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AN EMPIRICAL ANALYSIS OF THE FINANCING STRATEGY OF CALLABLE BONDS

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Abstract

This paper empirically analyzes the call timing of callable bonds to see how refunding opportunity, cost of financial distress, agency cost of debt, and private information affect the call decision. The empirical results show that firms issue callable bonds, convertible or not, to enjoy future refunding options; that the cost of financial distress weakly expedites calling convertible bonds but not non-convertibles; that firms which are in debt delay calling non-convertibles but not convertibles; that callable bonds, convertible or not, are issued to mitigate adverse selection under information asymmetry; and that after the end of call protection periods the call intensity monotonically decreases for the non-convertible bonds but not for the convertible bonds.

1. Introduction

This paper explores the motivations for designing and calling callable non-convertible bonds and callable convertible bonds. It investigates whether callable debt has a relative advantage over non-callable bonds or straight equity; how a firm determines to exercise an embedded call option; and how calling is different between callable non-convertible bonds and callable convertible bonds.

Having issued a callable bond, a firm makes a decision to call the bond based on its own characteristics and the outside environment. The factors predicted to affect calling are classified into two categories. One is a set of firm characteristics including the cost of financial distress, the agency cost of debt, the information released after issuance, and the transaction cost of refunding. The other category includes the movements of the market interest rate and the stock value. We estimate the hazard rate of calling a bond at each point in time as a function of the set of predicted factors observed by that time.

In this paper, we analyze both callable non-convertible bonds and callable convertible bonds. A call option provides the issuing firm with an optional right to redeem the bond at a pre-determined call price before maturity. In the case of a callable non-convertible bond, once the firm exercises the call option, the bondholder has no other choice but to exchange the bond for cash.

A conversion option provides the bondholder with an optional right to convert the bond into equity according to a pre-determined conversion ratio. In the case of a callable convertible bond, once the firm exercises the call option, the bondholder chooses either to convert it into equity or to exchange it for cash. The choice depends on the relative magnitude of the call price and the conversion value. The conversion value is the value of the shares a bondholder receives upon conversion of a unit of bond. If the call price were higher than the conversion value, the bondholder would not exercise the conversion option and receive cash (non-conversion forcing call). If the conversion value were higher than the call price, the bondholder would choose to exercise the conversion option and receive shares (conversion forcing call).

A callable bond might be issued primarily to utilize favorable refunding opportunities in the future. Firms face an incentive to issue a callable non-convertible bond when they expect the market interest rate to fall after issuance, and an incentive to issue a callable convertible bond when they expect stock prices to go up. By calling outstanding bonds, firms refund at a lower interest rate (callable non-convertible bonds and non-conversion forcing calls), or force bond-equity swap (conversion forcing calls).

However, future refunding may not be the only reason why firms issue callable bonds. In the United States, firms relied on callable bonds more heavily during the late 1970s and early 1980s, when the market interest rate kept rising, than during the late 1980s and early 1990s, when the market interest rate kept falling. The one-year Treasury bill rate in the secondary market showed a uniform increase from 4.64% in December 1976 to 14.7% in August 1981. Thereafter, the market interest rate fluctuated, generally going down, but remained above 10% until September 1984. The one-year Treasury bill rate uniformly decreased from 9.93% in October 1984 to 3.33% in July 1993. According to Moody's Industrial Manuals, about 90% of the listed bonds issued from the late 1970s to 1982 were callable, whereas only about 60% of all bonds issued since 1983 have been callable.

This paper empirically analyzes the call decision of firms to see how recapitalization opportunities, cost of financial distress, agency cost of debt, and private information affect the call decision. This paper differs from previous studies and, indeed, has several advantages over them. Harris and Raviv (1985) analyzed the calling of a callable convertible bond but ignored the actual call structure. In their model, a firm is assumed to have a callable convertible bond with a call price of zero so that the firm can always force a conversion. Unlike Harris and Raviv, this paper takes into account the actual call structures in analyzing the call timing. Vu (1986) examined the stock price reaction to calling a non-convertible bond. Unlike Vu, this paper directly analyzes the decision to call using survival analysis techniques, and thus better addresses the call design and call timing issues.

The rest of the paper is organized as follows. Section 2 reviews the existing literature. Section 3 sketches the theoretical predictions and draws testable hypotheses regarding the effect on call timing of the cost of financial distress, the agency cost of debt, information asymmetry, and refunding opportunity. Section 4 discusses various measurement issues and describes the empirical model. Section 5 identifies the data sources and presents selective summary statistics. Section 6 shows the estimation results for each of the non-convertible bonds and convertible bonds. Section 7 concludes the paper. Other details relating to measurement issues, summary statistics, and empirical results can be found in the Appendix.

2. Literature review

To explain the prevalence of callable debt, previous studies have investigated whether a callable bond has a relative advantage over a non-callable bond or straight equity.

These studies have identified several advantages of a callable bond including its ability to facilitate recapitalization, mitigate default cost, provide tax subsidy, and signal private information.

2.1 Literature related to callable non-convertible debt

The literature suggests that the most prominent function of a callable bond is to facilitate recapitalization in the future. For a non-convertible bond, a call provision facilitates the issuing of a new security. For instance, Pye (1966) views a call provision as a pure option to facilitate refunding when the market interest rate falls. Vu (1986) suggests that a call provision is included to facilitate removing restrictive financing covenants and thus to facilitate recapitalization. He finds that firms are willing to pay a higher call premium if calling removes a restrictive covenant. Narayanan and Lim (1989) also find evidences supporting Vu's findings. Many callable zero-coupon bonds have restrictive covenants compared with non-callable counterparts because they can be removed by calling.

Smith and Warner (1979) postulate that a call provision mitigates the agency cost of debt. When a firm is in debt, the manager who acts in the interests of the shareholders may attempt to extract bondholder wealth in favor of the shareholders. This action typically entails increasing the firm's risk, which does not necessarily lead to firm value maximization. Bondholders rationally expect this kind of managerial incentive distortion when evaluating the value of a bond at the time of purchase, which results in firm value reduction ultimately damaging the shareholder interests. A call provision mitigates this type of agency cost because it facilitates refunding before maturity. This is because the manager's action to reduce firm value is penalized later at the time of refunding.

Fischer, Heinkel, and Zechner (1989) postulate that firms have the incentive to call bonds as soon as the recapitalization benefits the shareholders. The call time that serves shareholders' interests comes earlier than the call time that maximizes firm value, creating a potential agency cost of recapitalization. Bondholders demand a higher coupon rate to compensate for an early redemption. The resulting higher coupon rate becomes a burden to the firm. Since a firm eventually bears this kind of agency cost, it attempts to pre-commit to calling no earlier than the firm-value maximizing time. This explains why many callable bonds have so-called call protection periods, whether absolute or conditional, immediately after issuance.

Under a condition of information asymmetry, the call option benefits firms, especially good ones, by providing them with recapitalization opportunities. A good firm can easily refund by calling outstanding debts after favorable information is released.

2.2 Literature related to callable convertible debt

Callable convertible bonds are equity-like as well as debt-like issues. They can replicate the cash flows of issuing callable non-convertible bonds followed by those of issuing straight equity.

Several studies have examined whether the types of bonds issued signal private information. Stein (1992) suggests that good firms issue long-term debts to signal their good type while bad firms issue callable convertible debts to reduce default risk. Good firms can manage risks arising from the issuing of a long-term bond, whereas bad firms cannot. According to Stein, when callable convertible bonds are issued for deferred equity financing under information asymmetry, a good firm forces a conversion by calling the bonds after favorable information is released.

Smith and Warner (1979) and Green (1984) postulate that a callable convertible debt mitigates the aforementioned agency cost of debt more efficiently than a callable non-convertible bond does. As discussed earlier, the call option mitigates the agency cost of debt because it offers a refunding opportunity before maturity. The conversion option further mitigates the agency cost of debt because it offers bondholders the right to eventually be shareholders. In equity-financed firms, shareholder wealth maximization complies with firm value maximization, thus avoiding the agency cost of debt. According to this view, callable convertible bonds are a debt-like issue.

Dann and Mikkelson (1984) find that common shareholders earn significantly negative abnormal returns both at the announcement of a convertible bond offering and at issuance. In contrast, the effect of a non-convertible bond offering is only marginally negative at the initial announcement and almost zero at issuance. They conclude that convertible bonds are an equity-like issue.

The optimal timing of call and conversion has also been studied in the literature. Brennan and Schwartz (1977) claim that it is optimal for firms to call a convertible bond as soon as the conversion value exceeds the call price. Ingersoll (1977) finds that in practice calling is deferred long after the optimal timing predicted by Brennan and Schwartz (1977). Harris and Raviv (1985) attempt to resolve this apparent discrepancy using a signaling argument under a condition of information asymmetry. According to them, good firms voluntarily choose to defer calling to signal their good type, whereas poor firms are less likely to defer calling because they have higher probabilities of being unable to force a conversion in a later stage. Further, Wee (1995) suggests that a callable convertible bond is designed to be converted if the realized return of the issuing firm is relatively low.

Empirical studies support that calling a convertible bond is related with low performance of a firm. Lin and Chen (1991) find that stock prices show a negative reaction to the announcement of calling a convertible bond. Ofer and Natarajan (1987) document a drop in profitability upon calling a convertible bond.

3. The determinants of call timing: a theoretical overview

This paper studies how calling a callable bond is influenced by firm characteristics and market conditions. Using survival analysis techniques, this paper empirically analyzes the impact on call decisions of movements in the market interest rate, the transaction cost of refunding, the cost of financial distress, the agency cost of debt, revealed information after issuance, the structure of the call clause, the change in stock price, and the elapsed time since issuance. The theoretical predictions are briefly outlined below.

3.1 Refunding opportunity

Refunding opportunity affects the decision to call. Market interest rate movements and the transaction cost of refunding influence the call timing. Stock price movements also matter in the case of callable convertible bonds.

(1) Non-convertible bonds

The decision to call a non-convertible bond depends crucially on the availability of refunding opportunity and the transaction cost of refunding. A firm is more likely to exercise the call option when the spread between the bond's interest rate and the market interest rate gets larger, and less likely to call when the transaction cost of refunding becomes larger.

This paper proxies the market interest rate with the one-year Treasury bill rate in the secondary market. The secondary market rate is preferred to the auction rate because the secondary market is deeper. The interest rate spread is measured by the bond's interest rate minus the one-year Treasury bill rate.

We postulate that there are economies of scale in refunding transactions, and that the unit refunding cost decreases with the size of refunding amount. This amount is expected to expedite the calling. We use the authorized amount of bond issue as a proxy for the refunding amount. We postulate that the unit refunding cost decreases as the natural logarithm of the authorized amount of bond issue gets larger.

(2) Convertible bonds

Refunding opportunity has a different impact on calling a convertible bond, depending on whether a call is conversion forcing or not. In the case of a non-conversion forcing call, calling is more likely when the market interest rate falls below the bond's interest rate and when the transaction cost of refunding is low. A conversion forcing call is more likely when the conversion value is higher than the conversion price (value of the bond submitted for conversion). The interest rate difference is less important in determining the time to exercise the conversion forcing call.

The conversion value of a convertible bond increases in the stock price. We use the stock price as a proxy of the conversion value. For each issue of the callable convertible bonds, we have normalized the corresponding stock price as one at the time of issuance, and then have constructed its price path using the monthly rates of return. Monthly rates of return are adjusted for stock split, dividend payment, etc.

To sum up, we expect that calling a convertible bond is more likely as the interest rate spread widens, as the unit refunding transaction cost decreases, and as the conversion value rises.

3.2 The cost of financial distress

A firm is in financial distress when the value of total liabilities exceeds the value of total assets including future business opportunities. Under a condition of financial distress, a firm is likely to go through financial restructuring or liquidation.

Financial distress is costly. First, restructuring or liquidation normally incurs a considerable amount of administrative cost, including legal expenses. The resale value of assets during restructuring or liquidation is likely to be lower than the value under the original firm. Second, bondholders are in general different from managers and shareholders. After restructuring, the former bondholders usually emerge as new shareholders. They tend to be less efficient at managing the firm or at monitoring professional managers compared with the original shareholders.

Rationally expecting the possibility of financial distress, creditors properly incorporate the expected cost of such distress when evaluating the value of a bond issue. This way, a default risk eventually costs the shareholders. In response, firms issue callable convertible bonds to reduce the chance of financial distress. By exercising call option embedded in callable convertible bonds, firms forces debt-equity swap without having to raise new funds. They tend to have a stronger incentive to exercise the call option and thus to avoid financial distress as the cost of financial distress becomes larger. Calling a convertible bond will be expedited as the cost of financial distress gets larger.

Non-convertible bonds do not quite serve this purpose. Calling entails recapitalization. To retire existing debts by calling non-convertible bonds, firms have to raise new funds. The cost of financial distress is not expected to have any significant effect on calling a callable non-convertible bond.

In the case of callable convertible bonds, firms face an incentive to exercise the call option either to redeem the bond or to induce a conversion when the cost of financial distress is high. Firms become equity- financed and thus free from additional borrowing once their convertible debts are converted into shares. Thus, faced with financing difficulties, managers are more willing to call the callable convertibles than the non-convertibles.

This paper proxies the cost of financial distress with the size of firm-specific assets. Firm-specific assets have a relatively low resale value at restructuring or liquidation compared with assets for general use. The paper measures the size of firm-specific assets by the proportion of fixed assets to total assets. Fixed assets include both tangibles and intangibles, whereas current assets are mostly cash, securities, and inventories. Intangibles are regarded as more fixed in nature than tangibles. Fixed assets, like intangibles, lose more of their value through resale.

3.3 The agency cost of debt

When a firm is in debt, a manager's action to maximize shareholder wealth does not necessarily comply with firm value maximization (see, for example, Barnea et al. 1980). This incentive distortion tends to be severe for firms that are highly in debt.

This cost is mitigated if the manager expects to recapitalize in the future. Thus, calling is delayed when the potential agency cost of debt, as measured by the amount of the debt, is large. The presence of an unexercised call option mitigates a manager's incentive distortion. This is because the manager's commitment to firm-value maximization is rewarded when the firm recapitalizes. As a result, firms that are in debt tend to defer calling and leave call options unexercised. This effect is expected to be stronger for the non-convertible bonds than for the convertible bonds since the possibility of forced refunding is higher in the case of calling the non-convertible bonds.

We proxy this agency cost of debt with the indebtedness, measured by the ratio of total liability to total asset.

3.4 Information asymmetry

Suppose that firms are classified as either good type or bad type depending on their profitability. Suppose also that there is information asymmetry in that firms know what type they are but the investors do not. In this situation, a good firm suffers from adverse selection. It will try to mitigate this problem by issuing callable bonds, expecting that its type will hopefully be revealed after bond issuance.

A good firm exercises the call option to recapitalize in a more favorable term after the information is released. We expect that a firm is more likely to call a bond when favorable information is released. We proxy this information release with the profitability of firms after the issuance, measured by the ratio of net income to total assets. This variable is expected to expedite the calling of a callable bond, whether convertible or non-convertible.

4. Measurement issues and the empirical model

This paper analyzes the time to call, measured by the interval from the time when calling becomes possible to the time when calling is in fact made. This paper uses the term “time to call” instead of the usual term “duration.” This is to avoid a possible confusion because “duration” is a term reserved to represent the weighted average maturity of a bond in finance.

By using survival analysis techniques, this paper estimates the hazard rate of call timing. The hazard rate shows the call intensity at each moment in time as a function of the available information at that time.

4.1 The measurement of the time to call

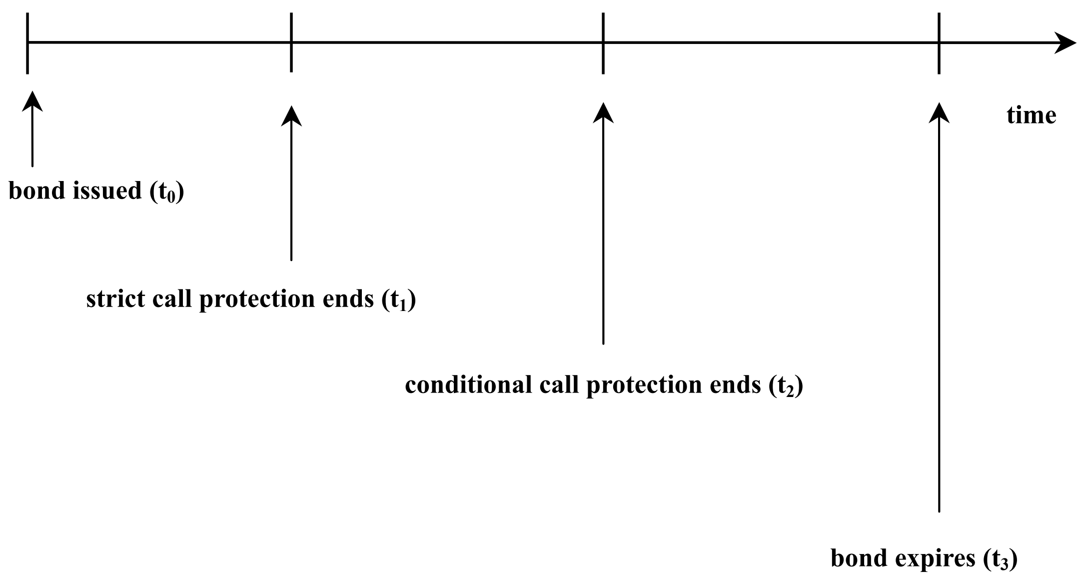
In practice, measuring the time to call of a callable bond is not straightforward because of the different structures that appear across different callable bonds. Time horizons are different for different bonds. Protection periods exist for some but not for others. The absolute call protection periods that prohibit calling under any circumstance, range from several months to several years when they exist. The conditional call protection periods that prohibit calling unless a certain pre-specified condition is met, may or may not exist. When they exist, they range from several months to several years. Also, the time intervals from the end of the absolute call protection period to call expiration are all different.

Figure 1 illustrates a hypothetical life path of a callable bond. There are four possible time points: t_0, t_1, t_2, and t_3 in increasing order. A firm issues a callable bond at time t_0. The bond matures at time t_3. The bond is not callable until t_1 in any circumstance. In some cases, a bond is not callable further until t_2 elapses under a certain set of conditions. After t_2, the bond is callable without restriction.

We call the time interval from t_0 to t_1 an absolute call protection period, and the time interval from t_1 to t_2 a conditional call protection period. When there is no absolute call protection period, we have $t_0 = t_1$. When there is no conditional call protection period, we have $t_1 = t_2$.

The conditional call protection clause takes a different form depending on whether the bond is convertible or not. In the case of a non-convertible bond, the bond is not callable before t_2 when refunding is made at a lower interest rate than the bond's interest rate. This is to protect the bondholder from a forced reinvestment as a result of the call, for which the return is likely to be lower than the retiring bond's interest rate. In the case of a callable convertible bond, the bond is not callable until t_2 elapses unless the corresponding stock price exceeds a certain level for a specified length of time. This is to guarantee the bondholder a minimum conversion value at an earlier stage.

<Figure 1> The hypothetical life path of callable bonds: from issuance to maturity



Now, let us consider how to define the time to call in a meaningful way. The time to call is the time interval from the end of the absolute call protection period to the actual call time. It measures how long the bond issuer waits until he exercises the call option after calling becomes possible. The absolute length of calendar time, however, is not a good measure. Calling a callable bond after one year of call eligibility has different implication depending on whether the bond has a longer life span or a shorter one.

To illustrate, let us take two callable bonds differing in their callable life spans. Suppose that one bond has a 10-year life span and the other bond has just a 5-year life span. If both bonds were called after one year of call eligibility, the call would have been exercised earlier in relative terms for the first bond than for the second. The first bond is called at 10% location in its life span, whereas the second bond is called at 20%.

We adopt percentage life as a measure of normalized time to call. The percentage life is defined as the ratio $(t_c - t_1)/(t_3 - t_1)$, where t_c is the observed call time if a call is made and is equal to t_3 if no call is made until maturity. The use of percentage life allows us to compare the time to call across different bonds.

Call observations are classified into three categories. First, there are bonds that are called during the sample period. These are complete observations because a call is actually observed. These bonds have a value of normalized time to call of less than one. Second, there are bonds that are neither called nor matured by the end of the sample period. These bonds are incomplete in spell and have a value of normalized time to call of less than one.

Finally, there are bonds that are not called until maturity. We say these observations are maturity censored. For these observations, the normalized time to call takes a value of one.

4.2 Controlling for heterogeneity in the structure of the call protection period

A callable bond may or may not have a conditional call protection clause. However, we measure the time to call from the end of the absolute call protection period whether there is a conditional call protection clause or not. Thus, the time to call variable may suffer from heterogeneity arising from whether a bond has a conditional call protection period or not.

Even though there is a conditional call protection clause, a manager may choose to avoid it and thus exercise the call before the expiration of the conditional call protection. This choice could be costly. For example, in the case of non-convertibles, the manager has to bypass opportunities of refunding at a lower interest rate to avoid the protection clause and thus be able to call early. Bypassing these opportunities is costly. Thus, the manager is less likely to make such a choice faced with a conditional call protection clause. We want to see whether this kind of effect in fact exists.

To capture differences in call patterns depending on whether there exists a conditional call protection clause or not, we first define a dummy variable (say, a call protection dummy) that takes a value of one if there is a conditional call protection clause and if this clause is currently binding, and zero otherwise. For callable bonds with conditional call protection clauses, this dummy variable becomes time varying. It takes a value of one during the conditional call protection period and zero thereafter. Of course, for callable bonds without a conditional call protection clause, this dummy variable takes a value of zero throughout.

The hazard rate should then be estimated separately for convertible bonds and non-convertible bonds, with the dummy variable included in each specification. Through the dummy, we want to see whether a conditional call protection clause in fact has a delaying effect on the time to call.

4.3 The empirical model

The empirical model we use is a hazard rate model specified as follows:

$$h(t \mid x_t) = h_0(t)\exp(x_t{}'\beta),$$

where $h(t \mid x_t)$ is the call hazard rate at time t given x_t, $h_0(t)$ is the so-called baseline hazard function, x_t is a collection of the explanatory variables available at time t, and β is a vector of unknown parameters. To make it always positive, let us represent $h_0(t)$ as $h_0(t) = \exp(g_0(t))$ so that the resulting hazard function becomes:

$$h(t \mid x_t) = \exp(g_0(t) + x_t{}'\beta).$$

To complete the model, we need to specify $g_0(t)$. We use a step function for $g_0(t)$ by introducing a set of time dummy variables to partition the unit interval. To design the partition to be used, we consider a trade-off between flexibility and reliability. If more steps are estimated, the resulting function is more flexible but less reliable, and vice versa. The chosen intervals in the step function are progressively wider over time to avoid the problem of thin data at later times. We end up partitioning the unit interval into five sub-intervals, {[0,0.1], (0.1, 0.2], (0.2, 0.3], (0.3, 0.5], (0.5, 1]}, by introducing four time dummy variables indicating the first four intervals together with an overall constant term. The coefficient of the first dummy variable shows whether the call hazard rate is higher (+) or lower (-) in the first sub-interval (birth to 10% of age) relative to the second half of the callable life span, and similarly for other dummies.

To test the theoretical implications using the time to call data, we let x_t include those variables discussed and defined in previous sections. Many explanatory variables are time varying in nature. Since a firm's financial situation and other environments keep changing, it is a better idea to use these time varying explanatory variables to explain a manager's decision to call at each moment in time. To control for the presence/absence of the conditional call protection, we also let x_t include the call protection dummy.

To sum, the set of variables used in the model specification are as follows.

Baseline hazard function: D[0,0.1], D(0.1,0.2], D(0.2,0.3] and D(0.3,0.5] are time-dummy variables defined on the intervals [0,0.1], (0.1,0.2], (0.2,0.3] and (0.3,0.5] respectively. These four dummy variables together with an overall constant term model the baseline hazard function as a step function with five steps.

Time varying covariates: FASS is the ratio, (fixed asset)/(total asset). DEBT is the ratio, [(total liability)/(total asset)]. PRO is the ratio, (net income)/(total asset). DFREE is the dummy variable measuring freedom from conditional call protection periods. It takes the value 0 if the callable bond is prohibited from being called by a conditional protection clause, and 1 otherwise. DINT is the difference, the bond's interest rate (%) minus the one-year Treasury bill rate (%).

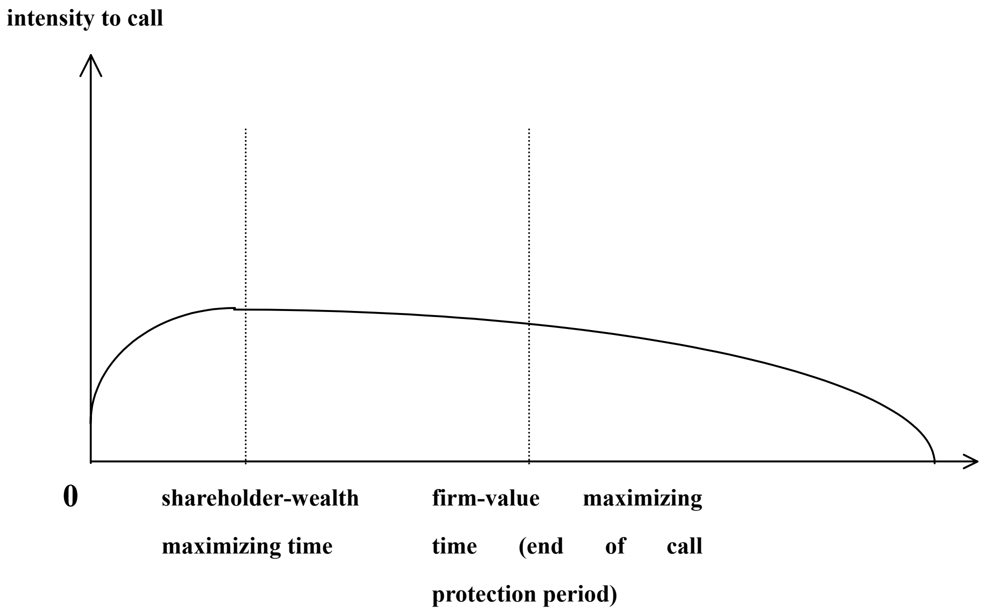
Time constant covariates: Ln(Amount) is the natural logarithm of the authorized amount of the bond issue measured in 1 million dollars. Callable life span is the length of time from the end of the absolute call protection period to maturity measured in 100 thousand days.

The above variables are commonly used for the hazard rate specification of the non-convertible bonds and the convertible bonds. In the case of the convertible bonds, VCONV is additionally used. VCONV is the normalized stock price so that the price at the time of issuance is one. VCONV is time-varying.

4.4 The baseline hazard

Existing literature provides implications for the shape of the baseline hazard function. Fischer, Heinkel and Zechner (1989) show that a manager has incentive to call a bond as soon as it is in the interest of the shareholders. They further show that this shareholder-wealth maximizing time of calling is earlier than the firm-value maximizing time, i.e., there is a potential incentive problem of recapitalization. To mitigate this agency cost, a firm can set the expiration of a call protection period matching the firm-value maximizing time. Thus, a firm has incentive to call a bond immediately after the expiration of a call protection period because the total gain from recapitalization decreases as calling is further deferred. This is illustrated in Figure 2.

<Figure 2> Call protection as a device to curb incentive distortion of recapitalization



We expect that this incentive be reflected in the shape of the baseline hazard function. Recall that we measure the time to call from the end of the absolute call protection period. Thus, the time origin coincides with the end of any call protection periods for bonds without a conditional call protection clause. For these bonds, we expect the baseline hazard function to exhibit a monotonically decreasing pattern.

Time zero is not necessarily the end of call protection period for bonds with a conditional call protection clause. For these bonds, the effective ending of call protection varies a lot depending on the structure of the conditional call clauses and also on whether the condition is met or not. Figures 6 and 7 in the appendix show that there is lots of variation in the normalized length of conditional call protection periods. We do not expect any visible baseline hazard pattern for these bonds with conditional call protection.

The above pattern is expected to emerge from curbing the agency cost of debt. We expect this pattern is stronger for bonds of a debt nature and weaker for bonds sharing an equity nature. Non-convertible bonds are more like a debt than convertible bonds. We expect the monotone decreasing baseline pattern most visible in calling non-convertible bonds without a conditional call protection clause. For other bonds, the baseline pattern is expected to be weak or invisible.

4.5 The construction of the likelihood function

To construct the likelihood function, we need to compute the probabilities of the following two forms:

$$f(T=t) \text{ or } P(T>t),\ 0 \le t \le 1,$$

where the first denotes the density of the event $T=t$ (a complete observation) and the second denotes the probability of the event $T>t$ (right-censored, whether incomplete or maturity censored).

To illustrate, let us assign a likelihood value to both the complete event $T=0.35$ and the right-censored event $T>0.35$. First, in the case of a complete observation, $T=0.35$ means that a callable bond survives 35% of its callable life and then is called immediately at 35% location of its callable life span. By using a relationship between the hazard rate function and the density function, we end up with $f(T=0.35) = h_0(0.35)\ \exp(x_{0.35}'\beta)\exp\left[-\int_0^{0.35} h_0(u)\ \exp(x_u'\beta)\,du\right]$. Second, in the case of a right-censored observation, $T>0.35$ means that a callable bond is only known to have survived 35% of its callable life. Similarly, we find $P(T>0.35) = \exp\left[-\int_0^{0.35} h_0(u)\ \exp(x_u'\beta)\,du\right]$.

Here arise several issues that need to be addressed in order to compute the above likelihood values from the available data. First, the time varying explanatory variables are recorded according to the calendar time (either monthly or yearly), not the normalized time. Therefore, we need to rearrange the data on time varying explanatory variables according to the normalized time. Since the time horizons are all different across different callable bonds, this has to be done on an individual basis (the details of this are in the Appendix). Once this has been done, assigning the above likelihood values is trivial. This is because the integration reduces to summation due to the discrete nature of the time varying explanatory variables as well as the baseline hazard function.

5. Data

In this section, we explain the data sources and present basic descriptive statistics before carrying out the survival analyses in the next section (additional summary statistics can be found in the Appendix).

5.1 Data sources

The sample of callable bonds is taken from those listed in Moody's Industrial Manuals. The sample bonds were issued between September 1, 1980 and December 31, 1991. Moody's Manuals provide important features of bonds, specifically, issuance date, call protection period, maturity, face value, coupon rate, and call date. Data needed to construct explanatory variables are collected from Compustat files, the Citibank database, CRSP (Center for Research in Security Prices) files, and the International Financial Statistics. Compustat files provide firm characteristics such as net income, liabilities, net fixed assets, and total assets. The market interest rates are taken from the Citibank database. CRSP files provide rates of return data. As a relevant price index, we use the industrial price index available from the International Financial Statistics.

The sample excludes callable bonds that are retired or suspected to have retired before or after a major merger or acquisition. Specifically, the sample excludes the bonds called by either an acquiring or an acquired firm within 12 months before and 6 months after a major merger or acquisition. The sample also excludes bonds wherein the issuing firm goes bankrupt after issuance. This is to preclude observations that are likely to show different call patterns. Also, we exclude data points that lack some relevant information such as financial ratios or the coupon rate. In the end, we have 586 usable observations for callable non-convertible bonds and 166 usable observations for callable convertible bonds.

5.2 statistics

Tables 1 and 2 show selected sample data used in this paper.

<Table 1> Selected sample data: callable non-convertible bonds[1]

Company name	Issuance Date	Acquisition Date	End of absolute call protection	End of conditional call protection	Call date	Expiration date
Abbott Industries	19830201	.	.	19930201	19870101	20130201
Abbott Industries	19830201	.	19900201	.	19900201	19930201
Allied Siganl Inc (Allied Corp)	19831001	19850919	.	19941101	19870227	20091101
American Medical Holdings Inc	19840115	.	19910115	.	19911108	19940115
American Medical Holdings Inc	19840115	.	.	19940115	19870819	20140115
American Medical Holdings Inc	19850601	.	19920601	.	19920610	19950601
American Medical Holdings Inc	19850601	.	.	19950601	19930701	20150601
American Medical Holdings Inc	19860115	.	19900115	.	19910115	19910115
American Medical Holdings Inc	19860201	.	19910201	.	19930201	19930201
Armco Inc	19811201	.	19851201	.	19860101	19861201
Atlantic Richfield Co	19811201	.	.	.	19911201	19911201
Atlantic Richfield Co	19820915	.	.	19920915	19870430	20120915
Atlantic Richfield Co	19830415	.	.	19930415	19900301	20130415
Atlantic Richfield Co	19850601	.	.	19950601	19900301	20150601
Atlantic Richfield Co	19851015	.	19921015	.	19930101	19951015
Atlantic Richfield Co	19860101	.	19930101	.	19930101	19960101
Baxter Int'l Inc	19870615	.	19880615	.	19930701	20180615
Baxter Int'l Inc (American Hosp. Supply)	19820815	19851125	19890901	.	19890901	19920901
Cabot Corp	19820801	.	.	.	19860930	19920801
Cabot Corp	19841101	.	.	19911101	19870427	19941101
Cabot Corp	19850901	.	.	19920901	19880427	19950901
Chevron Corp	19841101	.	19911101	.	19920101	19941101
Chevron Corp	19860301	.	19930301	.	19930516	19960301
Chevron Corp	19860415	.	19930415	.	19930416	19960415
Chevron Corp	19850201	.	19890201	.	19900201	19900201
Chevron Corp	19850601	.	19920601	.	19920616	19950601
Comdisco Inc	19860515	.	19920515	.	19920629	19940515
Data General Corp	19850515	.	.	19950515	19870518	20150515
Digital Equipment Corp	19840401	.	19910415	.	19910415	19940415
Digital Equipment Corp	19840415	.	.	19940415	19860619	20140415

1
In the case of acquisition, the firm within parentheses is acquired by the firm outside. If a firm which has issued a callable bond is acquired by another firm during the life of the callable bond, we use the acquisition date instead of the original

<Table 2> Selected sample data: callable convertible bonds

Company name	Issuance date	Acquisition date	End of absolute call protection	End of conditional call protection	Call date	Expiration date
Action Industries Inc	19830401		19850401		19930701	19980401
Anacomp Inc	19820115		19840115	19870115	19930701	20020115
Anacomp Inc	19840701				19870507	19950701
Automatic Data Processing Inc	19850215			19870215	19870216	20100215
Automatic Data Processing Inc	19860301			19890101	19891116	20110301
Black & Decker Corp	19870715			19900715	19900101	20020715
Boise Cascade Corp	19860501			19890301	19930701	20160501
Bowater Inc	19841215				19870224	20091215
Browning-Ferris Industries Inc	19870801		19900815		19930701	20120815
Caesars World Inc	19860401			19880401	19870701	20060401
Champion Int'l Corp	19860415			19890422	19930701	20110415
Comdisco Inc	19830501			19841101	19860701	20030501
Crane Co	19851001			19871001	19870331	20051001
Deere & Company	19830315			19850315	19871016	20080315
Diagnostic/Retrieval Systems Inc	19830801		19850801		19930801	19930801
Digital Equipment Corp	19840901			19860916	19860417	20090901
Dole Food Co Inc	19830615				19870101	20130615
Eaton Corp	19831216		19851215		19870116	20081215
EDO Corp	19861215			19891215	19930701	20111215
Emerson Electric Co (Liebert Corp)	19851115			19871201	19930701	20101115
Flowers Industries Inc	19850301			19870301	19920819	20050301
General Dynamics Corp (Cessna Aircraft Co)	19830701	19860316	19850701		19900101	20080701
Gillette Co	19821112		19830301		19860701	20130301
Grow Group Inc	19860201				19930625	20060201
Grumman Corp	19840815			19870815	19930707	20090815
H.J.Heinz Co	19850215		19880215		19900101	20150215
Harcourt Brace Jovanovich Inc	19860315			19890315	19880101	20110315
Hercules Inc	19850815		19880815		19930701	20100815
Int'l Paper Co	19870923			19900923	19930701	20020923
Int'l Paper Co	19870315			19890315	19911121	20120315
Int'l Rectifier Corp	19850615		19870615		19910614	20100615

issuance date as the birth date of the bond.

Table 3 cross-tabulates the sample callable bonds by convertibility, presence/absence of an absolute call protection clause, and presence/absence of a conditional call protection clause. As can be seen, most callable bonds have either an absolute call protection clause or a conditional call protection clause, but seldom both. We infer that the two types of call protection clause function as substitutes rather than as complements in protecting investors.

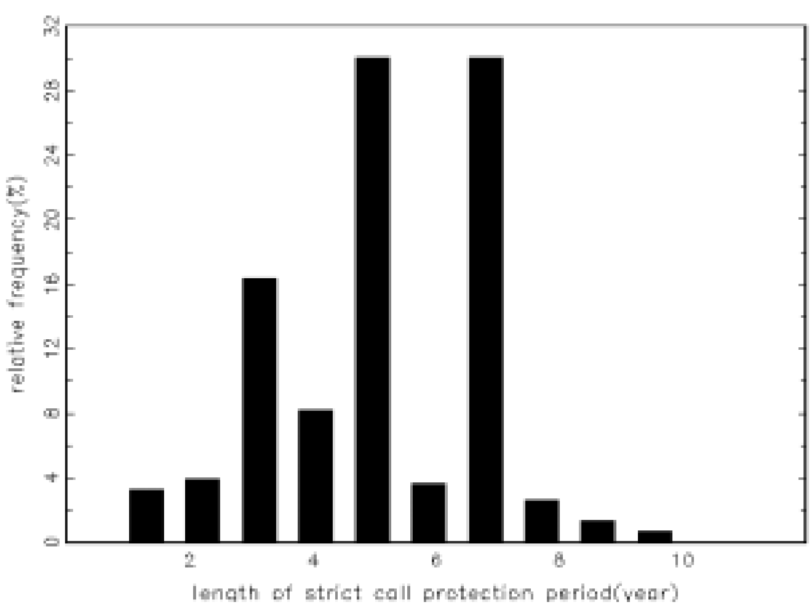
<Table 3> Joint distribution of absolute and conditional call protection clauses

Non-convertible bonds		**Conditional call protection period**	
		Exist	**Not exist**
Absolute call protection period	**Exist**	**0.04**	**0.48**
	Not exist	**0.36**	**0.12**
Convertible bonds		**Conditional call protection period**	
		Exist	**Not exist**
Absolute call protection period	**Exist**	**0.03**	**0.26**
	Not exist	**0.50**	**0.21**

For call protection, non-convertible bonds prefer an absolute call protection to a conditional counterpart. It is opposite for the convertible bonds. This difference seems to reflect that investors in non-convertible bonds care for a safe long-term investment whereas investors in convertible bonds care for possibility of conversion before maturity.

Figures 3 and 4 show the distribution of the length of the absolute call protection period $(t_1 - t_0)$ when it exists for the sub-sample of callable non-convertible bonds and the sub-sample of callable convertible bonds. The mean length of the absolute call protection period is 5.14 years for the non-convertibles, and it is 2.28 years for the convertibles. On the average, the absolute call protection period is longer for the non-convertible bonds than for the convertibles, lending another support to the fact that non-convertible bonds are more of a debt compared with convertible bonds.

<Figure 3> Histogram showing length of absolute call protection period: callable non-convertible bonds with an absolute call protection period



<Figure 4> Histogram showing length of absolute call protection period: callable convertible bonds with an absolute call protection period

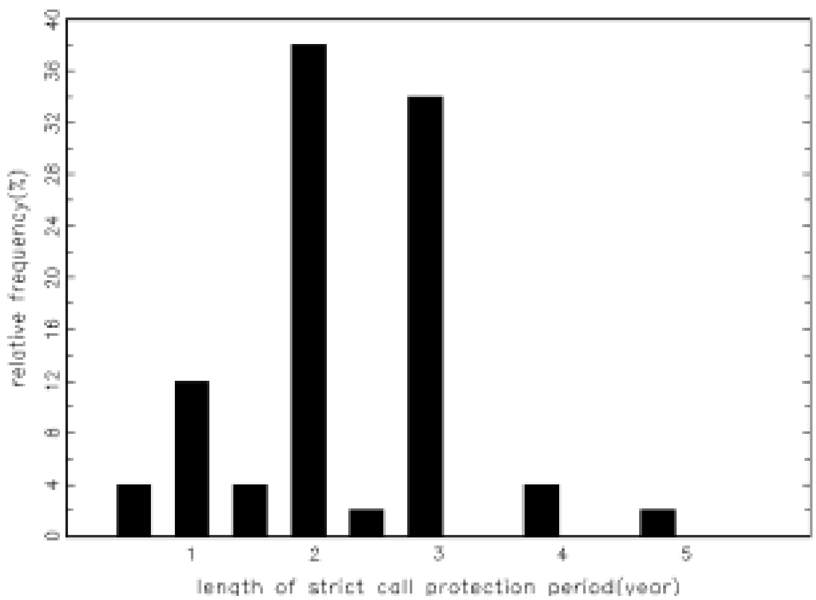


Table 4 shows a classification of the sample data by convertibility and censoring status. An observation is said to be complete when its call time is observed within the sampling horizon $(T = t, 0 < t < 1)$. An observation is said to be incomplete when its call option has not been exercised by the end of the sample observation period, which comes before maturity $(T > t, 0 < t < 1)$. Finally, an observation is said to be maturity censored when its call option has not been exercised by the maturity $(T > 1)$.

<Table 4> Classification of sample data by convertibility and censoring status

	Non-convertible bonds		Convertible bonds	
	Total Number	Proportion (%)	Total Number	Proportion (%)
Complete	367	62.6	88	53.0
Incomplete	173	29.5	77	46.4
Maturity censored	46	7.8	1	0.6
Total	586	100.0	166	100.0

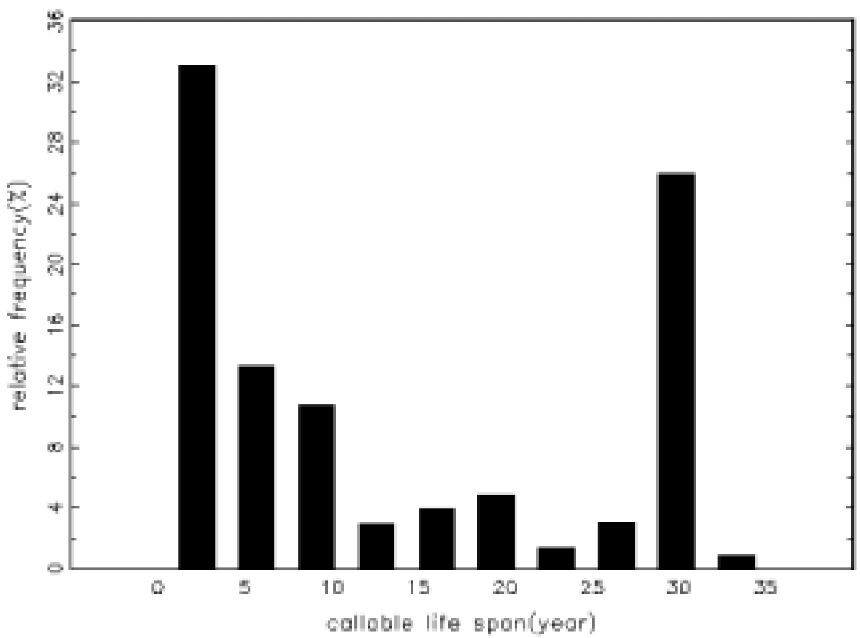
Table 5 shows mean and standard deviation of the covariates used in our empirical model for each sub-sample of the non-convertible bonds and the convertible bonds.

<Table 5> Mean and standard deviation of covariates used for estimation

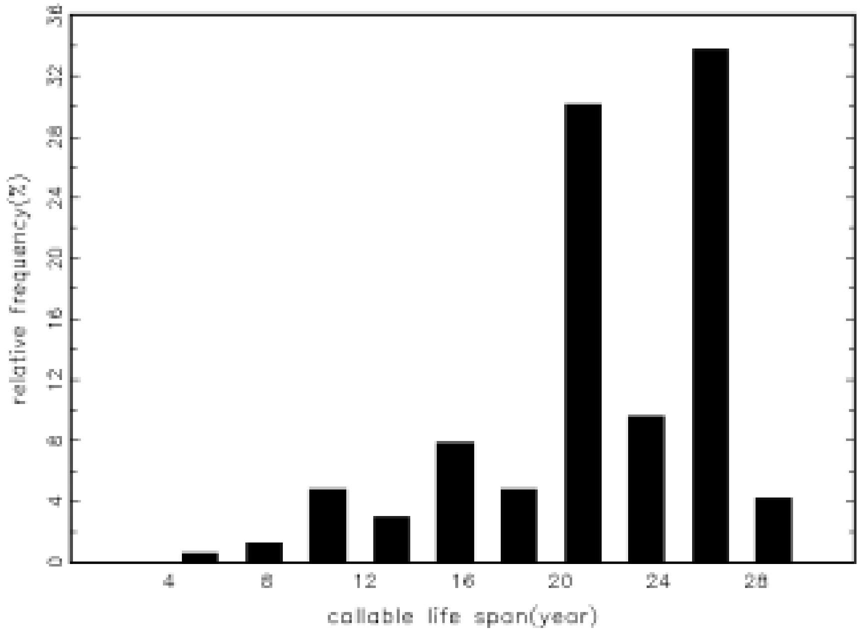
	Non-convertible bonds		Convertible bonds	
	Mean	SD	Mean	SD
FASS	0.4122	0.2121	0.3277	0.1954
DEBT	0.3664	0.2005	0.3635	0.1727
PRO	0.0302	0.0883	0.0184	0.0982
DFREE	0.4199	0.4935	0.7231	0.4475
DINT(%)	4.3366	2.8072	1.6321	2.3813
Ln(Amount)	4.7550	0.8401	3.9784	0.9452
VCONV	.	.	0.9678	0.5489
Callable life span (year)	13.7034	11.5003	21.2006	4.9861

Figures 5 and 6 show the distribution of the callable life span $(t_3 - t_1)$ for the sub-sample of callable non-convertible bonds and the sub-sample of callable convertible bonds. Here we are using an absolute time scale, not a relative one. By looking at these figures, we can see how the callable life span has different lengths across different callable bonds.

<Figure 5> Histogram showing callable life span: callable non-convertible bonds



<Figure 6> Histogram showing callable life span: callable convertible bonds



6. Results

In this section, we present the estimation results for the call hazard rate function for each of the non-convertible bonds and the convertible bonds. Tables 6 and 7 show these results. In the Appendix, we also present other call hazard function estimates. For this purpose, each sub-sample of the non-convertible bonds and the convertible bonds are further classified according to the presence or absence of the conditional call protection period. Tables 9-12 in the Appendix show these results. Findings are basically the same as those reported in Tables 6 and 7 other than that the statistical significance in general drops due to sample split.

<Table 6> Call hazard function estimates: non-convertible bonds

Variable	Estimate	Expected Sign	Standard error	t-value	p-value
Constant	-2.62		0.38	-6.97	0.00
D[0,0.1]	1.57		0.22	7.15	0.00
D(0.1,0.2)	0.77		0.23	3.36	0.00
D(0.2,0.3)	0.83		0.24	3.46	0.00
D(0.3,0.5)	0.78		0.23	3.45	0.00
FASS	0.39		0.34	1.15	0.25
DEBT	-2.23		0.40	-5.59	0.00
PRO	4.98		1.21	4.10	0.00
DFREE	0.66		0.18	3.61	0.00
DINT	0.12		0.06	1.95	0.05
DINT•Ln(Amount)	0.06		0.01	5.35	0.00
Callable life span	5.75		2.36	2.44	0.01

D[0,0.1], D(0.1,0.2], D(0.2,0.3] and **D(0.3,0.5]** are time-dummy variables defined on the intervals [0,0.1], (0.1,0.2], (0.2,0.3] and (0.3,0.5] respectively.
FASS is the ratio, (fixed asset)/(total asset).
DEBT is the ratio, [(total liability)/(total asset)].
PRO is the ratio, (net income)/(total asset).
DFREE is the dummy variable measuring freedom from conditional call protection periods. It is time varying and takes the value 0 if the callable bond is prohibited from being called by a conditional protection clause, and 1 otherwise.
DINT is the difference, the bond's interest rate minus the one-year Treasury bill rate.
Ln(Amount) is the natural logarithm of the authorized amount of the bond issue measured in 1 million dollars.
Callable life span is the length of time from *t1* to *t3* measured in 100 thousand days.

<Table 7> **Call hazard function estimates: convertible bonds**

Variable	Estimate	Expected Sign	Standard error	t-value	p-value
Constant	-4.78		1.24	-3.84	0.00
D[0,0.1]	0.87		0.76	1.15	0.25
D(0.1,0.2]	1.30		0.69	1.87	0.06
D(0.2,0.3]	0.36		0.77	0.47	0.64
D(0.3,0.5]	0.74		0.71	1.04	0.30
FASS	0.90		0.52	1.72	0.09
DEBT	1.39		0.93	1.49	0.14
PRO	6.48		2.32	2.80	0.01
DFREE	0.67		0.37	1.82	0.07
DINT	-0.13		0.12	-1.07	0.29
DINT•Ln(Amount)	0.09		0.04	2.28	0.02
VCONV	1.11		0.20	5.69	0.00
Callable life span	20.49		9.82	2.09	0.04

VCONV is the normalized stock price so that the price at the time of issuance is one.

The findings can be summarized as follows. First, calling a non-convertible bond is not expedited as the cost of financial distress increases. This effect is not statistically significant for the callable non-convertible bonds, whereas this effect is marginally significant at 10% level for the callable convertible bonds. Calling a convertible bond is weakly expedited as the cost of financial distress increases. Comparing Tables 9-12 in the

Appendix, this effect is only statistically significant for the convertible bonds without a conditional call protection clause.

Second, calling tends to be deferred in the case of callable non-convertible bonds if the potential agency cost of debt is large. This effect cannot be found for the callable convertible bonds (wrong in sign, though insignificant). This supports the postulation that the distortion of manager incentive in a levied firm can be mitigated if a callable non-convertible bond is outstanding. Results in Tables 9-12 in the Appendix are basically the same.

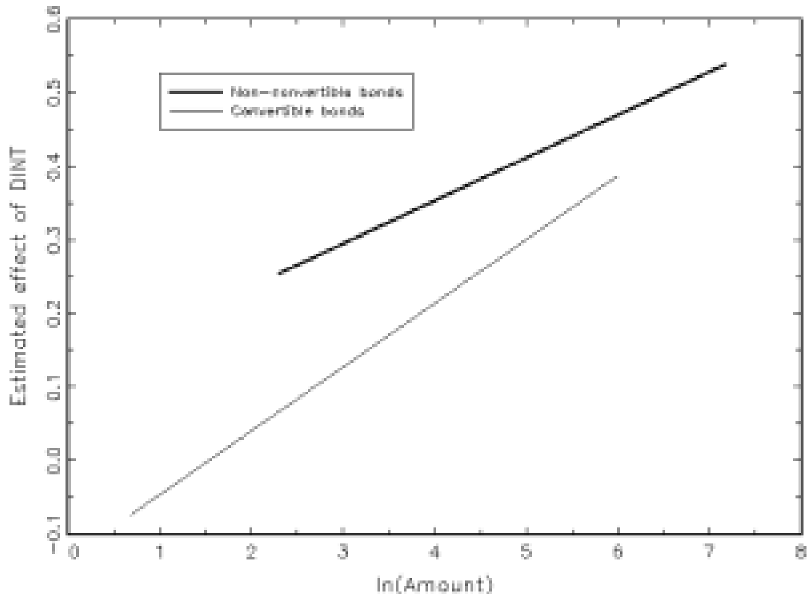
Third, a firm tends to speed up calling if favorable information is released after issuance. Excepting one case, this effect is found significant regardless of convertibility and whether or not each sub-sample is further split based on presence/absence of a conditional call protection clause. In the case of convertible bonds with a conditional call clause, the profitability variable turns out insignificant. This is potentially due to the fact that a call is possible only when stock value satisfies a certain condition under which profitability measure (PRO) and the stock value (VCONV) would be highly collinear.

Fourth, freedom from conditional call protection clauses speeds up calling as should be the case. Callable bonds of a longer life span tend to live a shorter percentage life. These two effects are commonly found regardless of whether a callable bond is convertible or not. Calling a convertible bond is expedited as the conversion value increases, possibly due to conversion forcing call.

Fifth, to compare the effect on calling of the interest rate spread across non-convertible and convertible bonds and to see how this effect interacts with the transaction cost, we plot the estimated effects separately as a function of transaction cost. Specifically, Figure 7 shows the estimated values of $\partial \log h(t \mid x_t) / \partial \mathrm{DINT}$ against ln(Amount) separately for each sub-sample.

As you see, the effect on calling of the interest rate spread is stronger for the non-convertible bonds than for the convertible bonds. For both types of bonds, this effect increases in ln(Amount) suggesting that the interest effect gets stronger as the unit refunding transaction cost drops.

<Figure 7> Estimated effect of DINT in each sub-sample



The following table numerically summarizes the above graph by showing the estimated effects together with their standard errors as computed at three levels of the transaction cost for each sub-sample.

<Table 8> Estimated effect of DINT in each sub-sample

Transaction Cost	ln(Amount)	Non-convertible bonds		Convertible bonds	
		Estimated effect	S.E.	Estimated effect	S.E.
High	2.5	0.266	0.050	0.084	0.042
Medium	4.0	0.353	0.057	0.214	0.036
Low	5.5	0.441	0.103	0.344	0.036

Sixth, the baseline hazard function shows a monotonically decreasing pattern for the non-convertibles bonds, but not for the convertible bonds. Tables 9-12 in the Appendix show that this monotonic pattern is in fact only significant for the non-convertible bonds without a conditional call protection clause, which is consistent with our prior expectation.

Lastly, in other model specifications not reported here (available upon request), we have included return volatility as an additional determinant of the call hazard rate. We have tried two different measures. One is the standard deviation of the stock rates of return using the most recent 12-month data, and the other using the most recent 24-month data. These volatility measures are time-varying in that they measure the volatility using the most recent data at each point in time. Option theory predicts that the higher the rate of return volatility, the higher the value of the conversion option. Return volatility would give firms an incentive to exercise the call option early to preempt the conversion option of the bond holders. In our estimation, none of the volatility measures turns out statistically significant, convertibles or non-convertibles.

7. Concluding remarks

The empirical results are consistent with the theoretical predictions that the cost of financial distress expedites calling, of which the effect is only marginally significant for the convertible bonds but not significant for the callable non-convertible bonds; and that a callable non-convertible bond mitigates the agency cost of debt because firms that are highly in debt delay calling a callable non-convertible bond.

This paper shows that a callable bond, convertible or not, is called to issue a new security if the market interest rate falls; that the interest effect becomes stronger as the transaction cost of refunding is low; that calling a callable convertible bond is significantly expedited by a rise in the conversion value, which suggests that firms often call callable convertible bonds to force a conversion; and that calling a callable bond, convertible or not, is significantly expedited if favorable information is released after issuance, which supports the view that callable bonds mitigate the problem of adverse selection under information asymmetry.

Additionally, this paper shows that callable bonds of a longer life span tend to live a shorter percentage life; and that after the end of call protection periods the call intensity monotonically decreases for the non-convertible bonds but not for the convertible bonds.

The empirical results in this paper lend a support to the view that a convertible bond is partly an equity-like issue (Stein 1992) and partly a debt-like issue (Smith and Warner 1979; Green 1984). On one hand, callable convertible bonds are often called to force a conversion, suggesting that a callable convertible bond is an instrument of deferred equity financing. On the other hand, callable convertible bonds are not a perfect equity-equivalent security. Calling a callable convertible bond is also heavily affected by the refunding opportunity measured by the coupon rate minus the market interest rate, which is a property of debts.

Appendix: Measurement issues, descriptive statistics, and other results

The measurement of time

Let us explain the various time concepts, the time intervals, and normalized time to call by using an example. Consider a convertible bond in Table 2 that was issued by Action Industries Inc. on April 1, 1983. The absolute call protection period ended on April 1, 1985. The company called the bond on July 1, 1993 before it matures on April 1, 1998. There is no conditional call protection period. Using the notation defined in the text, we have $t_0 = 1983/04/01$ (April 1, 1983), $t_1 = t_2 = 1985/04/01$, $t_c = 1993/07/01$, and $t_3 = 1998/04/01$. The callable life span is computed as follows (using one year as the measurement unit):

$t_3 - t_1 = (1998 - 1985) + (4 - 4)/12 + (1 - 1)/365 = 13.$ The time to call is $t_c - t_1 = (1993 - 1985) + (7 - 4)/12 + (1 - 1)/365 = 8.25$. Finally, the normalized time is computed as $t = (t_c - t_1)/(t_3 - t_1) = 8.25/13 = 0.6346$. The callable bond is called at around 63% location of its callable life.

For some observations, various calendar times are available up to a specific date; for others, they are only up to months or years. In the latter case, we need approximations. We adopt mid-point approximation within an interval. For example, when a date is known only up to a year, say 1999, then 1999/07/01 is assigned. When a date is known up to a month, say May 1999, 1999/05/16 is assigned.

Normalization and time varying explanatory variables

At each moment in time, the decision to exercise a call or not is made based on whatever information is then available. In our data set, some explanatory variables are measured annually and others monthly. Suppose it is July 10, 1986. To the corporate manager, yearly data is available for the years up to and including 1985 (up to the previous year) and monthly data is available for the months up to and including June 1986 (up to the previous month). We assume that data for the current year is not available for the yearly data and similarly that data for the current month is not available for the monthly data.

In our data set, variables such as FASS, DEBT and PRO are recorded annually, and variables such as DINT and VCONV are recorded monthly. These variables form time varying explanatory variables in our estimation. For these time varying variables, we assume that the most recently available data affect the decision to call and thus appear in the call hazard rate function. For example, in specifying the hazard rate for July 10, 1986, year 1985 values are used for the yearly recorded explanatory variables, whereas June 1986 values are used for the monthly recorded explanatory variables.

Let us try to understand the way the time varying explanatory variables are rearranged according to the normalized time. This understanding is very important for properly assigning a likelihood value to each individual observation. Note that our hazard rate model uses the normalized time scale, whereas the data are recorded according to calendar time. We have to reconcile this discrepancy. Since our explanatory variables are recorded discretely, we assume that each explanatory variable only varies across different observation intervals and stays the same within each observation interval.

For each callable bond, we observe a realized sample path of each explanatory variable from birth to death, where a death is defined as the earliest time point among call time, right-censoring time, and maturity time. At a point in time between birth and death, the relevant explanatory variable value affecting a manager's call decision is the most recent one. For each time-varying explanatory variable, collection of the relevant values over the course of a call life will form a sample path. Once a realization of an explanatory variable path is thus constructed, we map it on to the normalized time scale. The resulting sample path in the unit time interval will be a step function covering the time horizon from birth to the percentage death point. The number of steps will be larger for the monthly recorded data and smaller for the yearly recorded data.

Once the sample paths are constructed over the unit interval for the time varying explanatory variables, we can easily compute individual likelihood values. This is because the integration appearing in the likelihood function (see subsection 4.4 of the text) reduces to summation due to the step function nature of the time varying explanatory variables as well as of the baseline hazard function.

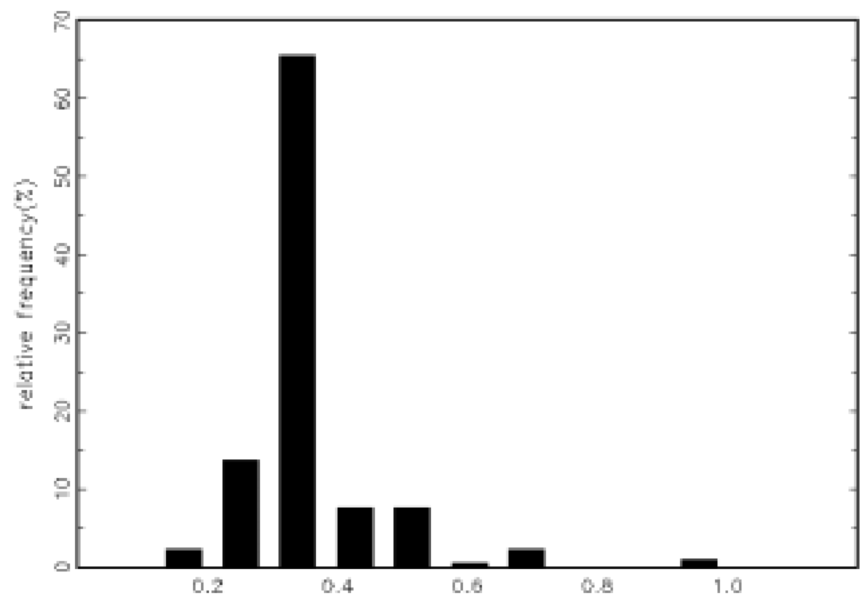
Note that we have already modeled the baseline hazard function as a step function with five steps partitioning the unit interval. The partition points can be represented as a set: A={0, 0.1, 0.2, 0.3, 0.5, 1}. Given a callable bond, the sample path of a monthly recorded explanatory variable will be a step function over the unit interval. This step function will partition the unit interval. Let us refer to the resulting set of partition points as B, which is common to all monthly data. Similarly, let us refer to the set of partition points for the yearly recorded data as C. Of course, C will be a subset of B. Let D be the union of the above three sets, A, B, and C.

Then, the hazard rate function $h(t \mid x_t) = h_0(t)\ \exp(x_t{'}\beta)$ itself will become a step function in the unit interval with steps shifting only at points in set D. Using this hazard rate path, we can easily assign individual likelihood values. Note that sets B and C (and thus D) will be different depending on individual call structures. Therefore, we have to assign individual likelihood values on an individual basis.

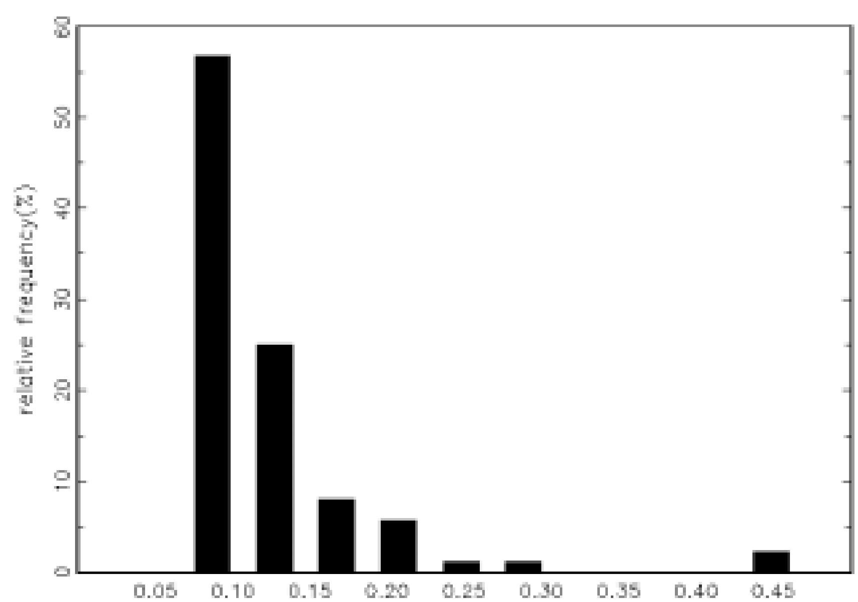
Other descriptive statistics

Figures 8 and 9 show the distribution of the normalized time to the end of the conditional call protection periods for those bonds with a conditional call protection clause for the sub-sample of non-convertible bonds and the sub-sample of convertible bonds. The convertible bonds have shorter percentage life covered by a conditional call clause than the non-convertible bonds.

<Figure 8> Histogram showing normalized time to the end of the conditional call protection period: callable non-convertible bonds

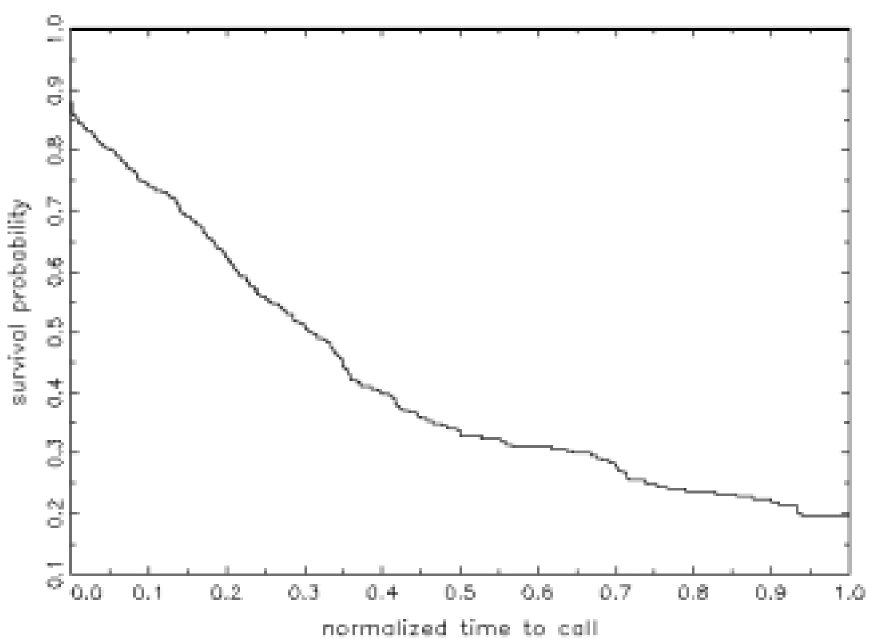


<Figure 9> Histogram showing normalized time to the end of the conditional call protection period: callable convertible bonds

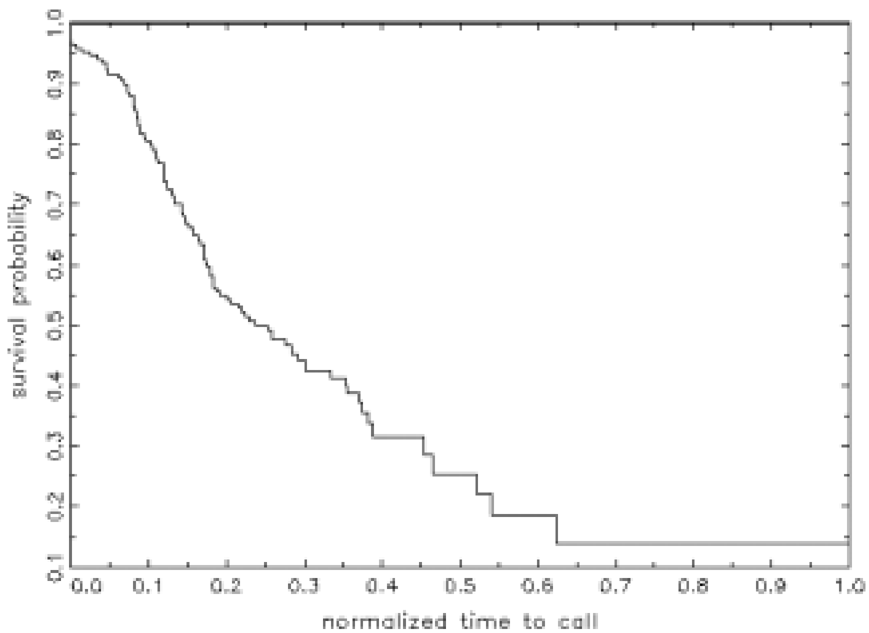


To account for right-censoring, we compute Kaplan-Meier survival function estimates. Figures 10 and 11 show the Kaplan-Meier survival function estimates for the sub-sample of non-convertible bonds and the sub-sample of convertible bonds. From Figures 10 and 11, we observe that about two thirds of calls are made before 50% location of its callable life span for the callable non-convertible bonds, whereas about three fourths of calls are exercised before 50% location of its life span for the callable convertible bonds.

<Figure 10> Survival function estimate for normalized time to call: callable non-convertible bonds



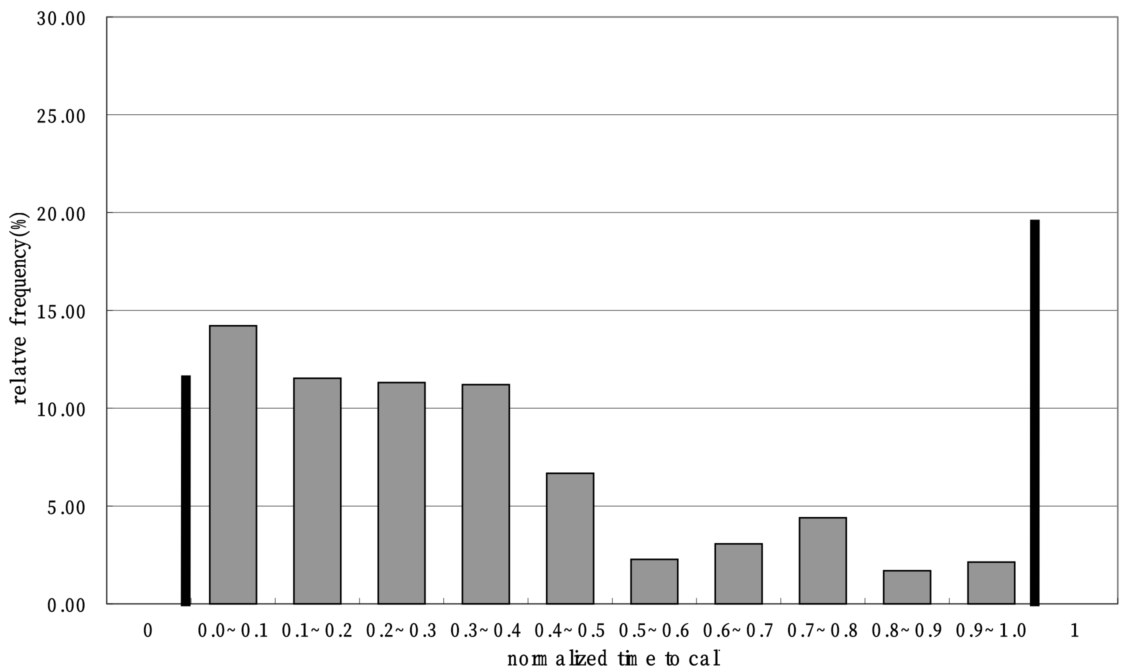
<Figure 11> Survival function estimate for normalized time to call: callable convertible bonds



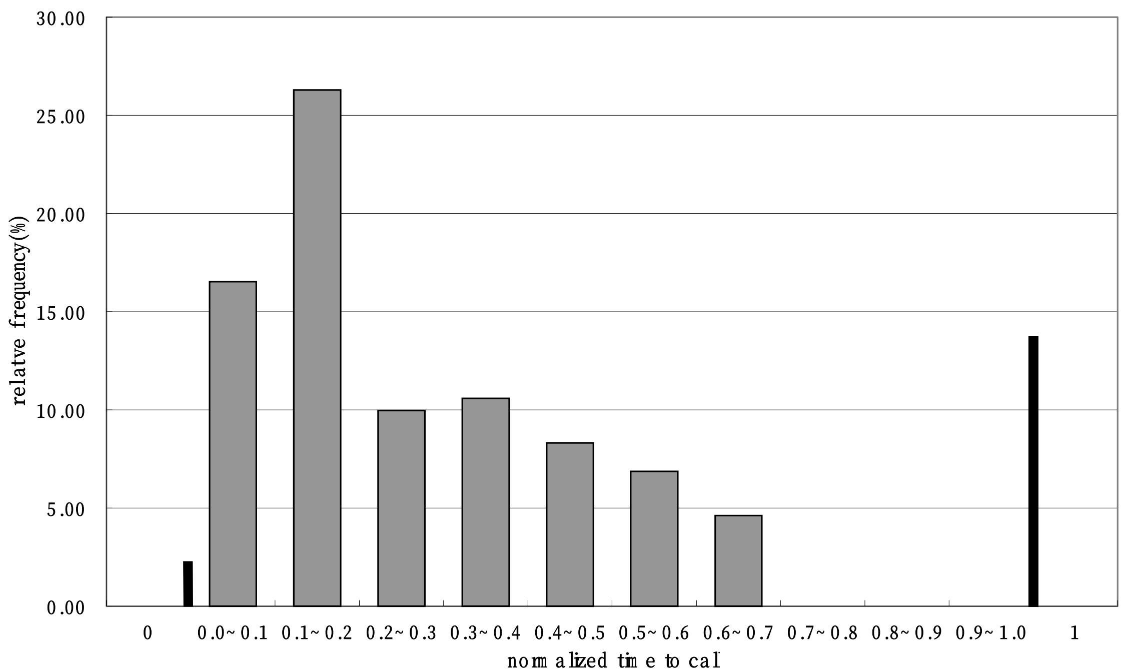
Figures 12 and 13 show the distribution of the normalized time to call for the sub-sample of non-convertible bonds and the sub-sample of convertible bonds. These histograms are constructed using the information contained in Figures 10 and 11. They show the relative frequency of time to call for each decile of callable life span (10 bars in the middle), proportion of calls made exactly at absolute call ending point (thick line on the left), and the proportion of calls not exercised until maturity (thick line on the right).

By comparing Figures 12 and 13, we observe that the time to call is more spread throughout its life for the non-convertible bonds than for the convertible bonds. As you see, 11.7 % of calls are made right after the absolute call protection period ends whereas 19.7% of calls are left unexercised until maturity for callable non-convertible bonds. These figures are 2.4% and 13.9% for the callable convertible bonds.

<Figure 12> Histogram showing normalized time to call: callable non-convertible bonds

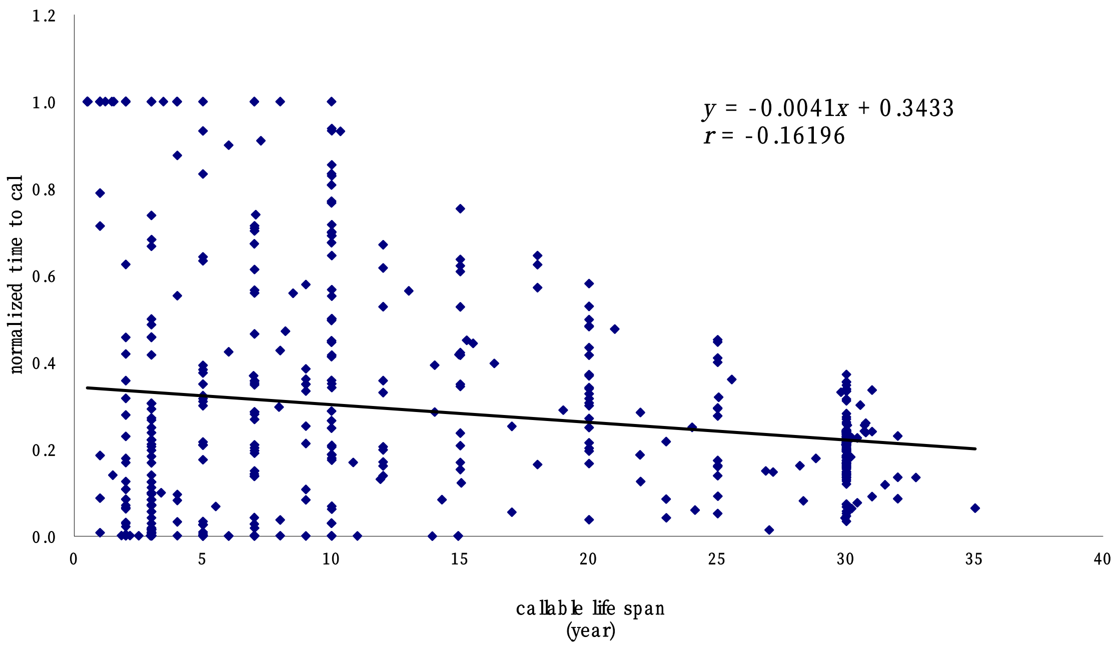


<Figure 13> Histogram showing normalized time to call: callable convertible bonds

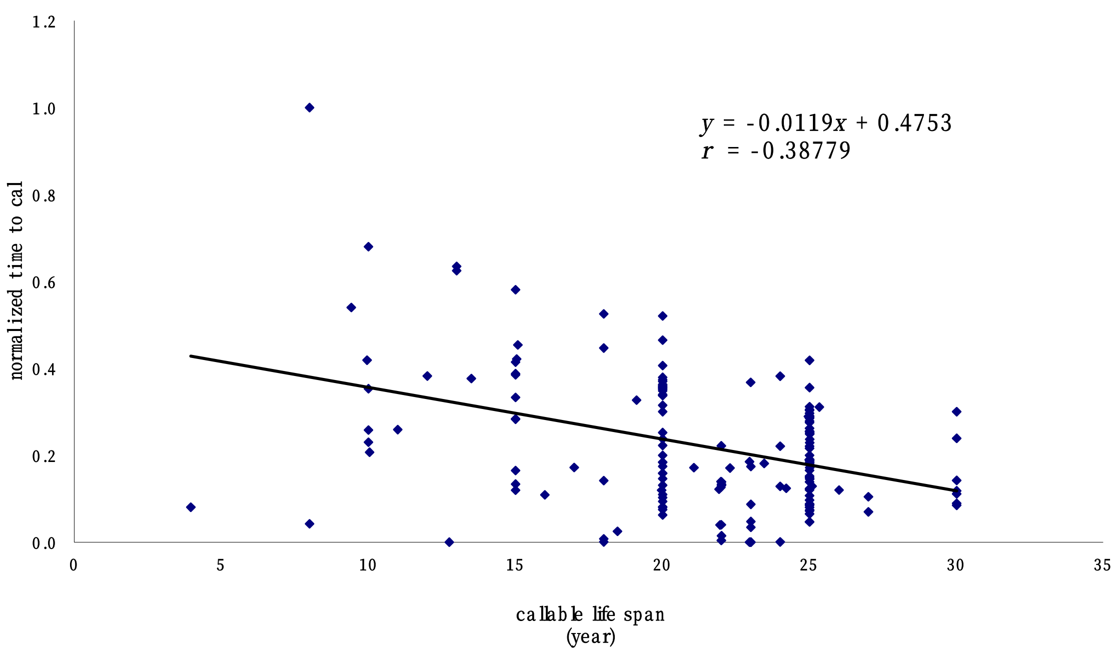


To see whether the normalized time to call differs systematically across callable bonds of different life spans, we draw scatterplots of the normalized time to call against the callable life span for the sub-sample of non-convertible bonds and the sub-sample of convertible bonds. Figures 14 and 15 show these scatterplots. We also include simple linear regression lines with correlation coefficients.

<Figure 14> Scatterplot showing normalized call time vs. callable life span: non-convertible bonds



<Figure 15> Scatterplot showing normalized time to call vs. callable life span: convertible bonds



These scatterplots show that a callable bond with a longer life span is called earlier in terms of percentage of life. This is true for callable non-convertible bonds as well as for callable convertible bonds. We naturally expect that the call hazard rate would be higher for a callable bond with a longer life span than for a similar bond with a shorter life span at each percentage point in callable life.

Other estimation results

Tables 9-12 show the call hazard function estimates for each of four sub-samples classified by convertibility and presence/absence of conditional call protection periods.

<Table 9> Call hazard function estimates: non-convertible bonds with conditional call clause

Variable	Estimate	Standard error	t-value	p-value
Constant	-2.75	0.81	-3.37	0.00
D[0,0.1]	-0.56	0.65	-0.87	0.38
D(0.1,0.2)	0.00	0.59	0.00	1.00
D(0.2,0.3)	-0.09	0.57	-0.16	0.88
D(0.3,0.5)	0.28	0.46	0.62	0.54
FASS	-0.03	0.47	-0.07	0.94
DEBT	-2.08	0.60	-3.47	0.00
PRO	4.92	1.64	3.00	0.00
DFREE	0.48	0.37	1.30	0.19
DINT	0.15	0.12	1.22	0.22
DINT•Ln(Amount)	0.08	0.02	3.70	0.00
Callable life span	14.33	4.00	3.58	0.00

<Table 10> Call hazard function estimates: nonconvertible bonds without conditional call clause

Variable	Estimate	Standard error	t-value	p-value
Constant	-1.70	0.39	-4.30	0.00
D[0,0.1]	2.18	0.25	8.65	0.00
D(0.1,0.2)	0.57	0.31	1.82	0.07
D(0.2,0.3)	0.86	0.31	2.79	0.01
D(0.3,0.5)	0.81	0.29	2.83	0.00
FASS	0.40	0.41	0.97	0.33
DEBT	-2.21	0.55	-4.05	0.00
PRO	5.18	1.68	3.08	0.00
DINT	0.07	0.07	0.99	0.32
DINT•Ln(Amount)	0.05	0.01	4.32	0.00
Callable life span	-0.32	3.12	-0.10	0.92

<Table 11> Call hazard function estimates: convertible bonds with conditional call clause

Variable	Estimate	Standard error	t-value	p-value
Constant	-4.13	1.09	-3.78	0.00
D[0,0.1]	0.10	1.21	0.08	0.94
D(0.1,0.2)	0.49	0.86	0.57	0.57
D(0.2,0.3)	-1.28	0.88	-1.45	0.15
D(0.3,0.5)	-0.36	0.64	-0.57	0.57
FASS	-0.29	0.80	-0.37	0.72
DEBT	2.93	1.49	1.97	0.05
PRO	0.78	3.67	0.21	0.83
DFREE	0.92	0.78	1.18	0.24
DINT	-0.90	0.28	-3.24	0.00
DINT•Ln(Amount)	0.27	0.08	3.65	0.00
VCONV	2.60	0.29	8.92	0.00
Callable life span	-0.14	13.00	-0.01	0.99

<Table 12> Call hazard function estimates: convertible bonds without conditional call clause

Variable	Estimate	Standard error	t-value	p-value
Constant	-3.89	1.67	-2.33	0.02
D[0,0.1]	0.75	1.01	0.75	0.45
D(0.1,0.2)	0.96	0.88	1.09	0.28
D(0.2,0.3)	0.25	0.99	0.26	0.80
D(0.3,0.5)	-0.34	1.06	-0.32	0.75
FASS	1.54	0.68	2.27	0.02
DEBT	0.30	1.43	0.21	0.84
PRO	7.03	2.57	2.73	0.01
DINT	0.07	0.14	0.49	0.63
DINT•Ln(Amount)	0.02	0.05	0.52	0.61
VCONV	1.00	0.21	4.75	0.00
Callable life span	23.80	14.53	1.64	0.10

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