Hunting for Short-term Bonds via Flexibility: the Call Policy from the Perspective of Debt Maturity Decision in the Corporate Bond Market

Liang-Chih Liu [*] Lei Zhou [†] Tian-Shyr Dai [‡] Kevin Tseng [§]

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Abstract

This paper uncovers that firms are executing the following strategy: they issue a callable bond with a longer stated maturity but a shorter call protection, and then refinance this callable with another callable close to the expiration of its stipulated call protection period. This strategy explains the widening gap between effective and stated maturities as well as the diminishing gap between effective maturity and length of call protection. By locking in longer-term financing upon the issuance of a callable but frequently conducting early refinancing with another callable, a firm can imitate shorter-term debt financing to alleviate agency conflicts without incurring significant refinancing risk. Since a callable issuer becomes safer by implementing this call-to-shorten strategy as compared to simply adopting shorter-term noncallable financing, the costs of debt might decrease, particularly for highly leveraged firms whose creditworthiness is vulnerable to refinancing risk. To confirm this argument theoretically, a novel structural credit risk model with an accessible numerical framework is constructed. In this model featuring debt refinancing, we will not only investigate the connection between costs of debt and refinancing risk, but also the connection between the intended call policy and the optimal arrangement for the length of call protection. Our empirical results are consistent with the predicted outcomes. Firms having a greater refinancing risk may issue callable bonds with shorter call protection and refinance sooner. In addition, the call-to-shorten strategy reduces the costs associated with the use of bonds by these firms, as it makes them safer.

(JEL Classification: G3, G12, G32, G33)

Keywords: stated maturity, effective maturity, callable bond, call protection, refinancing risk

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1 Introduction

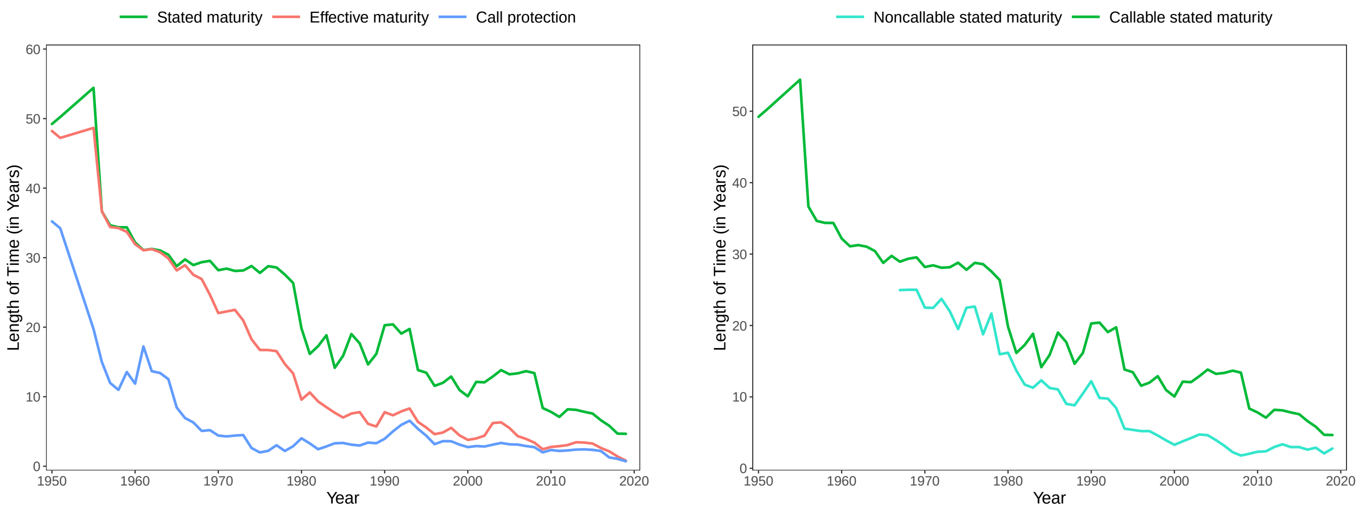
Financial flexibility represents the ability of a firm to access and restructure its financing at a low cost. — Gamba and Triantis (2008)

According to the surveys conducted by Graham and Harvey (2001) and Brounen et al. (2004), a sizable proportion of CFOs seek to preserve financial flexibility when making capital structure decisions, as such flexibility can enhance the firms' risk-bearing capacity in both good and bad times. This paper uncovers that firms are executing the following strategy to preserve financial flexibility by utilizing callable bonds: they issue a callable bond with a longer stated maturity but a shorter call protection, and then refinance this callable with another callable at the date close to the expiration of its specified call protection period.[1] By locking in longer-term financing upon the issuance of a callable but frequently conducting early refinancing with another callable, firms can imitate shorter-term debt financing to alleviate agency conflicts without incurring the risk of having to borrow in bad times. As the callable issuers become safer by preserving the option to not shorten the bonds, the cost of debt will decline. The implementation of this "call-to-shorten" strategy may explain the widening gap between effective and stated bond maturities as well as the narrowing gap between effective maturity and length of call protection, as seen in recent decades in **Figure 1(a)**. Comparing the blue curve in the same figure to the cyan curve in **Figure 1(b)** also reveals that, in recent decades, the length of call protection appears to be structured close to the stated maturity of noncallable bonds. While almost all existing literature focuses on a firm's choice of stated bond maturity (e.g., He and Milbradt, 2016; Chen et al., 2021; Dangl and Zechner, 2021), we center on the arrangement for the length of call protection, which is significantly closer to the effective maturity, the real bond's life selected by firms.

Two suggested examples are shown in **Table 1** to illustrate how the call-to-shorten strategy is implemented. In panel (a), General Mills INC. issued 25-year and 12-year callable bonds in 1998 and 1999, respectively, with a 5-year and 4-year call protection period stipulated at issuance. Due to their early redemption on the first call dates, the effective maturities of the two bonds were 5 and 4 years, respectively. To refinance the redemption payments, the firm issued another four callable bonds with 1-year call protection close to the redemption dates of the two previously-issued callables. In other words, General Mills INC. imitated the shorter-term debt financing with 5-year and 4-year noncallable bonds by early redeeming two longer-term callables just on their first call dates. The later-issued four callables were again redeemed on their first call dates to emulate the shorter-term debt financing with four 1-year noncallable bonds. In panel (b), Barclay Bank PLC. issued three long-term callables in 2011 with 1-year call protection. The bank imitated the shorter-term financing with three 1-year noncallable bonds by early redeeming the three callables just on their first call dates. To refinance the redemption payments, the bank issued another two callable bonds with 1-year call protection close to the redemption date of the three previously-issued callables. The later-issued two callables were again redeemed on their first call dates to mimic the shorter-term debt financing with two 1-year noncallable bonds.

Applying the call-to-shorten strategy to preserve financial flexibility relates the arrangement for the length of call protection to debt maturity decision. According to the seminal work of Myers (1977), the issue on debt maturity decision stems from the fact that leveraged firms with greater growth opportunities may have more over- or under-investment incentives, which can result in severer stockholder-bondholder conflicts of interest. To mitigate the agency conflicts, leveraged firms tend

[1] Brown and Powers (2020) also shows that callable bonds are almost twice as likely to be retire early as the non-callables.



(a) (b)

Figure 1: Average Effective Maturity and Length of Call Protection for Callable Bonds and Average Stated Maturity for Callable and Noncallable Bonds over 1950–2019. The bond data are collected from Mergent Fixed Income Securities Database (i.e., *Mergent FISD*) for every year between 1950 and 2019. This figure excludes the callables that are still outstanding in December 2019. The green curves in both panels indicate the average stated maturity of the callable corporate bonds issued during the x-axis year. The red and blue curves in panel (a) indicate the average effective maturity and length of call protection for these callables, respectively. The cyan curve in panel (b) represents the average stated maturity of the newly-issued noncallable corporate bonds. The length of a stated bond maturity is the time span in years between its offering and maturity dates. The length of a effective bond maturity is the time span in years between its offering and call effective dates. The length of call protection is the time span in years between its offering and first call dates.

to issue shorter-term bonds having relatively insensitive values to changes in firm value. Since firms owns the option to shorten callable bonds at discretion by conducting early redemption as suggested in **Figure 2**, Robbins and Schatzberg (1986) argue that longer-term callable bonds can substitute for shorter-term noncallable bonds in controlling the agency conflicts. However, we note that the substitution of a call provision by shorter stated maturity is not perfect. Although a shorter-term noncallable can alleviate agency conflicts, arranging shorter maturities for all bonds may expose the firms to a higher rollover risk, thus exacerbating their creditworthiness (He and Xiong, 2012). Alternatively, by specifying a longer maturity at issuance to lock in a longer-term financing and a shorter call protection, a callable issuer owns the option to execute early redemption right on the first call date and imitate a shorter-term bond. Since the issuer also has the flexibility to delay the redemption date due to its weak financial status or the poor market condition, the refinancing risk can be significantly smaller than that when using a shorter-term noncallable directly. This may explain why firms relies mostly on longer-term callable bonds to levered up instead of shorter-term noncallable bonds in recent decades. Indeed, according to the statistics reported by Securities Industry and Financial Markets Association, the share of callable bonds accounts for nearly 90% of total new corporate bond issues in the current U.S. market.[2]

Although shorter-term bonds can alleviate the agency conflicts, a leveraged firm tends to balance this benefit against a greater rollover risk. Diamond (1991) and Childs et al. (2005) thus suggest a

[2]See http://www.sifma.org/research/statistics.aspx.

<table>
<tr><th colspan="5">Panel (a): General Mills INC.</th></tr>
<tr><th>Bond CUSIP</th><th>Offering Date</th><th>First Call Date</th><th>Call Effective Date</th><th>Maturity Date</th></tr>
<tr><td>37033LEY8</td><td>1998-02-05</td><td>2003-02-05</td><td>2003-02-05</td><td>2023-02-05</td></tr>
<tr><td>37033LFF8</td><td>1999-01-15</td><td>2003-01-22</td><td>2003-01-22</td><td>2011-01-22</td></tr>
<tr><td>37033EAX0</td><td rowspan="2">2003-01-31</td><td rowspan="4">2004-02-15</td><td rowspan="4">2004-02-15</td><td>2008-02-05</td></tr>
<tr><td>37033EAY8</td><td>2010-02-05</td></tr>
<tr><td>37033EAZ5</td><td rowspan="2">2003-02-07</td><td>2008-02-12</td></tr>
<tr><td>37033EBA9</td><td>2010-02-12</td></tr>
<tr><th colspan="5">Panel (b): Barclay Bank PLC.</th></tr>
<tr><th>Bond CUSIP</th><th>Offering Date</th><th>First Call Date</th><th>Call Effective Date</th><th>Maturity Date</th></tr>
<tr><td>06738JCE2</td><td rowspan="3">2011-02-14</td><td rowspan="3">2012-02-17</td><td rowspan="3">2012-02-17</td><td>2024-02-17</td></tr>
<tr><td>06738JC93</td><td>2026-02-17</td></tr>
<tr><td>06738JD27</td><td>2031-02-17</td></tr>
<tr><td>06738JZ23</td><td rowspan="2">2012-02-10</td><td rowspan="2">2013-02-15</td><td rowspan="2">2013-02-15</td><td>2017-02-15</td></tr>
<tr><td>06738KL74</td><td>2022-02-15</td></tr>
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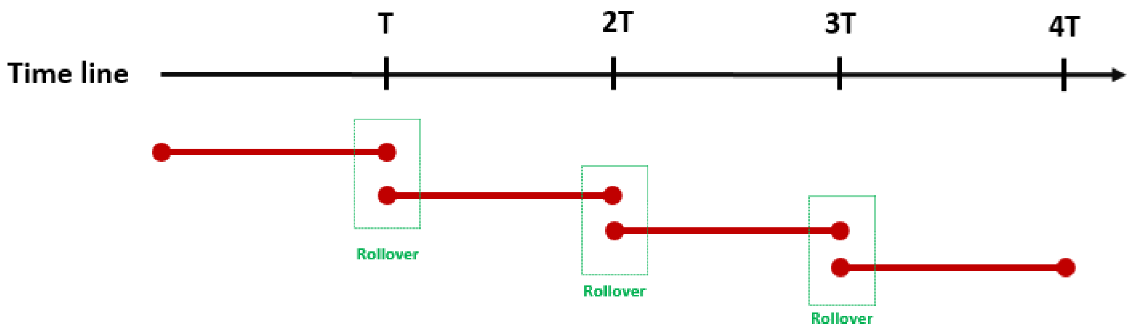
Table 1: Early Redemption and Refinancing Activities Conducted by General Mills INC. and Barclay Bank PLC. This table gives two examples of early redemption and refinancing activities. Panel (a) exhibits six callable bonds issued by General Mills INC., an American manufacturer of branded consumer foods sold through retail stores. The latter four callables were issued just near the early redemption dates of the former two previously-issued bonds. Panel (b) exhibits five callable bonds issued by Barclay Bank PLC. The latter two callables were issued just near the early redemption dates of the former three previously-issued bonds.

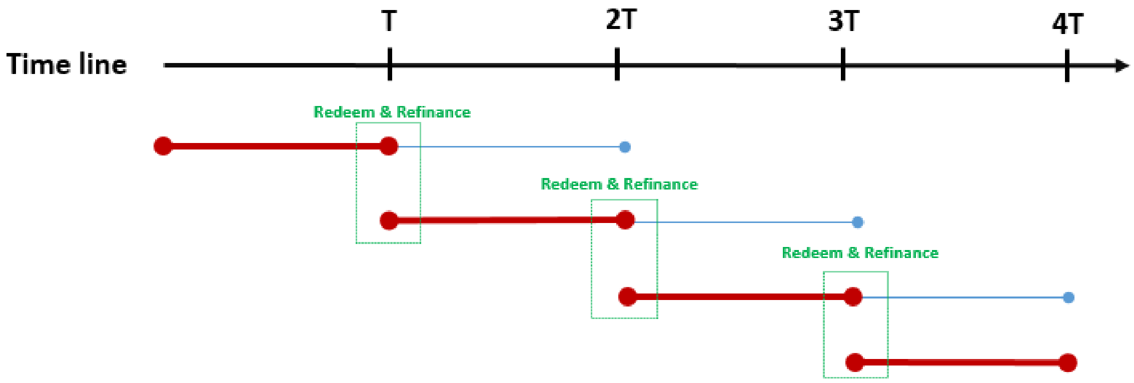
positive relation between the choice of leverage and stated debt maturity. However, we argue that this positive relation can be attenuated if the firm adopts the call-to-shorten strategy to hunt for shorter-term bonds. Given a stated bond maturity, a callable issuer attain the option to execute early redemption on the first call date by stipulating a shorter call protection at issuance. Since this arrangement also preserves more flexibility for the issuer to delay the redemption date, refinancing risk can be considerably diminished. Therefore, rather than just lengthening the stated maturity further, we suggest that higher leverage should encourage the choice of callable bonds with shorter call protection to reduce agency conflicts.[3]

To implement this superior strategy, a firm tends to frequently formulate a debt structure with properly-designed callables with relatively short call protection to facilitate earlier bond redemption and refinancing. Given a low enough interest rate level and good financial status, the refinancing activities will be conducted early, at times close to the first call dates determined at the bond issuance date. Thus the effective maturities of callables should be close to the lengths of call protection periods other than the bond stated maturities. Another important element to complete the employment of this "call-to-shorten" strategy is the action timing. If the market is accommodating, the early refinancing

[3] In contrast to the argument from Diamond (1991) and Childs et al. (2005), Myers (1977) suggests a negative relation between the choice of leverage and stated debt maturity, since leverage and stated maturity serve as substitutes in controlling agency conflicts. The choice of shorter call protection is in accordance with Myers (1977)'s argument for the choice of shorter-term bonds by firms with higher leverage. On the other hand, although Sarkar (2001) argues that highly leveraged firms tend to issue bonds with call features, he does not address how the length of call protection is structured.



(a) Debt Structure with T-year Noncallables



(b) Debt Structure with 2T-year Callables

Figure 2: Debt Structure over Time. This figure illustrates two different debt financing strategies. In panel (a), the firm rolls over a maturing T-year noncallable by issuing another T-year noncallable over and over. In panel (b), a $2T$-year callable is issued to refinance the early redemption of another otherwise identical outstanding callable. The debt structure in panel (a) can be imitated via the one in panel (b) if the firm redeems the outstanding callable early T-year after its offering date and refinances the redemption payment by issuing another callable over and over again.

activities will be conducted at times close to the first call dates stated at issuances. This theoretical close range between effective maturity and call protection reveals that the design for the lengths of call protection periods should consider intended call policies and will match real maturity intention. And this idea is exactly in harmonization with the phenomenon we observed in real world as displayed in **Figure** 1.

The shifting of average effective maturity from the average stated maturity to the average length of call protection implies that this "call-to-shorten" strategy may be the driving force behind the designs for the lengths of call protection periods. And the trend that the length of call protection is designed to get close to the stated maturity of noncallable bonds present a corroborative evidence of the application of this strategy. In addition, the observed declining trend in bond maturity over time also highlights the issue of rollover risk, since it increases the exposure of firms to liquidity and credit shocks (Custódio et al. (2013) and Butler and Yi (2022)). Under such a circumstances, the superiority of our proposed strategy becomes more significant. This probably explains why callable bonds dominate the corporate bond market. Indeed, according to the statistics reported by the Securities Industry and Financial Markets Association, the corporate bond issuance volume in the US market grew from 337.4 billion in 1996 to 2,280.5 billion dollars in 2020; bonds with call provisions also increased from 14% of the total issuance volume in 1996 to nearly 90% in 2020 [4].

We want to further address the question that high-leverage firms will have more incentives to adopt this strategy as Diamond (1991) state that firms with high-leverage should balance the benefits of using short-term debt against the greater risk of refunding short-term debt. So for the purpose to reduce refinancing risk and enhance the financing flexibility, we argue that high leverage firms tend to issue callables with short call protection and imitate short-term bonds by frequently retiring and refinancing the callables, because the rollover risk is more devastating for them. Also this strategy appeals to firms having greater rollover risk, such as the firms having more debt due in the near future or the ones preferring short-term debt. Our paper investigates this advantage of this strategy through both empirical studies and risk-neutral valuations.

Insights and phenomena for above debt raising strategies can be theoretically and empirically confirmed in this paper. By extending the structural credit risk models proposed by Leland and Toft (1996) (abbreviated as **LT** hereafter) and Childs et al. (2005), we model rollover risks and the changes of debt structures composed of short-term noncallable and long-term callable bonds. We extend the state transition forest pioneered by Liu et al. (2016) and Liu et al. (2022) to analyze optimal call and refinance decisions by embedding the Bellman equation into the forest, or a complicated version of the CRR tree(Cox et al., 1979). We evaluate the values of equity and debt holders via the risk-neutral valuation method then optimize the decisions of bond designs and early redemption. our forest model theoretically analyzes the relationships among costs of debts, credit risks, debt rollover frequencies, call policies, and the optimal lengths of call protection periods. To our knowledge, our model is the first to analyze optimal lengths of call protection periods, as no feasible models address such problems as mentioned in Powers (2021).

Guided by the theoretical model results, we conduct the empirical studies to provide real world evidence of the applicability and superiority of our proposed call-to-shorten strategy. We set up the 2SLS regression model by extending the framework of Xu (2018) which argues that speculative-grade firms tend to use callables to extend their debt maturity. Our results verify the short protection periods trends nowadays for both high leverage(rollover risk) and low leverage(rollover risk) firms. But the significant shrank of effective maturity only works in high leverage(rollover risk) firms which is consistent with our superiority assumption. These two results indicate the wide usage of the strategy to reduce the rollover risks, thus enhancing the financial flexibility. Following the improvement of debt structure flexibility, the cost of debt for high leverage(rollover risk) firms will experience a decline proofed by the negative significant results of interest obligation level. Different from other empirical studies, we approach the debt maturity management from the aspect of call protection and effective maturity rather than the stated maturity.

The rest of the paper presents our theoretical analyses and empirical studies as follows. **Section 2** describes how the construction of our theoretical quantitative model for modeling refinancing decisions. Sensitive analyses based on our theoretical model in **Section 4** describes the relationship among rollover risk, leverage ratio, and refinancing decisions. To empirically confirms our theoretical analyses, **Section 3** details the procedures of bond data collection, data preprocessing, and the two-stage least square regressions model. Empirical evidences in **Section 5** verify our hypotheses for explaining real world phenomena, such as **Figure 1**, and theoretical analyses results. **Section 6** concludes.

[4]See http://www.sifma.org/research/statistics.aspx).

2 Model

To analyze the decisions for raising shorter-term noncallables and longer-term callables with different lengths of call protection, we extend **LT**'s structural credit risk model to consider optimal default and early refinancing decisions given the presence of debt flotation costs, tax shield benefits, and bankruptcy costs. To assess early refinancing decisions and corresponding uncertain changes in debt structures, our model extends the state transition forest model pioneered by Liu et al. (2016, 2022). We quantitatively analyze how the issuer's financial status influences the debt-raising decisions and the design for the length of call protection period to explain the empirical phenomenon of emulating shorter-term noncallables via callables, as illustrated in **Figure 1**.

2.1 The Economy and the Callable Issuer

A structural model specifies the evolution of the market value of a firm's assets and the conditions leading to default. I follow He and Xiong (2012) by supposing that the firm's asset value at any time t in the absence of leverage, V_t, obeys the following process under the risk-neutral probability measure:

$$\frac{dV_t}{V_t} = (r - q)dt + \sigma dz. \tag{1}$$

In above equation, the constant q, $q \geq 0$, denotes the payout ratio governing the available cash flow. I assume that the firm does not hold cash reserves and all of the cash flow available is used to service contractually-obligated debt payments and dividends. In particular, the cash payout at time t, $qV_t dt$, is used first to fulfill interest payments and the remaining value (if any) is distributed to the firm's equity holders as dividends. If the cash cannot meet the interest payments, the firm may issue new equity to cover the shortfall (see Chen, 2010). The constant σ, $\sigma > 0$, represents the firm value volatility can be interpreted as the firm's business risk as in Merton (1974). I follow Fan and Sundaresan (2000) by setting σ as a constant, since the firm manager (or the equity holders) cannot alter the business risk arbitrarily due to restrictive covenants included in the outstanding bonds of the firm. dz denotes a standard Brownian motion.

The firm has a two-bond debt structure containing a longer-term T-year callable bond and a shorter-term T/m-year noncallable bond for any integer $m \in [1, T]$. The callable (noncallable) bond has the face value F_L (F_S) and the coupon rate C_L (C_S) paid continuously. In addition, the callable has P-year protection against being called at a pre-specified call price, $P \in (0, T]$. That is, after the expiration of the call protection, the call price should be K_t for $t \in [P, T]$ stated at issuance. Note that the effective call price will be the stated call price K_t plus accrued interests. On the other hand, the shorter-term and the longer-term bonds are treated as equal-priority as in He and Milbradt (2016), but the different-priority setting can be also accommodated without difficulty. In a structural model, all outstanding bonds and equity of a firm can be regarded as contingent claims on the firm's unleveraged assets. Therefore, the values of the firm's equity, the T/m-year noncallable, and the T-year callable bond at time t are denoted by $E(V_t, t \,|\, P)$, $SB(V_t, t \,|\, T/m)$, and $CB(V_t, t \,|\, P, T)$, respectively. The total firm's leveraged asset value at $t = 0$, V_0^L, is then expressed as

$$V_0^L = E(V_0, 0 \,|\, P) + SB(V_0, 0 \,|\, T/m) + CB(V_0, 0 \,|\, P, T). \tag{2}$$

In the later discussion, we let $SB(V_0, 0 \,|\, T/m) \equiv SB_{T/m}(V_0, 0 \,|\, T/m)$, where the subscript represents that this noncallable's maturity date is on $t = T/m$. In addition, $CB(V_0, 0 \,|\, P, T) \equiv CB_{pT,T}(V_0, 0 \,|\, P, T)$, where the two subscripts represent that this callable's first call and maturity dates are on $t = pT$ and T, respectively. And $E(V_0, 0 \,|\, P) \equiv E_{T/m,T}(V_0, 0 \,|\, P)$ to represent the value of leveraged equity with two bonds due on date $t = T/m$ and T.

For comparison purpose, the aforementioned callable issuer is regarded as an advanced-case firm. A base-case firm is an otherwise identical firm with the debt structure comprising merely one noncallable bond. The noncallable's face value is $F_L + F_S$.

Three types of market frictions are considered, for these real-world frictions can influence the callable issuer's choice of length of call protection. When raising corporate bonds, both of the base- and advanced-case firms incur a proportional cost of γ, $\gamma \in (0, 1)$, which is expressed as a fraction of the market value of the newly-issued bond (see Leland, 1998; Childs et al., 2005). Notice that γ increases with the magnitude of market recession and with the deterioration in the firm's creditworthiness (see He and Xiong, 2012; He and Milbradt, 2014). When using bonds, the firms earn tax shield benefits but incur bankruptcy costs (see Leland and Toft, 1996; Chen et al., 2021). As long as the firms are solvent, their coupon payments are tax-deductible at rate τ, $\tau \in (0, 1)$. Once the firms are liquidated after going bankrupt, a constant fraction ω, $\omega \in (0, 1)$, of the firm's asset value is lost as liquidation costs (e.g., the legal fees).

2.2 Default and Early Refinancing Decision

In our framework, part of **LT**'s settings of stationary debt structure are adopted to deal with a firm's financing problem. As in He and Milbradt (2016), both of the base- and advanced-case firms are committed to refinance any retired bond in such a way that the total bond face value is kept at a constant. Any new bond will be replaced by another new bond with the same coupon rate, face value, and stated time to maturity. Although the firms will service time-independent debt payments under this constant book leverage policy, their equity holders are the residual claimants of the gains and losses from the refinancing (He and Xiong, 2012). That is, if the cash flow from raising a new bond is higher than the required payment of a maturing bond, the gain will be immediately paid out to the equity holders. If the opposite situation occurs, the loss will be paid off by issuing more equity at the market price.

Instead of having a bond's principal retiring at a constant rate over time as in Dangl and Zechner (2021), we assumes that it should be retired all at once as in Chen et al. (2021). Since a noncallable bond can only be rolled over at its maturity date, the m in **Equation (2)** governs the callable issuer's rollover frequency. That is, a greater m given T implies a shorter maturity of the noncallable and hence a higher rollover frequency. The lumpiness in maturity structure is a prevalent feature observed from the data in Choi et al. (2018), and Chen et al. (2021) argue that such feature plays a crucial role in the connection between observed debt maturity and the corresponding default risk.

A callable bond can be refinanced with another callable before its maturity date at a pre-specified call price after the expiration of its call protection period. In our framework, the base-case (advanced-case) firm makes its default (both its default and early refinancing decisions) with the objective of maximizing its equity holders' value. In particular, the default decision is made whenever the firm is unable to fulfill its debt obligation via equity financing as in Chen (2010). In addition, the early refinancing decision is made *after the issuance* of a callable bond according to the call provision terms stipulated *at the issuance* of the callable. That thus allows our framework to associate the optimal length of call protection at issuance with the intended call decision after issuance.

2.3 The Callable Issuer's Problem

The callable issuer (i.e., the advanced-case firm) acts in the interest of its equity holders. At time $t = 0$, the issuer chooses the length of the call protection P according to the given bond maturity structure (i.e., T and m) and level of total bond face value (i.e., F_L plus F_S) to maximize the equity value *right before the issuance* of the callable. *After the issuance* of the callable, the issuer chooses the time to default on its outstanding bonds and the time to early refinance the callable bond with another *otherwise identical* callable to maximize the equity value. Having set up the model, an implementable numerical framework is proposed to solve for the optimal P.

2.4 Numerical implementation

2.4.1 Background knowledge of a CRR Tree

To consider a firm with the debt structure featuring lumpy bond maturity, we exploit the tree method. Under a structural model of credit risk, all outstanding bonds and equity are viewed as contingent claims on the issuer's unleveraged assets and can be evaluated by derivatives pricing methods once the asset value is characterized. A tree is a popular numerical technique for capturing the asset value dynamics. It divides a certain time interval into equal-length time steps; bonds and equity can then be evaluated via backward induction on the tree. Pricing on trees is robust, since the pricing results will converge to the theoretical values as the number of time steps approaches to infinity (see Duffie, 1996).

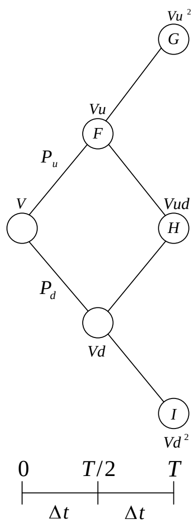


Figure 3: The CRR Tree.

The CRR tree proposed by Cox et al. (1979) can discretely characterize the diffusion process of **Equation (1)** via four parameters, u, d, P_u and P_d. u and d parameterize the state of the asset value, from the initial value V either up to Vu or down to Vd at the next time step. P_u and P_d parameterize the probability of up and down movement of the firm's asset value for each time step. Given the interest rate r, the firm value volatility σ and the time interval $[0, T]$ with n equal-length time steps Δt, $\Delta t = T/n$,

$$u = e^{\sigma\sqrt{\Delta t}}, \quad d = e^{-\sigma\sqrt{\Delta t}},$$
$$P_u = \frac{e^{(r-q)\Delta t} - d}{u-d}, \quad P_d = 1 - P_u.$$

Figure 3 illustrates the CRR tree with $n = 2$. Note that the log-distance between any two vertically adjacent nodes on the CRR tree (e.g., node G and H) is $2\sigma\sqrt{\Delta t}$. If I define the notation $\upsilon(X)$ as the asset value on node X and $f(t, V)$ as the discounted expected value of a contingent claim at time t when the asset value is V, then the discounted expected value of a contingent claim on node F can be expressed in the form of backward induction on the tree:

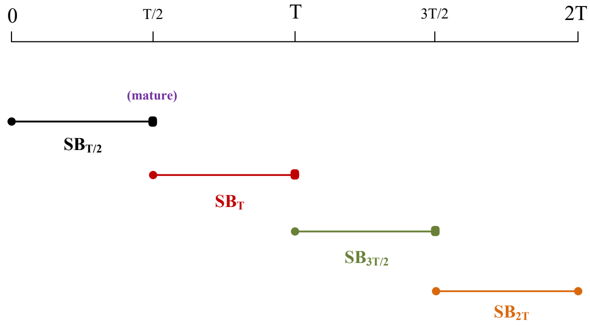
$$f(T/2, \upsilon(F)) \equiv e^{-r\Delta t}(P_u \times f(T, \upsilon(G)) + P_d \times f(T, \upsilon(H))).$$

To capture rollover (refinancing) risks and the changes of debt structures comprising shorter-term noncallable and longer-term callable bonds due to early refinancing, we extend the state-transition forest pioneered by Liu et al. (2016) and Liu et al. (2022). The forest is a complicated version of CRR trees arranged in layers. The optimal call and refinancing decisions can be found by embedding the Bellman equation into the forest. The values of equity and bond holders can thus be evaluated via the backward induction within the forest given the length of call protection period.

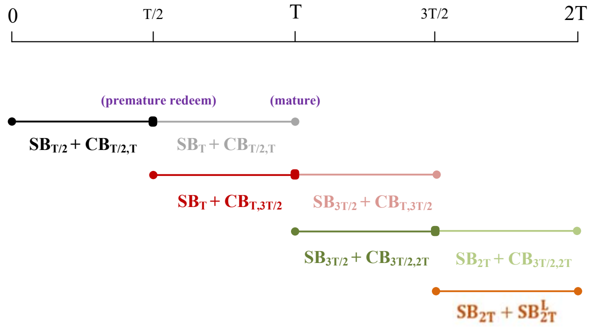
2.4.2 The forest based on CRR trees

Suppose that the advanced-case firm obeys the constant book leverage policy as in **LT**'s framework. The firm has the debt structure consisting of a T/m-year noncallable and a T-year callable bond. Notice that the m governs the frequency of debt rollover. Instead of supposing a perfectly granular maturity structure, we consider a lumpy one with all of a bond's principal maturing on its stated maturity date. The firm will keep servicing its contractually-obligated debt payments until it announces default and files for bankruptcy or until it chooses to close its business and liquidate its assets. Assume that the business closing date is $N \times T$ years from $t = 0$. Though $N > 2$ and more call dates are not difficult to accommodate, we hereinbelow let $N = 2$ and $m = 2$, and suppose that the T-year callable bond can only be redeemed and refinanced at time $t = T/2$ for ease of illustration. In such a case, the length of call protection (i.e., the period between the bond issuance date and first call date) P is $T/2$. Notice that the previously-issued bonds will be redeemed via the fund raised via the issuances of otherwise identical bonds. If the maturity date of a newly-issued callables exceed $2T$, the bond will be cut short and become a noncallable with the maturity date $t = 2T$. In summary, a $T/2$-year noncallable $SB_{T/2}$ and a T-year callable $CB_{T/2,T}$ in **Equation (2)** will be evaluated via a $2T$-year framework. Within the same $2T$-year framework, the equity and the T/m-year noncallable can also evaluated as follows.

Extended from **Figure 4**, the following **Figure 5** displays the corresponding forest structure comprised by four CRR trees with the branching probabilities P_u and P_d. Given that the firm value dynamics obeys **Equation (1)**, the first layer tree in **Figure 5(b)** captures two states of debt structure: (1) $SB_{T/2}$ and $CB_{T/2,T}$; (2) SB_T and $CB_{T/2,T}$. The second layer tree captures: (1) SB_T and $CB_{T,3T/2}$; (2) $SB_{3T/2}$ and $CB_{T,3T/2}$. The third layer tree captures: (1) $SB_{3T/2}$ and $CB_{3T/2,2T}$; (2) SB_{2T} and $CB_{3T/2,2T}$. The fourth layer tree captures the debt structure consisting of two noncallables SB_{2T} and SB^L_{2T}. If the firm decides to early redeem the $CB_{T/2,T}$ and reissuing the $CB_{T,3T/2}$ at time $t = T/2$, its debt structure shifts from the first layer to the second one. The value of the SB_T,



(a) Base-case firm



(b) Advanced-case firm

Figure 4: Evaluation framework for the base- and advanced-case firm.

$CB_{T,3T/2}$, and the corresponding $E_{T,3T/2}$ can be evaluated via the backward induction on the second layer CRR tree. If the firm in turn redeem the $CB_{T/2,T}$ at its maturity date $t = T$ and reissuing the $CB_{3T/2,2T}$, its debt structure shifts from the first layer to the third one. The value of the $SB_{3T/2}$, $CB_{3T/2,2T}$, and the corresponding $E_{3T/2,2T}$ can be evaluated via the backward induction on the third layer CRR tree. The backward induction procedure within the forest in **Figure 5(b)** will be detailed in Appendix A.

3 Data and calibration

In this section, we first report our collected data, including bond-level and firm-level data. Then we introduce the estimation procedure for the variables characterizing our data. Finally, we describe how our model parameters are calibrated to capture the important features of the collected data.

3.1 Data

We use the Mergent Fixed Income Securities Database (*Mergent FISD*) for the bond-level data. To focus on bonds subject to default risks, we only kept the corporate bonds that are not issued by government-sponsored entities. In addition, we only included the bonds whose call effective dates lie between their offering and maturity dates.[5] If the bonds are callable, we only consider the ones whose first call dates are set between their offering and maturity dates. To confirm data completeness, we merge the information on first call dates from *Mergent FISD*, *Bloomberg*, and the Securities Data Company (*SDC*) Platinum.[6]

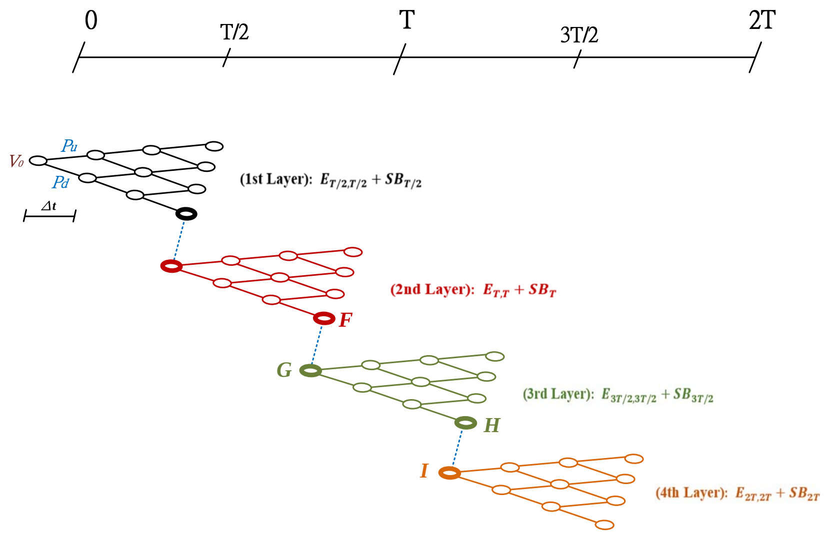
To retrieve the corresponding firm-level data, we match our collected bond issuers to the firms in *Compustat*.[7] We only consider the firms having at least three consecutive annual records in *Compustat* and three consecutive annual observations of public bonds outstanding in *Mergent FISD*. Our final sample includes 5,148 U.S. firms and 80,743 firm-year observations during the period of 1990–2018. The sample covers 121,978 bonds, including 41,670 callables and 80,308 noncallables.

To clearly illustrate the data characteristics and the relation between bond-level and firm-level variables, we first denote the length of bond maturity (call protection period) stated on the bond

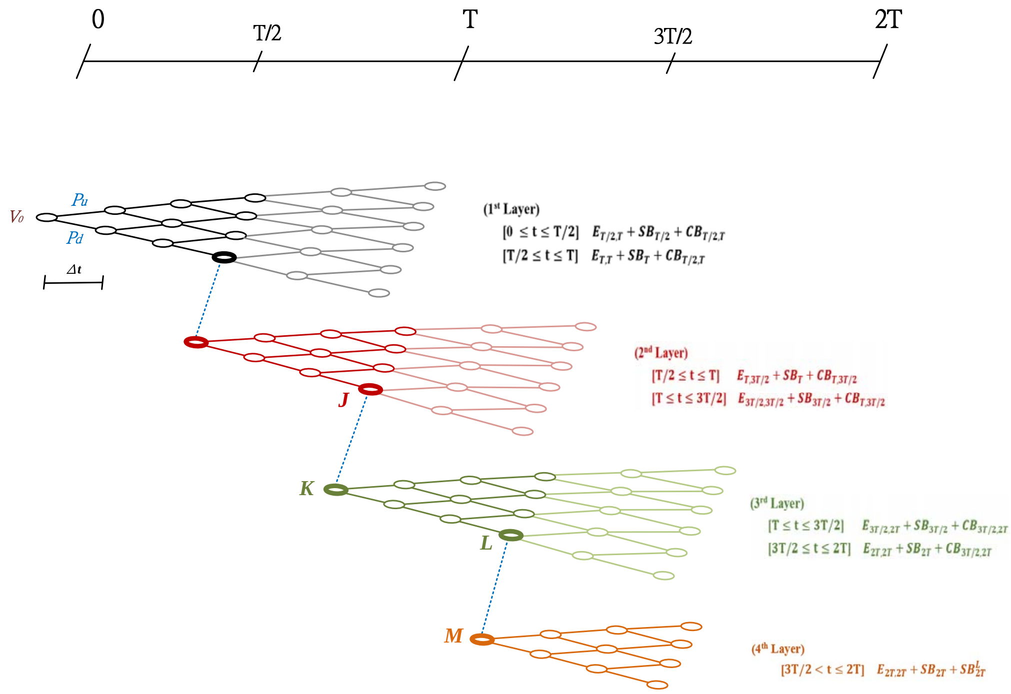
[5]In our following analysis, we regards the following five types of actions as calls: (1) call, (2) repurchase, (3) tender offer, (4) refunded, and (5) mature. For more details on action types, please see Appendix D.

[6]Details on the interpretation of initial call data are shown in Appendix B.

[7]Details on the data matching procedure are described in Appendix C.



(a) Base-case firm



(b) Advanced-case firm

Figure 5: Forest Structure Comprised by CRR Trees.

issuance date by *BondStaM* (*BondCProt*), whose value is the length of the time in years between a bond offering date and the corresponding bond maturity date (first call date). In addition, we denote the length of bond effective maturity by *BondEffM*, whose value is the length of the time in years between the bond offering date and the call effective date. The length of the time eliminated from the original bond's life due to early redemption *BondElim* can thus be defined as *BondStaM* − *BondEffM*. For the comparison purpose, two relative measures *BondCProtR* and *BondElimR* are further defined as *BondCProt*/*BondStaM* and *BondElim*/*BondStaM*. A smaller *BondCProtR* refers to a shorter call

Variable	N	Mean	Median	Stdev
Panel A: Callable bonds				
BondStaM (yrs)	41,670	12.29	10.01	8.98
BondEffM (yrs)	33,537	4.55	4.15	3.40
BondCProt(yrs)	41,646	3.77	2.98	5.34
BondCProtR	41,646	0.32	0.25	0.29
BondElim (yrs)	33,537	6.45	4.70	7.07
BondElimR	33,537	0.50	0.57	0.35
BondCoupon (%)	40,485	6.17	6.00	2.84
Offering amount($millions)	41,670	332.63	175.00	2,052.70
Bond rating	17,529	8.39	8.00	4.07
Covenant count	41,670	2.60	0.00	3.35
Panel B: Noncallable bonds				
BondStaM (yrs)	80,308	4.58	3.01	5.41
BondCoupon (%)	76,949	4.80	4.52	4.89
Offering amount($millions)	80,308	164.54	8.26	1,978.93
Bond rating	28,446	5.44	5.00	2.34
Covenant count	80,308	0.39	0.00	1.28

Table 2: Bond characteristics summary. This table reports summary statistics for our final bond sample. N and Stdev denote the number of bond sample and the standard deviation, respectively. Callable bonds are the bonds with the flag CALLABLE = Y in *Mergent FISD*, and noncallable bonds are those with the flag CALLABLE = N. *BondStaM*(*BondCProt*) denotes the length of bond maturity (call protection) stated on bond issuance date. *BondEffM* denotes the length of bond effective maturity. *BondElim* denotes the length of the time eliminated from the original bond's life due to early redemption. *BondCProtR* and *BondElimR* are two relative measures defined as *BondCProt*/*BondStaM* and *BondElim*/*BondStaM*, respectively. *BondCoupon* is the coupon rate for each bond. *Bond rating* is the bond issuer's ordinal rating; AAA = 1, AA+ = 2,..., etc. *Covenant count* is the number of restrictive covenants present in one bond. More details on the variable definitions are shown in Appendix D.

protection. Similarly, a greater *BondElimR* implies an earlier bond redemption. Finally, we denote a bond coupon rate in percentages by *BondCoupon*.

In **Table 2**, we compare the callable's sample characteristics with the noncallables'. Relative to the noncallables' mean *BondStaM*, the callables' are longer, which echoes Robbins and Schatzberg (1986)'s argument that embedding call provisions in bonds is a useful substitute for stating shorter bond maturities. We particularly notice that the callables' mean *BondEffM* 4.55 years is close to the noncallables' mean *BondStaM* of 4.58 years. Furthermore, the callables' median *BondCProt* of 2.98 years is also close to the noncallables' median *BondStaM* of 3.01 years. On the other hand, the callables' median ordinal rating is 8 (i.e., BBB+), while the noncallables' is 5 (i.e., A+), which is consistent to Brown and Powers (2020)'s observation that the callables' ratings are on average worse than the noncallables'. In addition, the mean number of restrictive covenants in the callables is greater than that in the noncallables, which also echoes Billett et al. (2007)'s finding that covenant protection is increasing in bond maturity.

Some of our firm-level variables are defined based on the bond-level data as follows. If firm i had l bonds outstanding in year t, the firm-level bond stated maturity in years (coupon rate in percentages) is defined as

$$FirmStaM_{i,t} = \frac{1}{l}\sum_{j=1}^{l} BondStaM_{i,t,j}; \tag{3}$$

$$FirmCoupon_{i,t} = \frac{1}{l}\sum_{j=1}^{l} BondCoupon_{i,t,j}. \tag{4}$$

We treat $FirmCoupon_{i,t}$ as the proxy for the cost of using bond capital in year t. Similarly, if the firm i has l_c callable bonds outstanding in year t, $l_c \leq l$, the firm-level length of call protection is defined in ratio form as

$$FirmCProtR_{i,t} = \frac{1}{l_c}\sum_{j=1}^{l_c} BondCProtR_{i,t,j}. \tag{5}$$

On the other hand, to measure how early the premature bond redemptions are conducted, we exploit the length of time eliminated from the length of the stated bond maturity. This firm-level measure *FirmElimR* is defined only when the early redemptions are conducted by the firm i in year t as follows

$$FirmElimR_{i,t} = \frac{1}{l_e}\sum_{j=1}^{l_e} BondElimR_{i,t,j}, \tag{6}$$

where $l_e \leq l$. Intuitively, the smaller $FirmCallPR_{i,t}$ is, the shorter the l_c outstanding callables' call protection are in year t. Furthermore, the greater $FirmElimR_{i,t}$ is, the earlier the l_e bonds are redeemed.

Table 3 reports the firm characteristics summary. From the perspective of the firm-year observations, our sample firms have median *FirmStaM* of 10 years close to the median *BondStaM* of our collected callable bonds and the benchmark setting in several studies such as Chen et al. (2021) and Dangl and Zechner (2021). By observing the mean *FirmCProtR* and *FirmElimR*, we find that on average the firms have outstanding callables with nearly half bond's life as call protection and eliminate a quarter of bonds' life once early redemption is conducted. In **Table 4**, we further conduct univariate tests of differences in bond characteristics depending on the firm leverage ratio *Lev*. We find that the high-leverage firms' *BondStaM* is significantly longer than the low-leverage firms', which echoes the argument from Diamond (1991) and Childs et al. (2005) that higher-leverage firms tend to increase their stated debt maturity for reducing the risk of having to frequently experience debt rollover. We also notice that these high-leverage firms have significantly smaller *BondEffM*, *BondCProt* (*BondCProtR*), and greater *BondElim* (*BondElimR*). This implies that these firms tend to on the other hand issue the callables with shorter call protection and conduct bond redemption earlier.

3.2 Calibration

To facilitate the quantitative analysis in the next section, our model parameters given in **Table 5** are estimated in two steps. First, a subset of parameters for market condition and firm characteristics are exogenously specified to be consistent with those in the literature to calibrate standard structural credit risk models. The parameters for debt structure are then calibrated to capture the important features of our collected data.

By following Dangl and Zechner (2021)'s estimates, we first assume that a firm's income is taxed

Variable	Firm-year Obs	Mean	Median	Stdev
Firm-level bond data				
FirmStaM (yrs)	46,812	11.81	10.00	6.80
FirmCProtR	26,560	0.51	0.49	0.23
FirmElimR	15,732	0.26	0.13	0.29
FirmCoupon (%)	48,082	7.11	7.04	2.64
Other firm fundamentals				
Total assets ($millions)	78,034	14,473.95	1,711.02	48,047.42
Leverage	78,015	3.91	2.61	6.99
Curlia	73,986	0.20	0.08	0.26
M/B ratio	65,491	1.75	1.34	1.21
Tangible	75,090	0.33	0.26	0.28
EBITDA/Total assets	75,050	0.10	0.11	0.13
Cash/Total assets	77,945	0.12	0.05	0.16
Equity return	63,536	0.15	0.06	0.62
Firm rating	38,401	10.05	10.00	3.90

Table 3: Firm characteristics summary. This table reports summary statistics for our firm-level data during the period of 1990–2018. *Leverage* refers to the leverage ratio of *Total Asset* to total stockholders' equity. *Curlia* denotes the ratio of debt in current liability to the sum of debt in current liability and long-term debt. *M/B ratio* refers to market-to-book ratio. *Tangible* refers to tangible assets. *EBITDA* represents earnings before interest, tax, depreciation and amortization. *Cash* represents cash and short-term investment. *Firm rating* refers to S&P long-term firm credit rating. The definition of all variables on these firm fundamentals are detailed in **Table 13** in Appendix D .

	Low-Leverage	High-leverage	Difference	t-value
BondStaM (yrs)	11.58	12.09	-0.51 ***	-3.16
BondEffM (yrs)	6.46	4.54	1.92 ***	9.92
BondCProt (yrs)	4.03	2.97	1.06 ***	22.77
BondCProtR	0.41	0.28	0.13 ***	34.41
BondElim (yrs)	6.46	7.55	-1.09 ***	-7.6
BondElimR	0.46	0.57	-0.11 ***	-14.09

Table 4: Comparisons of bond characteristics between low- and high-leverage firms. The comparison is performed via *BondStaM*, *BondEffM*, *BondCProt*, *BondCProtR*, *BondElim*, and *BondElimR*. The values represent the subsample averages of the bond issuers in the left column. In particular, firms are classified as the low- or high-leverage in one year according to the sample firms' median *Lev* in that year in the sample period 1990–2018. The corresponding subsample represents the outstanding bonds issued by the firms when they are classified as the low- or high-leverage in that year. *, **, and *** denote that the difference in bond characteristics is statistically significantly at the 10%, 5% and 1% level, respectively.

at a constant statutory rate $\tau = 30.6\%$, which is calibrated to effective marginal tax rates recorded in *Compustat MTR* database. Second, since the median ratings of our collected bonds are investment-grade (i.e., BBB+ for the callables and A+ for the noncallables), we choose $\gamma = 0.5\%$ of the market value of a newly-issued bond as in He and Xiong (2012) for A-rated bonds. Third, according to the estimates in Huang et al. (2020), the average payout ratio for a sample of firms is 2.14%. In particular, the average for the A-rated firms is 2.02% and for the BB-rated firms is 2.15%. Since the average ordinal rating of our sample firms is close to 10 (i.e., BBB−), we choose $q = 2\%$ as in He and Xiong (2012) due to the small variation in payout ratio across different ratings. Similarly, the estimates in Zhang et al. (2009) shows that A-rated firms have an average firm value volatility of 21% and BB-rated firms have an average of 23%. Due to the small variation in firm value volatility across different ratings, we choose $\sigma = 21\%$ since the average rating of our sample firms is close to the investment-grade. Fourth, the bankruptcy cost ω is referred to Glover (2016), who estimates the mean firm's cost of default with 45% and median firm's cost with 37% of asset value by applying a structural trade-off model of a firm with time-varying macroeconomic conditions. We adopt $\omega = 37\%$ as in Dangl and Zechner (2021).

We specify other model parameters according to our collected data. First, the stated maturity of the callable bond T is set to 10 years, since the median *BondStaM* of our collected callables is close to 10 years as displayed in **Table 2**. We then set the risk-free rate r to 4.61%, which is the median 10-year Treasury rate during the period of 1990–2018 according to data from the Federal Reserve Board's H.15 Report. On the other hand, if a firm has an outstanding noncallable with the maturity shorter than the callable, we calibrate the ratio of the noncallable face value to the total debt face value F to the median *Curlia* 8% in **Table 3**. We finally estimate the F for our baseline firm by taking aforementioned parameters as given and mimicking the method in He and Xiong (2012), whose hypothetical firm is similar to our base-case firm. Notice that the base-case firm has an outstanding noncallable. If the firm has the rating equal to the median rating of our sample firms (i.e., BBB−), we choose a suitable F so that the firm issues a 1-year noncallable at par and the bond have a bond yield of 7.22%, which is the median yield for BBB bonds during the period of 1990–2018 according to data from the Federal Reserve Board's H.15 Report. The F is solved to be 61.38 when we normalize the firm's current asset value to $V_0 = 100$. We thus set the total debt face values for a low-leverage and a high-leverage firms to 51.38 and 71.38, respectively.

4 Quantitative analysis

In this section, we examine the quantitative implications of our model based on the calibrated parameters in Section 3.2. In Section 4.1, we first illustrate that the length of call protection can be optimally chosen at a callable issuance to facilitate the needs for subsequent debt refinancing. Then we provide comparative statics for optimal lengths of call protection and the corresponding expected maturities of the callables in Section 4.2. Finally, we study the welfare consequences of the call-to-shorten strategy by comparing the costs of using callables with those of using shorter-term noncallables in Section 4.3.

4.1 The optimal choice of call protection period

Ceteris paribus, a callable bond with a shorter call protection is cheaper, since the shorter call protection gives the callable issuer more flexibility to conduct the early redemption at its equity holders' best interest against the callable holder's. However, if the callable is issued at par, such a call risk

A. Exogenously specified parameters			
Market Condition			
Corporate tax rate: τ			30.6%
Debt issue cost: γ			0.5%
Firm Characteristics			
Payout rate: q			2%
Firm value volatility: σ			21%
Bankruptcy cost: ω			37%
Current fundamental: V_0			100
B. Estimated parameters			
Risk-free rate: r			4.61%
Stated Maturity of the callable: T			10 year
Proportion of the shorter-term noncallable			8%
Total debt face value: F	Low	Benchmark	High
	51.38	61.38	71.38

Table 5: Baseline model parameters. Panel A summarizes the exogenous specified parameters. The parameters for market condition include risk-free rate, corporate tax rate, and bond refinancing cost. The parameters for firm characteristics include payout rate, firm value volatility, bankruptcy recovery rate, and firm's current fundamental. Panel B summarizes the estimated parameters.

will be fully compensated via a higher par yield, which offsets the equity holders' benefits from the flexibility granted by the shorter call protection. That makes the issuer neutral to the choice of call protection period, as illustrated by the horizontal dotted line in **Figure 6**.

If the issuer refinances each redemption of a callable with another callable over and over again, specifying a shorter call protection grants it additional flexibility to avoid the risk of having to issue a new bond in its unhealthy times. Though a shorter call protection implies a higher required premium on call risk, such a credit enhancement effect can on the other hand decrease the required premium on default risk to thus benefit the equity holders. Therefore, to maximize the equity holders' benefits, the callable issuer should strike the right balance between the benefit from assigning a shorter call protection and the higher premium for compensating the call risk. The hump-shaped solid curve in **Figure 6** shows that assigning a 3-year call protection for a 10-year callable is optimal to the benchmark firm's equity holders if debt refinancing will be conducted over and over. This calibrated assignment is close to the median *BondCProt* 2.98 as displayed in **Table 2**.

4.2 Optimal call protection period and expected maturity

To reduce the risk of having to frequently experience debt rollover, a firm tends to increase its stated debt maturity as its leverage increases (Diamond, 1991; Childs et al., 2005). However, the tradeoff between the choice of stated maturity and leverage can be broken by using callable bonds. A callable issuer can imitate shorter-term debt financing without exposing itself to severe rollover risk by locking in longer-term debt financing at callable issuances and conducting early refinancing with another callables repeatedly according to the specified lengths of call protection. To maximize the benefit from implementing such a call-to-shorten strategy, To implement such a call-to-shorten strategy at the best interest of the equity holders, the length of call protection should be optimally chosen by striking the right balance between the benefit from assigning a shorter call protection and the higher premium on call risk for a callable holder.

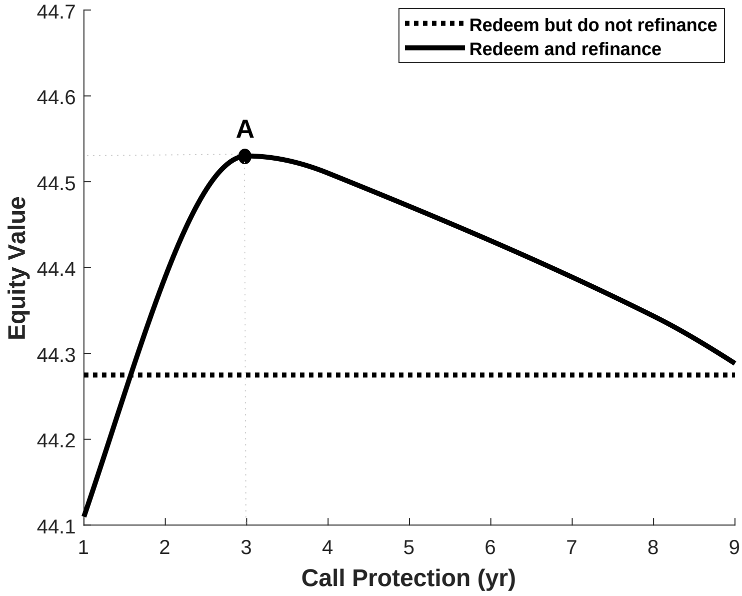
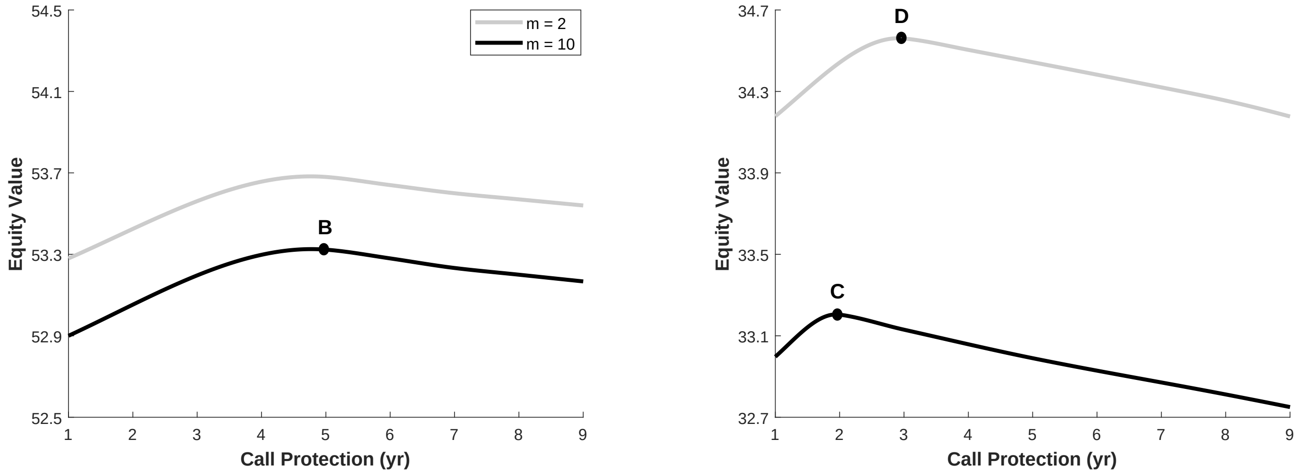


Figure 6: The presence of optimal call protection period. The x-axis represents the length of call protection period in years, which ranges from 1 to 9 years for a 10-year callable bond whose contractually-specified call dates are on 1 year, 2 years, ..., 9 years from the offering date. The corresponding call prices are equal to the bond face value. The y-axis is the callable issuer's equity value. The horizontal dotted line denotes the case that the issuer will merely conduct premature redemption. The solid curve indicates the case that the issuer will simultaneously conduct premature redemption and refinancing. The newly-issued callables has the par value F is 61.38 given the issuer's current fundamental $V_0 = 100$. The callable with a specified length of call protection on the x-axis is priced at par on its offering date $t = 0$ for consistency. All other parameter values follow those in **Table 5**. Dot A represents the choice of the call protection period that maximizes the callable issuer's equity value.

Figure 7 illustrates the optimal choice of call protection period for a low- and a high-leverage (m) issuer. By observing the variations in equity values from $m = 2$ to 10, we can find that the variation for a high-leverage issuer in panel (b) is much more salient than an otherwise identical low-leverage issuer in panel (a). This reveals the nature that the high-leverage issuer's creditworthiness is more vulnerable to refinancing risk. Thus, to formulate the call-to-shorten strategy at the best interest of the equity holders, the high-leverage (m) issuer tends to specify a shorter call protection than the low-leverage (m) does, since it grants the former issuer more flexibility to mitigate refinancing risk and thus significantly decrease credit risk. Such a choice of the shorter call protection can further facilitate earlier debt refinancing with another otherwise identical callable to repeat the next earlier debt refinancing. The shorter expected maturity displayed in **Figure 8** confirm this fact. Consequently, the high-leverage (m) issuer imitate shorter-term debt financing to alleviate agency conflicts without exposing the callable issuer to severe rollover risk.

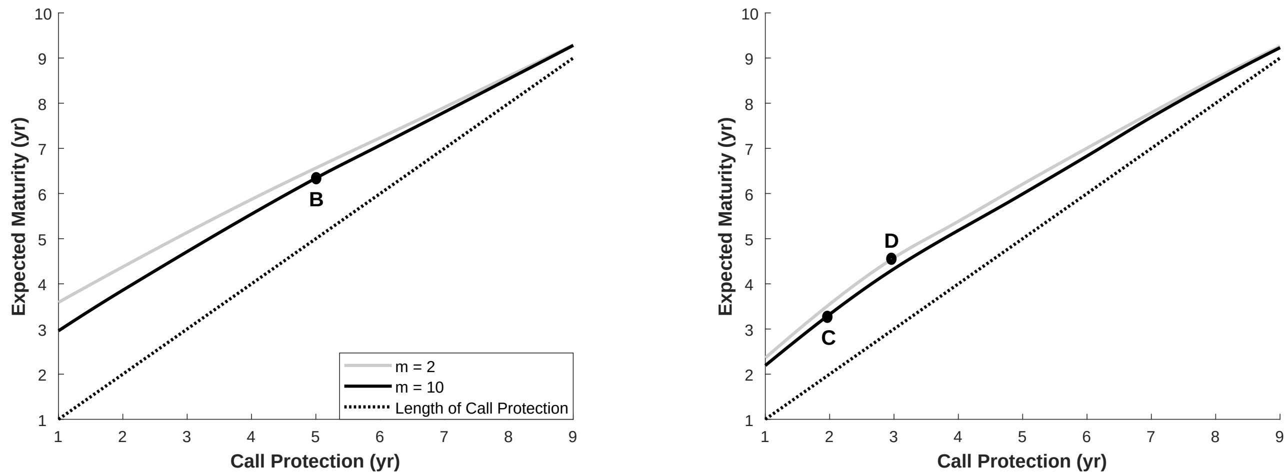
4.3 Welfare consequence

By locking in longer-term debt financing at callable issuances and conducting early refinancing with another callables according to the specified length of call protection, shorter-term debt financing are imitated to alleviate agency conflicts without exposing the callable issuer to severe rollover risk. Since rollover risk is more devastating to high-leverage firms (i.e., high total debt face value), such a call-



(a) Low-leverage firm (b) High-leverage firm

Figure 7: Optimal length of call protection for a low- and a high-leverage firms. The x- and y-axis in both panels denote the length of call protection period in years and the corresponding callable issuer's equity value, respectively. Given the stated maturity for the callable $T = 10$ years, the black and gray curves refer to the cases that the stated maturities for the shorter-term noncallable are 1 year (i.e., $m = 10$) and 5 years (i.e., $m = 2$), respectively. The total debt face value is set to 51.38 and 71.38 in panels (a) and (b), respectively. All other parameter values follow those in **Table 5**. Dots B, C, and D represent the choices of the call protection period that maximize the callable issuers' equity values.



(a) Low-leverage firm (b) High-leverage firm

Figure 8: Expected maturities for the callable bonds issued by the low- and the high-leverage firms. The x- and y-axis in both panels denote the length of call protection period in years and the corresponding expected maturities for the callables given that the bonds are not defaulted prematurely. the dotted lines refer to the expected maturities as the callables are redeemed and refinanced on their first call dates. All settings are identical to those in **Figure 7**. Dots B, C, and D are the expected maturities for the callables with the lengths of the call protection B, C, and D in **Figure 7**, respectively.

to-shorten strategy can effectively suppress their costs of debt financing to thus circumvent the debt overhang problem. This strategy also appeals to the firms having greater rollover risk, such as the ones preferring shorter-term bonds and thus having higher rollover frequency (i.e., high m).

Figure 9 illustrates the relations between coupon rates and total debt face values for the base and advanced case issuers. Compared to the base-case firm, the one adopting the call-to-shorten strategy can lower the noncallables' coupon rates (i.e., the solid curves are generally below the dotted ones in panel (b)), since the callables can avoid the risk of having to refinance with a large amount of new bonds and thus relieve the burden of having to roll over maturing noncallables when the issuer's prevailing status is unhealthy. On the other hand, since the required premiums on callables include credit and call spreads over the risk-free rate, the callable' coupon rates in panel (a) are generally higher than the noncallables' when the total debt face value is relatively low. However, as the total debt face value is getting higher, the noncallables' credit spreads for the base case issuer will be significantly amplified by the risk of having to roll over a large amount of maturing bonds. Due to the flexibility offered by the specified call period, the advanced case issuer can avoid such a risk to on the other hand suppress the callable's credit spread. That thus results in break-even points in coupon rates in panel (a) when the total debt face value is high enough.

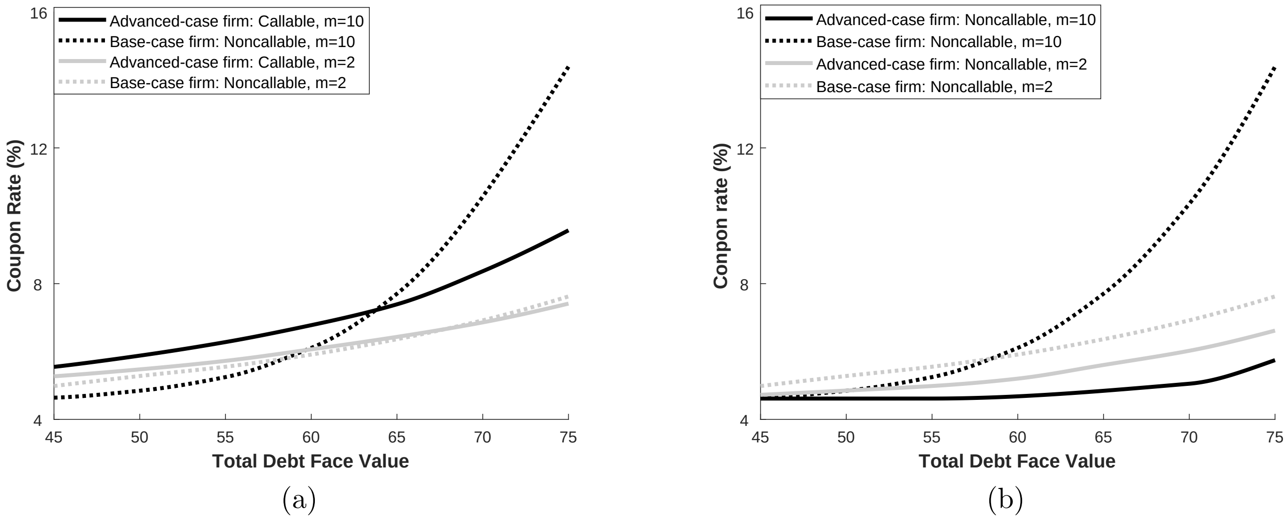


Figure 9: Par coupon rates for longer-term callable bonds and shorter-term noncallable bonds. The x- and y-axis denote the total debt face value and the corresponding coupon rates when bonds are issued at par at $t = 0$, respectively. Given the stated maturity for the callable $T = 10$ years, the black and gray curves denotes the cases that the stated maturities for the shorter-term noncallable are 1 year (i.e., $m = 10$) and 5 years (i.e., $m = 2$), respectively. The dotted curves in panels (a) and (b) refer to the coupon rates for the base-case firm's noncallables when $m = 10$ and 2, respectively. The solid curves in panels (a) and (b) refer to the coupon rates for the advanced-case firm's callables and the noncallables, respectively. The lengths of the call protection periods are set to the stated maturities for the shorter-term noncallable. All other parameter values follow those in **Table 5**.

5 Empirical Evidence

In this section, we conduct the empirical studies by building up the regressions to present a validation to the proposed strategy and the theoretical implications derived in **Section 4**. We will start our tests from the idea whether high-leverage(high-rollover-risk) firms tend to issue callables with short call protection. Then by execute the strategy, we are expecting an frequent refinancing by retiring existing callables to shorten the maturity and reissue new callables with short protection. As a result of adopting this strategy with two steps performed, we are expecting an decrease of rollover risk and thus of credit risk, which reflected as an cost reduction of using bond capital.

5.1 Methodology

The strategy we proposed have a born intention to expand capacity of firms to self-regulate in terms of precautionary debt maturity management. An early refinancing activity that deviated from established schedule could be an explicit representation of firms' desire to restructure their debt maturity to enhance the flexibility and strengthen the adaptability for potential uncertainty. So we adopt the setting of early refinancing in Xu (2018) as a proxy for firm's attempt of precautionary management. Specifically, a firm can modify its current debt structure by conducting early refinancing behaviors that issue a new bond (i.e. a refinancing bond) 1) within a 3-month window centered on the retirement date of a old bond (i.e. a retired bond) and also 2) at least 6 months before the stated maturity date of the retired bond.

Note that a retired bond should be a callable or redeemable as the implied condition in our definition. That means this retired bond would be retired at least 3 months before its scheduled due date which is literally its stated maturity date. Coinciding with Xu (2018), we identify our retired bonds by the methods of redemption, including fixed calls, make-whole calls, repurchases and tender offers. If a firm i issues a qualified refinancing bond at year t, then we can say this firm conduct a early refinancing activity at year t. Related to our implication, the activity could result in the shorter protection issuance and earlier calling back execution if our strategy are performed. And this implementation could utilize the call option most by transfer its optionality to firms' flexibility thus benefiting firms with a possible lower issuing cost.

In our sample which composed of 5148 firms during 1990-2018, 1454 firms are conducting early refinancing activities with an average 12 times out of 29. It implies that once firms conducted an early refinancing activity, they would conduct it frequently rather than occasionally which also reflects the precautionary management intentions.

A challenge related to our analysis is the endogenicity concern. The timing firm conducting the early refinancing activities and the timing firm determining the termination of bonds are likely chosen at the same time. Besides the simultaneity, omitted variables can also bias the ordinary least-squares (OLS) estimates of the impact of early refinancing on *FirmElimR* to either direction. And it is also the concern for *FirmCProtR* and *FirmCoupon* analysis as both of them are set to be embedded at issuance timing. Thus, we use the two-stage least squares (2SLS) regression for the multivariate analysis. We followed Xu (2018) and use a turn callable dummy $D(TurnCallable)$ as the instrumental variable since the timing of turning callable is positive shock for firms which is disconnect from unobservable determinants of elimination and protection and makes firms exposed to early refinancing activities easier. So our IV regressions for elimination, protection, and cost of debt are:

First stage :

$$D(EarlyRefinance)_{i,t} = \beta_0 + \beta_1 D(TurnCallable)_{i,t} + \beta_i Controls_{i,t} + e_{i.t}; \tag{7}$$

Second stage :

$$\begin{aligned} FirmCProtR_{i,t} &= \delta_0 + \delta_1 D(Early\widehat{Refinance})_{i,t} + \delta_i Controls_{i,t} + \varepsilon_{i,t}, & (8)\\ FirmElimR_{i,t} &= \gamma_0 + \gamma_1 D(Early\widehat{Refinance})_{i,t} + \gamma_i Controls_{i.t} + \varepsilon_{i,t}, & (9)\\ FirmCoupon_{i,t} &= \phi_0 + \phi_1 D(Early\widehat{Refinance})_{i,t} + \phi_i Controls_{i,t} + \varepsilon_{i,t}. & (10) \end{aligned}$$

In our regression, $D(TurnCallable)_{i,t}$ equals one if first call date of those bonds issued by firm i is at year t. $D(EarlyRefinance)_{i,t}$ equals one if firm $i$conduct an early refinancing activity we defined previous at time t.

Three dependent variables, *FirmCallPR*, *FirmElimR*, and *FirmCoupon*, will be tested in this paper as a response to our three theoretical implications by adopting proposed call-to-shorten strategy to enhance financing flexibility. All the three varibales are defined in **Section 3**.

Rollover risk can be measured by the three following ways in this paper. First, we use the debt refinancing intensity (*RI*) defined by Friewald et al. (2021). We follow their procedures by setting missing values of DD1 to DD5 and DLTT to zero.[8] We also remove observations whose total debt is greater than total assets and whose debt maturing in more than one year is lower than the sum of DD2, DD3, DD4, and DD5. To capture the high rollover-risk nature of financial firms, we reformulate our refinancing intensity measure as $RI = DD1/(DD1 + DLTT)$. Second, we can follow Gopalan et al. (2014) to measure a firm's exposure to rollover risk using the variable *LT-1* defined as DD1 divided by its book value of total assets proposed by Gopalan et al. (2014). Firms with a higher value of *LT-1* have a larger amount of long-term debt maturing with one year and, therefore, are likely to be exposed to greater rollover risk. Third, we can proxy the rollover risk by current liability *Curlia* defined as the portion of short-term debt to the sum of short-term and long-term debt following Duchin et al. (2010).

Controls in both two stages comprise variables related to firm characteristics and credit market condition measures. Those firm characteristic variables considered in our analysis are *ln(Assets)*, *Leverage*, *M/B Ratio*, *Tangible*, *EBITDA*, *Cash/Total assets*, and *Equity return*, which are detailed defined in Appendix D.[9] To mitigate the impact of outliers and the possible coding errors, we winsorize all firm variables at the upper and lower one percentiles, and apply the winsorization to all regression analyses. Corporate term spread which is measured as the difference between the 10- and 1-year corporate yield is considered to measure the credit market conditions.[10] To control for time-unvarying unobservables that might also affect a given firm's maturity choice, firm fixed effects are included in our regression. Year fixed effects are included to control for the interest rate and observable credit market conditions affecting firms' maturity choices.

5.2 Results

Motivated by the paradigm modeled in **Section 4**, we analyze whether firm would conduct precautionary management on their debt maturity structures and thus leading to the maturity evolution observed in the bond market as **Figure 1** shows.

First, we analyze the overall trends of maturity structure for the full sample and make some connection with nowadays bonds issuing market. Then we study the intention driven by different kinds of firms and try to provide an empirical evidence from three dimensions: *FirmCProtR*, *FirmElimR* and *FirmCoupon*, which are exactly the three implications stated in **Section 4**.

Full sample regression results are presented in **Table 6**. The coefficient estimates for *FirmStatM* are negative and significant, which is correspondence to the decreasing trend of stated maturity. The stated maturity would reduced at a scale of 5.55 years in one-standard-deviation change. Likewise, the

[8] These variables are defined in *Compustat* to represent the dollar amount of long-term debt payable in the first (second, third, fourth, fifth and beyond first) year.

[9] We also run regressions with *Firm rating* as one of firms controls and the results are the same.

[10] We collect three market condition measures from Federal Reserve Board's H.15 Report, including corporate term spread, Baa-Aaa Spread, and the 3-month T-bill rate. The latter two provide similar results as corporate term spread.

call protection ratio of callable bonds are getting shorter nowadays as the estimates of *FirmCProtR* are also negatively significant. The magnitude of protection ratio shortening is 18.2%, which cannot be ignored. While the stated maturity and call protection experience a shortening trends, the elimination which stands for the distance of effective maturity and stated maturity is becoming larger. The deviation of effective maturity from stated maturity broaden in a scale of 21.79% from our estimation.

Continuing to investigate the superiority of the proposed call-to-shorten strategy, we believed that firms with high leverage would have more incentives to adopt this strategy as **Table 7** and **Table 8** represent. From **Table 7**, we know that firms prefer short protection period because it can guarantee the feasibility of earlier retirement and refinancing, no matter what kind of firms they are. But the magnitude of coefficient estimates indicate the intensity of firms intentions. The coefficient estimate of protection in high leverage sample is much smaller than the number in low leverage group, which means high leverage firms have more incentives to shorten the call protection to obtain callability earlier and receive the financial flexibility with widen call period. For a one-standard-deviation increase in early refinance, the decrease in protection ratio of high leverage firms is 20.46% but the decrease of low leverage firms stops at the level 10% which is only the half of high leverage firms. And the decreasing scale 20.46% is larger than 18.2% in **Table 6** and is more close to 18.2% than low leverage group estimate 10%, which highlight the dominance of high leverage firms sample.

Those rollover risk scenarios represented by *RI*, *LT-1*, and *Curlia* give the same indication as leverage case shows in spite of different magnitudes. Taking *RI* as the main example, firms with high rollover risk have a negatively significant estimate of 19.8%, which is larger than the full sample estimate 18.2% and the low rollover group one 15.4%. This greater magnitude indicates that firms with high rollover risk would have stronger intention to issue callable bonds with shorter protection. While both the results of leverage and rollover risk give an response to the theoretical implication one, the difference in leverage groups (20.46% - 10.00%) is greater than the difference in rollover groups (19.81% - 15.43%), which is also indicates the higher intention for leveraged firms to conduct debt maturity management through protection design, as we mentioned that call protection is more close to their real maturity desire.

While the results of protection shows an general mutual intention of adopting call-to-shorten strategy for all the firms with magnitude gradient, the retiring behavior indicates an more obvious difference between high- and low- groups. As **Table 8** tells, coefficient estimate of firm elimination ratio in high-leverage sample is positively significant while low-leverage sample fails to get a significant estimate, which means high-leverage firms would complete the implement of the strategy by retiring and refinancing early but low leverage firms would not. And it consists with our theoretical implication two. By conducting the strategy, high-leverage firms take advantage of the flexibility callable bonds granted by eliminating the call period in a 25.43% scope for a one-standard-deviation increase in early refinance. Same results can be reached by rollover risk cases from column (4) to column (9) in **Table 8**, but in a larger magnitude of 31.59% if we take high rollover risk firms represented by *RI* as an example. Different from the larger magnitude in leverage groups from **Table 7**, the rollover risk groups experience a widen gap in high and low sub-samples. And the high rollover risk firms embrace an deeper elimination ratio than high leverage ones, which implies that the flexibility would exploited more by the feature of refinancing risk. Aligned with the *FirmCProtR* and *FirmElimR* regression results, we could come to a conclusion that high leverage firms have more incentives to adopt this superior strategy and this strategy also appeals to high rollover risk firms. And what is more, the complement of this strategy is oriented towards the effective date which should being taken seriously but never have had in the literature.

Finally, we turn our attention to the indispensable part when issuing bonds, that is the issuance cost. As we stated in **Section 3**, coupon here represents the cost of debt of the issuing firm. And consistent with our implication three, the coefficient estimate of coupon is negatively significant in the regression of high-leverage firms but shows no significance in the low-leverage ones. This results specify the high leverage firms could benefit an issuance cost reduction by executing this call-to-shorten strategy, because the financial flexibility provided by this strategy can reduce the refinancing risk thus reducing the default risk and enhancing the financial status. And the decreasing scale of high rollover risk firms 0.84 is larger than that of high-leverage firms 0.77, which echoes the results in **Table 8**. The one who exploit the financial flexibility provided by this call-to-shorten strategy would experience a higher cost deduction benefit. And this welfare implication can help to explain the prevalence of callable bonds.

Table 6: Full sample regressions on three horizons.

This table reports IV regression results, where $D(EarlyRefinance)_{i,t}$ is instrumented by $D(TurnCallable)_{i,t}$, a dummy variable indicating that some bonds are scheduled to become callable in year t for firm i. The independent variable $D(EarlyRefinance)_{i,t}$ is a dummy variable which equals 1 when firm i conducts a early refinancing activity at year t. Three dependent are analyzed in this table. *FirmStatM* is the average bond maturity. *FirmCProtR* is the average protection ratio, and *FirmElimR* is the average elimination ratio. High and Low groups are divided by their corresponding median value. Additional firm characteristic controls include *ln(Assets)*, *Leverage*, *M/B Ratio*, *Tangible*, *EBITDA*, *Cash/Total assets*, and *Equity return*. Observations are at firm-year level. Firm fixed effects and year fixed effects are included. The value of t-statistics adjusted for clustering at the firm level are reported in parentheses.*,**, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	Full Sample		
	(1) *FirmStatM*	(2) *FirmCProtR*	(3) *FirmElimR*
$D(EarlyRefinance)$	**-5.5492*** **	**-0.1820*** **	**0.2179*** **
	(-6.82)	(-7.36)	(3.16)
TermSpread	-0.7461***	0.0080	-0.0482***
	(-5.85)	(1.22)	(-4.04)
ln(Asset)	-0.1710	0.0099*	-0.0257***
	(-1.24)	(1.65)	(-3.13)
Leverage	0.0012	0.0003	-0.0010**
	(0.22)	(1.58)	(-2.19)
M/B Ratio	-0.1065	0.0041	-0.0173***
	(-1.29)	(1.04)	(-2.58)
Tangibility	0.3588	0.0342	-0.0408
	(0.47)	(0.91)	(-0.88)
EBITDA	2.1075***	0.0134	0.0671
	(3.76)	(0.52)	(1.27)
Cash/Total assets	1.0282	-0.0018	0.1794***
	(1.60)	(-0.05)	(3.43)
Equity return	-0.0537	0.0075***	0.0069
	(-1.13)	(3.87)	(1.10)
	First Stage		
$D(TurnCallable)$	0.0968***	0.1573***	0.0804***
	(20.38)	(19.50)	(8.93)
Firm_FE	Y	Y	Y
Year_FE	Y	Y	Y
Adj. R-squared	-0.0445	0.2309	0.0916
Obs.	34631	18967	10628

Table 7: IV regressions of *FirmCProtR*.

This table reports IV regression results, where $D(EarlyRefinance)_{i,t}$ is instrumented by $D(TurnCallable)_{i,t}$, a dummy variable indicating that some bonds are scheduled to become callable in year t for firm i. The independent variable $D(EarlyRefinance)_{i,t}$ is a dummy variable which equals 1 when firm i conducts a early refinancing activity at year t. The dependent variable is *FirmCProtR* which calculated as the average protection ratio. High and Low groups are divided by their corresponding median value. Additional firm characteristic controls include *ln(Assets)*, *Leverage*, *M/B Ratio*, *Tangible*, *EBITDA*, *Cash/Total assets*, and *Equity return*. Observations are at firm-year level. Firm fixed effects and year fixed effects are included. The value of t-statistics adjusted for clustering at the firm level are reported in parentheses.*,**, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	Dependent variable = *FirmCProtR*								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Full Sample	High *Leverage*	Low *Leverage*	High *RI*	Low *RI*	High *LT-1*	Low *LT-1*	High *Curlia*	Low *Curlia*
$D(EarlyRefinance)$	-0.1820***	**-0.2046*** **	**-0.1000*** **	**-0.1981*** **	**-0.1543*** **	**-0.2142*** **	**-0.1245*** **	**-0.1698*** **	**-0.1461*** **
	(-7.36)	(-5.91)	(-2.82)	(-4.21)	(-5.64)	(-5.61)	(-4.07)	(-3.66)	(-5.48)
Termspread	0.0080	0.0167	-0.0111	0.0080	0.0056	0.0133	0.0080	-0.0080	0.0193
	(1.22)	(1.06)	(-1.04)	(0.76)	(0.14)	(0.48)	(0.71)	(-0.92)	(1.32)
ln(Asset)	0.0099*	-0.0111	0.0254***	0.0099	0.0070	0.0025	0.0089	0.0057	0.0072
	(1.65)	(-1.36)	(2.80)	(1.07)	(0.89)	(0.29)	(0.95)	(0.60)	(1.09)
Leverage	0.0003	-0.0003	0.0001	0.0004	0.0002	0.0001	0.0005	0.0010**	0.0002
	(1.58)	(-0.68)	(0.14)	(1.07)	(0.68)	(0.26)	(1.47)	(2.17)	(0.77)
M/B Ratio	0.0041	0.0108*	0.0048	-0.0060	0.0102*	-0.0026	0.0099*	-0.0005	0.0043
	(1.04)	(1.75)	(0.97)	(-0.87)	(1.80)	(-0.42)	(1.91)	(-0.06)	(0.96)
Tangible	0.0342	0.0643	0.0213	0.0119	0.0160	0.0406	0.0196	-0.0739	0.0533
	(0.91)	(1.18)	(0.42)	(0.23)	(0.36)	(0.85)	(0.40)	(-1.11)	(1.37)
EBITDA	0.0134	-0.0119	-0.0154	0.0432	0.0148	0.0215	0.0056	0.0579	-0.0104
	(0.52)	(-0.27)	(-0.45)	(0.83)	(0.43)	(0.47)	(0.15)	(1.30)	(-0.38)
Cash/Total asset	-0.0018	-0.0242	0.0467	-0.0396	-0.0473	-0.0204	-0.0134	-0.0381	-0.0028
	(-0.05)	(-0.45)	(1.15)	(-0.69)	(-1.15)	(-0.38)	(-0.30)	(-0.63)	(-0.08)
Equity return	0.0075***	0.0099***	0.0016	0.0132***	0.0053*	0.0154***	0.0029	0.0047	0.0082***
	(3.87)	(3.63)	(0.54)	(3.79)	(1.80)	(5.03)	(0.92)	(1.33)	(3.64)
	First Stage								
$D(TurnCallable)$	0.1573***	0.1509***	0.1608***	0.1329***	0.1757***	0.1443***	0.1825***	0.1403***	0.1704***
	(19.50)	(13.99)	(12.48)	(10.43)	(14.77)	(12.21)	(14.06)	(11.59)	(15.47)
Firm_FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year_FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Adj. R-squared	0.2309	0.1872	0.2764	0.3459	0.1588	0.2584	0.2209	0.4065	0.1032
Obs.	18967	10507	7858	6983	10022	8020	8201	6715	11357

Table 8: IV regressions of *FirmElimR*.

This table reports IV regression results, where $D(EarlyRefinance)_{i,t}$ is instrumented by $D(TurnCallable)_{i,t}$, a dummy variable indicating that some bonds are scheduled to become callable in year t for firm i. The independent variable $D(EarlyRefinance)_{i,t}$ is a dummy variable which equals 1 when firm i conducts a early refinancing activity at year t. The dependent variable is *FirmElimR* which calculated as the average elimination ratio. High and Low groups are divided by their corresponding median value. Additional firm characteristic controls include *ln(Assets)*, *Leverage*, *M/B Ratio*, *Tangible*, *EBITDA*, *Cash/Total assets*, and *Equity return*. Observations are at firm-year level. Firm fixed effects and year fixed effects are included. The value of t-statistics adjusted for clustering at the firm level are reported in parentheses.*,**, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	Dependent variable = *FirmElimR*								
	(1) Full Sample	(2) High *Leverage*	(3) Low *Leverage*	(4) High *RI*	(5) Low *RI*	(6) High *LT-1*	(7) Low *LT-1*	(8) High *Curlia*	(9) Low *Curlia*
$D(EarlyRefinance)$	0.2179***	**0.2453*** **	**0.1905**	**0.3159*** **	**0.1415**	**0.3417*** **	**0.0270**	**0.2905*** **	**0.0806**
	(3.16)	(3.17)	(1.38)	(3.47)	(1.40)	(3.86)	(0.25)	(3.62)	(0.74)
Termspread	-0.0482***	-0.0552**	-0.0434	-0.0537**	-0.0341*	-0.0710***	-0.0330	-0.0412**	-0.0597
	(-4.04)	(-2.12)	(-0.14)	(-2.14)	(-1.79)	(-3.24)	(-1.33)	(-2.57)	(-1.45)
ln(Asset)	-0.0257***	-0.0282**	-0.0156	-0.0339***	-0.0208	-0.0306***	-0.0167	-0.0249**	-0.0219*
	(-3.13)	(-2.41)	(-1.13)	(-2.85)	(-1.54)	(-2.71)	(-1.07)	(-2.00)	(-1.94)
Leverage	-0.0010**	-0.0015*	-0.0006	-0.0005	-0.0011	-0.0006	-0.0004	-0.0011	-0.0007
	(-2.19)	(-1.84)	(-0.38)	(-0.74)	(-1.54)	(-1.04)	(-0.42)	(-1.55)	(-1.18)
M/B Ratio	-0.0173***	-0.0182	-0.0127	-0.0157	-0.0178	-0.0222***	-0.0024	-0.0170	-0.0224**
	(-2.58)	(-1.59)	(-1.38)	(-1.63)	(-1.42)	(-2.58)	(-0.22)	(-1.57)	(-2.06)
Tangible	-0.0408	-0.0348	-0.1198	-0.0228	-0.1205	-0.0076	-0.1825*	-0.0065	-0.0604
	(-0.88)	(-0.64)	(-1.43)	(-0.34)	(-1.60)	(-0.11)	(-1.94)	(-0.10)	(-0.93)
EBITDA	0.0671	0.0586	0.0887	0.0140	0.2098***	-0.0603	0.2110***	0.1486	0.0356
	(1.27)	(0.68)	(0.98)	(0.17)	(2.76)	(-0.68)	(2.78)	(1.44)	(0.53)
Cash/Total asset	0.1794***	0.2455***	0.0931	0.1568**	0.2416***	0.2317***	0.1580*	0.1688**	0.2343***
	(3.43)	(3.42)	(1.17)	(2.00)	(2.73)	(2.88)	(1.67)	(2.15)	(2.71)
Equity return	0.0069	0.0082	0.0033	-0.0011	0.0124	0.0037	0.0231**	0.0037	0.0103
	(1.10)	(1.04)	(0.28)	(-0.12)	(1.31)	(0.40)	(2.12)	(0.34)	(1.16)
	First Stage								
$D(TurnCallable)$	0.0804***	0.0901***	0.0743***	0.0847***	0.0844***	0.0877***	0.09600***	0.0965***	0.0742***
	(8.93)	(6.99)	(5.30)	(7.19)	(5.07)	(7.44)	(4.97)	(7.90)	(5.12)
Firm_FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year_FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Adj. R-squared	0.0916	0.0831	0.1116	0.1292	0.0342	0.0821	0.0549	0.1193	0.0909
Obs.	10628	6154	3941	5740	3735	5981	2743	5320	4543

Table 9: IV regressions of *FirmCoupon*.

This table reports IV regression results, where $D(EarlyRefinance)_{i,t}$ is instrumented by $D(TurnCallable)_{i,t}$, a dummy variable indicating that some bonds are scheduled to become callable in year t for firm i. The independent variable $D(EarlyRefinance)_{i,t}$ is a dummy variable which equals 1 when firm i conducts a early refinancing activity at year t. The dependent variable is *FirmCoupon* which calculated as the average coupon of each outstanding bond. High and Low groups are divided by their corresponding median value. Additional firm characteristic controls include *M/B Ratio*, *Tangible*, *EBITDA*, *Cash/Total assets*, and *Equity return*. Observations are at firm-year level. Firm fixed effects and year fixed effects are included. The value of t-statistics adjusted for clustering at the firm level are reported in parentheses.*,**, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	Dependent variable = *FirmCoupon*								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Full Sample	High *Leverage*	Low *Leverage*	High *RI*	Low *RI*	High *LT-1*	Low *LT-1*	High *Curlia*	Low *Curlia*
$D(EarlyRefinance)$	-0.1616	**-0.7673*** **	**0.4559**	**-0.8423** **	**0.0642**	**-0.5413** **	**0.0542**	**-0.8205** **	**0.1290**
	(-0.76)	(-2.98)	(1.27)	(-2.29)	(0.25)	(-1.65)	(0.20)	(-2.26)	(0.52)
Termspread	-0.6533	-0.7296***	-0.5328***	-0.6333***	-0.6426***	-0.5869	-0.5931***	-0.7768***	-0.5288***
	(-1.00)	(-12.97)	(-2.63)	(-11.27)	(-6.62)	(-1.61)	(-12.74)	(-14.45)	(-9.60)
ln(Asset)	-0.4369***	-0.3849***	-0.5034***	-0.3783***	-0.4708***	-0.4211***	-0.4115***	-0.4030***	-0.4548***
	(-9.76)	(-6.93)	(-7.98)	(-6.78)	(-7.98)	(-7.05)	(-6.94)	(-6.50)	(-8.26)
Leverage	0.0037**	0.0107***	-0.0058	0.0047**	0.0052**	0.0048**	0.0050**	0.0041*	0.0036**
	(2.46)	(3.71)	(-1.01)	(2.00)	(2.53)	(2.43)	(2.14)	(1.69)	(2.06)
M/B Ratio	-0.1606***	-0.1585***	-0.1479***	-0.1695***	-0.2150***	-0.1467***	-0.2032***	-0.1600***	-0.1764***
	(-6.31)	(-3.48)	(-5.07)	(-4.20)	(-6.18)	(-3.45)	(-6.52)	(-3.72)	(-5.82)
Tangible	-0.3991*	-0.4997	0.0835	-0.6697**	-0.3021	-0.5474*	-0.1661	-0.8307**	-0.1230
	(-1.74)	(-1.46)	(0.24)	(-2.09)	(-1.03)	(-1.80)	(-0.54)	(-2.41)	(-0.42)
EBITDA	-0.1040	-0.2197	0.0805	0.2387	-0.3316	0.4240	-0.1897	0.0963	-0.2467
	(-0.59)	(-0.82)	(0.33)	(0.79)	(-1.26)	(1.35)	(-0.77)	(0.32)	(-1.09)
Cash/Total asset	-0.7344***	-0.3069	-0.5758**	-0.6960**	-0.6646***	-1.0017***	-0.4693**	-0.1120	-0.9180***
	(-3.73)	(-0.96)	(-2.32)	(-2.39)	(-2.75)	(-3.36)	(-2.03)	(-0.37)	(-3.49)
Equity return	0.1276***	0.1226***	0.1387***	0.1415***	0.1494***	0.1465***	0.1253***	0.1229***	0.1303***
	(8.90)	(5.99)	(5.58)	(6.52)	(6.76)	(6.37)	(5.69)	(4.41)	(7.02)
	First Stage								
$D(TurnCallable)$	0.0914***	0.0977***	0.0788***	0.0809***	0.1024***	0.0861***	0.0983***	0.0884***	0.0979***
	(20.15)	(14.90)	(12.46)	(12.15)	(15.28)	(13.13)	(14.03)	(13.05)	(15.47)
Firm_FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year_FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Adj. R-squared	0.2750	0.2976	0.2308	0.2922	0.2592	0.2854	0.2426	0.3392	0.2152
Obs.	35805	19262	15821	14749	17926	15762	15084	15671	18834

We do another test of leverage change before and after the early refinancing activities and the results are listed in **Table 10**. We do not observe significant leverage change for both before and after the early refinancing activities. And the difference itself is also too trivial to be concerned. This results also consist with the maturity rat race theory by Brunnermeier and Oehmke (2013). It is also worth noting that firm conducting early refinancing have a higher leverage than those firms that never conducting early refinancing, which is also reasonable under our theoretical framework.

Table 10: Changes of firm leverage after the early refinancing activity.
This table shows the leverage change in three comparison. We compute the average leverage before the early refinancing year, at the refinancing year, and after the refinancing year. And then do the pair wise comparison. Moreover, we compare the results with firms not conducting early refinancing activity at same year. The difference is computed as the latter year value minus the former year value.

	Leverage with early refinancing			Leverage without early refinancing		
Before refinance	5.83		5.79	3.82		3.84
Refinancing year		5.83	5.82		3.84	3.81
After refinance	5.71	5.72		3.80	3.81	
Difference	-0.11	-0.11	-0.03	-0.02	-0.03	-0.03
(t-value)	-0.51	-0.50	0.14	-0.55	-0.73	-0.91
(p-value)	0.61	0.62	0.89	0.58	0.47	0.36

6 Conclusion

This paper shed a light on the field of debt maturity management by corporate bonds. We observe the discrepancy of bonds' stated maturity and effective maturity and the corresponding coherence of bonds effective maturity and call protection. Based on the observation, we conduct an comprehensive analyses of callable bonds from the aspect of call protection and effective maturity, to explicit the precautionary debt maturity management and dynamic financing strategy nowadays. We first point out that the call-to-shorten strategy is spreading in the bond market by taking advantage of callable bonds and this strategy could bring benefits for bond issuers. Then to illustrate the rationality of this strategy, we construct a novel structural credit risk model to analyze the welfare implications by functioning the refinancing with callable bonds in debt structure. We next conduct the empirical studies to provide the realistic evidence for our proposal. We show that the strategy by exploiting the flexibility provided call provisions can be a superior one to hunt for short-term debt structure, especially for those firms with high leverage or high refinancing risk, in both theoretical and empirical dimensions. The implement of our proposed call-to-shorten strategy could picture the evolution of bonds' effective maturity and provide a possible interpretation for the widening difference between effective and stated bond maturity. Our theory can also provide an sound explanation for the prevalence of callable bonds from the perspective of refinancing risk management.

References

Billett, M. T., T.-H. D. KING, and D. C. Mauer (2007). Growth opportunities and the choice of leverage, debt maturity, and covenants. *The Journal of Finance 62*(2), 697–730.

Broadie, M. and Ö. Kaya (2007). A binomial lattice method for pricing corporate debt and modeling chapter 11 proceedings. *Journal of Financial and Quantitative Analysis 42*(2), 279–312.

Brounen, D., A. De Jong, and K. Koedijk (2004). Corporate finance in europe: Confronting theory with practice. *Financial management*, 71–101.

Brown, S. and E. Powers (2020). The life cycle of make-whole call provisions. *Journal of Corporate Finance 65*, 101772.

Brunnermeier, M. K. and M. Oehmke (2013). The maturity rat race. *The Journal of Finance 68*(2), 483–521.

Butler, A. W. and H. Yi (2022). Aging and public financing costs: Evidence from us municipal bond markets. *Journal of Public Economics 211*, 104665.

Chen, H. (2010). Macroeconomic conditions and the puzzles of credit spreads and capital structure. *The Journal of Finance 65*(6), 2171–2212.

Chen, H., Y. Xu, and J. Yang (2021). Systematic risk, debt maturity, and the term structure of credit spreads. *Journal of Financial Economics 139*(3), 770–799.

Childs, P. D., D. C. Mauer, and S. H. Ott (2005). Interactions of corporate financing and investment decisions: The effects of agency conflicts. *Journal of Financial Economics 76*(3), 667–690.

Choi, J., D. Hackbarth, and J. Zechner (2018). Corporate debt maturity profiles. *Journal of Financial Economics 130*(3), 484–502.

Cox, J. C., S. A. Ross, and M. Rubinstein (1979). Option pricing: A simplified approach. *Journal of Financial Economics 7*(3), 229–263.

Custódio, C., M. A. Ferreira, and L. Laureano (2013). Why are us firms using more short-term debt? *Journal of Financial Economics 108*(1), 182–212.

Dangl, T. and J. Zechner (2021). Debt maturity and the dynamics of leverage. *The Review of Financial Studies 34*(12), 5796–5840.

Diamond, D. W. (1991). Debt maturity structure and liquidity risk. *The Quarterly Journal of Economics 106*(3), 709–737.

Duchin, R., O. Ozbas, and B. A. Sensoy (2010). Costly external finance, corporate investment, and the subprime mortgage credit crisis. *Journal of financial economics 97*(3), 418–435.

Duffie, D. (1996). *Dynamic asset pricing theory.* Princeton University Press.

Fan, H. and S. M. Sundaresan (2000). Debt valuation, renegotiation, and optimal dividend policy. *Review of Financial Studies 13*(4), 1057–1099.

Friewald, N., F. Nagler, and C. Wagner (2021). Debt refinancing and equity returns. *Journal of Finance, Forthcoming*.

Gamba, A. and A. Triantis (2008). The value of financial flexibility. *The journal of finance 63*(5), 2263–2296.

Glover, B. (2016). The expected cost of default. *Journal of Financial Economics 119*(2), 284–299.

Gopalan, R., F. Song, and V. Yerramilli (2014). Debt maturity structure and credit quality. *Journal of Financial and Quantitative Analysis 49*(4), 817–842.

Graham, J. R. and C. R. Harvey (2001). The theory and practice of corporate finance: Evidence from the field. *Journal of Financial Economics 60*(2), 187–243.

He, Z. and K. Milbradt (2014). Endogenous liquidity and defaultable bonds. *Econometrica 82*(4), 1443–1508.

He, Z. and K. Milbradt (2016). Dynamic debt maturity. *The Review of Financial Studies 29*(10), 2677–2736.

He, Z. and W. Xiong (2012). Rollover risk and credit risk. *The Journal of Finance 67*(2), 391–430.

Huang, J.-Z., Z. Shi, and H. Zhou (2020). Specification analysis of structural credit risk models. *Review of Finance 24*(1), 45–98.

Leland, H. E. (1998). Agency costs, risk management, and capital structure. *The Journal of Finance 53*(4), 1213–1243.

Leland, H. E. and K. B. Toft (1996). Optimal capital structure, endogenous bankruptcy, and the term structure of credit spreads. *The Journal of Finance 51*(3), 987–1019.

Liu, L.-C., T.-S. Dai, H.-H. Chang, and L. Zhou (2022). A novel state-transition forest: pricing corporate securities with intertemporal exercise policies and corresponding capital structure changes. *Quantitative Finance 22*(11), 2021–2045.

Liu, L.-C., T.-S. Dai, and C.-J. Wang (2016). Evaluating corporate bonds and analyzing claim holders' decisions with complex debt structure. *Journal of Banking & Finance 72*, 151–174.

Merton, R. C. (1974). On the pricing of corporate debt: The risk structure of interest rates. *The Journal of Finance 29*(2), 449–470.

Myers, S. C. (1977). Determinants of corporate borrowing. *Journal of Financial Economics 5*(2), 147–175.

Powers, E. (2021). The optimality of call provision terms. *Management Science 67*(10), 6581–6601.

Robbins, E. H. and J. D. Schatzberg (1986). Callable bonds: A risk-reducing signalling mechanism. *The Journal of Finance 41*(4), 935–949.

Sarkar, S. (2001). Probability of call and likelihood of the call feature in a corporate bond. *Journal of banking & finance 25*(3), 505–533.

Xu, Q. (2018). Kicking maturity down the road: early refinancing and maturity management in the corporate bond market. *The Review of Financial Studies 31*(8), 3061–3097.

Zhang, B. Y., H. Zhou, and H. Zhu (2009). Explaining credit default swap spreads with the equity volatility and jump risks of individual firms. *The Review of Financial Studies 22*(12), 5099–5131.

Appendix A Backward induction procedure within the forest

A.1 Backward induction procedure in Figure 5(b)

The backward induction procedure within the forest of **Figure 5(b)** will be detailed as follows. To take rollover gains and losses into account, the values of other later-issued bonds are needed to be evaluated. As illustrated in **Figure 10**, the first two later-issued bonds are the otherwise identical $T/2$-year SB_T and T-year $CB_{T,3T/2}$ that are issued at time $t = T/2$ to refund the maturing $SB_{T/2}$ and the premature redemption of the $CB_{T/2,T}$. The second two bonds are the otherwise identical $SB_{3T/2}$ and $CB_{3T/2,2T}$ that are issued at time $t = T$ to refund the maturing SB_T and the premature redemption of the $CB_{T,3T/2}$. The third two bonds are two otherwise identical $T/2$-year SB_{2T} and SB^L_{2T} that are issued at time $t = 3T/2$ to refund the maturing $SB_{3T/2}$ and the premature redemption of the $CB_{3T/2,2T}$. Notice that the noncallable SB^L_{2T} and the callable $CB_{3T/2,2T}$ have the same coupon rate C_L and face value F_L. Thus, the backward induction procedure starts from time $t = 2T$ and can be separated into nine stages as follows.

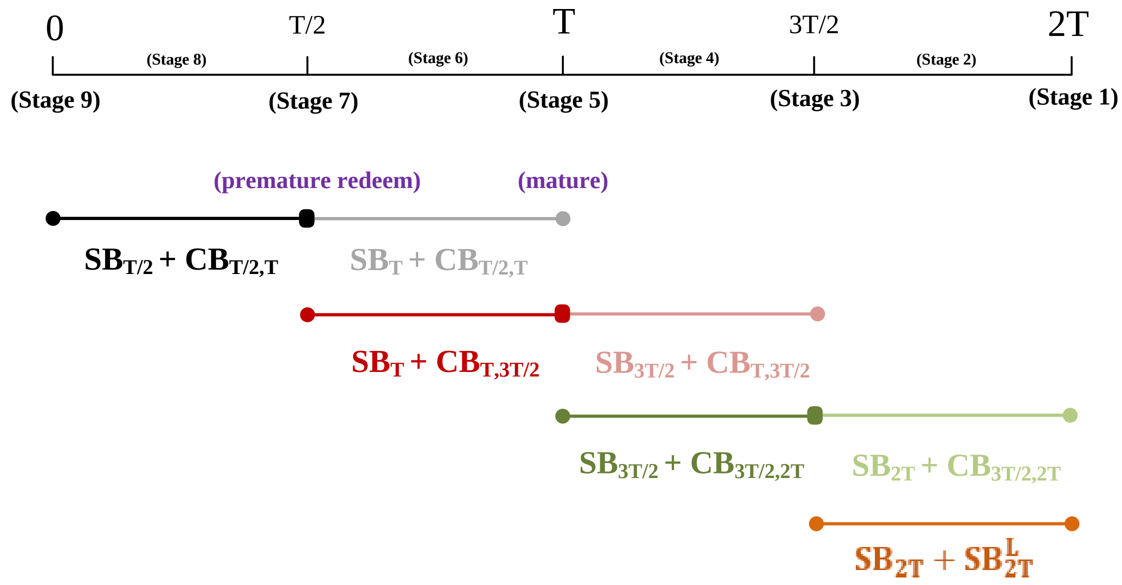


Figure 10: Backward induction stages.

Stage 1: $t = 2T$

As illustrated in **Figure 10**, there are two states of debt structure. The first state is the one consisting of two $T/2$-year noncallables SB_{2T} and SB^L_{2T}, and the other is the one consisting of a $T/2$-year SB_{2T} and a T-year callable $CB_{3T/2,2T}$. Each state can be captured by a CRR tree.

[Stage 1–State 1]:

To obey the constant book leverage policy, the firm will refund the $CB_{3T/2,2T}$ by issuing the SB^L_{2T} when the callable is prematurely redeemed at time $t = 3T/2$. Thus, its capital structure will consist of the SB_{2T}, the SB^L_{2T}, and the equity $E_{2T,2T}$ as $t \in (3T/2, 2T]$. Then, the equity value is

$$E_{aT,bT}(V_t, t) = max\,(V_t + \delta_t - F_S(1 + (1-\tau)C_S\Delta t) - F_L(1 + (1-\tau)C_L\Delta t)\,,\,0)\,, \tag{11}$$

where $a = b = 2$. Notice that the δ_t in above equation represents the cash for debt repayments and dividends. I follow Broadie and Kaya (2007) to set $\delta_t = V_t e^{q\Delta t} - V_t$ if the asset value dynamics of

Equation (1) is discretely characterized by a CRR tree. The δ_t will converge to $qV_t dt$ if Δt is small enough. The values of the corresponding two noncallables are

$$SB_{aT}(V_t, t \,|\, T/2) = \begin{cases} F_S + F_S C_S \Delta t & \text{if } E_{aT,bT}(V_t, t) > 0, \\ (1-\omega)(V_t + \delta_t) \times \frac{F_S}{F_S + F_L} & \text{otherwise,} \end{cases} \tag{12}$$

$$SB^L_{bT}(V_t, t \,|\, T/2) = \begin{cases} F_L + F_L C_L \Delta t & \text{if } E_{aT,bT}(V_t, t) > 0, \\ (1-\omega)(V_t + \delta_t) \times \frac{F_L}{F_S + F_L} & \text{otherwise.} \end{cases} \tag{13}$$

[Stage 1–State 2]:

If the $CB_{3T/2,2T}$ is not prematurely redeemed, the capital structure in turn consists of the SB_{2T}, the $CB_{3T/2,2T}$, and the equity $E_{2T,2T}$ as $t \in [3T/2, 2T]$. Since the $CB_{3T/2,2T}$ and SB^L_{2T} have the same coupon rate and face value, the equity value $E_{aT,bT}(V_t, t \,|\, P)$ can be expressed as **Equations (11)**. The values of the corresponding SB_{2T} and $CB_{3T/2,2T}$ are

$$SB_{aT}(V_t, t \,|\, T/2) = \begin{cases} F_S + F_S C_S \Delta t & \text{if } E_{aT,bT}(V_t, t \,|\, P) > 0, \\ (1-\omega)(V_t + \delta_t) \times \frac{F_S}{F_S + F_L} & \text{otherwise,} \end{cases} \tag{14}$$

$$CB_{pT,bT}(V_t, t \,|\, P, T) = \begin{cases} F_L + F_L C_L \Delta t & \text{if } E_{aT,bT}(V_t, t \,|\, P) > 0, \\ (1-\omega)(V_t + \delta_t) \times \frac{F_L}{F_S + F_L} & \text{otherwise,} \end{cases} \tag{15}$$

where $a = b = 2$ and $p = 3/2$.

Stage 2: $3T/2 < t < 2T$

[Stage 2–State 1]:

When the debt structure consists of SB_{2T} and SB^L_{2T}, the equity value is expressed as

$$E_{aT,bT}(V_t, t \,|\, P) = max\left(\underbrace{ContE_{aT,bT}}_{\mathbf{A}} + \delta_t - (F_S C_S + F_L C_L)(1-\tau)\Delta t, 0\right), \tag{16}$$

where $a = b = 2$, and the part A is the discounted expected value calculated via a CRR tree:

$$ContE_{aT,bT} = \Big(E_{aT,bT}(V_t u, t + \Delta t)P_u + E_{aT,bT}(V_t d, t + \Delta t)P_d\Big)e^{-r\Delta t}. \tag{17}$$

The values of SB_{2T} and SB^L_{2T} are

$$SB_{aT}(V_t, t \,|\, T/2) = \begin{cases} ContSB_{aT} + F_S C_S \Delta t & \text{if } E_{aT,bT}(V_t, t) > 0, \\ (1-\omega)(V_t + \delta_t) \times \frac{F_S}{F_S + F_L} & \text{otherwise,} \end{cases} \tag{18}$$

$$SB^L_{bT}(V_t, t \,|\, T/2) = \begin{cases} ContSB^L_{bT} + F_S C_S \Delta t & \text{if } E_{aT,bT}(V_t, t) > 0, \\ (1-\omega)(V_t + \delta_t) \times \frac{F_L}{F_S + F_L} & \text{otherwise,} \end{cases}$$

where

$$ContSB_{aT} = \Big(SB_{aT}(V_t u, t+\Delta t\,|\,T/2)P_u + SB_{aT}(V_t d, t+\Delta t\,|\,T/2)P_d\Big)e^{-r\Delta t}, \tag{19}$$

$$ContSB^L_{bT} = \Big(SB^L_{bT}(V_t u, t+\Delta t\,|\,T/2)P_u + SB^L_{bT}(V_t d, t+\Delta t\,|\,T/2)P_d\Big)e^{-r\Delta t}. \tag{20}$$

[Stage 2–State 2]:

When the debt structure consists of SB_{2T} and $CB_{3T/2,2T}$, the equity value is in turn expressed as

$$E_{aT,bT}(V_t, t|P) = max\left(\underbrace{ContE_{aT,bT}}_{\mathbf{B}} + \delta_t - (F_S C_S + F_L C_L)(1-\tau)\Delta t, 0\right), \tag{21}$$

where $a = b = 2$, and the part B is the discounted expected value:

$$ContE_{aT,bT} = \Big(E_{aT,bT}(V_t u, t+\Delta t\,|\,P)P_u + E_{aT,bT}(V_t d, t+\Delta t\,|\,P)P_d\Big)e^{-r\Delta t}. \tag{22}$$

The SB_{2T} value is

$$SB_{aT}(V_t, t\,|\,T/2) = \begin{cases} ContSB_{aT} + F_S C_S \Delta t & \text{if } E_{aT,bT}(V_t, t\,|\,P) > 0, \\ (1-\omega)(V_t + \delta_t) \times \frac{F_S}{F_S + F_L} & \text{otherwise,} \end{cases} \tag{23}$$

where $ContSB_{aT}$ can be expressed as **Equation (19)**; the $CB_{3T/2,2T}$ value is

$$CB_{pT,bT}(V_t, t\,|\,P, T) = \begin{cases} \underbrace{ContCB_{pT,bT}}_{\mathbf{C}} + F_L C_L \Delta t & \text{if } E_{aT,bT}(V_t, t\,|\,P) > 0, \\ (1-\omega)(V_t + \delta_t) \times \frac{F_L}{F_S + F_L} & \text{otherwise,} \end{cases} \tag{24}$$

where $p = 3/2$, and the part C is expressed as

$$ContCB_{pT,bT} = \Big(CB_{pT,bT}(V_t u, t+\Delta t\,|\,P, T)P_u + CB_{pT,bT}(V_t d, t+\Delta t\,|\,P, T)P_d\Big)e^{-r\Delta t}. \tag{25}$$

Stage 3: $t = 3T/2$

As illustrated in **Figure 10**, there are three states of debt structure. The first state is the one consisting of two $T/2$-year noncallable SB_{2T} and SB^L_{2T}. The second is the one consisting of a $T/2$-year SB_{2T} and a T-year callable $CB_{3T/2,2T}$. The third is the one consisting of a $T/2$-year $SB_{3T/2}$ and a T-year $CB_{T,3T/2}$. If the $CB_{3T/2,2T}$ is prematurely refinanced by issuing the SB^L_{2T} at time $t = 3T/2$, the debt structure will shift from the **State 2** to the **State 1**. On the other hand, if $CB_{T,3T/2}$ matures and refinanced by issuing the SB^L_{2T}, the debt structure will shift from the **State 3** to the **State 1**.

[Stage 3–State 1]:

When the debt structure consists of SB_{2T} and SB^L_{2T}, the equity value can be expressed as **Equation (17)**, and the corresponding values of the two noncallables can be expressed as **Equations (19)** and **(20)**, respectively.

[Stage 3–State 2]:

The noncallable $SB_{3T/2}$ is maturing at $t = 3T/2$ and is refinanced by issuing the otherwise identical SB_{2T}. On the other hand, since $t = 3T/2$ is the first call date for the callable $CB_{3T/2,2T}$, the firm can choose to early refinance it by issuing the SB^L_{2T} or keep its to its stated maturity optimally. Thus, the equity value is expressed as

$$
\begin{aligned}
&E_{aT,bT}(V_t,t|P)\\
&\quad= max\Bigg(\underbrace{E_{(a+\frac{1}{2})T,bT}(V_t,t)}_{\mathbf{D}}+\delta_t+\overbrace{(1-\gamma)\underbrace{SB_{(a+\frac{1}{2})T}(V_t,t\,|\,T/2)}_{\mathbf{E1}}-F_S\big(1+C_S(1-\tau)\Delta t\big)}^{\mathbf{E}}\\
&\qquad+\overbrace{(1-\gamma)\underbrace{SB^L_{bT}(V_t,t\,|\,T/2)}_{\mathbf{F1}}-\underbrace{\big(K_t+(F_LC_L(1-\tau)\Delta t)\big)}_{\mathbf{F2}}}^{\mathbf{F}},\\
&\qquad\underbrace{E_{(a+\frac{1}{2})T,bT}(V_t,t\,|\,P)}_{\mathbf{G}}+\delta_t+\overbrace{(1-\gamma)\underbrace{SB_{(a+\frac{1}{2})T}(V_t,t,|\,T/2)}_{\mathbf{E1}}-F_S\big(1+C_S(1-\tau)\Delta t\big)}^{\mathbf{E}}\\
&\qquad-(F_LC_L(1-\tau)\Delta t)\,,\,0\Bigg),
\end{aligned}
\tag{26}
$$

where $a = 3/2$ and $b = 2$.

In above **Equation (26)**, the part D refers to the equity value when the firm rolls the maturing $SB_{3T/2}$ over by issuing the SB_{2T} and decides to early refinance the $CB_{3T/2,2T}$ by issuing the SB^L_{2T}. The parts D, E1, and F1 are evaluated in **Stage 3–State 1**, and the part F2 represents the effective call price. In addition, parts E and F reveal the risk of debt refunding if their values are negative. On the other hand, the part G refers to the equity value when the firm rolls the maturing noncallable over and decides not to early refinance the callable. Its value can be evaluated by the **Equation (22)** in **Stage 2–State 2**. The corresponding value of the maturing $SB_{3T/2}$ can be expressed by **Equation (14)**, and the value of the $CB_{3T/2,2T}$ is expressed as

$$
CB_{pT,bT}(V_t,t\,|\,P)=\begin{cases}
K_t+F_LC_L\Delta t & \text{if } E_{aT,bT}(V_t,t\,|\,P)>0\\
& \text{and call is announced}\\
ContCB_{pT,bT}+F_LC_L\Delta t & \text{if } E_{aT,bT}(V_t,t\,|\,P)>0\\
& \text{and call is not announced}\\
(1-\omega)(V_t+\delta_t)\times\frac{F_L}{F_L+F_L} & \text{otherwise,}
\end{cases}
\tag{27}
$$

where p is 3/2, and $ContCB_{pT,bT}$ can be expressed as the **Equation (25)**.

[Stage 3–State 3]:

Since the $SB_{3T/2}$ and $CB_{T,3T/2}$ are maturing, the firm will roll them over by issuing the SB_{2T} and

SB^L_{2T} to keep its leverage ratio constant. Therefore, the equity value is expressed as

$$
\begin{aligned}
&E_{aT,bT}(V_t,t|P)\\
&= max\Bigg(\underbrace{E_{(a+\frac{1}{2})T,(b+\frac{1}{2})T}(V_t,t)}_{\mathbf{H}} + \delta_t + \overbrace{(1-\gamma)\underbrace{SB_{(a+\frac{1}{2})T}(V_t,t\,|\,T/2)}_{\mathbf{E1}} - F_S\big(1+C_S(1-\tau)\Delta t\big)}^{\mathbf{E}}\\
&\quad + \overbrace{(1-\gamma)\underbrace{SB^L_{bT}(V_t,t\,|\,T/2)}_{\mathbf{F1}} - F_L(1+C_L(1-\tau)\Delta t)}^{\mathbf{F'}},\, 0\Bigg),
\end{aligned}
\tag{28}
$$

where $a = b = 3/2$.

In the **Equation (28)**, the part H refers to the equity value when the firm rolls the maturing bonds over by issuing SB_{2T} and SB^L_{2T}. The parts E1, F1, and H are evaluated in **Stage 3–State 1**, and the parts E and F' reveal the rollover losses (gains) if their values are negative (positive). The corresponding values of the maturing $SB_{3T/2}$ and $CB_{T,3T/2}$ can then be expressed by **Equations (14)** and **(15)**, where $p = 1$.

Stage 4: $T < t < 3T/2$

As illustrated in **Figure 10**, there are two states of debt structure. The first state is the one consisting of a $T/2$-year noncallable $SB_{3T/2}$ and a T-year callable $CB_{3T/2,2T}$. The values of the corresponding equity and the two bonds can be evaluated via **Equations (21)**, **(23)**, and **(24)** based on the evaluation results in **Stage 3–State 2**, where $a = 3/2$, $b = 2$, and $p = 3/2$. The second is the one consisting of a $T/2$-year $SB_{3T/2}$ and a T-year $CB_{T,3T/2}$, and the values of the corresponding equity and the two bonds can also be evaluated via the same equations based on the evaluation results in **Stage 3–State 3**, where $a = b = 3/2$, and $p = 1$.

Stage 5: $t = T$

As illustrated in **Figure 10**, there are three states of debt structure. The first state is the one consisting of two $T/2$-year $SB_{3T/2}$ and a T-year $CB_{3T/2,2T}$. The second is the one consisting of a $T/2$-year $SB_{3T/2}$ and a T-year $CB_{T,3T/2}$. The third is the one consisting of a $T/2$-year SB_T and a T-year $CB_{T/2,T}$. If the $CB_{T,3T/2}$ is prematurely refinanced by issuing the $CB_{3T/2,2T}$ at time $t = T$, the debt structure will shift from the **State 2** to the **State 1**. If $CB_{T/2,T}$ matures and refinanced by issuing the $CB_{3T/2,2T}$, the debt structure will shift from the **State 3** to the **State 1**.

[Stage 5–State 1]:

When the debt structure consists of $SB_{3T/2}$ and $CB_{3T/2,2T}$, the equity value can be expressed as **Equation (22)**, and the corresponding values of the two bonds can be expressed as **Equations (19)** and **(25)**, where $a = 3/2$, $b = 2$, and $p = 3/2$.

[Stage 5–State 2]:

The noncallable SB_T is maturing at $t = T$ and is refinanced by issuing the otherwise identical $SB_{3T/2}$. On the other hand, since $t = T$ is the first call date for the $CB_{T,3T/2}$, the firm can choose to early refinance it by issuing the $CB_{3T/2,2T}$ or keep its to its stated maturity optimally. Thus, the equity value is expressed as

$$
\begin{aligned}
&E_{aT,bT}(V_t,t|P)\\
&= max\Bigg(\underbrace{E_{(a+\frac{1}{2})T,(b+\frac{1}{2})T}(V_t,t\,|\,P)}_{\mathbf{I}} + \delta_t + \overbrace{(1-\gamma)\,\underbrace{SB_{(a+\frac{1}{2})T}(V_t,t\,|\,T/2)}_{\mathbf{J1}} - F_S\big(1+C_S(1-\tau)\Delta t\big)}^{\mathbf{J}}\\
&\quad + \overbrace{(1-\gamma)\,\underbrace{CB_{(p+\frac{1}{2})T,(b+\frac{1}{2})T}(V_t,t\,|\,P,T)}_{\mathbf{K1}} - \big(K_t + (F_LC_L(1-\tau)\Delta t)\big)}^{\mathbf{K}},\\
&\quad \underbrace{E_{(a+\frac{1}{2})T,bT}(V_t,t\,|\,P)}_{\mathbf{L}} + \delta_t + \overbrace{(1-\gamma)\,\underbrace{SB_{(a+\frac{1}{2})T}(V_t,t\,|\,T/2)}_{\mathbf{J1}} - F_S\big(1+C_S(1-\tau)\Delta t\big)}^{\mathbf{J}}\\
&\quad -(F_LC_L(1-\tau)\Delta t)\,,\,0\Bigg),
\end{aligned}
\tag{29}
$$

where $a = 1$, $b = 3/2$, and $p = 1$.

In above **Equation (29)**, the part I refers to the equity value when the firm rolls the maturing SB_T over by issuing the $SB_{3T/2}$ and decides to early refinance the $CB_{T,3T/2}$ by issuing the $CB_{3T/2,2T}$. The parts I, J1, and K1 are evaluated in **Stage 5–State 1**. In addition, parts J and K reveal the risk of debt refunding if their values are negative. The part L refers to the equity value when the firm rolls the maturing noncallable over and decides not to early refinance the callable. Its value can be evaluated by the **Equation (22)** in **Stage 4**. The corresponding values of the SB_T and $CB_{T,3T/2}$ can be expressed by **Equations (14)** and **(27)**, respectively.

[Stage 5–State 3]:

Since the SB_T and $CB_{T/2,T}$ are maturing, the firm will roll them over by issuing the $SB_{3T/2}$ and $CB_{3T/2,2T}$ to keep its leverage ratio constant. Therefore, the equity value is expressed as

$$
\begin{aligned}
&E_{aT,bT}(V_t,t|P)\\
&= max\Bigg(\underbrace{E_{(a+\frac{1}{2})T,(b+1)T}(V_t,t\,|\,P)}_{\mathbf{N}} + \delta_t + \overbrace{(1-\gamma)\,\underbrace{SB_{(a+\frac{1}{2})T}(V_t,t\,|\,T/2)}_{\mathbf{J1}} - F_S\big(1+C_S(1-\tau)\Delta t\big)}^{\mathbf{J}}\\
&\quad + \overbrace{(1-\gamma)\,\underbrace{CB_{(p+1)T,(b+1)T}(V_t,t\,|\,P,T)}_{\mathbf{M1}} - F_L(1+C_L(1-\tau)\Delta t)}^{\mathbf{M}}\,,\,0\Bigg),
\end{aligned}
\tag{30}
$$

where $a = b = 1$ and $p = 1/2$.

In above **Equation (30)**, the part N refers to the equity value when the firm rolls the maturing bonds over by issuing $SB_{3T/2}$ and $CB_{3T/2,2T}$. The parts N, J1, and M1 are evaluated in **Stage 5–State 1**, and the parts J and M reveal the rollover losses (gains) if their values are negative (positive). The corresponding values of the maturing SB_T and $CB_{T/2,T}$ can then be expressed by the

Equations (14) and **(15)**, respectively.

Stage 6: $T/2 < t < T$

As illustrated in **Figure 10**, there are two states of debt structure. The first state is the one consisting of a $T/2$-year SB_T and a T-year $CB_{T,3T/2}$. The values of the corresponding equity and the two bonds can be evaluated via the **Equations (21)**, **(23)**, and **(24)** based on the evaluation results in the **Stage 5–State 2**, where $a = 1$, $b = 3/2$, and $p = 1$. The second is the one consisting of a $T/2$-year SB_T and a T-year $CB_{T/2,T}$, and the values of the corresponding equity and the two bonds can also be evaluated via the same equations based on the evaluation results in **Stage 5–State 3**, where $a = b = 1$, and $p = 1/2$.

Stage 7: $t = T/2$

As illustrated in **Figure 10**, the states of debt structure are identical to those in the **Stage 6**. The first state is the one consisting of SB_T and $CB_{T,3T/2}$, and the second is the one consisting of $SB_{T/2}$ and $CB_{T/2,T}$. If the $CB_{T/2,T}$ in **Stage 7–State 2** is prematurely refinanced by issuing the $CB_{T,3T/2}$ at time $t = T/2$, the debt structure will shift from the **State 2** toward the **State 1**. On one hand, the values of the equity, the SB_T, and the $CB_{T,3T/2}$ in the **State 1** can be evaluated via the **Equations (22)**, **(19)**, and **(25)**, where $a = 1$, $b = 3/2$, and $p = 1$. Based on the evaluation results in the **State 1**, the values of the equity, the $SB_{T/2}$, and the $CB_{T/2,T}$ in the **State 2** can be evaluated via **Equations (29)**, **(14)**, and **(27)**, where $a = 1/2$, $b = 1$, and $p = 1/2$.

Stage 8: $0 < t < T/2$

As illustrated in **Figure 10**, the debt structure is the one consisting of $SB_{T/2}$ and $CB_{T/2,T}$. The values of the corresponding equity and the two bonds can also be evaluated via the **Equations (22)**, **(19)**, and **(25)**, where $a = 1/2$, $b = 1$, and $p = 1/2$.

Stage 9: $t = 0$

The values of the equity and the corresponding $SB_{T/2}$ and $CB_{T/2,T}$ can be evaluated via the **Equations (22)**, **(19)**, and **(25)**, where $a = 1$, $b = 1$, and $p = 1/2$. I let $E(V_0, 0 \,|\, P) \equiv E_{T/2,T}(V_0, 0 \,|\, P)$, $SB(V_0, 0 \,|\, T/2) \equiv SB_{T/2}(V_0, 0 \,|\, T/2)$, and $CB(V_0, 0 \,|\, P, T) \equiv CB_{T/2,T}(V_0, 0 \,|\, P, T)$, where $P = T/2$ in this case.

A.2 Extension

The $T/2$ noncallable $SB_{T/2}$, the T-year callable $CB_{T/2,T}$, and the corresponding equity are evaluated via above backward induction procedure in the $2T$-year framework when their issuing firm commits to the constant book leverage policy ex ante. At least three extensions can be made without difficulty. The first is the one from above $2T$-year framework to the NT-year one, for any $N > 2$. The second is the one from $m = 2$ to $m > 2$ that increases the firm's frequency of debt rollover. The two extensions can be handled simply by adding more stages the backward induction procedure. For example, if $N = 3$ and $m = 4$, the backward induction procedure will be separated from 9 (i.e., $2 \times 4{+}1$) to 25 (i.e., $3 \times 8{+}1$) stages. The third is the one from a single call date during the life of the callable to multiple call dates. The states of debt structure will increase with the increment of call dates, and I plan to incorporate more layers of CRR trees into a forest to capture all possible states of debt structure. For example, if the number of stated call dates during the life of a T-year callable increases from 1 toward 3 within the $2T$-year framework, the number of tree layers will increase from 4 as in **Figure 5(b)** to 8. This extension will greatly facilitate the analysis of optimal length of call protection period driven by a callable issuer's intended call policy.

Appendix B First call date data interpretation

Our data on first call dates are collected from *Mergent FISD*, *Bloomberg*, and *SDC*. The collection procedure starts from *Mergent FISD* through several channels as follows. The first and the largest one is the CALL_SCHEDULE recorded in *Mergent FISD*. For the bonds having complete data on call schedules, we pick the earliest call dates as their first call dates. For those bonds having complete data on call schedules in *Bloomberg*, we also pick the earliest call dates as their first call dates For the callable bonds having identifiable information in column CALLDATE in *SDC*, we treat them as first call dates, too. The three sources of data on first call dates are merged together based on nine-digit issue CUSIPs. The second channel is the REFUNDING_DATE in *Mergent FISD*. If a callable bond has refund protection, we pick its refunding date as its first call date by following Powers (2021). If a bond has both call schedule as well as refunding protection, we pick the earliest call date in call schedule. The third channel is the MAKE_WHOLE_START_DATE in *Mergent FISD*. If a callable bond is gifted with a make-whole feature but does not have call schedule as well as refunding protection, we pick its make-whole start date as its first call date. The fourth channel is the information recorded in column INITIAL_CALL_DATA in *Mergent FISD*. If a callable bond has no call schedule, refunding date, and make-whole start date, we pick the dates following "NC" as the first call dates. For example, if the recorded information is "NC 10/16/2015 CONT @ PAR", the date "10/16/2015" is picked as the first call date. On the other hand, if the recorded information start with "CC", which denotes Continuously Callable, we will pick the bond offering date as the first call date.

Table 11: First Call Date data interpretation
This table list four first call date types based on the classification of call dates we obtained from FISD , Bloomberg and SDC.

First Call Date Type	Description
CALL DATE	If CALL DATE can be found in the FISD CALL SCHEDULE or SDC, then FIRST CALL DATE is the earliest CALL DATE.
REFUNDING DATE	If REFUND_PROTECTION = "Y", then FIRST CALL DATE is the REFUNDING_DATE from FISD.
MAKE_WHOLE_START_DATE	If MAKE WHOLE = "Y", then FIRST CALL DATE is the MAKE_WHOLE_START_DATE from FISD.
INITIAL CALL DATA	If INITIAL CALL DATA = "NC", then First Call Date is the specified date following "NC". If INITIAL CALL DATA = "CC", then First Call Date is the OFFERING DATE.

The effective date is the action date of a bond corresponding to the ACTION TYPE. Our method of calculation only focus on the ACTION TYPEs which would lead to changes of outstanding amount, which coded as “B”, “E”,“P”, “IRP”, “T”, “F” and “IM” in *Mergent FISD*. The bonds have to be no outstanding amount for the computation of *BondElim*. So with a purpose of being more precise, we list all the historical effective dates and their corresponding outstanding amount. Combined with the ACTION TYPE, we construct the changes of outstanding amount with action type for each bond, and the valid effective date are those date with specific action amount and specified action types. If the bond is called back partially in the same year, we will take a average value of the effective date as the yearly observation; if the bond is called back partially in different years, then this bond will been seen as a combination of several separated bonds which means the effective date counts in these effective year respectively.

Appendix C Mapping *Mergent FISD* with *Compustat*

We merge bond data from *Mergent FISD* with firm data which come from *Compustat* to build our firm level sample. To match *Mergent FISD* data to *Compustat* data, we need CUSIP and CIK as a bridge because the unique ID for *Compustat*, GVKEY, is not recorded in *Mergent FISD*, only CUSIP and CIK are documented in *Compustat*. It is also same with *SDC* that only CUSIP can be looked up. Another challenge is the incompleteness of firm level data. For the purpose of improving the integrity of data, we hand collect data from U.S. Security and Exchange Commission (SEC) to supplement some missing data. Some bond issuers' information in *Mergent FISD* are different or missing from what we can look up nowadays in *Compustat* due to reasons like corporate restructuring, so we use the information from SEC and other public finance information platforms like *Bloomberg* to replace and fill.

Appendix D Variable definitions

Variables in **Table 12** are showing bonds characters from a firm level horizon. *TurnCallable* is a dummy variable which equals one only at the year of first call date. *EarlyRefinance* is a dummy variable which equals one at a bond's issuing year if it could satisfy the requirement of early refinancing activity we defined in **Section 5**. *BondStaM* is the stated maturity which is decided at issuance and stays unchanged during the whole lifetime of bonds.[11] *BondElim* is computed as the time length from offering date to effective date we just defined. Then *BondElimR* is the ratio of bond eliminated year to stated maturity. *BondCProt* is the call protection period of callable bonds which is computed as the time length from offering date to first call date. *BondCProtR* is the ratio of protected period to the stated maturity. *BondCoupon* is the coupon rate of each bond. While most of the coupon rate in our sample are fixed-type, we trace the change of those floating coupon rate bonds and adjust by yearly.

Firm-level data in Panel C is calculated based on the bond data in Panel A and Panel B. The *TurnCallable* (or *EarlyRefinance*) of a firm at a year equals one if there is at least one bond turns callable (or been early refinanced) at that year. For other firm-level variables in panel C, they are calculated as the average value of bond data in panel A and panel B in the corresponding location.

Other firm controls we used in this paper are from compustat and details are showing in **Table 13**. To mitigate the impact of outliers and the possible coding errors, we winsorize all firm variables at the upper and lower one percentiles, and apply the winsorization to all analyses.

[11] We calculate two date distance by a precision of days, but we show the number with a unit of year. For example, maturity based on days calculation in this example is 10.03 rather than a integer 10. And same rules are followed for the other related variables.

Table 12: Firm level data identification

This table provides the variable construction of firm level data from bond level data. We start with a simple case: a firm with two callable bonds outstanding during 1998-2009. Callable bond 1 issues at year 1998 with a 10-year stated maturity and its effective year is 2003 which is the same year as first call date. Callable bond 2 issues at year 2001 with a 8-year stated maturity and its effective year is 2004 which is the same year as first call date.

Panel A : Callable Bond 1	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TurnCallable (Dummy)	0	0	0	0	0	1	0	0	0	0	0	
EarlyRefinance(Dummy)	1	0	0	0	0	0	0	0	0	0	0	
BondStaM(yrs)	10	10	10	10	10							
BondElim(yrs)						5						
BondElimR						0.5						
BondCProt(yrs)	5	5	5	5	5							
BondCProtR	0.5	0.5	0.5	0.5	0.5							
BondCoupon(%)	7	7	7	7	7							

Panel B : Callable Bond 2	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TurnCallable (Dummy)				0	0	0	1	0	0	0	0	0
EarlyRefinance(Dummy)				0	0	0	0	0	0	0	0	0
BondStaM(yrs)				8	8	8						
BondElim(yrs)							5					
BondElimR							0.625					
BondCProt(yrs)				3	3	3						
BondCProtR				0.38	0.38	0.38						
BondCoupon(%)				4.8	4.8	4.8						

Panel C : Firm Level	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
TurnCallable (Dummy)	0	0	0	0	0	1	1	0	0	0	0	0
EarlyRefinance (Dummy)	1	0	0	0	0	0	0	0	0	0	0	0
FirmStaM	10	10	10	9	9	8						
FirmElim(yrs)						5	5					
FirmElim						0.5	0.625					
FirmCProt(yrs)	5	5	5	4	4	3						
FirmCProtR	0.5	0.5	0.5	0.44	0.44	0.38						
FirmCoupon(%)	7	7	7	5.9	5.9	4.8						

Table 13: Variable Definitions

This table provides the construction of all the control variables used in the regression. And all the other variables we mentioned in this paper. Variables in uppercase letters refer to the compustat items. DD1 is Long-Term Debt Due in One Year, DLTT is Total Long-Term Debt. Both Bond rating and Firm rating are taken the value at the offering date.

Variable	Definition
Panel A : Bond	
BondStaM	Bond's offering date to maturity date in years
BondCProt	Bond's offering date to first call date in years
BondEffM	Bond's offering date to effective date in years
Covenant count	Bond's covenant numbers, classified following Billett et al. (2007).
Bond rating	Bond's rating in FISD. Priority of rating types: $SPR \succ MR \succ FR \succ DPR$.
Panel B : Firm	
Leverage	Total Asset/Total Stockholders' Equity
RI	Refinancing Intensity, RI = DD1/(DD1+DLTT)
LT-1	LT-1 = DD1/Total assets
Curlia	Current Liability = Debt in Current Liabilities(DLC)/Total Assets
ln(Asset)	Natural log of Total Assets(AT)
Tangibility	Property, plant and equipment(PPENT)/Total Assets
M/B Ratio	Market-to-Book Ratio = (Total Assets - Common equity + Common shares outstanding $\times$ closing price (fiscal year))/Total assets
EBITDA	EBITDA/Total assets = Earnings before interest, tax, depreciation and amortization/Total assets
Cash/Total assets	Cash and short-term investment (CHE)/Total assets
Equity return	Equity return = ΔClosing price (fiscal year)/L.Closing price (fiscal year), adjusted for cumulative adjustment factor if applicable
TermSpread	the difference between the 10- and 1- year corporate yield
Baa-Aaa	Moody's seasoned Baa corporate rate minus the seasoned Aaa rate
3-Month T-bill Rate	3-Month Treasury Bill Rate
Firm rating	S&P domestic long-term issuer credit rating. Ordinalized rating: 1 = AAA, 2 = AA+, etc.

Appendix E Robustness for nonfinancial firms

We also do tests with non-financial firms[12], and the results are almost the same.[13]

Table 14: Applying all non-financial-firm-year samples to the two-stage regressions in Equations (8)—(10).

This table reports the two-stage regression results, where $D(EarlyRefinance)_{i,t}$ is instrumented by $D(TurnCallable)_{i,t}$, a dummy variable indicating that some bonds are scheduled to become callable in year t for firm i. The independent dummy variable $D(EarlyRefinance)_{i,t}$ equals 1 when firm i conducts a early refinancing activity at year t. Three dependent are analysed in this table. *FirmStaM* is the average bond maturity. *FirmCProtR* is the average protection ratio and *FirmElimR* is the average elimination ratio. High and Low groups are divided by their corresponding median value. Additional firm characteristic controls include *ln(Assets)*, *Leverage*, *M/B Ratio*, *Tangible*, *EBITDA*, *Cash/Total assets*, and *Equity return*. Observations are at firm-year level. Firm fixed effects and year fixed effects are included. The value of t-statistics adjusted for clustering at the firm level are reported in parentheses.*,**, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	Full Sample - Non-Financial Firms		
	(1)	(2)	(3)
	FirmStaM	*FirmCProtR*	*FirmElimR*
$D(EarlyRefinance)$	-5.7519***	-0.1747***	0.1648**
	(-6.25)	(-6.77)	(2.15)
Termspread	-0.7554***	-0.0262	-0.0334
	(-6.49)	(-0.15)	(-0.62)
ln(Asset)	-0.1770	0.0085	-0.0208**
	(-1.19)	(1.05)	(-2.03)
Leverage	0.0036	0.0001	-0.0007
	(0.64)	(0.46)	(-1.36)
M/B Ratio	-0.1005	-0.0009	-0.0122
	(-1.19)	(-0.15)	(-1.51)
Tangible	0.1239	0.0527	-0.0760
	(0.15)	(1.12)	(-1.40)
EBITDA	1.9579***	0.0267	0.0956
	(3.50)	(0.89)	(1.60)
Cash/Total asset	0.3557	0.0385	0.2101***
	(0.52)	(0.84)	(3.12)
Equity return	-0.0508	0.0124***	-0.0002
	(-1.00)	(5.45)	(-0.03)
	First Stage		
$D(TurnCallable)$	0.0921***	0.1568***	0.0791***
	(19.02)	(18.41)	(8.10)
Firm_FE	Y	Y	Y
Year_FE	Y	Y	Y
Adj. R-squared	-0.0518	0.2224	0.1051
Obs.	29219	16356	8703

[12] All non-financial firm observations are identified by Fama-French 12 industry classification. We also run the regression by identifying the firms with the North American Industry Classification System (NAICS) and the 2-Digit SIC code to do the industrial classification. Regression results, so we do not report it in our paper.

[13] To highlight the difference between sample restricted non-financial firms and sample with no restriction, we measure $RI = (DD1 + DD2 + DD3)/(DD1 + DLTT)$ and $LT - 1 = (DD1 + DD2)/TotalAssets$ in **Table 17**.

Table 15: Non-Financial Firms : IV regressions of *FirmCProtR*.

This table reports IV regression results, where $D(EarlyRefinance)_{i,t}$ is instrumented by $D(TurnCallable)_{i,t}$, a dummy variable indicating that some bonds are scheduled to become callable in year t for firm i. The independent variable $D(EarlyRefinance)_{i,t}$ is a dummy variable which equals 1 when firm i conducts a early refinancing activity at year t. The dependent variable is *FirmCProtR* which calculated as the average protection ratio. High and Low groups are divided by their corresponding median value. Additional firm characteristic controls include *ln(Assets)*, *Leverage*, *M/B Ratio*, *Tangible*, *EBITDA*, *Cash/Total assets*, and *Equity return*. Observations are at firm-year level. Firm fixed effects and year fixed effects are included. The value of t-statistics adjusted for clustering at the firm level are reported in parentheses.*,**, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	Dependent variable = *FirmCProtR*								
	(1) Full Sample	(2) High *Leverage*	(3) Low *Leverage*	(4) High *RI*	(5) Low *RI*	(6) High *LT-1*	(7) Low *LT-1*	(8) High *Curlia*	(9) Low *Curlia*
$D(EarlyRefinance)$	-0.1837***	-0.2099***	-0.1113***	-0.2109***	-0.1487***	-0.2152***	-0.1143***	-0.1655***	-0.1422***
	(-7.07)	(-5.58)	(-3.10)	(-4.28)	(-5.02)	(-5.58)	(-3.67)	(-3.00)	(-5.25)
Termspread	0.0105	0.0227***	-0.0125	0.0057	0.0066	0.0108	0.0060	-0.0028	0.0173**
	(1.50)	(2.89)	(-1.15)	(0.52)	(0.69)	(0.22)	(0.28)	(-0.21)	(2.05)
ln(Asset)	0.0147**	-0.0040	0.0281***	0.0137	0.0120	0.0046	0.0134	0.0126	0.0111
	(2.32)	(-0.46)	(3.02)	(1.38)	(1.44)	(0.51)	(1.39)	(1.16)	(1.63)
Leverage	0.0002	-0.0004	0.0001	0.0001	0.0001	-0.0001	0.0004	0.0004	0.0001
	(0.98)	(-1.02)	(0.09)	(0.38)	(0.47)	(-0.42)	(1.14)	(1.02)	(0.43)
M/B Ratio	0.0056	0.0120*	0.0065	-0.0044	0.0110*	-0.0005	0.0108**	-0.0009	0.0058
	(1.41)	(1.89)	(1.27)	(-0.63)	(1.89)	(-0.08)	(2.04)	(-0.12)	(1.30)
Tangible	0.0433	0.0940	0.0179	0.0156	0.0417	0.0402	0.0311	-0.0632	0.0578
	(1.09)	(1.54)	(0.33)	(0.27)	(0.86)	(0.76)	(0.61)	(-0.86)	(1.38)
EBITDA	0.0099	-0.0203	-0.0142	0.0189	0.0126	0.0071	0.0061	0.0418	-0.0071
	(0.37)	(-0.44)	(-0.40)	(0.34)	(0.36)	(0.14)	(0.16)	(0.93)	(-0.26)
Cash/Total asset	0.0171	0.0207	0.0453	-0.0148	-0.0152	-0.0052	0.0247	-0.0215	0.0044
	(0.50)	(0.43)	(1.07)	(-0.24)	(-0.36)	(-0.09)	(0.57)	(-0.33)	(0.12)
Equity return	0.0070***	0.0099***	0.0008	0.0141***	0.0059*	0.0159***	0.0023	0.0048	0.0078***
	(3.54)	(3.43)	(0.28)	(3.89)	(1.94)	(5.07)	(0.70)	(1.29)	(3.45)
	First Stage								
$D(TurnCallable)$	0.1568***	0.1484***	0.1624***	0.1350***	0.1745***	0.1493***	0.1827***	0.1279***	0.1742***
	(18.41)	(12.57)	(12.27)	(10.07)	(13.88)	(12.24)	(13.20)	(10.03)	(15.21)
Firm_FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year_FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Adj. R-squared	0.2224	0.1474	0.2700	0.3385	0.1516	0.2538	0.2122	0.4471	0.0944
Obs.	16356	8300	7478	5929	8628	7056	7380	5067	10499

Table 16: Non-Financial Firms : IV regressions of *FirmElimR*.

This table reports IV regression results, where $D(EarlyRefinance)_{i,t}$ is instrumented by $D(TurnCallable)_{i,t}$, a dummy variable indicating that some bonds are scheduled to become callable in year t for firm i. The independent variable $D(EarlyRefinance)_{i,t}$ is a dummy variable which equals 1 when firm i conducts a early refinancing activity at year t. The dependent variable is *FirmElimR* which calculated as the average elimination ratio. High and Low groups are divided by their corresponding median value. Additional firm characteristic controls include *ln(Assets)*, *Leverage*, *M/B Ratio*, *Tangible*, *EBITDA*, *Cash/Total assets*, and *Equity return*. Observations are at firm-year level. Firm fixed effects and year fixed effects are included. The value of t-statistics adjusted for clustering at the firm level are reported in parentheses.*,**, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	Dependent variable = *FirmElimR*								
	(1) Full Sample	(2) High *Leverage*	(3) Low *Leverage*	(4) High *RI*	(5) Low *RI*	(6) High *LT-1*	(7) Low *LT-1*	(8) High *Curlia*	(9) Low *Curlia*
$D(EarlyRefinance)$	0.1901**	0.1966**	0.2469*	0.2995***	0.0254	0.3410***	-0.0489	0.2151**	0.1283
	(2.43)	(2.16)	(1.69)	(3.30)	(0.19)	(3.86)	(-0.39)	(2.33)	(1.12)
Termspread	-0.0549***	-0.0697	-0.0438	-0.0630	-0.0341	-0.0790***	-0.0391*	-0.0435**	-0.0703***
	(-2.58)	(-0.37)	(-1.51)	(-0.92)	(-0.07)	(-3.65)	(-1.80)	(-2.12)	(-3.63)
ln(Asset)	-0.0246***	-0.0304**	-0.0149	-0.0276**	-0.0117	-0.0266**	-0.0024	-0.0334**	-0.0144
	(-2.75)	(-2.19)	(-1.04)	(-2.09)	(-0.77)	(-2.19)	(-0.15)	(-2.30)	(-1.24)
Leverage	-0.0006	-0.0004	-0.0010	0.0002	-0.0007	-0.0001	0.0002	-0.0002	-0.0006
	(-1.18)	(-0.43)	(-0.60)	(0.27)	(-1.03)	(-0.21)	(0.20)	(-0.25)	(-0.93)
M/B Ratio	-0.0183***	-0.0145	-0.0145	-0.0152	-0.0122	-0.0222**	-0.0006	-0.0178	-0.0216**
	(-2.65)	(-1.28)	(-1.52)	(-1.51)	(-0.94)	(-2.49)	(-0.05)	(-1.63)	(-1.98)
Tangible	-0.0706	-0.0810	-0.1156	-0.0388	-0.1631**	-0.0292	-0.1964**	-0.0795	-0.0678
	(-1.41)	(-1.27)	(-1.33)	(-0.56)	(-2.01)	(-0.42)	(-2.04)	(-1.13)	(-0.96)
EBITDA	0.0735	0.0821	0.0781	0.0399	0.2035***	-0.0330	0.1837**	0.1529	0.0400
	(1.34)	(0.94)	(0.80)	(0.47)	(2.60)	(-0.36)	(2.25)	(1.45)	(0.58)
Cash/Total asset	0.2112***	0.3094***	0.1256	0.1893**	0.2581***	0.2517***	0.2284**	0.1823*	0.2685***
	(3.60)	(3.53)	(1.52)	(2.08)	(2.73)	(2.86)	(2.27)	(1.94)	(2.95)
Equity return	0.0080	0.0079	0.0031	-0.0026	0.0134	0.0028	0.0203*	0.0044	0.0080
	(1.17)	(0.90)	(0.25)	(-0.25)	(1.36)	(0.27)	(1.84)	(0.33)	(0.84)
	First Stage								
$D(TurnCallable)$	0.0791***	0.0911***	0.0721***	0.0917***	0.0723***	0.0932***	0.0876***	0.0980***	0.0745***
	(8.10)	(6.00)	(5.02)	(7.38)	(3.86)	(7.64)	(4.19)	(7.38)	(4.81)
Firm_FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year_FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Adj. R-squared	0.1051	0.1080	0.0916	0.1470	0.0607	0.0961	0.0362	0.1550	0.0860
Obs.	8703	4439	3760	4745	2925	5124	2360	3917	4097

Table 17: Non-Financial Firms : IV regressions of *FirmCoupon*.

This table reports IV regression results, where $D(EarlyRefinance)_{i,t}$ is instrumented by $D(TurnCallable)_{i,t}$, a dummy variable indicating that some bonds are scheduled to become callable in year t for firm i. The independent variable $D(EarlyRefinance)_{i,t}$ is a dummy variable which equals 1 when firm i conducts a early refinancing activity at year t. The dependent variable is *FirmCoupon* which calculated as the average coupon of each outstanding bond. High and Low groups are divided by their corresponding median value. Additional firm characteristic controls include *ln(Assets)*, *Leverage*, *M/B Ratio*, *Tangible*, *EBITDA*, *Cash/Total assets*, *Equity return*, and *Firm rating*. Observations are at firm-year level. Firm fixed effects and year fixed effects are included. The value of t-statistics adjusted for clustering at the firm level are reported in parentheses.*,**, and *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	Dependent variable = *FirmCoupon*								
	(1) Full Sample	(2) High *Leverage*	(3) Low *Leverage*	(4) High *RI*	(5) Low *RI*	(6) High *LT-1*	(7) Low *LT-1*	(8) High *Curlia*	(9) Low *Curlia*
$D(EarlyRefinance)$	-0.4389*	-0.5529**	-0.2640	-1.0245**	-0.1252	-0.7032**	-0.1128	-0.9300**	-0.3379
	(-1.91)	(-2.01)	(-0.71)	(-2.32)	(-0.50)	(-2.20)	(-0.38)	(-2.13)	(-1.33)
Termspread	-0.6905***	-0.7333	-0.6102*	-0.7000***	-0.7078***	-0.7066***	-0.6537***	-0.8102***	-0.5886***
	(-4.06)	(-0.89)	(-1.81)	(-9.93)	(-11.90)	(-11.00)	(-9.23)	(-13.69)	(-4.47)
ln(Asset)	-0.3575***	-0.3581***	-0.4065***	-0.4048***	-0.3118***	-0.3683***	-0.3000***	-0.3709***	-0.3552***
	(-6.46)	(-4.98)	(-4.92)	(-5.20)	(-4.37)	(-4.85)	(-3.78)	(-4.47)	(-5.25)
Leverage	0.0029*	0.0047	-0.0013	0.0047*	0.0036	0.0034*	0.0031	0.0013	0.0042**
	(1.78)	(1.46)	(-0.19)	(1.95)	(1.59)	(1.91)	(0.90)	(0.50)	(2.04)
M/B Ratio	-0.1592***	-0.1389**	-0.1543***	-0.1799***	-0.2014***	-0.1396**	-0.2311***	-0.1544***	-0.1797***
	(-4.31)	(-2.13)	(-3.54)	(-3.47)	(-3.83)	(-2.55)	(-4.49)	(-2.89)	(-3.81)
Tangible	-0.4450	-0.4251	-0.2644	-0.3491	-0.5962	-0.2933	-0.2990	-0.8248*	-0.3328
	(-1.53)	(-1.04)	(-0.59)	(-0.83)	(-1.61)	(-0.68)	(-0.81)	(-1.94)	(-0.94)
EBITDA	0.3963*	0.0791	0.7221**	0.7002*	0.3849	0.6376	0.6665**	0.5517	0.2789
	(1.74)	(0.25)	(2.03)	(1.84)	(1.15)	(1.63)	(2.02)	(1.46)	(1.01)
Cash/Total asset	-1.1631***	-1.0940**	-0.9208***	-1.1917***	-1.0742***	-1.5984***	-1.2160***	-0.4922	-1.4036***
	(-4.07)	(-2.33)	(-2.62)	(-3.09)	(-3.02)	(-3.97)	(-3.37)	(-1.17)	(-3.74)
Equity return	0.0690***	0.0552*	0.0847***	0.0612**	0.0933***	0.0882***	0.0883***	0.0421	0.0806***
	(3.64)	(1.90)	(2.83)	(2.13)	(3.01)	(3.18)	(2.66)	(1.27)	(3.28)
Firm rating	0.1237***	0.1225***	0.1090***	0.1055***	0.1738***	0.1317***	0.1338***	0.1021***	0.1435***
	(9.33)	(8.01)	(4.74)	(6.83)	(8.00)	(8.51)	(5.64)	(6.57)	(7.34)
	First Stage								
$D(TurnCallable)$	0.1027***	0.1007***	0.0870***	0.0747***	0.1221***	0.0911***	0.1142***	0.0859***	0.1052***
	(19.86)	(13.52)	(11.31)	(10.02)	(15.37)	(11.38)	(12.50)	(11.89)	(14.10)
Firm_FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year_FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Adj. R-squared	0.2930	0.3086	0.2650	0.3178	0.2580	0.3545	0.2555	0.3635	0.2439
Obs.	23156	11818	10846	10408	11183	10087	8291	9543	12922