

## **Convertible Bond Issuance, Risk, and Firm Financial Policy: A New Approach**

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### **ABSTRACT**

This paper develops a new model of convertible bonds in the firm's financial policy that addresses several empirical puzzles that are not consistent with extant theory. The model demonstrates that managers of all types of firms, irrespective of quality would choose convertible bonds in their financing plans when facing uncertainties about the timing of the project. This result holds even for the case in which management's prognosis about the likelihood of success of the project is correct. Convertible bond issuance can be optimal for firms that do not have an established record of strong historical performance but have opportunity sets that include good projects subject to timing uncertainties. For other firms, there may be cost/benefit tradeoffs on their use. Investors can derive direct benefits from the signaling properties of convertibles: their issuance per se is a credible signal on the expected future prospects of the firm. Furthermore, convertibles provide indirect advantages to investors since they help to complete the markets. Alternative instruments are incapable of replicating the payout structure of convertibles in a cost-effective manner. These direct vs. indirect effects can be empirically tested, based on the return structure of naked vs. hedged positions in convertible bonds.

*JEL Classifications:* G12, G32

*Keywords:* convertible bond issuance; timing uncertainty; signalling; market completion

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## I. INTRODUCTION

Convertible bonds ('CBs' hereinafter) are hybrid securities with both debt and equity features, and have served as a major source of financing for firms over the past two decades. According to SDC data, from 1995 to 2006, the total value of CB issues increased in the US by 581.60%. Over this period, the ratio of CB financing to equity financing expanded from 10.15% to 36.75%.

The popularity of CBs appears puzzling from a number of perspectives. First, establishing a fair price for any particular CB is complex, due to its long-term option-like characteristics. CBs are typically embedded with interacting indenture components that may not respond uniformly to expected or unexpected events. Consequently, it is still a challenge to 'correctly' price CBs for both issuers and investors. CBs, as complex financial instruments for problems related to financing and investment are not consistent with the Principle of Ockham's Razor.<sup>1</sup> Why do firms issue CBs and do investors find them attractive? The purpose of this paper is to develop a theoretical model to address these issues.

Researchers have identified several justifications for CB issuance including: providing lower cost financing relative to straight bonds or pure equity financing, dealing with asymmetric information, tax benefits, risk mitigation benefits, as well as agency benefits (e.g., Jensen and Meckling, 1976; Green, 1984; Brennan and Schwartz 1988; Stein, 1992; Jalan and Barone-Adesi, 1995; Isagawa, 2000 and 2002; Loncarski, Horst, and Veld, 2006a).

Counterbalancing these benefits of CBs are various potential costs, however.<sup>2</sup> CBs could be more expensive than either pure equity or straight debt financing, given the firm's *ex ante* prospects. For example, if a firm projects some likelihood of poor performance *ex ante*, CBs might not be converted. And issuers may be forced to redeem CBs when their cash flow is already under pressure. Firms on the verge of financial distress will encounter further difficulties in their future financing plans as a consequence of CB investor disappointment. Managers put at risk both their personal portfolios invested in the firm and their reputation for their future careers. In this scenario, issuers could be better off if they had chosen equity financing instead. On the other hand, if the management is certain about the favourable prospects of their new projects, it could be cheaper for them to use some other form of financing besides convertibles. Specifically, they could issue regular corporate bonds at the initial financing stage for the new project, then wait until the stock price rises to reflect the benefits of the project, and then finance with equity. We refer to this alternative (straight debt followed by straight equity) serial financing plan as AP henceforth.

Additionally, CB financing introduces an element of uncertainty to the firm's cash flow and future financing requirements due to the uncertain nature of investor holding periods over longer horizons. Firms with a large overhang of unconverted CB's often face difficulties when they must resort to capital markets for subsequent financing. Empirically, the conversion process of CBs is slow (e.g., Ederington, Caton and Campbell, 1997; Byrd, Mann, Moore and Ramanlal, 1998). Several empirical studies show that the price of CBs has to stay well above the conversion price for a considerable period of time before issuers use their call rights to force investors to exercise their CBs. It appears that issuers do not deploy theoretically optimal call strategies, such as that of Brennan and Schwartz (1977a): "call the bond as soon as the

value of the bond if called is equal to the value if not called.”

Suboptimal call policies can be attributed to a number of factors: 1) management wants CBs to be converted into equity, 2) financial stress could show up if CBs are called too early, and 3) to call is a bad signal for the issuer. Investors also tend to hold CBs longer than would appear optimal for a number of reasons<sup>3</sup>, including: 1) their desire to share in the upside potential of the firm – holding a CB is less risky than holding the underlying stocks of the company since investors receive a more stable stream of returns when they buy the CBs; 2) it is optimal to hold an American call option, which is a key term embedded in CBs, until maturity without exercise; and 3) investors can set up hedged portfolios by combining CBs with other CBs, call or put options, bonds and underlying shares to realize good portfolio returns with low-risk, as demonstrated in Fabozzi, Liu, and Switzer (2009).

Empirically, what could be the difference in dilution effect between the CB financing plan and the AP plan? Fabozzi, Switzer, and Liu (2009) note that from 1990 to 2006, a simulated portfolio comprised of the underlying stocks of all the issuers whose issue size is at least \$100 million generates a return of 24.18% and 41.97% respectively at the end of the second and third year from the issue date. If the sample includes observations only with a rating of B or lower, the returns are 50.58% and 92.29%; and that for a rating of Caa or lower becomes as high as 210.63% and 264.48% at the end of the second and third year from the issue date. In contrast, the average conversion premium of CBs in the same period is only 28.20%.<sup>4</sup> If these CB issuing firms had chosen the AP plan instead - i.e. to first issue regular bonds to meet capital requirements, as there are no dilution effects,<sup>5</sup> it is safe to say that the stock returns of the firm after the bond issuance could be similar to those provided by the CB financing plan. Consequently, if these firms chosen to issue equity two or three years after the regular bond financing, the equity issuance price should be higher than the conversion price in the CB financing plan. Consequently the dilution effects of AP seem to be less, especially for lower-rated issuers with larger issue size. It would appear that CB financing should be dominated by AP. Although there are some interest rate-cost savings by issuing CBs compared with issuing straight corporate bonds, this cost is only charged in the life of the bond, not the life of the firm. The dilution effect is more important for current shareholders.

This puzzle cannot be well explained in the extant theoretical literature. Two papers are relevant to this puzzle. Stein (1992) develops a backdoor equity financing theory of CBs, which asserts that medium quality firms prefer to postpone their equity financing, only if information asymmetries completely disappear at the second period. However, the results of Fabozzi, Liu, and Switzer (2009) indicate that to postpone the equity financing for two or three years is not a bad idea for such firms. Thus, the empirical evidence supports the alternative rationale proposed in this paper: issuers choose to use CBs in order to flexibly deal with uncertainties. Mayers (1998) deems CBs a better financing plan than two-period straight debt since CBs can reduce financing costs. However, Mayers (1998) does not address the AP.<sup>6</sup>

Two additional reasons might help to justify the puzzling choices of issuers. First, CB issuers cannot implement the AP due to debt capacity constraints, which can be measured by the type of assets can be pledged, how much debt a firm has already used, and the profitability of the firm. Does the debt capacity differ greatly between CB issuers vs. non-issuers? Debt capacity ratios can be inferred from the empirical

estimates of Essig (1992).<sup>7</sup> Based on these results, the difference in debt capacity between firms with CBs in their capital structure and firms who do not use CBs is marginal: the ratio<sup>8</sup> of property, plant and equipment plus inventory to total assets is 57.13%, and 57.85%; the ratio of total debt to market value of equity is 83.95% and 83.32%; the ratio of EBDIT to sales is 13.51% and 13.36% respectively for the CB users vs. nonusers. Using COMPUSTAT data, we note that in the period from 1995 to 2006, CB issuing firms with a rating of B or lower have a long-term debt to equity ratio of 14.15%, and a total debt to equity ratio of 69.02%. The CB offering as such does not affect their overall debt ratio.<sup>9</sup> Hence, debt capacity constraints do not appear to influence choices between issuance of CB's vs. AP.

Another potential reason for issuing CB's is that the delayed equity issuance in the AP may occur at significant price discounts. However, if issuers use the proceeds to make good investments, equity issuance may not be bad news at all. Jung, Kim and Stulz (1996) find that firms with the most valuable investment opportunities do not experience adverse stock returns when they issue equity. Furthermore, according to Fabozzi, Liu and Switzer (2009), two to three years subsequent to the CB issuance, pronounced equity price increases are observed for CB issuing firms. Consequently, we cannot say these firms choose CBs because the price discount in equity financing would be larger.

This paper develops a model that directly addresses the question: "Why do firms issue CBs rather than equity or straight debt, given managers' expectations about the firms' future performance?" This model serves to characterize the behavioral aspects of both managers and investors when facing uncertainties. The model demonstrates that in an environment of *timing uncertainty*, in which firms cannot predict when a new project will become fully operational, CB issuance could be an optimal financial decision for managers, firms, and investors. Firms that lack a strong historical performance record as well as those with a limited portfolio of promising new projects will have greater incentives to issue CB's than other types of firms. This hypothesis is supported by the empirical evidence.

The discrete model used herein is most comparable to that of Stein (1992) and Mayers (1998). However, our model is based on different assumptions and has different implications. Stein's (1992) model is based on asymmetric information about assets in place, and tries to use convertibility to solve a financing problem at the time of the CB issuance. Mayers' (1998) model is based on uncertainty about the value of future investment options, and tries to solve a future financing problem using the objective of cost minimization. This paper is based on uncertainty about the timing of the cash flows of a newly invested project, and tries to analyze the time-varying risk profiles of firms, in order to address why firm still want to use CB instead of the AP plan when the financing cost of CBs is not necessarily low.

This paper has relevance for corporate financing and investment decisions and financial engineering practice. The remainder of this paper is organized as follows: Section II provides a brief literature review. Section III introduces a new model that addresses the role of convertible bonds in the firm's financial policy. Section IV sets forth the empirical evidence that supports the model. Section V provides a summary and conclusion.

## II. LITERATURE REVIEW

The question of why firms use CBs and how the market reacts to their issuance has been addressed in a considerable body of research over the past half century. Modigliani and Miller (1958, 1961, and 1963) propose that financing decisions, including those related to the issuance of convertibles, are irrelevant to the firm's valuation. Stiglitz (1969 and 1974) shows the irrelevance theory to be valid under more general conditions. However, Jensen and Meckling (1976) and Green (1984) provide seminal arguments that CBs can be used to alleviate existing shareholders' risk-taking incentives that are at the expense of bondholders by allowing debt holders to share in the upside. Myers and Majluf (1984) and Myers (1984) argue that firms issue CBs to avoid asymmetric information in their pecking order theory. They argue that CBs should dominate equity financing since CBs are less risky. Heinkel and Zechner (1990) show that with information asymmetry, CB's have a role in mitigating the over-investment problem faced by all-equity financed firms. Constantinides and Grundy (1989) and Stein (1992) suggest that firms use CBs to inject new equity into the capital structure with lower asymmetric information costs. Lewis, Rogalski, and Seward (2001) explain the use of CBs based on equity market rationing, which supports Stein (1992). Baker and Wurgler (2002) extend the asymmetric information approach and demonstrate that firms can use different financial instruments to time the market based on managements' expectations.

Brennan and Kraus (1987) and Brennan and Schwartz (1988) argue that the appeal of CB's relates to their insensitivity to company risk. Mayers (1998) argues that firms use CBs to reduce financing costs as an alternative to sequential financings using equity and/or straight debt in the presence of serially correlated real options/investment opportunities. Carlson, Fisher, and Giammarino (2004, 2006) confirm that beta provides a good measure of risk for studying the return dynamics around equity financing.

Several empirical papers have examined the motivation for firms to issue CB's, firm characteristics associated with CB issues, and the market reaction to CB issuance. Billingsley and Smith (1996) conclude that firms use convertibles primarily as an alternative to straight debt as a means to preserve cash flow via lower interest costs. Essig (1992) shows that the ratios of R&D to sales, market value to book value of equity, and long-term debt to equity as well as the volatility of the firm's cash flows, are all positively associated with firms' propensities to employ convertible debt. Lee and Figlewicz (1999) compare different characteristics of firms that issue convertible debt versus convertible preferred stock. The choice of the former is found to be associated with proxies for asymmetric information, financial distress, and taxes.

In sum, the existing theoretical literature cannot fully address the puzzle of CB financing. Several empirical studies have identified and tested factors that help explain CB financing. These studies have largely focused on the issuers' perspective only. Our argument is that from an incentive compatibility perspective, one should focus both on issuers and investors to study the role of CBs in the firm's financial policy.

## III. A NEW PERSPECTIVE ON CB ISSUANCE

We propose an alternative perspective for the popularity of CBs. This approach is rooted in the unique structure of CB's as contingent claims that appeal to both firms and investors facing uncertainties.

### A. Background Assumptions and Exposition of the Approach

The analysis starts with the basic premise that CBs can be tailored to the expectations of managers concerning uncertainty. The conversion premium can be set to adjust the likelihood of future conversion. The maturity is normally set to be quite long in order to decrease risks resulting from technical delays in the project or from unfavorable market conditions. The actual life of CBs could be shortened by the call rights set by issuers. Coupon rates can be flexibly set to change the holding value of CBs in different time periods. Mandatory conversion can also be used to facilitate the conversion. The conversion price could bear a reset option to facilitate the conversion of CBs. Put rights may be added to make CBs more attractive. By issuing CBs, managers in fact possess a real option to make their financing and investment decisions simultaneously, so that they can comfortably wait for further information before committing additional resources to the project.

A side effect of the incorporation of diverse contingent claims within the CB indenture, transforms CBs into structured financial notes that balance the requirement of issuers and investors.<sup>10</sup> By investing in CBs, investors simultaneously get a combination of different financial instruments, which might be technically impossible to replicate or prohibitive in terms of financial costs to replicate.<sup>11</sup> As illustrated in Fabozzi, Liu and Switzer (2009), profitable trading opportunities exist using:

- a) combinations of CB's with underlying stocks, exploiting the non-linear price relationship between CBs and underlying stocks;
- b) combinations of CB's with call or put options; and
- c) combinations of CB's with other CBs, or corporate bonds.

There is a high probability that investment opportunities will appear among different financial instruments when their prices fluctuate. Hedging can be used to mitigate or eliminate investment risk. In fact, several studies show that CB hedge funds generate meaningful returns with low volatilities compared with the stock mutual funds, and even index funds,<sup>12</sup> and these returns cannot be explained by Fama-French factor models.

Second, issuance can be accomplished without too much difficulty since the value of CBs can be easily agreed upon by parties, who recognize the inherent uncertainties surrounding the payoffs. A CB is a combination of a straight non-callable corporate bond and several options for investors and issuers. When the volatility of underlying stocks increase, the bond price goes down, but the conversion option value goes up. *Ceteris paribus*, the value of CBs remains relatively stable. As the life of CBs is normally long, an increase in the value of conversion option can more than compensate for the depreciation in the value of the pure bond component of. In addition, the risks of CBs serve to restrain excess risk-seeking activities of management. When the future performance is poor, CB holders can maintain their positions until maturity, while earning the bond interest component. Alternatively, prior to maturity CBs holders can redeem their CBs based on the put rights established in the CB indentures. In the event of bankruptcy, CB holders have pre-emptive rights to the firms' assets relative to equity holders. On the whole, CBs returns will be linked to equity returns, but their overall risk will be lower than that of a pure equity investment.

Third, by using CBs, issuers can credibly signal the upside potential of their new projects to investors when facing uncertainty. Since conversion prices are normally set

at a premium over current stock prices, and stock prices tend to stay well above conversion prices for an extended period prior to conversion, managers should believe that their firms has great upside potential when they choose to issue CBs. Otherwise, they would be better off to issue equity to eliminate potential financial distress risk associated with CBs. The implication of this consideration is investors could gain by holding naked long position of CBs at the issuance.

In sum, CBs can have a beneficial role for issuers, in conveying information about the firm's prospects to potential investors, in the presence of uncertainty.

### **B. The Model in a Continuous-Time Framework**

Technically, the valuation models of CBs can be classified into several categories. The first group, known in the literature as *structural models*, uses the value of the firm as the underlying state variable, with the lower reorganization boundary and the allocation of residual values of the firm on liquidation are treated exogenously (Sundaresan, 2000). Ingersoll (1977) and Nyborg (1996) use this method to price CBs, and Lewis (1991) extends it to incorporate more complicated capital structures. These models are well entrenched in economic theory, and are straightforward to implement when sufficient restrictions are included for deriving closed form solutions. However, empirically, such models have several limitations, including: 1) different call and put features cannot be easily incorporated, 2) path-dependent features cannot be incorporated, and 3) there is no reliable data source of firm value in continuous time.

An alternative to structural models that is favored by practitioners is the class of *reduced form* models that use the value of equity as the underlying state variable, with default outcomes and recovery rates set exogenously. For these models, a CB is a corporate bond plus a call option on firm equity. One common practice when we study the risks and sensitivities of CBs is to treat the call option of CBs as the main source of risk of CBs and calculate the Greeks<sup>13</sup> of CBs based on Black and Scholes (1973).

Models based on binomial trees represent an extension of the reduced form modeling approach. These models incorporate credit risk into CB valuation. Goldman Sachs (1994) is the first to price CBs using the binomial tree method proposed by Cox, Ross, and Rubinstein (1979). Tsiveriotis and Fernandes (1998) formulize this method. Carayannopoulos and Kalimipalli (2003) use a trinomial tree to incorporate credit-risk. Shivers (2003) incorporates more CB features in setting up their binomial trees. Other models are based on simulations. Buchan (1997) extends the Monte Carlo simulation methodology to price CBs. These numerical methods allow for the incorporation of many CB features into the estimation. However their computation time is huge and the availability of data makes it hard to fully meet the requirements of parameter inputs.<sup>14</sup>

Our approach herein is to develop a new structural model for CBs, which extends previous work, to allow us to calculate the value of the CB issuing firm from the issue date.

Assume that a firm has a value  $V$  which follows a diffusion process with constant rate of return volatility:<sup>15</sup>

$$\frac{dV}{V} = \mu dt + \sigma dW \quad (1)$$

where  $\mu(\bullet)$  is the drift, and  $W$  is a standard Brownian motion. Similar to Black and Cox

(1976), we assume that there exists a riskless asset that pays a constant rate of interest  $r$ . We assume further that at the outset there is only equity in the firm's capital structure, and the firm subsequently chooses to issue CBs to raise capital. Let  $F1(V, \tau)$  and  $F2(V, \tau)$  be the values of CB and equity respectively. The Value of the firm,  $V$  can be written as:

$$V = F1(V, \tau) + F2(V, \tau) \quad (2)$$

It is well-known that the CB's value follows the partial differential equation

$$\frac{1}{2}\sigma^2V^2F1_{VV}(V, \tau) + rVF1_V(V, \tau) - rF1(V, \tau) + F1_\tau = 0 \quad (3)$$

where  $F1_V$  and  $F1_{VV}$  are the first-order and second-order of partial differential of  $F1$  with respect to  $V$  respectively,  $\tau$  is the time to maturity.

Substituting  $F2=V-F1$  into the formula, we have

$$\frac{1}{2}\sigma^2V^2F2_{VV}(V, \tau) + rVF2_V(V, \tau) - rF2(V, \tau) + F2_\tau = 0 \quad (4)$$

It should be noted that if one were to assume that the value of the financial asset is time-independent, following Leland (1994), we can derive close-form solutions incorporating default risk and recovery rates. Sarkar (2003) extends this approach to study the early and late calls of CBs. Since we assume the financial asset is time-dependent, Leland-type models in which  $t$  is not present, cannot be employed here. Imposing the boundary conditions, obtain the solution of Equation (3) as:

$$F1(V, T) = e^{-rT}E^Q \left[ \begin{array}{l} V_T, V_T \leq B \\ B, \gamma V_T \leq B \leq V_T \\ \gamma V_T, B \leq \gamma V_T \end{array} \right] \quad (5)$$

Consequently, we have:

**LEMMA 1**

The value of the equity  $F2(V, T)$  for a firm with a convertible bond  $F1(V, T)$  in its capital structure is given by:

$$\begin{aligned} F2(V, T) &= V - F1(V, T) = e^{-rT}E^Q \left[ \begin{array}{l} 0, V_T \leq B \\ V_T - B, \gamma V_T \leq B \leq V_T \\ (1 - \gamma)V_T, B \leq \gamma V_T \end{array} \right] \\ &= C(V, B, T) - \gamma C\left(V, \frac{B}{\gamma}, T\right) \end{aligned}$$

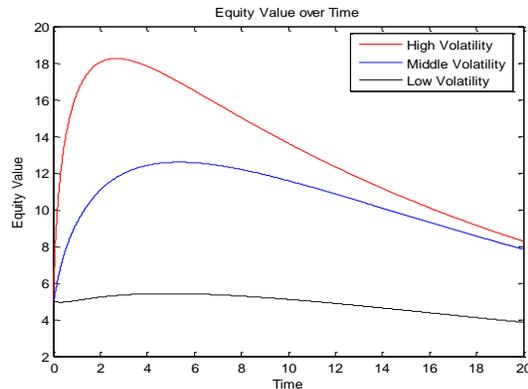
where  $B$  is the contracted payment to CB holder at maturity of the part without conversion;  $C(\bullet)$  is the call option value in Black-Scholes formula;  $\gamma$  is the dilution factor ( $\gamma = \frac{m}{m+n}$ ),  $m$  is the shares converted from CBs,  $n$  is the initial shares before the CB issuance.

Using Lemma 1 we can study the relationship between firm's equity value and time. Part A and Part B of Figure 3-1 depict this relationship with smaller ( $\gamma=10\%$ ) and bigger ( $\gamma=50\%$ ) dilution factor respectively.<sup>16</sup> We find that the relationship is bell-shaped. At the criteria of maximum of shareholder's value, the use of CBs is more suitable for firms with lower level of risk. This is especially true if the CB issue size is relatively big compared to the current shareholder value, which is shown in the Part B of Figure 1.

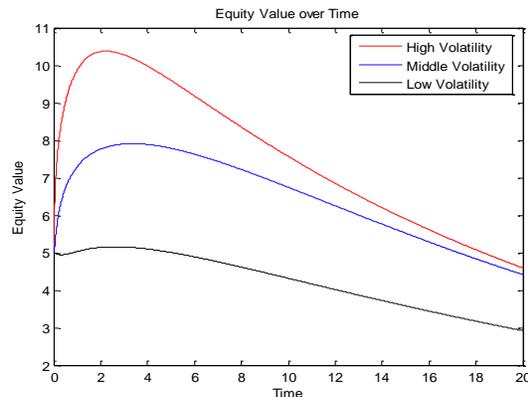
**Figure 1**  
The fluctuation of equity value over time

This figure depicts the change of equity value over time. The red, blue and black lines are CB issuers with a volatility of high level, middle level and low level, respectively.

**Part A. Low dilution factor scenario ( $\gamma=10\%$ )**



**Part B. High dilution factor scenario ( $\gamma=50\%$ )**



In a similar vein, we can extend Lemma 1 to incorporate regular corporate bonds in the firm's capital structure. The results are provided in Appendix C.

Extending Merton (1974), let  $\sigma_2$  be the standard deviation of the return on the equity of the firm.

**LEMMA 2**

The ratio of the risk of the firm after the CB issuance  $\sigma$ , to the risk of the firm before the CB issuance  $\sigma_2$  is given by:<sup>17</sup>

$$\frac{\sigma}{\sigma_2} = \frac{1}{\Phi(d_1) - \gamma\Phi(d_1')}$$

$$d_1 = \frac{\ln\left(\frac{V}{B}\right) + \left(r + \frac{\sigma^2}{2}\right)\tau}{\sigma\sqrt{\tau}} \quad \text{and} \quad d_1' = \frac{\ln\left(\frac{V\gamma}{B}\right) + \left(r + \frac{\sigma^2}{2}\right)\tau}{\sigma\sqrt{\tau}}$$

where  $\Phi(\bullet)$  is the cumulative distribution function of the standard normal distribution.

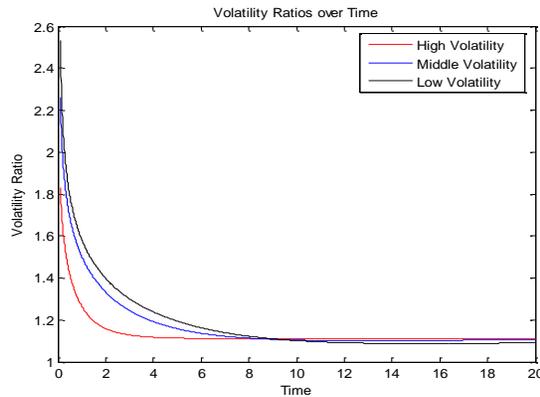
Figure 2 depicts the relationship of the ratios of total risk to equity risk over time after the CB issuance. Since we assume that there are only two assets in the firm's capital structure, the additional risk of the firm is brought by the issuance of CBs. We find that the CB issuance increases the total risk of the issuing firm. Furthermore, the lower the risk before the issuance, the higher the percentage increases of the total risk because of the CB issuance. Firms with higher risks before the CB issuance experience a more rapid decline in total risk over time relative to their counterparts.

**Figure 2**

The variation of risk ratios over time

This figure illustrates the dynamics of the ratio of total volatility to equity volatility for CB issuers after the CB issuance. The red, blue and black lines are CB issuers with a volatility of high level, middle level and low level respectively.

**Panel A. Low dilution factor scenario ( $\gamma=10\%$ )**



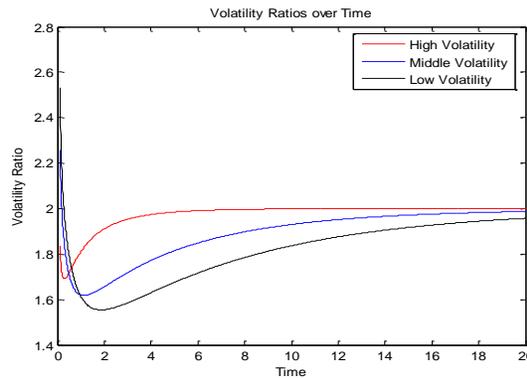
**Panel B. High dilution factor scenario ( $\gamma=50\%$ )**

Figure 1 and Figure 2 serve to illustrate that with uncertainty on the timing of payouts for the CB-financed project, there are different expected return/risk dynamics for firms with different levels of risk. On the whole, CB financing of new projects is more appropriate for firms whose risk profiles are not low. This can be empirically tested by looking at the impact of firm risk and issuance risk on the abnormal returns around the issuance date of CBs for firms with different risk profiles. Variation of the risk profiles over time should also influence the returns of underlying stocks after the CB issuance date. Volatility related proxies can measure the risks of CBs and equities. The standard deviation of beta is selected to measure the risk of equities since: 1) beta is a better measurement of risk than the standard deviation when we deal with diversified portfolios; 2) we want to evaluate the determinants of abnormal returns, not the returns, so we resort to higher moments of the beta; and 3) the standard deviation of beta can measure the fluctuation of the market's attitude toward the firm issuing CBs. Vega, which measures the sensitivity of the CB price to the volatility of underlying stocks, represents one aspect of the issuance risk. Another aspect of the issuance risk is the liquidation/dilution effect that is dependent on the relative size of the CB issuance.

The reduced form of the CB model essentially separates the bond and option components of the instrument. The bond component is evaluated as a corporate bond belonging to the risk class represented by its rating, while the equity part of the CB is an option to exchange the bond for the number of shares represented by the conversion ratio. This option will be in-the-money if the share price exceeds the conversion price, the share equivalent of the market value of the bond component, which plays the role of the option's strike price. This evaluation can only be considered an approximation, since neither the conversion price stays constant over the life of the CB, nor does the call option follow the Black-Scholes option model. The value of the CB's bond component varies with macroeconomic conditions as the risk spread appropriate to its class changes, implying that the conversion price (the option's strike price) is not constant. Similarly, the Black-Scholes model applied to the option component assumes that there is no default risk of the firm, since the lognormal model of the underlying equity does not hold under such risk. Last but not least, the risk of the bond issue affects directly the option value in a complex way, since both the strike price and the probability distribution of the equity value change with it. Nonetheless, the reduced

form of the model has been established as a professionally acceptable practice, and for this reason we use it for our main series of empirical tests.

Under the Black-Scholes model the risk of the option component with respect to the equity value is measured by the delta, while the Vega measures the sensitivity of CB price to the volatility of the underlying stock; the latter measure is particularly important here because of the approximate nature of the Black-Scholes model applied to the CB. Both delta and Vega are calculated by using the reduced form models of Black and Scholes (1973), extended by Merton (1973).

$$\begin{aligned} \text{Delta} &= e^{-q(T-t)} \Phi \left( \frac{\ln\left(\frac{S}{X}\right) + \left(r - q + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{(T-t)}} \right) \\ \text{Vega} &= e^{-q(T-t)} S \sqrt{(T-t)} \phi \left( \frac{\ln\left(\frac{S}{X}\right) + \left(r - q + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{(T-t)}} \right) \end{aligned} \quad (6)$$

The structural estimate of Vega better-grounded in theory than the reduced form version, since it explicitly incorporates the dilution factor. However, in practice it is somewhat problematic. The conversion price should be calculated based on face value. However, our available data only provide the actual proceeds of the CB offering. So strictly speaking, empirical work based on the proceeds of CB can only be deemed as a proxy for the real Vega.

$$\begin{aligned} \text{Delta1} &= e^{-q(T-t)} \left[ \Phi \left( \frac{\ln\left(\frac{S}{X}\right) + \left(r - q + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{(T-t)}} \right) - \gamma \Phi \left( \frac{\ln\left(\frac{S\gamma}{X}\right) + \left(r - q + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{(T-t)}} \right) \right] \\ \text{Vega1} &= e^{-q(T-t)} V \sqrt{(T-t)} \left[ \phi \left( \frac{\ln\left(\frac{V}{B}\right) + \left(r - q + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{(T-t)}} \right) - \gamma \phi \left( \frac{\ln\left(\frac{V\gamma}{B}\right) + \left(r - q + \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{(T-t)}} \right) \right] \end{aligned} \quad (7)$$

### C. The Rationale in the Discrete-Time Model

We adapt the traditional Stein (1992) model to study the firm's choice among three major financing instruments: a (regular) corporate bond, equity, and CBs. The purpose of the financing is to support a new investment project that has payouts that occur at uncertain dates in the future. In other words, there is uncertainty in the timing at which the project will become fully operational. Several assumptions are made to facilitate the

analysis:

1). There are two time periods demarcated by three date points (date 0, 1, 2). At date 0, the firm faces an investment opportunity, but does not have any free cash flows to finance its new project. The project requires an overall investment of  $K_A$  or a minimum initial investment of  $K_0$  at date 0. If the project has not fully operational, in the sense of producing cash flows that are sufficient to guarantee that a positive net present value (NPV) overall is generated at date 1, additional external funds must be raised to support a further investment of  $K_1$ . If the project becomes fully operational, the net present value of cash flows generated ( $X$ ) exceed the amount of capital invested. The project does not generate positive operating cash flows sufficient to guarantee a positive NPV until it becomes fully operational. If it becomes fully operational at date 1, it will generate positive cash flows for date 1 and date 2. The project is large in the sense that its NPV is economically substantial – i.e. its outcome will have a significant impact on the firm's stock price. If the firm has not yet decided to abandon the project, it does not have any other resources to start another new project.

2). Ex-ante at date 0, managers of the firm correctly anticipate the likelihood of whether the project will be successful at date 2. However, there is uncertainty as to when the project can be fully operational, which can be reached at date 1 or date 2 with a probability of  $P_1$  and  $P_2$  respectively, where  $P_1 \leq P_2$ .<sup>18</sup> Investors judge the quality of firms and the probability of the success of the project based on firms' track record and all publicly available information to date.<sup>19</sup>

3). The interests of managers are in line with those of shareholders. If the expected discounted cash flows generated by the project are less than the investment outlay, managers will decline the project. That is, we do not consider the agency problem in this model.

4). When a bond is issued to finance the project, it cannot be paid back before the maturity date. For simplicity, the interest cost is assumed to be zero.

With the above assumptions, we can assert that if the firm chooses to finance its new project using a bond, it will choose a relatively long maturity bond. Otherwise, financial distress will show up if the project cannot reach its full potential before the maturity date of the bond. However, extending maturity too long may be hazardous. If the maturity goes much beyond the date when the project is fully operational, the issuer might not have the ability or incentive to issue additional equity to pay back the bond. Financial costs might also be higher than necessary if the maturity is set too long since it is normally the case that the longer the maturity, the higher the interest cost.

Furthermore sequential financing of  $K_0$  and  $K_1$  is not optimal. If the project cannot become fully operational with the passage of time, investors are apt to lower their expectations of the likelihood of the success of the project. Additional financing, if available, would be at much higher financing costs.

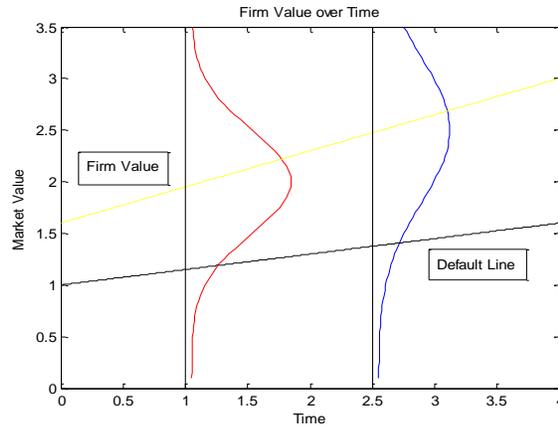
To illustrate, we differentiate amongst three types of firms, and compare three alternative financing plans: 1) equity financing, 2) debt financing with maturity at date 2 followed by equity financing (an AP plan), and 3) CB financing.

The basic idea of this analysis is illustrated in Figure 3. Since there are uncertainties about the timing of the new project, at the end of each time period, outside investors would adjust their expectations of the mean and standard deviation of the project's cash flows, if the project has not reached its full production level. Financing conditions could deteriorate because of the higher standard deviation, even if the mean

value of the project's payout is higher than its present value. As long as the firm's management has an unbiased projection of the true future performance of the firm, a financing plan with CBs could be suitable because management can downplay its promise on the timing to investors while maintaining the right to adjust the conversion process contingent on the performance of the new project. However, as there is a signal of uncertainty when firms choose to issue CBs, it could be perceived as bad news if strong firms finance the project with CBs.

**Figure 3**  
Firm value over time

This figure illustrates the dynamics of the market value of firm over time. The red and blue curves are the firm value density function at  $t_1$  and  $t_2$  after issuance respectively. The yellow dash line is the firm value. Time 0 is the CB issuance date.



### 1. Good firms, which have good historical performance

A firm with a good track record is deemed more trustworthy by investors when it deals with new projects. Such a firm has a good reputational standing in the market. The firm is also interested in upholding this reputation. If managers turn good firms into bad ones, they will suffer an irrevocable reputational loss. The managers of good firms have a higher reputational capital at stake when they invest in risky projects so they tend to be conservative. It is easier for investors to agree with these firms' financing decisions and managers' expectations about new projects.

If the managers of good firms deem that  $P_2=1$ , they should choose the AP. In this case, equity can be issued at a much higher price than the current price. Their possible loss is the higher interest cost when the project in fact becomes fully operational at date 1. However, given the reduced dilution costs, AP is optimal for current shareholders. Additionally, as good firms can get higher ratings when issuing bond, their bond financing costs in the AP are low.

If the managers of good firms perceive  $P_2 < 1$  and  $P_2 X \geq K_A$ , to use CB financing plan could be optimal. CB financing is better than the equity financing because the conversion price is higher than the current stock price. Furthermore, CB financing

might be better than the AP. If the project is not operational at date 2, the equity financing portion in the AP could be more expensive because the stock price could be lower than that at date 0, which will result in higher dilution effects. If the project becomes fully operational at date 2, the AP dominates. The AP adds more uncertainties to the project and current shareholders. Since managers of good firms are likely to have strong ex-ante confidence in the prospects of their new project, they may not choose CBs. If a good firm chooses to issue CBs, this could be perceived by investors as negative information. The risk profile of issuers is likely to be higher after the CB issuance because the benefits of CB financing by good firms will be offset by the additional risks brought by CB issuance.

## **2. Weak firms, which have poor or limited historical performance**

Managers of weak firms or firms with a limited track record have greater incentives to seek risky opportunities to improve business operations. If they fail, the market may treat it as just another pratfall. However if they succeed, investors may think that it is due to management manipulation.

If weak firms choose to issue bonds, they will have to pay higher premia, to reflect their lower ratings. Long maturity bonds could also be problematic for these firms. Furthermore, if the project has not been completed at date 2, the financial distress cost is higher for the weak firms. Consequently the AP is not an optimal strategy for weak firms. If they choose to issue equity, the dilution effect will be larger as the current stock price is low, and the market discount factor is high. Hence, CB's could be an appropriate choice for weak firms, provided that their managers deem the projects to be good enough to support the CB cost. Otherwise, equity financing will be optimal. After the CB issuance, the risk profile of issuers is lower in the former scenario because the benefits of using CBs by weak firms more than offset the additional risks brought by CB issuance.

A CB financing plan for a weak firm signals managerial confidence in the project: Hence, investors could deem such a plan as good news if they are convinced that the probability of the project's success is high. Consequently, the news of CB issuance from a weak firm could generate a positive market reaction.

## **3. Ordinary firms, with non-exceptional historical performance**

Ordinary firms normally have some non-exceptional historical performance that would easily captivate the confidence of new investors. Most firms belong to this group. When initiating financing plans for a new project, managers need some binding mechanism to attract new investors.

When the managers of ordinary firms deem  $P_2=1$ , they could try to mimic good firms and choose the AP. Alternatively, they can choose to issue CB's, which would allow new investors to share in the benefits of the new project, while saving interest costs of straight bond financing. In this way, ordinary firms could attract new long-term shareholders, without immediately harming (through dilution) existing shareholders.

If managers of ordinary firms perceive  $P_2 < 1$  and  $P_2 X \geq K_A$ , they could determine whether they want to face the financial stress if the new project cannot be fully operational at date 2. The probability of financial stress is larger for ordinary firms than

for good firms, so ordinary firms are more apt to choose CB financing plan. CBs help mitigate business operational and financial risk. Investors, use CB issuance as a (noisy) signal of the probability of success of the project. After CB issuance, an ordinary firm's risk profile has a higher probability of improving, relative to that of a weak firm. Consequently, the market reaction to CB issuance by ordinary firms tends to be positive. This is something similar to what Stein (1992) suggests, but is based on risk variation analysis.

The risk analysis in discrete time differs from that under the continuous-time framework because it considers the variation of original risks of firms associated with CB issuance. This analysis implies that the abnormal returns around CB issuance should be positively related to the firm volatility risk, but negatively to issuance risk. The underlying stock returns will depend on the variation of the risk profiles of firms after the CB issuance. Since the overall risks of the firms (the sum of the risks of firms and issuance) are higher, the underlying stock returns should decrease subsequent to CB issuance. With the passage of time, if the project proves to be good, the reduction in firm risks will outweigh that effects of increased CB issuance risk<sup>20</sup>, and the firm's underlying stock price should increase. This is a matter that can be empirically tested.

We can extend the analysis, to introduce uncertainty in the size of the cash flow that the project can generate, as well as the accuracy of management's expectation of the success of the project. These uncertainties strengthen the case for CB's as a dominant financing strategy for such firms.

To summarize, even if their judgment about whether a project will be successful is correct, when facing uncertainties about the timing of the project, managers of all types of firms could be apt to choose CBs in their financing plans. However, cost/benefit trade-offs for CB's may be present, and as a consequence, their issuance per se need not always be good news for the market. In fact, it is optimal to issue CBs for firms which do not have strong historical performance but have opportunity sets that include good projects with uncertainties. Furthermore, if managerial reputation is important, we can suspect that for larger firms, whose reputation cost is higher, the upside scenarios are more likely to prevail.

#### **IV. COMPARISONS OF THE APPROACH WITH PREVIOUS THEORETICAL AND EMPIRICAL WORK**

##### **A. Limitations on Forecasting Prowess**

Buchanana, Hodgesb and Theis (2001) confirm that large hedgers are poor forecasters of the direction of the price change. Forecasts of stock prices are also a challenge for experts such as mutual fund managers and financial analysts. Mutual funds with passive investment strategies such as index funds do not necessarily generate worse returns than those with active investment strategies. Henriksson (1984) finds that mutual fund managers are not good at timing the return of the market portfolio. Following Jensen (1968) pioneering study, other studies have also demonstrated it is not evident that such managers outperform the market – e.g., Fama (1998), Chen, Jegadeesh, and Wermers (2000), Lewellen and Shanken (2002), Elton, Gruber and Blake (2003), etc.

### **B. Market Reaction to the Issuance of CBs**

Essig (1992) finds that proxies for estimation risks are significant in both the probabilistic model of the decision to use convertibles and the regression model of the proportion of the capital structure including convertible securities. Liu and Switzer (2010) demonstrate that, CB issuance-specific and company-related risk can explain the abnormal returns in the two days surrounding the issue date of CBs, and their explanatory power almost vanishes in windows far from the issue date. As a consequence, when trading around the issue date, risks related to CBs and company need to be considered.

Fabozzi, Liu and Switzer (2009) find that there is a U-shape in the normalized volatility series: volatility declines until 3.05 years after the issue date, and then rises thereafter. This “stylized fact” may be consistent with changing degrees of confidence about the prospectus of the issuer through time.<sup>21</sup>

### **C. The Benefits of CB's to Investors**

Based on our model, CBs may be associated with risk reduction benefits. In addition the model predicateds two potentially profitable trading strategies. The first is to hold a naked long position of CBs from the issue date to capture the premium that represents the future upside expectation from the firm's management. The possibility of achieving superior returns under this strategy is larger if the issuer possesses higher reputation cost when poor performance shows up. Fabozzi, Liu and Switzer (2009) confirm that naked long position of CBs<sup>22</sup> can derive an average return of 37.26% at the end of the third year from the issuance. A strategy that is based on investments in issues with ratings of CCC or under can achieve a simulated return of 184.91% three years after the issuance.

The second trading strategy predicated by the model involves hedging CBs with different financial instruments. Fabozzi, Liu and Switzer (2009) investigate the returns and risks of a set of hedging strategies related to CBs. Hedged positions that are based on the characteristics of the convertibles are shown to provide superior absolute and relative returns. The delta neutral portfolio by long buying CBs and short selling underlying stocks produces a return of 3.99%<sup>23</sup> one year after the issuance. A bullish gamma hedging strategy can generate a return of 4.79% of the same period. Volatility convergence hedging and credit spread convergence hedging strategies involving different CBs yield returns of 1.50% and 6.01% respectively at the end of first month. An annualized return of 32.39% can be realized by the hedging between CBs and call options, and year-end return of 16.72% by hedging between CBs and bonds. Overall, some profitable opportunities are identified for investors to utilize the structured nature/structural characteristics of CBs.

## **V. CONCLUSION**

Empirically, it is found that CB issuers, especially those who are large in size but low in rating, do not issue normal corporate bonds first and then issue equity sometime thereafter, although this alternative financing plan could significantly ameliorate dilution effects. This puzzle cannot be well explained in the existing theoretical

literature.

This paper proposes that when making their financing and investment decisions, firms and investors prefer CBs because CBs offer more flexibility to deal with uncertainties. A model is developed to demonstrate that even if managerial judgment about the success of a future project is correct, firms would include CBs in their financing plans when facing with uncertainties about the *timing* of the project. However, cost/benefit trade-offs for CBs may be present, and as a consequence, their issuance per se need not always be good news for the market. In fact, it is optimal for firms who do not have strong historical performance but have opportunity sets that include good projects with uncertainties to issue CBs. Based on previous studies in behavioral finance and efficient markets, the rationale has been examined and justified.

This rationale implies that investors could derive significant benefits from investing in CBs by applying the following two trading strategies. The first is to hold a naked long position of CB's from the issue date because CBs incorporate a premium that represents the future upside expectation from the management. The possibility of achieving superior returns under this strategy is larger if the issuer possesses higher reputation cost when poor performance shows up. The second trading strategy predicated by the rationale involves hedging CBs with different financial instruments. This is because when tailoring CBs according to their requirements under uncertainties, issuers in effect transform CBs into structured financial notes that balance the requirement of issuers and investors. By investing in CBs, investors simultaneously get a combination of different financial instruments, which would otherwise require additional financial costs to replicate, or no chance to replicate at all. Hence, possible investment opportunities might show up among different financial instruments when the prices fluctuate.

From all the above, CBs can be advantageous for some firms and investors. However, CB issuance would not be deemed as good news for firms with too many risks. Weak firms with credible managers may be well suited to issuing CB's. Otherwise equity financing of their new projects may be more appropriate. While strong firms also have incentives to use of CBs, if they do so, investors' estimation of the new project could be distorted, which might generate an adverse market reaction.

To the best of our knowledge, this study is the first in this area to analyze CBs from the perspective of both firms and investors, and reflects the dynamics of a market place wherein the characteristics both issuers and investors change through time. Future work could lie in the further analysis of the *ex-ante* and *ex-post* expectations of managers before and after the issuance of CBs.

#### ENDNOTES

1. The principle says that "the explanation of any phenomenon should make as few assumptions as possible, eliminating those that make no difference in the observable predictions of the explanatory hypothesis or theory."
2. Knutson (1971) looks at the accounting implications of convertible bond costs and their impact on the financial statements of firms. He suggests that managers should be aware of how costly convertible securities are likely to be.
3. When holding CBs, not the stocks, investors can benefits from the coupon payment. The dividend is a cost of CB holders if the conversion price is not

adjusted when the firm pays dividends. However, some CBs do have the terms about adjustment upon dividends.

4. The average conversion premium for CBs with a B or lower and CCC or lower issuance rating is 33.82% and 24.86% respectively in the same database.
5. Although interest cost is higher because of the higher coupon rates of normal corporate bonds.
6. In SDC, there are some issuers keep issuing CBs across limited time periods, which cannot be explained by the sequential argument.
7. Essig (1992) confirms that the estimates in Table 8 are robust on a year-to-year basis in his sample.
8. These are weighted averages based on market capitalization.
9. It is apparent, therefore, that firms adjust the maturity structure of their debt after the CB issuance.
10. Das (2000) argues that the combinations of derivatives and underlying financial instruments which exhibit structures with special risk/return profiles that may not be otherwise attainable on the capital market without significant transaction costs being incurred – at least for private investors.
11. According to SDC, from 1986 to 2005, the average life of the CBs is 16.75 years, while the largest is 30.09 years. The long-maturity of the call option in CBs makes it hard to get in ordinary option market.
12. Woodson and Woodson (2002) find that the returns of convertible, equity index, and bonds are 14.28%, 8.69%, and 6.55%, while the standard deviation are 8.62%, 13.25%, and 4.29% respectively.
13. Delta, Gamma, and Vega etc.
14. The simulation-based method can decrease the number of computation time. However, to price American options (which one of the CB's main features) is still tedious.
15. We assume the CB is a zero-coupon bond for simplicity.
16. In our database, the range of  $\gamma$  is [0.002, 13.522].
17. If we deem CBs will mostly probably be converted into underlying shares, the total risks of a CB issuer have positive relation to the risk of equity of the firm in the future.
18. This is reasonable since the possibility of fulfilling a project normally grows larger as time goes on.
19.  $P_1$  and  $P_2$  could be different for the firms and investors. Please note this differs from the asymmetric information assumption. This assumption just says investors keep updating their belief of the firm, which better portray the reality.
20. The conversion of CBs into underlying stocks also helps this risk deduction process.
21. We cannot infer from the volatility series that investors and issuers are expecting the real life of CBs to be too long.
22. The proceeds amount plus the over-allotment sold in the hosted market of the convertible bonds should be in excess of \$100 million.
23. The returns are calculated as portfolios without self-capital investment, except the call option hedging. Returns are not annualized unless otherwise specified.

**APPENDIX A**  
Proof of Lemma 1

By substituting Lemma 6 into the partial differential equation of equity, which is Equation 4, we can test whether the formula for the value of equity is correct.

$$\begin{aligned}
& rV\Phi(d_1) - \gamma rV\Phi(d_1') + 0.5\sigma V \frac{\phi(d_1)}{\sqrt{T}} - 0.5\gamma\sigma V \frac{\phi(d_1')}{\sqrt{T}} - 0.5\sigma V \frac{\phi(d_1)}{\sqrt{T}} - rBe^{-rT}\Phi(d_2) + \dots \\
& + 0.5\gamma\sigma V \frac{\phi(d_1')}{\sqrt{T}} + \gamma rBe^{-rT}\Phi(d_2') \tag{A.1} \\
& = \left( rV\Phi(d_1) - rBe^{-rT}\Phi(d_2) \right) - \left( \gamma rV\Phi(d_1') - \gamma rBe^{-rT}\Phi(d_2') \right) \\
& = rF2
\end{aligned}$$

where

$$\begin{aligned}
d_1 &= \frac{\ln\left(\frac{V}{B}\right) + \left(r + \frac{\sigma^2}{2}\right)\tau}{\sigma\sqrt{\tau}} \quad \text{and} \quad d_2 = d_1 - \sigma\sqrt{\tau} \\
d_1' &= \frac{\ln\left(\frac{V\gamma}{B}\right) + \left(r + \frac{\sigma^2}{2}\right)\tau}{\sigma\sqrt{\tau}} \quad \text{and} \quad d_2' = d_1' - \sigma\sqrt{\tau}
\end{aligned}$$

where  $\Phi(\bullet)$  is the cumulative distribution function of the standard normal distribution.  $\phi(\bullet)$  is the probability distribution function of the standard normal distribution.

**APPENDIX B**  
Proof of Lemma 2

We further assume that the equity of the firm follows stochastic differential equation as

$$\frac{dF2}{F2} = \mu_1 dt + \sigma_2 dW_1 \tag{B.1}$$

By Ito's Lemma, we can write

$$\begin{aligned}
dF2 &= F2_V dV + \frac{1}{2} F2_{VV} (dV)^2 + F2_t dt \\
dF2 &= \left[ \frac{1}{2} \sigma^2 V^2 F2_{VV} + \mu_1 F2_V + F2_t \right] dt + \sigma V F2_V dW_2 \tag{B.2}
\end{aligned}$$

By comparing the terms in Lemma (A.1) and Lemma (A.3), we have

$$\frac{\sigma}{\sigma_2} = \frac{\sigma V}{\sigma V F_{2V}} \quad (\text{B.3})$$

So, we have

$$\frac{\sigma}{\sigma_2} = \left( \frac{1}{\Phi(d_1) - \gamma \Phi(d_1')} \right) \quad (\text{B.4})$$

### APPENDIX C

#### CB Pricing with Normal Corporate Bond in Firm's Capital Structure

Similar to the process of deriving Lemma 1, we can derive CB pricing formulae when the firm's capital structure includes normal corporate bond. Now the firm value is equal to

$$V = F1(V, \tau) + F2(V, \tau) + F3(V, \tau) \quad (\text{C.1})$$

where  $F3(V, \tau)$  is the value of normal corporate bond. We assume the face value and maturity  $t$  are  $(B_1, T_1)$  and  $(B_2, T_2)$  for convertible bond  $F1$  and normal corporate bond  $F3$  respectively. Without loss of generality, we further require that  $T_2 < T_1$ . Then we can evaluate CB at time  $T_2$ .

$$F3 = V - C(V, B_2, T_2)$$

$$F1 = \begin{cases} 0, & V_{T_2} \leq B_2 \\ V_{T_2} - C(V_{T_2}, B_1, T_1 - T_2) + \gamma C(V_{T_2}, \frac{B_1}{\gamma}, T_1 - T_2), & V_{T_2} > B_2 \end{cases}$$

$$F2 = V - F1 - F3$$

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