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評價可轉換公司債之信用風險模型研究
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摘要

可轉換公司債是一種重要的公司債，它允許債券投資人將債券轉換成發行公司的股票，以分享公司的獲利和成長。建構一個精確地具違約風險的可轉債的評價方法十分棘手，因為必須同時處理可轉債所具備的債券和權益特性，和這些特性和公司的違約風險的複雜關聯。本研究計畫建構一個兩因子的樹狀結構，可同時模擬股價和短利的隨機過程，以處理可轉債的權益和債券特性。本文使用結構式模型來處理信用風險，該模型將股票視為以公司資產為標的物的衍生性金融商品。透過衍生性商品的評價公式和股票價格，可推得對應的公司資產價值以及違約風險。此外，股權的稀釋效應(源自可轉債的轉換)和公司違約時的回復率也可以內生推得。本文提供的數值實驗和敏感度分析驗證了評價模型的正確性。

關鍵字:可轉債，信用風險，結構式模型，樹狀結構

Abstract

A convertible bond is one of the important type of corporate bonds that attract investors by allowing them to convert the bond into the issuing firm's stock to share the profit and the growth of the firm. Developing an accurate method for pricing convertible bonds can be intractable due to convertible bond's hybrid attributes of both fixed-income securities and equities, and their complex relations to firm's default risk. This project develop a two-factor tree model (stock prices and interest rates) for evaluating the hybrid features of convertible bonds. I follow the structural credit risk model by viewing the stock price as a contingent claim on the firm's asset. Therefore, the evolution of the firm value process and in consequence the default probability can be endogenous derived from the stock price process. In addition, both the dilution effect (due to bond conversions) and the recovery rate (if the firm defaults) can also be derived endogenously in my model. Numerical results and sensitive analysis are given to verify the robustness of my model.

Keywords: convertible bond, credit risk, structural model, tree.

1 Preface

A convertible bond is a kind of corporate bond that allows a bond holder to share the profit and growth of the issuing firm by converting his bond into a predetermined amount of the firm's stocks at certain predetermined time points. It can be viewed as a bond with an embedded call option on the issuer's stock. With the upside potential of the embedded call option, the investor would buy a convertible bond even if it is issued at higher price or carries a lower coupon rate. Thus the firm can raise debt capital with less interest expense by issuing convertible bonds. Nowadays, convertible bonds are frequently traded in the financial markets. Developing a robust method for accurately pricing vulnerable convertible bonds is thus important. However, it can be intractable due to convertible bond's hybrid attributes of both fixed-income securities and equities, and their complex relations among these attributes and the default risk.

2 The Goal of this Research Project

This project develop a robust method for pricing vulnerable convertible bonds. To evaluate convertible bond under the consideration of its hybrid attributes of fixed-income securities and equities, our method simultaneously models the evolutions of issuing firm's stock price process and the short-term interest rate process. To simultaneously model relation between issuing firm's default risk and the stock price, my project incorporate the first-passage model, a structural credit risk model that allows premature defaults, into our pricing method. Specifically, the stock of issuing firm is viewed as a down-and-out call option of the firm's value. Thus the firm's asset value and its volatility can be endogenously solved by slightly modifying the formulas for structural credit risk model proposed in Merton (1974). In addition, the default probability and the recovery rate can be simultaneously solved under this framework. Besides, the dilution effect due to bond conversion can be also analyzed by substituting the firm value endogenously derived in my method into the equations for capital structure proposed in Brennan and Schwartz (1980). Our numerical experiments suggest that my method not only provides reasonable pricing results, but also clearly sketch the theoretical relations among the the prices of contingent claims (like stock and bonds) on firm value and the default event.

3 Literature Review

Brennan and Schwartz (1977) assume that the firm value process follows the lognormal diffusion process and derive a partial differential equation (`PDE`) for pricing convertible bonds. Brennan and Schwartz (1980) incorporate the Vasicek short rate model (see Vasicek, 1977) into their `PDE` pricing method. The `PDE` is solved numerically by the finite difference method since modeling the optimal convertible and callable strategies is a free boundary problem which can not be solved analytically. Their methods are hard to be applied since the firm value can not be directly observed from the real world markets. That might be why most recent convertible bond pricing methods model the stock price process instead of firm value process. Besides, premature defaults are not considered in their methods.

Tsiveriotis and Fernandes (1998) use CRR tree (see Cox et al., 1979) to model the stock price process and use this tree to price defaultable convertible bonds. Instead of explicitly analyzing the default event, they decompose the value of convertible bond into equity and debt components. During the backward induction procedure, the default risk is considered by discounting the future cash flows of debt component by the risky rate, as we price defaultable bonds. The equity component is discounted by the risk-free rate as we price derivatives with risk-neutral variation method. On the other hand, Hung and Wang (2002) explicitly model the default events by taking advantage of the reduced model pioneered by Jarrow and Turnbull (1995), and develop a tree for pricing defaultable convertible bonds. The reduced model is a credit risk model that directly models the default process of the firm without modeling the firm value. Hung and Wang (2002) model the term structure of the risk-free interest rate with BDT interest model (see Black et al., 1990). They assume that the recovery rate is given exogenously and solve the default probability at each time step of the tree by calibrating the term structure of the credit spread. These default probabilities are incorporated into their two-factor (the stock price and the short rate) tree model to price defaultable convertible bonds. Chambers and Lu (2007) argue that the correlation between the interest rate and the stock price is not considered in Hung and Wang (2002) paper. However, the correlation seems to affect convertible bond prices significantly as suggested in Ho and Pfeffer (1996). Thus they propose a new pricing method incorporating the correlation factor into the Hung and Wang's tree model.

In these reduced-form based models, the endogenously modeled stock price process is irrelevant to the default probabilities in their model. However, a higher stock price should imply that the firm is in a better financial status and has lower default risk, and vice versa. On the other hand, the tree model proposed in Bandreddi et al. (2007)

suggests that the default probability can be described as a function of the stock price. But their function can not be well explained theoretically. To address this problem, my method take advantage of the structural model, which view the stock price as a call option on firm's value (see Merton, 1974). The relation between the default probability and the stock price can be theoretically explained.

4 Preliminaries

4.1 Modeling the Stock Price Process

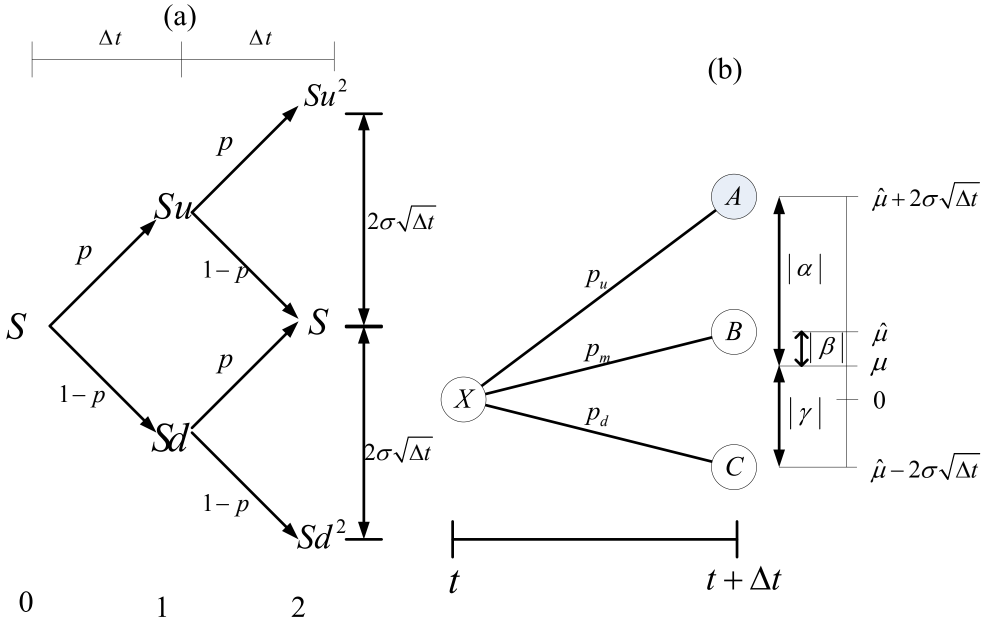

Figure 1: **The Structure of CRR Tree and the Trinomial Structure.** A two-time-step CRR tree is illustrated in panel (a). u and d denote the upward and downward multiplication factors of the CRR tree. The log-price between two adjacent nodes at the same time step is $2\sigma\sqrt{\Delta t}$. The trinomial structure is illustrated in panel (b). $\hat{\mu} + 2\sigma\sqrt{\Delta t}$, $\hat{\mu}$, $\hat{\mu} - 2\sigma\sqrt{\Delta t}$ denote the $v(X)$-log-prices for nodes A, B, and C, respectively. μ denotes the conditional expectation of $v(X)$-log-price at time $t + \Delta t$. $|\alpha|$, $|\beta|$, and $|\gamma|$ denote the log distance between μ and nodes A, B, and C, respectively. In both panels, the branching probability for each branch is listed next to the branch.

If the firm is solvent, the stock price of the issuing firm at time t, S_t, is assumed to follow the lognormal diffusion process

$$dS_t = r_t\, S_t\, dt + \sigma_s\, S_t\, dZ_s, \tag{1}$$

where r_t denotes the risk-free short rate at time t, σ_s denotes the stock price volatility, Z_s is a Brownian motion. Otherwise, the stock price is zero once the firm defaults. Note that r_t is assumed to be a constant r in my one-factor tree.

To model the stock price process of a defaultable firm, I use a modification version of the CRR tree (see Cox et al., 1979) illustrated in panel (a) of Fig. 1 with occasional insertion of trinomial structure (see Dai and Lyuu, 2010) illustrated illustrated in panel (b) to keep my tree structure valid. In the CRR tree structure, the stock price S can move upward to Su with probability p and move downward to Sd with probability $1-p$, where Δt denotes the length of a time step, $u = e^{\sigma_s \sqrt{\Delta t}}$, $d = 1/u$, and $p = \frac{e^{r_t \Delta t} - d}{u-d}$. Define the V-log-price of stock price V' as $\ln(V'/V)$ for convenience. Then the log-distance between the S-log-prices of any two adjacent nodes at the same time step of the CRR lattice is $2\sigma\sqrt{\Delta t}$.

Dealing with the default events with the CRR tree might result in invalid branching probabilities as discussed later. The trinomial structure illustrated in Fig. 1 (b) will be inserted (if necessary) into the CRR tree to deal with this problem. Denote the stock price of node Z as $v(Z)$ for convenience. By the lognormality of stock price, the mean μ and the variance `Var` of the $v(X)$-log-price of the stock price at time $t+\Delta t$, $S_{t+\Delta t}$, given $S_t = v(X)$ are

$$\begin{aligned} \mu &\equiv \left(r - \sigma^2/2\right)\Delta t, \qquad (2) \\ \text{Var} &\equiv \sigma^2 \Delta t. \end{aligned}$$

The outgoing trinomial branches from node X to node A, B, and C should match μ and variance `Var` with feasible branching probabilities; that is, the branching probabilities p_u, p_m, and p_d must be between 0 and 1 to keep the trinomial structure valid. Recall that the log distance between any two adjacent nodes at the time $t+\Delta t$ is $2\sigma\sqrt{\Delta t}$ due to the nature of CRR lattice. Therefore, at time $t+\Delta t$, there must exist a unique node B whose $v(X)$-log-price $\hat{\mu}$ lies in the interval $[\,\mu - \sigma\sqrt{\Delta t}, \mu + \sigma\sqrt{\Delta t}\,)$. We select node B and its two adjacent nodes A and C to construct a trinomial structure from node X. The branching probabilities from node X (i.e., p_u, p_m, p_d) can be obtained by solving

$$\begin{aligned} p_u\alpha + p_m\beta + p_d\gamma &= 0, \qquad (3) \\ p_u(\alpha)^2 + p_m(\beta)^2 + p_d(\gamma)^2 &= \text{Var}, \qquad (4) \\ p_u + p_m + p_d &= 1, \qquad (5) \end{aligned}$$

where the conditional mean and the variance are matched in Eqs. (3) and (4), respectively, $\alpha \equiv \hat{\mu} + 2\sigma\sqrt{\Delta t} - \mu$, $\beta \equiv \hat{\mu} - \mu$, and $\gamma \equiv \hat{\mu} - 2\sigma\sqrt{\Delta t} - \mu$. Dai and Lyuu (2010) suggest that Eqs. (3)–(5) yield valid branching probabilities.

5 Pricing Convertible Bonds with a Novel One-Factor Tree Model

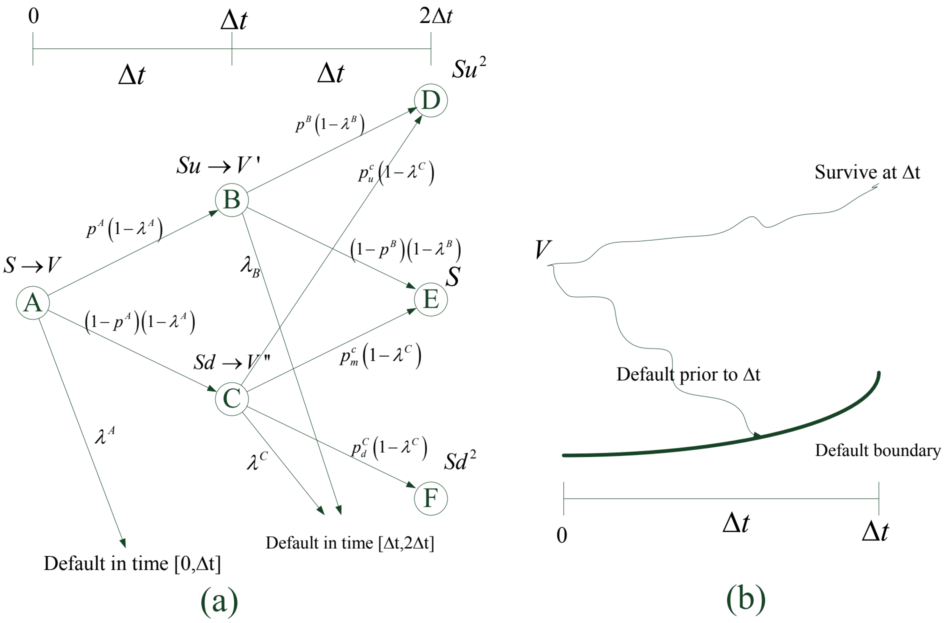

Figure 2: **The Stock Tree and Its Linkage to Firm Value and Default Risk.** A two-time-step one-factor tree for modeling the evolution of stock price is illustrated in panel (a). The stock prices and the corresponding firm values for nodes A, B, and C are listed above the node. The probability for each branch is listed on the branch. λ_A, λ_B, and λ_C denotes the default probabilities for nodes A, B, and C, respectively. The outgoing trinomial structure (given the firm survives during time $[\Delta t, 2\Delta t]$) follows the construction method discussed in Fig. 1 (b). Panel (b) explain how to calculate the default probability under the first passage model.

To keep discussion easy, I will first introduce a simplified version of the pricing method, the one-factor tree (see Fig. 2 (a)), that simulates the evolution of stock price process without considering the interest rate risk. The relation between the stock price and the default risk can be modeled by taking advantage of the first-passage model. The vulnerable convertible bond without considering interest rate risk can be evaluated under this one-factor tree.

The equity value can be viewed as a contingent claim on the firm value in the first-passage model proposed in Black and Cox (1976). Specifically, the firm defaults and equity holders receive nothing once its value hits the exogenously given default boundary. The default boundary at time t, B_t, is set as $De^{-\gamma(T-t)}$, where D denotes the amount of debt due at maturity date T, γ denotes exogenously defined variable.

Thus, the equity value at time t, E_t, can be viewed as a down-and-out call option on the firm value V_t since the payoff of the equity at time T is

$$E_T = \begin{cases} (V_T - D)^+ & if \;\; V_t > B_t,\, 0 \leq t \leq T, \\ 0 & \qquad\qquad otherwise, \end{cases}$$

where V_t and B_t denotes the firm value at time t. Thus the equity value can be evaluated by the down-and-out call option pricing formula as follows:

$$E_t = V_t N(x) - De^{-rT}N(x - \sigma_v\sqrt{T}) - V_t({}^{B_t}\!/\!_{V_t})^{2\lambda}N(y) + De^{-rT}({}^{B_t}\!/\!_{V_t})^{2\lambda-2}N(y - \sigma_v\sqrt{T}), \quad (6)$$

where N denotes the cumulative distribution function of standard normal random variable,

$$x = \frac{\ln({}^{V_t}\!/\!_{B_t})}{\sigma_v\sqrt{T}} + \Lambda\sigma_v\sqrt{T}, \quad y = \frac{\ln({}^{B_t}\!/\!_{V_t})}{\sigma_v\sqrt{T}} + \Lambda\sigma_v\sqrt{T}, \Lambda = (r - \sigma_v^2/2)/\sigma_v^2.$$

Besides, the relation between the equity value, equity value's volatility (which is equal to the stock price volatility σ_s), the firm value V_t, and firm value's volatility σ_v can be derived by Ito's lemma as suggested in Black and Cox (1976) as follows.

$$\sigma_e E_t = N(x)\sigma_v V_t, \quad (7)$$

Note the equity value E_t can be estimated by multiplying the stock price by the number of outstanding shares, and the stock price volatility σ_s can be estimated by either the implied volatility derived by the stock's options or the historical volatility derived by the historical stock prices. Thus the firm's value at time t, V_t, and its volatility σ_v can be solved by substituting E_t and σ_s into Eqs. (6) and (7).

With above procedure, we can obtain the firm value for each node of one-factor tree as illustrated in Fig. 2 (a). Then we can estimate the default probability λ^X, the conditional probability for the firm defaults within a time step Δt given the stock price begins at node X. Take Fig. 2 (b) for example. λ^A denotes the probability that the firm value begins at V and hits the default boundary within a time step Δt. This default probability can be calculated by taking advantage of the reflection principle (see Shreve, 2004). Specifically, define the first hitting time τ as $\inf\{t \geq 0 : V_t \leq B_t\}$. The probability to hit the default boundary prior to time s given the information up to time t ,F_t, as follows:

$$\begin{aligned} P(\tau \leq s|F_t) &= \mathrm{N}\left(\frac{\ln(B_t/V_t) - \left(r - \kappa - \gamma - 0.5\sigma_V^2\right)(s-t)}{\sigma_V\sqrt{s-t}}\right) \qquad (8) \\ &+ (B_t/V_t)\exp\left[2\left(\frac{r - \gamma - 0.5\sigma_V^2}{\sigma_V^2}\right)\right]\mathrm{N}\left(\frac{\ln(B_t/V_t) + \left(r - \kappa - \gamma - 0.5\sigma_v^2\right)(s-t)}{\sigma_V\sqrt{s-t}}\right). \end{aligned}$$

λ^A is obtained by substituting 0, Δt for t and s into Eq. (8). The default probabilities for other nodes, says λ^B and λ^C, can be derived in similar ways.

To keep the stock price grows at the risk-free rate under the consideration of default possibility, the branching probabilities in the CRR tree must be adjusted. The default intensity for an arbitrary node X, λ'^X, can be derived from the default probability as follows:

$$e^{-\lambda'^X \Delta t} = 1 - \lambda^X \ \Rightarrow \lambda'^X = \frac{-\ln(1-\lambda^X)}{\Delta t}.$$

The following derivation shows that the stock price grows at the risk-free rate by setting the upward branch probability for node X, p^X, as $\frac{\exp\left((r+\lambda'^X)\Delta t\right)-d}{u-d}$:

$$\begin{aligned} & e^{-r\Delta t}\left[0(1-e^{-\lambda'^X\Delta t}) + Sup^X e^{-\lambda'^X\Delta t} + Sd\left(1-p^X\right)e^{-\lambda'^X\Delta t}\right] \\ = \ & e^{-\left(r+\lambda'^X\right)\Delta t}\left[Su\frac{e^{\left(r+\lambda'^X\right)\Delta t}-d}{u-d} + Sd\frac{u-e^{\left(r+\lambda'^X\right)\Delta t}}{u-d}\right] \\ = \ & S. \end{aligned}$$

Take node A in Fig. 2 (a) for example. The stock price will become 0 due to firm default with probability λ^A, move up to Su with probability $p^A(a-\lambda^A)$, and move down to Sd with probability $\left(1-p^A\right)\left(1-\lambda^A\right)$.

Note that the branching probabilities might be infeasible if the short rate r_t or the default density λ'^X is too high. Specifically, the upward branching probability for node X exceeds one if $\left(r_t+\lambda'^X\right)\Delta t > \sigma\sqrt{\Delta t}$. To address this problem, the outgoing branches will adopt the trinomial structure introduced in Fig. 1 (b) instead of binomial one. Take node C in Fig. 2 (a) for example. The trinomial structure is constructed by changing the mean of stock return μ defined in Eq. (2) as $\left(r+\lambda'^C\right)\Delta t$ to make the conditional growth rate of stock price $r+\lambda'^C$ given that the firm survives at time $2\Delta t$. This will ensure that the stock price from node C still grows at the risk free rate, which can be verified as follows:

$$\begin{aligned} & e^{-r\Delta t}\left[0(1-e^{-\lambda'^X\Delta t}) + e^{-\lambda'^X\Delta t}\left(Su^2p_u^C + Sp_m^C + Sd^2p_d^C\right)\right] \\ = \ & e^{-r\Delta t}\left[e^{-\lambda'^X\Delta t}e^{\left(r+\lambda'^X\right)}\right] \\ = \ & S. \end{aligned}$$

Note that in this example, node E and its adjacent nodes C and E are chosen as successor nodes connected by the outgoing branches from node C under the condition that Sd-log price of node E, i.e., $\ln(S/Sd)$, is within the range of $[\left(r+\lambda'^C-\sigma^2/2\right)\Delta t - \sigma\sqrt{\Delta t}, \left(r+\lambda'^C-\sigma^2/2\right)\Delta t + \sigma\sqrt{\Delta t}]$. The valid branching probabilities (i.e., p_u^c, p_m^c, and p_d^c) can be solved by Eqs. (3)–(5). The default probability within a time step Δt can be obtained by Eq. (8).

The recovery rate in each node of my tree model can be endogenously determined. For an arbitrary node X at time t, the bond value contributed from the recovery of firm's default during the time interval $[t, t+\Delta t]$ can be expressed as

$$F_D \equiv \frac{\int_t^{t+\Delta t} p(s)\left[f_2 B_s - \mathrm{SB}_\tau\right]^+ e^{-r_t(s-t)}}{N_C}, \tag{9}$$

where B_s denotes the default boundary at time s, SB_s denotes the value required to repay the bonds senior to convertible bonds at time s, and N_C denotes the number of outstanding convertible bonds. The density of default probability $p(s)$ can be derived by differentiating Eq. (8) with respect to s. Recall that the recovery rate is defined as the amount recovered in the event of a default as a percentage of the face value. Thus we have

$$F_D = \lambda^X \delta^X F, \tag{10}$$

where δ^X denotes the recovery rate at node X, and F denotes the face value of the bond. δ^X can be endogenously derived by substituting F_D obtained from Eq. (9) and λ^X obtained from Eq. (8) into Eq. (10).

Converting the convertible bonds into stocks would increase the number of outstanding stocks and dilute the stock value. Without considering the dilution effect, the conversion value of a convertible bond would be overestimated as qS^{BC}, where S^{BC} denotes the stock value before conversion. To model the dilution effect, we follow Brennan and Schwartz (1980) assumption that the firm asset is composed of three securities: straight bonds, convertible bonds, and stocks. Thus the firm value before the conversion of convertible bonds can be expressed as follows:

$$V = N_B B + N_C C + N_O S^{\mathrm{BC}}, \tag{11}$$

where B denotes the market value of each straight bond, N_B denotes the number of straight bonds, C denotes the value of a convertible bond, N_C denotes the number of convertible bonds, and N_O denotes the number of stocks. After converting the convertible bonds into the stock, the firm asset is composed of straight bonds and stocks:

$$V = N_B B + (N_O + N_C q)\, S^{\mathrm{AC}},$$

where q denotes conversion ratio, $N_C q$ denotes the incremental amounts of stocks due to bond conversion, and S^{AC} denotes the stock price after bond conversion. Thus the conversion value is $qS^{\mathrm{AC}} = \frac{q(V-N_B B)}{N_O+N_C q}$.

6 Extension to a Two-Factor Pricing Model

Both the stock price process and the Hull-White short-term interest rate process Hull and While (1990) are simulated in my two-factor tree method. The stock price is simulated with the CRR tree with the occasional trinomial branches insertions as illustrated in Fig. 2 (a). The short rate process is simulated by the Hull and White interest rate tree (see Hull and While, 1996). Our tree is then constructed by merging these two trees. The correlations between the stock price process and the short rate process is modeled by the branching probabilities adjustment method proposed in Brigo and Mercurio (2006); Hull and While (1994).

Briys and De Varenne (1997) propose the bond pricing formula under the Hull-White term structure model, and this formula is applied to solve the firm value and its volatility given the equity value and the interest rate term structure in my method. Specifically, the equity value E can be expressed as the firm value V minus the debt value$D(V)$

$$E = V - D(V), \tag{12}$$

where the debt value $D_t(V)$ can be expressed as as function of the firm value V as follows:

$$\begin{aligned} D_t = FP(t,T)\,[1 - P_E(\ell_t, 1) + P_E\left(q_t, \ell_t/q_t\right) - (1-f_1)\ell_t\left(N(-d_3) + N(-d_4)/q_t\right) \quad (13)\\ -(1-f_2)\ell_t\left(N(d_3) - N(d_1) + \frac{N(d_4) - n(d_6)}{q_t}\right)\Bigg], \end{aligned}$$

where F denotes face value, $P(t,T)$ denotes the value at time t of a zero coupon bond matured at time T, f_1 and f_2 denote the liquidation cost at maturity and prior to maturity. Therefore the firm value at time V_t and its volatility σ_v is obtained by substituting the equity value E_t and its volatility that can be observed from the market into Eqs. (12) and (7).

7 Numerical Results

We price the six-year zero-coupon convertible bond issued by Lucent discussed in Hung and Wang (2002); Chambers and Lu (2007). These two papers are based on the reduced model and the parameters that can be directly found in their papers are listed as follows. The initial stock price S_0 is 15.006, the stock volatility $\sigma_s = 0.353836$, the time to maturity is 6 years, the number of time steps is 6, the face value of the convertible bond is 100, the conversion ratio is 5.07524, and the correlation between the stock and the interest rate is -0.1. The call prices are 94.205, 96.098, and 98.030 for the fourth, the fifth, and the sixth year, respectively. The risk-free zero coupon rates are 5.969%, 6.209%, 6.373%, 6.455%, 6.504%, and 6.554% for the first, the second, . . ., and the sixth year. Other parameters that are not considered in reduced credit risk models, like the number of outstanding stocks, are derived from the financial report of Lucent. The numbers of outstanding stocks and convertible bonds are 642,062,656 and 2,290,000, respectively. The payment of straight bond due at maturity is estimated by the value of liability minus the face value of convertible bonds; which is 20,195,000,000 in this example. The pricing results proposed by Hung and Wang (2002) and Chambers and Lu (2007) are 90.4633 and 90.83511, respectively. Our pricing result 90.1903, like the results in aforementioned two papers, are close to the market price 88.706.

8 Conclusions and Self Evaluation of the Project

This research project develop the a convertible bond pricing method based on the structural model. To evaluate convertible bond under the consideration of its hybrid attributes of fixed-income securities and equities, our method simultaneously models the evolutions of issuing firms stock price process and the short-term interest rate process. The relations among the default probability, the firm value, the stock price, and the dilution effect are endogenously built. Numerical results verify the robustness of my model. I am now currently organize the researching results of this project and submit it to an academic journal. I will try to incorporate the reduced credit risk model into my pricing method. I will also try to extend this pricing method to price other vulnerable securities.

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出席國際學術會議心得報告

計畫編號	NSC 99-2410-H-009 -022
計畫名稱	評價可轉換公司債之信用風險模型研究
出國人員姓名 服務機關及職稱	戴天時 交通大學資財系副教授
會議時間地點	美國 Asheville 11/17~11/20
會議名稱	2010 Southern Finance Conference annual meeting
發表論文題目	Realized Tax Benefits and Capital Structures

一、參加會議經過

今年在美國Asheville舉辦的2010 Southern Finance Conference annual meeting是美國舉辦的重要的財金研討會暨Southern finance association 的年會，本研討會是全世界幾個最重要而且水準也最高的財金研討會之一。我在這個研討會中主要發表的paper提供數值評價模型來分析資本結構，該數值方法可處理數值計算誤差，並處理公司資產價值因配息(或配股立)而出現跳動的問題，並指出公司的最適資本結構如何受不同的配息或股利政策的影響。American University 的 Kent Baker提供不少懇切的意見，他認為我的論文數據模擬的做的不錯，不過希望我能著重在重要財務意含的分析，例如分析債券條款的影響以及公司的最適股利政策。

此外，我還參加了其他session，例如在探討選擇權評價的session中，Prof. Chang就用實證的方法分析當市場上有不得放空的限制或是標的股票價格太高時，對put call parity 的影響。Prof. Caver則分析實質選擇權對於產油公司的股價之影響，Prof. Cain則使用選擇權的角度，建構公司的投資機會模型，並分析公司的最適持有現金量，以確保公司可掌握投資機會，避免違約風險，又不至於持有太多閒置資金。

在其他session中Prof. Abhay 則分析房地產共同基金的績效，並分析REIT的投資表現跟基金經理人進場時間的關係。Prof. Suite則講解如何將研究成果發表成論文，並分析目前的教職市場以及不同等級的學校對研究的要求。有另一個學者則報告如何提高計算Conditional Value at Risk 的效率，他並使用Quasi-Monte Carlo simulation，來驗證在適當的統計工具下，可用較少量的樣本資料以及較少的計算時間，就可以得到精確的統計評估數據。這些統計工具的應用方面的研究，對於實證上有很大的幫助。

二、與會心得

這幾年參與過幾場國際學術研討會，我覺得對學術研究及國際視野的拓展都十分有幫助。在研討會上一方面可跟其他大學的人互動，知道研究領域的最新動態。另一方面也

可接觸不同國家的人，學習他們的文化以及思維模式，提伸自己的世界觀。本人十分感謝國科會及交大能提供適當的補助，並且希望政府能夠針對支持學者參與相關的學術活動，提高研究水平。

國科會補助計畫衍生研發成果推廣資料表

日期:2011/10/24

國科會補助計畫	計畫名稱：評價可轉換公司債之信用風險模型研究		
	計畫主持人：戴天時		
	計畫編號：99-2410-H-009-022-　　學門領域：財務		
研發成果名稱	（中文）創新可轉債評價模型		
	（英文）A Novel Convertible Bond Pricing Model		
成果歸屬機構	國立交通大學	發明人（創作人）	戴天時
技術說明	（中文）可轉換公司債是一種重要的公司債，它允許債券投資人將債券轉換成發行公司的股票，以分享公司的獲利和成長。評價可轉換公司債時，違約風險和股權稀釋效過是兩個重要議題，之前的評價模型都過度簡化或忽視這兩個議題。我的評價模型採用結構式信用風險模型，使用股價推論隱含的公司價格和違約機率，所以可清楚描述可轉債的股權和債權的雙重特性和違約風險及股權稀釋效果的複雜關係。因此我的評價模型可以提供更貼近真實市場現象的分析。		
	（英文）A convertible bond is one of the important type of corporate bonds that attract investors by allowing them to convert the bond into the issuing firm’s stock to share the profit and the growth of the firm. The default risk and the dilution effect are key factors in evaluating convertible bonds. These two factors are simplified or even ignored in previous pricing frameworks. My pricing model adopts the structural credit risk model and uses the stock price to derive the implicit firm value and the default probability. Thus both the debt and equity attributes of convertible bonds and their complex relations to default risk and dilution effect can be modeled. My pricing model can provide more realistic analysis than other current existing models.		
產業別	金融業；證券業；證券期貨控股業		
技術/產品應用範圍	金融投資機構可用此模型計算可轉債的價格及是否具有投資效益。發行公司可用此模型分析發行可轉債的投資效益。		
技術移轉可行性及預期效益	由於本方法使用結構式信用風險模型來處理可轉債的信用風險，所以股價的高低可以反應違約機率的大小，而且也可同時處理債權轉換成股權的稀釋效果，較其他現有的可轉債評價模型更貼近真實市場的現象。本方法的程式撰寫容易，且不須昂貴的電腦硬體設備支援，故技術移轉容易。		

註：本項研發成果若尚未申請專利，請勿揭露可申請專利之主要內容。

99 年度專題研究計畫研究成果彙整表

計畫主持人：戴天時　**計畫編號：**99-2410-H-009-022-

計畫名稱：評價可轉換公司債之信用風險模型研究

成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	3	3	60%		Tian-Shyr Dai, Chuan-Ju Wang, and Yuh-Dauh Lyuu ’ Evaluating Corporate Debts with Complex Liability Structures and Debt Covenants under the Jump-Diffusion Process’ 2010 Annual Conference of Taiwan Finance Association and CTFA Conference Tian-Shyr Dai, Chun-Yuan Chiu, Accurate Approximation Formulae for Evaluating

							Theories and Practices of Securities and Financial Markets will be held on December 9-10, 2011 in Hsi-Tze Bay , Kaohsiung , Taiwan
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	3	3	50%	篇	Tian-Shyr Dai and Yuh-Dauh Lyuu. ‘‘The Bino-Trinomial Tree: A Simple Model for Efficient and Accurate Option Pricing .’’ Journal of Derivatives, Vol.17 2010, pages:7-24(SSCI) Tian-Shyr Dai, Yuh-Dauh Lyuu, Chuan-Ju Wang, and

							Limin Liu, and Tian-Shyr Dai. ‘‘A Reliable Fingerprint Orientation Estimation Algorithm.’’ JOURNAL OF INFORMATION SCIENCE AND ENGINEERING, 2011,27:353:368 (SCI)
		研究報告/技術報告	0	0	100%		
		研討會論文	4	4	60%		Tian-Shyr Dai, Wayne Y Lee , Chuan-Ju Wang Realized Tax Benefits and Capital Structure Southern Finance Association 2010 Annual Meetings November 17 - 20, 2010 Grove Park Inn Resort & Spa Asheville, North Carolina Tian-Shyr Dai, Chuan-Ju Wang, and Yuh-Dauh Lyuu ’ Evaluating Corporate Debts

							Approximation Formulae for Evaluating Barrier Stock Options with Discrete Dividends and The Application in Credit Risk Valuation 2011, Southern Finance Association 2011 Annual Meetings Shanon Yang, Dai Tian-Shyr ’A Flexible Tree for Evaluating Guaranteed Minimum Withdrawal Benefits Contract with a Surrender Option’ 2012 WRIA Meeting in Kailua, Kona, Hawaii
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)		參加 FMA2011，為全球最大的財務研討會之一，並且和之前訪問 University of Arkansas 所認識的學者碰面，討論新的研究計畫，並建立國外研究領域的人脈。					

🟥	成果項目	量化	名稱或內容性質簡述

科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■達成目標

□未達成目標（請說明，以 100 字為限）

　□實驗失敗

　□因故實驗中斷

　□其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形：

論文：□已發表 □未發表之文稿 ■撰寫中 □無

專利：□已獲得 □申請中 ■無

技轉：□已技轉 □洽談中 ■無

其他：（以 100 字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限）

本論文結案報告, 已成功完成原計畫的構想:將結構式信用風險模型和股價樹結合, 建構具違約風險的可轉換公司債的評價模型, 近年來信用風險議題廣受各界重視，而且有不少論文，討論可轉債的違約議題，但是因為可轉債同時具備股權和債權的特性，現有模型都無法合理解釋股票價格和違約風險的關係。本研究計畫使用結構式信用風險模型的假設:假定股票為以公司資產為標的物的選擇權，推導隱含的公司價格和對應的違約機率，將其資訊結合到股價樹中，建構數值評價模型。此外，可轉債轉換時的股權稀釋效果，也可透過上述隱含公司價格推論出稀釋後的股票價格。故本論文對可轉債的評價，提出更具理論基礎及貼近真實世界現像的分析。本研究成果目前已改寫成英文論文，並準備投到國際財務研討會和期刊。