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*Original Paper*

# The Analysis of Chinese Convertible Bond Market

Yuxin Tian[1] & Jun Chen[1*]

[1] SILC Business School, Shanghai University, Shanghai, China

[*] Dr. Jun Chen, SILC Business School, Shanghai University, Shanghai, China

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***Abstract***

*Convertible bond is a type of hybrid security with both bond- and stock-like features. The Chinese market of convertible bonds has developed dramatically during the last decade. This paper will conduct a comprehensive analysis of this market. Firstly, a brief introduction of convertible bond and the historical evolution of this market in China is presented, then we analyze various investment risks related to convertible bonds. Next, this paper proposes the basic valuation model for convertible bonds, which is the Black-Scholes model and modifies it by taking the delusion effect of conversion into account, leading to the Gailai-Schneller model. In addition, the differences of the outcomes obtained by these two models are compared and analyzed based on the pricing of Shanghai Electric convertible bond. In the sixth part, this paper mainly explains two types of applications of convertible bonds in portfolio management. In the end, several problems existing in Chinese convertible market as well as some suggestions for solving them are discussed.*

***Keywords***

*Chinese convertible bond market, Black-Scholes model, Gailai-Schneller model*

## 1. Introduction

Convertible bond is a hybrid instrument that is derived from the common corporate bond market with bond-, equity- and option-like properties simultaneously. It provides bondholders with the right to convert their bonds into underlying shares of the issuing corporation in terms of certain predetermined conditions, which can be exercised through both physical settle and cash settle. China's convertible corporate bonds can currently be issued by both listed and unlisted companies, with the emphasis from state-owned enterprises to private ones. Among the listed companies, A-share companies mainly issue convertible bonds to domestic investors while those of B-share companies are mainly for overseas investors.

Convertible bonds usually have lower coupon rates than ordinary corporate bonds or even bank deposit

rates since the return on the stock options can offset this drawback. In addition, most convertible bonds are embedded with call options including protected and unprotected ones, allowing the issuer to redeem them at a specified price once the call provision is triggered before maturity. Similarly, convertible bonds can also carry put options which enable holders to sell them back at the put price when put provisions are activated before maturity. Along with features of pure bonds, redemption clause and repurchase clause, a typical convertible bond contrast should also contain warrant and amendment clause to conversion price. Generally, there are six key elements of a convertible bond:

**1) Coupon rate**: It is regarded as the most basic feature as a bond, which is the key factor to be considered when the investor is deciding whether to purchase a convertible bond. Generally, it is determined by the credit rating and the projected performance of the issuing company, current level of market interest rate as well as other provisions of the bond.

**2) Maturity**: It is generally related with investment risks.

**3) Conversion price**: It is determined by the average stock price within a period before issuance of the convertible bond plus a certain premium. It is also the strike price for investors to convert.

**4) Conversion ratio**: It represents the number of shares that can be converted into by a convertible bond, and is expressed as the par value of a convertible bond divided by conversion ratio.

**5) Downward Reversion clause**: It is designed to protect investors when the stock price of the issuing company is much lower than expectations due to the issuance of new shares, stock split, dividends payout, etc. If above situations happen, Investors can exercise their rights at 70%-80% of the original conversion price.

**6) Call provision and put provision**: This paper has explained them before.

The main purpose of this paper is to comprehensively analyze the Chinese convertible bond market from six perspectives and to lay stress on the comparison of two pricing models, which are he Black-Scholes Model and the Gailai-Schneller Model, in terms of the Shanghai Electric convertible bond. To introduce this market in detail, the historical evolution is presented firstly, then some investment risks and applications of convertible bonds are presented. After analyzing the pricing of convertible bonds, this article proposes four problems existing in Chinese convertible bond market as well as for suggestions for its future development.

## 2. Literature Review

This paper relates to literature about the analytical pricing models for convertible bonds, among which the most frequently applied methods are the Black-Scholes Model and the Gailai-Schneller Model.

Firstly, the core concept of analytical pricing models is to use analytical expressions to derive the theoretical value of convertible bonds, among which the most typical method is the Black-Scholes Model. The earliest application of this pricing model to convertible bond pricing is proposed by Ingersoll (1977) and Brennan & Schwartz (1977), they select the value of the issuing company as the underlying variable and value the bond price through contingent claims. However, this pricing method

is not practical since the company values cannot be precisely obtained. Later, Zhang and Tao (1999) utilized the single-factor model based on the volatility of stock returns to analyze the applications of BSM to Chinese convertible bond pricing. The authors concluded that the total value of a convertible bond consists of the pure bond value and the value of an embedded option owned by investors. This study establishes the basic framework to measure the value of convertible bonds, however, there are other various factors influencing the bond price that should be considered. Under this condition, some two-factor models emerged as required. Zheng and Cheng (2000) construct the rate-price combined model and divide convertible bonds into four categories based on coupon rates and conversion prices. Subsequently, credit risk is gradually be considered as the third factor in pricing models.

The Black-Scholes Model is a widely applied pricing approach for convertible bond since it can basically suit its various additional clauses. Jiang (2010) believes that the influences of call and put provisions and the downward adjustment clauses on convertible bond prices can also be measured by the BSM since they can be considered as options. The expanded application of Black-Scholes pricing model has been approved to better estimate the real price of convertible bonds. However, the effects of the issuance are not contained in this model. To modify the impact of equity delusion and the leverage changes on bond prices, Gailai-Schneller Model is more advanced. Liao and Zhang (2012) claim that the issuance of convertible bonds will bring about higher equity risks, leading to greater volatility of stock returns. Inspired by Gailai-Schneller Model, they proposed the delusion factor and leverage effect that may influence the conversion price based on MM propositions, then add these two factors into BSM. The research result indicates that the stock delusion has a negative effect on convertible bond prices while it is closer to the actual situation.

Based on these two main pricing models for convertible bonds, this paper analyzes the different pricing outcomes of a same convertible bond, which is Shanghai Electric convertible bond derived from BSM and GSM. The contribution of this article is concluding general relationships of these two models' outcomes by artificial simulation assuming certain stock prices of the issuing company.

## 3. Historical Evolution

Since the first convertible bond was issued by Erie railway company in New York in 1843, convertible bond has become a main approach for enterprises of developed countries to raise funds in the capital market. While Chinese bond market started relatively late in 1991, it has experienced dramatic and high-speed developments over the following two decades as various policies and trading rules were announced. The development trend in its history can be indicated by Figure 1 below.

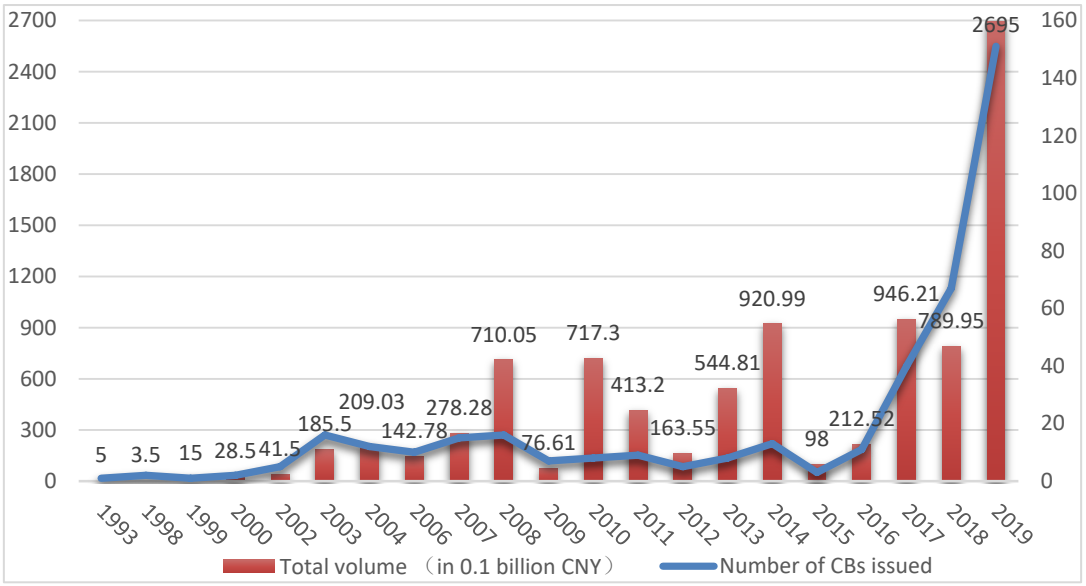


**Figure 1. Number of Convertible Bonds Issued and Total Volume of Each Year**

Summarizing related literature, the evolution and development of Chinese convertible bond market can be divided into four stages as follows.

The first stage is referred to as ***embryonic stage*** **(1991-1997)**, during which convertible bonds were mainly issued by small-sized listed companies and the usages were very experimental. Qiong energy was the first non-listed company to issue convertible bonds in 1991, and it has realized 30% share conversion. On the other hand, the first convertible bond in domestic A share market was issued by Shenzhen Baoan enterprise in November 1992. Unfortunately, only 2.7% of the bonds were converted into common shares due to the company's performance decline and technical defects. In 1993, China Textile Machinery (CTM) and China South Glass Holdings Ltd. (CSG) were approved to issue convertible bonds to overseas investors, which is the first time that China and foreign capitals were connected through B shares. However, the development of convertible bond market was impeded by the rise of other financing methods like right issue and private placement over 6 years. There are only 13 Chinese companies raising funds through issuing convertible during 1991 to 1997, until when China Securities Regulatory Commission (CSRC) published the *Interim Measures for the Administration of Convertible Corporate Bonds*, which put the issuance of hybrid securities on the normalized track. Some specific examples of Chinese convertible bonds issued in the embryonic period are demonstrated in Table 1.

**Table 1. Chinese Convertible Bonds Issued in the Embryonic Period**

| | Issuing company | Date of Issuance | Issuance size | Coupon rate | Maturity |
|---|---|---|---|---|---|
| **Onshore** | Qiong Energy | 1991.08 | ￥30,000 | 10% | 3 years |
| | Chengdu Gongyi | 1992.08 | ￥59,225,000 | -- | -- |
| | Shenzhen Baoan | 1992.12 | ￥500,000,000 | 3% | 3 years |
| **Offshore** | CTM (B share) | 1993.11 | CNF35,000,000 | 1% | 5 years |
| | CSG (B share) | 1995.06 | $ 45,000,000 | 5.25% | 5 years |

The second development stage is called ***Exploratory stage*** **(1997-2001)**, which started after the first normative document was put on stage. This regulation mainly takes the state-owned enterprises as pilots, specifying the standards to reach for the issuance of convertible bonds and the commitments to be complied with by the underwriters. As a consequence, three unlisted companies (Nanning Chemical, Wujiang Silk and Maoming Petrochemical) and two listed companies (Shanghai Hongqiao airport, Angang New rolling) successively issued convertible bonds in the following three years, which further enlarge the market size and trading varieties of convertible bonds.

The third stage is the ***maturing period*** **(2001-2009)** since various aspects of Chinese convertible bond market was getting improved and perfected. In April 2001, CSRC issued *measures for the implementation of the issuance of convertible corporate bonds by listed companies*, which filtered out small-scale enterprises with low financial performance and established the legal status of convertible bonds in China's capital market. Since then, there has been an explosive growth of the market size of convertible bonds. From 2002 to 2009, 60 listed companies in total issued convertible bonds in Shenzhen and Shanghai stock exchanges to raise funds. The issuing companies came from various industries, such as Xining Special Steel, Fengyuan biochemical, etc.

However, the market value of A-share declined sharply by 40% from April 2004 to June 2005, then the value of options embedded in convertible bonds also decreased. In 2005, due to the reform of split share structure and the inquiry system for new share issuance, the convertible bond market entered a downturn. With the promulgation of *the administrative measures for the issuance of securities by listed companies* in May 2006, the issuance and listing of convertible bonds was restarted, indicating that China's convertible bond market has entered a new stage of gradual maturity. Consequently, Ma Gang bond emerged as time requires on November 13 2006, which is the first convertible bond that can be traded separately in Chinese securities history. In 2008, warrant bonds dominated the primary market of convertible bonds for the reason that 63.285 billion yuan of its total financing 71.005 billion yuan were issued for warrant bonds.

Finally, Chinese convertible bond is staying at a period of ***rapid growth and prosperity*** **(2009-today).** In 2010, the Bank of China issued one of the maximum ordinary convertible bonds in history, followed by industrial and Commercial Bank of China and Sinopec, which issued convertible bonds worth 25

billion yuan and 23 billion yuan respectively. In 2017, China EverBright Bank issued 30 billion CNY of convertible bonds, which are more than the total value for the whole year of 2016. By the end of 2017, 23 listed companies issued convertible bonds with total volume 60.3 billion CNY. By contrast, the convertible bond market blew out in 2019, issuing 151 convertible bonds with the total volume reaching 269.5 billion CNY.

## 4. Investment Risk

### *4.1 Credit Risk*

Credit risk is the most common risk of bonds exposed to investors. As a kind of subordinated bond, convertible bond is less secure than senior corporate bonds. If the issuing company is poor in operation or performance during the term to maturity of convertible bonds, it may lose the ability to pay off debts or even go bankrupt. At this time, the bondholders will suffer part or all of risk losses that cannot be compensated. Apart from the default risk, credit risk also includes the changes on bond values caused by conversions among various credit ratings.

Furthermore, failure to convert bonds into shares is also regarded as default. In this circumstance, bondholders can only get coupon payments and principal as a plain vanilla bond, which makes the market conversion premium they paid in vain. By May 2019, 115 of 279 convertible bonds (excluding warrants) issued in Shanghai and Shenzhen exchange markets have been delisted, and 10 of them have not been forced to be redeemed (Lin, 2016). For the reason that the downward revision of stock prices was not in place while the prices of underlying stocks declined for a long term, the listed companies can only repay the principal and interest at maturity.

### *4.2 Market Risk*

#### 4.2.1 Interest Rate Risk

The price of convertible bonds is inversely correlated with the market interest rate. Meanwhile, the rise of interest rate may also reduce the stock prices, which in turn bring down the bond prices and make investors suffer from capital losses. China stipulates that the coupon interest rate of convertible bonds shall not be higher than the deposit interest rate of the bank in the same period. Therefore, once convertible bonds cannot be converted into stocks, investors' income will be lower than that of savings deposits. Currently, most convertible bonds issued adopt the progressive method to set the interest rate, which generally fluctuates up and down 1% (Chen, 2020). Consequently, investing in convertible bonds with relatively higher coupon rates can obtain higher return even if the conversion cannot be realized. Interest risk can be measured by a set of duration index.

#### 4.2.2 Stock Price Risk

The risk of price reduction of a convertible bond is also significantly influenced by the expectation of underlying stock prices on the secondary market. The value of the embedded call option will decrease once stock price increases, thus reducing the price of the convertible bond. Once the stock price fell down below the conversion price, investors will lose the opportunity to convert their bonds into stocks

and gain dividends.

In China, the stock market is not very developed and mature, so it is highly speculative and the stock price is volatile. Therefore, the stock price cannot reflect or even deviate a lot from the company's actual operating performance. These adverse factors from the stock market will further enlarge the risks in the convertible bond market. In addition, if the convertible bonds are issued when the stock market is in an upsurge period, the possibility of failure to convert tends to be higher even if the conversion price is set reasonably.

4.2.3 Foreign Exchange Risk

Some B-share companies issue convertible bonds specifically to foreign investors. Under such condition, these convertible bonds are denominated in foreign currencies. Therefore, the appreciation of foreign currencies will lead to a higher coupon payment as well as principal in terms of domestic currency.

4.2.4 Measurement of the Downside Risk

Since the minimum price of a convertible bond is the greater of its conversion value and straight value while the conversion value is fluctuated with interest rates, investors generally regard the straight value as a floor price of convertible bond. As a result, the downside risk of a convertible bond can be measured as follows:

$$\textbf{\textit{Premium over straight value}} = \frac{\textbf{\textit{market price of the convertible bond}}}{\textbf{\textit{straight value}}} - \mathbf{1} \quad (1)$$

Ceteris paribus, the greater premium over straight, the higher downward risk.

*4.3 Call Risk*

The mandatory redemption clause of a convertible bond provides the issuing company with a call option to repurchase part or all of the bond before maturity. This option is generally exercised when the stock price is high or the market interest rate is relatively low so that the bond issuer can refinance at a lower cost. This clause has two disadvantages for the investor: Firstly, the potential of convertible bond appreciation will be much lower than stocks since the call price acts as a ceiling on the rise of convertible bond values when interest rate declines. Secondly, investors have to confront the reinvestment risk when convertible bonds were redeemed under a low market interest level.

In practice, if bondholders do not sell the convertible bond or carry out the stock conversion after the issuer announces the mandatory redemption, they will eventually suffer a loss of market value. This phenomenon did really happen. According to statistics, there were still more than 1 million convertible bonds that had not been converted into shares when "Minsheng CB" was delisted on June 25, 2015 while there were also more than 8,000 When "Goer CB" was delisted on June 30, 2017 (Li, 2005).

*4.4 Liquidity Risk*

This kind of risk is exposed to investors who do not hold convertible bonds to maturity. As long as the conversion starts, less shares available to be converted will reduce the liquidity of convertible bonds. Since convertible bonds are also tradable in the secondary market, there are times when they cannot be

traded at their fair value and when the transaction prices are much different under various market conditions.

The liquidity of Chinese corporate bond market was continuously low over a long period. In 2004, the trading volume of 5 convertible bonds listed on Shanghai and Shenzhen exchanges was zero (Xiao, 2002).

*4.5 Other Risks Related to Enterprise Reform*

4.5.1 Takeover Risk

Corporation takeovers generally represents that the stock price is less likely to rise sufficiently for bondholders to benefit from various conversion features. What is worse, the original underlying stock may stop trade afterwards, leaving investors lower coupon payments than a comparable-risk non-convertible corporate bond.

4.5.2 Risk of Listing

This kind of risk only exists in unlisted issuing companies of convertible bonds. If the shares of the unlisted company fail to go to public during the maturity, investors have to suffer from the loss of conversion opportunities.

4.5.3 Delusion Risk

During the period of issuing convertible bonds, the net earnings per share will be diluted and the share price will fall when the listed company implements right issue or private placement. If the conversion ratio is not adjusted at this time, it will be difficult for investors to realize the conversion.

## 5. Valuation Models of Convertible Bond

Basically, the value of a convertible bond consists of two parts, which are the value as a comparable plain bond and the value of a call option or warrant on the stock. The approximated formula is as below:

**Convertible bond value = straight value + price of the call option on the stock**

Since most convertible bonds embed call options and put options, which are beneficial for the issuer and the investor respectively, the convertible bond price should be adjusted as:

**V (Convertible bond) = straight value + P (call option on the stock) + P (put option on the bond) – P (call option on the bond)**

*5.1 Valuation of the Straight Bond*

Firstly, the value of a nonconvertible corporate bond with comparable risks at time $t$ ($0 \le t \le T$) can be measured by DCF model, which is expressed as:

$$B = \sum_{n=0}^{[T-t]} \frac{I_{[t+n+1]}}{(1+r+r_c)^{T-t-[T-t]+n}} + \frac{F}{(1+r+r_c)^{T-t}} \quad (2)$$

where $B$ stands for the straight value of the convertible bond, $I_n$ is the coupon payment of year n, $F$ is the face value of the bond, $T$ is the time to maturity, and $[t]$ represent the maximum integral not exceeding t. All the cash flows are discounted at $(r+r_c)$ where $r$ is the risk-free rate and $r_c$ is the

risk premium of the issuing company.

*5.2 Valuation of the Call Option on Stock*

5.2.1 Black-Scholes Model

Based on the no-arbitrage theory, the Black-Scholes pricing model is aimed at valuing European option on a non-dividend paying stock. It has seven **assumptions** (Li, 2005):

- Underlying stocks are risky assets and can be freely traded.
- The price of underlying stock should obey a stochastic process where μ and σ are constants so that the price changes subject to the general Wiener process.
- During the term of validity of the option, there is no need to consider any income of the underlying assets, such as dividends, interest, etc.
- The market is efficient and there are risk-free arbitrage opportunities.
- The risk-free rate is constant and individual investors can borrow at this rate as much as they want.
- Trading is continuous and short selling is permitted.
- No transaction costs and taxes should be considered.

Now we can derive the BS Formula. Suppose *S* is the market price of the underlying stock, *f* is the price of the derivative of *S* and is a function of *S* and *t*. As $dt \to 0$, $(dt)^2$ and its higher order terms are assumed to be zero to simplify the derivation. According to Ito's lemma and the geometric Brownian motion of stock prices, we firstly obtain the process for the value change during time *t* of the option:

$$df = \left(\frac{\partial f}{\partial t} + \frac{\partial S}{\partial t}\mu S + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 f}{\partial S^2}\right) dt + \frac{\partial f}{\partial S}\sigma S dz \tag{3}$$

Since the market is efficient, a portfolio $\prod$ constructed through long $\frac{\partial f}{\partial S}$ units of stock and short sell 1 unit of *f* should earn a risk-free return without arbitrage during a short time period *dt*, therefore,

$$d\prod = d\left(-f + \frac{\partial f}{\partial S}S\right) = \prod dt \tag{4}$$

Which is

$$-\left(\frac{\partial f}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 f}{\partial S^2}\right) dt = r\left(-f + \frac{\partial f}{\partial S}S\right) dt \tag{5}$$

Rearranging the equation (5), we can obtain the Black-Scholes differential equation:

$$\frac{\partial f}{\partial t} + \frac{\partial f}{\partial S} rS + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 f}{\partial S^2} = rf \tag{6}$$

Now, this equation can be solved with a specific boundary of a call option: $C_T$=max ($S_T$-K, 0), and that of a put option: $P_T$=max (K-$S_T$, 0), K is the strike price and $S_T$ is the stock price at maturity. The current price for an option is computed as the following equations:

$$\begin{cases} c_t = S_t N(d_1) - Ke^{-r(T-t)} N(d_2) \\ p_t = Ke^{-r(T-t)} N(-d_2) - S_t N(-d_1) \end{cases} \tag{7}$$

where

$$d_1 = \frac{\ln(S_t/K) + (r + \frac{1}{2}\sigma^2)(T-t)}{\sigma\sqrt{T-t}}$$

$$d_2 = \frac{\ln(S_t/K) + (r - \frac{1}{2}\sigma^2)(T-t)}{\sigma\sqrt{T-t}} = d_1 - \sigma\sqrt{T-t}$$

$N(d_1)$ is the probability of exercising the call option in risk-neutral world,

$\sigma$ stands for the volatility of the underlying stock return.

Since one convertible bond can be converted into many shares, the total option valued included in a convertible bond should be the product of the conversion ratio and the unit value of the call option on stock. Finally, the B-S price of a convertible bond is the sum of its straight value and total option value, shown by equation (8).

$$\text{V (Convertible bond)} = \sum_{n=0}^{[T-t]} \frac{I_{[t+n+1]}}{(1+r+r_c)^{T-t-[T-t]+n}} + \frac{F}{(1+r+r_c)^{T-t}} + \frac{F}{Conversion\ price} \times [S_t N(d_1) - Ke^{-r(T-t)}N(d_2)] \quad (8)$$

5.2.2 Gailai-Schneller Model

The G-S Model is actually the modified version of the B-S Model since it further takes the delusion effects after conversion into consideration (Liao, Zhang, Xie, & Zhang, 2012). Suppose the market value of the issuing company when the convertible bond matures is $V_T$, and its outstanding shares is *N*, the number of matured bonds is *M* and the conversion ratio is $\varphi=F/K$. As a result, the new equity value of the issuing company after the conversion of all the convertible bonds will increase to $V_T + M\varphi K$ while the shares outstanding increase to N+Mφ. Consequently, the stock price will be updated to be $\frac{V_T+M\varphi K}{N+M\varphi.}$.

If the convertible bonds are converted at maturity, the actual gain of investors on a unit convertible bond should be: $\left(\frac{V_T+M\varphi K}{N+M\varphi.} - K\right) \times \varphi = \frac{N\varphi}{N+M\varphi.} \times (\frac{V_T}{N} - K)$, which can be only realized when the stock price reaches the conversion price. Therefore, the value of a conversion right at maturity date is $C_T$=max $[\frac{N\varphi}{N+M\varphi.} \times (\frac{V_T}{N} - K),\ 0]$, which can be understood as $\frac{N\varphi}{N+M\varphi.}$ units of call options on the underlying asset whose price is $\frac{V}{N}$. Taking this equation as a boundary to solve the B-S formula, we can finally derive the G-S valuation model for a call option:

$$c_t = \frac{N\varphi}{N+M\varphi.}\left[S_t N(d_1) - Ke^{-r(T-t)}N(d_2)\right] = \frac{NF}{NK+MF.}\left[S_t N(d_1) - Ke^{-r(T-t)}N(d_2)\right] \quad (9)$$

## 6. Empirical Analysis

In this section, the convertible bond issued by Shanghai Electric (Group) Corporation is selected to reflect the difference of the actual price and the theoretical price computed by BSM. The valuation is based on the first day of its issuance. The basic information of this convertible bond is shown in Table 2.

**Table 2. Issuance Information of Shanghai Electric Convertible Bond**

| | | | | |
|---|---|---|---|---|
| **Name** | Shanghai Electric Convertible Bond | | **Issuance code** | 113008 |
| **Issuing company** | Shanghai Electric | | | |
| **Initial stock price** | 10.13 yuan | | **Initial conversion price** | 10.72 yuan |
| **Listing date** | 2015-02-16 | | **Maturity date** | 2021-02-01 |
| **Face Value (CNY)** | 100.00 | | **Issue volume** | 6 billion CNY |
| **Credit rating** | AAA | | **Maturity (years)** | 6 |
| **Coupon rates** | **0.2%** for year 1, | **0.5%** for year 2, | **1.0%** for year3, | |
| | **1.5%** for year 4, | **1.5%** for year 5, | **1.6%** for year 6. | |
| **Call provision** | If the closing price of the company's shares is not lower than 130% of the current conversion price for at least 15 trading days in any 30 consecutive trading days, the company has the right to redeem part or all of the convertible bonds according to the face value of the bonds plus the accrued interest of the current period. | | | |
| **Put provision** | If the closing price of the company's shares is lower than 70% of the current conversion price for 30 consecutive trading days, the convertible bond holder has the right to sell all or part of the convertible bonds back to the company at 103% of the face value | | | |

Firstly, to measure the straight price of this convertible bond, we need to set an appropriate discount rate. Since Shanghai Electric is rated as AAA, here we refer to the average yield to maturity of six-year AAA corporate bonds in 2015, which is approximately 4.34%, as the discount rate. The data comes from the official website of China Bond (https://www.chinabond.com.cn/).

*6.1 Straight Price*

According to equation 2 and the discount rate of 4.34%,

$$B = \frac{100 * 0.2\%}{1 + 4.34\%} + \frac{100 * 0.5\%}{(1 + 4.34\%)^2} + \frac{100 * 1.0\%}{(1 + 4.34\%)^3} + \frac{100 * 1.5\%}{(1 + 4.34\%)^4}$$

$$+ \frac{100 * 1.5\%}{(1 + 4.34\%)^5} + \frac{100 * (1 + 1.6\%)}{(1 + 4.34\%)^6} = 82.7486$$

*6.2 B-S Valuation of the Call Option*

Next, to compute the price of the call option on stock, we need to firstly determine the volatility of the stock return $\sigma$. In this paper, the stock price volatility of Shanghai electric convertible bond is calculated based on the stock price of 90 consecutive trading days before its issuance. The daily return volatility is computed to be 4.0808% using the daily closing price of this stock from Wangyi Finance (http://www.quotes.money.163.com/trade/lsjysj_601727.html?year=2015&season=1). Assuming there are 252 trading days in a year, the yearly volatility $\sigma$ should be computed as follows:

$$\alpha_t = \ln\left(\frac{S_t}{S_{t-1}}\right),$$

$$\theta = \sqrt{\frac{\sum_{i=1}^{n}(\alpha_i - \bar{\alpha})^2}{n-1}} = 4.0808\%,$$

$$\sigma = \theta \times \sqrt{diy} = 4.0808\% * \sqrt{252} = 64.78\%.$$

With reference to the yield to maturity 5.32% of 5-year Certificate Treasury Bond in 2015, the risk-free interest rate can be expressed as the annual continuous compound interest rate

$$r = \ln(1 + 5.32\%) = 5.18\%$$

Then this paper input $\sigma = 64.78\%$, $r$=5.18%, $K$=10.72, $S_t$=10.13, T-t=6 into the BSM to value the call option price.

$$d_1 = \frac{\ln\left(10.13/10.72\right) + \left(5.18\% + \frac{1}{2} \times 64.78\%^2\right) \times 6}{64.78\% \times \sqrt{6}} = 0.9535$$

$$d_2 = \frac{\ln\left(10.13/10.72\right) + \left(5.18\% - \frac{1}{2} \times 64.78\%^2\right) \times 6}{64.78\% \times \sqrt{6}} = -0.6332$$

$c_1 = 10.13 * N(0.9326) - 10.72e^{-5.18\% \times 6} * N(-0.6541) = 6.3377$

This is the value of one unit call option included in the Shanghai Electric convertible bond, where $N(0.9326)$ and $N(-0.6541)$ can be obtained by using the function of NORM.S. DIST in excel. Since a convertible bond can be converted into many shares, which equals the conversion ratio, the total option value of this convertible bond should be:

$$B\text{-}S \quad C = \frac{Par\ value}{conversion\ price} \times c_1 = \frac{100}{10.72} \times 6.3377 = 59.1203$$

Lastly, adding the straight value and the total value of the call option on stock, the theoretical value of Shanghai Electric convertible bond should be:

$$V = B + C = 82.7486 + 59.1203 = 141.8689$$

According to statistics from the website of East Economy (http://www.data.eastmoney.com/kzz/detail/113008.html), the actual closing price of this convertible bond on 16 February 2015 is 133.31 yuan, of which 86 yuan is the straight price and 90.39 is the value of call option. Therefore, the theoretical value of the convertible bond measured by the B-S formula is much higher than the issuing price (par value) and even higher than the closing price. This phenomenon may be caused by several reasons. Firstly, Shanghai Electric Corporation may cut its profits in favor of

customers so that it can attract more investments. The other reason is the undervaluation of this convertible bond due to the lack of considerations about the financing strategy.

However, the application of the BSM has drawbacks since some of its assumptions are to ideal, for example, it does not take the repurchase and the redemption clause into account. According to the call provision demonstrated in Table 2, the call option on this bond will be exercised at 130% of the conversion price, 13.936. Therefore, the value of this call option owned by Shanghai Electric is:

$$d_1 = \frac{\ln\left(10.13/13.936\right) + \left(5.18\% + \frac{1}{2} \times 64.78\%^2\right) \times 6}{64.78\% \times \sqrt{6}} = 0.7882$$

$$d_2 = \frac{\ln\left(10.13/13.936\right) + \left(5.18\% - \frac{1}{2} \times 64.78\%^2\right) \times 6}{64.78\% \times \sqrt{6}} = -0.7985$$

$c_2 = 10.13 * N(0.6703) - 13.936e^{-5.18\% \times 6} * N(-0.9165)$ =5.7816

Similarly, when the trigger price of the put option is 70%*10.72=7.054 yuan, its value can be computed as:

$$d_1 = \frac{\ln\left(10.13/7.054\right) + \left(5.18\% + \frac{1}{2} \times 64.78\%^2\right) \times 6}{64.78\% \times \sqrt{6}} = 1.2173$$

$$d_2 = \frac{\ln\left(10.13/7.054\right) + \left(5.18\% - \frac{1}{2} \times 64.78\%^2\right) \times 6}{64.78\% \times \sqrt{6}} = -0.3694$$

$p = 7.054e^{-5.18\% \times 6} * N(0.3694) - 10.13 * N(-1.2173)$ =2.1979

Therefore, considering the possibility of exercising the call option and put option of this bond, the adjusted price of Shanghai Electric convertible bond should be

$$V_{BS} = B + C - c_2 + p = 82.7486 + 59.1203 - 5.7816 + 2.1979 = 138.2852$$

After adjustment, we can see that the bond value is closer to the actual closing price on its issue date, 133.31.

*6.3 G-S Valuation of the Call Option*

Next, this paper applies the G-S model for the call option valuation and analyze the difference between the B-S price and the G-S price of Shanghai Electric Convertible Bond. An additional information needed here is the number of shares at issuance, which is 9,850,714,660 shares.

$$G\text{-}S\ \ C = \frac{9{,}850{,}714{,}660 * 100}{9{,}850{,}714{,}660 * 10.72 + 60000000 * 100} \times [10.13 * N(0.9326) - 10.72e^{-5.18\% \times 6} * N(-0.6541)] = 8.82 \times 6.3377 = 55.9418$$

Therefore, the theoretical price of Shanghai Electric Convertible Bond obtained from G-S method is:

$$V_{GS} = B + C - c_2 + p = 82.7486 + 55.9418 - 5.7816 + 2.1979 = 135.1067$$

By comparison, the G-S valuation considering the delusion effects of stock conversion can reduce the errors and obtain a bond price that is closer to the actual one.

*6.4 The Comparison between B-S and G-S Valuation*

In the case of valuing Shanghai Electric convertible bond, the results indicate that G-S model can measure the call option value more precisely than B-S model does and has generally lower outcomes. To explore whether this relationship exists at all levels of the stock price, this paper compares the two

bond values obtained from B-S and G-S model when stock price is 10, 20, …, 100 respectively. When we examine the effect of price changes of the underlying stock, other parameters including volatility $\sigma$, conversion price, interest rates should remain unchanged. The comparison is clearly illustrated by Figure 2.

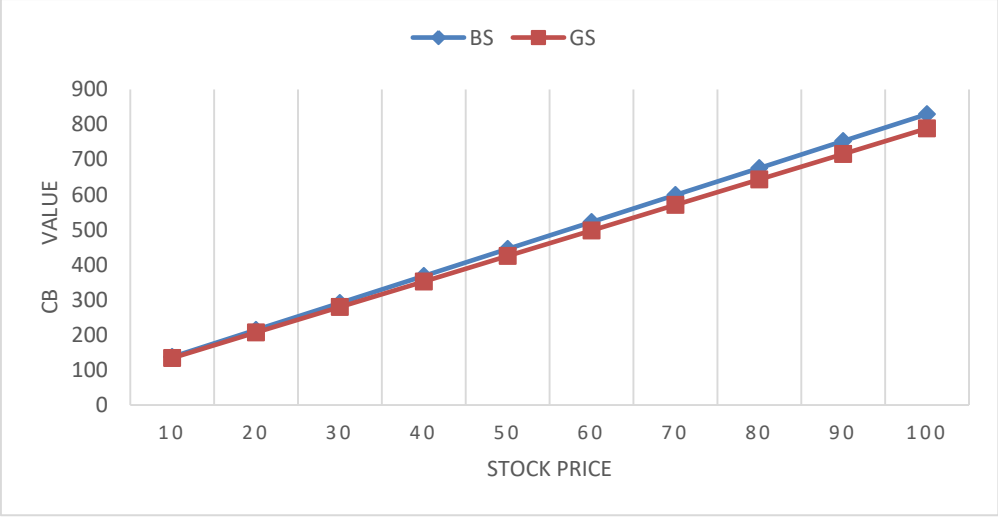


**Figure 2. The Comparison of B-S and G-S Valuation of Shanghai Electric CB**

To conclude, the bond prices measured by these two methods have similar trend as they both increase as the stock price rises. While the difference between these two outcomes is not too significant, G-S model always leads to lower prices of the convertible bond and this difference tends to become larger when the stock price is higher.

## 7. The Application of Convertible Bonds in Portfolio Management

### *7.1 Investment Purpose*

Since convertible bonds simultaneously contain the features of bond and stock, which are all risky assets that can produce returns, investors can choose different kinds of convertible bonds in terms of their own risk preferences when constructing their investment portfolios.

#### 7.1.1 For Risk-averse Investors

For investors who mainly invest in bonds in pursue of lower risk and stable returns, they can they can replace part of their ordinary bonds in their portfolio into convertible bonds to appropriately improve the overall return. To measure the substitution effect, they can compute the benchmark yield difference, which is:

$$\text{benchmark yield difference} = y_c - y_{corp}$$

where $y_c$ is the yield to maturity of a convertible bond and $y_{corp}$ is that of a corporate bond of same maturity? This indicator can effectively reflect how much yield the investor needs to sacrifice in order

to obtain the conversion right. The choice between pure bonds and convertible bonds depends on the specific tolerance to risks of each individual.

7.1.2 For Risk-neutral Investors

As for investors who always balance the risks and returns of their portfolios, both their risk tolerances and requirements of returns are higher than risk-averse investors. Under this circumstance, investing in convertible bonds whose prices are close to par is a good choice for them. To be more specific, convertible bonds that are priced between 90 to 110 can optimally balance the bond- and stock-like features. The volume of such convertible bonds is relatively stable in the market, which accounts for around 1/3 (Dai, 2005).

7.1.3 For Risk-chasing Investors

Some convertible bonds with more stock-like features can be chosen to substitute some stocks in a portfolio. As a result, the convertible bond has similar aggressiveness as stocks when the stock price is situated at higher levels, meanwhile, it has a price floor and is resilient to price decreases than stocks so that is can protect investors and increase the total returns of portfolios.

A famous investment strategy called conversion strategy reasonably utilizes this feature and the high correlation between underlying stocks and convertible bond to gain greater incomes (Dai, 2005). That is, an investor can replace the ordinary shares in his portfolio with convertible bonds when conversion premium is relatively low, so that the investor provides protections for his stocks while maintaining the same return. Likewise, as the aggressiveness of convertible bonds will be much lower when the conversion premium is high, which means the risk level is lower, investors can consider to convert these bonds into stocks.

*7.2 Arbitrage Purpose*

A classic arbitrage strategy of constructing a market neutral portfolio consists of the long position of convertible bonds and the short position of underlying stocks (Huang & Feng, 2017). The purpose of short stocks was to hedge its price risk. The specific operation is to purchase one unit of convertible bond at $P_0$ on the listing day and short sell *delta* $\Delta$ units of common stocks. The difference between the cash inflows and outflows can be compensated by risk-free borrowing or lending.

Let $\psi_t$ be the value of this portfolio, $\beta_t$ be the conversion ratio, $S_t$ be the stock price at time t. Then when t>0, this portfolio will generate an income (loss):

$$\psi_t - \psi_{t-1} = (R_t^{CB} - _{t-1}) * \beta_{t-1} * R_t^S \pm MM_t$$

where $R_t^{CB}$ is the return of the conversion bond, which equals to $(P_t - P_{t-1})$; $R_t^S$ is the return of common shares and equals to $(S_t - S_{t-1} + Div_t)$; MM is the change of cash flows caused by lending or borrowing, which should be $(P_{t-1} - \Delta * S_{t-1} * \beta_{t-1})$*(1+ risk-free rate/252). Therefore, the return on this portfolio can be measured as $\frac{\psi_t - \psi_{t-1}}{\psi_{t-1}}$.

## 8. Main Problems of Chinese Convertible Bond Market

### *8.1 Unfavorable Issuing Conditions for New Economy Growth*

Since most enterprises issue convertible bonds to raise funds at lower financing costs and postpone the equity premium at the same time, the issuance of convertible bonds is especially suitable for growth companies with small scale but growing financing demand and limited credit scale due to relatively large risks. However, relative regulations in China states that and the issuing enterprises are required to make continuous profits in the past three years, with the net asset profit rate reaching 10% on average (Yan, 2011). Therefore, most of the domestic enterprises issuing convertible bonds are from traditional industries such as steel, machinery, automobile, infrastructure construction, etc. while the possibility for unlisted companies to issue convertible bonds is small. This kind of policy encouraging listing enterprises to issue convertible bonds but strictly restricts unlisted or non-profit enterprises is not conducive to the long-term development of the convertible bond market and the expansion of the transaction scale. It can be seen that the industry distribution of China's convertible bond market still needs to be diversified.

### *8.2 Lack of Innovation on Product Designs*

Currently, the type of Chinese tradable convertible bonds is simple and few, only common convertible bond and warrants are included. In addition, most of them are designed in the same way, not only has the interest rate basically been close to 0.8% in recent years, but also the premium level of stock conversion has fluctuated with the stock market. In Europe and other overseas markets, the initial conversion premium is generally 15% - 30%, mostly 20% - 25% (Liu, Zhang, & He, 2010). Moreover, domestic convertible bonds are generally supported by unlimited downward adjustment provisions, which conflicts with the interests of medium-sized and small shareholders.

### *8.3 Impure Motives of Issuing Companies*

In China's convertible bond market, convertible bond has become a tool to get cheap interest to some extent. For example, some companies maliciously reduce the stock price before the maturity of the convertible bonds, and the conversion of bondholders will not be exercised. XinSteel convertible bond is a good example of lowering the stock price. Despite the failure of conversion, XingSteel corporation took up billions of cash at a cost significantly lower than the interest on bank loans. Another example is that China Merchants Bank, which launched 10 billion yuan of convertible bond financing scheme just one year later just went public in 2002 and raised 10.7 billion yuan (Liu, Zhang, & He, 2010).

### *8.4 High Liquidity Risk*

Since the convertible bond have dual characteristics of bond and stock, this market faces higher risk that the liquidity suddenly disappears if all kinds of institutions are massively clustered in it. Due to the lack of trading scales, varieties and institutional investors of convertible bonds in China, the liquidity of this market is seriously weak. At one time, the "annual turnover rate" of corporate bonds was only 0.23, which is far lower than the 2.1 of treasury bond trading and the 1.92 turnover rate of Shanghai A-share

market (Lu, 2014), while the convertible bond market even had zero trading volume per day, facing the awkward situation of "no market with price".

## 9. Suggestions for Chinese Convertible Bond Market

### *9.1 Completing Credit Rating System and Increase Information Transparency*

The development of credit rating system in Chinese convertible bond market is still lagging behind and its integrity and reliability have not been unanimously recognized by the investors. In order to ensure the investment safety of convertible bonds, guarantees and collaterals are mainly adopted in China. By contrast, the three major markets of the United States, the European Union and Japan all conduct detailed and standardized credit evaluation on the companies issuing convertible bonds, which further determines the level of interest rates and the amount of convertible premium. The establishment and improvement of credit rating system has become an urgent task as increasing foreign capitals rush in Chinese grading system. Thereafter, the regulations on the issuance, approval processes and relative information disclosing requirements should also be stricter.

### *9.2 Promoting Innovation and Diversity of Products*

Our country should encourage issuing companies to create different types of convertible bonds through changing specific clauses, and give them priorities to be examined and approved. First, gradually extend the issuance period of convertible bonds. The shortest term of domestic convertible bonds is 3 years while the longest is 5 years, which are much shorter than that of foreign convertible bonds. This may force the company to have short-term behavior when choosing financing projects, which is not beneficial to the long-term development of the company. Secondly, the issuance of convertible bonds through the public offering and private placement should be allowed in parallel. Chinese convertible bond market is supposed to formulate the relevant regulations of private offering and reduce its costs based on the successful experience of the international mature market.

### *9.3 Involving Institutional Investors*

To improve the completeness and diversity of the investors in Chinese convertible bond market, we should promote the growth of institutional investors. According to statistics, they currently hold more than 90% of the convertible bonds in circulation in the market. Moreover, the proportion of QFII (qualified foreign institutional investors), which recently accounts for nearly 8% of the convertible bonds, has gradually increased their investments in Chinese market (Lu, 2014). Appropriately expanding the convertible bonds issued abroad like European market and American market will enable companies not only to finance more extensively but keep up with the developments of the international market.

### *9.4 Lowering the Barriers to Entry for Growth Companies*

The supervision department of Chinese market should shift the focus of the approval from the performances of issuing companies to the project of raising funds, from supporting large enterprises to high growth enterprises so as to improve the domestic ability of independent innovation. Therefore, it is

necessary to modify the restrictions on issuance indexes such as net assets and asset liability ratio. Utilizing the convertible bond market to support high-tech enterprises can activate the financial characteristics of convertible bonds and promote their healthy development. This is not only in line with the state's policy of encouraging innovation and changing the mode of economic growth, but also creates a broader market space for the development of convertible bonds.

## 10. Conclusion

In conclusion, this paper comprehensively analyzes the Chinese convertible bond market from 5 perspectives. Firstly, after briefly introducing the basic concepts of convertible bond, this paper describes 4 stages of the historical evolution of this market, which are embryonic, exploratory, maturing and rapid growing stages respectively. Then, several main risks of investing in convertible bonds are discussed, including credit risk, three types of market risks, call risk, etc. As for pricing a convertible bond, this paper firstly derives and presents the Black-Scholes Model for option valuation, then modifies it with Gailai-Schneller Model since it further considers the delusion effect of stock conversion. Based on these two theoretical models above, Shanghai Electric convertible bond is chosen to conduct an empirical analysis so as to examine the difference of the outcomes obtained from the two pricing models. It can be concluded that the G-S model usually leads to a lower pricing outcome of the convertible bond compared with the B-S model and this outcome is also closer to the actual price. The fourth aspect of the analysis is the application of convertible bonds in portfolio management, which can be basically divided into investment functions and arbitrage function. Lastly, summarizing relative literature, this paper presents four main problems of Chinese convertible bond market as well as four suggestions.

However, the B-S model or even G-S model are not the best approaches to price a convertible bond since the assumptions of using the differential equations are too strict and not realistic. To improve the accuracy and add more influence factors of bond price, other numerical pricing methods including Binomial Option Pricing and Monte Carlo Simulation can be applied.

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