Hindawi
Wireless Communications and Mobile Computing
Volume 2021, Article ID 5510715, 9 pages
https://doi.org/10.1155/2021/5510715

Research Article

Application of Nonarbitrage Pricing Model and Finite Element Numerical Solution in the Value of Convertible Bonds in the Stock Market

Xiaoxiao Guo

College of Commercial, Wuxi Taihu University, Wuxi, 214064 Jiangsu, China

Correspondence should be addressed to Xiaoxiao Guo; guoxx@wxu.edu.cn

Received 9 January 2021; Revised 1 March 2021; Accepted 16 March 2021; Published 1 April 2021

Academic Editor: Wenqing Wu

Because of its creditor's rights, equity, and options, convertible bonds have been developed rapidly since its emergence and have become one of the main tools in the financial market. One of the core problems of convertible bonds is pricing. The research on the pricing model of convertible bonds in China is relatively late. Most of them use foreign technologies, but they are quite different from the actual situation in China, and most of the models are characterized by a single factor. Therefore, this paper puts forward the nonarbitrage pricing model in the stock market and the application of the finite element numerical solution in the value of convertible bonds. The biggest innovation of this paper is to design a combined pricing model by using the model of nonarbitrage pricing theory and finite element numerical solution. The model combines the advantages of the nonarbitrage pricing theory and finite element numerical solution, and through the design of this paper, the model effectively improves the calculation accuracy and is suitable for most of the current market environment. While improving the comprehensive performance of the pricing model, it also simplifies the calculation methods and steps. In order to further verify the actual effect of the pricing model in this paper, the traditional binary tree model is taken as the experimental contrast object, including the comparative analysis of the market price and the theoretical price of the convertible bond, the comparative experiment of the prediction effect between the model and the binary tree model, and the analysis of the relative price error of the convertible bond. The results show that the comprehensive performance of the pricing model in this paper is significantly better than the traditional binary tree model. This study has achieved ideal results and can be widely recommended.

1. Introduction

A convertible bond is a kind of corporate bond. The holder has the right to convert the bond into a certain number of common shares of the issuing company within a certain period of time. With the nature of creditor's rights, stock rights, and options, it is a kind of financial derivative investment product with ingenious design and strong vitality, which is often called a convertible bond. Convertible bonds were first issued in the United States in the mid-19th century and have experienced a long process of development. In the 1970s, convertible bonds began to develop rapidly. At present, it has become one of the main financing and investment tools in the world stock market. In Asia, the financing amount of convertible bonds has exceeded that of stock financing, and in Europe, the financing amount of convertible bonds has been close to half of that of stocks. China's convertible bond market began in the early 1990s. After a period of downturn, especially in 2002, the issuance of convertible bonds fluctuated, and the situation deteriorated further. In a short period of half a year, the sales of convertible bonds reversed significantly. In 2003, the issuance of convertible bonds was sluggish. A total of 16 convertible bonds were issued in the whole year, raising an accumulated amount of 18.15 billion yuan, which exceeded the financing scale of allotment shares in that year, and became one of the main means of refinancing for listed companies. The unique charm of convertible bonds is gradually recognized by more investors, and the convertible bond market is generally bullish.

Before the mid-1970s, the theoretical research of convertible bonds mainly focused on the establishment of the basic concept of a convertible bond, the determination of conversion price, and the adjustment method. Due to the backwardness of theoretical methods and research tools, most of the work is limited to the characterization of the value characteristics of convertible bonds, which cannot be discussed in depth. Since the mid-1970s, the research on convertible bonds has entered a stage of rapid development. In modern research, option pricing theory and technology have been greatly expanded, mainly reflected in the pricing model, research object, and numerical simulation. In the pricing model, the restrictive assumptions in the derivation of the original option pricing formula are relaxed. In modern option pricing, the interest rate can be stochastic, the stock price process cannot be a geometric Brownian motion, and the price process can include jump, transaction cost, and dividend payment. Almost all financial products can be included in the option pricing framework. In terms of numerical simulation, the rapid development of the computer provides material guarantee for the numerical simulation of financial product pricing, and the development of some computing technologies provides technical support for numerical simulation. Finite difference method, grid method, and finite element method have been widely used in the pricing of financial products. In this process, the pricing of convertible claims is no exception. But at the same time, the pricing models of convertible bonds are mostly single factor models, and there are many deficiencies. Therefore, this paper puts forward the nonarbitrage pricing model in the stock market and the application of the finite element numerical solution in the value of convertible bonds.

First of all, this paper studies the basic theory and core concepts of the convertible bond and pricing model. Through the research, this paper believes that the convertible bond is one of the most important financial instruments, which plays an important role in China's financial market and economic development. Then, in view of the shortcomings of the existing convertible bond pricing model, this paper innovatively proposes a combined pricing model which combines the nonarbitrage pricing theory and the finite element numerical solution. Based on the theory of nonarbitrage pricing, the model defines the market as a one-dimensional standard Brownian motion and recalculates the value of the company. According to the characteristics of the existing market, this model also fully considers the control of credit risk and makes a detailed and clear division of the upper limit and lower limit of arbitrage. According to the preliminary calculation results, the finite element numerical method is used to optimize and calculate the total value of bonds. Through a series of optimization operations, the model can effectively improve the calculation accuracy. In order to further verify the actual effect of the pricing model in this paper, a number of practical examples including the comparative analysis of the market price and theoretical price of convertible bonds, comparative experiment of the prediction effect between this model and the binary tree model, and analysis of the relative price error of convertible bonds are given. Through the analysis of experimental data, we can see that the calculation results of this pricing model are more accurate than the traditional binary tree model, and the calculated results are more in line with the actual market value [1–3].

The second part of this paper introduces the related research, the third part gives the basic concept and theory of the article, the fourth part discusses and gives the pricing model based on nonarbitrage and the finite element method, the fifth part explains the effect of the method proposed in this paper, and the sixth part summarizes the full text.

2. Related Works

The pricing model of foreign convertible bonds first appeared in the 1960s. In this period, the theory holds that the price of convertible bonds is equal to the larger value between the value of convertible bonds as ordinary bonds and the discounted value of convertible bonds at a certain time in the future. The emergence of the Black-Scholes' option pricing theory and the rapid development of computer technology in 1973 have fundamentally changed the development of convertible bond pricing theory. The convertible bond pricing theory has been mature after more than 30 years of development.

Due to the development of the pricing theory of convertible bonds in foreign countries, the research of convertible bonds in China is based on the reference of foreign models, combined with the actual situation of China, such as the design of various terms or numerical methods. Zhang [4] used Monte Carlo simulation and the finite difference numerical method to price the redemption terms and redemption terms of domestic convertible bonds and analyzed the impact of these two terms on convertible bonds. Zhao et al. [5] use the finite difference method and binary tree method to solve this problem. Based on the pricing model of convertible bonds, this paper analyzes the impact of these two terms on convertible bonds under random interest rates. This paper discusses five factors that affect the pricing of convertible bonds, establishes a two factor pricing model based on the stock price and interest rate, and makes an empirical test of airport convertible bonds. It is found that the convertible bonds in China are not sensitive to the change of interest rate, which leads to some technical problems such as large calculation error and inaccurate trend prediction and analysis. Therefore, this paper proposes a combination of nonarbitrage theory and finite element method to improve the pricing accuracy of the model.

3. Basic Theory and Core Concepts of This Paper

3.1. Definition of Convertible Bonds. On March 25, 1997, the Securities Commission of the State Council issued the Interim Measures for the administration of convertible company bonds. Among them, Article 3 defines convertible bonds as follows: convertible corporate bonds refer to corporate bonds issued by issuers in accordance with legal procedures and can be converted into stocks within a certain period of time in accordance with agreed conditions. The issuers here include domestic listed companies and joint stock limited companies established after the overall or partial restructuring of key state-owned enterprises.

Like ordinary bonds, convertible bonds have several elements, such as face value, coupon rate, and maturity. The coupon rate of convertible bonds is mainly determined by the market interest rate level, enterprise credit rating, and issuing conditions. Generally speaking, the higher the market interest rate, the higher the coupon rate, and the lower the enterprise credit rating, the higher the coupon rate. Other issuing conditions will also affect the coupon rate, for example, the redemption clause limits the upper limit of investors' income, and the coupon rate can be appropriately increased. The repurchase clause protects the investors' income, increases the financial burden and risk of the issuing company, and can appropriately reduce the coupon rate. At the same time, it should be noted that the coupon rate of convertible bonds is lower than that of ordinary bonds with the same maturity and credit rating and sometimes even lower than the bank deposit interest rate of the same period. Due to the existence of convertible options, convertible bonds have the characteristics of bonds, stocks, and options. These options include equity conversion, that is, the right of investors to convert convertible bonds into common shares of the company at a certain price within a certain period of time according to the agreement. Put back right refers to the right of investors to sell convertible bonds back to the company at a certain price under certain conditions. Redemption right refers to the company's right to redeem convertible bonds in accordance with the agreement under certain conditions. The right to reduce the conversion price refers to the right of the company to reduce the conversion price under certain conditions [6, 7].

3.2. Value Analysis of Convertible Bond. A convertible bond is a kind of hybrid bond; the coupon rate is generally lower than the corresponding period bond. Investors are willing to accept lower interest rates because they attach more importance to the option of converting bonds into corporate shares. When the stock market of the issuing enterprise performs well and the stock price continues to rise, the convertible bond holder can convert the convertible bond into the common stock of the company at the conversion price lower than the current stock price and obtain the conversion income. If the stock price of the enterprise is low, investors will choose to hold the bond to obtain stable interest income or recover the investment principal on schedule. It not only has the characteristics of ordinary bonds but also has the characteristics of equity. For standard convertible bonds, it gives investors the lowest return in the form of value, that is, the value of ordinary interest-bearing bonds composed of bond coupon payment and principal repayment at maturity. At the same time, when the stock rises to a certain level, that is, when the stock value reaches a certain level, investors also have the right to convert to the common stock of the issuer.

The option value of convertible bonds refers to the right of a convertible bond holder to purchase corresponding stock at any time before the maturity of the convertible bond. If he/she is willing and meets the conditions, he/she can convert the convertible bond into stock. Due to the value of options, the actual value of convertible bonds is always higher than the bottom line before maturity. The difference between the market value of convertible bonds and the bottom-line value is the call right value and option value of stocks [8, 9].

3.3. Nonarbitrage Pricing. In the process of pricing financial assets, the nonarbitrage pricing method is not only a common pricing method but also one of the most basic principles in pricing theory.

Strictly speaking, arbitrage means that in the process of trading financial assets, traders can obtain risk-free returns without initial investment. However, if the market is effective, the market price must be adjusted according to arbitrage behavior and return to equilibrium. This is the nonarbitrage pricing principle. We can apply the nonarbitrage pricing method to term pricing from another perspective. The idea is as follows: in an efficient market, without arbitrage opportunities, investors can build a risk-free portfolio, including derivative positions and underlying asset positions. By adjusting the investment ratio of the underlying asset and the derivative asset, the long-term profit (or loss) of the underlying asset can offset the short-term loss (or profit) of the derivative. This principle actually represents an equilibrium condition between the expected yield of the derivative securities, the expected yield rate of the underlying security, and the risk-free interest rate. The binary tree pricing model of convertible bonds is a successful application of this principle [10–12].

3.4. Brief Introduction of Finite Element Method. The uniform finite element method is a numerical approximation method combined with the variational method or weak formulation method. The following structure is the same in any d dimensional space: for example, for a weak formula formed in an infinite dimensional function space V, the following structure is the same:

$$V = H^1(\Omega) = \left\{ w \in L^2(\Omega) \colon \nabla w \in L^2(\Omega)^d \right\}. \tag{1}$$

It consists of finite dimensional subspace V_h of V, such as continuous piecewise affine function space on some triangles, and problem test function space when V_h replaces V. In the simple finite element method, the space V is established as follows:

(1) The region is divided into nonoverlapping elements with simple fixed shape. Examples include one-dimensional spacing, two-dimensional triangles or quadrangles, three-dimensional tetrahedrons, prisms, or hexahedrons. Usually, the element set is an unstructured mesh, called triangulation

(2) The maximum dimension k of the polynomial approximation of the selected element

(3) V_h consists of functions in V and is restricted by the highest degree of polynomials less than k

The programming of this method has certain similarity in each dimension, but the grid generation of different latitudes is very independent [13–15].

4. Pricing Model Based on No Arbitrage and Finite Element Method

4.1. Establishment of Nonarbitrage Pricing Model. Suppose $(\Omega, F, \{F_t\}, P)$ is a complete probability space with flow. One dimensional standard Brownian $W = (W_t, 0 \le t \le T)$ motion is defined on it. It is assumed that the flow $\{F_t, 0 \le t \le T\}$ is generated by Brownian motion and satisfies the general conditions.

4.1.1. Hypothesis

(1) There are three types of financial instruments continuously traded in the market. These three financial instruments are stocks, convertible bonds, and cash market accounts. Risk free rate $r > 0$

(2) Determine the time periods T and $0 < T < \infty$

(3) Assuming that the asset value of the company at t is X_t, the asset value of the company consists of the equity value and the convertible bond value, where D_t is the market value of a single convertible bond at time t, assuming that the convertible bond is a single bond, only to ensure that all debts are immediately convertible, and S_t is the total value of the stock at t

(4) Convertible bonds are not callable

(5) Shareholders receive δS_t and $\delta \ge 0$ dividends continuously

(6) The bondholder pays interest continuously at the interest rate $\alpha > 0$

(7) If the bondholder does not choose to convert before T, then T and min (X_T, L) are obtained, where L is the face value of the convertible bond

Since the market is complete, we know that there is an equivalent martingale measure $Q \sim P$ from the nonarbitrage pricing principle. Under the equivalent martingale measure Q, the stock price discount + cumulative dividend discount and convertible bond price discount + accumulated interest discount are all local martingales. Under the risk neutral probability Q, the value of the company satisfies the following stochastic differential equation:

$$dX_t = rX_t dt - \alpha dt - \delta S_t dt + \sigma X_t dw_t^*. \tag{2}$$

σ is the constant volatility and $\{W_t^*, 0 \le t \le T\}$ is the Brownian motion with medium risk Q.

4.2. Credit Risks. Now consider a convertible bond with credit risk. This paper uses the default risk model to deal with the credit risk of convertible bonds. Suppose the default risk rate $[t_{i-1}, t_i]$ and λ_i for a period of time; when the company defaults, the bondholder can only get a surface part and finally assumes the recovery rate i, that is, the ratio of the bond price to book value ξ_i.

If there are risk-free zero-coupon bonds with different maturities in the financial market, the price is called $\{p(1), p(2), p(3), \cdots, p(n)\}$, while the price of risk-free zero-coupon corporate bonds with different maturities is $\{D(1), D(2), D(3), \cdots, D(n)\}$; thus, the term structure of the risk-free interest rate can be obtained. If the recovery rate ξ_i is known, the default risk rate λ_i of the bond can be obtained from it. The specific analysis process is as follows:

If the one-year risk-free interest rate is r_0 and the risk interest rate is r_1^*, then there are

$$e^{-r_1^*} = [1 \cdot (1 - \lambda_1) + \xi_1 \cdot \lambda_1] e^{-r_0}. \tag{3}$$

When calculating λ_1, we can get λ_2 from the above formula. By analogy, we can get the default rate $\{\lambda_1, i \ge 1\}$ of each bond.

4.3. Arbitrage Cap. When the price of the CSI 300 stock index futures is overestimated to a certain extent, arbitrageurs in the market can carry out arbitrage by selling futures contracts and buying a stock portfolio. Arbitrageurs will adopt this strategy: first, sell the price of the CSI 300 stock index futures contract for the next month or quarter$F_t$and$t$and purchase the stock portfolio based on the sample weight of the CSI 300 index in the Shanghai and Shenzhen stock markets;$t$is the current air ticket purchase of a package of stocksS_t. Then, funds and investors need to borrow money from banks to transfer the trading cost μF_t of the stock index futures contract, the margin ηF_t, and the price t of the CSI300 futures contract. The transaction cost θS_t of the stock portfolio is separately calculated at time t on time S_t to obtain the risk-free loan interest rate.

When the contract of CSI 300 index futures matures, it will be delivered in cash. On the expiration date of the contract, the arbitrage operator will deliver the stock portfolio in the futures exchange, sell it in the stock market, and carry out arbitrage by using the unreasonable price at the t moment. This strategy allows investors to receive cash delivery from futures at any time, return margin sell stock portfolios and complete transactions, and obtain stock interest and the final value of the fund at any time. At the same time, they need to repay the principal and interest on the bank loans.

4.4. Lower Limit of Arbitrage. If the price of the Shenzhen Shanghai 300 stock index futures contract is obviously undervalued, we can use the method of buying a stock index futures contract and selling a stock portfolio to carry out reverse arbitrage. Investors first buy the CSI300 Stock Index Futures t according to the price F_t and then short the stock index futures contract t of the stock portfolio, income S_t, and cash payment. The stock portfolio includes the transaction cost μF_t of the futures market, the margin ηF_t, and the transaction cost S_t of the futures contract. The stock portfolio will receive the bank deposit income at time t according to the risk-free interest rate and withdraw the deposit interest and principal on the maturity date θS_t of the CSI 300 contract.

Similar to the arbitrage strategy mentioned above, assets $F_t - S_T$ are paid when they are due and delivered in the stock index futures market T, and the margin ηF_t is returned from the stock index futures market. On the T maturity date, the investor receives S_t from 300 shares purchased from the Shanghai and Shenzhen stock markets in the amount of $(1+\theta)S_T$, during which the investor does not hold shares. Therefore, in contrast, after losing the cycle, his stock portfolio should receive dividends, subtracting the final value of opportunity cost D_T in calculating the final cash flow.

4.5. Finite Element Numerical Solution of the Model. In this paper, we use the finite difference method to estimate the price of convertible bonds, that is, to solve the governing equation of the pricing model of convertible bonds. Therefore, the pricing problem of convertible bonds must be limited in a limited region. In this paper, the infinite region of the pricing problem is divided into a bounded region: take sufficiently large s and R values and assume that they are the upper bounds of the stock price and interest rate, respectively. Obviously, this assumption is reasonable. The areas of pricing problems are truncated, such as

$$(s, r, t) = [0, S] \times [0, R] \times [0, T]. \tag{4}$$

If $\Omega = [0, S] \times [0, R]$, then the region is $\Omega \times [0, T]$.

The governing equation of the pricing model is derived as follows:

$$\frac{\partial V}{\partial t} + rs\frac{\partial V}{\partial s} + \frac{1}{2}\left(\frac{\partial^2 V}{\partial s^2}\sigma_1^2 s^2 + \frac{\partial^2 V}{\partial r^2}w^2 + 2\frac{\partial^2 V}{\partial s \partial r}\rho\sigma_1 s w\right) - rV + p\left(\max\left(ns(1-\eta^*), R^* B\right) + \eta^* s\frac{\partial V}{\partial s} - V\right) = (w\lambda - u + p\lambda_1)\frac{\partial V}{\partial r}. \tag{5}$$

The conditions of the equation on domain $(s, r, t) = [0, S] \times [0, R] \times [0, T]$ are as follows:

(1) At the expiration of the contract, the value shall be the greater of the face value and the exchange value

(2) When the company's share price is high enough, investors will definitely consider converting bonds into stocks

(3) When the stock price of the company is very low, the value of the bond can be equal to the value of the ordinary bond regardless of the repurchase conditions

Table 1: Sample information of convertible bonds.

Name and research number of convertible bonds	Listing date
Brother convertible bond (A)	2017-12-27
Guozhen convertible bonds (B)	2017-12-25
Shengyi convertible bonds (C)	2017-12-11
Crystal bonds (D)	2017-12-12
Jichuan convertible bonds (E)	2017-11-29

(4) When the market interest rate is large enough, bond investors will consider selling. Therefore, the value of bonds can be considered as zero without considering the conditions of redemption and repurchase. If the bonds meet the conditions for redemption or resale, the value shall be the redemption or resale price

(5) When the interest rate tends to zero, the value of the bond is difficult to determine. Only when the interest rate tends to zero, the partial derivative of the bond value to interest rate will be limited

4.6. Total Value of Convertible Bonds. According to the above value calculation method, the option price including the value of each period of convertible bond can be obtained. According to the nonarbitrage pricing algorithm, the following model can be established to price the convertible bond.

(1) On the terminal node, the value of bonds is as follows:

$$\max\left(V_o, V_B\right), \tag{6}$$

where the stock price V_O is the conversion value of the bond at maturity, expressed as the stock price multiplied by the conversion ratio at maturity. V_B is the net value of the bond at maturity, equal to the sum of the face value of the bond and the final interest.

(2) At the intermediate node, the value of the bond is

$$\max\left(V_B, V_c, V_p, V_r, V_o\right), \tag{7}$$

where V_B is the value of the basic terms of the bond, V_c is the value of the bond's redemption period, V_p the value of the bond's repurchase clause, and V_r is the value of the bond's modification clause, that is, the value of the bond without considering other additional terms. All the values here need to be converted into the corresponding value of the whole bond according to the face value and conversion price of the bond. According to the reverse calculation algorithm, the value of each node is calculated in turn, and the theoretical value of each bond is finally obtained.

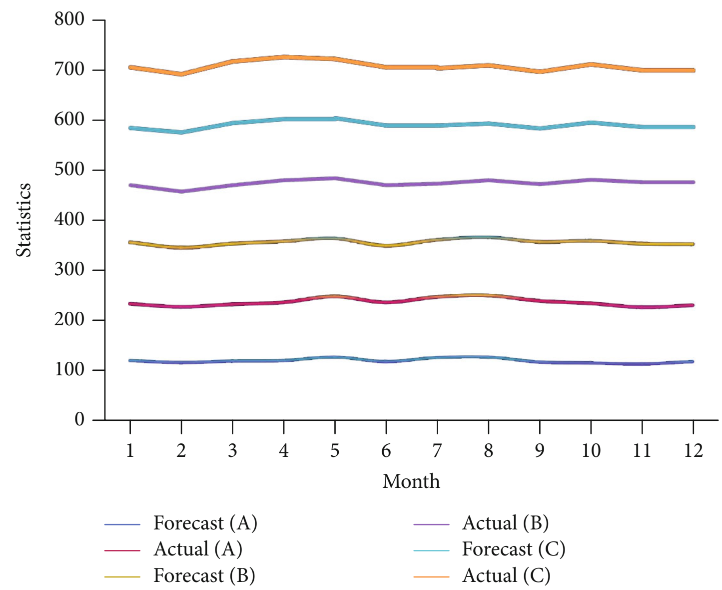

FIGURE 1: Comparative analysis of market price and theoretical price of convertible bond.

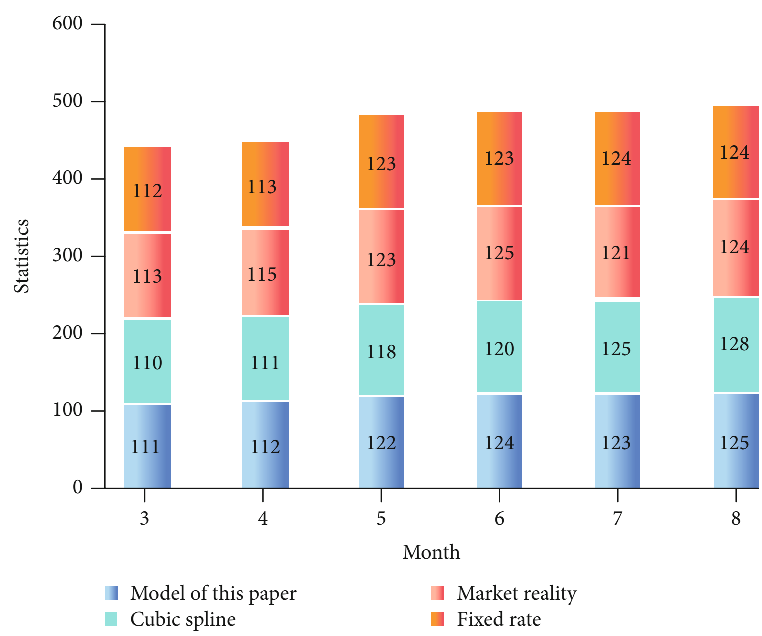

FIGURE 2: Comparative analysis of the impact of term structure of interest rate on convertible bond pricing.

5. Case Analysis

5.1. Sample Selection. This part of the research sample is composed of five convertible bonds listed in 2017 and still in trading, and the research range is from January 2, 2018, to November 30, 2018, excluding 2118 sample points after statutory holidays, closing date of convertible bonds, and closing date of benchmark stocks. The selected convertible bonds are shown in Table 1.

5.2. Comparative Analysis of Market Price and Theoretical Price of Bonds. It can be seen from the comparison results in Figure 1 that, in general, the theoretical value of convertible bonds in China is overestimated, but the gap between the theoretical value and the market price is small, and the model fitting is good. Although the value of some convertible bonds has been underestimated for some time, the theoretical value of convertible bonds has been underestimated. Take Guozhen convertible bonds as an example. Before the suspension of Guozhen convertible bonds in July 2018, the company's operating performance was not good. In mid-August, the stock price suddenly fell, leading to the theoretical value of the Guozhen convertible bond falling below the market price since mid-August. Among them, Brother convertible bonds and Shengyi convertible bonds are closer to the theoretical price, and the model fitting effect is better. Overall analysis shows that the market price trend predicted by the model is similar to the theoretical price.

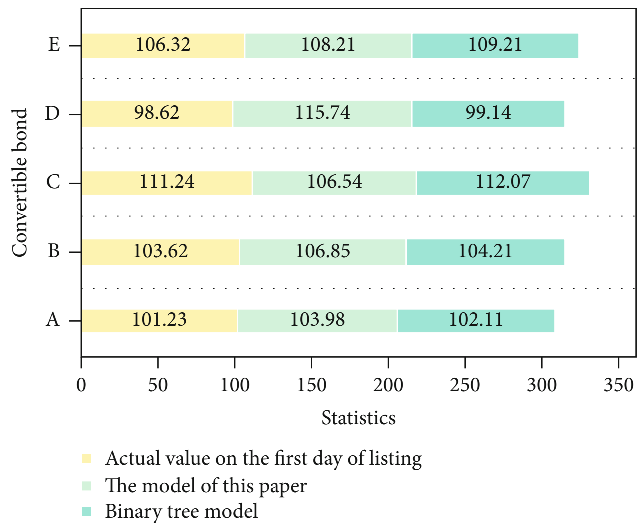

Figure 3: Comparison of the prediction results between the model of this paper and the binary tree model.

Table 2: Statistical results of relative error calculation.

Name and research number of convertible bonds	Maximum value	Minimum value	Average value
Brother convertible bond (A)	-0.1625	-0.0472	-0.1041
Guozhen convertible bonds (B)	0.0714	-0.0011	0.012
Shengyi convertible bonds (C)	-0.1118	-0.0014	-0.0614
Crystal bonds (D)	0.1251	0.0007	0.0974
Jichuan convertible bonds (E)	-0.0852	0.0048	-0.0214

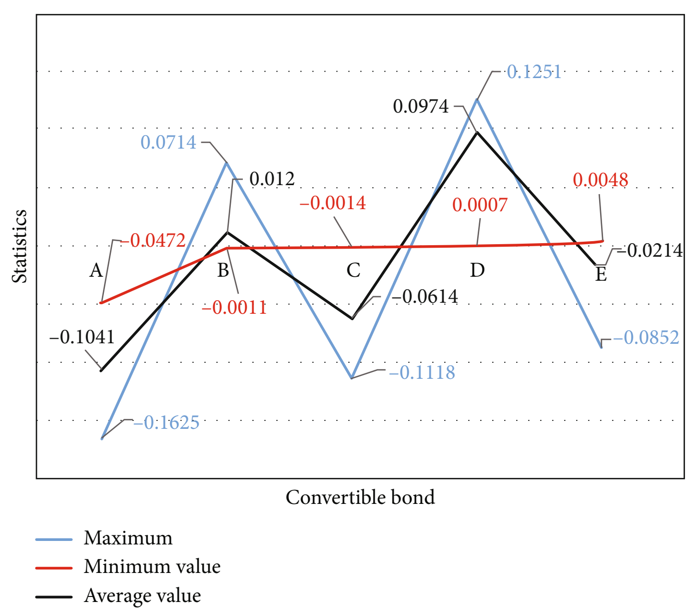

Figure 4: Analysis of experimental results of relative price error of convertible bonds.

5.3. Influence of Term Structure of Interest Rate on Convertible Bond Pricing. On the basis of the pricing model in this paper, we use the model and cubic spline to estimate the theoretical value of the convertible bond and compare it with the market price and fixed interest rate results, as shown in Figure 2. It can be seen from the analysis results in Figure 2 that the theoretical value of convertible bonds estimated by the model is slightly higher than that estimated by the cubic polynomial spline model and is closer to the market price than that estimated by the cubic polynomial spline model. The main reason is that the risk-free interest rate calculated by the index model is greater than the risk-free interest rate calculated by the spline function model in the short term. In addition, it can be seen that the estimation results of the fixed interest rate and the estimation trend of the model are very stable. Because the change of the risk-free interest rate is very small in a short time, the static risk-free interest rate can be used to replace the dynamic risk-free interest rate. The results show that the pricing model in this paper has higher accuracy.

5.4. A Comparative Experiment on the Prediction Effect of the Model and the Binary Tree Model. In order to test the prediction effect of the model, it is compared with the traditional binary tree model. The simulation results of five kinds of convertible bonds are shown in Figure 3.

According to the result analysis in Figure 3, except for Jichuan convertible bonds, the error values of the other four convertible bonds are smaller than the traditional binary tree model, and the error values of Jichuan convertible bonds are all within 3%. Generally speaking, the combination pricing model in this paper is closer to the actual market value than the traditional binary tree model. Therefore, this paper considers that the combination pricing model studied in this paper is superior to the traditional binary tree model in forecasting ability and can replace the traditional binary tree model.

5.5. Analysis of Relative Price Error of Convertible Bonds. It can be seen from the statistical results in Table 2 and Figure 4 that the volatility significantly reduces the relative price error of pricing after the model is modified. From the maximum value of the relative price error, except for the Guozhen convertible bonds which did not decline, the rest fell. From the minimum value of the relative price error, except for the Brother convertible bonds, the other relative price errors are decreasing. From the average value of the relative price error, the Guozhen convertible bonds increased and the rest decreased. The average relative price error of the five convertible bonds is -0.0113, that is, the simulated price is 1.32% lower than the market price. But the relative price error of the five convertible bonds is -0.0213, that is, the simulated price is 2.15% lower than the market price. From the overall results, the calculation error is relatively small, and the effect of error improvement is obvious.

6. Conclusions

The financial market is an important part of economic development, which plays an important strategic role in national development. Because of its own advantages, convertible bonds play an important role in the economic activities of various countries. The research on convertible bonds in China is relatively late. In the late 1970s, convertible bonds developed rapidly in China. Although the scale of convertible bond trading in China is very large and the development trend is good, there is little research on the pricing model of convertible bonds. At present, most of the domestic pricing technology is used abroad, but due to the different market conditions, the calculation accuracy is not high. The research on the application of the nonarbitrage pricing model and the finite element numerical solution in the value of convertible bonds proposed in this paper, to a certain extent, makes up for the lack of research in this field. The pricing model studied in this paper is based on the nonarbitrage pricing theory and finite element numerical solution. These two methods are one of the mainstream pricing theories at present, and their combination design is the biggest innovation of this paper. The combination design improves the traditional pricing model of single factor deficiencies, but also further enhances the accuracy of the pricing model. In the final comparative experiment, the traditional binary tree model is taken as the main contrast experimental object. Through the analysis of experimental data, the pricing model based on the nonarbitrage pricing theory and finite element numerical solution is significantly better than the traditional binary tree model in the calculation error value and market development trend prediction analysis, and the comprehensive performance has been significantly improved.

Data Availability

No data were used to support this study.

Conflicts of Interest

The author declares that she has no conflicts of interest.

Acknowledgments

This work was supported by the Research Center for Industrial Transformation, Innovation, and Development in Southern Jiangsu Province and Key Construction Base of Philosophy and Social Sciences in Colleges and Universities in Jiangsu Province, No. 2018ZDJD-B008. This work was also supported by the Research on the Linkage Mode of Business Innovation and Industrial Innovation of Investment Banks in Southern Jiangsu Province, No. 2017ZSJD020.

References

[1] J. R. Hoffmeister, P. A. Hays, and G. D. Kelley, "Conditions affecting the timing of convertible bond sales," *Journal of Business Research*, vol. 15, no. 1, pp. 101–106, 1987.

[2] Z. Zhang, Q. Qi, and J. Deng, "Building intelligent transportation cloud data center based on SOA," *Journal of Ambient Intelligence and Humanized Computing*, vol. 8, no. 2, pp. 1–11, 2017.

[3] H. Yan, S. Yang, and zhao, "Research on convertible bond pricing efficiency based on nonparametric fixed effect panel data model," *China Finance Review International*, vol. 6, no. 1, pp. 32–55, 2016.

[4] S. Zhang, "Finite difference method for barrier option pricing under stochastic volatility," *Liaoning Gongcheng Jishu Daxue Xuebao (Ziran Kexue Ban)/Journal of Liaoning Technical University (Natural Science Edition)*, vol. 36, no. 10, pp. 1111–1115, 2017.

[5] Z. Jing, F. Zhaoben, and J. Zhu, "The prediction of corporate bond credit spreads on output and inflation: a study based on the BMA model," *Mathematical Statistics and Management*, vol. 37, no. 1, pp. 183–194, 2018.

[6] D. Yaman, "Industry effects and convertible bond sequence," *Global Journal of Business Research*, vol. 10, no. 3, pp. 9–20, 2017.

[7] M. J. Wang, Y. W. Lin, and T. S. Lee, "A study of the causality between convertible bond prices and stock prices in conversion-price reset periods—time-series and cross-section analyses," *Asia-Pacific Journal of Financial Studies*, vol. 44, no. 3, pp. 447–474, 2015.

[8] Z. Zhang, W. Liu, and X. Zhang, "Valuation of convertible bond under uncertain mean-reverting stock model," *Journal of Ambient Intelligence & Humanized Computing*, vol. 8, no. 5, pp. 641–650, 2017.

[9] L. Wang and H. Jiang, "Directors from bank and convertible bond issuing: Chinese evidence," *Finance and Economics Theory and Practice*, vol. 38, no. 1, pp. 88–94, 2017.

[10] A. Amerjee, "The foreign currency convertible bond crisis: counting chickens before they hatched," *International Journal of Public Law and Policy*, vol. 4, no. 3, pp. 279–292, 2014.

[11] T. R. Bielecki, I. Cialenco, and R. Rodriguez, "No-arbitrage pricing for dividend-paying securities in discrete-time markets with transaction costs," *Mathematical Finance*, vol. 25, no. 4, pp. 673–701, 2015.

[12] S. Hendriks and C. Martini, "The extended SSVI volatility surface," *The Journal of Computational Finance*, vol. 22, no. 5, pp. 25–39, 2019.

[13] K. Boukir, "A high-order characteristic/finite element method for the incompressible Navier-Stokes equations," *International Journal for Numerical Methods in Fluids*, vol. 25, no. 12, pp. 1421–1454, 2015.

[14] F. Tornabene, N. Fantuzzi, F. Ubertini, and E. Viola, "Strong formulation finite element method based on differential quadrature: a survey," *Applied Mechanics Reviews*, vol. 67, no. 2, pp. 145–175, 2015.

[15] M. E. Mabsout, L. C. Reese, and J. L. Tassoulas, "Study of pile driving by finite-element method," *Journal of Geotechnical Engineering*, vol. 121, no. 7, pp. 535–543, 2016.