Callable or convertible debt? The role of debt overhang and covenants*

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Abstract. We analyze what role debt overhang and covenants have in affecting a manager's choice between issuing callable or convertible debt. Callable bonds provide a higher coupon to bondholders in exchange for a firm's repurchase option of its claim, whereas convertible bonds offer bondholders the option to exchange debt to equity. Using a dynamic capital structure theory model with an investment choice, we show that firms which are more exposed to debt overhang issue callable rather than convertible bonds. However, convertible bonds are preferred if the firm has more debt. Furthermore, if bonds have covenants attached, callable bonds are more likely to be issued. Our empirical findings support the theory.

Keywords: Bond characteristics, dynamic model, growth option, debt overhang, covenants

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1 Introduction

The U.S. corporate bond market is massive with a principal amount of more than $9.3 trillion by 2018; a considerable fraction of bonds has callable and, to a smaller extent, convertible features.[1] From a managerial perspective, the firm offers callable bonds with a premium to bondholders in exchange for the repurchase option of their claim. With convertible bonds, investors have the option to exchange a firm's debt upon which the firm provides a debt-for-equity exchange. In this paper, we analyze what role debt overhang and covenants have in affecting a manager's choice between issuing these two types of bond contracts. The key trade-off hinges on the embedded options in the debt contract. To understand this trade-off we set up a dynamic capital structure theory model that includes an investment choice. Specifically, a firm has a growth option which increases earnings, but the outstanding debt implies a debt overhang friction. We investigate how a manager takes this into account when initially choosing between issuing debt with either callable or convertible features.

Our analysis focuses on two key managerial considerations: First, the effect of debt overhang and second, the role of bond covenants. Each of those imply two different perspectives depending on whether the firm has an ex post or an ex ante point of view. The ex post point of view presupposes that the firm has debt in place. Looking at the debt overhang problem, the focus is thus on minimizing the wealth transfer from debt holders to equity holders when the growth option is exercised. That purpose is best served with a debt contract that gives the exercise rights to equity holders; i.e., callable debt is preferred. The ex ante point of view takes into account that debt holders at the time of a debt issuance foresee the equity holders' self-interested behavior. Of course, the growth option is indirectly valuable for debt

[1] These aggregate statistics are based on data from the Securities Industry and Financial Markets Association (SIFMA, `http://sifma.org/research/statistics.aspx`). Becker et al. (2018) note that one third of all U.S. corporate bonds have a fixed call feature, whereas the U.S. convertible bond market is worth about $200 billion and recent newspaper articles noticed that in light of the turmoil of the COVID-19 pandemic has increased with over $64 billion in the first half of 2020 (ICLG and Goodwin Procter LLP).

holders, but they correctly anticipate that the implementation is postponed compared to a no-debt case. This effect decreases the value of debt and may in turn make it optimal for the firm to grant ex post rights to debt holders. This can be done with convertible debt. Intuitively, the trade-off between the ex post and ex ante point of view should favor callable debt over convertible debt if the firm has a relatively low level of leverage. If the firm is in a financial state where it needs to give more ex post rights to debt holders, it can also obtain this by using covenants. For example, covenants can provide value-protection to debt holders when the firm's prospects deteriorate. However, because covenants provide ex post rights, equity holders take them into account ex ante. Thus a trade-off between ex ante and ex post concerns arises. Since convertible debt is more creditor friendly than callable debt, such covenants are generally more expensive for a firm issuing convertible debt. Hence, firms with existing bond covenants are more likely to issue callable bonds compared to convertible bonds.

To summarize, in order to understand the role of debt overhang and covenants in connection to the debt issuance decision, the key theoretical trade-off evolves around the ex ante and ex post perspective surrounding their embedded options. Ex post, the benefit from convertible debt goes to bondholders, whereas for callable debt equity holders receive the benefits since they are long an option. Ex ante, the differences in these rights imply that convertible debt has a higher value than callable debt.

Besides the effects on debt overhang and covenants, our theoretical analysis offers several further testable implications. Firms issue convertible debt with a lower coupon than callable debt since holders of convertible debt have the option to convert their claim into equity, and therefore holders of callable debt need to be compensated by a higher coupon. Moreover, the holding time of callable bonds is longer than that of convertible bonds. emphasize Last, small firms with higher leverage ratios are expected to issue callable debt because for these firms the growth option is more valuable and thus the ex ante view dominates. On the other hand big firms with lower leverage ratios are expected to issue convertible debt.

We test and confirm our model's predictions using a detailed sample of U.S. corporate bonds between 1990 and 2017. In line with anecdotal evidence, we first document that callable bonds are issued with a larger coupon and held for a longer period compared to convertible bonds. Firms issue callable bonds with longer maturity and a higher offering amount compared to convertible bonds. Interestingly, the effect of leverage on the probability of issuing callable bonds is non-monotonic with respect to firm size. Small firms with a higher leverage ratio are more likely to issue callable bonds, whereas big firms with a lower leverage ratio rather issue convertible bonds. Using a measure of debt overhang by Alanis et al. (2018), we subsequently link this to the probability of issuing callable rather than convertible bonds. Confirming the model's implications, firms that are more exposed to debt overhang are more likely to issue callable bonds. Moreover, firms with existing bond covenants are more likely to issue callable bonds compared to convertible bonds. Last, conditional on having a covenant in place, the likelihood of issuing callable bonds increases even more if they are exposed to more debt overhang.

Different forms of debt repurchases have been studied extensively in the previous literature. Mao and Tserlukevich (2015) build a model of a firm repurchasing its corporate debt and find that costly bankruptcy encourages repurchase while taxation and transaction costs discourage repurchase. The expected gain from repurchase increases with the risk of default, and thus, with a high risk of default, there is a more significant probability that the debt holders will give concessions. Our model framework incorporates similar features, but it considers both the issuance and repurchase of callable and convertible corporate debt. Julio (2013) provides an investment-based explanation as a motive for why firms choose to repurchase debt. The market for debt repurchases serves as a substitute for renegotiation and firms are more likely to repurchase outstanding debt when investment frictions are relatively high. This improvement is more pronounced for firms with higher expected transfers to bondholders. If managers believe their stock to be undervalued, Billingsley and Smith (1996) provide survey evidence that firms like to issue convertible bonds. Frantz and Instefjord (2019) also analyze the restructuring of debt in the presence of debt overhang. In their model, carrying old debt over the investment threshold causes distortions to the timing of the investment decision. Kruse et al. (2014) study empirically the decision to repurchase debt and examine the market reaction to announcements of offers to repurchase outstanding debt. Companies repurchase debt to circumvent restrictive covenants, which allows them to pursue promising investment opportunities. Our paper adds to the discussion by examining if the debt overhang problem influences the ex-ante optimal debt contract. Chen et al. (2010) analyze a firm's decision to issue a callable or non-callable bond and argue that callable bonds are used to reduce the risk-shifting problem in case investment opportunities become poor. Becker et al. (2018) show that call features limit debt overhang by restricting value gains to corporate creditors. We add to these findings a detailed analysis of the tendency to issue either convertible or callable debt; we find that firms prefer to issue convertible bonds if the debt overhang problem is less severe and financing needs are large.

Our paper relates to the literature using a real options approach to analyze debt choice, most prominently Lyandres and Zhdanov (2014) and Hennessy and Tserlukevich (2008). The former paper develops a model analyzing convertible bonds and the implementation of a growth option. The key focus in that paper is investment timing and the central trade-off builds on debt postponing investment timing through the debt overhang channel whereas convertible debt accelerates investment timing through a dilution channel. They show that convertible bonds can in many cases be constructed so that the firm invests as an all-equity firm. As in Lyandres and Zhdanov (2014), we consider a growth option which does not alter the risk dynamics of the firm's earnings. However, our paper differs in several aspects. First, our focus is directed towards value maximization and optimal capital structure rather than investment timing per se. Second, convertible debt contracts often have anti-dilution adjustments included and we impose that assumption.[2] This diminishes the dilution effect in Lyandres and Zhdanov (2014) and hence the firm's manager is in our model much less inclined to invest early. Third, the firm does not become an all-equity firm after conversion in our framework. Fourth, we elaborate on a comparison between convertible debt and callable debt in our model as well as in our empirical analysis. Hennessy and Tserlukevich (2008) also analyze the choice between callable and convertible debt. They focus on moral hazard and find that if managers can increase the volatility without reducing the asset drift, then callable bonds are optimal. Convertible bonds mitigate risk shifting and are thus optimal if risk-shifting reduces the asset drift sufficiently. Their model predicts that callable bonds have a lower coupon compared to convertibles and that pure convertibles are held longer than pure callables. In contrast, we keep earnings dynamics unchanged by investments. By doing so we focus on debt overhang issues and the use of debt in a tax advantage and bankruptcy cost trade-off. Therefore, our model relates more to the ex ante and ex post perspective regarding embedded options in the debt contract. Convertible bonds are thus not valuable because they reduce asset substitution risk; instead, they are valuable because they grant debt holders a larger share of the firm's upside potential and by that reduces bankruptcy risk. Our model predicts that callable bonds have a higher coupon compared to convertibles, that the holding period of callable debt is longer, and that convertibles are less used if debt overhang is large. Our empirical analysis confirms these predictions.

The remainder of the paper is organized as follows. Section 2 presents our model framework in which we define the debt contract for callable and convertible debt. Section 3 considers how our model relates to the debt overhang problem. Section 4 presents our numerical implementation of the model, introduces covenants, and presents our testable hypotheses.

[2] Convertible bonds frequently include anti-dilution provisions that specify adjustments to the conversion price to protect against equity dilution that hurts bond holders. Examples of dilution actions by firms could be stock splits, new equity issuance, share repurchases etc. Anti-dilution considerations are a well-known theme in the law literature (e.g., Kahan, 1995; Woronoff and Rosen, 2005).

Section 5 presents our data and empirical results. Last, Section 6 concludes. Proofs are provided in the appendix.

2 Model

We consider a firm with debt and equity. Debt is beneficial due to tax subsidies, but it is costly due to bankruptcy costs. The firm has two options to actively affect its value. First, the firm has a growth option which increases earnings. Second, the firm has an option to restructure its capital structure. We start by elaborating on the general details of the model and subsequently turn to the specifications of the firm's capital structure.

Our overall objective is to better understand a firm's incentives to prefer either convertible or callable debt. To focus on this we assume that the firm initially has a certain amount of debt. Specifically, we assume that at the onset of our analysis, i.e., at $t = 0$, debt must fund an investment equal to I_0 (see, e.g. Shibata and Nishihara, 2012; Flor and Hirth, 2013). Once I_0 is in place, the firm receives earnings before interest and taxes (EBIT) at time t denoted as x_t. Similar to Goldstein et al. (2001) and Hennessy and Tserlukevich (2008), EBIT evolves according to a geometric Brownian motion

$$dx_t = \mu x_t dt + \sigma x_t dz_t, \tag{1}$$

with initial value x_0. $z = (z_t)$ is a standard Brownian motion, all agents are risk neutral and evaluate cash flows with the constant risk-free interest rate r, where $\mu < r$. The firm faces a tax rate τ and debt is issued as a perpetual contract with a constant tax-deductible coupon rate $C > 0$. To fund I_0 we allow the firm to choose between callable debt and convertible debt.[3] Bankruptcy is triggered by equity holders. In this case, equity holders receive a value

[3] In undisclosed results we also consider straight debt. However, since straight debt turns out not to be optimal for a large set of parameters, we focus in the following on callable debt and convertible debt. The

of zero and debt holders take over the firm. The process of going through bankruptcy is costly, and hence we assume that debt holders lose a fraction, α, of the firm.

Once the initial capital structure is in place, the equity holders have a perpetual option to exploit a growth opportunity by paying an investment cost I_1. To highlight the effect of debt overhang on the initial financing choice (e.g., Myers, 1977), we focus the analysis and assume that the future growth option is financed with equity (e.g., Julio, 2013; Frantz and Instefjord, 2019; Kruse et al., 2014; Lyandres and Zhdanov, 2014). Once installed, the growth option scales up EBIT by a factor $\Pi > 1$. We assume that the growth opportunity is lost upon bankruptcy if it has not been used before. Similarly, default exhausts the firm's possibility to exploit the tax shield. However, the firm has a second option to actively change its capital structure. Once the initial debt is either called or converted, the firm can issue debt one more time to exploit the tax shield. To keep the analysis tractable, we restrict this debt contract to be a perpetual non-callable-convertible bond, i.e., straight debt.

We analyze the optimal choice of the initial debt contract by studying each of the two debt contracts separately and then compare the initial firm value conditional on a given contract. In our parsimonious setup one of those two alternatives is optimal. That is, if the firm can choose a callable-convertible bond, then it is either the option to call or to convert which is valuable. This is due to the fact that we consider a one-dimensional framework.[4]

For expositional reasons it is convenient to first consider a general case. Below we valuate debt and equity, but let us for now consider a general claim F which depends on EBIT and value transfers at a lower threshold (default) and an upper threshold (investment).

Proposition 1. *Assume that when x reaches $\overline{x} > x_0$ then F pays $\overline{F}$, that when x reaches*

intuition behind this hinges on that straight debt allows for less flexibility for the firm to adjust its capital structure in the future.

[4]If we expand the analysis to include more risk factors, for example, by having recession-normal-boom states in the economy, then a callable-straight-convertible mix could become optimal. We abstract from this extension to focus on the main implications of a future debt overhang problem when a growth option is in place.

$\underline{x} < x_0$ *then* F *pays* $\underline{F}$*, and that* F *pays the flow* $h_0 + h_1 x$ *until either* $\overline{x}$ *or* $\underline{x}$ *is hit the first time. With* $\overline{x}$*,* $\underline{x}$*,* $\overline{F}$*,* $\underline{F}$*,* h_0*, and* h_1 *as given constants, the value of the claim* F *is*

$$F(x) = \left(\frac{h_0}{r} + \frac{h_1}{r-\mu}x\right)(1 - p_u(x;\underline{x},\overline{x}) - p_d(x;\underline{x},\overline{x})) + p_u(x;\underline{x},\overline{x})\overline{F} + p_d(x;\underline{x},\overline{x})\underline{F}, \qquad (2)$$

where

$$p_u(x;\underline{x},\overline{x}) = \frac{\underline{x}^{\beta_2}x^{\beta_1} - \underline{x}^{\beta_1}x^{\beta_2}}{\overline{x}^{\beta_1}\underline{x}^{\beta_2} - \underline{x}^{\beta_1}\overline{x}^{\beta_2}}, \qquad \textit{and} \qquad p_d(x;\underline{x},\overline{x}) = \frac{-\overline{x}^{\beta_2}x^{\beta_1} + \overline{x}^{\beta_1}x^{\beta_2}}{\overline{x}^{\beta_1}\underline{x}^{\beta_2} - \underline{x}^{\beta_1}\overline{x}^{\beta_2}}. \qquad (3)$$

The two terms in (3) have a convenient interpretation. $p_u(x;\underline{x},\overline{x})$ is the present value of receiving one unit of account at investment, conditional on not reaching default, $\underline{x}$, before. $p_d(x;\underline{x},\overline{x})$ is the present value of receiving one unit of account at default, conditional on not investing before. For convenience, we will henceforth denote the present value factors as p_u and p_d. Thus, the value of F in (2) can be interpreted as the value of getting the stream $h_0 + h_1 x$ until a threshold is hit (first two terms), the present value of hitting the upper threshold (third term), and the present value of hitting the lower threshold (last term). With this proposition, we are ready to consider the values for debt and equity for convertible and callable debt, respectively. In doing so, the threshold values $\overline{F}$ and $\underline{F}$ in the proposition are linked to the specific claim by the value-matching conditions.

The model implies three stages and is solved by backwards induction. To ease interpretation it is convenient to introduce the value of the unlevered firm as V_U. The unlevered firm receives EBIT and pays the fraction τ in taxes. If the growth option has been implemented, the profit flow is $(1-\tau)\Pi x$; that is, $h_0 = 0$ and $h_1 = (1-\tau)\Pi$ in Proposition 1 and we have:

$$V_U(x;\Pi) = (1-\tau)\frac{\Pi x}{r-\mu}. \qquad (4)$$

We explain below that debt holders at default receive a scaled version of the value in (4).

The model begins with stage 0 and the firm has an option to invest. Investment triggers stage 1 and the debt holders still have their initial contract. In the last stage of the model, stage 2, there is an infinitesimal period of time at which the firm has no debt outstanding. Thus, the firm has an incentive to issue new debt due to its tax shield. At this stage, the firm issues an amount of debt that maximizes the firm's value. We denote the optimally levered firm value as $A_2(x)$ and provide the details in the appendix. We now turn to the specifics of the first two stages.

2.1 Convertible debt

Suppose the firm initially issues convertible debt. Denote the market value as $D_0^{con}(x)$ and let $D_1^{con}(x)$ be the debt value after the growth option has been exercised.[5] The convertible option feature allows the debt holders to call the debt and receive a package specified in the debt contract. For simplicity we assume that debt can be converted into a known share, s, of the book value of equity. Naturally, the debt holders cannot be forced to supply new equity ($s > 0$) nor can they receive the hole firm ($s < 1$). We assume that conversion takes place after the equity holders invest in the growth opportunity. Alternatively, debt holders would have to pay their share of the investment cost which is not optimal for them. The time line is depicted in Figure 1.

Consider first stage 1. Thus, the firm has invested in the growth opportunity, but the debt holders have not yet converted their contract into equity. Then one of two things can happen. Either the cash flow increases enough inducing the debt holders to convert their claim. This happens the first time cash flow reaches the level $x_{u_1}^{con}$. At this point the firm sets the capital structure to maximize the its value. The new firm value is $A_2(x)$ which is shared between the pre-conversion debt and equity holders, where the former receives the

[5] In general, we let the superscript indicate the type of debt, whereas the subscript indicates whether or not the growth option is exercised; i.e., the state of the model.

fraction s. This yields two value-matching conditions at the conversion threshold:

$$D_1^{con}(x_{u_1}^{con}) = sA_2(x_{u_1}^{con}), \tag{5}$$

$$E_1^{con}(x_{u_1}^{con}) = (1-s)A_2(x_{u_1}^{con}). \tag{6}$$

Another possible outcome is that the cash flow decreases so much that equity holders decide to default which occurs when cash flow decreases to $x_{d_1}^{con}$. At default, equity gives up all value and debt holders take over the firm. The transfer of control rights is costly and costs a fraction, α, of the value. We assume the post-default firm stays unlevered implying that the firm value is the reduced perpetual value of the existing production. This gives the two value-matching conditions at the default threshold:

$$D_1^{con}(x_{d_1}^{con}) = (1-\alpha)V_U(x_{d_1}^{con}; \Pi), \tag{7}$$

$$E_1^{con}(x_{d_1}^{con}) = 0. \tag{8}$$

With convertible debt, the debt holders have an ex post right to convert their claim to equity. They do so at a point in time which is optimal from their point of view. On the other hand, equity holders decide when to default. Therefore, the conversion trigger point $x_{u_1}^{con}$ and the default trigger $x_{d_1}^{con}$ are found by the smooth-pasting conditions

$$D_1^{con\prime}(x_{u_1}^{con}) = sA_2'(x_{u_1}^{con}), \tag{9}$$

$$E_1^{con\prime}(x_{d_1}^{con}) = 0. \tag{10}$$

The next step is to derive the conditions for the debt value and the equity value before investment has taken place. Prior to investment, the equity holders default if cash flow decreases enough. Since investment increases the payoff by Π, we expect that $x_{d_0}^{con} > x_{d_1}^{con}$. If cash flow increases, investing in the growth opportunity becomes more attractive. Eventually, the value of waiting to invest is sufficiently low and the equity holders decide to invest. We assume this happens at $x_{u_0}^{con}$. The specific value-matching conditions for the debt value and the equity value at the respective boundaries are:

$$D_0^{con}(x_{u_0}^{con}) = D_1^{con}(x_{u_0}^{con}), \tag{11}$$

$$E_0^{con}(x_{u_0}^{con}) = E_1^{con}(x_{u_0}^{con}) - I_1, \tag{12}$$

$$D_0^{con}(x_{d_0}^{con}) = (1-\alpha)V_U(x_{d_0}^{con};1), \tag{13}$$

$$E_0^{con}(x_{d_0}^{con}) = 0. \tag{14}$$

At this stage in the model, it is the equity holders who have the right to either invest or to default. Therefore, the trigger for investment and default are found by solving the pair of smooth-pasting conditions

$$E_0'(x_{u_0}^{con}) = E_1'(x_{u_0}^{con}), \tag{15}$$

$$E_0'(x_{d_0}^{con}) = 0. \tag{16}$$

2.1.1 Valuation of debt and equity

For a given coupon rate C^{con}, we use Proposition 1 to obtain the stage 0 and the stage 1 values of debt:

$$D_0^{con}(x) = \frac{C^{con}}{r} + p_{u,0}\left(D_1(x_{u_0}^{con}) - \frac{C^{con}}{r}\right) + p_{d,0}\left((1-\alpha)V_U(x_{d_0}^{con};1) - \frac{C^{con}}{r}\right), \tag{17}$$

$$D_1^{con}(x) = \frac{C^{con}}{r} + p_{u,1}\left(sA_2(x_{u_1}^{con}) - \frac{C^{con}}{r}\right) + p_{d,1}\left((1-\alpha)V_U(x_{d_1}^{con};\Pi) - \frac{C^{con}}{r}\right). \tag{18}$$

The first term of the stage 0 debt value in (17) is the present value of receiving the coupon forever. The debt holders get another value if investment or default occurs. If the firm invests, debt holders receive the stage 1 value of debt and losses their current stream of coupon payments. This is discounted with $p_{u,0}$. In case of default, debt holders receive the value of the unlevered firm less the cost of default. The factor $p_{d,0}$ adjusts for discounting. Looking at the stage 1 value of debt in (18), post-investment, debt holders continue to receive coupon payments until they convert their claim or the firm defaults. Upon conversion, debt holders effectively receive a fraction of the optimally levered firm which is discounted with $p_{u,1}$. The case of default is at in stage 1, but with EBIT scaled.

The stage 0 and the stage 1 values of the equity claims are

$$\begin{aligned} E_0^{con}(x) &= V_U(x;1) - (1-\tau)\frac{C^{con}}{r} + p_{u,0}\left(E_1(x_{u_0}^{con}) - I_1 - \left(V_U(x_{u_0}^{con};1) - (1-\tau)\frac{C^{con}}{r}\right)\right) \\ &\quad - p_{d,0}\left(V_U(x_{d_0}^{con};1) - (1-\tau)\frac{C^{con}}{r}\right), \qquad (19) \\ E_1^{con}(x) &= V_U(x;\Pi) - (1-\tau)\frac{C^{con}}{r} + p_{u,1}\left((1-s)A_2(x_{u_1}^{con}) - \left(V_U(x_{u_1}^{con};\Pi) - (1-\tau)\frac{C}{r}\right)\right) \\ &\quad - p_{d,1}\left(V_U(x_{d_1}^{con};\Pi) - (1-\tau)\frac{C^{con}}{r}\right). \qquad (20) \end{aligned}$$

Before investment equity holders receive the value of the unlevered firm less the coupon payment to debt holders which correspond to the first two terms of the stage 0 value in (19). If the firm invests, equity holders receive the stage 1 value of equity, pay the investment cost and give up their current earnings. In case of default, equity holders give up all value, and debt holders take over the firm. If earnings increase sufficiently such that the firm invests, (20) presents the stage 1 value function for equity. Post-investment, the first two terms represent that equity holders receive the value of the unlevered firm (with scaled EBIT) less the coupon payments until either conversion or default occurs. If earnings increase sufficiently such that conversion occurs, equity holders are forced to give up s of their shares and the firm continues as an optimally levered firm. Finally, the last term represents default at which equity holders give up all value, and debt holders take over the firm.

2.2 Callable debt

The firm initially issues callable debt and has a growth option available. As above, the debt induces a debt overhang problem. After investment, the firm continues as a levered firm with an option to restructure its capital. The time line is depicted in Figure 2.

Callable debt gives the firm the option to buy back the debt at a fixed price. In addition to the principal, the firm pays a premium which is the fraction p of the principal. The firm optimally calls its debt when the underlying state variable becomes high enough. We denote this level of the state variable as $x_{u_1}^{cal}$. Since a higher level of the cash flow also increases the present value of the investment opportunity – because the investment cost, I_1, is constant – the value of waiting to invest decreases in x. Thus, the firm eventually wants to invest. When the equity holders infuse capital, this also benefits the debt holders. Thus, equity holders have a lower incentive to provide capital to fund the investment; this is the debt overhang friction. However, when the before-investment cash flow increases the net transfer to debt holders is smaller and decreases the risk of default. We consider that the firm invests in the growth opportunity before it calls the initial debt.[6] Once the debt is called, the firm optimally exercises its option to reset its capital structure.[7] This yields two value-matching conditions at the call threshold:

$$D_1^{cal}(x_{u_1}^{cal}) = (1+p)D_0^{cal}(x_0), \tag{21}$$

$$E_1^{cal}(x_{u_1}^{cal}) = A_2(x_{u_1}^{cal}) - (1+p)D_0^{cal}(x_0). \tag{22}$$

When the debt is called, the debt holders receive the principal and the call premium in exchange for their debt claim. We assume that debt is issued at par; that is, the principal is

[6] The alternative of first calling and then investing at a later point in time is generally too costly because the firm then foregoes the tax advantage in a period.

[7] Thus, whether the firm initially has convertible debt or callable debt a non-defaulted firm ends having exercised its growth option and resets its capital structure with perpetual non-callable-convertible debt.

equal to the initial debt value. Thus, condition (21) states that the debt holders receive a premium relative to the initial debt value. Condition (22) points out that the equity holders get the optimally levered firm value once the initial debt holders are paid.

The debt value and equity value must at the investment threshold satisfy value-matching conditions similar to (11)–(12), respectively. On the other hand, the cash flow can decrease so much that equity holders decide to default. Denote x_d^{cal} the cash flow at default. At the default threshold conditions similar to (13)–(14) hold. The decision to investment or to default belongs to the equity holders, and thus smooth-pasting conditions similar to (15)–(16) must hold at the optimal boundaries.

2.2.1 Valuation of debt and equity

Suppose the firm issues callable debt with call premium p and coupon rate C^{cal}. We again use Proposition 1 to derive the stage 0 and the stage 1 values of debt:

$$D_0^{cal}(x) = \frac{C^{cal}}{r} + p_{u,0}\left(D_1^{cal}(x_{u_0}^{cal}) - \frac{C^{cal}}{r}\right) + p_{d,0}\left((1-\alpha)V_U(x_{d_0}^{cal};1) - \frac{C^{cal}}{r}\right), \tag{23}$$

$$D_1^{cal}(x) = \frac{C^{cal}}{r} + p_{u,1}\left((1+p)D_0^{cal}(x_0) - \frac{C^{cal}}{r}\right) + p_{d,1}\left((1-\alpha)V_U(x_{d_1}^{cal};\Pi) - \frac{C^{cal}}{r}\right). \tag{24}$$

The stage 0 debt value in (23) is basically as in the case of convertible debt. Subsequent to the investment, the stage 1 debt value is given by (24). The first term is the present value of the coupon payments until either the call threshold or the default boundary is hit. The second term corresponds to the debt being called by equity holders at $x_{u_1}^{cal}$. At this point the debt holders receive the principal and the call premium, see (21). They get this in exchange for future coupon payments. The last term corresponds to the debt holders taking over the post-defaulted firm, as in (23), but with a scaled EBIT.

The stage 0 and the stage 1 values of the equity claims are

$$E_0^{cal}(x) = V_U(x;1) - (1-\tau)\frac{C^{cal}}{r} + p_{u,0}\left(E_1(x_{u_0}^{cal}) - I_1 - \left(V_U(x_{u_0}^{cal};1) - (1-\tau)\frac{C^{cal}}{r}\right)\right)$$
$$- p_{d,0}\left(V_U(x_{d_0}^{cal};1) - (1-\tau)\frac{C^{cal}}{r}\right), \tag{25}$$
$$E_1^{cal}(x) = V_U(x;\Pi) - (1-\tau)\frac{C^{cal}}{r} + p_{u,1}\Bigg(A_2(x_{u_1}^{cal}) - (1+p)D^{cal}(x_0)$$
$$- \left(V_U(x_{u_1}^{cal};\Pi) - (1-\tau)\frac{C^{cal}}{r}\right)\Bigg) - p_{d,1}\left(V_U(x_{d_1}^{cal};\Pi) - (1-\tau)\frac{C^{cal}}{r}\right). \tag{26}$$

Before investing, the value of equity is essentially as in the case with convertible debt, see (19). Post-investment, equity holders receive the value of the unlevered firm with EBIT scaled up less the after-tax coupon payments. The third term corresponds to equity holders calling the debt and subsequently optimally levering up the firm, see (22). The last term corresponds to the value when equity holders default and give up the firm.

3 Debt overhang and debt repurchase

To understand how the different types of debt contracts affect the investment decision, we first consider an all-equity firm. This firm's incentive for paying the investment cost I_1 is not disturbed by any outstanding debt nor the incentive to issue debt after implementing the growth option. Following the literature (e.g., Morellec and Schürhoff, 2011; Clausen and Flor, 2015), the firm invests at $x_{u,FB}$, where

$$x_{u,FB} = \frac{\beta_1}{\beta_1 - 1}\frac{I_1}{\Pi - 1}\frac{r-\mu}{1-\tau}. \tag{27}$$

At the time of investment, the net present value is

$$NPV_{FB} = \frac{I_1}{\beta_1 - 1}. \tag{28}$$

The investment threshold (27) and the at-investment net present value (28) provide useful intuition which is also relevant for the case with debt. First, a more valuable growth opportunity (higher Π) expedites the time of investment. This is a standard result from capital budgeting using real options analysis; the effect stems from a lower value of waiting to invest. Intuitively, if the growth opportunity is sufficiently valuable, the firm should optimally invest immediately. Second, the value-added at investment is exactly offset by the earlier time of investment, and hence, the net present value does not depend on the scaling parameter at investment.[8]

In a similar vein, a higher investment cost I_1 incentivizes the firm to wait for a sufficiently high level of cash flow, which in turn increases the present value of the growth opportunity. Thus, a higher investment cost postpones the time of investment. However, in contrast to the scaling factor Π, the investment cost increases the at-investment net present value of the growth opportunity. This implies that a higher investment cost has two counterweighing effects. The direct, static, effect makes the investment less attractive because as a now-or-never decision, a higher investment cost decreases the growth opportunity's net present value. The indirect, dynamic, effect increases the at-investment net present value, and by that mitigates the direct effect. These effects are particularly important when debt comes into play.

When the firm has debt, the debt overhang problem discourages equity holders from undertaking the investment. The lower the net present value of the investment is, the worse is the debt overhang problem because the wealth transfer from the equity holders to the

[8]Prior to investment we have the intuitive effect that a higher investment cost (higher scaling) decreases (increases) the net present value. This is due to the effect through the investment threshold $x_{u,FB}$.

debt holders increases. Thus, the direct effect of a higher investment cost amplifies the debt overhang problem. To mitigate this effect, the firm tends to issue a debt contract which the firm can control ex-post. That is, debt overhang tends to favor callable debt. On the other hand, the indirect effect of a higher investment cost increases the net present value of the growth opportunity at the time of investment. Furthermore, the present value of the firm's existing activities is also high, implying that the default risk of the outstanding debt is small. In turn, this decreases the wealth transfer to the debt holders at the time of investment. Thus, when the firm has the option to wait, a higher investment cost mitigates the debt overhang problem. This effect can dominate so that a higher investment cost decreases the debt overhang problem. This makes it cheaper for the firm to grant ex-post rights to debt holders and, as a result, the firm prefers to issue convertible debt ex-ante. We elaborate further on this discussion in the numerical analysis below.

4 Numerical analysis, covenants, and implications

To deepen the understanding of our model's implications we use a numerical analysis. We also introduce the possibility to issue debt with covenants. Subsequently we simulate the model and use this to formulate empirical predictions.

4.1 Simulation procedure and variable definitions

For the implementation of the model, we use parameter values for our base case simulation presented in Table 1. The parameters follow previous literature (e.g., Cooper, 2006; Christensen et al., 2014; Hackbarth and Johnson, 2015).

The model yields intuitive effects in terms of debt value and equity value. Figure 3 plots the value of debt and equity in the base case as a function of EBIT, x; Panel 3(a) focuses on EBIT before investment. The debt value in stage 0 (stage 1) is depicted as a magenta (orange) curve, the equity value in stage 0 (stage 1) is depicted as a green (cyan) curve. As expected, equity value has a convex form and stage 0 debt has a concave form. The initial funding condition is depicted with the dot-dashed horizontal line ($I_0 = 8$). Thus, the stage 0 debt value is equal to 8 at the onset ($x_0 = 0.3$). Implementing the growth option costs $I_1 = 5$ which is paid by the equity holders. This occurs to the right in the figure. Therefore, the value of equity increases by I_0 to satisfy the value-matching condition. Exercising the growth option benefits both equity holders and debt holders. Panel 3(b) focuses on this case and shows that the conversion option is particularly valuable for convertible debt when EBIT is high. Thus, the stage 1 debt value is concave-convex (e.g., Lyandres and Zhdanov, 2014) and debt increases substantially when profits are high. This effect is exactly the benefit to debt holders that a convertible debt contract offer. At the default boundary, to the left in the figure, equity holders receive nothing irrespective of the growth option being exercised or not. However, if the growth option is exercised, debt holders take over a firm with a positively scaled EBIT and hence their value is higher given a level of x. Panel 3(c) and panel 3(d) consider callable debt in a similar manner. A key difference is seen in the debt value. After investment, the debt value increases much more moderately in EBIT (it may even be slightly decreasing close to the call threshold). This spills over to the stage 0 debt value and equity value. The reason for this is that callable debt limits the debt holders' benefit of high profits much more than convertible debt. Thus, a firm in a "strong" position should tend to issue callable debt, whereas a firm in a "weak" position has to grant more rights to creditors. Letting debt benefit from future prosperous times is one way to do so. Furthermore, comparing the right-end of panel 3(b) with that of panel 3(d) we observe that the convertible threshold is much lower than the callable threshold. Later results confirm that this is a general effect.

4.1.1 Debt overhang

To address the implications of debt overhang we need a way to measure this friction. In our empirical analysis we use the measure introduced in Alanis et al. (2018). This empirical measure of debt overhang, EDO, which we describe below in more detail (see (33)), basically consists of three factors:

$$\text{EDO} = \frac{\text{total debt}}{\text{capital stock}} \cdot \text{Recovery Rate} \cdot \Pr(\text{default}). \tag{29}$$

To relate this to our model we interpret the first factor as leverage. The last two factors effectively measures the present value received by debt holders at default, and thus we calculate the debt overhang measure as follows in the simulation:

$$\text{EDO} = \frac{D_0(x_0)}{D_0(x_0) + E_0(x_0)} p_{d,0}(1-\alpha)V_U(x_{d_0}; 1), \tag{30}$$

where the default probability $p_{d,0}$ from Proposition 1 uses the relevant upper and lower boundaries.

4.1.2 Covenants

Firms often issue debt with covenants and these covenants are implemented in a variety of forms (e.g., Smith Jr and Warner, 1979; Chava et al., 2010; Bienz et al., 2010). We consider covenants which impact the lower threshold and protect debt holders at default. Specifically, we implement a net worth covenant. The covenant specifies that the firm is declared default if the value obtained in bankruptcy gets below a certain level of the principal. Since debt is issued at par we implement a covenant requiring that

$$\text{value in default} \geq \rho D_0(x_0), \tag{31}$$

which implies a covenant induced default threshold, $x_{0,d}^{cov}$:

$$x_{0,d}^{cov} = \frac{(r-\mu)\rho D_0(x_0)}{(1-\alpha)(1-\tau)}, \tag{32}$$

where ρ is the degree of protection. After investing in the growth option, the covenant-default threshold is scaled down by the EBIT factor Π.

Panel 3(e) and panel 3(f) depict the debt and equity values before investment in the case with convertible debt and callable debt, respectively. Since we assume that the initial debt value is fixed, the covenant-default threshold does not depend on whether it is a convertible or callable debt contract. The horizontal dashed line corresponds to the covenant induced default threshold. We observe that the covenant impacts the convertible debt more than the callable debt. In particular when EBIT is low. To see the intuition for this recall that a covenant adds ex post protection to the debt holders, but it is ex ante costly for the equity holders. Since convertible debt is at the onset more creditor friendly than callable debt, we expect that a covenant is more costly for convertible debt. Therefore, an intuitive reaction from the equity holders at debt issuance is to increase the coupon—to better exploit the tax shield—and to decrease the share, s, for convertible debt. As a result the value of the two debt contracts becomes closer to each other for low levels of EBIT. Furthermore, since covenants distort investment decisions, the debt overhang problem turns out worse for both types of debt contracts.

4.2 Analysis of simulated data and hypotheses development

We generate simulated data from our model by considering a variety of parameterizations in addition to the base case in Table 1. To understand the main trade-off between convertible and callable debt we start the analysis by first considering debt without covenants. The results for convertible and callable debt are presented in Table 2 and 3, receptively.[9] Both tables consider three levels of the investment cost when the growth option is exercised, I_1. For each level of the investment cost we vary the initial debt I_0, as stated in the first column. The next two columns contain the details of the debt contract. Column four shows the value of equity, columns five and six report the default and the investment threshold. Subsequent to implementing the growth option, columns seven and eight report the default threshold and the threshold at which debt is either converted or called. Leverage is reported in column nine, and column 10 contains the debt overhang measure EDO.

4.2.1 General bond characteristics

The results for convertible debt in Table 2 show the intuitive effects that higher initial debt increases both leverage and debt overhang, albeit the latter effect is not very strong. Increasing the investment cost, I_1, tends to have similar effects, but since the growth option is exercised in the future, the impact on leverage is small. There seems to be a non-monotonic effect in debt overhang. To understand this, it is important to notice that the investment cost has a huge impact on the timing of the investment as well as when debt holders decide to convert their debt to equity. For example, if the initial debt is kept at 7, and the investment cost is relatively low, e.g. 4, then investment takes place when the market index increases to $x = 0.3356$ (about a 12% increase) and debt is converted when the index increases to $x = 1.1043$. Thus, debt holders wait quite long before converting their claim. Debt overhang is 0.0245 in this case. For a higher investment cost, $I_1 = 5$, equity holders postpone exploiting the growth option until $x = 0.4083$. However, the debt holders convert their claim already at $x = 0.8842$. This stems from the fact that the equity holders initially prefer to decrease

[9] The firm may also issue straight debt, but this is not optimal for the parameters we have considered. For example, in the base case with $I_0 = 5, I_1 = 8$ the coupon is 0.254 and equity has value 13.21. If instead $I_0 = 4, I_1 = 6$, then the coupon is 0.168 and equity has value 16.07. In both cases callable debt as well as convertible debt dominate straight debt.

the coupon and instead increase the share to the debt holders at conversion. As a result, debt overhang increases to 0.0552. Increasing the investment cost further, $I_1 = 6$, similarly induces equity holders to invest later and debt holders to convert earlier. However, this will eventually collapse into one threshold at which equity holders invest and the debt holders convert their claim immediately thereafter.[10] The effect of this boundary solution is that the debt is converted early and debt overhang consequently becomes lower (0.0592).

Table 3 reveals that issuing callable debt implies some of the same effects. A higher initial level of debt increases again leverage and debt overhang. However, increasing the investment cost does lead to some differences compared to the case with convertible debt. Generally, the coupon and the call premium both increase. This makes sense because callable debt yields more decision rights to equity holders. Since a higher investment cost makes the growth option less valuable (even without initial debt), equity holders are initially more interested in exploiting the tax shield and this leads to higher coupons. On the other hand, they do not want to increase the coupon too much because they also want to curb the risk of default and so the call premium increases just enough to attain the desired initial value of debt. As with convertible debt, investment occurs later for higher investment costs, but not much later than with convertible debt. However, the point at which debt is called is much later than when convertible debt is exchanged, Using the same example as with convertible debt ($I_0 = 7$), increasing the investment cost from 4 to 6 increases the call boundary from $x = 1.0142$ to $x = 1.1463$. Thus, callable debt is outstanding for a much longer period of time with a higher likelihood of default which makes it more risky.

Therefore, the implications of these results lead to the following two empirical hypotheses:

Hypothesis 1a: Firms issue callable bonds with a higher coupon compared to convert-

[10] Simply solving the model for higher investment costs implies that debt holders would like to exercise their claim before the equity holders do, but under the assumption that the (old) equity holders still pay the full investment cost. This is implausible. Thus, we also solve the model assuming that either debt holders exercise early and pay their share of the investment cost or assuming that debt holders exercise immediately after the equity holders do. The latter is the optimal solution for the debt holders.

ible bonds.

Hypothesis 1b: Compared to the conversion of convertible bonds, callable bonds are held for a longer period before they are called.

4.2.2 Debt overhang

The debt overhang problem implies two different perspectives dependent on whether the firm has an ex post or an ex ante point of view (e.g., Stein, 2003). The ex post point of view presupposes that the firm has debt in place. Therefore, the focus is on minimizing the wealth transfer from the debt holders to the equity holders when the growth option is exercised. That purpose is best served with a debt contract giving the exercise rights to the equity holders; that is, callable debt is preferred. The ex ante point of view takes into account that debt holders at the time of the debt issuance foresee the equity holders' self-interested behavior. Of course, the growth option is indirectly valuable for the debt holders, but they correctly anticipate that the implementation is postponed compared to a no-debt case. This effect decreases the value of debt and may in turn make it optimal for the firm to grant ex post rights to the debt holders. This can be done with convertible debt. Intuitively, the trade-off between the ex post and ex ante point of view should favor callable debt over convertible debt for a relatively low level of initial debt.

The simulated data confirm this pattern. Comparing Table 2 with Table 3 for a given level of initial debt, we see that the firm maximizes its value by issuing convertible debt when initial debt is high. For example, assuming the growth option costs $I_1 = 5$ to implement, the firm's value with $I_0 = 7$ is 21.51 with convertible debt and 21.54 with callable debt. Thus, callable debt is optimal. For a higher initial debt level, $I_0 = 8$, convertible debt yields a firm value of 21.51 and callable debt a firm value of 21.50. Hence, convertible debt is optimal. This in turn implies that debt overhang is larger for callable debt than for convertible and that debt overhang increases monotonically with initial debt and investment costs for callable debt. As an outcome, callable debt can be subject to a much higher level of debt overhang than convertible debt. Stated differently, since relatively high initial debt implies that convertible debt is optimal, we find that observed convertible debt should be related to a low level of debt overhang. Similar, if the firm decides to issue callable debt, debt overhang plays a larger role. Therefore:

Hypothesis 2: Firms that are more exposed to debt overhang tend to issue callable rather than convertible bonds.

4.2.3 Covenants

Covenants grant rights to the debt holders and are therefore likely to affect the ex ante and ex post trade-off discussed above. Since convertible debt is more creditor friendly than callable debt, we expect that net worth covenants are generally more expensive for a firm issuing convertible debt.[11] Table 4 reports the results for a covenant protecting 25% of the principal with convertible debt; the results for callable debt are reported in Table 5. As expected, covenants impact convertible debt more than callable debt. With convertible debt, the covenant makes the firm choose a higher coupon and a lower future share of equity. This is intuitive because the covenant forces the firm into default for a higher level of the market profitability index. To circumvent this friction, the firm grants higher coupons (with a tax shield) which in itself induce an earlier (ex post optimally chosen) default. The higher coupon allows the firm to limit sharing the benefit of the growth option. For example, with $I_0 = 8$ and $I_1 = 5$, the coupon increases from 0.14 to 0.22 and the share decreases from 0.26 to 0.14. The default boundary (before exercising the growth option) increases from 0.0364 to 0.0627 at which the covenant becomes effective.

The impact is smaller for callable debt. Callable debt already carries a high coupon, and

[11] In contrast, if we consider covenants limiting future investments, such covenants seem more aligned with the creditor rights with convertible debt, and thus such covenants are likely more expensive for callable debt. For tractability, we focus on net worth covenants.

thus the ex post optimal default threshold without the covenant is relatively high and close to the covenant-induced default threshold. Using the above example, the default threshold increases from 0.0567 to 0.0627. Consequently, the firm is generally better off issuing callable debt, if it has to include a net worth covenant. As Tables 4 and 5 show, our simulated data confirm this. The firm only issues convertible debt if the initial debt is high and the investment cost is low. Hence this leads to the following hypothesis:

Hypothesis 3a: Firms with existing bond covenants are more likely to issue callable bonds compared to convertible bonds.

Including a covenant does not impact firm value and leverage dramatically in our simulated data. We previously argued that firms exposed to debt overhang tend to issue callable debt. Combining the effects, we therefore expect that firms with covenants being subject to debt overhang tend to issue callable debt.

Hypothesis 3b: If firms have existing bond covenants and are also exposed to more debt overhang, then they are even more likely to issue callable bonds.

Occasionally firms violate a covenant and subsequently have to issue new debt. Our model does not allow for a specific analysis of how violating a covenant impacts future debt characteristics. However, from our discussion with the ex ante and the ex post trade-off, we conjecture that a recent covenant violation causes concerns with the creditors. The firm therefore has to issue the more creditor friendly convertible debt although it would not have done so, had a covenant not been violated.

Hypothesis 3c: Firms whose covenants have previously been violated are more likely to issue convertible bonds compared to callable bonds.

4.2.4 Leverage and the growth option – a size effect

Next, we want to understand how the opportunity to expand the firm affects the choice between convertible and callable debt. In terms of the model, the growth option is parameterized by the investment cost, I_1, and the scaling of earnings, Π. To save space we focus on the investment cost; however, a higher scaling intuitively impacts in the same vein as a lower investment cost and increases the value of the growth option.[12] Clearly, the firm is more eager to undertake the investment in this case. We see this effect in Tables 2 and 3: A higher investment cost increases the investment threshold. Intuitively, we also find that a higher investment cost makes the growth option less important for the firm, and thus the firm initially tends to emphasize the ex ante view over the ex post view. That is, higher investment costs increases the firm's willingness to issue convertible debt. Our simulated data in Table 2 and Table 3 confirm this.

When analyzing empirical data it is not entirely obvious how to study the effect of, e.g., the investment cost of a growth option.[13] Therefore, we seek a measure which is empirically accessible. Looking at simulated data, we see that a higher investment cost monotonically decreases the firm value for a given amount of initial debt. This makes sense because a higher investment cost decreases the value of the growth option, and this is taken into account in the market's valuation of the firm. Therefore, we also interpret the investment cost as being inversely related to the size of the firm. Consequently, since a smaller investment cost increases the firm's incentive to issue callable debt, we conjecture that larger firms tend to issue callable debt.

Hypothesis 4a: Larger firms are more likely to issue callable bonds compared to convertible bonds.

We next examine the effect of leverage. We earlier argued that higher initial debt, which monotonically increases leverage, makes the firm put more emphasis on the ex ante point

[12] In a basic "first best" option to invest model, it is easy to see that the parameters impact the decision to invest exactly like this, see equation (27).

[13] Linking investment decisions to investment opportunities theoretically, a simple Q theory implies that a firm should invest if its marginal adjustment and purchase cost of investing is bigger than the replacement cost of capital. However – as is well known – the investment opportunities (marginal Q) are empirically unobservable, and replacing it with the average Q (i.e., the firm's market-to-book ratio or Tobin's Q) is problematic due to measurement errors (Whited and Erickson, 2000).

of view and hence it tends to issue convertible debt. Based on this, a natural conjecture is that higher leverage should make the firm more in favor of convertible debt. This cogent observation notwithstanding, we note that leverage is in our model effectively the inverse of the size of the firm. Thus, we want to be careful in interpreting what our model says with respect to both size and leverage simultaneously.[14] However, based on our existing analysis and the effect of the ex ante and ex post trade-off, we conjecture that leverage has a different effect on the firm's debt choice depending on the size of the firm. If the firm is relatively small, it is more important for the firm to have the control rights over future growth opportunities. Thus, if the firm increases its leverage, we expect that the firm tends to issue callable debt. In contrast, we conjecture that relatively large firms tend to focus more on their existing production rather than undertaking new innovative growth options – in particular, if the firm's leverage is already high.[15] Therefore, we conjecture that large firms has a tendency to use convertible debt, if they increase their leverage.

Hypothesis 4b: The effect of leverage on the probability of issuing callable debt is non-monotonic with regards to firm size. Small firms with higher leverage ratios are expected to issue callable debt whereas big firms with lower leverage ratios are expected to issue convertible debt.

[14]It is outside the scope of our paper to specifically include size as a determinant in the model. We leave this as an interesting path for future work.

[15]While the empirical evidence relating leverage to firm size find mostly a positive relationship (e.g., **?**Fama and French, 2002), Faulkender and Petersen (2006) document a weakly negative relationship. Recently, Lé and Vinas (2019) show that firms fund their investment in fixed assets mainly with bank debt when they are small whereas the biggest firms rely on a more diversified funding strategy. However, to the best of our knowledge, there is little empirical evidence quantifying how different forms of investments vary with firm size.

5 Empirical analysis

5.1 Data and descriptive statistics

Our data combines information on both firm and bond characteristics. We collect quarterly data on firms' accounting variables from Compustat. We exclude financials, utilities, and governmental firms (SIC codes 6000-6999, 4900-4999, and 9000-9999), as these firms are subject to different regulations. We collect the firms' bond information using the Mergent Fixed Income Securities Database (FISD) and merge it with the balance sheet data using firms' CUSIPs. We limit the analysis from 1990 to 2017, as the FISD database has limited coverage prior to that.

The information in the FISD database allows us to define whether a debt issue is convertible or callable. The database contains the flags "Convertible" and "Redeemable", indicating that the issue can be converted to common stock or another security of the issuer or that the bond is redeemable under certain circumstances. We define a convertible issue as a bond issue with a flag on convertible, no flag on redeemable, and for which the conversion commodity type is either "American Depository Shares" (ADS), "Common Stocks" (CS), "Class A Common Stock" (CSA), "Class B Common Stock" (CSB) or "Preferred Stock" (PS).[16] We thus focus on convertible bonds that are not callable. We define a callable bond as a bond with a flag on redeemable but no flag on convertible.[17]

From the bond information we are mainly interested in the following variables: a bond's

[16]These comprise 99.18% of the conversion types in the database. Other conversion commodity types include Note/Debenture (DEB), Not available (NA), Purchase contract (PC), U.S. Dollar (USD).

[17]In our sample, this applies to 33% of all convertible bonds. Hence, the proportion of convertible issues that are not callable is larger than that of King and Mauer (2014) (18%), which could be attributed to the fact that these authors use the SDC data as opposed to the FISD data that we use. Non-callable convertible bonds have are broadly comparable compared to convertible bonds that can be called in terms of the average offering amount (350.000 USD vs. 300.000 USD) and coupon (3.4% vs. 4.0%), though they have a shorter maturity (6 years vs. 13 years) and holding time (2.5 years vs. 3.5 years). Data limitations prevent us from using SDC data. Moreover, we exclude all issues with flags on both convertible and redeemable, since our theoretical analysis focuses on the characteristics for either callable or convertible debt.

maturity, its coupon, its offering amount, its holding time, and whether covenants are attached. We define the bonds' holding period as the period between the issuance of the bond until the bond is converted or called. For convertible bonds, this refers to the earliest partial conversion, since bondholders do not all voluntarily convert at the same time. To examine the role of covenants, we focus on covenants that fit to our above described theoretical analysis and we rely on balance sheet restrictive covenants as defined by Bienz et al. (2010). These include declining and maintaining net worth covenants as well as fixed charge covenants.[18]

To match the information on bond issues to the accounting data from Compustat, we recognize that each firm may issue several bonds in the same quarter. We want to determine the characteristics of a firm issuing one type of bond over the other. Therefore, we focus on firm-year quarters in which firm issues either only callable bonds or only convertible bonds. If multiple bonds of the same type are issued in the same quarter, the average of our variables of interest is used.[19] All variables are defined according to the literature (e.g., Lemmon et al., 2008; Frank and Goyal, 2009; Leary and Roberts, 2010) and Table 6 in the Appendix provides a list of variable definitions. To link the issuance of callable or convertible debt to a measure of debt overhang, we use the measure developed by Alanis et al. (2018), which represents the current value of lenders' rights to recoveries in default.[20] One advantage of this measure is that it does not rely on the credit agencies' ability to assess firms' risk of default correctly. For every firm i and year t the debt overhang measure is given as

$$\text{Debt overhang} = \frac{D_t}{K_t} \cdot \text{Recovery Rate} \cdot \left[\sum_{s=1}^{20} \omega_t \left[1 - 0.05(s-1)\right] (1+r)^{-s} \right]. \qquad (33)$$

D represents the total debt and K refers to the capital stock. The recovery rate for defaulted

[18]The following covenant types are used (FISD code in parenthesis): "declining net worth" (bh12), "maintenance net worth" (ir7), "net earnings test issuance" (ir16), "fixed charge coverage" (ir17), "leverage test" (ir18), and "rating decline" (bh10).

[19]If in a given quarter, a firm issues several callable bonds, the average (e.g., maturity) is calculated.

[20]We thank Alanis et al. (2018) for sharing this data.

senior unsecured bonds is from Altman and Kishore (1996) who group defaulted bonds by SIC codes to account for the fact that the average prices at default vary between industries. Together, the first two terms of the debt overhang measure represents a measure for the creditors' recovery in default. The last term is a measure for the probability that the firm defaults, where a hazard model is used to forecast the default probabilities ω.[21] Hence, as discussed above, this empirical debt overhang measure resembles closely the measure that is used in the simulation analysis.

Descriptive statistics

The final sample comprises of 7,243 firm-quarters in which the firms issue only callable bonds and 768 firm-quarters in which the firms issue only convertible bonds. Table 7 Panel A shows the descriptive statistics for the quarters in which the firms issue callable bonds and Panel B for quarters in which the firms issue convertible debt. In general, the median values of maturity and coupon are 9.49 and 6.15. They are significantly higher for callable bonds than for convertible bonds (9.70 and 7.00 vs. 5.03 and 3.00, respectively). Additionally, the median holding time of a callable bond is also larger than the one of a convertible bond (2.55 years vs. 1.05 years). Firms that issue callable bonds tend to have more leverage, a higher return on assets, less cash, and more tangible assets. Further, they are larger in size, have a lower Tobin's Q, and have a lower mean of debt overhang. These descriptive statistics indicate that Hypotheses 1a and 1b hold, yet, to analyze this more formally we next turn to regression analyses.

[21]This model allows Alanis et al. (2018) to estimate default probabilities for each firm-year, without relying on the availability of a bond rating. The hazard model has been shown to outperform other bankruptcy predicting model. Previous literature, e.g., Hennessy et al. (2007), uses the Moody's hazard rate of default. However, this restricts the sample of firms for which we can compute a measure of debt overhang. Furthermore, credit rating based default measures assign the same default probability to all firms within a credit rating class. They do so even though investors may not perceive them as having the same credit risk.

5.2 Empirical strategy

We estimate the probability of issuing callable debt rather than convertible debt.[22] To do so, we use the following probit regression (using a linear probability model leads to similar results):

$$Pr(call)_{i,t} = \theta_0 + \gamma_1 \text{ maturity}_{i,t} + \gamma_2 \text{ offering\_amount}_{t,i} + \gamma_3 \text{ coupon}_{t,i} + \gamma_4 \text{ holding\_time}_{t,i} + \gamma_5 \text{ debt\_overhang}_{t,i} + \gamma_6 \text{ covenant}_{t,i} + \beta X_{i,t} + \alpha_y + \alpha_{ind} + \varepsilon_{i,t}, \tag{34}$$

where $Pr(call)$ is equal to one if the bond issuance was callable and zero if it was convertible. The variable *debt_overhang* is defined as described above and the variable *covenant* is a dummy variable that is equal to one if a firm's outstanding bonds have balance sheet restrictive covenants attached in a given quarter and zero otherwise. All models include year- (α_y) and industry- (α_{ind}) fixed effects. This should help address concerns that our results are mainly driven by unobservable characteristics of the industry or the year, which are not captured by the set of firm-level control variables in Equation (34). The heteroscedasticity robust standard errors are clustered at the firm level in order to capture the time-series correlation within firms in the error term.

To examine the effect of firm size and leverage, we include the interaction of these two variables into the above regression framework. Moreover, we add a variable that measures whether a firm's previously issued bonds have been subject to covenant violations and we interact this variable with the dummy whether firms' bonds have covenants.

[22]We recognize that the decision to issue callable or convertible debt is endogenous to the firm. However, we refrain from a more general, causal, analysis. Instead we seek to document which factors correlate with the probability of issuing callable rather than convertible debt.

5.3 Empirical results

We first examine how the main bond characteristics relate to the probability of issuing a callable bond. Supporting Hypotheses 1a and 1b, Column (1) of Table 8 shows that issuing a callable bond is positively related to the bond's coupon and the holding time, i.e., the time between issuance and action date of the bond. Increasing the coupon by one percentage point (standard deviation) on average increases the probability of issuing a callable bond by 3.5% (7.2%). The intuition behind this finding is that since holders of convertible debt have the option to convert the claim into equity, callable debt holders require a higher coupon as compensation. This finding is consistent with previous empirical literature, but differs from the theoretical predictions of Hennessy and Tserlukevich (2008). Furthermore, there is a significant positive relationship between the issuance of a callable bond and the bond's maturity. This finding is similar to Becker et al. (2018). However, their paper focuses only on callable bonds and does not consider convertible bonds. We also find a positive correlation between the issuance of a callable bond and offering amount. Thus, compared to convertible bonds, we expect callable bonds to have a longer maturity and a higher offering amount.

Adding firm characteristics and echoing the previous literature (e.g., Kish and Livingston, 1992; Robak and Kish, 2000), column (2) shows that more profitable firms are more likely to issue callable bonds, whereas firms with higher cash levels are more likely to issue convertible bonds. Increasing the return to assets (cash) by one percentage points increases (decreases) the probability of issuing callable bonds by 47.4% (2.4%). Stated differently, a one standard deviation increase in profitability (cash) increases (decreases) the probability of issuing callable debt by 5.5% (2.2%).

Column (3) supports our second empirical hypothesis by showing that there is a positive relation between our measure of debt overhang and the probability of issuing a callable rather than convertible bond. A one standard deviation increase in the debt overhang measure increases the probability of issuing a callable bond by 0.5%. This suggests that to mitigate the effect of debt overhang, the firms tend to issue a debt contract which ex post can be controlled by the firm.

As a next step, we examine the relationship between issuing callable vs. convertible debt and covenants. First, Column (4) of Table 8 adds a dummy variable if the outstanding debt has a net-worth covenant attached. Consistent with our Hypothesis 3a, having a covenant in place increases the probability of issuing callable debt by 14.2%.[23] Second, Columns (2) and (3) of Table 9 confirm Hypotheses 3b and 3c: Firms with existing bond covenants are more likely to issue callable bonds if they are exposed to more debt overhang. Conditional on having a covenant, an increase in the debt overhang measure further increases the probability of issuing callable debt. Moreover, firms whose debt issuance has a net-worth covenant attached and whose covenants have previously been violated are 11.5% more likely to issue convertible bonds compared to callable bonds, indicating that firms issue more creditor friendly debt than they would have done otherwise.

Last, we examine the effect of firm size and leverage. Notice that while size has a positive and significant effect on issuing callable debt in all specifications of Table 8 (consistent with Hypothesis 4a), leverage is never significant in the basic regression specification. Therefore, in line with the above discussion, Column 1 in Table 9 includes an interaction term between firm size and leverage. Interestingly, using this regression specification induces both variables to be significant individually: A one percentage point increase in size (leverage) increases the probability of issuing callable debt by 3.6% (28.9%), or stated differently, a one standard deviation increase in either leverage or size increases the probability of issuing callable debt by 4.7% and 4.6%, respectively. However, the interaction term is negative and again highly significant. To interpret the interaction of these two continuous variables, Figure 4 plots the adjusted predictions for different levels of firm size. In line with Hypothesis 4b, we find that

[23]Adding industry fixed effects in column (5) does not materially affect size or significance of these results.

the slope is positive for small firms meaning that there is a positive and significant effect of leverage with regards to the probability of issuing callable debt. For larger firms, this effect reverses, i.e., for these firms, more leverage increases the probability of issuing convertible debt (decreases the probability of issuing callable debt).

To summarize, we find support for the hypotheses described in Section 4.2. The probability of issuing callable rather than convertible debt correlates significantly with the bond characteristics (Hypotheses 1a & 1b), the severity of the debt overhang that a firm is subject to (Hypothesis 2), the bond covenants (Hypotheses 3a & 3b), and the interaction between firm size and leverage (Hypothesis 3c).

6 Conclusion

Using a dynamic model, this paper examines the role of debt overhang and covenants in a manager's choice between issuing callable or convertible debt. While callable debt provides a premium to bondholders in exchange for firms' repurchase option of their claim, convertible debt offers investors the option to exchange firms' debt to equity. Our model predicts that firms that are more exposed to debt overhang issue callable rather than convertible bonds. Stated differently, with debt overhang, firms are more likely to issue debt contracts which they can control ex-post. Moreover, firms with existing bond covenants are more likely to issue callable bonds compared to convertible bonds. The intuition behind this is that since convertible debt is more creditor friendly than callable debt, such covenants are generally more expensive for a firm issuing convertible debt. Hence, firms with existing bond covenants are more likely to issue callable bonds compared to convertible bonds. Last, firms issue callable debt with a higher coupon compared to convertible debt and the time between the issuance of callable debt until it is called is longer than the time between issuance and conversion for convertible bonds. Data on U.S. corporate bond issues between 1990 and 2017 confirm these predictions.

References

Alanis, E., S. Chava, and P. Kumar (2018). Shareholder Bargaining Power, Debt Overhang, and Investment. *Review of Corporate Finance Studies 7*, 276–318.

Altman, E. I. and V. M. Kishore (1996). Almost Everything You Wanted to Know about Recoveries on Defaulted Bonds. *Financial Analysts Journal 52*, 57–64.

Becker, B., M. Campello, V. Thell, and D. Yan (2018). Debt Overhang and the Life Cycle of Callable Bonds. *Working Paper*.

Bienz, C., A. Faure-Grimaud, and Z. Fluck (2010). The defeasance of control rights. *Working Paper*.

Billingsley, R. S. and D. M. Smith (1996). Why do firms issue convertible debt? *Financial Management*, 93–99.

Chava, S., P. Kumar, and A. Warga (2010). Managerial agency and bond covenants. *The Review of Financial Studies 23*(3), 1120–1148.

Chen, Z., C. X. Mao, and Y. Wang (2010). Why Firms Issue Callable Bonds: Hedging Investment Uncertainty. *Journal of Corporate Finance 15*(4), 588–607.

Christensen, P. O., C. R. Flor, D. Lando, and K. R. Miltersen (2014). Dynamic Capital Structure with Callable Debt and Debt Renegotiation. *Journal of Corporate Finance 29*, 644–666.

Clausen, S. and C. R. Flor (2015). The impact of assets-in-place, corporate financing and investment decisions. *Journal of Banking and Finance 61*, 64–80.

Cooper, I. (2006). Asset Pricing Implications of Nonconvex Adjustment Costs and Irreversibility of Investment. *Journal of Finance 61*, 139–170.

Dixit, A. K. and R. S. Pindyck (1994). *Investment under Uncertainty.* Princeton, New Jersey, USA: Princeton University Press.

Fama, E. F. and K. R. French (2002). Testing trade-off and pecking order predictions about dividends and debt. *Review of Financial Studies 15*(1), 1–33.

Faulkender, M. and M. A. Petersen (2006). Does the source of capital affect capital structure? *The Review of Financial Studies 19*(1), 45–79.

Flor, C. R. and S. Hirth (2013). Asset liquidity, corporate investment, and endogenous financing costs. *Journal of Banking & Finance 37*(2), 474–489.

Frank, M. Z. and V. K. Goyal (2009). Capital Structure Decisions: Which Factors Are Reliably Important? *Financial Management 38*, 1–37.

Frantz, P. and N. Instefjord (2019). Debt overhang and non-distressed debt restructuring. *The Journal of Fixed Income 37*, 75–88.

Goldstein, R., N. Ju, and H. E. Leland (2001). An EBIT-Based Model of Dynamic Capital Structure. *Journal of Business 74*(4), 483–512.

Hackbarth, D. and T. Johnson (2015). Real options and risk dynamics. *Review of Economic Studies 82*, 1449–1482.

Hackbarth, D. and D. C. Mauer (2012). Optimal Priority Structure, Capital Structure, and Investment. *Review of Financial Studies 25*(3), 747–796.

Hennessy, C. A., A. Levy, and T. M. Whited (2007). Testing Q theory with financing frictions. *Journal of Financial Economics 83*, 691–717.

Hennessy, C. A. and Y. Tserlukevich (2008). Taxation, agency conflicts, and the choice between callable and convertible debt. *Journal of Economic Theory 143*, 374–404.

Julio, B. (2013). Corporate Investment and the Option to Repurchase Debt. *Working Paper*.

Kahan, M. (1995). Anti-dilution provisions in convertible securities. *Stanford Journal of Law, Business & Finance 2*, 147–166.

King, T.-H. D. and D. C. Mauer (2014). Determinants of corporate call policy for convertible bonds. *Journal of Corporate Finance 24*, 112–134.

Kish, R. and M. Livingston (1992). Determinants of the Call Option on Corporate Bonds. *Journal of Banking & Finance 16*, 687–703.

Kruse, T., T. Nohel, and S. K. Todd (2014). The Decision to Repurchase Debt. *Journal of Applied Corporate Finance 26*, 85–93.

Lé, M. and F. Vinas (2019). How do firms fund their investment? Firm size and funding mix. *Working Paper*.

Leary, M. T. and M. R. Roberts (2010). The pecking order, debt capacity, and information asymmetry. *Journal of Financial Economics 95*, 332–355.

Lemmon, M. L., M. R. Roberts, and J. F. Zender (2008). Back to the Beginning: Persistence and the Cross-Section of Corporate Capital Structure. *Journal of Finance 63*, 1575 – 1608.

Lyandres, E. and A. Zhdanov (2014). Convertible debt and investment timing. *Journal of Corporate Finance 24*, 21–37.

Mao, L. and Y. Tserlukevich (2015). Repurchasing debt. *Management Science 61*, 1648–1662.

Morellec, E. and N. Schürhoff (2011). Corporate investment and financing under asymmetric information. *Journal of Financial Economics 99*(2), 262–288.

Myers, S. (1977). The determinants of corporate borrowing. *Journal of Financial Economics 5*, 147–175.

Robak, P. J. and R. J. Kish (2000). Revisiting the determinants of the corporate debt call option: new evidence 1987-1996. *Journal of Financial and Strategic Decisions 13*, 83–96.

Shibata, T. and M. Nishihara (2012). Investment timing under debt issuance constraint. *Journal of Banking & Finance 36*, 981–991.

Smith Jr, C. W. and J. B. Warner (1979). On financial contracting: An analysis of bond covenants. *Journal of Financial Economics 7*(2), 117–161.

Stein, J. C. (2003). Agency, Information and Corporate Investment. In *Handbook of the Economics of Finance*, Chapter 2, pp. 111–165. Elsevier.

Whited, T. and T. Erickson (2000). Measurement error and the relationship between investment and Q. *Journal of Political Economy 108*, 1027–1057.

Woronoff, M. A. and J. A. Rosen (2005). Understanding anti-dilution provisions in convertible securities. *Fordham L. Rev. 74*, 129.

7 Appendix

7.1 Proof of Proposition 1

Proof. We first derive the value of a general claim, F, which depends on x as a state variable. In addition, the claim hold of F receives the payment $\overline{F}$ when x reaches a high level of the state variable, $\overline{x}$. Similarly, $\underline{F}$ is received when x reaches a low level of the state variable, $\underline{x}$. Finally, let the claim holder receive the payment flow $h_0 + h_1 x$ until either $\underline{x}$ or $\overline{x}$ is hit the first time. Since the dynamics of x follows (1) and the required rate of return on any claim is the risk-free rate of return, standard arguments give us that the claim F must satisfy the ordinary differential equation (see e.g., Dixit and Pindyck, 1994; Hackbarth and Mauer, 2012; Christensen et al., 2014)

$$\frac{1}{2}\sigma^2 x^2 F''(x) + \mu x F'(x) - rF(x) + h_1(x) + h_0 = 0. \tag{35}$$

Given this we also have that

$$F(x) = \frac{h_1 x}{r-\mu} + \frac{h_0}{r} + f_1 x^{\beta_1} + f_2 x^{\beta_2}, \tag{36}$$

where the coefficients f_1 and f_2 are to be found below. Note that the assumption $\mu < r$ comes into play here. The powers, β_i, solve the quadratic equation

$$\frac{1}{2}\sigma^2 \beta_i(\beta_i - 1) + \mu\beta_i - r = 0, \tag{37}$$

with $\beta_1 > 1$ and $\beta_2 < 0$. To find the coefficients f_1 and f_2 we use the value matching conditions to get two equations:

$$\frac{h_1\overline{x}}{r-\mu} + \frac{h_0}{r} + f_1\overline{x}^{\beta_1} + f_2\overline{x}^{\beta_2} = \overline{F}, \tag{38}$$

$$\frac{h_1\underline{x}}{r-\mu} + \frac{h_0}{r} + f_1\underline{x}^{\beta_1} + f_2\underline{x}^{\beta_2} = \underline{F} \tag{39}$$

Linear algebra gives us that the solution on vector form is

$$\begin{pmatrix} f_1 \\ f_2 \end{pmatrix} = \frac{1}{\overline{x}^{\beta_1}\underline{x}^{\beta_2} - \underline{x}^{\beta_1}\overline{x}^{\beta_2}} \begin{pmatrix} \underline{x}^{\beta_2} & -\overline{x}^{\beta_2} \\ -\underline{x}^{\beta_1} & \overline{x}^{\beta_1} \end{pmatrix} \begin{pmatrix} \overline{F} - \frac{h_1\overline{x}}{r-\mu} - \frac{h_0}{r} \\ \underline{F} - \frac{h_1\underline{x}}{r-\mu} - \frac{h_0}{r} \end{pmatrix}. \tag{40}$$

The present value claim that gives one unit of account, if x hits $\overline{x}$ before $\underline{x}$, can thus be derived setting $h_0 = h_1 = \underline{F} = 0$ and $\overline{F} = 1$. After manipulating we get

$$p_u(x;\overline{x}) = \frac{\underline{x}^{\beta_2}x^{\beta_1} - \underline{x}^{\beta_1}x^{\beta_2}}{\overline{x}^{\beta_1}\underline{x}^{\beta_2} - \underline{x}^{\beta_1}\overline{x}^{\beta_2}}, \quad \text{and} \quad p_d(x;\overline{x}) = \frac{-\overline{x}^{\beta_2}x^{\beta_1} + \overline{x}^{\beta_1}x^{\beta_2}}{\overline{x}^{\beta_1}\underline{x}^{\beta_2} - \underline{x}^{\beta_1}\overline{x}^{\beta_2}}. \tag{41}$$

Using the two equations in (41) yields equation (3). Plugging this and (40) into (36) yields the expression as stated in equation (2). □

7.2 A simplified analysis of converting and calling debt

To gain further intuition about the difference between convertible debt and the callable debt, we consider the timing of conversion. That is when debt holders convert their debt as well as when equity holders call outstanding debt. Since we are interested in the boundary for a high cash flow level, we abstract from the possibility to default. For simplification, we assume that the principal of callable debt is proportional to the perpetual value of receiving the coupon, $mC^{cal}/r, m \geq 1$.

With these assumptions we obtain the threshold x_u^{con} for which debt holders convert their debt

$$x_u^{con} = \frac{\beta_1}{\beta_1 - 1}\frac{C^{con}}{r}\frac{1}{sA_2(1)}. \tag{42}$$

The conversion threshold (42) intuitively depends on the core parameters. First, $\frac{\beta_1}{\beta_1-1} > 1$ is the standard scaling due to the value of the option to wait. Next, the higher the perpetual value of the coupon rate is, the higher must the value of the alternative (becoming a shareholder) be, which implies a higher level of the existing cash flow. Finally, a higher share or a more profitable restructured firm (either through Π or through the tax shield) make the alternative more valuable from the debt holders' point of view. Therefore, they are incentivized to convert their debt earlier.

Turning to callable debt, the threshold, x_u^{cal}, for which the equity holders call the outstanding debt is

$$x_u^{cal} = \frac{\beta_1}{\beta_1 - 1}\left(m(1+p) - (1-\tau)\right)\frac{C^{cal}}{r}\frac{1}{A_2(1) - (1-\tau)\frac{\Pi}{r-\mu}}. \tag{43}$$

Again, $\frac{\beta_1}{\beta_1-1} > 1$ is the standard scaling due to the value of the option to wait. With callable debt, the alternative for equity holders is to call debt and restructure the capital. This alternative implies that equity holders must pay the call premium p. In return, equity holders obtain the full claim on the underlying. Thus, equity holders call the debt only when the value of the underlying is higher than the cost of obtaining the full claim. Finally, a more profitable growth opportunity makes the benefit of restructuring the capital more value which in turn decreases the value of waiting.[24]

[24]Note that $A_2(1) - (1-\tau)\frac{\Pi}{r-\mu}$ in (43) is the tax advantage of debt per unit of EBIT. This advantage increases in Π.

7.3 Figures and tables

Figure 1: **Time line for a firm issuing convertible debt**
This figure presents the time line for a firm that initially issued convertible debt. The firm is initially financed with debt and equity (E_0^{con}, $D_0^{con} = I_0$). If earnings decrease to $x = x_{d_0}^{con}$, the firm defaults and continues as an unlevered firm ($E_1 = 0, D_1^{con} = (1-\alpha)V_U$). If earnings increase sufficiently the firm invests at $x = x_{u_0}^{con}$ ($E_0 = E_1 - I_1$, $D_0^{con} = D_1^{con}$). Post-investment, if earnings increase to $x = x_{u_1}^{con}$ the debt is converted to equity and the firm issues new debt ($E_1 = (1-s)A_2(x_{u_1}^{con}), D_1^{con} = sA_2(x_{u_1}^{con})$). If earnings decrease to $x = x_{d_1}^{con}$ the firm defaults and continues as an unlevered firm ($E_2 = 0, D_2^{con} = (1-\alpha)V_U$).

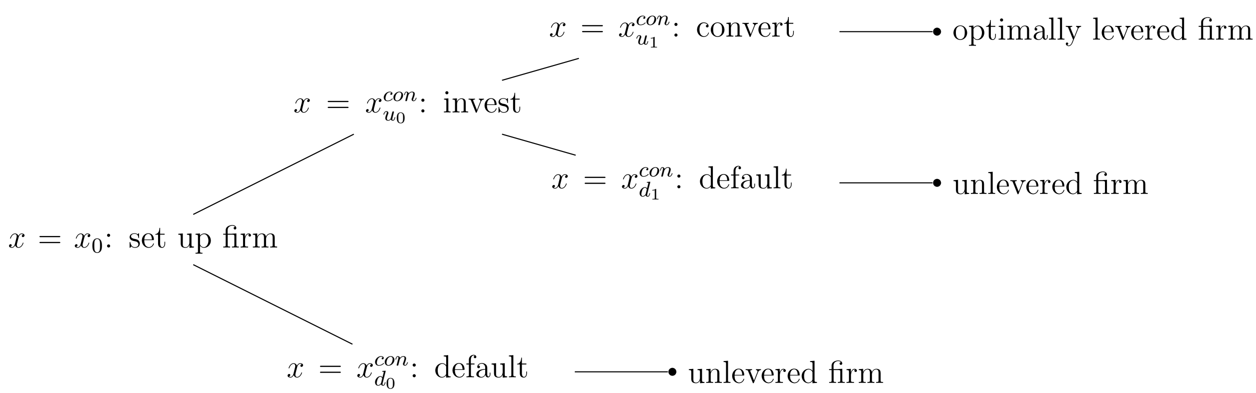
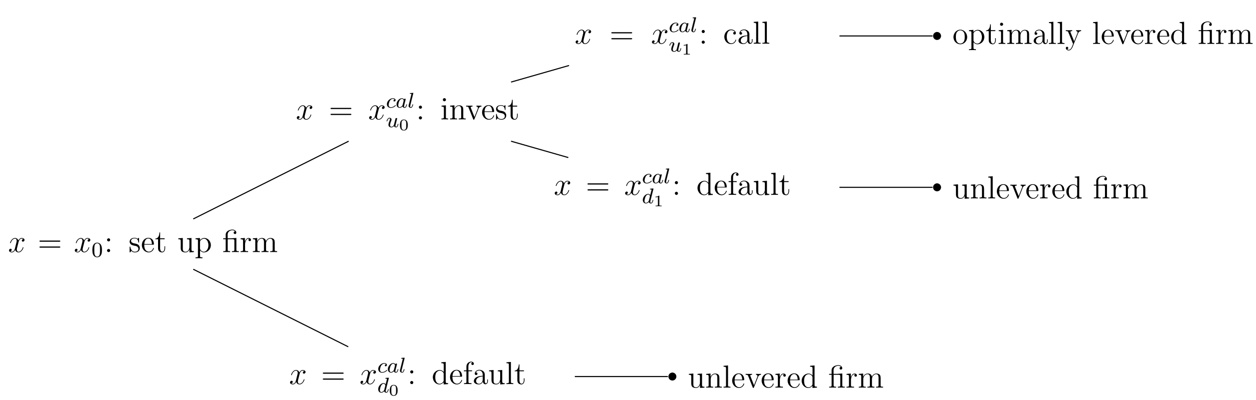
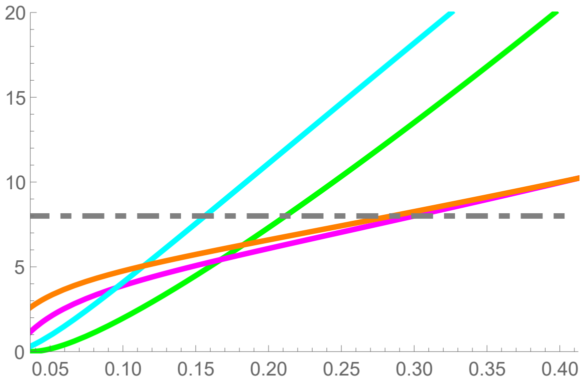
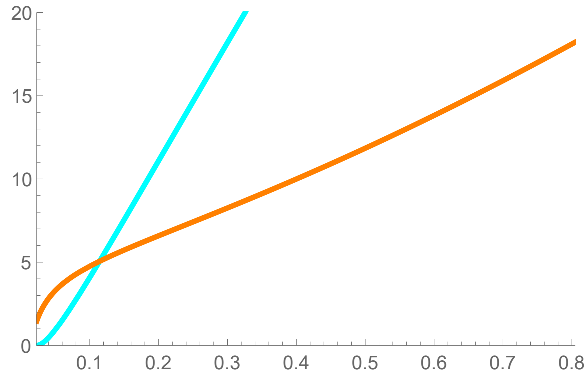


Figure 2: **Time line for a firm issuing callable debt**
This figure presents the time line for a firm that initially issued callable debt. The firm is initially financed with debt and equity (E_0^{cal}, $D_0^{cal} = I_0$). If earnings decrease to $x = x_{d_0}^{cal}$, the firm defaults and continues as an unlevered firm ($E_1^{cal} = 0, D_1^{cal} = (1-\alpha)V_U$). If earnings increase sufficiently the firm invests at $x = x_{u_0}^{cal}$. Post-investment, if earnings increase to $x = x_{u_1}^{cal}$ the debt is called and the firm issues new debt ($E_1^{cal} = A_2(x_{u_1}^{cal}) - (1+p)D_0^{cal}(x_0), D_1^{cal} = (1+p)D_0^{cal}(x_0)$). If earnings decrease to $x = x_{d_1}^{cal}$ the firm defaults and continues as an unlevered firm ($E_2 = 0, D_2^{cal} = (1-\alpha)V_U$).

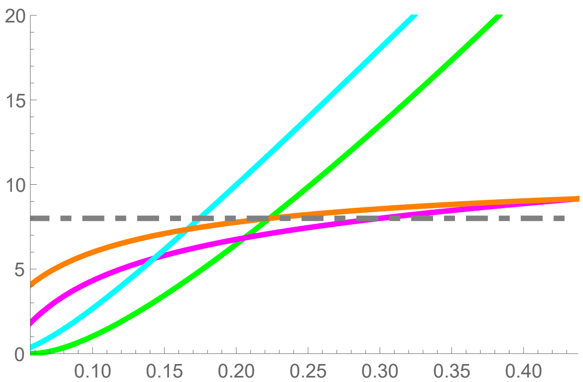




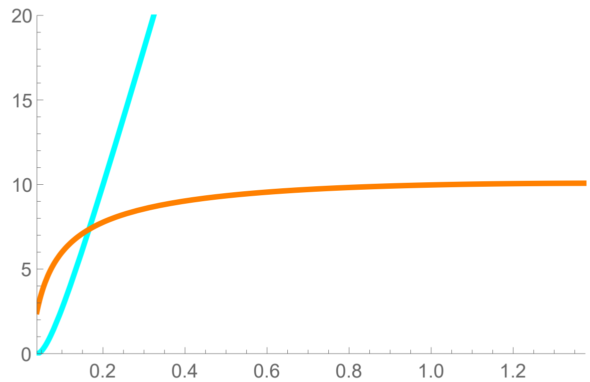
(a) Convertible debt without covenant. Before investment.



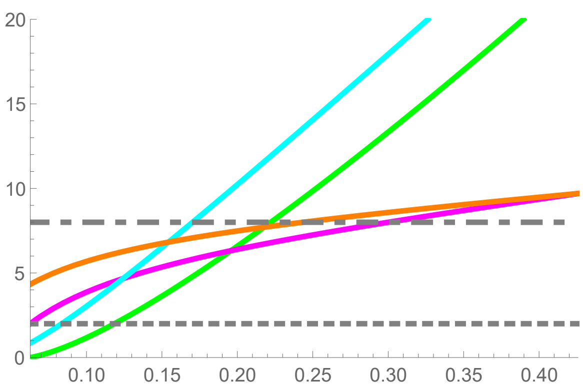
(b) Convertible debt without covenant. After investment.



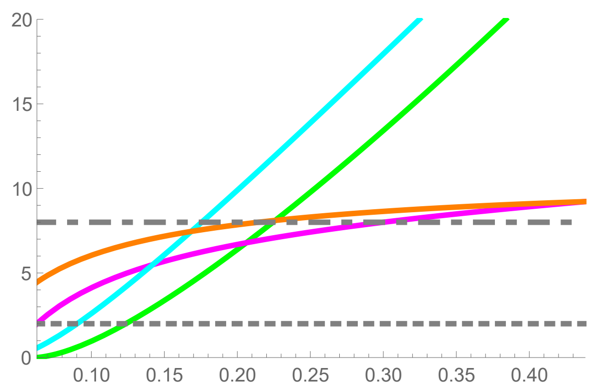
(c) Callable debt without covenant. Before investment.



(d) Callable debt without covenant. After investment.



(e) Convertible debt with covenant. Before investment.



(f) Callable debt with covenant. Before investment.

Figure 3: **Debt and equity values in the base case.** Debt (equity) before investment, $x \in (x_{0,d}, x_{0,u})$: Magenta (green). Debt (equity) after investment, $x \in (x_{1,d}, x_{1,u})$: Orange (cyan). The initial debt is 8 (gray, dot-dashed line). The threshold for net worth covenant ($\rho = 0.25$) is the dashed line.

Table 1: **Parameters**
This table presents our parameters for the base case simulation of the model. Our parameters follow previous literature (e.g., Cooper, 2006; Christensen et al., 2014; Hackbarth and Johnson, 2015).

		Parameter choices
Risk neutral drift of the EBIT process	μ	0
Volatility of the EBIT process	σ	0.25
Initial value of the EBIT process	x_0	0.3
Risk free interest rate	r	0.02
Tax rate	τ	0.15
Bankruptcy costs	α	0.25
Investment scalar	Π	2
Initial cost of setting up the firm	I_0	8
Cost of investment	I_1	5

	Coupon	Share	Equity	$x_{d_0}^{con}$	$x_{u_0}^{con}$	$x_{d_1}^{con}$	$x_{u_1}^{con}$	Lev	EDO
				$I_1 = 4$					
$I_0 = 6$	0.110	0.1710	16.3555	0.0270	0.3281	0.0172	0.9821	0.2683	0.0125
$I_0 = 7$	0.139	0.1899	15.3782	0.0336	0.3356	0.0219	1.1043	0.3128	0.0245
$I_0 = 8$	0.159	0.2264	14.3862	0.0386	0.3413	0.0253	1.0367	0.3574	0.0389
$I_0 = 9$	0.167	0.2801	13.3786	0.0414	0.3444	0.0270	0.8527	0.4022	0.0515
				$I_1 = 5$					
$I_0 = 6$	0.060	0.2269	15.5111	0.0162	0.3927	0.0095	0.3927	0.2789	0.0158
$I_0 = 7$	0.128	0.2151	14.5139	0.0322	0.4083	0.0203	0.8842	0.3254	0.0552
$I_0 = 8$	0.143	0.2575	13.5130	0.0364	0.4127	0.0229	0.8047	0.3719	0.0774
$I_0 = 9$	0.134	0.3220	12.4998	0.0356	0.4114	0.0219	0.5806	0.4186	0.0837
				$I_1 = 6$					
$I_0 = 6$	0.071	0.2228	14.8777	0.0192	0.4710	0.0113	0.4710	0.2874	0.0299
$I_0 = 7$	0.086	0.2602	13.8782	0.0234	0.4745	0.0138	0.4745	0.3353	0.0469
$I_0 = 8$	0.090	0.3049	12.8724	0.0250	0.4758	0.0146	0.4758	0.3833	0.0592
$I_0 = 9$	0.081	0.3571	11.8661	0.0235	0.4742	0.0134	0.4742	0.4313	0.0606

Table 2: Convertible debt. Base case has $I_0 = 5, I_1 = 8$. Occasionally $x_{u_0}^{con}$ and $x_{u_1}^{con}$ are equal (see footnote 10).

	Coupon	Premium	Equity	$x_{d_0}^{cal}$	$x_{u_0}^{cal}$	$x_{d_1}^{cal}$	$x_{u_1}^{cal}$	Lev	EDO
				$I_1 = 4$					
$I_0 = 6$	0.172	0.1027	16.4244	0.0386	0.3421	0.0262	0.8287	0.2676	0.0296
$I_0 = 7$	0.208	0.1458	15.4208	0.0459	0.3512	0.0317	1.0142	0.3122	0.0522
$I_0 = 8$	0.247	0.1972	14.3942	0.0537	0.3612	0.0376	1.2369	0.3572	0.0866
$I_0 = 9$	0.289	0.2740	13.3372	0.0619	0.3721	0.0441	1.6139	0.4029	0.1365
				$I_1 = 5$					
$I_0 = 6$	0.177	0.1513	15.5541	0.0405	0.4183	0.0270	0.9143	0.2784	0.0698
$I_0 = 7$	0.215	0.1974	14.5398	0.0483	0.4277	0.0328	1.1046	0.3250	0.1104
$I_0 = 8$	0.256	0.2595	13.5007	0.0567	0.4381	0.0390	1.3764	0.3721	0.1676
$I_0 = 9$	0.302	0.3096	12.4290	0.0658	0.4498	0.0460	1.5598	0.4200	0.2467
				$I_1 = 6$					
$I_0 = 6$	0.181	0.1733	14.9089	0.0420	0.4944	0.0276	0.9196	0.2870	0.0990
$I_0 = 7$	0.220	0.2288	13.8865	0.0502	0.5038	0.0335	1.1463	0.3351	0.1534
$I_0 = 8$	0.263	0.2866	12.8380	0.0590	0.5145	0.0401	1.3763	0.3839	0.2280
$I_0 = 9$	0.310	0.3674	11.7546	0.0686	0.5264	0.0473	1.7358	0.4336	0.3293

Table 3: Callable debt. Base case has $I_0 = 5, I_1 = 8$.

	Coupon	Share	Equity	$x^{con}_{d_0}$	$x^{con}_{u_0}$	$x^{con}_{d_1}$	$x^{con}_{u_1}$	Lev	EDO
					$I_1 = 4$				
$I_0 = 6$	0.143	0.1057	16.2907	0.0471	0.3281	*0.0235*	2.1552	0.2692	0.0284
$I_0 = 7$	0.177	0.1137	15.3100	0.0549	0.3366	*0.0275*	2.4705	0.3138	0.0522
$I_0 = 8$	0.201	0.1532	14.3041	0.0627	0.3414	0.0314	2.0263	0.3538	0.0808
$I_0 = 9$	0.224	0.1970	13.2678	0.0706	0.3462	0.0353	1.7079	0.4042	0.1193
					$I_1 = 5$				
$I_0 = 6$	0.152	0.0995	15.3754	0.0471	0.4085	*0.0235*	2.4496	0.2807	0.0809
$I_0 = 7$	0.178	0.1341	14.3665	0.0549	0.4142	0.0277	2.0760	0.3276	0.1259
$I_0 = 8$	0.220	0.1376	13.3317	0.0627	0.4263	0.0342	2.4953	0.3750	0.1865
$I_0 = 9$	0.267	0.1374	12.2732	0.0706	0.4400	0.0416	3.0312	0.4231	0.2664
					$I_1 = 6$				
$I_0 = 6$	0.154	0.1051	14.7171	0.0471	0.4856	0.0238	2.3384	0.2896	0.1156
$I_0 = 7$	0.195	0.1051	13.7028	0.0549	0.4964	0.0302	2.9663	0.3381	0.1736
$I_0 = 8$	0.239	0.1051	12.6714	0.0627	0.5083	0.0370	3.6294	0.3870	0.2483
$I_0 = 9$	0.286	0.1069	11.6208	0.0706	0.5211	0.0443	4.2644	0.4365	0.3426

Table 4: Convertible debt with covenant: $PV(x) > \rho D_0$. Base case has $I_0 = 5, I_1 = 8$. $\rho = 0.25$, $x^{con}_{d_1} = \max\{x^d_{1,SP}, x^d_{1,COV}\}$, the ***slanted font*** is used if the covenant is effective.

	Coupon	Premium	Equity	$x^{cal}_{d_0}$	$x^{cal}_{u_0}$	$x^{cal}_{d_1}$	$x^{cal}_{u_1}$	Lev	EDO
					$I_1 = 4$				
$I_0 = 6$	0.173	0.1064	16.3927	0.0471	0.3395	0.0264	0.8238	0.2679	0.0378
$I_0 = 7$	0.209	0.1615	15.3737	0.0549	0.3485	0.0319	1.0628	0.3129	0.0655
$I_0 = 8$	0.249	0.2115	14.3298	0.0627	0.3590	0.0380	1.2696	0.3583	0.1067
$I_0 = 9$	0.293	0.2632	13.2569	0.0706	0.3710	0.0447	1.4719	0.4044	0.1654
					$I_1 = 5$				
$I_0 = 6$	0.181	0.1339	15.4939	0.0471	0.4180	0.0276	0.7794	0.2791	0.0872
$I_0 = 7$	0.219	0.1854	14.4680	0.0549	0.4275	0.0334	0.9807	0.3261	0.1338
$I_0 = 8$	0.261	0.2334	13.4229	0.0627	0.4384	0.0397	1.1561	0.3734	0.1956
$I_0 = 9$	0.307	0.2821	12.3563	0.0706	0.4505	0.0467	1.322	0.4214	0.2758
					$I_1 = 6$				
$I_0 = 6$	0.185	0.1578	14.8496	0.0471	0.4947	0.0282	0.7931	0.2878	0.1175
$I_0 = 7$	0.225	0.1982	13.8234	0.0549	0.5045	0.0343	0.9304	0.3362	0.1758
$I_0 = 8$	0.268	0.2475	12.7816	0.0627	0.5154	0.0408	1.1030	0.3850	0.2506
$I_0 = 9$	0.314	0.3152	11.7222	0.0706	0.5272	0.0478	1.3718	0.4343	0.3447

Table 5: Callable debt with covenant $PV(x) > \rho D_0$: Base case has $I_0 = 5, I_1 = 8$. $\rho = 0.25$, $x^{cal}_{d_1} = \max\{x^d_{1,SP}, x^d_{1,COV}\}$, the ***slanted font*** is used if the covenant is effective.

Table 6: **Variable definitions**
This table describes the variables used in the empirical analysis. All loan-level variables in Panel A are obtained from the the Mergent Fixed Income Securities Database (FISD), all firm-level variables in Panel B are constructed from Compustat, and the measure of debt overhang in Panel C is provided by Alanis et al. (2018).

Variable	**Definition**
Panel A: Loan-level variables	
Maturity	maturity date - offering date
Holding time	effective date - offering date
Coupon	coupon
Offering amount	log(offering amount)
Covenants	= 1 if balance sheet restrictive covenants are attached to a bond a given quarter, and 0 otherwise.
Previous covenant violation	= 1 if any outstanding bond's covenant has been violated, and 0 otherwise.
Panel B: Firm-level variables	
Firm size	log(book assets (atq))
Total debt	short term debt (dlcq) + long term debt (dlttq)
Leverage	total debt / book assets
Return on assets	operating income before depreciation (oibdpq) / book assets
Dividend repurchase	preferred dividends (dvpq) + purchase of common and preferred stock (prstck) / book assets
Market equity	price close (prccq) ∗ common shares (cshprq)
Market-to-book	(market equity + total debt) / book assets
Tobin's q	(book assets + (common shares outstanding (cshoq) ∗ price close) - common equity (ceqq)) / book assets
Investment	capital expenditures (capx) / book assets
Panel C: Debt overhang	
Debt overhang	$\frac{D_t}{K_t} \cdot \text{Recovery Rate} \cdot \left[\sum_{s=1}^{20} \omega_t \left[1 - 0.05(s-1)\right](1+r)^{-s}\right]$

Table 7: **Summary Statistics**

This table presents the summary statistics for our sample of callable and convertible bond issues. Panel A presents descriptive statistics for firm year quarters in which callable bonds are issued. Panel B presents descriptive statistics for firm year quarters in which convertible bonds are issued. The asterisks on the means and median in Panel A report a t-test of difference for the mean and a Wilcoxon rank-sum test for the median (the symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively). The sample period covers 1990 to 2017; financials, utilities, and governmental firms (SIC codes 6000-6999, 4900-4999, and 9000-9999) are excluded. All variables are defined in Table 6.

	count	mean	median	st.dev.	p10	p90
Panel A: Callable						
Maturity	7243	10.84***	9.70***	7.60	5.42	19.92
Offering amount	7243	12.61***	12.61***	0.85	11.61	13.60
Coupon	7243	7.03***	7.00***	2.94	3.14	10.88
Holding time	7243	3.50***	2.55***	3.66	0.00	9.31
Leverage	7071	0.43***	0.39***	0.24	0.19	0.71
Return on assets	6823	0.03***	0.03***	0.03	0.01	0.06
Cash	7065	0.09***	0.05***	0.12	0.01	0.22
Dividend repurchase	6608	0.02***	0.00***	0.08	0.00	0.05
Tangibility	7017	0.37***	0.31***	0.26	0.06	0.79
Size	7071	8.24***	8.17***	1.69	6.06	10.46
Tobin's Q	6351	1.72***	1.45***	0.92	1.02	2.66
Covenants	7243	0.17***	0.00***	0.37	0.00	1.00
Debt overhang	4810	0.10	0.01***	1.96	0.00	0.11
Panel B: Convertible						
Maturity	768	6.02	5.03	3.81	3.76	7.05
Offering amount	768	12.26	12.21	0.95	11.16	13.53
Coupon	768	3.32	3.00	2.38	0.75	6.25
Holding time	768	2.31	1.05	2.38	0.00	5.73
Leverage	765	0.40	0.35	0.26	0.16	0.68
Return on assets	719	-0.01	0.02	0.46	-0.05	0.05
Cash	764	0.31	0.23	0.26	0.03	0.71
Dividend repurchase	663	0.02	0.00	0.06	0.00	0.08
Tangibility	763	0.20	0.11	0.21	0.02	0.57
Size	765	7.15	7.00	1.42	5.53	9.13
Tobin's Q	760	2.58	1.81	3.53	1.01	4.79
Covenants	768	0.01	0.00	0.08	0.00	0.00
Debt overhang	580	0.25	0.01	3.67	0.00	0.18

Table 8: **Callable vs. convertible bond issuances**
This table presents the results of our baseline probit regression. We regress the probability of issuing a callable bond (relative to issuing a convertible bond) on bond characteristics as well as firm characteristics. In model one we include bond characteristics, model two further includes firm characteristics, in model three we add the measure of debt overhand, and finally, model four and five also include covenants. All columns report the marginal effects and all variables are defined in Table 6. The standard errors are clustered at the firm level. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
	Callable	Callable	Callable	Callable	Callable
Maturity	0.013***	0.009***	0.009***	0.008***	0.008***
	(8.67)	(6.75)	(5.86)	(6.05)	(6.59)
Offering amount	0.075***	0.022***	0.023***	0.021***	0.020***
	(12.06)	(3.03)	(2.80)	(2.72)	(2.62)
Coupon	0.035***	0.032***	0.031***	0.028***	0.028***
	(20.36)	(18.90)	(17.16)	(17.46)	(17.79)
Holding time	0.005***	0.003***	0.004***	0.004***	0.003***
	(4.29)	(2.88)	(3.04)	(3.27)	(2.72)
Debt overhang			0.002***	0.002***	0.001**
			(2.60)	(2.71)	(2.23)
Covenants				0.142***	0.140***
				(6.48)	(6.80)
Leverage		0.017	-0.011	-0.010	-0.010
		(0.99)	(-0.54)	(-0.55)	(-0.58)
Return on assets		0.474***	0.512***	0.477***	0.473***
		(4.99)	(5.06)	(5.65)	(5.17)
Cash		−0.133***	−0.137***	−0.126***	−0.110***
		(-5.49)	(-4.82)	(-4.92)	(-4.37)
Dividend repurchase		0.069	0.043	0.041	0.047
		(1.00)	(0.59)	(0.65)	(0.66)
Tangibility		-0.003	0.001	-0.003	-0.021
		(-0.23)	(0.06)	(-0.21)	(-0.94)
Size		0.030***	0.029***	0.023***	0.022***
		(8.71)	(7.39)	(5.70)	(5.55)
Age		0.012***	0.013***	0.010**	0.008**
		(3.34)	(2.89)	(2.45)	(2.00)
Tobin's Q		0.008***	0.005*	0.005*	0.003
		(2.90)	(1.68)	(1.77)	(1.01)
Year FE	Y	Y	Y	Y	Y
Industry FE	N	N	N	N	Y
Observations	7419	5900	4431	4431	4226
Pseudo R^2	0.490	0.620	0.633	0.672	0.694

Table 9: **Callable vs. convertible bond issuances: size, leverage, and covenants**
This table presents the results when regressing the probability of issuing a callable bond (relative to issuing a convertible bond) on firm and bond characteristics. In model one we include the interaction of firm size and leverage, model two includes and interaction of covenants and the debt overhang measure, models three and four further include a dummy variable that is one if the firm has been subject to previous covenant violations and the interaction with covenants. All columns report the marginal effects and all variables are defined in Table 6. The standard errors are clustered at the firm level. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
	Callable	Callable	Callable	Callable
Size	0.036***	0.023***	0.021***	0.021***
	(6.52)	(5.56)	(5.14)	(5.16)
Leverage	0.289***	-0.011	-0.009	-0.010
	(3.45)	(-0.67)	(-0.57)	(-0.63)
Size × Leverage	−0.042***			
	(-3.72)			
Debt overhang	0.000	0.002**	0.001**	0.001**
	(0.41)	(2.37)	(2.24)	(2.32)
Covenants	0.139***	0.117***	0.172***	0.147***
	(6.85)	(6.22)	(5.81)	(6.22)
Covenants × Debt overhang		1.611*		0.980***
		(1.78)		(3.63)
Previous covenant violation			−0.014*	−0.014*
			(-1.66)	(-1.66)
Covenants × Previous covenant violation			−0.115***	−0.096***
			(-3.11)	(-2.99)
Bond controls	Y	Y	Y	Y
Firm controls	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Observations	4226	4226	4226	4226
Pseudo R^2	0.702	0.696	0.698	0.699

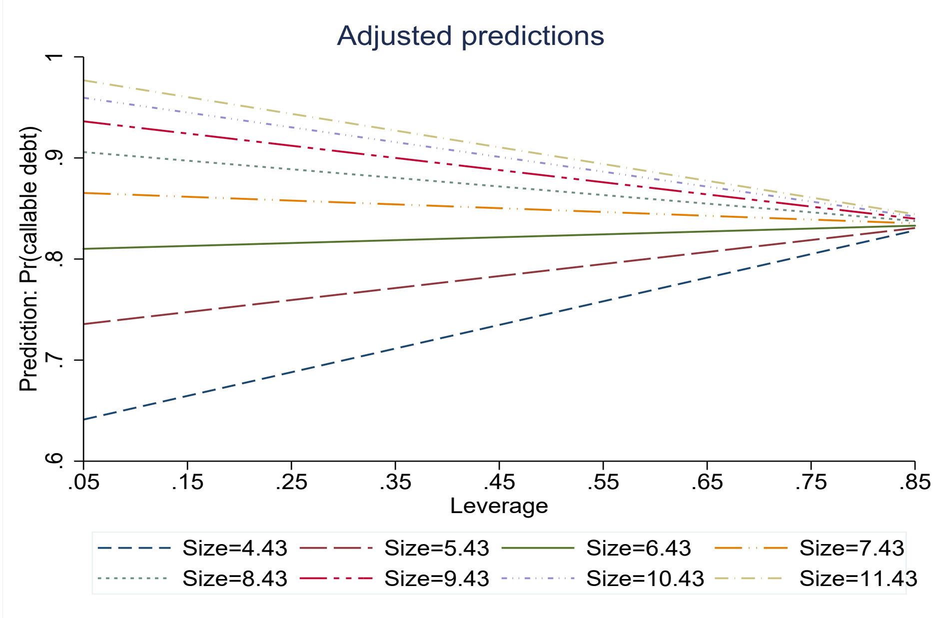


Figure 4: **Predictive margins of issuing callable debt**
This figure plots the relationship between the probability of issuing callable debt and leverage for different levels of firm size.