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Research Article

The Empirical Research of the Relationship on Underlying Stock Volatility in China Convertible Bonds Market

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Abstract: The study tries to improve the pricing efficiency of pricing models for the convertible bond by calculating the volatility of the underlying stock more accurately. By deducing the relationship between the historical volatility before the convertible bond issue which can be calculated accurately and the historical volatility of the underlying stock after the convertible bond issue which is suitable for pricing models and can't be calculated accurately in China, the after volatility can be calculated directly and accurately.

Keywords: Convertible bonds issue, pricing efficiency, the underlying stock volatility, the relationship

INTRODUCTION

The convertible bond is a special security of the company issued legally by the issuer, which can be converted into a certain number of underlying securities by a certain percentage or price within a certain period, which is generally converted into the ordinary share of the issuing company. The convertible bond has excellent financing and investment functions, which make it to be one of the fastest growing financial derivatives currently. However, the pricing efficiency of existing pricing models for the convertible bond is generally not high at present. The history of research about convertible bonds pricing, only 40 years at abroad, no more than 10 years in the domestic. Reasonable pricing has an important influence on the development of convertible bonds and the imprecision of convertible bond pricing models will definitely lead to the blindness of investment, undermine investors' investment enthusiasm, impact the development of convertible bonds and make the financing and investment functions of convertible bonds cannot play nice. Over the past 10 years, the vast majority of domestic scholars did research about the convertible bond pricing only by combing foreign models with Chinese actual data and often ignored assumptions and parameters of foreign models, which were not suitable for China, the result is efficient of pricing was not high. The pricing model which is suitable for Chinese convertible bonds market has not been designed and therefore improving the pricing efficiency of pricing models based on Chinese actual has an important theoretical and practical significance. One of aspects which mainly impact the accuracy of convertible bond pricing models is: The estimation of model parameters. A parameter estimation which is extremely necessary and important for almost all convertible bonds pricing models is the volatility estimation of the underlying stock. It is better to be implied volatility; however, implied volatility can't be obtained in China and the historical volatility of the underlying stock after the convertible bond issue (referred to as the after volatility) is often used to replace the implied volatility. However, time after convertible bonds issue is generally short, so the data for the underlying stock volatility estimation are insufficient. While time before convertible bonds issue is so long that there are enough data for the historical volatility of the underlying stock before the convertible bonds issue (referred to as the before volatility). Thus, we can calculate the after volatility, by calculating accurately the before volatility and their relationship. The purposes of this study are:

- **The purpose 1:** Make sure the average impact which is made by China convertible bonds issue on the volatility of the underlying stock and the relationship between the size of the influence and the time period.
- **The purpose 2:** Calculate the specific relationship $\sigma_A = f(\sigma_B)$, σ_A means the after volatility, σ_B means the before volatility, the same below.

LITERATURE REVIEW

Existed empirical conclusions for purpose 1 are generally same: convertible bonds issue decline the volatility of the underlying stock. Zhen and Lin, (2004): convertible bonds issue had an impact on volatility, reducing the volatility of the underlying stock. Other related research conclusions were similar. There are also exceptions, such as Lin (2009) got the conclusion:

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convertible bonds issue had no impact on the volatility of the underlying stock. Existed empirical conclusions for purpose 2 are not consistent. Zhen and Lin (2004) further got the relationship between the before volatility and the after volatility is $\sigma_A = \sigma_B - 5\%$. Many people use the conclusion directly such as Zhao (2008). Ma and Tang (2004) researching the historical volatility of the underlying stock of six convertible bonds, got the relationship between the before volatility and the after volatility is $\sigma_A = \sigma_B - 23.8\%$ and some people use the conclusion directly such as Hong and Chao (2007). Fei (2004) got the relationship is $\sigma_A = \sigma_B$, which meant the inherent trend of stock volatility did not change with the convertible bond issue and listing. Some people think it is unnecessary to amend the historical volatility of the underlying stock after the convertible bond issue, which means we can calculate and use the after volatility for pricing directly, such as Yang (2008), Xiao (2011) and Meng and Chen (2008) and so on. Of course, we know it is not accurate. The reason why it is unnecessary to amend the historical volatility of the underlying stock after the convertible bond issue usually is that it is too complex to amend, because the historical volatility of the underlying stock is related to so many factors. However, in order to improve the pricing efficiency of pricing models for the convertible bond, the volatility which is suitable for pricing models in China convertible bonds market must be calculated accurately and amended.

DATA AND ESTIMATION METHOD

Data principle and data source: One of the keys to estimate the volatility accurately is to find a suitable estimation time period. For stock data, it is better to use the time period of 90-180 days (Wang and Wu, 2001; Fang and Fan, 2001). The data source is the historical data of the underlying stock of 19 currently listed convertible bonds in Chinese convertible bonds market during three corresponding time periods before and after convertible bonds issue. The three corresponding time periods are 150 days, 112 days and 90 days.

Volatility estimation method: The formula (Ding and Qin, 2000) is:

$$\hat{\sigma}_{yz} = \sqrt{\hat{\sigma}_o^2 + k\hat{\sigma}_c^2 + (1-k)\hat{\sigma}_{rs}^2}$$

$$\hat{\sigma}_o^2 = \frac{1}{n-1}\sum_{t=1}^{n}(o_t - \bar{o})^2, \quad \bar{o} = \frac{1}{n}\sum_{t=1}^{n} o_t;$$

$$\hat{\sigma}_c^2 = \frac{1}{n-1}\sum_{t=1}^{n}(c_t - \bar{c})^2, \quad \bar{c} = \frac{1}{n}\sum_{t=1}^{n} c_t;$$

$$\hat{\sigma}_{rs}^2 = \frac{1}{n}\sum_{t=1}^{n}[u_t(u_t - c_t) + d_t(d_t - c_t)],$$

$$k = \frac{0.34}{1.34 + (n+1)/(n-1)}$$

In the above formula, C_t, O_t, H_t, L_t, respectively represent the closing price, the opening price, highest price and the lowest price of the underlying stock in the t trading day and:

$$o_t = \ln O_t - \ln C_{t-1}; \quad u_t = \ln H_t - \ln O_t;$$
$$d_t = \ln L_t - \ln O_t; \quad c_t = \ln C_t - \ln O_t$$

It is day volatility estimates formula and the annual volatility formula is $\hat{\sigma}_{\text{year}} = \hat{\sigma}_{yz} \times \sqrt{N}$, is the number of trading days in one year. In this study, N = 242. The selection of k can make sure the minimum variance of $\hat{\sigma}_{yz}^2$ and n represents number of trading days during the sample period.

EMPIRICAL TEST AND RELATIONSHIP DEDUCING

Empirical test: Based on above estimation formula and original data, "The Volatility Summary Table" can be gotten.

In Table1, the corresponding form is vacant if the underlying stock data of the corresponding time period are not enough. Average value means the average volatility of the underlying stock during three corresponding time periods before and after the convertible bond issue and average difference is the arithmetic mean of the volatility difference of the underlying stock during three corresponding time periods. Difference is equal to the before volatility minus the after volatility.

Impact made by China convertible bonds issue on the volatility of the underlying stock is about 1.4-8.1% and the total average difference is 4.5%, which is similar to the conclusion got by Zhen and Hai (2004). We also can find that the time period is shorter, the smaller difference value is smaller .All conclusions can be gotten from the last line of the Table 1. The purpose 1 is achieved.

Relationship derivation: Based on the data in the last two row of Table 1. The follow scatterplot can be gotten. "Before" means σ_B, "after" means σ_A, (Fig. 1).

The before volatility and the after volatility show good linear relationship in the scatter plot and next is regression analysis.

In Table 2, the coefficient of determination is 0.72376 and the F-distribution value is 44.5417 which are greater than the critical value $F_{0.05}(1,17) = 4.45$, which mean the overall regression equation is a linear significance. The t- distribution value is 6.673963 which is greater than the critical value $t_{0.025}(17) = 2.110$ and means regression equation

Table 1: The volatility summary table

	The before and after volatility						Average value	
Abbreviation	$150\sigma_B$	$150\ \sigma_A$	$112\ \sigma_B$	$112\ \sigma_A$	$90\ \sigma_B$	$90\sigma_A$	σ_B	σ_A
Xing gang	0.733	0.682	0.743	0.701	0.678	0.741	0.718	0.708
Bo Hui	0.534	0.404	0.484	0.391	0.512	0.421	0.511	0.405
Shuang Lang	0.498	0.514	0.471	0.506	0.455	0.524	0.475	0.513
Ge hua	0.423	0.241	0.354	0.227	0.321	0.233	0.366	0.233
Hai yun	0.334	0.337	0.338	0.328	0.338	0.344	0.337	0.336
Guo tou	0.279	0.262	0.298	0.255	0.305	0.271	0.294	0.263
Shi hua	0.266	0.174	0.267	0.164	0.261	0.153	0.265	0.164
Chuan tou	0.407	0.289	0.359	0.293	0.334	0.307	0.367	0.296
Zhong hai	0.248		0.235	0.287	0.221	0.299	0.235	0.293
Guo dian	0.215		0.225		0.239	0.248	0.226	0.248
Cheng Xing	0.741	0.679	0.838	0.691	0.931	0.707	0.837	0.692
Zhong Hang	0.205	0.232	0.196	0.231	0.181	0.231	0.194	0.232
GongHang	0.187	0.265	0.201	0.295	0.197	0.325	0.195	0.295
ShenJi	0.202		0.202	0.214	0.195	0.205	0.201	0.208
TangGang	0.669	0.975	0.642	0.672	0.661	0.713	0.658	0.787
Mei Feng	0.353	0.339	0.335	0.358	0.342	0.355	0.344	0.351
Zhong Ding	0.476	0.573	0.475	0.633	0.473	0.682	0.476	0.631
Yan Jing	0.352	0.251	0.354	0.271	0.339	0.292	0.348	0.271
JunLun2	0.641	0.682	0.691	0.413	0.754	0.412	0.691	0.412
Average ifference	0.081		0.041		0.014		0.045	

Primary data; DaZhiHui software

Table 2: Regression analysis table

Dependent variable: After
Method: least squares
Date: 09/05/12/time: 11:05
Sample: 1 19
Included observations: 19

Variable	Coefficient	S. E.	T-statistic	Prob.
C	0.05243	0.055210	0.949636	0.3556
Before	0.81957	0.122801	6.673963	0.0000
R-squared	0.72376	Mean dependent var		0.38621
Adjusted R-squared	0.70751	S.D. dependent var		0.18849
S.E. of regression	0.10194	Akaike info criterion		-1.62951
Sum squared resid	0.17666	Schwarz criterion		-1.53010
Log likelihood	17.4804	F-statistic		44.5417
Durbin-Watson stat	1.80559	Prob. (f-statistic)		0.00000

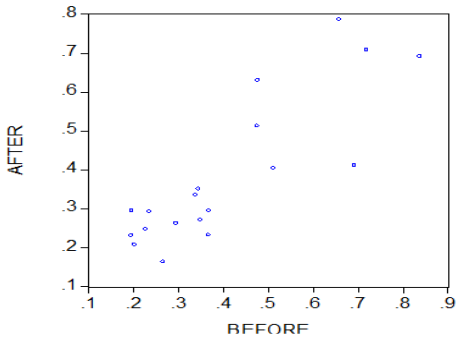

Fig. 1: Volatility scatter plot

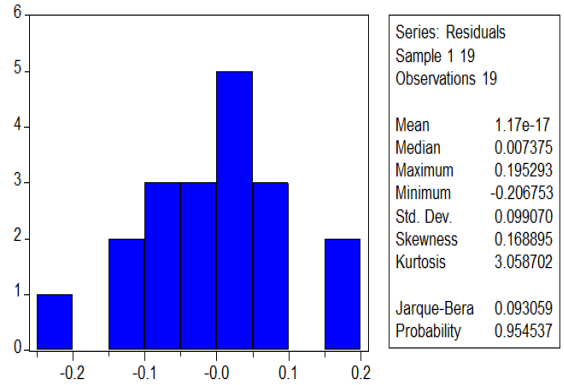

Fig. 2: Residuals normality test

Table 3: White Heteroskedasticity test

F-statistic	3.2598	Probability	0.064933
Obs*R^2	5.5006	Probability	0.063906

coefficient is significant. Next, test whether residuals meet the regression assumptions. First, test residuals independence with DW statistic. In Table 2, DW statistic is 1.80559 and d_u = 1.28, 4 – d_u = 2.72, so residuals are independent. Next, test heteroscedasticity with White statistic.

From Table 3, we can see the accompanying probability of White statistic is 0.063906, in the 5% significance level, the variance is same. Test residuals normality with residuals histogram and Jarque-Bera statistic.

From the Fig. 2, we can see the residuals histogram is standard for the bell-shaped and the accompanying

probability of Jarque-Bera statistic is 0.954537, in the 5% significance level, residuals fit the normal distribution.

In summary, the relationship between the after volatility and the before volatility is $\partial_A = 0.81957\partial_B + 0.05243$. The purpose 2 is achieved.

CONCLUSION

By researching the historical volatility of the underlying stock during three corresponding time periods before and after China convertible bonds issue, get the following two conclusions:

- The average impact made by China convertible bonds issue on the historical volatility of the underlying stock is decreasing volatility by 1.4% - 8.1% and the total average difference is 4.5%. The time period shorter, the impact smaller
- The relationship between the after volatility and the before volatility is $\partial_A = 0.81957\partial_B + 0.05243$

From Fig. 1: Volatility plot, Fig. 2: Residuals normality test and Table 3 White heteroskedasticity test, we know that the relationship is established. The two conclusions are different from previous conclusions and provide a feasible way to improve the pricing efficiency of convertible bonds pricing models and are also conducive to the faster and better development of China convertible bonds.

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