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Numerical Simulation of Option Pricing Model in the Evaluation of High-Tech Enterprise

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ABSTRACT. *The High-tech enterprise has much difference with traditional enterprise, it's value consists of uncertain assets and certain assets, and the uncertain assets mostly use the Option pricing model. This passage considered paying dividends on the basis of evaluating Real option pricing model with Patent value, Thus gain the pricing model for paying dividends and regular payment of dividends pricing model, and then according to the actual situation, combined with the thoughts of Monte Carlo Method, we'll use regular payment of dividends pricing model to simulate the value evaluation of high and new technology.*

KEYWORDS: *High-tech Enterprise; Monte Carlo Method; Paying Dividends; Real Option; Uncertainty of Assets*

1. Introduction

Measuring the value of an enterprise is the premise of understanding it, the enterprise value management make the enterprise value assessment be of vital importance. At the same time, the value potential of the new era's development mainly comes form the intangible assets and the intellectual property rights, so, the high-tech enterprise becomes the major energy of realizing economic sustainable development of our country. Compared with the traditional enterprise, however, the high-tech enterprise grows faster and has bigger uncertainty in the future, some high-tech enterprises lack the data that needed in traditional value evaluation method. [1] With these characteristics, the value of the high-tech enterprise cannot be assessed effectively by traditional value evaluation method.

The value of the high-tech enterprise can be divided into two parts: the value of the uncertainty asset and that of the certainty asset. As for certainty asset, we can use traditional value evaluation method, such as *Replace Cost Method*, *Market Comparison Method* and *Discount Cash Flow Method*. [2] The uncertainty asset

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means intangible assets and potential opportunity value; current evaluation methods have Dividend discount model, Price-earning comparison, and Black-Scholes model and so on. [3] According to the characteristics of high-tech enterprises, this passage applies Option Pricing Theory to evaluate the value of the uncertainty asset in high-tech enterprise.

2. Option Pricing Model

Option is a power that the holder can but not must be pre-agreed price to buy or sell a property or goods. [2] The options which are researched by us are financial options and real options. The real option which is option in the product development issues and productive investment is extended by the financial option. Specially, a company has an investment opportunity of project when it evaluates a project. And it likes a purchase options which can give the company a power to get this project by capitalized cost in a certain period of time. [4]

2.1. Black-Scholes Model

Black-Scholes Model [5] is widely used to calculate the value in Option Pricing Model and some financial areas such as enterprise bond, investment and insurance. We list the model as follows:

$$d_1 = \frac{\ln(\frac{S}{X}) + (r + \frac{\sigma^2}{2})(T-t)}{\sigma\sqrt{T\text{-t}}}, d_2 = d_1 - \sigma\sqrt{T-t} \tag{1}$$

$$C_t = SN(d_1) - Xe^{-r(T-t)}N(d_2) \text{——} Call\ Option \tag{2}$$

Where: S is the value of the underlying asset, X is the strike price of the option, T is the term of the option, r is the risk-free rate per year, σ is the volatility of the price of the underlying asset.

2.2. Financial Option Pricing Model and Real Option Pricing Model

The Financial Option Pricing Model based on Black-Scholes Model is:

$$g_t = SN(d_1) - Xe^{-r(T-t)}N(d_2) \text{——} Call\ Option \tag{3}$$

Yang Chunpeng [6]Listed the differences of the input variables between the Financial Option Pricing Model and the Real Option Pricing Model (Table 1)

Table 1. The differences of the input variables between the Financial Option Pricing Model and the Real Option Pricing Model

Stock Option	Real Option
Current Value of Stock: *S*	Current Value of Cash Flow Earning of Project: *P*

Strike of Option: X	The Investment Cost of Project: V
Valid Period of Option: T	The duration of Investment opportunities of Project: T
The Uncertainty of Prices of Stock: σ	The Uncertainty of Prices of Project: θ
Risk-Free Interest Rate: r	Risk-Free Interest Rate: r

Then we could get a similar Real Option Pricing Model which is refer to the formula of the Financial Option Pricing Model as follows:

$$k_1 = \frac{\ln(\frac{P}{V}) + (r + \frac{\theta^2}{2})(T-t)}{\sigma\sqrt{T\text{-t}}}, k_2 = k_1 - \theta\sqrt{T-t} \quad (4)$$

$$C_t = PN(k_1) - Ve^{-r(T-t)}N(k_2) \quad (5)$$

2.3. The Real Option Pricing Model of The Assessment of the Value of Patent[6]

We see the patent the investor bought or possessed as an extended right which would be effective in the future, and the investor could use the right and produce their patent products at that time

$$C_t = [PN(k_1) - Ve^{-r(T-t)}N(k_2)] - \sum_{i=1}^{T} \frac{F_i}{(1+\mu)^i} \quad (6)$$

Where: P is the present value of the total cash flow which is generated in the process of producing the patent products, V is the cost of the investment, T is the term between the investor possessing the right and using the right, r is the risk-free rate, θ is the corresponding standard deviation, μ is the discount rate of cash flow, F_{i} is the cost of producing the patent products per year.

3. Option Pricing Model of Paying Dividends

The researchers divided the real options available to the option of give up, extension-type option, extended options, the options of contract and turn-based option [7]. The high-tech enterprises had more and more intangible assets, and patent right, proprietary technology accounted for a larger proportion in it. So assessment of the value of patents is the same as to evaluate the value of uncertainty of assets in High-tech enterprises. And patent has a deadline, so we need introduce the cost of year delay. In fact, it is equivalent to a dividend of financial options in the rate of return [8]. Due to nonpayment dividend is one of assumptions of the *Black-Scholes* pricing model, so we should improve the option pricing of the patent.

3.1. The Real Option Pricing Model of Continuous Dividend Payments

We promote the assumption of *Black-Scholes* pricing model as follow:

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- Stocks pay dividends continuously and the dividend yield is *y (t). The* dividend start to the year that the advanced flows became positive, and the extraction rate is the dividends paid by companies accounted for the proportion of after-tax profit;

- We define Risk-free interest rate $r = r(t)$;

- The stock price follows the stochastic differential equation as follow: $dS = \mu(t)Sdt + \sigma(t)SdZ$

Where: *dZ is* differential process.

And the improved option pricing model is shown as follow:

$$C_t = [Pe^{-y(T-t)}N(k_1) - Ve^{-r(T-t)}N(k_2)] - \sum_{i=1}^{T}\frac{F_i}{(1+\mu)^i} \tag{7}$$

3.2. The Real Option Pricing Model of Regular Dividend Payments

In fact, stock does not pay dividends continuously. In the real market transactions, dividends was paid in a fixed time t_i and the bonus is a fixed amount *Q* ($0< t_i <T$). *We* assume that primary assets are paid at a fixed date. Due to the stock price will change before and after the dividend payment, so we get an equation $P(t_i-0)=P(t_i+0)$, but the price of options is continuous before and after $t=t_i$, so we get another equation as follow: $K(P(t_i-0),(t_i-0) = K(P(t_i+0), t_i+0)$[9].

According to the above, we deduced the expression as follow:

$$C_t = P^* N(k_1) - Ve^{-r(T-t)}N(k_2),\ P^* = P - Q\sum_{i=1}^{n} e^{-rt_i} \tag{8}$$

$$k_1 = \frac{\ln(\frac{P^*}{V}) + (r + \frac{\theta^2}{2})(T-t)}{\sigma\sqrt{T\text{-t}}}, k_2 = k_1 - \theta\sqrt{T-t} \tag{9}$$

Where: *P is* the present value of total cash flow of the investors' production of patented products. V is the investment costs of investors' production of patented products. T is the deadline that the Investor starts to own patents and end to the specific implementation of the patent product. The *r is* risk-free interest rate, θ is standard deviation, μ is the discount rate of the cash flow, F_i is the yearly cost for investors to produce patented products, t_i is the dividend date.

We get the pricing formula with equation (7) and equation (8) was shown as follow:

$$C_t = [P^* N(k_1) - Ve^{-r(T-t)}N(k_2)] - \sum_{i=1}^{T}\frac{F_i}{(1+\mu)^i} \tag{10}$$

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4. Option Pricing Model of Paying Dividends

We suppose that a new product was developed by a Co., Ltd. The investment costs that production of the technology products is 1.8 million Yuan. The cost of annual investment is 0.15 million Yuan, and we are expected to ready for product the production after 3 years. The total cash flow of three years of production is 6.5 million Yuan. The annual risk-free interest rate is 0.032, the standard deviation of the project value is 0.2, the cash flow discount rate is 0.2 and the annual bonus rate which was paid in a fixed amount is 0.015.

The formula (10) was launched as follow:

$$C_t = [PN(k_1) - Ve^{-r(T-t)}N(k_2)] - Q\sum_{i=1}^{n} e^{-rt_i} N(k_1) - \sum_{i=1}^{T} \frac{F_i}{(1+\mu)^i} = C_1 - Q\sum_{i=1}^{n} e^{-rt_i} N(k_1) - \sum_{i=1}^{T} \frac{F_i}{(1+\mu)^i} \tag{11}$$

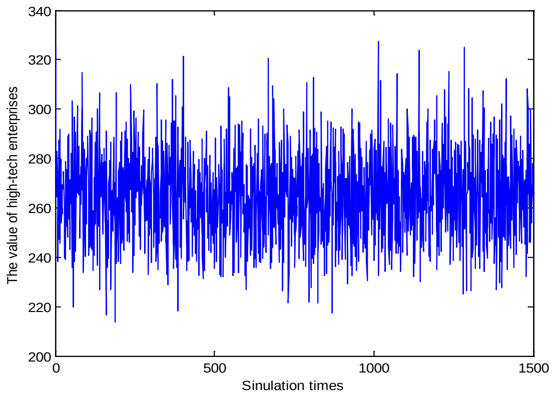

Figure 1. The result of the simulation of Monte Carlo Method

According to the idea of Monte Carlo on simulating option value by Shijun Zhou [10].Finally, we get the following figure which was simulated 1500.

We can found from the figure1 above, the simulation results in 2.6 million yuan from top to bottom changes.

5. Conclusion

For getting the improved option pricing model, in this article, we use the real pricing option model with patent pricing method and consider continuous to pay dividends and regular pay dividends. We choose the real pricing option model of the value of patent of regular dividends payments according to actual situation, and use the model to evaluate the uncertainty of assets of High-tech enterprise. The value of

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the case which is given at last the end is supposed, and maybe there is a big difference with the actual situation. However, the result of the simulation of Monte Carlo Method is convergence at a certain value. Therefore, the real pricing option model of the value of patent of regular dividends payments is better to evaluate the uncertainty of assets of High-tech enterprise.

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