Financing Uncertain Growth

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Abstract

We examine interactions between investment and financing decisions in a dynamic model where the firm may alter the mix of debt and equity financing and may exercise a growth option. The key feature of the model is that the growth option arrives randomly and can be lost due to competition or technological obsolescence. We find that the firm will typically finance the exercise of the growth option with equity and may wait years before recapitalizing to a higher debt level. The lack of coordination between the timing of investment and debt financing helps explain a number of findings in the empirical literature, including violation of the financing pecking order, debt conservatism, apparent market timing of security issues, and more pronounced underperformance following equity issues than debt issues. Lastly, the analysis quantifies interactions between growth options and financial flexibility and shows that growth-financing synergy can contribute significantly to firm value.

Keywords: Uncertain Growth Options, Security Issue Timing, Investment and Financing Interactions

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1. Introduction

The interaction between investment and financing decisions is one of the most important topics in corporate finance. While prior studies provide numerous insights on how the firm's financial structure interacts with its investment policy, there is relatively little research on the firm's timing of financing activities relative to its investment decisions. In particular, the timing of financing is an important dimension for understanding financial dynamics during the process of a firm's investment and growth.

In this paper, we use a dynamic trade-off model to analyze how a firm optimally times its financing decisions when it anticipates a growth option in the future. The novel feature of our model is that the growth option arrives randomly and may subsequently disappear because of competition or technological obsolescence. This type of growth option captures the key features of R&D where the arrival of growth options tends to be independent of the firms existing operations and their value may quickly dissipate if not promptly acted upon. This is especially true in high technology industries, but also common in traditional industries with substantial competition. Thus an important feature of uncertain growth opportunities is that their arrival can occur in low cash flow states where the firm would not want to finance investment with debt and may not have the luxury of waiting for a higher cash flow state so that it can finance investment with debt. An immediate implication is that capital structure decisions (i.e., issuing additional debt) may not coincide with investment decisions.

The timing inconsistency between investment and financing decisions can explain a number of puzzling financing patterns documented in the empirical literature. First, we find that growth options tend to be financed with equity; a result inconsistent with the pecking order of financing (e.g., Myers (1984)) but consistent with empirical evidence in Frank and Goyal (2003), Fama and French (2005), Bharath, Pasquariello, and Wu (2009), and Leary and Roberts (2010). Second, our model provides an investment based explanation for debt conservatism, and can help explain the puzzling capital structure persistence documented by Lemmon, Roberts, and Zender (2008). Third, our model provides an investment based explanation for the new issues puzzle (e.g., Loughran and Ritter (1995)) that can explain why stock underperformance after equity issues is more pronounced than after debt issues. Fourth, absent any market timing incentives, our analysis illustrates that firms tend to decrease leverage when their market-to-book ratio is high and increase leverage when their market-to-book ratio is low; a phenomenon that Baker and Wurgler (2002) document empirically and attribute to equity market timing. Lastly, the analysis quantifies interactions between growth options and financial flexibility and shows that growth-financing synergy can contribute significantly to firm value.

Debt financing accompanies the exercise of growth options in extant dynamic financing and investment models. This is either assumed explicitly in the model or is a byproduct of the modeling assumptions.[1] Indeed, Hackbarth and Mauer (2012) show that when the firm may choose when to make debt financing and growth option exercise decisions, it will make them simultaneously. Our analysis shows, however, that the critical condition that produces this result is that the firm has monopolistic access to growth options that are always available and never lose value.[2] The model in this paper makes an important and realistic departure from this setting

[1] For example, see Mauer and Triantis (1994), Mauer and Ott (2000), Childs, Mauer, and Ott (2005), Mauer and Sarkar (2005), Sundaresan and Wang (2007), Tserlukevich (2008), Gomes and Schmid (2010), Morellec and Schurhoff (2011), and Hackbarth and Mauer (2012).

[2] A general practice in the literature is to model growth opportunities as productivity shocks to capital, and depending on the stochastic process for the evolution of the shock, firms can invest any point in time in the future. This implies that the firm invests when the productivity shock reaches an upper threshold, and since a high productivity shock also implies a high debt capacity, the investment is financed with debt.

by assuming that growth options arrive randomly and may subsequently disappear because of competition or technological obsolescence.[3]

In a model with assets-in-place that generate a stochastic stream of cash flows, we allow for the possibility that a growth option may appear. In the spirit of R&D innovations, we assume that the arrival rate of the growth option is independent of the cash flows from assets-in-place (i.e., the growth option can arrive in a low or high cash flow state). Once the growth option arrives, however, it may be lost because of competition or technological obsolescence. The firm chooses an initial capital structure and has the option to restructure (i.e., issue debt to alter the initial debt-equity mix) anytime in the future. The firm may choose to restructure when it exercises the growth option, or it may separate the two decisions by financing the exercise of the growth option with an equity issue. The firm chooses its initial capital structure and the capital structure after restructuring by trading off tax benefits of debt against bankruptcy costs triggered by an endogenous default decision.

We find that it is always optimal to restructure after the growth option arrives because the firm can use the cash flows from exercising the growth option to support additional debt. We further find that restructuring rarely coincides with the decision to exercise the growth option because the restructuring option almost always has positive remaining time value at the optimal exercise point for the growth option (i.e., the cash flow state may be high enough to generate positive value from exercising the growth option before it is lost but too low to encourage the

[3]A handful of authors have explored how competition that can destroy the value of a growth option influences the timing of investment. In the first such attempt, Trigeorgis (1991) modeled the exercise of a real option as an American option on a stock that pays a dividend. Subsequent authors such as Mauer and Ott (1995, 2000) and Morellec and Schurhoff (2011) model the arrival of competition as a Poisson process that eliminates the investment opportunity. All of these papers show that the possibility of losing the option encourages early exercise. Leahy (1993) shows, however, that competition need not encourage early exercise of growth options when firms are free to enter and exit the market. More recently, however, Back and Paulsen (2009) show that the option to delay investment in a competitive equilibrium investment game has zero value. Note that all of these analyses differ from our setting where the firm faces the uncertain arrival of a growth option that may subsequently disappear.

firm to issue additional debt). Thus, when the firm faces an uncertain growth option, it generally uses equity to finance investment. This result illustrates that when growth option uncertainty and cash flow dynamics are taken into consideration, the financing of investment can be inconsistent with the pecking order theory of Myers (1984) and Myers and Majluf (1984). As noted above, violations of the pecking order for financing decisions have been documented in numerous empirical studies. Our model shows that uncertain investment opportunities can help explain these violations.

Consistent with the empirical evidence documented in Graham (2000), the firm in the model can exhibit considerable debt conservatism. Since the firm typically does not restructure to a higher debt level until well after the arrival and subsequent investment in the growth option, the average market leverage ratio can be quite low for extended periods of time. An additional factor driving the firm to choose a relatively low initial debt level is that the firm is concerned about losing valuable future growth and restructuring options in bankruptcy. Thus, although debt structure in the model is driven by a classical tax and bankruptcy cost tradeoff, our analysis shows that uncertain growth options may help to explain why firms tend to appear underleveraged.

Our analysis contributes to a better understanding of the new issues puzzle of Loughran and Ritter (1995) – negative relation between corporate external financing activity and future stock returns – by showing that the composition of external financing matters for the relation between external financing and expected returns. In particular, equity issues predict a decrease in expected returns (equity beta) because the equity issue funds the conversion of an uncertain growth option to lower risk assets-in-place. In contrast, there is no change in investment when the firm restructures by issuing debt. The increase in leverage without a corresponding change in asset risk increases expected returns (equity beta). Thus our model predicts underperformance following equity issues and little or no underperformance following debt issues.[4]

The leverage-*Q* dynamics in our model can also give rise to what appears to be equity market timing when no timing is taking place. Baker and Wurgler (2002) document a negative relation between firms' leverage ratios and their historical market-to-book ratios, and use this finding to argue that firms time equity issues when their market values are relatively high. In our model, since Tobin's *Q* is relatively high prior to exercising the growth option and since the option is typically financed with equity, there is a negative relation between leverage and lagged Tobin's *Q*. This negative relation is also evident after investment in the growth option because the decline in Tobin's *Q* is followed by an increase in leverage when the firm subsequently recapitalizes. Thus optimal financing and investment decisions in our model generate a leverage-*Q* pattern that resembles equity market timing.

Lastly, we examine interactions between financing and investment decisions. We document positive synergies between growth options and financing decisions in that their value together is significantly larger than the sum of their separate values. Our analysis also shows that the value of the restructuring option is small in comparison to the value of the growth option, which is consistent with the empirical findings that firms' capital structures tend to be persistent (Lemmon, Roberts, and Zender (2008)) with infrequent rebalancing (Leary and Roberts (2005)).

Our work is closely related to a growing body of literature that studies interactions between investment and financing decisions in dynamic models. Several strands of this literature have predictions that are complementary to those of our model. In particular, Tsyplakov (2008) and Morellec and Schurhoff (2011) show that other types of frictions can lead to violations of the

[4] The predicted differential performance following equity and debt issues is consistent with the empirical evidence in Loughran and Ritter (1995), Spiess and Affleck-Graves (1995, 1999), and Lyandres, Sun, and Zhang (2008).

pecking order for financing decisions. In a model with time-to-build, Tsyplakov shows that investment will be financed with equity. In a model where the timing of investment can signal private information, Morellec and Schurhoff show that a firm may prefer to finance a growth option with equity. Our analysis shows that uncertainty over the arrival and subsequent disappearance of investment opportunities can drive a preference for equity-financed investment.

Carlson, Fisher, and Giammarino (2006) and Li, Livdan, and Zhang (2009) also have models predicting underperformance following equity issues. In sharp contrast with our analysis, however, these papers have no predictions for performance following debt issues because they assume all-equity financing. In related work, Gomes and Schmid (2010) study how leverage and growth options influence equity beta (expected returns). In a dynamic model that allows for debt and equity financing, they show that high leverage firms may have lower equity betas (expected returns) than low leverage firms because the positive influence of growth options on equity risk vanishes when the firm invests in a growth option financed with debt. The key difference between the Gomes and Schmid paper and our paper is that their analysis predicts underperformance following debt issues, while our analysis predicts little or no underperformance following debt issues.

Lastly, Hennessy and Whited (2005) and Tsyplakov (2008) also find a negative relation between leverage and *Q*, but the mechanisms in their models generating this result are quite different from the mechanism in our model. Hennessy and Whited get a negative relation by a combination of leverage hysteresis and path-dependent financial policies, while Tsyplakov gets a negative relation because equity is a preferred source of financing when investments take time-to-build. In comparison, our model predicts a negative relation between leverage and *Q* because it is generally optimal to finance uncertain growth with equity.

The remainder of the paper is organized as follows. Section 2 presents the model. Section 3 discusses the main results and implications. Section 4 examines interactions between financing and investment decisions. Section 5 concludes. All derivations are in the appendices.

2. The Model

Consider a firm with assets-in-place and a randomly arriving growth option. At every point in time t, assets-in-place generate earnings before interest and taxes (EBIT) of X_t, which evolve according to geometric Brownian motion with initial value $X_0 > 0$, drift μ, and volatility σ under the risk-neutral probability measure. A risk-free security yields a constant r per unit time with $\delta \equiv r - \mu > 0$.

The growth option arrives randomly at (random) time $\tilde{T}_1 \geq 0$ according to a Poisson process with arrival rate λ_1 and an expected arrival time of $\mathrm{E}[\tilde{T}_1] = 1/\lambda_1$ years. The growth option is assumed to be a new investment opportunity generated through R&D and its arrival is therefore independent of the state of the firm's existing operations. In terms of model primitives, this means that λ_1 is a constant and not a function of X_t. The firm may exercise the growth option by paying a fixed investment cost $I > 0$ which can be financed with a combination of debt and equity. The benefit from exercising the growth option is that overall firm cash flows increase to ΠX_t where $\Pi > 1$, so that the *net* benefit from exercising the growth option is $(\Pi - 1)X_t - I$.[5]

[5] Note that although the arrival of the growth option is independent of X_t, for mathematical tractability we model the benefit from exercising the option as proportional to X_t. As discussed below, one implication of this assumption is that the exercise policy for the growth option is a critical value for X_t at which the firm will invest.

Once the growth option arrives, it is an infinitely lived American option subject to the risk that it may be lost. This risk, which we feel is a reasonable and realistic addition to any real options framework, could arise from competition or from technological obsolescence. In any case, the firm may not have the luxury of waiting to invest. To model this risk in a tractable fashion, we assume that the growth option jumps to a zero value according to a Poisson process with probability $\lambda_2 dt$, where λ_2 is the constant intensity parameter. We assume that the growth option cannot disappear before it arrives. As such, the Poisson process for the arrival of the growth option and the Poisson process for the disappearance of the growth option are separate and stochastically independent. We denote the random time from the arrival of the growth option until it is lost as $\tilde{T}_2$, and so the expected time is $\mathrm{E}[\tilde{T}_2] = 1/\lambda_2$ years.

Note that as λ_2 gets large, the growth option converges to the textbook now or nothing investment opportunity that must be accepted or rejected the instant it arrives; and as λ_2 goes to zero, the growth option converges to an infinitely-lived American option that the firm may exercise at any point in time in the future without fear that it would ever be lost. In this regard, our model covers a full range of growth opportunities of which the firm may have varying degrees of control.

The investment policy for the growth option, denoted X_I, is a yet-to-be-determined value of X_t at which the firm exercises the option by paying I and receiving a perpetuity of $(\Pi - 1)X_t$ thereafter. Note that prior to the arrival of the growth option, X_t may exceed X_I with no investment; and at the arrival of the growth option (i.e., at $\tilde{T}_1$), either $X(\tilde{T}_1) \geq X_I$ and the firm invests immediately or $X(\tilde{T}_1) < X_I$ and the firm waits to invest. In the latter case, if X_t never equals or exceeds X_I over $\tilde{T}_1 \leq t \leq \tilde{T}_1 + \tilde{T}_2$ the growth option is lost.

The firm chooses an initial capital structure at time 0 (i.e., mix of debt and equity) and has the option to recapitalize (i.e., change the debt level) any time after the arrival of the growth option.[6] For tractability, all debt is assumed to have infinite maturity and the coupon payment on debt is chosen to maximize firm value according to a tax shield and expected bankruptcy cost trade-off framework. We assume a constant corporate tax rate, $\tau \in (0,1)$, with a full loss offset provision. Bankruptcy costs include the loss of interest tax shields, the loss of the growth option if it has not arrived or has arrived and has not been exercised, and a constant fraction $0 < b < 1$ of the value of assets-in-place. The decision to default on debt payments and declare bankruptcy is endogenously determined to maximize the market value of equity. In bankruptcy, equity holders receive nothing (i.e., absolute priority is respected) and bondholders assume ownership of the firm's assets-in-place net of bankruptcy costs.

The initial debt issue has coupon payment, C_0, which is chosen to maximize time 0 ex-ante equity value (i.e., the sum of equity plus the proceeds from the initial debt issue). After the arrival of the growth option, the firm has the option to issue new debt and retire the initial debt. The initial debt must be bought back at par value, F, which is assumed to be the market value of the debt when it is issued at time 0. Following standard practice in the literature (see, e.g., Goldstein et al. (2001), Hackbarth (2008), and Chen (2010)), we assume that the firm can only increase the debt level when it restructures. Given perpetual debt, this requirement implies that the coupon of the new debt, C_1, is chosen to maximize firm value at the point of restructuring *and* satisfies the condition that $C_1 > C_0$. We find that the constraint $C_1 > C_0$ is never binding, so the firm never chooses to optimally recapitalize to a lower coupon. This result, which we verify

[6] Extensive simulations of the model reveal that for economically reasonable parameter values it is never optimal to restructure debt prior to the arrival of the growth option. In fact, the firm will always restructure at the point that the firm exercises the growth option or at a point in time after the growth option is exercised.

numerically, is consistent with the analysis in Leland (1994) who shows that it is never optimal for the firm to voluntarily decrease the debt level because the wealth transfer from equity holders to the remaining debt holders always offsets any potential benefits (e.g., reducing the probability of bankruptcy). The result that the firm will optimally only increase debt is consistent with empirical evidence of high transaction costs associated with downward debt restructurings (see, e.g., Asquith, Gertner, and Scharfstein (1994) and Gilson (1997)).

Given that the state variable in the model is the earnings stream generated by assets-in-place, X_t, the optimal restructuring threshold, like the investment and bankruptcy thresholds, is a critical level of earnings at which the firm chooses to restructure. This restructuring threshold, X_{R1}, is chosen to maximize firm value. Finally, to complete the specification for the firm's restructuring option, we recognize that the growth option may disappear before the firm has an opportunity to restructure. We denote the firm value maximizing coupon and restructuring threshold should the growth option disappear (i.e., for $t > \tilde{T}_2$) as C_2 and X_{R2}, respectively.

Since the firm does not restructure prior to the arrival of the growth option at $\tilde{T}_1$, there are three possibilities for the relative values of the investment threshold, X_I, and the restructuring threshold, X_{R1}. In the case where $X_I < X_{R1}$, if $X(\tilde{T}_1) < X_I$, the firm waits to invest and subsequently waits to restructure; if $X_I \leq X(\tilde{T}_1) < X_{R1}$, the firm investment immediately and waits to restructure; and if $X(\tilde{T}_1) \geq X_{R1}$, the firm invests and restructures immediately. In the case where $X_I = X_{R1}$, the firm invests and restructures if $X(\tilde{T}_1) \geq X_I$ and waits to invest and restructure if $X(\tilde{T}_1) < X_I$. The third case is where $X_{R1} < X_I$. This case can be ruled out because the firm never optimally restructures prior to investing in the growth option. The reason is that the advantage of restructuring early – earning incrementally larger debt tax shields sooner – is offset by higher debt capacity and therefore debt tax shields after investing in the growth option and the possibility of greater bankruptcy risk if the growth option is lost after restructuring.[7] Finally, note that regardless of the relative values of X_I and X_{R1}, if $X(\tilde{T}_1) < X_I$, the growth option may disappear while the firm waits to invest. As discussed above, the firm may then restructure at X_{R2}.

We solve for the investment and restructuring thresholds for the cases where $X_I < X_{R1}$ and $X_I = X_{R1}$. For each case, we also solve for the endogenous default thresholds, the optimal coupons (C_0^* and C_1^*), and the restructuring threshold and optimal coupon when the growth option is lost (X_{R2} and C_2^*). We choose the case – $X_I < X_{R1}$ or $X_I = X_{R1}$ – that gives the largest initial (time 0) firm value as the optimal solution. Derivations are in Appendices A and B.

3. Investment and financing policies when growth options are uncertain

3.1 Parameter values

Although elements of the model can be solved in closed-form (e.g., values and default thresholds after investment in the growth option), its complexity precludes an overall closed-form solution. We therefore solve the model numerically using the following base case parameter values: the initial pre-tax cash flow, X_0, is 11, the cash flow multiplier if the firm invests in the growth option, Π, is 2.0, the investment outlay, I, is 200, the arrival rate of the growth option, λ_1, is 0.25 (which gives an expected arrival time of 1/0.25 = 4 years), the

[7] In numerical analysis using a wide range of parameter values, we find that $X_I \leq X_{R1}$, which confirms our intuition that it is always optimal to restructure coincident with or after exercising the growth option. Hackbarth and Mauer (2012) establish a similar result in a model where the firm has immediate access to a growth option that can never be lost to competition or technological obsolescence. In their framework, the firm will always exercise the growth option and restructure simultaneously (i.e., the growth option is always debt-financed).

intensity parameter for the disappearance of the growth option once it arrives, λ_2, is 0.50 (which gives an expected time to disappearance of 1/0.50 = 2 years), 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, b, are 25% of the liquidation value of assets in bankruptcy. These parameter values are chosen to match empirical estimates and/or base case parameter values in prior studies.[8]

3.2 Base case results

Table 1 reports the optimal initial coupon, C_0^*, the optimal restructuring coupon, C_1^*, the investment threshold, X_I, the restructuring threshold, X_{R1}, the default threshold before the growth opportunity arrives, X_d, the initial firm value, V_0, the initial market leverage ratio, ML_0, the credit spread (in basis points) of the initial debt issue, $CS_0 = \frac{C_0^*}{F} - r$, the initial Tobin's Q, Q_0, the initial equity beta, β_0, the market leverage ratio immediately after investment, ML_I, the credit spread of the initial debt issue immediately after investment, $CS_I = C_0^* / D^I(X_I, C_0^*) - r$, Tobin's Q immediately after investment, Q_I, equity beta immediately after investment, β_I, the market leverage ratio immediately after restructuring, ML_{R1}, the credit spread of the new debt issue immediately after restructuring, $CS_{R1} = C_1^* / D^{IR}(X_{R1}, C_1^*) - r$, Tobin's Q immediately after restructuring, Q_{R1}, equity beta immediately after restructuring, β_{R1}, and the first passage time

[8] For example, see Strebulaev (2007), Tserlukevich (2008), Tsyplakov (2008), and Hackbarth and Mauer (2012). Note that we set $X_0 = 11$ so there is value associated with waiting to invest – assuming the growth option has arrived – as reflected in an investment threshold of $X_I = 14.38$.

from X_I to X_{R1} conditional on no default prior to restructuring, FPT.[9] For brevity, the firm's financing policy if the growth option is lost before the firm invests is not reported in Table 1. The first row contains base case results, while subsequent rows report results for variation in parameter values.

For the base case, the investment threshold is $X_I = 14.38$ and the restructuring threshold is $X_{R1} = 18.00$. Thus, when the growth option arrives at $\tilde{T}_1$, if $X(\tilde{T}_1) < X_I$, the firm waits until $X = X_I$ to invest and finances the investment with equity; if $X_I \le X(\tilde{T}_1) < X_{R1}$, the firm invests immediately and finances the investment with equity; and if $X(\tilde{T}_1) \ge X_{R1}$, the firm invests immediately and finances the investment with a new debt issue. Using standard calculations for geometric Brownian motion, the probability that $X(\tilde{T}_1) \ge X_{R1}$ is 0.09. The implication is that there is less than a one in ten chance that the firm will finance growth with debt. From a different perspective, if the growth option arrived at $X(\tilde{T}_1) = X_I$, the firm will finance the growth opportunity with equity and will then wait on average 4.29 years before issuing additional debt (i.e., FPT = 4.29 years). The implication is that uncertain growth opportunities are generally financed with equity rather than debt.

This result is driven by the interplay between the random arrival of the growth option and the limited time to invest because it may be lost. Thus the growth option may arrive in a low cash flow state and the firm may not have the luxury to wait to invest in a higher cash flow state where the additional debt capacity of the growth option would make it optimal to finance the

[9] The market leverage ratio is the market value of debt divided by total firm value. Tobin's Q is firm value divided by assets-in-place. Assets-in-place are calculated as $((1-\tau)X)/\delta$ before investment and $((1-\tau)\Pi X)/\delta$ after investment. The equity beta is calculated as $\beta(X,C) = [(X \cdot E_x(X,C))/E(X,C)]\beta_X$, where the cash flow beta, β_X, is normalized to 1.0. The first passage time from X_I to X_{R1} is the expected time it takes X to reach X_{R1} when starting at X_I, conditional on X not being absorbed at X_{dI}.

investment with debt. The firm therefore uses equity to finance investment in the growth option before it is lost, and then waits for a higher cash flow before restructuring with a new debt issue having a larger coupon (i.e., $X_{R1} > X_I$).

Consistent with the delayed debt issue decision in our model, Leary and Roberts (2005) report that decreases in leverage due to large equity issues are reversed by a debt issue two to four years after the equity issue. The decision to finance growth with equity is also consistent with a growing stream of empirical evidence showing violations of the pecking-order for financing decisions under which debt issues are preferred to equity issues because of adverse selection problems resulting from asymmetric information.[10] For example, Frank and Goyal (2003) find that small high-growth firms that are typically viewed as having a high degree of information asymmetry are actually more likely to issue equity rather than debt. In a similar vein, Leary and Roberts (2010) report that only 17% of the firms in their sample follow the pecking order prescription of issuing debt rather than equity despite having the capacity to issue debt.

Our analysis shows that violations of the pecking order can be explained by uncertain growth options. Thus, for example, the model predicts that equity financing is the preferred form of external financing for firms with growth options generated by R&D activity in highly competitive industries (e.g., the hi-tech industry). As a special case, however, the model predicts that the pecking order preference for debt financing will hold for firms where growth options arrive regularly and the firm has a comparative advantage in exercising these options or faces little competition. Thus as seen in Table 1, as λ_1 increases or λ_2 decreases, the distance between the investment and restructuring thresholds decreases. For example, if after arriving the growth

[10] See, e.g., Bharath, Pasquariello, and Wu (2009), Fama and French (2005), Frank and Goyal (2003), Leary and Roberts (2010), and Lyandres, Sun, and Zhang (2008).

option is expected to be lost sometime in the next ten years (i.e., $\lambda_2 = 0.10$), the investment and restructuring boundaries coincide and the firm will finance the growth option with debt.

Even though X_I and X_{R1} converge as λ_2 decreases, the uncertain arrival of the growth option drives differences in policy choices in comparison to the standard real options assumptions that the firm has immediate access to the growth option ($\lambda_1 = \infty$) and it will never be lost ($\lambda_2 = 0$). This "frictionless" case has investment and restructuring thresholds of $X_I = X_{R1} = 26.11$. In comparison, even though the thresholds converge to $X_I = X_{R1} = 18.29$ when $\lambda_1 = 0.25$ and $\lambda_2 = 0.10$ (see Table 1), they continue to be significantly lower than the frictionless thresholds. The reason is that the firm's initial (i.e., at $X = X_0$) debt capacity is lower when facing an uncertain growth option, and consequently the firm is more eager to invest and lever up once the growth option arrives.

Ours is not the only theory that can help explain violations of financing pecking-order behavior. As noted above, Tsyplakov (2008) predicts a preference for equity financing in a model with time-to-build that generates a lag between investment and the cash flow generated by the investment. From a different perspective, Morellec and Schurhoff (2011) show in a dynamic model with asymmetric information that firms with positive private information can signal their type by using equity financing to invest early in a real option. In comparison, our analysis shows that absent information asymmetry and time-to-build frictions, uncertain growth options can also generate a preference for equity financing.

Panel A of Figure 1 illustrates the relation between the firm's market leverage ratio, ML, and X. The solid curve depicts the market leverage ratio before the arrival of the growth option at (random) time $\tilde{T}_1$, and the dashed curve depicts the market leverage ratio after the arrival of the growth option. The two vertical lines are the locations of the investment threshold X_I and the restructuring threshold X_{R1}, respectively.

The most striking features of the leverage dynamics in Panel A are the jump down in leverage after investment and the jump up in leverage after restructuring. The jump down in leverage along the dashed curve reflects equity-financed investment in the growth option at $X = X_I$. The jump up in leverage along the dashed curve at $X = X_{R1}$ reflects the decision to restructure and increase the debt level at a later point in time, i.e., $X_{R1} > X_I$.

The leverage dynamics illustrate that the firm can exhibit debt conservatism for an extended period of time. Thus starting at an initial leverage ratio of 0.42, the leverage ratio declines along the solid curve to about 0.32 at X_I.[11] Assuming the growth option arrives and the firm invests, the market leverage ratio drops to 0.20. The leverage ratio further declines along the dashed curve to 0.16 before the firm restructures to a much higher leverage ratio at X_{R1}. In the model, debt conservatism is driven by the decoupling of the investment and restructuring decisions. Since investment in growth is equity-financed and the time between investment and restructuring decisions can be years, the sharp decrease in leverage at investment is slow to reverse.

Panel B of Figure 1 illustrates the dynamics of the credit spread. Prior to the arrival of the growth opportunity (solid line), the credit spread is monotonically decreasing in X. The credit spread of debt *after* the growth option arrives (dashed line) has a sawtooth pattern; decreasing prior to X_I, increasing between $X_I < X < X_{R1}$ in anticipation of being called when the firm restructures its debt, and decreasing thereafter as X increases.

[11] Notice that for $X < X_I$, the leverage ratio before the arrival of the growth option (solid line) is always less than the leverage ratio after the arrival of the growth option (dashed line). The firm is more conservative with its choice of leverage before arrival because the growth option is lost in bankruptcy.

Panel C of Figure 1 illustrates the dynamics of the equity beta. Note that the equity beta is simply the elasticity of the market value of equity with respect to X multiplied by the beta of X, which we normalize to one. As in the previous figures, the solid curve plots the equity beta as a function of X prior to the arrival of the growth option, while the dashed curve plots the equity beta as a function of X after the arrival of the growth option.

Changes in the equity beta are driven by two factors: (a) the sensitivity of equity to the portfolio of assets-in-place and the growth option; and (b) the sensitivity of equity to financial leverage. As expected, the equity beta is decreasing in X prior to the arrival of the growth option (solid graph). The interesting beta dynamics are after the arrival of the growth option (dashed graph). For this case, first observe that equity beta is increasing as X approaches X_I. The intuition follows from the property that option sensitivity to volatility is maximized when an option is at the money. Thus as X approaches X_I, the equity beta reflects this heightened sensitivity since equity is a claim on a portfolio of assets that includes the growth option.[12] As soon as $X = X_I$, however, there is a sharp decrease in the equity beta because exercise of the growth option transforms the option into less risky assets-in-place. Note that since the growth option is financed with equity there is not an offsetting increase in risk associated with an increase in leverage. Finally, observe that when $X = X_{R1}$, the increase in leverage sharply increases the equity beta.

The dynamics of the equity beta has implications for the new issues puzzle (Loughran and Ritter (1995)), which is a negative relation between corporate external financing activity and future stock returns. The managerial market timing hypothesis of Loughran and Ritter (1995, 2000) and Ritter (2003) argues that there is a negative relation between equity financing and

[12] This effect overrides the anticipation of the reduction of risk associated with the decrease of financial leverage when the firm exercises the equity-financed growth option.

future stock returns because firms issue equity when it is overvalued to exploit market mispricing. Thus the marketing timing hypothesis predicts managers issue equity when they believe equity is overvalued and debt when they believe equity is undervalued, with the prediction of lower future stock returns for equity issuers than for debt issuers. The upshot is that the composition of external financing matters for the relation between external financing and expected stock returns.

In contrast, investment based explanations predict a negative relation between *any* external financing and expected stock returns. On the one hand, the *q*-theory of investment (Cochrane (1991, 1996) and Li and Zhang (2010)) argues that a decrease in expected return or cost of capital increases marginal *q* which encourages investment. Since a large source of funding for investment is through external financing, there is a negative relation between external financing and expected returns. On the other hand, the real options theory (Berk, Green, and Naik (1999) and Carlson, Fisher, and Giammarino (2004, 2006) argues that when firms invest, growth options are converted to less risky asset-in-place, and in response, expected returns decrease. This also predict a negative relation between external financing and expected stock returns if the exercise of growth options is funded through external financing.

Our model delivers predictions that are consistent with the managerial market timing hypothesis, even though managers are not trying to strategically time security issues. Analogous to the investment-based real options theory, we find that equity issues predicted a decrease in expected returns (equity beta) because the equity issue funds the conversion of a growth option to lower risk assets-in-place. In contrast, there is no change in investment when the firm recapitalizes by issuing debt. The increase in leverage without a corresponding reduction in asset risk increases expected returns (equity beta). Thus our model predicts lower stock returns after equity issues, but not after debt issues, which is consistent with empirical evidence (see, e.g., Loughran and Ritter (1995), Spiess and Affleck-Graves (1995, 1999), and Lyandres, Sun, and Zhang (2008)).

Panel D of Figure 1 illustrates the relation between Tobin's Q and X. Tobin's Q is increasing in X before the arrival of the growth option (solid curve) because the market value of the firm anticipates the arrival the option and its value is an increasing function of X. For $X < X_I$, Tobin's Q is also an increasing function of X after the arrival of the growth option (dashed curve). Once the firm invests at $X = X_I$, however, the growth option is transformed into assets-in-place and Q drops sharply and is essentially independent of X thereafter. As seen in Table 1, Tobin's Q is 1.23 at X_0 and 1.05 after investment at $X = X_I$. These value for Q are roughly consistent with the data.[13]

Given what we now know about how a firm will choose to finance an uncertain growth option, this pattern in Tobin's Q may suggest that the firm is timing equity issues when it is not. In an influential paper, Baker and Wurgler (2002) show that the external finance-weighted average Q is negatively related to the firm's current leverage.[14] They argue that this is consistent with equity market timing. In particular, firms tend to issue (repurchase) equity when their market value is relatively high (low), and past market timing attempts have persistent effects on capital structure. Our analysis of financing and investment decisions with an uncertain growth option induces a negative relation between the external finance-weighted average Q and leverage without equity market timing.

[13] Flannery and Rangan (2006) report a mean (median) market-to-book ratio of 1.62 (1.04) in a Compustat sample from 1965 to 2001, while Frank and Goyal (2009) report a mean (median) market-to-book ratio of 1.76 (1.00) in a Compustat sample from 1950 to 2003. More recently, Hackbarth and Mauer (2012) report a median market-to-book ratio of 1.37 in a Compustat sample from 1980 to 2007.

[14] The external finance-weighted average Q is the average of a firm's historical market-to-book ratios weighted by the amount of external financing activity.

With an uncertain growth option, the firm tends to finance the exercise of the option with an equity issue rather than a debt issue. This results in a low leverage ratio after investment, and since the option can arrive in a low cash flow state, a fairly long timespan between investment and when the firm optimally restructures and changes its debt level. The external finance-weighted average Q is then simply the Q ratio at the time of investment – the point on the solid curve in Panel D of Figure 1 at X_I – weighted by 1.0 (i.e., equity issue divided by the total amount of external finance which is simply the equity issue). Since the Q ratio at the time of investment is relatively high and the firm's leverage level is low, this induces the requisite negative relation between leverage and the historical external finance-weighted Q over the time period before the firm restructures.

Once the firm restructures, the leverage ratio jumps upward as seen in Panel A of Figure 1. However, the historical external finance-weighted average Q falls. This is because the Q ratio at the time of the new debt issue is relatively low (see the dashed curve in Panel D of Figure 1 at X_{R1}), and when part of the weighted average, it drags down the historical external finance-weighted average Q. This opposite co-movement of leverage and the external finance-weighted average Q again induces a negative relation between the two variables. Thus, when there are uncertain growth options and therefore a high likelihood of equity-financed investment followed by debt financing at a later time, the associated leverage and Q dynamics can produce a pattern that is consistent with equity market timing behavior, even though the firm's decisions are not driven by any incentive to time the market.

3.3 Effects of parameter variation on investment and financing policies

The rows below the base case in Table 1 show that the investment and financing dynamics discussed above are robust to variation in parameter values. Particularly, the timing inconsistency between investment and restructuring is a general result as long as the growth opportunity is not immediately available and the firm risks losing it while waiting to invest.

The key effect of the arrival rate of the growth option on model outcomes is that as λ_1 increases, the firm's cash flow, X, has less time to grow before the option disappears – for any value of $\lambda_2 > 0$.[15] As seen in Table 1, variation in λ_1 from 0.10 (expected arrival in 10 years) to 0.40 (expected arrival in 2.5 years) decreases the restructuring threshold, X_{R1}, but has a negligible effect on the investment threshold, X_I. Thus the firm is unwilling to compromise on when it is willing to commit $I = 200$ to exercise the growth option but does decrease the restructuring threshold. The net effect is that as λ_1 increases, the optimal initial and restructuring coupons, C_0^* and C_1^*, decrease as does firm value.

For a given arrival rate of the growth option, an increase in the likelihood of competition or technological obsolescence reduces the value of waiting to invest but does not (directly) influence the decision to restructure. Thus as seen in Table 1, an increase in λ_2 decreases X_I and overall firm value but has a negligible effect on X_{R1} and the coupon choices.[16] Lastly, as

[15] The growth option cannot disappear until it arrives, so as the arrival rate λ_1 increases the window of time the firm can invest decreases given $\lambda_2 > 0$.

[16] Note in Table 1 that there is a slight non-linear relation between λ_2 and C_0^*, C_1^*, and X_{R1}. A smaller λ_2 generally implies a longer expected waiting time before investment (X_I is higher) and therefore a lower probability of exercising the growth option, but a larger value for the growth option (Tobin's Q_0 is higher). The longer waiting time has an ambiguous effect on the firm's initial leverage choice; although the firm has an incentive to use more debt to boost tax shields while it waits, a larger initial leverage increases expected bankruptcy costs. The lower probability of exercising the growth option magnifies the significance of choosing higher debt to earn additional tax shields, but the increased value of the growth option magnifies the significance of expected bankruptcy costs. Taken together, the effect of λ_2 on the firm's initial leverage choice can be non-monotonic and this in turn can induce a non-monotonic effect on the restructuring threshold and corresponding leverage choice.

noted above, observe in Table 1 that the investment and restructuring thresholds coverage as λ_2 decreases. This convergence, however, is very slow. In particular, λ_2 must be about 0.10 (i.e., the growth option is expected to disappear in 10 years) before the two thresholds are essentially equal.[17]

As the growth rate of cash flows, μ, increases, the firm optimally chooses a larger initial coupon, C_0^*, and invests sooner to boost pre-tax cash flows and moderate bankruptcy risk. Note also that with the larger initial coupon, the firm waits longer to restructure to $C_1^* > C_0^*$. Since X_I is decreasing in μ and X_{R1} is increasing in μ, the expected first passage time between the thresholds increases significantly. In particular, as seen in Table 1, FPT is only 0.33 years when $\mu = 0.005$ and increases to 7.68 years when $\mu = 0.015$. The empirical implications are that firms expecting faster cash flow growth wait longer to issue debt after investment and wait longer between debt issues (i.e., the time between X_0 and X_{R1} is also increasing in μ).

As expected, higher cash flow volatility increases both the investment threshold and the restructuring threshold. This follows directly from option pricing theory where an increase in uncertainty increases the value of waiting and thereby encourages later exercise. The influence of higher cash flow volatility on optimal leverage is substantial. As seen in in Table 1, an increase in σ from 0.20 to 0.30 results in a significant decrease in the initial market leverage ratio – from 0.52 to 0.37 – despite a higher overall firm value. Note also that although higher volatility increases the optimal coupon when the firm restructures, the market leverage ratio immediately after restructuring decreases. The decrease in optimal leverage reflects greater bankruptcy risk

[17] Although Table 1 reports that $X_I = X_{R1} = 18.29$ when $\lambda_2 = 0.10$, X_{R1} is slightly larger than X_I.

and therefore cost of debt financing. Thus, observe that the credit spreads of debt at time 0 and at the restructuring point sharply increase as volatility increases.

An increase in the corporate tax rate has two primary effects. On the one hand, the firm's after-tax cash flows are lower which decreases the value of assets-in-place and the value of the grow option. This decreases overall firm value and encourages the firm to wait longer before investing in the growth option and subsequently restructuring (i.e., both X_I and X_{R1} increase as τ increases). The firm attempts to mitigate the higher tax burden, however, by increasing the coupon of the initial debt issue, C_0^*, and the coupon of the new debt issue when it restructures, C_1^*. As a result, we see in Table 1 that as the corporate tax rate increases from 0.10 to 0.20, the initial market leverage ratio, ML_0, increases from 0.34 to 0.47 and the market leverage ratio immediately after restructuring, ML_{R1}, increases from 0.44 to 0.60.

The primary effect of an increase in bankruptcy costs is that optimal leverage decreases. As seen in Table 1, as proportional bankruptcy costs, b, increase from 0.10 to 0.40, the optimal initial coupon (market leverage ratio) decreases from 9.23 (0.51) to 5.68 (0.35) and the restructuring coupon (market leverage ratio) decreases from 33.00 (0.66) to 20.30 (0.45). As expected, an increase in bankruptcy costs decreases firm value.

The firm pursues a more aggressive growth option investment policy as the option's cash flow multiplier, Π, increases. Thus, as Π increases from 1.75 to 2.25, X_I decreases from 19.23 to 11.37, and the probability that the firm immediately invests in the growth option when it arrives increases from 0.07 to 0.40 (not reported in Table 1). The increase in the payoff of the growth option, however, has a negligible effect on financial policy. Although the increase in the cash flow multiplier encourages the firm to use more debt initially in anticipation of being able to earn larger interest tax shields, the increase in the value of the growth option makes bankruptcy prior to the exercise of the option more costly which tempers the incentive to increase leverage. As seen in the table, the increase in Π from 1.75 to 2.25 results in only small increases in C_0^* and C_1^* and virtually no changes in ML_0 and ML_{R1}.

4. Interactions between financing and investment decisions

We examine the values of and the interactions between the growth and restructuring options. Table 2 reports model outcomes for a firm with a progressively more flexible (valuable) growth option, with and without a restructuring option. In addition to no growth option, the three growth option cases examined in the table are a (i) "fleeting growth option" where the option arrives randomly and disappears immediately after arrival (i.e., once the option arrives the firm has a now or never investment decision); (ii) "temporary growth option" where the option arrives randomly and may disappear (i.e., the situation examined in Section 3); and (iii) "permanent growth option" where the firm may exercise the option at any time without threat of competition or technological obsolescence (i.e., the standard real options setting where the option is immediately available and is never lost).[18] For expositional purposes, the cases reported in the table are given the short-hand notation (i, j), where i = N (no growth option), F (fleeting growth option), T (temporary growth option), and P (permanent growth option); and j = N (no restructuring option) and R (restructuring option). The parameter values used for the computations reported in Table 2 are the base case values from Table 1.

As seen in the table, firm value, V_0, is 197.09 in case NN where the firm has no growth opportunity and no restructuring option, and increases to 199.23 when the firm has the flexibility to restructure debt (i.e., case NR). The restructuring option, however, increases firm value by

[18] Computational details for these various cases are available upon request.

only 1.09% in the absence of the growth option. In comparison, V_0 is 225.64 in case TN, and 250.94 in case PN. That is, in the absence of a restructuring option, a temporary growth option increases firm value by 14.49% (relative to case NN), while a permanent growth option increases firm value by 27.32% (relative to case NN). Thus, compared with the value of the growth option, the value of the restructuring option is modest, which suggests that firms should restructure infrequently. This is consistent with results in Lemmon, Roberts, and Zender (2008) who find empirically that firms' capital structures are very persistent.

Importantly, however, when the firm has a growth option, the option to restructure is more valuable. Comparing case TN with case TR, firm value increases from 225.64 to 230.73. That is, the restructuring option increases firm value by 2.26% when the firm has a temporary growth option, which is double the value added by the restructuring option when the firm has no growth option (1.09%). Similarly, comparing case PN with case PR, firm value increases from 250.94 to 257.59. That is, the restructuring option adds 2.65% to firm value when the firm has a permanent growth option. Since the growth option enhances firm cash flows (or might do so in the case of a fleeting or temporary growth option), the firm's debt capacity and tax shield benefits also increase, and therefore so does the value added by the restructuring option.

The restructuring option also makes the growth option more valuable. Comparing cases NR and TR, firm value increases from 199.23 to 230.73. That is, given that the firm has a restructuring option, a temporary growth option increases firm value by 15.81%, as opposed to 14.49% when the firm has no restructuring option (i.e., the increase in firm value when moving from NN to TN). Similarly, comparing cases NR and PR, firm value increases from 199.23 to 257.59, which is a 29.29% increase in firm value versus a 27.32% increase in firm value when the firm has no restructuring option (i.e., the increase in firm value when moving from NN to PN).

To understand why the restructuring option enhances the value of the growth option, first recall that the growth option affects the value of the restructuring option by influencing the amount and timing of future cash flows and therefore the trade-off between debt tax shields and bankruptcy costs. As such, we can view the growth option as an option on a portfolio which consists of the claim to incremental cash flows from investment and the restructuring option, if available, to optimally adjust the debt-equity mix. Since having the restructuring option increases the value of the portfolio underlying the growth option, the value of the growth option in turn increases.

Since the growth option and the restructuring option are mutually value-enhancing, the firm enjoys a growth-financing synergy when it has both. As seen in Table 2, relative to the case where the firm has no growth option and no restructuring option (NN), having a restructuring option and a temporary growth option (TR) increases firm value by 17.07% (230.73/197.09 − 1). Since, independently, the restructuring option and the temporary growth option increase firm value by 1.09% and 14.49%, respectively, the synergy between the uncertain growth option and the restructuring option adds another 1.49% (= 17.07 − 1.09 − 14.49) to firm value. The synergy between the restructuring option and the permanent growth option is even more significant. Having both options increases firm value by 30.70% (257.59/197.09 − 1). Since the restructuring option and the permanent growth option independently contribute 1.09% and 27.32% to firm value, the synergy between the two is 2.29% (= 30.70 − 1.09 − 27.32).

5. Conclusions

We examine interactions between investment and financing decisions in a setting where the firm has a randomly arriving and potentially disappearing growth option and where the firm makes an initial capital structure choice and has an option to recapitalize in the future. In contrast to standard real options models where the firm has monopolistic access to a growth option that it can always profitably exercise in the future, the growth option in our model can arrive in a bad cash flow state and the firm may not have the luxury of waiting to invest. We argue that this type of growth option is more realistic; especially in industries where competition and/or technological obsolescence are the norm.

We find that the firm will typically finance the exercise of the growth option with equity and will wait before recapitalizing and increasing its debt level. The lack of coordination between the timing of investment and debt financing can help explain a number of findings in the empirical literature, including violation of the financing pecking order, debt conservatism, apparent market timing of security issues, and more pronounced underperformance after equity issues than after debt issues. Analysis of the model also quantifies economically significant interactions between growth options and financial flexibility

Appendix A. Equity and debt values

Here we present equity and debt values for the cases before and after the growth option arrives. We proceed by working backwards from a point in time after arrival of the growth option to before arrival of the growth option.

Equity and debt values after restructuring and investment in the growth option

If restructuring occurs after the firm has exercised the growth option, the firm's EBIT is ΠX and the coupon payment of the debt is C_1. For $X > X_{dIR}$, standard arguments give the value of equity as

$$E^{IR}(X, C_1) = (1-\tau)\left(\frac{\Pi X}{\delta} - \frac{C_1}{r}\right) - (1-\tau)\left(\frac{\Pi X_{dIR}}{\delta} - \frac{C_1}{r}\right)\left(\frac{X}{X_{dIR}}\right)^{\beta_2}, \tag{A1}$$

where X_{dIR} is the default threshold, the ratio $(X / X_{dIR})^{\beta_2}$ is the value of a contingent claim paying \$1 if EBIT hits X_{dIR} the first time from above, and $\beta_2 < 0$ is the negative root of the quadratic equation $x(x-1)\sigma^2/2 + x\mu - r = 0$. Since default is determined endogenously to maximize the market value of equity, equity value in (A1) must satisfy a smooth-pasting condition at the default threshold, $\partial E^{IR} / \partial X \,|_{X = X_{dIR}} = 0$. Using this condition, we may determine that

$$X_{dIR} = \left(\frac{\beta_2}{\beta_2 - 1}\right)\left(\frac{C_1 / r}{\Pi / \delta}\right). \tag{A2}$$

The market value of debt after restructuring and investment in the growth option is, for $X > X_{dIR}$, given by

$$D^{IR}(X,C_1)=\frac{C_1}{r}\left(1-\left(\frac{X}{X_{dIR}}\right)^{\beta_2}\right)+(1-b)\frac{(1-\tau)\Pi X_{dIR}}{\delta}\left(\frac{X}{X_{dIR}}\right)^{\beta_2}, \tag{A3}$$

where $(1-b)((1-\tau)\Pi X_{dIR})/\delta$ is the net of proportional bankruptcy costs, *b*, liquidation value of assets in bankruptcy (i.e., when $X = X_{dIR}$). Summing (A1) and (A3), we may compute firm value after restructuring and investment as

$$V^{IR}(X,C_1)=\frac{(1-\tau)\Pi X}{\delta}+\frac{\tau C_1}{r}\left(1-\left(\frac{X}{X_{dIR}}\right)^{\beta_2}\right)-\frac{b(1-\tau)\Pi X_{dIR}}{\delta}\left(\frac{X}{X_{dIR}}\right)^{\beta_2}, \tag{A4}$$

which is the sum of unlevered value (i.e., value of assets-in-place) and tax shield value, minus bankruptcy costs. The optimal coupon at the restructuring threshold, C_1^*, can be found by maximizing (A4) with respect to C_1 and setting $X = X_{R1}$:

$$C_1^* = \frac{(\beta_2-1)r\Pi}{\beta_2\delta}\psi X_{R1}, \tag{A5}$$

where $\psi = \left[1-\beta_2(1+b/\tau-b)\right]^{\beta_2^{-1}}$.

Equity and debt values after restructuring when the growth option is lost

We denote C_2 as the coupon of debt if the firm restructures after the growth option is lost because of competition or technological obsolescence. In this case, the value of equity and debt – for $X > X_{dR}$ – are equal to

$$E^R(X,C_2)=(1-\tau)\left(\frac{X}{\delta}-\frac{C_2}{r}\right)-(1-\tau)\left(\frac{X_{dR}}{\delta}-\frac{C_2}{r}\right)\left(\frac{X}{X_{dR}}\right)^{\beta_2}, \tag{A6}$$

and

$$D^R(X,C_2)=\frac{C_2}{r}\left(1-\left(\frac{X}{X_{dR}}\right)^{\beta_2}\right)+(1-b)\frac{(1-\tau)X_{dR}}{\delta}\left(\frac{X}{X_{dR}}\right)^{\beta_2}, \tag{A7}$$

where the default threshold, X_{dR}, satisfies $\partial E^R/\partial X|_{X=X_{dR}}=0$ and is equal to

$$X_{dR}=\left(\frac{\beta_2}{\beta_2-1}\right)\left(\frac{\delta C_2}{r}\right). \tag{A8}$$

Summing (A6) and (A7) to compute firm value:

$$V^R(X,C_2)=\frac{(1-\tau)X}{\delta}+\frac{\tau C_2}{r}\left(1-\left(\frac{X}{X_{dR}}\right)^{\beta_2}\right)-\frac{b(1-\tau)X_{dR}}{\delta}\left(\frac{X}{X_{dR}}\right)^{\beta_2}, \tag{A9}$$

we may compute the firm value-maximizing coupon at the restructuring threshold, $X=X_{R2}$, as

$$C_2^*=\frac{(\beta_2-1)r}{\beta_2\delta}\psi X_{R2}, \tag{A10}$$

where ψ is defined below (A5).

Equity and debt values after investment but before restructuring

This case occurs when $X_I<X_{R1}$. If $X_I=X_{R1}$, investment and restructuring occur at the same time and this case does not exist. Thus when $X_I<X_{R1}$, the general solutions for the market values of equity and debt are

$$E^{I}(X,C_0)=\frac{(1-\tau)\Pi X}{\delta}-\frac{(1-\tau)C_0}{r}+\mathrm{A}_1X^{\beta_1}+\mathrm{A}_2X^{\beta_2}, \qquad X_{dI}<X<X_{R1}, \qquad \text{(A11)}$$

and

$$D^{I}(X,C_0)=\frac{C_0}{r}+\mathrm{B}_1X^{\beta_1}+\mathrm{B}_2X^{\beta_2}, \qquad X_{dI}<X<X_{R1}, \qquad \text{(A12)}$$

where the default threshold X_{dI} and the constants A_1, A_2, B_1, and B_2 are determined by boundary conditions discussed in Appendix B, and β_1 and β_2 are the positive and negative roots of the quadratic equation $x(x-1)\sigma^2/2+x\mu-r=0$.

Equity and debt values before restructuring given the growth option is lost

For this case, the general solutions for the market values of equity and debt are

$$E^{2}(X,C_0)=\frac{(1-\tau)X}{\delta}-\frac{(1-\tau)C_0}{r}+\mathrm{A}_3X^{\beta_1}+\mathrm{A}_4X^{\beta_2}, \qquad X_{d2}<X<X_{R2}, \qquad \text{(A13)}$$

and

$$D^{2}(X,C_0)=\frac{C_0}{r}+\mathrm{B}_3X^{\beta_1}+\mathrm{B}_4X^{\beta_2}, \qquad X_{d2}<X<X_{R2}, \qquad \text{(A14)}$$

where the default threshold X_{d2} and the constants A_3, A_4, B_3, and B_4 are determined by boundary conditions discussed in Appendix B.

Equity and debt values before restructuring and investment in the growth option

Assuming the growth option has arrived and has not been lost due to competition or technological obsolescence, the differential equations that the market values of equity and debt must satisfy are

$$(\sigma^2/2)X^2E^1_{XX} + \mu XE^1_X - rE^1 + (1-\tau)(X - C_0) + \lambda_2(E^2 - E^1) = 0\,, \qquad X_{d1} < X < X_I\,, \quad \text{(A15)}$$

and

$$(\sigma^2/2)X^2D^1_{XX} + \mu XD^1_X - rD^1 + C_0 + \lambda_2(D^2 - D^1) = 0\,, \qquad X_{d1} < X < X_I\,, \quad \text{(A16)}$$

where X_{d1} is the default threshold when the growth option is available but unexercised, and $\lambda_2(E^2 - E^1)$ and $\lambda_2(D^2 - D^1)$ capture the transition in value functions if the growth option is lost with probability $\lambda_2 dt$. Substituting E^2 in (A13) into (A15) and D^2 in (A14) into (A16), we obtain the following general solutions for E^1 and D^1:

$$E^1 = \frac{(1-\tau)X}{\delta} - \frac{(1-\tau)C_0}{r} + \mathrm{M}_1X^{\varphi_1} + \mathrm{M}_2X^{\varphi_2} + \mathrm{A}_3X^{\beta_1} + \mathrm{A}_4X^{\beta_2}\,, \qquad X_{d1} < X < X_I\,, \quad \text{(A17)}$$

and

$$D^1 = \frac{C_0}{r} + \mathrm{N}_1X^{\varphi_1} + \mathrm{N}_2X^{\varphi_2} + \mathrm{B}_3X^{\beta_1} + \mathrm{B}_4X^{\beta_2}\,, \qquad X_{d1} < X < X_I\,, \quad \text{(A18)}$$

where M_1, M_2, N_1, and N_2 are constants determined by boundary conditions, and φ_1 and φ_2 are the positive and negative roots of the quadratic equation $x(x-1)\sigma^2/2 + x\mu - (r + \lambda_2) = 0$.

Equity and debt values before the arrival of the growth option

The equity and debt values before the arrival of the growth option depend on the level of the firm's earnings, *X*, relative to X_{d1}, X_I, and X_{R1} because the arrival of the growth option with probability $\lambda_1 dt$ will determine whether the firm defaults immediately ($X \le X_{d1}$), waits to invest ($X_{d1} < X < X_I$), invests immediately ($X_I \le X < X_{R1}$), or invests and restructures immediately ($X \geq X_{R1}$). In what follows we consider each case in turn starting with high values of X and working through progressively lower values of X.

Region "H" (high): growth option arrives when $X \geq X_{R1}$. In this region, equity and debt values must satisfy the differential equations:

$$(\sigma^2/2)X^2E_{XX}^H + \mu XE_X^H - rE^H + (1-\tau)(X - C_0) + \lambda_1[\{E^{IR} - (I - D^{IR}) - F\} - E^H] = 0, \quad \text{(A19)}$$

and

$$(\sigma^2/2)X^2D_{XX}^H + \mu XD_X^H - rD^H + C_0 + \lambda_1[F - D^H] = 0, \quad \text{(A20)}$$

where F is the time 0 market value of debt which is defined below. Substituting (A1) and (A3) into (A19), the general solutions of (A19) and (A20) are

$$E^H(X, C_0) = \frac{[1-\tau+\lambda_1\Pi(\tau\psi+1-\tau)/\delta]X}{\delta+\lambda_1} - \frac{(1-\tau)C_0}{r+\lambda_1} - \frac{\lambda_1(F+I)}{r+\lambda_1} + \mathrm{O}_1X^{\gamma_1} + \mathrm{O}_2X^{\gamma_2}, \quad \text{(A21)}$$

and

$$D^H(X, C_0) = \frac{C_0 + \lambda_1 F}{r+\lambda_1} + P_1X^{\gamma_1} + P_2X^{\gamma_2}, \quad \text{(A22)}$$

where O_1, O_2, P_1, and P_2 are constants to be determined by boundary conditions, and γ_1 and γ_2 are the positive and negative roots of the quadratic equation $x(x-1)\sigma^2/2 + x\mu - (r+\lambda_1) = 0$. Note in (A21) and (A22) that we can set the constants O_1 and P_1 equal to zero using the no bubble conditions $E_X^h|_{X\to\infty} < \infty$ and $D_X^h|_{X\to\infty} < \infty$.

Region "M" (middle): growth option arrives when $X_I \leq X < X_{R1}$. This region exists when $X_I < X_{R1}$. If $X_I = X_{R1}$, investment and restructuring occur at the same time (see region "H") and this region does not exist. Thus when $X_I \leq X < X_{R1}$, the firm invests immediately but waits to restructure. The differential equations for the equity value, E^M, and debt value, D^M, are the same as those in (A19) and (A20) except the transition terms are $\lambda_1(E^I - E^M - I)$ and $\lambda_1(D^I - D^M)$, respectively. Substituting E^I in (A11) and D^I in (A12) into these differential equations and solving them gives the general solutions for equity and debt values in the middle region as

$$E^M(X, C_0) = \frac{(1-\tau)(1+\lambda_1\Pi/\delta)X}{\delta+\lambda_1} - \frac{(1-\tau)C_0}{r} - \frac{\lambda_1 I}{r+\lambda_1} + \mathrm{O}_3 X^{\gamma_1} + \mathrm{O}_4 X^{\gamma_2} + \mathrm{A}_1 X^{\beta_1} + \mathrm{A}_2 X^{\beta_2}, \quad \text{(A23)}$$

and

$$D^M(X, C_0) = \frac{C_0}{r} + \mathrm{P}_3 X^{\gamma_1} + \mathrm{P}_4 X^{\gamma_2} + \mathrm{B}_1 X^{\beta_1} + \mathrm{B}_2 X^{\beta_2}, \quad \text{(A24)}$$

where O_3, O_4, P_3, and P_4 are constants to be determined by boundary conditions.

Region "L" (low): growth option arrives when $X_{d1} < X < X_I$. In the low region, the firm will not invest (or restructure) should the growth option arrive in the next instant. The differential equations for the equity value, E^L, and debt value, D^L, are the same as those in (A19) and (A20) except the transition terms are $\lambda_1(E^1 - E^L)$ and $\lambda_1(D^1 - D^L)$, respectively. Substituting E^1 in (A17) and D^1 in (A18) into these differential equations and solving them gives the general solutions for equity and debt values in the low region as

$$E^L(X, C_0) = \frac{(1-\tau)X}{\delta} - \frac{(1-\tau)C_0}{r} + \mathrm{O}_5 X^{\gamma_1} + \mathrm{O}_6 X^{\gamma_2} + \frac{\lambda_1}{\lambda_1 - \lambda_2}\mathrm{M}_1 X^{\varphi_1}$$

$$+ \frac{\lambda_1}{\lambda_1 - \lambda_2}\mathrm{M}_2 X^{\varphi_2} + \mathrm{A}_3 X^{\beta_1} + \mathrm{A}_4 X^{\beta_2}, \quad \text{(A25)}$$

and

$$D^L(X,C_0) = \frac{C_0}{r} + \mathrm{P}_5 X^{\gamma_1} + \mathrm{P}_6 X^{\gamma_2} + \frac{\lambda_1}{\lambda_1 - \lambda_2}\mathrm{N}_1 X^{\varphi_1} + \frac{\lambda_1}{\lambda_1 - \lambda_2}\mathrm{N}_2 X^{\varphi_2} + \mathrm{B}_3 X^{\beta_1} + \mathrm{B}_4 X^{\beta_2}, \quad \text{(A26)}$$

where O_5, O_6, P_5, and P_6 are constants to be determined by boundary conditions.

Region "d" (default): growth option arrives when $X_d < X \le X_{d1}$. Denoting X_d as the default threshold before the growth option arrives and recalling that X_{d1} is the default threshold after the growth option arrives, if $X_d < X \le X_{d1}$ then the firm will default immediately should the growth option arrive in the next instant. Denoting E^d and D^d as the debt and equity values in this default region, the transition terms in the respective differential equations are $\lambda_1(0 - E^d)$ and $\lambda_1\left([(1-b)(1-\tau)X]/\delta - D^d\right)$. Note that equity jumps to zero value (assuming absolute priority is respected in bankruptcy) and debt value jumps to the liquidation value of assets net of bankruptcy costs. The general solutions for equity and debt values are

$$E^d(X,C_0) = \frac{(1-\tau)X}{\delta+\lambda_1} - \frac{(1-\tau)C_0}{r+\lambda_1} + \mathrm{O}_7 X^{\gamma_1} + \mathrm{O}_8 X^{\gamma_2}, \quad \text{(A27)}$$

and

$$D^d(X,C_0) = \frac{C_0}{r+\lambda_1} + \frac{\lambda_1(1-b)(1-\tau)X}{\delta(\delta+\lambda_1)} + \mathrm{P}_7 X^{\gamma_1} + \mathrm{P}_8 X^{\gamma_2}, \quad \text{(A28)}$$

where O_7, O_8, P_7, and P_8 are constants to be determined by boundary conditions.

Depending upon X_0 and therefore whether the firm is in region "*H*", "*M*", or "*L*" at time 0, the "face value" of debt is defined as $F \equiv D^j(X_0, C_0^*)$ for *j* = *H*, *M*, or *L*.[19] The corresponding

[19] To avoid the uninteresting solution where the firm defaults immediately when the growth option arrives, we assume $X_0 > X_{d1}$.

optimal initial coupon, C_0^*, is chosen to maximize firm value (i.e., the sum of the equity and debt values) in the corresponding region *H*, *M*, or *L*.

Appendix B. Optimal investment, restructuring, and default policies

Here we specify the boundary conditions that allow for the solutions of the investment, restructuring, and default thresholds as well as the constants in the general solutions for the equity and debt values presented in Appendix A. Specification of these boundary conditions completes the solution of the model for the case where $X_I \le X_{R1}$.[20] In the special case where $X_I = X_{R1}$, some of the boundary conditions differ from those when $X_I < X_{R1}$ and we describe them separately.

Growth option investment threshold when $X_I < X_{R1}$

The level of X at which the firm optimally invests in the growth option, X_I, is chosen to maximize firm value. The value-matching and smooth-pasting conditions that equity and debt values must satisfy at the optimal investment threshold are

$$E^1(X_I, C_0) = E^I(X_I, C_0) - I\,, \tag{B1}$$

$$D^1(X_I, C_0) = D^I(X_I, C_0)\,, \tag{B2}$$

and

$$[E_X^1(X, C_0) + D_X^1(X, C_0)]|_{X=X_I} = [E_X^I(X, C_0) + D_X^I(X, C_0)]|_{X=X_I}\,, \tag{B3}$$

[20] It is straightforward to solve the model for the case where $X_{R1} < X_I$. For economically reasonable parameter values, however, the firm never chooses to restructure before exercising the growth option and so we do not present this case. The model solution when $X_{R1} < X_I$ is available upon request.

where the subscripts in (B3) denote derivatives. Conditions (B1) and (B2) require, respectively that equity and debt values immediately before investment equal their respective values after investment. Since the firm waits to restructure, $X_I < X_{R1}$, (B1) implies that the growth option is all-equity financed.[21] Lastly, the smooth-pasting condition (B3) is the first-order optimality condition requiring that the investment threshold maximizes firm value.

Restructuring thresholds when $X_I < X_{R1}$

There are two restructuring thresholds. If the firm invests in the growth option before it is lost to competition or technological obsolesence, then the firm optimally restructures when $X = X_{R1}$. The boundary conditions that jointly determine the equity and debt values and the optimal restructuring threshold are

$$E^I(X_{R1}, C_0) = E^{IR}(X_{R1}, C_1) + D^{IR}(X_{R1}, C_1) - F, \tag{B4}$$

$$D^I(X_{R1}, C_0) = F, \tag{B5}$$

and

$$[E_X^I(X, C_0) + D_X^I(X, C_0)]|_{X = X_{R1}} = [E_X^{IR}(X, C_1) + D_X^{IR}(X, C_1)]|_{X = X_{R1}}, \tag{B6}$$

where the face value of the initial debt issue, F, is assumed to be equal to its market value when issued at $X = X_0$.[22] Condition (B4) requires that equity value immediately before restructuring equals equity value after restructuring plus the proceeds from the new debt issue with coupon

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[21] As discussed below, when $X_I = X_{R1}$ the firm will invest and restructure simultaneously so that condition (B1) becomes $E^1(X_I, C_0) = E^{IR}(X_I, C_1) - [I + (F - D^{IR}(X_I, C_1))]$. In this case, the growth option is (partially) equity-financed only if $I > D^{IR}(X_I, C_1) - F$.

[22] Assuming that X_0 is above the post growth option arrival default threshold, X_{d1}, $F \equiv D^L(X_0, C_0)$ if $X_0 < X_I < X_{R1}$ and $F \equiv D^M(X_0, C_0)$ if $X_I \le X_0 < X_{R1}$.

$C_1 > C_0$ minus the face value payment to retire the initial time 0 debt issue. Reflecting the retirement of the initial debt issue, condition (B5) sets the initial debt value at the restructuring threshold equal to its face value. Finally, condition (B6) is the smooth-pasting optimality condition requiring that the restructuring threshold is chosen to maximize firm value.

If the growth option is lost, then the restructuring threshold, X_{R2}, and the equity and debt values are jointly determined by the boundary conditions:

$$E^2(X_{R2},C_0) = E^R(X_{R2},C_2) + D^R(X_{R2},C_2) - F\,, \tag{B7}$$

$$D^2(X_{R2},C_0) = F\,, \tag{B8}$$

and

$$[E_X^2(X,C_0) + D_X^2(X,C_0)]|_{X=X_{R2}} = [E_X^R(X,C_2) + D_X^R(X,C_2)]|_{X=X_{R2}}\,, \tag{B9}$$

where analogous to (B4)-(B6), (B7) and (B8) are value-matching conditions and (B9) is the smooth-pasting optimality condition.

Investment and restructuring thresholds when $X_I = X_{R1}$

In the special case where $X_I = X_{R1}$, investment and restructuring occur at the same time. Therefore, in place of equations (B4)-(B6), the value-matching and smooth-pasting conditions that equity and debt values must satisfy at the optimal restructuring/investment threshold are

$$E^I(X_I,C_0) = E^{IR}(X_I,C_1) + D^{IR}(X_I,C_1) - F\,, \tag{B10}$$

$$D^I(X_I,C_0) = F\,, \tag{B11}$$

and

$$[E_X^I(X,C_0) + D_X^I(X,C_0)]|_{X=X_I} = [E_X^{IR}(X,C_1) + D_X^{IR}(X,C_1)]|_{X=X_I}\,, \tag{B12}$$

The same boundary conditions (B7)-(B9) apply at the restructuring threshold X_{R2}.

Default thresholds

In addition to the default thresholds after investment and restructuring, X_{dIR} in (A2), and after restructuring given the growth option disappeared, X_{dR} in (A8), there are four more default thresholds. The boundary conditions for the default threshold before restructuring but after investment, X_{dI}, are

$$E^I(X_{dI}, C_0) = 0, \quad E_X^I(X, C_0)|_{X=X_{dI}} = 0, \text{ and } D^I(X_{dI}, C_0) = \frac{(1-b)(1-\tau)\Pi X_{dI}}{\delta}. \tag{B13}$$

In the special case where $X_I = X_{R1}$, the conditions in (B13) no longer apply. The boundary conditions for the default threshold before restructuring given the growth option is lost, X_{d2}, are

$$E^2(X_{d2}, C_0) = 0, \quad E_X^2(X, C_0)|_{X=X_{d2}} = 0, \text{ and } D^2(X_{d2}, C_0) = \frac{(1-b)(1-\tau)X_{d2}}{\delta}. \tag{B14}$$

The boundary conditions for the default threshold before investment and restructuring but after the arrival of the growth option, X_{d1}, are

$$E^1(X_{d1}, C_0) = 0, \quad E_X^1(X, C_0)|_{X=X_{d1}} = 0, \text{ and } D^1(X_{d1}, C_0) = \frac{(1-b)(1-\tau)X_{d1}}{\delta}. \tag{B15}$$

Finally, the boundary conditions for the default threshold before the arrival of the growth option, X_d, are

$$E^d(X_d, C_0) = 0, \quad E_X^d(X, C_0)|_{X=X_d} = 0, \text{ and } D^d(X_d, C_0) = \frac{(1-b)(1-\tau)X_d}{\delta}. \tag{B16}$$

Continuity conditions

For the case where $X_I < X_{R1}$, there are four sets of general solutions for equity and debt values before the arrival of the growth option that correspond to different regions of X.[23] These values must smoothly paste together as X transitions between adjoining regions. The conditions for equity and debt values as X transitions from the high (H) region to the middle (M) region at the boundary $X = X_{R1}$ are

$$E^H(X_{R1}, C_0) = E^M(X_{R1}, C_0), \qquad D^H(X_{R1}, C_0) = D^M(X_{R1}, C_0), \tag{B17}$$

and

$$E_X^H(X, C_0)|_{X=X_{R1}} = E_X^M(X, C_0)|_{X=X_{R1}}, \qquad D_X^H(X, C_0)|_{X=X_{R1}} = D_X^M(X, C_0)|_{X=X_{R1}}. \tag{B18}$$

The conditions in (B17) require that the equity and debt value functions be continuous at X_{R1} and the conditions in (B18) require that the first derivatives of the equity and debt value functions be continuous at X_{R1}. In the literature, (B17) and (B18) are typically called value-matching and smooth-pasting conditions, respectively. Note, however, that the conditions in (B18) are not first-order optimality conditions. Heuristically, they are rationality conditions requiring that equity and debt values anticipate, and smoothly transition through, X_{R1}.

Similar conditions are required as X transitions from the middle (M) region to the low (L) region at the boundary $X = X_I$:

$$E^M(X_I, C_0) = E^L(X_I, C_0), \qquad D^M(X_I, C_0) = D^L(X_I, C_0), \tag{B19}$$

[23] Recall, for example, that these regions of X determine whether the firms will invest or invest and restructure if the growth option arrives in the next instant of time.

and

$$E_X^M(X,C_0)|_{X=X_I} = E_X^L(X,C_0)|_{X=X_I}, \qquad D_X^M(X,C_0)|_{X=X_I} = D_X^L(X,C_0)|_{X=X_I}. \qquad \text{(B20)}$$

Finally, we have a set of continuity conditions as X transitions from the low (L) region to the default (d) region at the boundary $X = X_{d1}$:

$$E^L(X_{d1},C_0) = E^d(X_{d1},C_0), \qquad D^L(X_{d1},C_0) = D^d(X_{d1},C_0), \qquad \text{(B21)}$$

and

$$E_X^L(X,C_0)|_{X=X_{d1}} = E_X^d(X,C_0)|_{X=X_{d1}}, \qquad D_X^L(X,C_0)|_{X=X_{d1}} = D_X^d(X,C_0)|_{X=X_{d1}}. \qquad \text{(B22)}$$

In the special case where $X_I = X_{R1}$, there are three sets of general solutions for equity and debt values before the arrival of the growth option that correspond to different regions of X (region “M” no longer exists). Again, these values must smoothly paste together as X transitions between adjoining regions. The conditions for equity and debt values as X transitions from the high (H) region to the low (L) region at the boundary $X = X_I$ are

$$E^H(X_I,C_0) = E^L(X_I,C_0), \qquad D^H(X_I,C_0) = D^L(X_I,C_0), \qquad \text{(B23)}$$

and

$$E_X^H(X,C_0)|_{X=X_I} = E_X^L(X,C_0)|_{X=X_I}, \qquad D_X^H(X,C_0)|_{X=X_I} = D_X^L(X,C_0)|_{X=X_I}. \qquad \text{(B24)}$$

Similarly, as X transitions from the low (L) region to the default (d) region at the boundary $X = X_{d1}$, the conditions in (B21) and (B22) apply.

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Table 1

The Effect of Parameter Variation on Financing and Investment Decisions

This table reports the optimal initial coupon, C_0^*, the optimal restructuring coupon, C_1^*, the investment threshold, X_I, the restructuring threshold, X_{R1}, the default threshold before the growth option arrives, X_d, the initial firm value, V_0, the initial market leverage ratio, ML_0, the credit spread (in basis points) of the initial debt issue, $CS_0 = \frac{C_0^*}{F} - r$, the initial Tobin's Q, Q_0, the initial equity beta, $\beta_0 = [(X_0 \cdot E_X(X_0, C_0^*))/E(X_0, C_0^*)]\beta_X$, the market leverage ratio immediately after investment in the growth option, ML_I, the credit spread of the initial debt issue immediately after investment in the growth option, $CS_I = C_0^* / D^I(X_I, C_0^*) - r$, Tobin's Q immediately after investment in the growth option, Q_I, equity beta immediately after investment in the growth option, $\beta_I = [(X_I \cdot E_X^I(X_I, C_0^*))/E^I(X_I, C_0^*)]\beta_X$, the market leverage ratio immediately after restructuring, ML_{R1}, the credit spread of the new debt issue immediately after restructuring, $CS_{R1} = C_1^* / D^{IR}(X_{R1}, C_1^*) - r$, Tobin's Q immediately after restructuring, Q_{R1}, equity beta immediately after restructuring, $\beta_{R1} = [(X_{R1} \cdot E_X^{IR}(X_{R1}, C_1^*))/E^{IR}(X_{R1}, C_1^*)]\beta_X$, and the first passage time from X_I to X_{R1} conditional on no default prior to restructuring, FPT. The market leverage ratio is the market value of debt divided by firm value. Tobin's Q is firm value divided by assets-in-place, where assets-in-place are calculated as $((1-\tau)X)/\delta$ before investment and $((1-\tau)\Pi X)/\delta$ after investment. In the equity beta calculations, we normalize the cash flow beta, β_X, at 1.0. The base case parameter values are as follows: the initial cash flow before taxes, X_0, is 11, the cash flow multiplier upon investment in the growth option, Π, is 2.0, the investment outlay to exercise the growth option, I, is 200, the arrival rate of the growth option, λ_1, is 0.25, the intensity parameter for the disappearance of the growth option once it arrives, λ_2, is 0.5, 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, b, are 25% of the value of assets-in-place at the time of bankruptcy.

Table 1 continued

	C_0^*	C_1^*	X_I	X_{R1}	X_d	V_0	ML_0	CS_0	Q_0	β_0	ML_I	CS_I	Q_I	β_I	ML_{R1}	CS_{R1}	Q_{R1}	β_{R1}	FPT
Base	7.09	25.35	14.38	18.00	2.96	230.73	0.42	137.50	1.23	2.05	0.19	108.40	1.05	1.26	0.53	135.48	1.05	1.87	4.29
$\lambda_1 = 0.10$	7.43	26.58	14.37	18.87	3.03	233.13	0.43	139.62	1.25	1.97	0.20	105.74	1.06	1.27	0.53	135.48	1.05	1.87	4.96
$\lambda_1 = 0.40$	7.02	25.11	14.38	17.83	2.97	227.86	0.42	136.72	1.22	2.10	0.19	108.76	1.05	1.26	0.53	135.48	1.05	1.87	4.15
$\lambda_2 = 0.10$	7.20	25.75	18.29	18.29	2.89	239.67	0.40	147.53	1.28	1.93	NA	NA	NA	NA	0.53	135.48	1.05	1.87	0.00
$\lambda_2 = 0.20$	6.91	24.70	16.32	17.54	2.84	235.11	0.40	138.72	1.26	1.96	0.16	126.82	1.05	1.23	0.53	135.48	1.05	1.87	1.62
$\lambda_2 = 1.00$	7.24	25.90	13.40	18.39	3.04	228.70	0.43	137.89	1.22	2.11	0.21	101.88	1.06	1.29	0.53	135.48	1.05	1.87	5.50
$\lambda_2 = 2.00$	7.36	26.32	12.72	18.69	3.14	227.48	0.44	138.44	1.22	2.14	0.23	98.69	1.06	1.31	0.53	135.48	1.05	1.87	6.21
$\mu = 0.005$	6.20	20.47	15.79	16.02	2.81	202.70	0.41	146.33	1.19	1.98	0.16	143.64	1.05	1.24	0.53	144.67	1.05	1.84	0.33
$\mu = 0.015$	8.26	32.25	12.93	20.55	3.14	267.35	0.43	125.91	1.29	2.12	0.23	85.50	1.06	1.30	0.54	126.75	1.06	1.89	7.68
$\sigma = 0.20$	8.39	23.96	13.58	16.63	4.59	227.10	0.52	116.91	1.21	2.48	0.25	87.73	1.06	1.37	0.58	92.45	1.06	2.04	5.51
$\sigma = 0.30$	6.73	29.89	15.15	21.27	2.43	234.66	0.37	177.42	1.25	1.86	0.17	134.45	1.05	1.22	0.50	185.97	1.05	1.75	4.33
$\tau = 0.10$	5.75	20.51	13.88	17.88	2.44	239.48	0.34	100.90	1.21	1.88	0.16	78.91	1.03	1.21	0.44	100.19	1.03	1.65	5.07
$\tau = 0.20$	8.09	28.99	14.90	18.20	3.34	223.05	0.47	169.84	1.27	2.18	0.21	135.04	1.09	1.30	0.60	165.94	1.09	2.04	3.76
$b = 0.10$	9.23	33.00	14.19	17.88	3.75	235.88	0.51	170.99	1.26	2.36	0.24	133.07	1.07	1.36	0.66	171.81	1.07	2.32	3.93
$b = 0.40$	5.68	20.30	14.51	17.76	2.41	227.62	0.35	116.55	1.22	1.86	0.16	94.23	1.04	1.20	0.45	115.48	1.04	1.65	4.27
$\Pi = 1.75$	7.01	25.06	19.23	20.33	2.98	212.34	0.45	136.81	1.14	1.92	0.16	127.60	1.05	1.23	0.53	135.48	1.05	1.87	1.27
$\Pi = 2.25$	8.09	28.93	11.37	18.26	3.26	258.51	0.42	139.89	1.38	2.25	0.25	96.50	1.06	1.33	0.53	135.48	1.05	1.87	6.93

Table 2

Interactions Between Financing and Investment Decisions

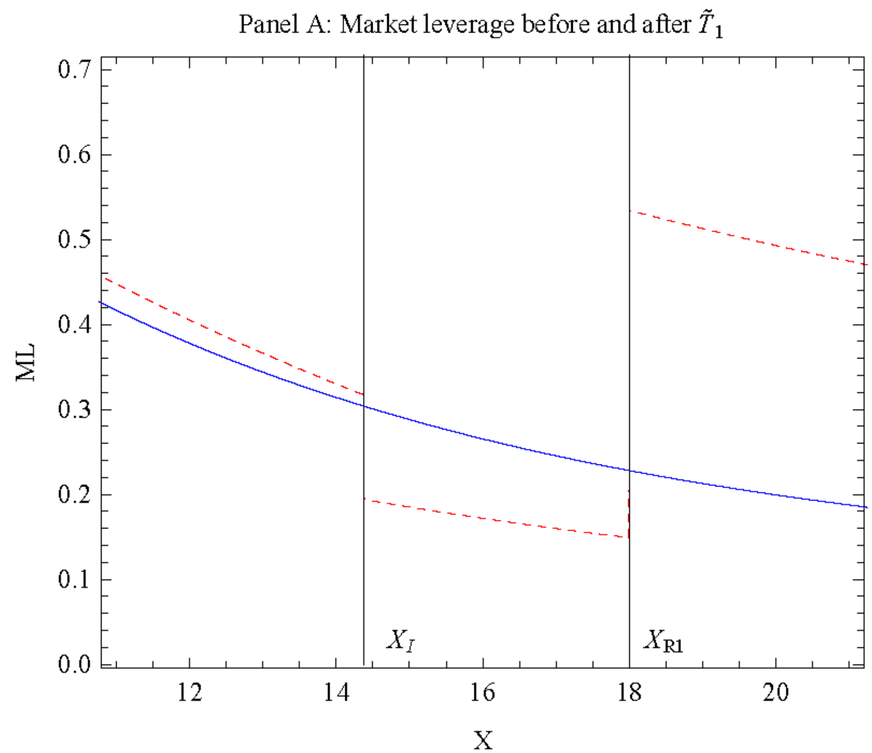
The table reports model outcomes for firms with various combinations of restructuring and growth options. A fleeting growth option arrives randomly and disappears immediately after arrival (i.e., once the growth option arrives the firm has a now or nothing investment decision). A temporary growth option arrives randomly and may quickly disappear (i.e., competition and/or technological obsolescence may destroy the value of the growth option). A permanent growth option refers to the case where the firm may exercise the option at any time without threat of competition or technological obsolescence (i.e., the classic real options case of monopolistic access to a growth option). For expositional purposes, the cases reported in the table are given the short-hand notation (i, j), where i = N (no growth option), F (fleeting growth option), T (temporary growth option), P (permanent growth option) and j = N (no restructuring option) and R (restructuring option). The parameter values used to solve the model are the same as those in the base case of Table 1. Exercise of the fleeting, temporary, and permanent growth options increases firm cash flows by the same factor, Π, and requires the same investment outlay, *I*. The variables reported in the columns of the table are defined in Table 1.

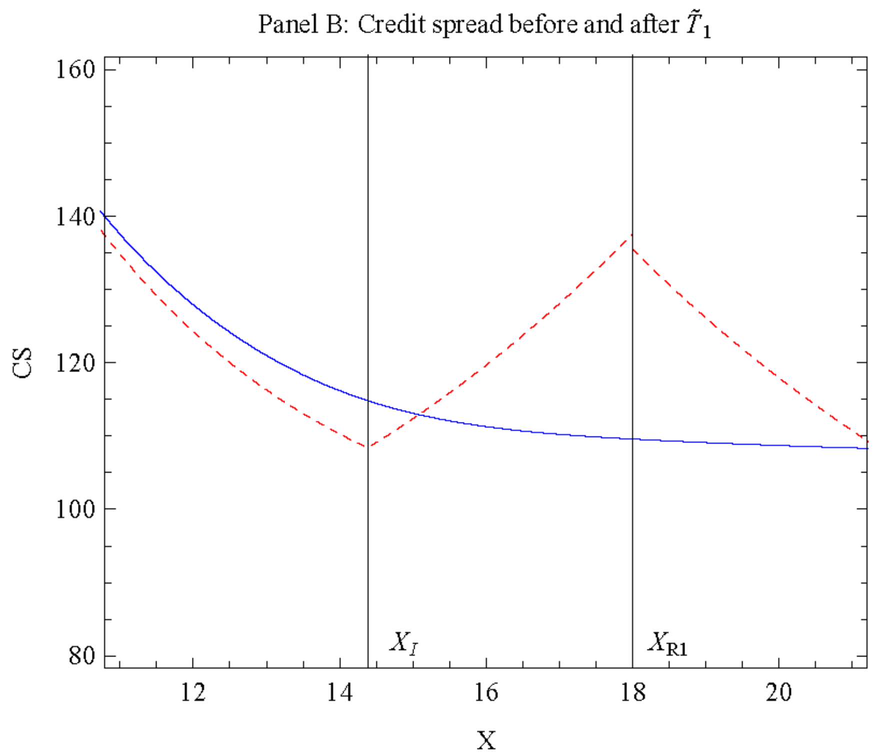
	C_0^*	C_1^*	X_I	X_{R1}	X_d	V_0	ML_0	CS_0	Q_0	ML_I	CS_I	Q_I	ML_{R1}	CS_{R1}	Q_{R1}
No growth option and no restructuring option (NN)	7.75	NA	NA	NA	3.36	197.09	0.53	135.48	1.05	NA	NA	NA	NA	NA	NA
Fleeting growth option and no restructuring option (FN)	8.82	NA	11.40	NA	3.74	220.99	0.54	136.60	1.18	0.33	63.72	1.04	NA	NA	NA
Temporary growth option and no restructuring option (TN)	8.76	NA	14.61	NA	3.75	225.64	0.53	138.30	1.21	0.26	47.12	1.04	NA	NA	NA
Permanent growth option and no restructuring option (PN)	8.52	NA	26.65	NA	3.22	250.94	0.46	131.59	1.34	0.15	22.90	1.02	NA	NA	NA
No growth option and restructuring option (NR)	7.20	25.74	NA	36.54	3.09	199.23	0.49	136.39	1.07	NA	NA	NA	0.53	135.48	1.05
Fleeting growth option and restructuring option (FR)	7.40	26.46	11.21	18.78	3.12	225.98	0.44	137.14	1.21	0.26	94.81	1.06	0.53	135.48	1.05
Temporary growth option and restructuring option (TR)	7.09	25.35	14.38	18.00	2.96	230.73	0.42	137.50	1.23	0.19	108.40	1.05	0.53	135.48	1.05
Permanent growth option and restructuring option (PR)	7.32	36.77	26.11	26.11	2.74	257.59	0.39	134.89	1.38	0.53	135.48	1.05	0.53	135.48	1.05

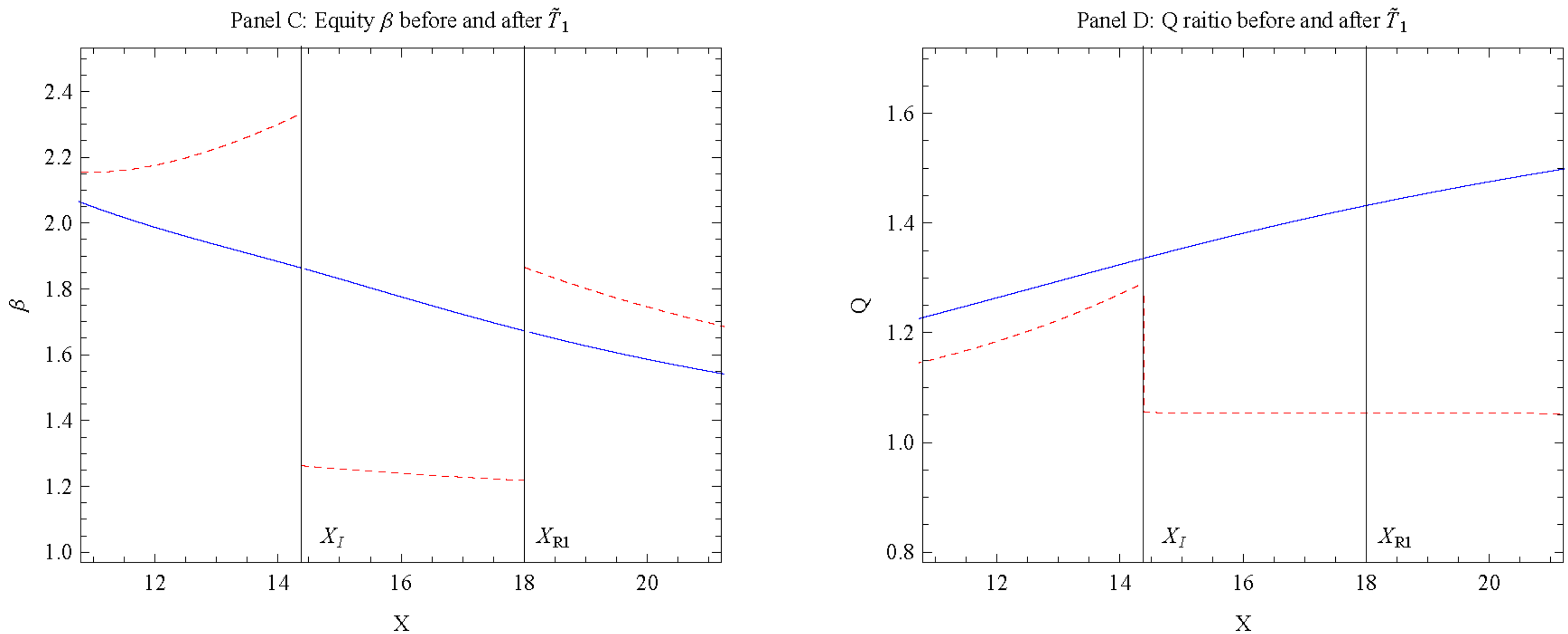
Figure 1

Leverage, Credit Spread, Equity Beta, and *Q* Dynamics

Panel A (B, C, D) illustrates the relation between the firm's market leverage (credit spread, equity beta, Tobin's *Q*) and the state variable *X* under the base case. The solid curve depicts the market leverage (credit spread (in basis points), equity beta, Tobin's *Q*) as a function of *X* before the arrival of the growth option at (random) time $\tilde{T}_1$. The dashed curve depicts the market leverage (credit spread (in basis points), equity beta, Tobin's *Q*) as a function of *X* after the arrival of the grow option at (random) time $\tilde{T}_1$. The two vertical lines indicate the locations of the investment threshold X_I and the restructuring threshold X_{R1}, respectively. The parameter values used to solve the model are the same as those in the base case of Table 1.






Panel C: Equity β before and after $\tilde{T}_1$
β
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
12
14
16
18
20
X
X_I
X_{R1}
Panel D: Q raitio before and after $\tilde{T}_1$
Q
1.6
1.4
1.2
1.0
0.8
12
14
16
18
20
X
X_I
X_{R1}