Corporate bonds pricing in China

—Base on the Vasicek model and credit spread

Xiao Ma[1,a,*], Weixuan Zhao[2,b]

[1]PhD candidate, Guanghua School of Management, Peking University, Beijing, China
[2]PhD, Price Certification Center of National Development and Reform Commission, Beijing, China
a.pkumaxiao@pku.edu.cn,b.nkuzhaoweixuan@163.com
**corresponding author*

Abstract: In this paper, we use Vasicek model to determine the pricing of corporate bonds under the risk-free interest rate, and adjust it through the credit spread to make it suitable for the pricing of corporate bonds with default risk. Furthermore, this paper tests the bond pricing model based on the bond data of three companies, and the results show that the model can well capture the bond price trend, but it is difficult to accurately capture the price fluctuation.

Keywords: bonds pricing, Vasicek model, credit spread, risk-free interest rate

1. Introduction

Since China issued corporate bonds for the first time in 2007, corporate bonds market in our country had been developed rapidly. With the vigorous development of China's corporate bonds, more and more attention has been aroused on how to determine and calculate the reasonable price of company bonds. And to solve this problem, we need to construct a reasonable corporate bonds pricing model. The corporate bond market are more mature than China, besides, the foreign scholars have done extensive and in-depth research on the corporate bonds pricing problem, so we can draw lessons from foreign bond pricing model. There are mainly two kinds of models abroad, one is Structural model, and the other one is Simple model. The Structural model does no-arbitrage analysis by the company's assets, debt and equity, while Simple model uses short-term interest rate and default intensity to do the analysis. Since the Simple model is more suitable in reality compared to the Structural model, here we will use the Simple model to calculate corporate bond pricing.

As for Simple model, Duffee (1999) did the first empirical evaluation. He pointed out that the default intensity depends on the firm-specific factor and the rate factor and then derived the pricing formula and fitted it with the actual data according to the Simple model pricing of Singleton & Duffee (1999) .He found that the variance of Simple model pricing is very small compared to the Structural model. Besides, Simple model can reflect the credit spread caused

by other factors other than default factor. However, he had also reported the shortcomings of simple model, which includes the instability of the parameter estimation.

Driessen (2005) also set up Simple model according to the framework of Duffee & Singleton (1999) and did empirical researches on it. In the set of default intensity, he extended the Duffee (1999) model so that the default intensity depends not only on the firm-specific factor and the rate factor, but also depends on the common default factor.

There are many models to determine the risk-free rate, and we will use Vasicek model. In this paper, we will first determine the corporate bond pricing under the risk-free rate using Vasicek model, and then we will adjust it by Credit spreads so that it will apply to the pricing of corporate bonds with default risk. Finally, we will test the bond pricing model by data of three companies.

2. Model

2.1 Construction of the model

In this article, under the frame structure of reduced-form model, we constructed a corporate pricing model based on term structure of risk-free rate and credit spreads. When it comes to risks of holding a bond, both risk-free and risky bond have interest rate risk. But for risky bond like corporate bond, there's another risk called credit risk. This risk arises because there are default possibility on corporate bond. The effect of interest rate on bond pricing is reflected in the model of risk-free bond pricing model. Then we add the effect of credit risk to model the corporate bond. Briefly, after we get the risk-free bond price, we take the credit risk of companies into consideration to get the corporate bond price.

2.2 The pricing model for risk-free bond

We assume the risk-free rate rt meet the Vasicek term structure model

$$dr_t = \kappa(\mu - r_t)dt + \sigma dW_t$$

Where dW_t is a Brownian motion, κ, μ and σ are all constants. μ is the long term mean level. All future r will move around a mean level μ in the long run; κ is the speed of adjustment. a characterizes the speed at which such interest rate will regroup around μ in time; σ is the volatility of interest rate.

Let P(t, T) denote the time t price of a risk free zero coupon bond with maturity date T.

$$B = (1 - e^{-\kappa\ (T-t)})/\kappa$$

$$A = (B - T + t)R - \sigma^2 B^2/(4\kappa)$$
$$R = \mu - \sigma^2(2\kappa^2) + \lambda\sigma/\kappa$$
$$P = e^{A-Br}$$

λ measures the market price of interest rate risk. According to previous research on this factor, in Vasicek model it should be a constant.

2.3 The pricing model for corporate bond

Referring the model constructed by Duffie and Singleton (1998), using the credit spreads data observed from the historical data, We can get

$$V(t,T) = P(t,T)e^{-cs}$$

$V(t,T)$ denotes price of a corporate bond with maturity date T at time t. Cs is the credit spread which is the difference between risky bond yields and risk-free bond yields and can be estimated by historical data.

3. Data source and Estimation Methods

3.1 Data sources

We use the Chibor(overnight) rate to represent the risk-free short rate with a sample size of 299 from 31st October 2013 to 8th, January 2015. Data was obtained from eastmoney.com.

We choose three corporate bonds: 13 Huaihua chemical (怀化工)(124404), 13 Wynn debt (永利债)(124418), and ST Neron debt(奈伦债) (111039).

The corresponding risk-free bond we use 13 national debt(国债)22 (19322), which has the same life length with the corporate bonds. These data can be found in CSMAR data base.

3.2 Estimation Method

For estimating parameters, we discretize the Vasicek term structure model to use the OLS estimation, the discretized function is as follow:

$$r_t - r_{t-1} = a_1 \times r_{t-1} + a_0 + \varepsilon$$

Here $a_1 = -\kappa$ and $a_0 = \kappa \times \mu$.

For estimating the credit spread cs, we use the difference between YTM of the bond we observed from the historical data and the YTM of the riskless bonds such as treasury bonds. The difference includes the characters of the firm and the coupon which treasuries don't have.

Cs= Historical YTM of the bond we price - The YTM of the riskless bonds

4. Estimation Results and Conclusion

4.1 Estimation Results

From OLS, we get the coefficients as follow:

Table1:

Parameters	Estimators
a_0	0.0014043
a_1	-0.0491596
σ	0.002699613
κ	0.0491596
μ	0.02856614

As for Cs, we get:

Table2:

Bond id	124404	124418	111039
Cs (%)	4.430105	4.429937	4.568073

We compare the price we estimate and the real price from the market for each three bond, the results and the graphs are shown:

Figure1:

Figure2:

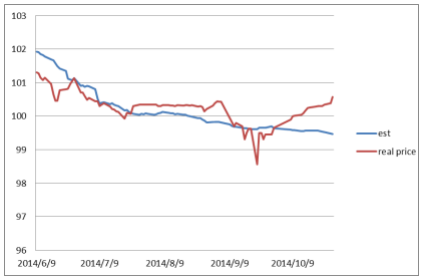

Figure3:

Table3:

Bond id	**abs_total_diff**	**average_abs_diff**	**average_related_diff**
124404	77.84789545	0.810915578	0.80%

124418	108.9706999	2.246818554	1.14%
111039	34.96819001	0.372002021	0.37%

4.2 Conclution

From the three graphs and the result chart we can see the estimation can capture the trend well. But it is hard to estimate the price exactly. For the reason, we think first, using cs to measure the credit spread is so ambiguous that the trend is affected more by the basic interest rate but less by the firms' characters. Second, the bond market is not active enough to show the real value of bonds. Third, the data we using is too limited to make the estimation exact.

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