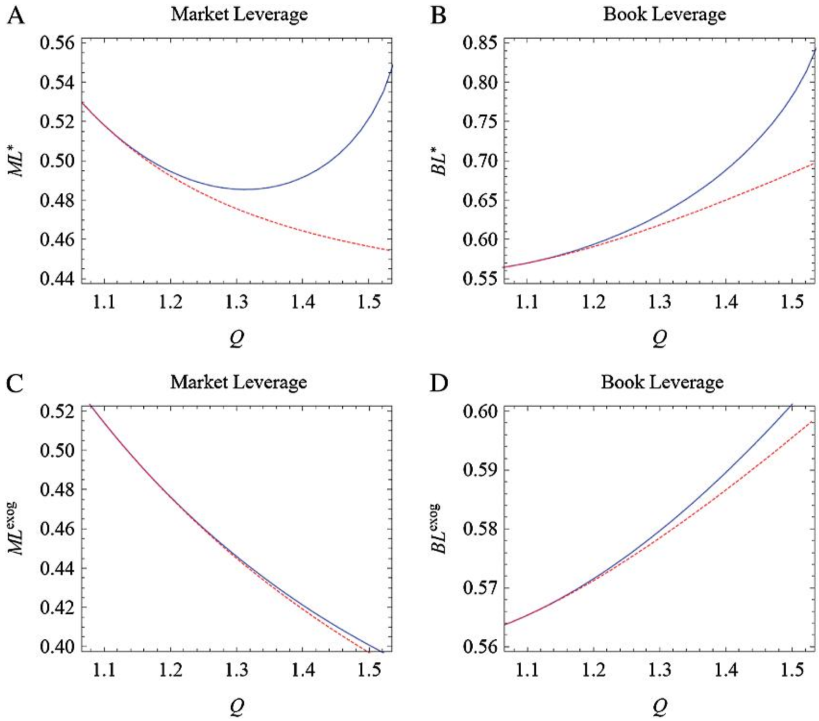

Figure 1
First- and second-best market and book leverage ratios as a function of Tobin's Q
Panels A and B plot market and book leverage ratios at the optimal coupon, C_0^* , as a function of Tobin's Q, and Panels C and D plot market and book leverage ratios at a fixed exogenously specified coupon, C_0^{exog}, 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 0) 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 initial cash flow, X_0, is 20, the cost of exercising the investment option, I_s, 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 stems from varying the investment option payoff factor, Π.

C_0^{exog}.[15] Book leverage, *BLev*, 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, *MLev*, and Tobin's Q are computed as in Table 1.[16]

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15 In Panels A and B, the optimal coupon maximizes firm value and so C_0^* varies as Q varies. In Panels C and D, $C_0^{exog} = 18.48$ is the average of first-best (20.09) and second-best (16.86) optimal coupons in Panel A of Table 1.

16 The graphs vary Q by varying $\Pi > 1$. The leverage ratio graphs are qualitatively similar if we vary Q by varying other model parameters (e.g., I_s), which directly affect the growth option value. Results are available on request.

Holding debt constant (C_0^{exog}), Panel C illustrates that the first- and second-best market leverage ratios are decreasing in Q, and Panel D illustrates that the first- and second-best book leverage ratios are increasing in Q. A similar pattern emerges in Panels A and B when debt endogenously adjusts (C_0^*), as Q varies, albeit with one difference. First, focusing on book leverage in Panel B, we see that both of the 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 or without agency conflicts. Evidence that is consistent with our model's prediction is reported in Fama and French (2002); Frank and Goyal (2009), who find that book leverage is positively related to the market-to-book asset ratio; and 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.[17]

The positive relation between book leverage and Tobin's Q in Panel B is (partially) reversed for market leverage in Panel A. As seen there, the second-best market leverage ratio (dashed line) is monotonically decreasing in Tobin's Q. However, observe that the first-best market leverage ratio 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 illustrates that market leverage and Q can be *negatively* related in a standard trade-off model when there are *no* stockholder–bondholder agency conflicts. This is important because the extant literature interprets an inverse relation between market (and book) leverage and Q as prima facie evidence of agency costs of debt.[18] Notably, the leverage-Q plots in Panel A imply that the standard interpretation is ambiguous. A refined test would be to estimate the relation between market leverage and Q for different subsamples of Q. A negative (positive) relation for high-Q subsamples implies that stockholder–bondholder agency conflicts are important (unimportant) economically, while a negative relation for low-Q subsamples is uninformative.[19]

The U-shape between market leverage and Q for the first-best case is due to an equity-financed, but firm-value maximizing, investment. While C_0^* is monotonically increasing with Q, which increases debt value and decreases

[17] 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; Johnson 2003) find a negative relation.

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

[19] 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_S=200 to I_S=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 1980–2007 period, the median market-to-book ratio of all nonfinancial firms on Compustat is 1.37.

equity value, the *proportions* of debt and equity value to total firm value are generally nonmonotonic, as long as investment is partly equity-financed. When growth opportunities contribute little to firm value (i.e., low Q), equity's (debt's) share of total firm value increases (decreases) with Q. Even though equityholders invest earlier when Q rises, they gain the upside from investing without paying too much (in a present-value sense). However, past some point equity's (debt's) share of total firm value decreases (increases) with Q because firm-value maximizing, but equity-financed, investment increasingly hurts equity value through the higher present value of the investment cost, while debt value continues to rise. Hence, market leverage first declines and then rises with Q. In contrast, market leverage for the second-best case monotonically declines with Q because the transfer from equityholders to debtholders does *not* affect investment. That is, the proportion of equity value accounted for by firm value is monotonically increasing with Q and market leverage is monotonically decreasing with Q.

Figure 2 graphs the first-best (solid line) and second-best (dashed line) credit spreads of debt as a function of Q for exogenous leverage (Panel A) and for endogenous leverage (Panel B). Comparing Panels A and B, we see that first-best credit spreads are greater than or equal to second-best credit spreads when leverage is endogenous because optimal leverage is larger under first-best than under second-best. The upshot is that it is important to control for leverage when using credit spreads to estimate the agency cost of debt. Figure 2 also reveals that regardless of whether debt is endogenous or exogenous,

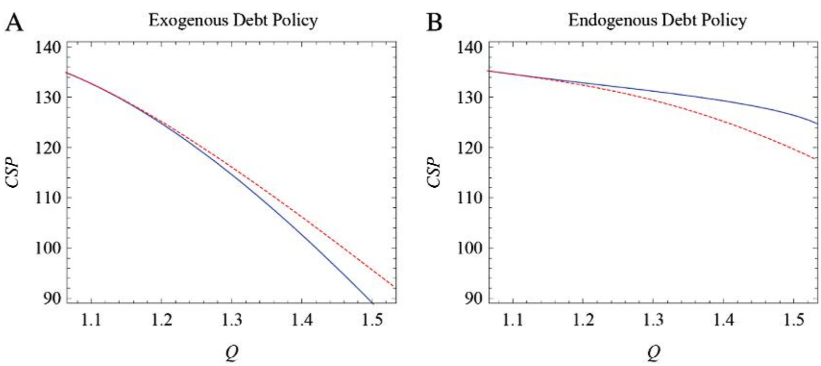

Figure 2
First- and second-best credit spreads for exogenous and endogenous debt policy as a function of Tobin's *Q*
Panel A plots credit spreads at a fixed exogenously specified coupon, C_0^{exog}, as a function of Tobin's Q, and Panel B plots credit spreads at the optimal coupon, C_0^*, as a function 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 $CSP_0 = C_0/D_I(X_0, C_0) - r$, using C_0^{exog} in Panel A and C_0^* in Panel B. The initial cash flow, X_0, is 20, the cost of exercising the investment option, I_s, 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 stems from varying the investment option payoff factor, Π.

first- and second-best credit spreads are decreasing in Q. Thus, the model provides the testable prediction that there should be an inverse relation between credit spreads and Q.[20]

2.3 Using financial contracting to resolve debt overhang

Panels B and C in Table 1 report financial contracting solutions to the debt overhang problem. In particular, we show how debt financing of the growth option can eliminate equityholders' incentive to underinvest in the growth option. Both solutions assume that the debt issued at time 0 (C_0) and at time T_s (C_s) have equal priority in bankruptcy.

Equityholders underinvest in the growth option because the investment promotes the claim of risky time 0 debt. The interesting question 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. In Panel B, we fix C_0 at the all-equity second-best solution value of 16.86 in Panel A and solve for the C_s, which motivates equityholders to invest at the all-equity first-best investment threshold, $X_s^{FB} = 24.12$. As seen there, the first-best threshold is restored when $C_s = 20.05$ 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 $I_s = 200$ and distribute a debt-financed dividend of 66.82.

An alternative solution is illustrated in Panels C1 and C2, where we allow the firm to optimize over C_0 and C_s, while imposing the constraint that the firm invests at the first-best all-equity-financed investment threshold, $X_s^{FB} = 24.12$. The difference between the two panels is that the solution in Panel C1 assumes that the firm *can* commit to first-best financing of the growth option (i.e., C_s is chosen to maximize the sum of equity value, proceeds from the new debt issue, *and* the initial debt value), while the solution in Panel C2 assumes that the firm *cannot* commit to first-best financing of the growth option (i.e., C_s is chosen to maximize equity value and the proceeds from the new debt issue). In comparison with the solution in Panel B, the interesting aspect of the solutions in Panels C1 and C2 is that the firm chooses a smaller time 0 coupon and a larger time T_s coupon. This is especially true in Panel C2 when the firm chooses C_s, ignoring the effect that it will have on the market value of the time 0 debt.

Panels D1–D3 report solutions that allow for the jointly optimal choice of C_0 and C_s. Panel D1 reports the first-best case in which the investment threshold is chosen to maximize total firm value and the choice of C_s does not ignore the influence of additional debt on outstanding debt (i.e., first-best investment and financing of the growth option). Panel D2 reports the second-best case in which the investment threshold is chosen to maximize equity value and the choice of

[20] Consistent with this prediction, Chen and Zhao (2006) find an inverse relation between credit spreads and growth opportunities. This helps explain why optimal leverage can be increasing in Q, despite there possibly being greater agency conflicts in high-growth-option firms.

C_s does not ignore the influence of additional debt on outstanding debt (i.e., second-best investment and first-best financing of the growth option). Finally, Panel D3 reports the second-best case in which the investment threshold is chosen to maximize equity value and the choice of C_s ignores the influence of additional debt on outstanding debt (i.e., second-best investment and financing of the growth option).

The solutions in Panels D1–D3 illustrate that having the option to issue debt in the future decreases the optimal amount to issue today. For example, comparing the first-best solution in Panel A (with no option to issue additional debt in the future) with that in Panel D1, we see that C_0^* decreases from 20.09 to 11.43, with corresponding leverage ratios of 0.54 and 0.30, respectively. Note that the decrease in initial leverage is especially severe in Panel D3, where the choice of additional debt ignores the dilutive effect on initial debt. This result helps explain the empirical finding in Graham (2000), who states that firms have overly conservative capital structures, even when there is a sizable net tax advantage to debt financing.[21] Debt conservatism in the model is driven by the interaction between investment and financing decisions. Since the higher cash flow, which is associated with the exercise of the growth option, allows the firm to support additional debt and thereby earn additional interest tax shields—and since the option is lost and/or severely deteriorated should the firm face financial distress before exercise—the firm chooses a more conservative capital structure today. In other words, firms with future growth options *optimally* retain financial flexibility.

Another striking result is that equityholders now *overinvest* in the growth option. In particular, observe that the first-best investment threshold in Panel D1 is larger than either one of the second-best investment thresholds in Panels D2 and D3. The reason is that debt financing of the growth option transfers wealth from initial debt to equity, especially when the firm cannot commit to first-best financing of the growth option (Panel D3). We will show how this incentive to overinvest is influenced by the priority ranking of the firm's debt issues.

Despite the conflict over the exercise timing and financing of the growth option, the agency cost of debt appears relatively small. Comparing firm values in Panels D1 (527.59) and D2 (525.93), the loss in firm value attributable to the conflict over exercise timing is AC $=$ 0.32%; comparing firm values in Panels D1 (527.59) and D3 (524.40), the loss in firm value attributable to the conflict over exercise timing and financing of the growth option is AC $=$ 0.61%. In a model designed to measure the agency cost of debt, Parrino and Weisbach (1999) also find modest cost estimates, which they argue suggests that, for most firms, stockholder–bondholder conflicts are not important determinants

21 Goldstein, Ju, and Leland (2001) and Strebulaev (2007) find similar results in models where investment policy is exogenous and the firm has the option to recapitalize in the future. Gorbenko and Strebulaev (2010) show that temporary cash flow shocks can also produce debt conservatism.

of capital structure. Our analysis suggests, however, that relatively low agency costs are attributable to an equilibrium feedback effect, i.e., once the firm's investment and financing decisions endogenously reflect bankruptcy costs, interest tax shields, and investment benefits, the residual agency problem is small because it has been "optimally minimized" by financial contracting.

2.4 Effect of parameter variation on investment and financing decisions

Table 2 reports model outcomes for variation in bankruptcy costs (α), corporate tax rate (τ), growth rate of cash flows (μ), volatility of cash flows (σ), and growth option payoff factor (Π). As seen there, an increase in bankruptcy costs reduces overinvestment and decreases the agency cost of debt. This result is driven by the inverse relation between optimal leverage and bankruptcy costs, which reduces equityholders' incentive to deviate from the first-best investment policy. Analogously, an increase in the tax rate increases optimal leverage and the agency cost of debt. An increase in the growth rate of cash flows also tends to increase optimal leverage, but the concomitant increase in overall firm value tends to moderate investment conflicts and thereby leave the agency cost of debt largely unchanged. An increase in the volatility of cash flows encourages the firm to delay the exercise of the growth option, which enhances the optimal amount of additional debt that the firm can issue in the future. This effect tends to increase sharply the credit spread of the firm's outstanding debt and increase the agency cost of debt. Finally, observe that the agency cost of debt *decreases* as the growth option component of firm value increases, since the optimal debt level tends to be lower. Thus, as Π increases, the deviation between the first- and second-best investment thresholds narrows.

Overall, the analysis predicts that the agency cost of debt is decreasing in bankruptcy costs and the growth option proportion of firm value and is increasing in the corporate tax rate and the volatility of cash flows. Perhaps the most striking empirical prediction is that the agency cost of debt decreases as the growth option component of firm value increases.

We also examine the relations between firm leverage and Tobin's Q (not reported) and credit spreads and Tobin's Q (not reported) for the case in which the growth option is debt-equity-financed. The relations are similar to those reported in Figures 1 and 2 for all-equity-financed investment. If investment is only partly equity-financed, the U-shape of first-best market leverage in Q is weaker. However, first- and second-best market leverage ratios both monotonically decline with Q if investment is largely debt-financed. This strengthens our model's empirical prediction that there is a negative relation between market leverage and Tobin's Q, *with or without* stockholder–bondholder conflict. Thus, one cannot interpret a negative relation between market leverage and Q as prima facie evidence of agency costs of debt.

Table 2
The effect of parameter variation on investment and financing decisions

		C_0^*	X_{dl}	X_s	C_s^*	X_{dh}	V_l	V_G	$MLev$	CSP_0	CSP_s	AC
First-best investment and financing of the growth option												
FB	$\alpha = 0.20$	12.14	4.30	26.42	28.24	8.76	530.49	151.31	0.31	142.51	145.00	
FB	$\alpha = 0.30$	10.79	3.90	26.58	23.94	7.54	525.12	151.58	0.28	127.80	127.64	
Second-best investment and first-best financing of the growth option												
SB	$\alpha = 0.20$	15.51	5.35	23.49	20.39	7.79	528.37	148.73	0.39	158.74	145.00	0.40
SB	$\alpha = 0.30$	12.63	4.48	24.08	18.84	6.83	523.79	149.94	0.33	137.62	127.64	0.25
Second-best investment and financing of the growth option												
SB	$\alpha = 0.20$	4.40	1.71	23.98	37.99	9.20	526.91	150.64	0.11	135.71	177.19	0.68
SB	$\alpha = 0.30$	4.95	1.92	24.54	32.95	8.22	522.27	151.22	0.13	124.24	159.85	0.54
First-best investment and financing of the growth option												
FB	$\tau = 0.10$	8.63	3.20	25.26	20.36	6.29	547.74	168.16	0.23	98.48	100.19	
FB	$\tau = 0.20$	13.88	4.82	27.93	30.60	9.65	509.99	135.39	0.35	166.89	165.94	
Second-best investment and first-best financing of the growth option												
SB	$\tau = 0.10$	9.99	3.65	23.55	17.03	5.86	547.05	167.27	0.26	104.55	100.19	0.13
SB	$\tau = 0.20$	16.85	5.74	24.15	21.60	8.34	507.04	131.99	0.42	184.93	165.94	0.58
Second-best investment and financing of the growth option												
SB	$\tau = 0.10$	2.94	1.18	24.05	28.89	6.91	546.15	168.12	0.08	92.34	120.38	0.29
SB	$\tau = 0.20$	6.94	2.59	24.61	39.82	10.15	504.87	134.13	0.18	166.56	213.59	1.01
First-best investment and financing of the growth option												
FB	$\mu = 0.008$	11.01	4.11	26.74	25.17	8.08	500.43	139.45	0.30	138.36	139.10	
FB	$\mu = 0.012$	11.90	4.07	26.29	26.71	8.13	557.15	164.60	0.29	130.78	131.94	

(continued)

Table 2
Continued

		C_0^*	X_{dl}	X_s	C_s^*	X_{dh}	V_l	V_G	$MLev$	CSP_0	CSP_s	AC
Second-best investment and first-best financing of the growth option												
SB	$\mu = 0.008$	13.14	4.82	24.10	19.47	7.28	498.92	137.50	0.35	150.69	139.10	0.30
SB	$\mu = 0.012$	14.77	4.94	23.51	19.75	7.27	555.31	162.45	0.36	143.58	131.94	0.33
Second-best investment and financing of the growth option												
SB	$\mu = 0.008$	4.76	1.92	24.55	34.46	8.76	497.34	138.92	0.13	132.47	173.73	0.62
SB	$\mu = 0.012$	4.69	1.75	24.00	36.24	8.62	553.86	164.15	0.12	126.57	162.24	0.59
First-best investment and financing of the growth option												
FB	$\sigma = 0.20$	11.90	5.04	22.81	20.98	8.22	526.26	143.93	0.33	92.86	92.45	
FB	$\sigma = 0.30$	11.12	3.37	30.62	31.91	8.13	532.34	160.28	0.27	181.26	185.97	
Second-best investment and first-best financing of the growth option												
SB	$\sigma = 0.20$	15.73	6.44	21.47	15.21	7.73	525.29	142.56	0.43	100.43	92.45	0.19
SB	$\sigma = 0.30$	11.50	3.47	26.48	25.72	7.03	530.39	158.22	0.27	188.85	185.97	0.37
Second-best investment and financing of the growth option												
SB	$\sigma = 0.20$	3.60	1.69	20.96	29.89	8.37	523.70	142.33	0.10	101.19	110.82	0.49
SB	$\sigma = 0.30$	5.47	1.77	27.86	42.17	9.00	529.36	160.37	0.13	168.29	231.57	0.56
First-best investment and financing of the growth option												
FB	$\Pi = 1.85$	11.90	4.40	31.22	28.77	9.54	486.70	113.24	0.33	134.42	135.48	
FB	$\Pi = 2.15$	10.99	3.80	23.01	23.85	7.03	573.48	194.46	0.26	134.85	135.48	

(continued)

Table 2
Continued

		C_0^*	X_{dl}	X_s	C_s^*	X_{dh}	V_l	V_G	$MLev$	CSP_0	CSP_s	AC
Second-best investment and first-best financing of the growth option												
SB	$\Pi = 1.85$	12.47	4.60	27.13	22.88	8.29	484.82	111.06	0.35	142.11	135.48	0.39
SB	$\Pi = 2.15$	15.87	5.25	21.53	16.73	6.58	572.41	193.11	0.37	145.10	135.48	0.19
Second-best investment and financing of the growth option												
SB	$\Pi = 1.85$	7.11	2.75	28.24	38.49	10.70	483.27	112.86	0.20	129.33	181.92	0.71
SB	$\Pi = 2.15$	3.52	1.37	21.28	33.05	7.38	571.25	193.59	0.08	145.88	160.82	0.39

The firm has assets-in-place that generate pre-tax earnings of X and an investment option that requires an investment expenditure of I_s and expands EBIT 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. For each parameter variation, we report three sets of model outcomes. First, we report the first-best case (FB) where the investment timing and financing of the growth option are chosen to maximize total firm value. We label this case "First-best investment and financing of the growth option." Second, we report the second-best case (SB) where the investment timing is chosen to maximize equity value and equityholders can commit to first-best financing of the growth option. We label this case "Second-best investment and first-best financing of the growth option." Third, we report the second-best case (SB) where the investment timing is chosen to maximize equity value and equityholders cannot commit to first-best financing of the growth option. We label this case "Second-best investment and financing of the growth option." The distinction between first- and second-best financing of the growth option is that under first-best financing the coupon of the additional debt issue, C_s^*, is chosen to maximize the sum of equity value, proceeds from the additional debt issue, and the initial debt value, while under second-best financing the coupon of the additional debt issue is chosen to maximize the sum of equity value and the proceeds from the additional debt issue (i.e., ignoring the initial debt value). In all three cases, the initial debt issue and the additional debt issue are assumed to have equal priority in bankruptcy. For variations of model parameters, the table reports the optimal initial debt coupon, C_0^*, the endogenous default threshold before investment, 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 investment, X_{dh}, total firm value, V_l, the growth option component of firm value, V_G, which is given by the second term in (9), the time 0 market leverage ratio, *MLev*, the credit spread (in basis points) of the initial debt issue at time 0, $CSP_0 = C_0^*/D_l(X_0, C_0^*) - r$, the credit spread of the additional debt issue at time T_s, $CSP_s = C_s^*/D_h(X_s, C_s^*) - r$, and the agency cost of debt (in %), $AC = V_l^{FB}/V_l^{SB} - 1$. Note that the results for the base case parameter values are reported in Panel D of Table 1. For each parameter variation, all other parameters are held constant at their base case values, which 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_s, 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.

3. Priority Structure

In this section, we relax the assumption of equal priority in bankruptcy and analyze how the allocation of priority among the firm's debt issues influences optimal capital structure, the exercise policy of the growth option, and firm value. As discussed in the law literature, there are three common types of debt priority rankings.[22] In the most basic, the first creditor is unsecured and shares pro rata with later unsecured creditors the assets of the firm in bankruptcy. This is our model's base case of equal priority, where the liquidation proceeds of the firm, $L_h(X_{dh})$, are shared with initial debt $\beta_0 L_h(X_{dh})$ and time T_s debt $\beta_s L_h(X_{dh})$, with $\beta_0 = C_0/(C_0 + C_s)$ and $\beta_s = 1 - \beta_0$. Alternatively, the first creditor may be secured and thereby have priority over later creditors, with respect to the assets of the firm in bankruptcy. We refer to this as me-first covenant for initial debt and specify that, in bankruptcy time 0, debt receives $\min[L_h(X_{dh}), C_0/r]$ and, in time T_s, debt receives $\{L_h(X_{dh}) - \min[L_h(X_{dh}), C_0/r]\}^+$, where C_0/r is the risk-free debt value. Finally, the first creditor may take an unsecured position, while later creditors have security. We refer to this as me-first covenant for additional debt and specify that it receives $\min[L_h(X_{dh}), C_s/r]$ and initial debt receives $\{L_h(X_{dh}) - \min[L_h(X_{dh}), C_s/r]\}^+$ in bankruptcy.[23]

For comparison we also calculate an "optimal priority structure," where we treat β_0 as an endogenous parameter and optimize jointly over priority structure, β_0, and capital structure, C_0 and C_s. This optimal priority rule allocates the fraction β_0^* of the liquidation proceeds, $L_h(X_{dh})$, to the initial debt and $1 - \beta_0^*$ of the liquidation proceeds to time T_s debt. We use this normative case to assess the relative efficiency of the three priority rules observed in practice.

3.1 Investment incentives and priority structure

Table 3 reports first- and second-best results for equal priority (Panel A), me-first for initial debt (Panel B), me-first for time T_s debt (Panel C), and optimal

[22] Although we were unable to find in the literature the exact origins of concern about priority among creditors in bankruptcy, it is well documented that the historical norm is equality or *pari passu*, which implies pro rata distributions in bankruptcy liquidations (see, e.g., Jackson and Kronman 1979; Schwartz 1989, 1997). As discussed in the law literature, primarily because of conflicts of interest among creditors, priority rules evolved to protect creditor claims in bankruptcy. These rules (or principles), which are detailed in Schwartz (1989), are specified in the Uniform Commercial Code (UCC) and establish the legislative/legal foundations for the three priority rules observed in practice.

[23] In the most comprehensive empirical work on priority of which we are aware, Bris, Ravid, and Sverdlove (2008) use the Fixed Investment Securities Database (FISD) to examine the priority of over 150,000 bonds issued by more than 10,000 companies from 1985 to 2004. They find that the majority of companies (68%) issue bonds of only one priority class, which is analogous to our case of equal priority (*pari passu*). About 35% of the companies in the sample issue junior debt, and more than 62% of these issuers have only junior debt issues. Because junior debt allows for the issuance of additional senior debt, issuers with junior debt correspond to our case of me-first for additional debt. Interestingly, out of all of the bonds in the database, only a small number (less than 1%) have a covenant precluding issues of senior debt, which would correspond to our case of me-first for initial debt. This latter finding is consistent with the results reported in Billett, King, and Mauer (2007), who find that in their sample of over 15,000 bond issues, only 1.4% have a me-first covenant.

Table 3
Alternative priority structures

	β_0	γ_0	β_0^*	C_0^*	X_{dl}	X_s	C_s^*	X_{dh}	V_l	V_G	$MLev$	CSP_0	CSP_s	AC
Panel A: Equal priority														
First-best investment and financing of the growth option														
FB	0.31	NA	NA	11.43	4.09	26.51	25.90	8.10	527.59	151.45	0.30	134.53	135.48	
Second-best investment and first-best financing of the growth option														
SB	0.42	NA	NA	13.90	4.87	23.80	19.62	7.27	525.93	149.41	0.35	147.10	135.48	0.32
Second-best investment and financing of the growth option														
SB	0.12	NA	NA	4.73	1.83	24.27	35.31	8.69	524.40	150.97	0.12	129.48	167.92	0.61
Panel B: Me-first covenant for time 0 debt														
First-best investment and financing of the growth option														
FB	0.29	0.88	NA	10.84	3.97	26.43	26.39	8.08	527.43	151.52	0.32	44.07	210.65	
Second-best investment and first-best financing of the growth option														
SB	0.22	0.65	NA	8.54	3.19	28.20	31.17	8.62	526.63	151.76	0.25	38.82	183.97	0.15
Second-best investment and financing of the growth option														
SB	0.46	1.00	NA	13.41	4.79	27.76	16.00	6.38	525.17	150.78	0.37	85.45	152.24	0.43
Panel C: Me-first covenant for time T_s debt														
First-best investment and financing of the growth option														
FB	0.32	0.00	NA	11.77	4.16	26.55	25.63	8.12	527.69	151.42	0.28	189.31	99.44	
Second-best investment and first-best financing of the growth option														
SB	0.07	0.00	NA	2.24	0.91	23.21	30.46	7.09	523.47	149.57	0.06	169.45	129.48	0.81
Second-best investment and financing of the growth option														
SB	0.09	0.00	NA	3.52	1.39	23.46	36.04	8.58	522.93	149.95	0.08	218.69	162.56	0.91

(*continued*)

Table 3
Continued

	β_0	γ_0	β_0^*	C_0^*	X_{dl}	X_s	C_s^*	X_{dh}	V_l	V_G	$MLev$	CSP_0	CSP_s	AC
Panel D: Optimal priority structure														
First-best investment and financing of the growth option														
FB	0.32	NA	0.00	11.77	4.16	26.55	25.63	8.12	527.69	151.42	0.28	189.31	99.44	
Second-best investment and first-best financing of the growth option														
SB	0.30	NA	0.59	11.22	4.06	26.40	25.97	8.07	527.51	151.46	0.31	88.78	171.37	0.03
Second-best investment and financing of the growth option														
SB	0.34	NA	0.57	12.03	4.31	25.61	22.94	7.59	527.34	151.10	0.32	103.66	157.70	0.07

The firm has assets-in-place that generate pre-tax earnings of X and an investment option that requires an investment expenditure of I_s and expands EBIT 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 outcomes 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 $R_i(X_{dh}) = \min[L_h(X_{dh}), C_i/r]$ for $i = 0, s$. 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 where capital structure and priority structure are jointly optimized, such that the optimal priority allocates the fraction β_0^* of the liquidation value of the firm in bankruptcy, $L_h(X_{dh})$, to the initial debt and $1 - \beta_0^*$ of the liquidation value of the firm in bankruptcy to the additional debt issued to finance the growth option. For comparison, Panel D also reports the equal priority weighting $\beta_0 = C_0^*/(C_0^* + C_s^*)$. In addition to β_0, γ_0, and β_0^*, the table reports the optimal initial debt coupon, C_0^*, the endogenous default threshold before investment, 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 investment, X_{dh}, total firm value, V_l, the growth option component of firm value, V_G, which is given by the second term in (9), the time 0 market leverage ratio, *MLev*, the credit spread (in basis points) of the initial debt issue at time 0, $CSP_0 = C_0^*/D_l(X_0, C_0^*) - r$, the credit spread of the additional debt issue at time T_s, $CSP_s = C_s^*/D_h(X_s, C_s^*) - r$, and the agency cost of debt (in %), $AC = V_l^{FB}/V_l^{SB} - 1$. 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_s, 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.

priority (Panel D). All priority cases are at the corresponding optimal capital structure (C_0^* and C_s^*). Note that the new variable, γ_0, reported for the me-first cases in Panels B and C, is the proportion of the firm's liquidation proceeds in bankruptcy, going to time 0 debt.

The table illustrates how priority structure influences equityholders' incentives to over- and underinvest in the growth option. Observe that the incentive to overinvest in Panel A, under equal priority, shifts to underinvestment in Panel B, under a me-first covenant for initial debt. Furthermore, note that a me-first covenant for time T_s debt in Panel C pushes the incentive back to overinvest. On the one hand, the analysis shows that, without protection for initial debt, equityholders have an incentive to dilute initial debtholders' claim by speeding up the debt-financed growth option exercise. On the other hand, protecting initial debt from dilution by means of a me-first covenant virtually guarantees that it will benefit from the exercise of the growth option without bearing any investment costs and thereby aggravates underinvestment.

This trade-off of investment incentives suggests that there is an *interior* optimal priority structure that balances over- and underinvestment incentives. Indeed, as shown in Panel D, the optimal priority structure allocates approximately 60% of the value of the firm in bankruptcy to initial debt. At this priority structure, agency costs are essentially zero and firm value is maximized. Intuitively, the optimal priority structure allocates enough protection to initial debt to discourage equity's dilution incentives yet preserves priority for additional debt to help fund the exercise of the growth option. An interesting question, given that this normative priority structure is not strictly feasible, is which priority rule—among those observed in corporate practice (i.e., equal priority or one of the me-first rules)—is most efficient. An inspection of Panels A–C of Table 3 suggests that the answer is a me-first covenant for initial debt, since this ranking produces the largest firm value and the smallest agency cost among the three rankings.

3.2 Optimal priority structure

Table 4 studies how variation in model parameters influences optimal priority structure, β_0^*. Similar to Table 2, we examine parameter variation when a second-best growth option investment decision is coupled with either a first- or second-best growth option financing choice.

The first set of rows varies an exogenously specified initial debt coupon, C_0, and optimizes over priority, β_0^*, and time T_s capital structure, C_s^*. This first case illustrates how optimal priority structure responds in situations in which the firm has excessive leverage. When there is an agency conflict over the timing of the exercise of the growth option only, the firm shifts priority from initial debt to time T_s debt as C_0 increases (i.e., β_0^* decreases). The reason is intuitive. As C_0 increases, the optimal amount of additional debt that the firm can issue in the future decreases. The firm responds by shifting priority to future debt

Table 4
The effect of parameter variation on optimal priority structure

		β_0	β_0^*	C_0^*	X_{dl}	X_s	C_s^*	X_{dh}	V_l	V_G	$MLev$	AC
First-best investment and financing of the growth option												
FB	$C_0 = 15$	0.40	0.00	15.00	5.13	26.60	22.47	8.13	527.26	150.62	0.35	
FB	$C_0 = 20$	0.54	0.00	20.00	6.57	26.14	16.82	7.99	524.92	148.82	0.45	
FB	$C_0 = 25$	0.72	0.00	25.00	7.97	24.64	9.70	7.53	520.63	146.27	0.55	
Second-best investment and first-best financing of the growth option												
SB	$C_0 = 15$	0.40	0.65	15.00	5.24	26.33	22.09	8.05	526.88	150.49	0.39	0.07
SB	$C_0 = 20$	0.55	0.60	20.00	6.73	25.59	16.05	7.82	524.19	148.55	0.49	0.14
SB	$C_0 = 25$	0.74	0.33	25.00	8.11	23.86	8.61	7.29	519.90	145.79	0.57	0.14
Second-best investment and financing of the growth option												
SB	$C_0 = 15$	0.41	0.64	15.00	5.24	26.22	21.96	8.02	526.88	150.49	0.39	0.07
SB	$C_0 = 20$	0.48	0.69	20.00	6.75	27.16	21.43	8.99	523.71	148.35	0.49	0.23
SB	$C_0 = 25$	0.53	0.70	25.00	8.17	27.89	21.84	10.16	517.08	144.85	0.58	0.69
First-best investment and financing of the growth option												
FB	$\alpha = 0.20$	0.31	0.00	12.59	4.38	26.48	27.87	8.78	530.61	151.25	0.29	
FB	$\alpha = 0.30$	0.32	0.00	11.05	3.95	26.61	23.73	7.55	525.19	151.55	0.27	
Second-best investment and first-best financing of the growth option												
SB	$\alpha = 0.20$	0.30	0.56	11.87	4.26	26.30	28.32	8.72	530.39	151.32	0.32	0.04
SB	$\alpha = 0.30$	0.31	0.63	10.62	3.87	26.48	23.99	7.51	525.05	151.59	0.30	0.03
Second-best investment and financing of the growth option												
SB	$\alpha = 0.20$	0.35	0.55	12.98	4.60	25.31	24.13	8.05	530.10	150.77	0.35	0.10
SB	$\alpha = 0.30$	0.34	0.59	11.21	4.05	25.85	21.82	7.17	524.95	151.34	0.31	0.05
First-best investment and financing of the growth option												
FB	$\tau = 0.10$	0.30	0.00	8.78	3.23	25.28	20.22	6.29	547.76	168.14	0.22	
FB	$\tau = 0.20$	0.32	0.00	14.43	4.92	28.03	30.21	9.69	510.21	135.31	0.34	

(continued)

Table 4
Continued

		β_0	β_0^*	C_0^*	X_{dl}	X_s	C_s^*	X_{dh}	V_l	V_G	$MLev$	AC
Second-best investment and first-best financing of the growth option												
SB	$\tau = 0.10$	0.30	0.56	8.54	3.18	25.23	20.40	6.28	547.72	168.16	0.24	0.01
SB	$\tau = 0.20$	0.31	0.63	13.50	4.76	27.69	30.60	9.57	509.77	135.40	0.37	0.09
Second-best investment and financing of the growth option												
SB	$\tau = 0.10$	0.33	0.52	9.20	3.40	24.65	18.28	5.96	547.62	167.96	0.25	0.03
SB	$\tau = 0.20$	0.35	0.61	14.30	5.01	26.71	27.02	8.97	509.53	134.89	0.39	0.13
First-best investment and financing of the growth option												
FB	$\mu = 0.008$	0.31	0.00	11.33	4.18	26.78	24.91	8.09	500.52	139.41	0.29	
FB	$\mu = 0.012$	0.32	0.00	12.26	4.14	26.34	26.42	8.14	557.25	164.55	0.28	
Second-best investment and first-best financing of the growth option												
SB	$\mu = 0.008$	0.30	0.59	10.82	4.08	26.63	25.22	8.05	500.35	139.45	0.31	0.03
SB	$\mu = 0.012$	0.30	0.60	11.66	4.03	26.18	26.79	8.10	557.06	164.61	0.31	0.03
Second-best investment and financing of the growth option												
SB	$\mu = 0.008$	0.34	0.56	11.54	4.31	25.87	22.42	7.58	500.20	139.10	0.33	0.06
SB	$\mu = 0.012$	0.35	0.57	12.57	4.30	25.35	23.51	7.60	556.87	164.23	0.32	0.07
First-best investment and financing of the growth option												
FB	$\sigma = 0.20$	0.37	0.00	12.23	5.11	22.85	20.69	8.23	526.33	143.92	0.31	
FB	$\sigma = 0.30$	0.27	0.00	11.45	3.42	30.67	31.65	8.14	532.44	160.23	0.26	
Second-best investment and first-best financing of the growth option												
SB	$\sigma = 0.20$	0.36	0.63	11.74	5.02	22.76	21.05	8.20	526.22	143.92	0.34	0.02
SB	$\sigma = 0.30$	0.25	0.55	10.86	3.33	30.45	31.94	8.08	532.23	160.32	0.28	0.04
Second-best investment and financing of the growth option												
SB	$\sigma = 0.20$	0.39	0.62	12.44	5.28	22.49	19.61	8.01	526.17	143.73	0.36	0.03
SB	$\sigma = 0.30$	0.30	0.51	11.62	3.53	28.97	27.04	7.30	531.92	159.83	0.29	0.10

(continued)

Table 4
Continued

		β_0	β_0^*	C_0^*	X_{dl}	X_s	C_s^*	X_{dh}	V_l	V_G	$MLev$	AC
First-best investment and financing of the growth option												
FB	$\Pi = 1.85$	0.30	0.00	12.19	4.46	31.27	28.54	9.56	486.81	113.20	0.32	
FB	$\Pi = 2.15$	0.33	0.00	11.36	3.87	23.04	23.54	7.04	573.53	194.44	0.25	
Second-best investment and first-best financing of the growth option												
SB	$\Pi = 1.85$	0.29	0.59	11.67	4.36	31.03	28.75	9.48	486.58	113.25	0.34	0.05
SB	$\Pi = 2.15$	0.31	0.58	10.79	3.77	22.95	23.96	7.01	573.43	194.47	0.28	0.02
Second-best investment and financing of the growth option												
SB	$\Pi = 1.85$	0.33	0.55	12.19	4.53	29.70	24.85	8.69	486.34	112.84	0.35	0.10
SB	$\Pi = 2.15$	0.36	0.58	12.01	4.14	22.55	21.53	6.77	573.34	194.20	0.30	0.03

The firm has assets-in-place that generate pre-tax earnings of X and an investment option that requires an investment expenditure of I_s and expands EBIT 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. For each parameter variation, we report three sets of model outcomes. First, we report the first-best case (FB) where the investment timing and financing of the growth option are chosen to maximize total firm value. We label this case "First-best investment and financing of the growth option." Second, we report the second-best case (SB) where the investment timing is chosen to maximize equity value and equityholders can commit to first-best financing of the growth option. We label this case "Second-best investment and first-best financing of the growth option." Third, we report the second-best case (SB) where the investment timing is chosen to maximize equity value and equityholders cannot commit to first-best financing of the growth option. We label this case "Second-best investment and financing of the growth option." The distinction between first- and second-best financing of the growth option is that under first-best financing the coupon of the additional debt issue, C_s^*, is chosen to maximize the sum of equity value, proceeds from the additional debt issue, and the initial debt value, while under second-best financing the coupon of the additional debt issue is chosen to maximize the sum of equity value and the proceeds from the additional debt issue (i.e., ignoring the initial debt value). In all three cases, we report model outcomes for the firm-value-maximizing optimal priority, β_0^*, which allocates the fraction β_0^* of the liquidation value of the firm in bankruptcy, $L_h(X_{dh})$, to the initial debt and $1-\beta_0^*$ of the liquidation value of the firm in bankruptcy to the additional debt issued to finance the growth option. For comparison, we also report the equal priority weighting $\beta_0 = C_0^*/(C_0^*+C_s^*)$, which is based on the coupons of initial debt (C_0^*) and additional debt (C_s^*). For variations of model parameters, the table reports β_0 and β_0^*, the optimal initial debt coupon, C_0^*, the endogenous default threshold before investment, 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 investment, X_{dh}, total firm value, V_l, the growth option component of firm value, V_G, which is given by the second term in (9), the time 0 market leverage ratio, *MLev*, and the agency cost of debt (in %), $AC = V_l^{FB}/V_l^{SB} - 1$. For each parameter variation, all other parameters are held constant at their base case values, which 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_s, 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.

in an effort to prop up the market value of, and therefore proceeds from, the future debt issue.[24]

The key empirical implication of this normative solution is that one should observe *priority spreading* as leverage and hence default risk increase. Thus, as a firm's credit quality deteriorates, our analysis predicts that the firm will allocate priority to future debt issues by optimally choosing a greater proportion of subordinate debt in its current debt structure. This prediction is consistent with the results in Rauh and Sufi (2010), who document that firms of lower credit quality tend to use multiple tiers of debt with different priority rankings.

The other comparative static results in Table 4 are similar to those in Table 2 (where we assume equal priority), except that they are more muted, since both capital structure *and* priority structure optimally adjust to parameter variation. Focusing on the effects of parameter variation on β_0^*, first observe in the second-best solutions that β_0^* increases as bankruptcy costs increase to mitigate the negative effect of higher bankruptcy costs on initial leverage. Similarly, β_0^* increases as the drift (μ) or tax (τ) rates increase. In these cases, however, the firm allocates priority to initial debt so that it can issue more of it and thereby maximize the value of interest tax shields. Finally, note that an increase in volatility (σ) decreases β_0^*, while an increase in the growth option payoff factor (Π) has little effect on β_0^*. As volatility increases, the growth option value increases and the firm waits longer to exercise the growth option. In response, the firm allocates marginally more priority to the time T_s debt issue. As Π increases, the growth option becomes more valuable, but in this case it is optimal to exercise it much sooner. Although the earlier exercise decision magnifies the expected present value of any investment distortions, this is largely offset by the "income effect" of a more valuable growth option and by the "leverage effect" of an optimally chosen lower initial coupon. As a result, β_0^* is fairly insensitive to Π.

3.3 Determinants of priority structure

In the extended model of Section 1.2, the firm chooses its capital structure, C_0^* and C_s^*, and a fraction of external equity, θ. We consider three issuance cost cases. For proportional debt flotation costs of $\varphi = 1.09\%$ estimated by Altinkilic and Hansen (2000), Hennessy and Whited (2007) use Simulated Method of Moments to obtain fixed, linear, and quadratic costs of equity issuance, $\{\lambda_0, \lambda_1,$ and $\lambda_2\}$, for large and small firms of {0.411, 0.061, and 0.0002} and {1.010, 0.129, and 0.0005}. We adopt these estimates for our cases of "Low" and "High" transaction costs, and we use their full sample estimates of {0.601, 0.095, and 0.0004} for our "Medium" case.

[24] This priority spreading phenomenon is not observed when there is an agency conflict over the financing of the growth option (i.e., second-best investment and financing of the growth option). In this case, it is always optimal to allocate more priority to initial debt as C_0 increases to offset the sharply higher cost of initial debt.

Table 5 studies the determinants of priority structure in the presence of these frictions. For various parameter values, we report inside equity value, $(1-\theta)E_l$, investment threshold, X_s, and optimal initial coupon, C_0^*, under (1) equal priority for initial and additional debt; (2) me-first for initial debt, (3) me-first for additional debt; and (4) optimal priority (β_0^* and $\beta_s^* = 1 - \beta_0^*$) for "No," "Low," "Medium," and "High" cost of external funds. For comparison with results without flotation costs, $(1–\theta)E_l$ is gross of the initial cost to set up the firm, I_0. Thus, as noted in Section 1.2, when there are no flotation costs, inside equity value equals total firm value.

We use optimal priority (4) as a benchmark for evaluating the three priority rules, (1)–(3), observed in practice. Panel A in Table 5 assumes that the timing of investment maximizes equity value (i.e., second-best investment timing) and that the coupon of the additional debt issue (C_s) used to finance the investment cost, I_s, maximizes total firm value (i.e., first-best financing of the growth option). Panel B of Table 5 also assumes second-best investment timing, but the coupon of the additional debt issue is chosen to maximize equity value plus the proceeds from the additional debt issue (i.e., second-best financing of the growth option).[25]

Among observed priority rules (1)–(3), when there are no issuance costs, retained equity value is always largest under me-first for initial debt. This preference is especially strong under second-best financing of the growth option (Panel B) because initial debtholders' claims are ignored under such a policy; therefore, the cost of initial debt is much higher. Notice that there is only a small difference in retained equity value between that under the normative optimal priority rule (4) and the maximizing choice among observed rules (1)–(3). At the base case in Panel A, retained equity value of 526.63 under me-first for initial debt is only slightly smaller than retained equity value of 527.51 under the normative optimal priority rule. This small gap (less than 0.20%) suggests that once the firm has chosen the best rule, among those observed in practice, there is little to be gained from adopting the normative optimal priority rule.

Having established the optimality of me-first for initial debt when the firm faces no issuance costs, we next consider how priority structure adjusts to debt and equity flotation costs. Because the flotation cost of debt is held constant, as the flotation cost of equity increases across the cases of low, medium, and high costs of external funds, the firm uses more debt and less external equity to economize on flotation costs. We can therefore investigate which priority structure is more efficient as C_0 *optimally* increases because of larger financing frictions.

[25] The case of second-best financing of the growth option ignores the impact of additional debt on initial debt value, which invites equityholders to use additional debt to dilute the claim of initial debt—a wealth transfer from initial debtholders to equityholders at time T_s. To mitigate this incentive problem and thereby lower the cost of initial debt, we anticipate that the firm has a strong incentive to choose a me-first priority rule for initial debt at time 0.

Table 5
Determinants of priority structure

Cost of external funds	(1) Equal priority $(1-\theta)E_l$	X_s	C_0^*	(2) Me-first for initial debt $(1-\theta)E_l$	X_s	C_0^*	(3) Me-first for additional debt $(1-\theta)E_l$	X_s	C_0^*	(4) Optimal priority $(1-\theta)E_l$	X_s	C_0^*	Maximum firm value of (1) – (3)
Panel A: Second-best investment timing and first-best financing of the growth option													
Base Case: $\sigma = 0.25$, $\alpha = 0.25$, $\tau = 0.15$, $\Pi = 2.00$													
No	525.93	23.80	13.90	**526.63**	28.20	8.54	523.47	23.21	2.24	527.51	26.40	11.22	526.63
Low	**515.97**	25.86	20.15	513.76	30.84	18.95	513.70	21.41	18.74	516.02	26.14	20.25	515.97
Medium	**513.51**	26.10	20.48	511.72	30.77	21.25	512.64	21.55	18.77	514.52	25.74	23.86	513.51
High	511.20	26.25	20.69	510.43	30.80	22.59	**511.48**	21.68	18.82	513.92	25.20	25.62	511.48
Increase in volatility, $\sigma = 0.40$													
No	543.90	33.81	8.41	**544.58**	44.58	7.48	542.44	33.57	4.00	545.66	39.89	10.43	544.58
Low	**529.14**	35.57	23.70	527.69	51.63	22.41	528.81	28.45	23.36	530.31	41.03	21.42	529.14
Medium	525.76	36.69	27.86	524.41	49.95	25.91	**528.69**	28.73	24.52	529.33	40.72	26.20	528.69
High	523.71	37.35	29.99	522.24	49.17	28.24	**528.07**	28.73	24.53	528.29	40.31	29.04	528.07
Increase in bankruptcy costs, $\alpha = 0.50$													
No	517.37	24.90	9.44	**517.87**	27.45	8.84	516.20	23.66	7.40	517.96	26.68	8.67	517.87
Low	500.77	27.01	15.34	501.29	28.25	14.60	**506.64**	24.98	14.30	507.57	27.00	17.66	506.64
Medium	493.39	28.24	17.62	493.97	29.28	17.10	**503.55**	25.65	15.66	504.06	27.49	20.82	503.55
High	487.49	29.25	19.12	488.17	30.20	18.71	**501.01**	26.18	16.43	501.56	28.12	21.32	501.01
Increase in tax rate, $\tau = 0.30$													
No	473.90	25.03	21.07	**476.71**	35.43	14.43	463.92	22.86	3.04	479.48	30.69	17.38	476.71
Low	**466.23**	26.31	24.70	466.17	39.40	22.65	451.39	20.19	21.44	470.03	31.64	21.52	466.23
Medium	**465.24**	26.74	26.19	465.18	38.96	23.82	451.21	20.19	21.45	468.37	31.85	23.40	465.24
High	**464.48**	27.01	27.07	464.31	38.70	24.64	450.82	20.20	21.49	467.17	31.93	24.58	464.48

(*continued*)

Table 5
Continued

Cost of external funds	(1) Equal priority $(1-\theta)E_l$	X_s	C_0^*	(2) Me-first for initial debt $(1-\theta)E_l$	X_s	C_0^*	(3) Me-first for additional debt $(1-\theta)E_l$	X_s	C_0^*	(4) Optimal priority $(1-\theta)E_l$	X_s	C_0^*	Maximum firm value of (1) – (3)
Decrease in investment option payoff factor, $\Pi = 1.50$													
No	409.86	42.70	12.31	**411.19**	56.27	12.43	406.42	38.48	8.56	411.43	51.88	12.81	411.19
Low	397.61	44.00	18.22	**399.12**	59.50	17.28	398.35	36.36	15.11	399.38	54.29	17.72	399.12
Medium	393.59	44.54	20.80	395.20	60.10	19.63	**397.06**	35.74	17.91	397.54	55.05	20.10	397.06
High	390.71	44.92	22.25	392.48	58.70	21.37	**396.43**	35.58	19.26	396.94	55.48	21.64	396.43
Panel B: Second-best investment timing and financing of the growth option													
Base Case: $\sigma = 0.25$, $\alpha = 0.25$, $\tau = 0.15$, $\Pi = 2.00$													
No	524.40	24.27	4.73	**525.17**	27.76	13.41	523.43	23.92	2.00	527.34	25.61	12.03	525.17
Low	501.40	24.87	14.20	**514.10**	29.34	18.51	499.70	23.27	5.29	515.59	27.72	18.90	514.10
Medium	492.96	25.23	18.47	**511.46**	30.10	20.71	484.01	22.67	6.93	513.35	28.24	21.33	511.46
High	487.37	25.51	21.14	**509.56**	30.63	22.02	467.58	22.19	8.12	511.90	28.60	22.69	509.56
Increase in volatility, $\sigma = 0.40$													
No	542.07	36.09	6.12	**543.51**	41.44	13.62	542.48	35.23	3.78	545.09	36.55	10.80	543.51
Low	519.49	35.56	16.19	**529.07**	43.76	21.70	522.04	33.41	8.07	530.26	39.93	21.80	529.07
Medium	509.15	35.34	22.22	**525.30**	44.90	25.62	509.61	31.95	10.55	526.34	41.12	26.03	525.30
High	502.02	35.27	26.34	**522.90**	45.62	28.02	497.70	30.84	12.37	523.92	41.80	28.53	522.90
Increase in bankruptcy costs, $\alpha = 0.50$													
No	516.14	25.32	5.15	**517.81**	26.96	9.34	515.45	24.84	3.41	517.95	26.48	8.81	517.81
Low	494.50	26.51	13.73	**502.46**	28.57	15.62	497.79	24.64	8.67	502.76	28.57	15.62	502.46
Medium	485.92	27.15	17.54	**496.62**	29.43	18.24	489.71	24.38	11.30	497.02	29.31	18.35	496.62
High	480.00	27.60	19.95	**492.55**	30.06	20.01	483.42	24.18	13.08	493.23	29.85	20.13	492.55

(*continued*)

Table 5
Continued

Cost of external funds	(1) Equal priority $(1-\theta)E_l$	X_s	C_0^*	(2) Me-first for initial debt $(1-\theta)E_l$	X_s	C_0^*	(3) Me-first for additional debt $(1-\theta)E_l$	X_s	C_0^*	(4) Optimal priority $(1-\theta)E_l$	X_s	C_0^*	Maximum firm value of (1) – (3)
Increase in tax rate, $\tau = 0.30$													
No	471.48	26.19	13.13	**476.21**	31.92	18.46	465.37	23.81	4.71	479.15	29.35	18.06	476.21
Low	456.49	27.68	20.06	**465.75**	33.13	21.57	445.24	23.66	8.15	469.98	31.01	21.77	465.75
Medium	451.74	28.30	23.19	**463.35**	33.61	23.12	433.04	23.27	9.95	468.37	31.67	23.45	463.35
High	448.37	28.70	25.19	**460.26**	33.91	24.12	420.94	22.95	11.34	467.17	32.09	24.51	460.26
Decrease in investment option payoff factor, $\Pi = 1.50$													
No	409.40	45.56	11.17	**409.83**	52.74	13.51	406.10	42.12	7.30	411.08	47.81	12.88	409.83
Low	394.91	46.00	16.66	**398.57**	54.32	17.98	393.73	40.80	10.23	399.12	50.55	17.90	398.57
Medium	389.23	45.94	19.48	**394.79**	54.89	20.24	387.44	39.51	11.58	395.17	51.62	20.27	394.79
High	385.02	45.93	21.37	**391.99**	55.20	21.72	381.80	38.56	12.49	392.29	52.33	21.79	391.99

The firm has assets-in-place that generate pre-tax earnings of X and an investment option that requires an investment expenditure of I_s and expands earnings 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. For variation in earnings volatility (σ), bankruptcy costs (α), corporate taxes (τ), and investment option payoff factor (Π), the table reports the value of inside equity, $(1-\theta)E_l$, the investment threshold, X_s, and the optimal initial debt coupon, C_0^*, for different priority structures and issuance costs. For comparison to results without flotation costs, the value of inside equity in the table is gross of the initial cost to set up the firm, I_0. Panel A assumes that the timing of investment is chosen to maximize equity value (i.e., second-best investment) and that the coupon of the additional debt issue (C_s) used to finance the growth option is chosen to maximize total firm value (i.e., first-best financing of the growth option). Panel B assumes that the timing of investment is chosen to maximize equity value (i.e., second-best investment) and that the coupon of the additional debt issue (C_s) used to finance the growth option is chosen to maximize equity value plus proceeds from the additional debt issue (i.e., second-best financing of the growth option). In all cases where issuance costs are not zero, proportional debt flotation costs, φ, are 1.09%. The costs of external equity, $\{\lambda_0, \lambda_1, \lambda_2\}$, in the cost function $\Lambda(x) = \lambda_0 + \lambda_1 x + \lambda_2 x^2$ for the cases of low, medium, and high issuance cost are {0.411, 0.061, 0.0002}, {0.601, 0.095, 0.0004}, and {1.010, 0.129, 0.0005}, respectively. Priority structure (1) assumes that the initial and additional debt issues share liquidation proceeds of the firm in bankruptcy in proportion to their coupons. Priority structure (2) assumes that in bankruptcy the initial debt issue receives liquidation proceeds (up to its risk-free debt value) before any residual proceeds are distributed to the additional debt issue. Priority structure (3) assumes that in bankruptcy the additional debt issue receives liquidation proceeds (up to its risk-free debt value) before any residual proceeds are distributed to the initial debt issue. Priority structure (4) assumes that the allocation of liquidation proceeds in bankruptcy is jointly chosen along with the initial and additional debt coupons to maximize initial firm value. For each parameter variation, all other parameters are held constant at their base case values, which are as follows: The initial cost to set up the firm, I_0, is 300, 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_s, 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.

For the base case parameter values in Panel A, the increase in C_0^*, as equity flotation costs increase, induces the firm to switch from me-first for initial debt (2) to equal priority (1) and then eventually switch to me-first for additional debt (3). The transition from me-first for initial debt to me-first for additional debt is quicker (i.e., at lower equity flotation costs) when volatility is higher (increase in volatility from base case $\sigma = 0.25$ to $\sigma = 0.40$) and when bankruptcy costs are larger (increase in bankruptcy costs from base case $\alpha = 0.25$ to $\alpha = 0.50$). As C_0^* increases, the increase in the risk and cost of default are more pronounced at higher volatility or higher bankruptcy costs. The firm is therefore quicker to give me-first priority status to future debt in order to boost debt capacity and hence avoid additional equity issuance costs. Our analysis therefore predicts that firms with high external financing costs (e.g., small and financially constrained firms), and especially riskier firms anticipated to have high financial distress costs, will preserve priority for future debt issues by using subordinate debt in their current debt structures. This prediction is supported by Rauh and Sufi (2010), who find that, relative to high-credit-quality firms, low-credit-quality firms are more likely to have debt structures containing subordinated debt, which allows for "priority spreading," as the firm seeks additional debt financing in the future.

As seen in Panel A of Table 5, an increase in the tax rate (from a base case of $\tau = 0.15$ to $\tau = 0.30$) slows the transition from me-first for initial debt to me-first for additional debt and results in equal priority (1) producing the highest retained equity value for low, medium, and high flotation costs. The reason is that, as the tax rate increases, more of the firm value derives from debt tax shields; therefore, the firm uses a larger proportion of debt financing both initially and in the future. To maximize the present value of tax shields and moderate the cost of future debt issues, the firm chooses equal priority for existing and new creditors.

The last experiment in Panel A shows that as the value of the growth option declines (i.e., Π decreases from a base case value of 2.0 to 1.5) me-first for initial debt (2) also maximizes inside equity value for large, mature, and unconstrained firms ("Low" cost of external funds). There are two reasons for this. First, since the firm waits longer to exercise the option, future tax shields on additional debt are less valuable and the firm is therefore encouraged to allocate priority to initial debt in order to maximize the value of tax shields. Second, because the firm waits for a higher cash flow level before exercising the option, the default risk of additional debt is small enough that it is of little consequence to the cost of additional debt to subordinate it, relative to initial debt. We see that, however, preserving priority for future debt (me-first for additional debt (3)) is more efficient for smaller and more financially constrained firms. Similar to the effect of higher bankruptcy costs, these firms enhance debt capacity at time T_s by preserving me-first provisions for additional debt in order to minimize future equity issue flotation costs. Finally, comparing these outcomes to the base case with a more valuable growth option indicates that equal priority (1) generates the highest retained equity value for low and medium flotation costs (i.e., somewhat financially constrained firms with better investment opportunities than in the last experiment).

Overall, our analysis of the effect of growth options on priority structure predicts that financially unconstrained and large firms with few growth opportunities should have debt structures that are composed primarily of senior and/or secured debt. Firms of medium size with good growth prospects should adopt equal priority rules, while financially constrained and small firms with or without growth opportunities should have debt structures in which existing bonds' indentures allow the firm to retain the option to finance future investments with senior claims. These predictions are largely in line with the empirical evidence. Bris, Ravid, and Sverdlove (2008) report that firms that issue only senior debt are much larger and have fewer investment opportunities (i.e., are more likely to pay dividends and by larger amounts) than are companies that issue only junior debt; Nash, Netter, and Poulsen (2003) and Chava, Kumar, and Warga (2010) find in new bond issues that subsequent financing restrictions (e.g., restrictions on funded debt, indebtedness, and senior debt issuance) are less likely in high market-to-book firms.[26]

Panel B in Table 5 presents results for the case of second-best financing of the growth option, where the coupon of the additional debt issue (C_s) used to finance the growth option maximizes equity value plus additional debt value (i.e., ignoring initial debt). As seen in Panel B, me-first for initial debt always strongly dominates any other priority structure. The reason for this robust result is that the other priority rules (i.e., equal priority or me-first for additional debt) invite excessive debt issuance at time T_s and hence substantial dilution of initial debt. The resulting higher cost of initial debt induces a suboptimal larger fraction of costly external equity to satisfy the initial funding condition, so it is optimal for current shareholders to give me-first priority to initial debt. In practice, however, the incentive to dilute existing debt claims under second-best financing of the growth option is likely to be substantially muted for at least a couple of reasons. First, unlike in our stylized model, the existence of additional future growth options to finance would naturally moderate the incentive to dilute prior debt claims. Second, the evidence on the rarity of me-first covenants in public debt issues strongly suggests that bondholders are not as concerned about this type of agency problem—dilution of existing debt claims with additional debt—either because transactions with the potential for dilution are not as prevalent or because debt contracts have evolved in other ways to mitigate dilution (e.g., poison puts to mitigate dilution from

[26] Opposite to our model's predictions, Barclay and Smith (1995) argue that firms with more growth options should have long-term debt structures largely comprised of senior claims to limit wealth transfers from bondholders to shareholders from either underinvestment or asset substitution. Consistent with their prediction, they find that high market-to-book firms use more capitalized leases and less subordinated debt as a fraction of total fixed claims. Yet, they also document that high market-to-book firms use a smaller fraction of secured debt.

highly leveraged transactions).[27] We therefore regard the model's empirical implications under first-best financing of the growth option in Panel A as more realistic and relevant than those under second-best financing in Panel B.

4. Conclusion

We study interactions between investment and financing decisions when equityholders choose the growth option exercise policy and the firm's debt structure decisions are driven by bankruptcy costs, agency costs, security issuance costs, interest tax shields, and investment benefits. 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 and the debt-equity mix used to finance the growth option. We establish that debt priority structure plays an important financial contracting role in mitigating stockholder–bondholder conflict over investment policy. Indeed, we show that the jointly optimal choice of capital structure and debt priority structure can virtually implement the first-best investment policy.

We show that agency conflicts over the timing and financing of future investments can produce quantitative estimates of optimal leverage levels that are of the same order of magnitude as empirically observed leverage levels. Our model also produces results that are consistent with empirical findings on priority structure. We find, for instance, that riskier firms with high financial distress costs tend to allocate priority to future debt issues by choosing a greater proportion of subordinate debt in their current debt structures. Our model also predicts that financially unconstrained firms with few growth opportunities prefer senior debt, while financially constrained firms, with or without growth opportunities, prefer junior debt.

Several additional results have important implications for capital structure research. The analysis shows that market leverage ratios can be negatively related to Tobin's Q even when there are no stockholder–bondholder agency conflicts. In general, one cannot use a negative relation between market leverage and Q as evidence for the existence of agency conflicts. The analysis also provides an explanation for the debt conservatism puzzle, since the option to use debt to finance future growth options significantly lowers the optimal amount of debt that the firm will use to finance its current assets-in-place (i.e., the firm optimally retains financial flexibility). We quantitatively show how agency costs affect optimal leverage and credit spreads on risky debt. Finally, the analysis provides a number of empirical predictions about the factors influencing the agency cost of debt. Of particular interest, we find that

[27] Malitz (1994) finds that the decline in the incidence of me-first covenants in debt issues coincided with the timing of the decline in LBOs and other highly leveraged transactions during her sample period. Billett, King, and Mauer (2007) and Bris, Ravid, and Sverdlove (2008) find a continuation of this trend in the paucity of me-first covenants in more recent public debt samples.

the agency cost of debt is decreasing in bankruptcy costs and in the growth option component of firm value.

Appendix 1: Derivations, Hitting Claims, and Passage Times

To derive and understand the value of any contingent claim security (such as equity and debt) in an intuitive way, we first present results for the values of Arrow–Debreu securities (hitting claims) that pay one dollar 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 first passage times for default and investment.

Applying arguments as in Goldstein, Ju, and Leland (2001), the hitting claim that pays one dollar contingent on X touching the level X_{dl} the first time from above *prior* to having ever reached X_s from below, and the hitting claim that pays one dollar contingent on X touching the level X_s from below *prior* to having ever reached X_{dl} from above, have the following values:

$$\Delta(X) = \mathrm{E}[e^{-rT_{dl}}|T_{dl} < T_s] = \frac{X^z X_s^a - X^a X_s^z}{X_{dl}^z X_s^a - X_{dl}^a X_s^z} \tag{A1}$$

and

$$\Sigma(X) = \mathrm{E}[e^{-rT_s}|T_s < T_{dl}] = \frac{X_{dl}^z X^a - X_{dl}^a X^z}{X_{dl}^z X_s^a - X_{dl}^a X_s^z}, \tag{A2}$$

where $\mathrm{E}[\cdot|\cdot]$ denotes conditional expectation, and T_{dl} and T_s denote the (random) default and investment times. The two roots of the quadratic equation $x(x-1)\sigma^2/2 + x\mu - r = 0$ are $a = -b - \sqrt{b^2 + 2\,r/\sigma^2} < 0$ and $z = -b + \sqrt{b^2 + 2\,r/\sigma^2} > 1$, where $b = (\mu - \sigma^2/2)/\sigma^2$.

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

$$E_l(X, C_0) = (1-\tau)\left(\frac{X}{r-\mu} - \frac{C_0}{r}\right) + E_1 X^a + E_2 X^z \tag{A3}$$

and

$$D_l(X, C_0) = \frac{C_0}{r} + D_1 X^a + D_2 X^z, \tag{A4}$$

where E_1, E_2, D_1, and D_2 are constants to be determined by boundary conditions.

Denoting X_{dl} as the default threshold and X_s as the investment threshold, $E_l(X, C_0)$ must satisfy the following default Equation (A5) and investment Equation (A6) boundary conditions

$$E_l(X_{dl}, C_0) = 0 \tag{A5}$$

and

$$E_l(X_s, C_0) = E_h(X_s, C) - \left[I_s - D_h(X_s, C_s)\right]. \tag{A6}$$

Substitution of Equations (2), (4), and (A3) into Equations (A5) and (A6) gives Equation (6). Note that if the term in square brackets on the right-hand side of Equation (A6) is positive, then it corresponds to the amount of equity financing used to invest in the growth option. If the term in square brackets is negative, however, then the investment is fully debt-financed and equityholders receive a debt-financed dividend. Whether $I_s < D_h(X_s, C_s)$ or not is endogenously determined by optimizing the joint choice of capital structure C_0 and C_s and priority structure. The constants in $D_l(X, C_0)$ are identified using the default boundary condition at X_{dl} and the value-matching boundary condition at X_s:

$$D_l(X_{dl}, C_0) = L_l(X_{dl}) \tag{A7}$$

and

$$D_l(X_s, C_0) = D_h(X_s, C_0), \tag{A8}$$

where $L_l(X_{dl}) = (1-\alpha)UX_{dl}$. Substitution of Equations (4) and (A4) into Equations (A7) and (A8) gives Equation (8).

To simplify the derivations of the subsequent probabilities and first passage times, let $\lambda = -(\mu - \sigma^2/2)$ and rearrange Equations (A1) and (A2) as follows:

$$\Delta(X) = \left(\frac{X}{X_{dl}}\right)^{\lambda/\sigma^2} \frac{\left(\frac{X_s}{X}\right)^{\sqrt{(\lambda/\sigma^2)^2 + 2r/\sigma^2}} - \left(\frac{X_s}{X}\right)^{-\sqrt{(\lambda/\sigma^2)^2 + 2r/\sigma^2}}}{\left(\frac{X_s}{X_{dl}}\right)^{\sqrt{(\lambda/\sigma^2)^2 + 2r/\sigma^2}} - \left(\frac{X_s}{X_{dl}}\right)^{-\sqrt{(\lambda/\sigma^2)^2 + 2r/\sigma^2}}} \tag{A9}$$

and

$$\Sigma(X) = \left(\frac{X}{X_s}\right)^{\lambda/\sigma^2} \frac{\left(\frac{X_{dl}}{X}\right)^{\sqrt{(\lambda/\sigma^2)^2 + 2r/\sigma^2}} - \left(\frac{X_{dl}}{X}\right)^{-\sqrt{(\lambda/\sigma^2)^2 + 2r/\sigma^2}}}{\left(\frac{X_{dl}}{X_s}\right)^{\sqrt{(\lambda/\sigma^2)^2 + 2r/\sigma^2}} - \left(\frac{X_{dl}}{X_s}\right)^{-\sqrt{(\lambda/\sigma^2)^2 + 2r/\sigma^2}}}. \tag{A10}$$

Using Equation (A9), we compute the probability of default to occur before investment:

$$\Pi_{dl}(X) = \lim_{r \downarrow 0} \Delta(X) = \lim_{r \downarrow 0} \mathrm{E}[e^{-rT_{dl}} | T_{dl} < T_s] = \frac{X_s^{2\lambda/\sigma^2} - X^{2\lambda/\sigma^2}}{X_s^{2\lambda/\sigma^2} - X_{dl}^{2\lambda/\sigma^2}}. \tag{A11}$$

Similarly, using (A6), we obtain the probability of investment to occur before default:

$$\Pi_s(X) = \lim_{r \downarrow 0} \Sigma(X) = \lim_{r \downarrow 0} \mathrm{E}[e^{-rT_s} | T_s < T_{dl}] = \frac{X^{2\lambda/\sigma^2} - X_{dl}^{2\lambda/\sigma^2}}{X_s^{2\lambda/\sigma^2} - X_{dl}^{2\lambda/\sigma^2}}. \tag{A12}$$

Note that these (conditional) default and investment probabilities are simply the limits of the corresponding Laplace transform (i.e., the corresponding hitting claim value) as the risk-free rate goes to zero. Further note that, by definition, we have 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 Equations (A1) and (A2):

$$\mathrm{E}[e^{-rT_e}] = \mathrm{E}[e^{-rT_{dl}} | T_{dl} < T_s] + \mathrm{E}[e^{-rT_s} | T_s < T_{dl}], \tag{A13}$$

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

$$\mathrm{L}(r; X, X_{dl}, X_s) = \int_0^\infty e^{-rt} g(t; X, X_{dl}, X_s)\, dt, \tag{A14}$$

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 $\mathrm{E}[T_e] = -\mathrm{L}'(0; X, X_{dl}, X_s)$ can be written as follows:

$$\mathrm{E}[T_e] = \mathrm{E}[T_{dl} | T_{dl} < T_s] + \mathrm{E}[T_s | T_s < T_{dl}], \tag{A15}$$

which we can evaluate, since Equation (A11) involves the expressions in Equations (A9) and (A10), i.e.,

$$\mathrm{E}[T_e] = -\lim_{r \downarrow 0} \frac{\partial \mathrm{E}[e^{-rT_e}]}{\partial r} = -\lim_{r \downarrow 0} \frac{\partial \mathrm{E}[e^{-rT_{dl}} | T_{dl} < T_s]}{\partial r} - \lim_{r \downarrow 0} \frac{\partial \mathrm{E}[e^{-rT_s} | T_s < T_{dl}]}{\partial r}. \tag{A16}$$

Hence, differentiating Equations (A5) and (A6) with respect to r, taking the limit as r goes to zero, and substituting the result into Equation (A16), we characterize $E[T_e]$ for $\lambda \neq 0$ analytically:

$$\frac{\left[\left(\frac{X_s}{X}\right)^{2\lambda/\sigma^2} - 1\right]\left[1 + \left(\frac{X_s}{X_{dl}}\right)^{2\lambda/\sigma^2}\right] \ln\left(\frac{X_s}{X_{dl}}\right) - \left[1 + \left(\frac{X_s}{X}\right)^{2\lambda/\sigma^2}\right]\left[\left(\frac{X_s}{X_{dl}}\right)^{2\lambda/\sigma^2} - 1\right] \ln\left(\frac{X_s}{X}\right)}{\lambda \left(\frac{X_{dl}}{X}\right)^{2\lambda/\sigma^2}\left[1 - \left(\frac{X_s}{X_{dl}}\right)^{2\lambda/\sigma^2}\right]^2} +$$
$$\frac{\left[\left(\frac{X_{dl}}{X}\right)^{2\lambda/\sigma^2} - 1\right]\left[1 + \left(\frac{X_{dl}}{X_s}\right)^{2\lambda/\sigma^2}\right] \ln\left(\frac{X_{dl}}{X_s}\right) - \left[1 + \left(\frac{X_{dl}}{X}\right)^{2\lambda/\sigma^2}\right]\left[\left(\frac{X_{dl}}{X_s}\right)^{2\lambda/\sigma^2} - 1\right] \ln\left(\frac{X_{dl}}{X}\right)}{\lambda \left(\frac{X_s}{X}\right)^{2\lambda/\sigma^2}\left[1 - \left(\frac{X_{dl}}{X_s}\right)^{2\lambda/\sigma^2}\right]^2}. \tag{A17}$$

As indicated by Equations (A15) and (A16), the second term in Equation (A17) is the expected time until investment conditional on no prior default, $\overline{T}_s = \mathrm{E}[T_s | T_s < T_{dl}]$, while the first term in Equation (A17) is the expected time until default conditional on no prior investment, $\overline{T}_{dl} = \mathrm{E}[T_{dl} | T_{dl} < T_s]$. After tedious algebra, the expected exit time of X from the interval (X_{dl}, X_s) in Equation (A17) simplifies to

$$\overline{T}_e = \mathrm{E}[T_e] = \frac{1}{\lambda}\left[\ln\left(\frac{X}{X_{dl}}\right)\right] + \frac{1}{\lambda}\left[\ln\left(\frac{X_{dl}}{X_s}\right)\right]\left[1 - \Pi_{dl}(X)\right]. \tag{A18}$$

The two-sided passage time has a surprisingly straightforward interpretation, since it is a convex combination of two one-sided passage times. The first term in Equation (A18) is the standard one-sided 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 Equation (A18) 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 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 2: Optimality of Joint Financing and Investment Decisions

Our analysis assumes that the timing of the additional debt issue coincides with the exercise of the growth option. Yet, shareholders cannot commit to investing and issuing debt simultaneously unless this strategy is optimal after time 0 debt has been issued. This appendix establishes the optimality of this joint choice for a wide range of economically interesting and realistic parameter values.[28] We separate the optimal time to issue additional debt, T_f, from the optimal time to invest, T_s, and compare the solution when the two decisions are separated, $T_f \neq T_s$, to that when they are combined, $T_f = T_s$. It is important to examine this alternative because shareholders might benefit from choosing when to invest *after* the additional debt has been issued, which would be in line with the same reasoning that shareholders typically do not optimally exercise their option to invest immediately at the time of the initial debt issue.

We first discuss the economic intuition behind why shareholders will *not* choose to issue additional debt before investing, and then verify this intuition based on extensive numerical simulations. Combining financing and investment decisions at time T_s is value-maximizing from shareholders' perspective, since separating financing and investment decisions leads to inferior interest tax shields and inferior investment incentives. Even for second-best (equity value maximization) outcomes, issuing debt before exercising the growth option is dominated by jointly timing the two decisions, since in the former case the cost of exercising the growth option is not debt-equity-financed but all-equity-financed, which reduces ex post equity value and hence exacerbates underinvestment. Moreover, the increase in debt coupon payments from C_0 to C_0+C_s also reduces ex post equity value and hence increases underinvestment further. Note that this effect is stronger for second-best financing decisions at time T_f, since this leads to a higher level of C_s than does first-best financing. Additionally, issuing additional debt before investment does not fully exploit the incremental tax shield value inherent in the growth option because the optimal coupon C_s and, hence, its tax shield contribution, is smaller than if the firm could wait and time the debt issue with the investment decision. Thus, it is typically not second-best optimal to time the additional debt issue before the growth option is exercised (both in terms of time 0 values for initial shareholders and in terms of ex post equity values given C_0).[29]

To verify this intuition, we solve the alternative model that lets the firm issue additional (first- or second-best optimal) debt at time T_f before exercising the option at time T_s.[30] We then compare time 0 firm (and equity) value of the baseline model in Section 2 (with $T_f = T_s$) with time 0 firm (and equity) value of the alternative model in which we let $T_f < T_s$.

Let X_f denote the additional debt restructuring threshold and X_s denote the investment threshold. As in the text, the time 0 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 $\beta_s = 1 - \beta_0 = C_s/C$. Recall that the roots, $a < 0$ and $z > 1$, solve $x(x-1)\sigma^2/2 + x\mu - r = 0$. Finally, the subscripts l, m, and h represent the (on average) *low*, *medium*, and *high* regions of earnings before investment and restructuring, after restructuring but before investment, and after restructuring and investment.

Region h, $t > T_s > T_f$: 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, so they are not reproduced here.

[28] For the firm to exercise its option in a reasonable time frame, the growth option needs to represent a nontrivial component of firm value. Clearly, if $\Pi \to 1$, then $X_s \to \infty$, and it will be optimal to issue additional debt prior to investing, assuming the value of the incremental tax shield is positive. We rule out this case because it is not interesting. Recall that, e.g., for our base case the growth option accounts for 29% of firm value.

[29] Note that it is not optimal for equityholders to invest an instant after T_f. The reason, as noted above, is that there will be a significant increase in debt overhang at T_f, because the firm will now have substantially more debt service (i.e., C_0 to $C_0 + C_s$) unless C_s is chosen to be small. This is in line with the same reasoning that shareholders typically do not optimally exercise their option to invest immediately at the time of the initial debt issue at time 0.

[30] In unreported results, we allow the firm to issue additional (first- or second-best optimal) debt after it optimally exercises the growth option (i.e., $T_f > T_s$). For a wide range of economically interesting and realistic parameter values, this alternative is also dominated by the solution that combines financing and investment decisions.

***Region m, $T_f \leq t < T_s$*:** The general solutions for equity, debt, and firm values in this region are

$$E_m(X,C) = (1-\tau)\left(\frac{X}{r-\mu} - \frac{C}{r}\right) + E_1 X^a + E_2 X^z, \tag{A19}$$

$$D_m(X,C_0) = \frac{C_0}{r} + D_1 X^a + D_2 X^z, \tag{A20}$$

$$D_m(X,C_s) = \frac{C_s}{r} + D_3 X^a + D_4 X^z, \tag{A21}$$

$$V_m(X,C) = \frac{(1-\tau)X}{r-\mu} + \frac{\tau C}{r} + V_1 X^a + V_2 X^z. \tag{A22}$$

The constants (E_1, E_2, D_1, D_2, D_3, D_4, V_1, and V_2) in (A19)–(A22) are determined by boundary conditions

$$E_m(X_{dm},C) = 0, \tag{A23}$$

$$E_m(X_s,C) = E_h(X_s,C) - I_s, \tag{A24}$$

$$D_m(X_{dm},C_0) = \beta_0 L_m(X_{dm}), \tag{A25}$$

$$D_m(X_s,C_0) = D_h(X_s,C_0), \tag{A26}$$

$$D_m(X_{dm},C_s) = \beta_s L_m(X_{dm}), \tag{A27}$$

$$D_m(X_s,C_s) = D_h(X_s,C_s), \tag{A28}$$

$$V_m(X_{dm},C) = L_m(X_{dm}), \tag{A29}$$

$$V_m(X_s,C) = V_h(X_s,C) - I_s, \tag{A30}$$

where $L_m(X_{dm}) = (1-\alpha)UX_{dm}$ with $U = (1-\tau)/(r-\mu)$, and X_{dm} denotes the endogenous default threshold in region m. Substituting (A19)–(A22) into (A23)–(A30), we obtain the solutions

$$\begin{aligned} E_m(X,C) &= (1-\tau)\left[\left(\frac{X}{r-\mu} - \frac{C}{r}\right) - \left(\frac{X_{dm}}{r-\mu} - \frac{C}{r}\right)\Delta(X)\right. \\ &\quad \left. + \left(\frac{(\Pi-1)X_s}{r-\mu} - \frac{I_s}{1-\tau} - \frac{C}{r}\left(\frac{1}{a-1}\right)\left(\frac{X_s}{X_{dh}}\right)^a\right)\Sigma(X)\right], \end{aligned} \tag{A31}$$

$$\begin{aligned} D_m(X,C_0) &= \frac{C_0}{r}\left[1 - \Delta(X) - \left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\right] \\ &\quad + \beta_0 L_m(X_{dm})\Delta(X) + \beta_0 L_h(X_{dh})\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X), \end{aligned} \tag{A32}$$

$$D_m(X, C_s) = \frac{C_s}{r}\left[1 - \Delta(X) - \left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\right] + \beta_s L_m(X_{dm})\Delta(X) + \beta_s L_h(X_{dh})\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X), \tag{A33}$$

$$V_m(X, C) = UX + (1-\tau)\left(\frac{(\Pi - 1)X_s}{r-\mu} - \frac{I_s}{1-\tau}\right)\Sigma(X) + \frac{\tau C_0}{r}\left[1 - \Delta(X) - \left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\right] + \frac{\tau C_s}{r}\left[1 - \left(\frac{X_s}{X_{dh}}\right)^a\right]\Sigma(X) - \alpha\left[UX_{dl}\Delta(X) + \Pi U X_{dh}\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X)\right], \tag{A34}$$

where

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

***Region l, $t < T_f < T_s$*:** The general solutions for equity, debt, and firm values in this region are

$$\tilde{E}_l(X, C_0) = (1-\tau)\left(\frac{X}{r-\mu} - \frac{C_0}{r}\right) + E_3 X^a + E_4 X^z, \tag{A35}$$

$$\tilde{D}_l(X, C_0) = \frac{C_0}{r} + D_5 X^a + D_6 X^z, \tag{A36}$$

$$\tilde{V}_l(X, C_0) = \frac{(1-\tau)X}{r-\mu} + \frac{\tau C_0}{r} + V_3 X^a + V_4 X^z. \tag{A37}$$

The constants (E_3, E_4, D_5, D_6, V_3, and V_4) in (A35)–(A37) are determined by boundary conditions

$$\tilde{E}_l(X_{dl}, C_0) = 0, \tag{A38}$$

$$\tilde{E}_l(X_f, C_0) = E_m(X_f, C) + D_m(X_f, C_s), \tag{A39}$$

$$\tilde{D}_l(X_{dl}, C_0) = L_l(X_{dl}), \tag{A40}$$

$$\tilde{D}_l(X_f, C_0) = D_m(X_f, C_0), \tag{A41}$$

$$\tilde{V}_l(X_{dl}, C_0) = L_l(X_{dl}), \tag{A42}$$

$$\tilde{V}_l(X_f, C_0) = V_m(X_f, C_0), \tag{A43}$$

where $L_l(X_{dl}) = (1-\alpha)UX_{dl}$ and X_{dl} denotes the endogenous default threshold in region l.

Substituting (A35)–(A37) into (A38)–(A43), we obtain the solutions

$$\begin{aligned}\tilde{E}_l(X, C_0) &= (1-\tau)\left[\left(\frac{X}{r-\mu} - \frac{C_0}{r}\right) - \left(\frac{X_{dl}}{r-\mu} - \frac{C_0}{r}\right)\tilde{\Delta}(X)\right] \\ &\quad + (1-\tau)\left[\frac{D_m(X_f, C_s)}{1-\tau} - \frac{C_s}{r} - \left(\frac{X_{dm}}{r-\mu} - \frac{C}{r}\right)\Delta(X_f)\right. \\ &\quad \left. + \left(\frac{(\Pi-1)X_s}{r-\mu} - \frac{I_s}{1-\tau} - \frac{C}{r}\left(\frac{1}{a-1}\right)\left(\frac{X_s}{X_{dh}}\right)^a\right)\Sigma(X_f)\right]\tilde{\Sigma}(X), \quad \text{(A44)}\end{aligned}$$

$$\begin{aligned}\tilde{D}_l(X, C_0) &= \frac{C_0}{r}\left[1 - \tilde{\Delta}(X) - \Delta(X_f)\tilde{\Sigma}(X) - \left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X_f)\tilde{\Sigma}(X)\right] \\ &\quad + L_l(X_{dl})\tilde{\Delta}(X) + \beta_0 L_m(X_{dm})\Delta(X_f)\tilde{\Sigma}(X) \\ &\quad + \beta_0 L_h(X_{dh})\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X_f)\tilde{\Sigma}(X), \quad \text{(A45)}\end{aligned}$$

$$\begin{aligned}\tilde{V}_l(X, C_0) &= UX + (1-\tau)\left(\frac{(\Pi-1)X_s}{r-\mu} - \frac{I_s}{1-\tau}\right)\Sigma(X_f)\tilde{\Sigma}(X) \\ &\quad + \frac{\tau C_0}{r}\left[1 - \tilde{\Delta}(X) - \Delta(X_f)\tilde{\Sigma}(X) - \left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X_f)\tilde{\Sigma}(X)\right] \\ &\quad + \frac{\tau C_s}{r}\left[1 - \Delta(X_f) - \left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X_f)\right]\tilde{\Sigma}(X) \\ &\quad - \alpha\left[UX_{dl}\tilde{\Delta}(X) + UX_{dm}\Delta(X_f)\tilde{\Sigma}(X)\right. \\ &\quad \left. + \Pi UX_{dh}\left(\frac{X_s}{X_{dh}}\right)^a \Sigma(X_f)\tilde{\Sigma}(X)\right], \quad \text{(A46)}\end{aligned}$$

where

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

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

$$\left.\frac{\partial \tilde{E}_l(X, C_0)}{\partial X}\right|_{X=X_{dl}} = 0, \quad \text{(A47)}$$

$$\left.\frac{\partial \tilde{E}_l(X, C_0)}{\partial X}\right|_{X=X_f} = \left.\frac{\partial E_m(X, C)}{\partial X}\right|_{X=X_f} + \left.\frac{\partial D_m(X, C_s)}{\partial X}\right|_{X=X_f}, \quad \text{(A48)}$$

$$\left.\frac{\partial E_m(X, C)}{\partial X}\right|_{X=X_{dm}} = 0, \quad \text{(A49)}$$

$$\left.\frac{\partial E_m(X, C)}{\partial X}\right|_{X=X_s} = \left.\frac{\partial E_h(X, C)}{\partial X}\right|_{X=X_s}. \tag{A50}$$

Since analytical comparison is impossible, we carry out extensive numerical analysis for a wide range of parameter values. Assuming first-best financing of the growth option, Figure 3 plots firm values, $V_l(X, C_0^*, C_s^*)$ and $\tilde{V}_l(X, \tilde{C}_0^*, \tilde{C}_s^*)$, for combining (solid lines) and separating (dashed lines) investment and financing decisions as a function of investment benefit, Π, corporate tax rate, τ, and earnings volatility, σ, to determine the ex ante optimal choice of (initial) shareholders at

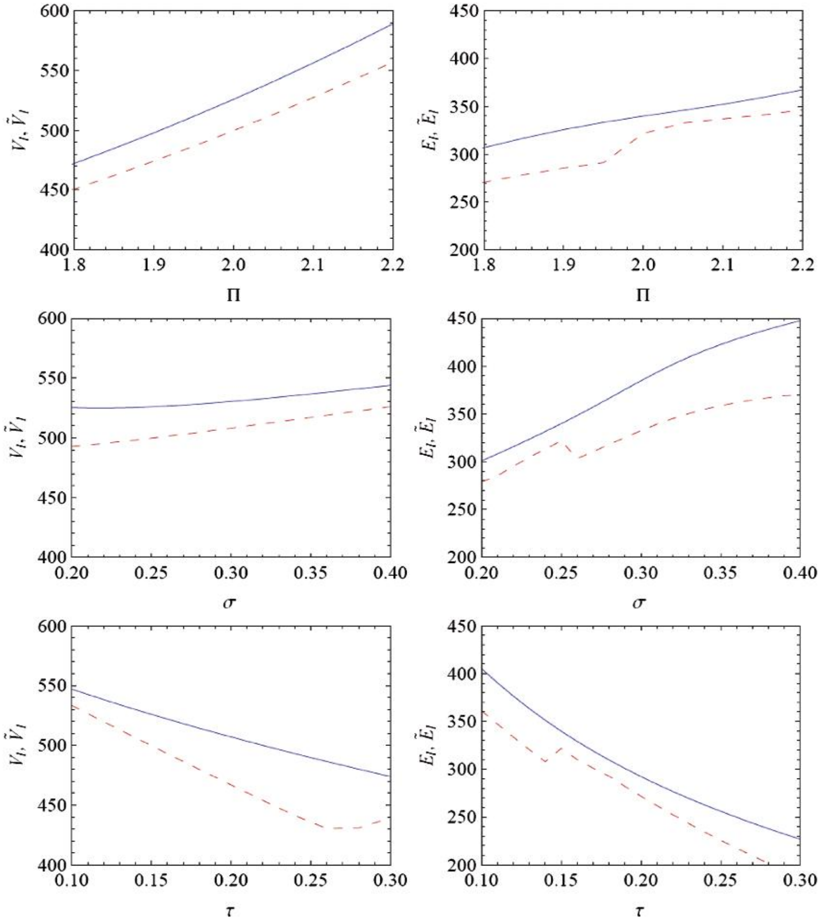

Figure 3
Combining versus separating the firm's financing and investment decisions
The figure plots equity and firm values for combining (solid lines) or separating (dashed lines) financing and investment decisions as a function of investment benefits, cash flow volatilities, and corporate taxes. The choice of C_s is first-best in that it also reflects initial debt value. The initial cash flow, X_0, is 20, the cost of exercising the investment option, I_s, is 200, the payoff from exercising the investment option, Π, is 2, 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.

time 0. Note that $\{C_0^*, C_s^*\}$ and $\{\tilde{C}_0^*, \tilde{C}_s^*\}$ maximize firm values under combining and separating decisions. To determine the ex post optimal choice of equityholders after time 0 (i.e., to check whether there is an incentive to switch from combining to separating decisions), we also plot equity values, $E_l(X, C_0^*, C_s^*)$ and $\tilde{E}_l(X, C_0^*, \tilde{C}_s^*)$, for combining and separating decisions. Anticipating the result that combining decisions maximizes total firm value at time 0, the separating equity claim, $\tilde{E}_l$, is based on the time 0 coupon, C_0^*, that maximizes V_l, but thereafter assumes separation of financing ($\tilde{C}_s^*$) and growth option investment decisions. All results in the figure are for first-best choices of C_s, but we obtain qualitatively similar results for second-best choices of C_s (available on request). Finally, debtholders foresee future actions of equityholders and value their claims accordingly (i.e., if equityholders have an incentive to switch the timing of decisions after time 0 and this implies lower debt values, then this is already reflected in debt values at time 0).

As seen in all panels of Figure 3, ex ante equity (i.e., firm) values and ex post equity values are higher under joint rather than separated financing and investment decisions. Thus, this appendix establishes that, for a large range of economically interesting and realistic parameter values around our base case specification, the second-best optimal sequence of events at time 0 and after time 0 is to combine financing and investment decisions.

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