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Research on the Valuation Mechanism of China's High-tech Start-up Enterprises in the Stage of High-Quality Development——the Compound Option Method

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Abstract:

China's economic development has shifted from a period of high-speed growth to a period of high-quality development.The proportion of new high-tech start-up enterprises in the new economic growth stage has been increasing, which has become an important power to achieve high-quality development of society. Different from previous traditional studies, this paper combines the characteristics of high-tech start-ups, introduces the concept of compound real option pricing, and explores a new way of evaluating the value of high-tech start-ups, so as to scientifically and reasonably measure the true value of high-tech start-ups in different stages, which is helpful for venture investors to correctly evaluate the equity value of high-tech start-ups in different periods and improve the accuracy of investment decisions. And through case analysis, it further verifies the effectiveness of compound real options in the multi-stage value evaluation of enterprises.

Keywords*: High-quality development, High-tech enterprises, Equity investment, Compound real options, Value evaluation.*

I. INTRODUCTION

The fourth industrial revolution is an irreversible trend in world development. Under this trend, it should be noted that in the stage of China's high-quality development, innovation is the first driving force for development, and technological innovation is the most important innovation. The development of high-tech entrepreneurial enterprises is closely related to the continuous innovation and development of high-tech [1]. In the initial stage of an enterprise, a large amount of capital needs to be invested in the purchase of instruments and equipment required by high and new technology, the production of products,

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and the opening of the market.Accordingly, the real option method is based on the total expected operating cash flow of the project and the investment of the underlying asset at the exercise price [2]. The premise of option pricing theory is that the underlying assets and risk-free loan assets can construct an equivalent portfolio, and the stocks are still valid after listing [3]. In the development of high-tech start-ups, products and enterprise architecture with core technologies are needed. Financial decision-making has the same importance [4]. By adjusting the stage selection of the original plan, investors can correctly analyze, quantify and evaluate the impact of each stage on the project value according to the influence of uncertain factors such as changes in environment and market. The important factor is the lack of funds for the development of high-tech start-ups and the need for external financing [5]. The process of financing will inevitably involve the judgment of corporate value. How to accurately value start-ups is the basic prerequisite for successful investment and financing [6].

Traditional investment decision-making theory is based on the assumption that investment is reversible or cannot be delayed. This assumption ignores some uncertain factors that contribute to the growth of value in the process of investment, such as the increase of market demand, the promotion of brand effect, the validity of patented technology and the time value of money. Because this assumption has great limitations, it may cause venture capitalists to invest less in start-ups, thus losing the opportunity of value appreciation and further investment in the future.

The upgrading and transformation of industrial structure is an inevitable requirement of current economic development, and independent innovation has become an important development strategy of the country. High-tech entrepreneurial enterprises are the dominant force in technological innovation. Their development and growth is an important guarantee for the transformation of my country's economic growth mode [7-9]. Therefore, reasonable valuation of them has become an important issue.

The venture capital's investment in the invested enterprise is not a point of time, but a continuous and phased process. The next phase of investment decision depends on the results of the previous phase of investment, and whether the previous phase of investment is successful or not, has great uncertainty. Therefore, the uncertain factors of the future value growth of the invested enterprises should be fully considered in the project investment. Real option theory fully considers many uncertain factors that may exist in multi-stage of start-up projects, and adopts flexible quantitative valuation for investment projects, so that investors have the right to invest or give up investment in a certain period of time in the Fig 1.

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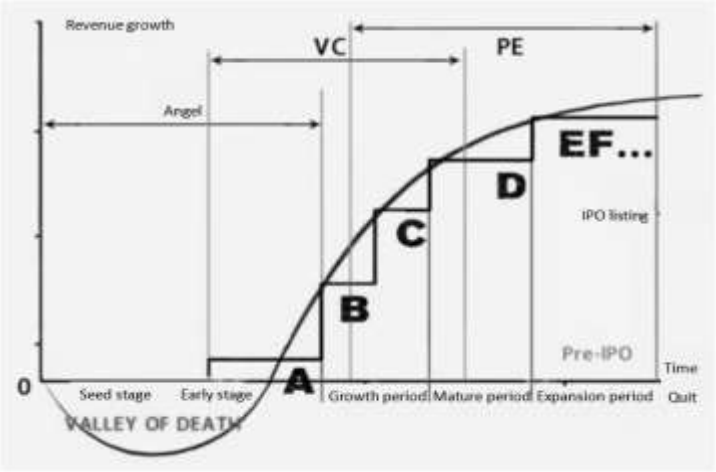

Fig 1: investment in different periods

Enterprise value can be regarded as a compound function, including the past and present profitability of the company and its future development potential. It also reflects the expectations of the company's current and potential investors. According to economic and financial theory, the common real options in investment mainly include deferred options, phase investment options, scale change options, abandon options, conversion options and growth options [10-11]. Investors who imitate financial options can be regarded as having real options, that is, the choice of investment in real assets.Investors have the right to choose whether to exercise options.If the expected market share of the product expands rapidly, cash flows will substantially increase after three years, with a positive net present value of the final investment [12]. Therefore, this opportunity can be invested. The real option theory provides a new perspective for the investment decision of enterprises [13]. It breaks through the limitations of traditional decision-making methods. In view of the environmental uncertainty, the option value is more effective and scientific than the net present value method [14].

II. OVERVIEW OF REAL OPTIONS THEORY

2.1 The Meaning and Characteristics of Real Options

The real option method is widely used in venture capital, corporate mergers and acquisitions, natural resource valuation, investment evaluation, intangible asset valuation, etc.[15-16]. The theoretical basis of real options pricing comes from Black and Scholes (1973), Merton (1973) and other pioneering work on financial option pricing [17-18]. Myers (1977) first introduced the concept of "real option" and introduced the financial option theory into the field of investment decision-making.

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In 2014, relevant scholars studied a new real option model [19] based on multiple uncertainties (CCS) investment valuation, and an attempt to apply the real option method in a continuous supply chain [20]. After that, they further studied the chain collaboration between real option contracts and dual purchasing sources [21]. Because they generally have innovative technologies, it is difficult for high-tech start-ups to find similar enterprises in industry, scale, business and financial status in the market, so it is difficult to use the market comparison method to evaluate such enterprises [22-24].

The real option method can make better use of the option characteristics to deal with the uncertainty of the project and avoid the risks of traditional valuation methods. Fig 2 shows the comparison between real option method and traditional investment evaluation method for the valuation of uncertain items.

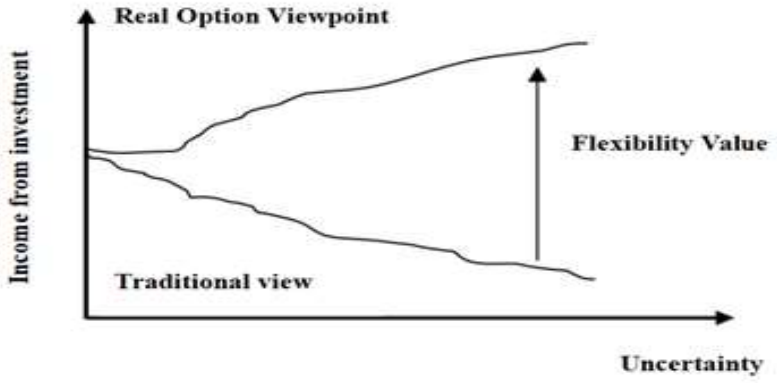

Fig 2: the valuation difference between the real option method and the traditional investment appraisal method for uncertain items

2.2 Research Progress of Compound Real Option Theory

In view of the fact that there are many uncertain factors in the investment of start-up projects, which implies a relatively large investment risk, in actual operation, investors usually divide the project into multiple stages. Using the compound real option method can better predict the various uncertainties that may appear in the multi-stage start-up project. Early composite options have been widely used in the field of financial option pricing. Geske (1979) first proposed the concept of composite real options, believing that many investment opportunities are essentially sequential, and that the next investment opportunity may not be fulfilled until the previous one succeeds[25].Pennings and Lint (2000) indicate that in the same investment project, multiple real options interact and cannot be separately valued [26].Trigeorgi and Reuer(2016) further pointed out that traditional valuation models tend to underestimate the opportunity value of investment, because the flexibility of decision-making and uncertainty in the future exist value or opportunity value, which also needs to be included in the

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investment value, while traditional models ignore this, which will lead to underestimation of investment value. Miller and Bertus (2005) applied option pricing theory to study strategic investment opportunities, and believed that the compound real option method made up for the value neglected by the discounted cash flow method [27]. Tavakkolnia (2016) uses a binary tree model to price compound real options for multi-stage strategic investment projects with multiple sources of uncertainty, and evaluates the investment value of R&D projects [28].

2.3Timing Behavior Analysis of Venture Capital

With the increase of subsequent investment, the production capacity and scale of the enterprise gradually expand, and the value created by the enterprise also increases.Therefore, the value of growth options is a very important component of the enterprise market value [29].The internal factors for the daily operation of an enterprise are relatively stable. According to the real option theory, under the uncertain conditions, enterprises should take actions to improve the profit opportunities that may arise in the future, instead of passively waiting for changes. This kind of advance micro-investment behavior enables the company to develop or make flexible decisions.

Investors will have an important influence on whether the investment will be exercised at a certain moment in the future. It can be considered that the asset investment valuation of physical projects and financial option pricing have a similar theoretical basis, which provides a theoretical basis for us to use financial option pricing models to solve project investment decision-making problems [30], in order to avoid and reduce risks. Looking for value growth points in sex. At the same time, using option pricing theory can correct and supplement the factors that are ignored, underestimated or undetermined by traditional investment methods in strategic value investment projects, so as to make a better valuation [31].Delaying investments means there will be similar investment opportunities in the future, even if you don't invest now. If investors are not satisfied with the investment conditions at that time, they can wait for the improvement of the investment conditions. The investment order refers to the staged investment strategy.

2.4 Application of Real Option Valuation Method

China's definition of high-tech enterprises is in the "state-supported high-tech fields, research, development and transformation of technological achievements, forming the core independent intellectual property rights of enterprises, and carrying out business activities on this basis" [32]. The biggest difference between high-tech start-ups and traditional companies is that the former has the characteristics of high growth and high returns. However, due to many factors and huge uncertainty, the risk is also high. In the estimation process, the difficulty of determining the relevant parameters continues to increase, which will obviously reduce the accuracy of the estimation. High-tech value is

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divided into existing asset value and potential growth option value.The value of existing assets is reflected in the ability to bring a stable cash flow to the enterprise.These can be analyzed using traditional valuation methods such as cash flow discount method, P/E ratio, P/E ratio, etc.The idea of valuation for high-tech start-ups is: First, under the precondition of excluding uncertainty, the current asset value owned by enterprises is evaluated according to the traditional valuation method. Secondly, according to the real option method, the potential value of future investment opportunities owned by enterprises is estimated. However, the main business, scale, strategy, ownership structure and trading activity of the enterprise may be quite different from those of the reference sample companies, so the reference significance of its financial indicators is actually not high. The traditional valuation method may produce large errors in estimating the value of such enterprises, which is not conducive to investors' investment decisions. Therefore, it is necessary to choose an appropriate valuation method to value the company that has the characteristics of a listed company in the initial period. In order to make up for the limitations of traditional valuation methods in this respect, it is necessary to provide new analysis and decision-making perspectives at the level of corporate investment theory and practice. Under the same conditions, investors can determine their investment goals based on the growth rate of the company.The real option valuation method is not a negation of the traditional valuation method, but an improvement and improvement of it.Each has its own scope of application.In specific applications, analysis should be based on actual conditions and the project itself.

III. REAL OPTIONS AND VALUATION MODELS

This paper studies the compound real option with multiple stages in time, and its two-stage form is shown in Fig 3.

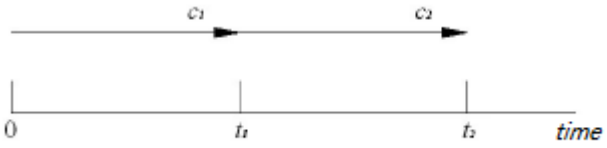

Fig 3: two-stage composite real option

In the two-stage compound real options, the duration of option C_1 in the first stage is $[0, t_1]$, and the duration of option C_2 in the second stage is $[t_1, t_2]$. This paper mainly studies the two-stage real option valuation based on the Geske model and extends it to n-stage. At the same time, it also studies the two-stage binary tree model in the discrete case, and also extends it to n-stage.

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3.1 Black-Scholes Option Pricing Model

The Black-Scholes model assumes the following important assumptions: (1) asset prices follow a lognormal distribution. (2) During the validity period of the option, the risk-free interest rate and the variable of return on financial assets are constant. (3) The market is frictionless, tax and transaction costs are not present, and all securities are fully separable. (4) Financial assets have no dividends or other income during the term of validity (this restriction has been relaxed). (5) European option (which can only be executed when the option expires). (6) There is no risk-free arbitrage opportunity. (7) The transaction is continuous. (8) Investors can borrow at risk-free interest rates.

For options, the two most basic types are call options and put options. A call option can also be called a call option, which means that the purchaser of the option has the right to buy a specified amount of the underlying object at the agreed price during the validity period of the option contract, but it is not an obligation to buy. The sell option can also be called a put option, which means that the purchaser of the option has the right to sell a certain amount of the underlying object at the agreed price during the validity period of the option contract, but it is not an obligation to sell.

According to the Black-Scholes model, the value C of the buyer's option is:

$$C = SN(d_1) - Xe^{-rT}N(d_2) \tag{1}$$

In which:

S: current value of subject matter
T: expiration time
X: the agreed price of the subject matter option
$N(d_1)$, $N(d_2)$ are the cumulative probability that the variable is less than d_1 and d_2 under the standard normal distribution

$$d_1 = \frac{\ln\left(\frac{S}{X}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \tag{2}$$

$$d_2 = \frac{\ln\left(\frac{S}{X}\right) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T} \tag{3}$$

r: Risk free interest rate
σ: Volatility (standard deviation of annual return)

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According to the hypothesis of Black-Scholes model, there is a parity relationship between the call right and the call right, so the seller's option is obtained from the buyer's option. That is, the relationship between the seller's option value p and the buyer's option value is:

$$C+ Xe^{-rT} = S + P \tag{4}$$

So you can get:

$$\begin{aligned} P &= C + Xe\text{-}rT - S \\ &= SN(d1) – Xe\text{-}rTN(d2) + Xe\text{-}rT – S \\ &= Xe^{-rT} [1 - N(d2)] - S[1 - N(d1)] \end{aligned} \tag{5}$$

That is to say:

$$P = Xe^{-rT}N(-d2) - S\ N(-d1) \tag{6}$$

3.2 Geske Model

The Black-Scholes model can get the option value of one stage, that is, the execution time is the only end point. In practice, many options are not the case. Generally, venture capital investment in emerging companies is in multiple rounds, that is, there are several stages. Although option pricing is analyzed in each stage, the stages are not independent, but mutually exclusive. Has an impact. Therefore, we need to extend the Black Scholes option model to a multi-stage option model. Geske (1979) extended the Black Scholes model, proposed the concept of multi-stage option pricing, that is, compound option, for the first time, and established a two-stage compound option model, which also laid a theoretical foundation for future research.

Geske model is based on the development of Black-Scholes model. It is assumed that when the asset price conforms to Wiener process, the price of compound option can be expressed in the form of binary normal distribution. This paper refers to the Geske model to construct a compound real option pricing model for venture capitalists' investment in enterprises. The number of stages is 2, that is, the first round of investment time t0, the second round of investment time node t1, and the investment exit (end) time node t2. At the same time, the second round of investment opportunities must exist after the establishment of the first round of investment, that is, the second round of investment at T1 time point is possible only after the investment at t0 time point.

At the same time, this paper has the following two assumptions:

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The underlying asset of the real option is an enterprise, the current value of which is V, and the change of the current value of the enterprise conforms to the geometric Brownian motion.

The venture capitalist is risk-neutral, and the investment plan for the company is two phases, with the investment amount of each phase I1 and I2.

From a practical point of view, the first round of investment is used for new product development and market development of enterprises, and the second round of investment can also be regarded as a call option with term to a certain extent.

The elements of compound real option are based on Black-Scholes model, namely: market price of subject matter (enterprise), execution price of subject matter (enterprise), price volatility, risk-free interest rate and maturity time. Among them, the risk-free interest rate can be replaced by the actual interest rate on the market, such as the corresponding national debt interest rate. The execution price and expiration time are both given and can be obtained directly. Market prices and volatility can be calculated based on historical data in the capital market.

In this way, the calculation formula of compound real option C_2 can be obtained according to Geske model:

$$C_2 = VN\left(k + \sigma\sqrt{T}\right) - I_2 e^{-rt} N(k) \tag{7}$$

$$k = \frac{\ln\left(\frac{V}{I_2}\right) + \left(r - \frac{1}{2}\sigma^2\right)T}{\sigma\sqrt{T}} \tag{8}$$

V: enterprise price at t_1;
I1: the first-stage investment cost of the venture capitalist, and the execution price of C_1;
R: risk-free interest rate
σ: Volatility
t_0: the point in time when the compound real option C1 is obtained
t_1: The expiration date of the compound real option C1
$T=t_2-t_1$;
$T_1=t_1-t_0$
$T_2=t_2-t_0$
N (·) is the univariate cumulative normal distribution function;
The calculation formula of compound real option C1 is:

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$$C_1 = VN_2\left(h+\sigma\sqrt{T_1};k+\sigma\sqrt{T_2};\sqrt{\frac{T_1}{T_2}}\right)-I_2e^{-rt_2}N_2\left(h,k;\sqrt{\frac{T_1}{T_2}}\right)-I_1e^{-rt_1}N(h) \quad (9)$$

$$h=\frac{\ln(V/V^*)+\left(r-\frac{1}{2}\sigma_v^2\right)T_1}{\sigma_v\cdot\sqrt{T_1}} \quad (10)$$

$$k=\frac{\ln(V/I_2)+\left(r-\frac{1}{2}\sigma_v^2\right)T_2}{\sigma_v\cdot\sqrt{T_2}} \quad (11)$$

V: enterprise value at t_0

I_2: the investment cost of the venture capitalist in the second stage, that is, the execution price of C_2.

The value of V* can be obtained by solving C_2-I_1=0.

N_2 (.) is a binary cumulative normal distribution function

The relationship between these five variables:

$$\frac{\partial C_1}{\partial V}=N_2\left(h+\sigma_v\sqrt{T_1},k+\sigma_v\sqrt{T_2};\sqrt{T_1/T_2}\right)\equiv N(\cdot)>0$$

$$\frac{\partial C_1}{\partial\sigma_V^2}=\frac{N_2(\cdot)}{N\left(k+\sigma_v\sqrt{T_2}\right)}I_2\cdot e^{-r\tau_2}\cdot N'(k)\cdot\frac{\sqrt{T_2}}{2\sigma_v}>0$$

$$\frac{\partial C_1}{\partial t_2}=\frac{N_2(\cdot)}{N\left(k+\sigma_v\sqrt{T_2}\right)}I_2\cdot e^{-r\tau_2}\cdot\left[N'(k)\cdot\frac{\sigma_v}{2\sqrt{T_2}}+r\cdot N(k)\right]>0$$

$$\frac{\partial C_1}{\partial r}=\frac{N_2(\cdot)}{N\left(k+\sigma_v\sqrt{T_2}\right)}I_2\cdot T_2\cdot e^{-r\tau_2}\cdot N(k)>0$$

$$\frac{\partial C_1}{\partial I_2}=-e^{-r\tau_2}\cdot N_2\left(h,k;\sqrt{T_1/T_2}\right)<0$$

For venture capitalists, the execution price of the corresponding real option is the cost of investment in the enterprise. The value of real options depends on the income obtained from the investment in the enterprise.

3.3 Compound Real Option of Order

In this way, Geske model can adopt option valuation method for two-stage investment, but in reality, for most emerging enterprises, it is divided into seed period, start-up period, growth period, mature

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period and other periods, which may accept one to several rounds of investment, so there are often multiple stages or rounds of investment for these emerging enterprises. Not only that, considering that each development stage of an enterprise has different characteristics and faces different uncertainties. Therefore, for investors, it is necessary to determine investment strategies based on specific circumstances and refer to all expectations of investment companies at different times. The environment, development prospects and value changes, etc., respond to different risk trend assessments. Then, for such practical application, we need to consider extending the original Geske model to more stages to better meet the actual situation.

To further deduce the formula, a risk-free arbitrage portfolio is defined first. The practice of this portfolio is to buy an underlying asset for hedging when selling an option contract, and the purchase of assets is achieved by borrowing at risk-free interest rate.

The original model believes that the subject matter V obeys geometric Brownian motion, the risk-free asset is $\frac{dA}{a} = rdt$, and Ck represents the (n-k+1)-order compound real option value. $C_k(v,t_k)$ is the second-order differentiable function of the subject V, and it is all differentiable at the time point t_k. According to Ito's lemma, we can get:

$$dC_k = \frac{\partial C_k}{\partial t}dt + \frac{\partial C_k}{\partial V}dv + \frac{1}{2}\frac{\partial^2 C_k}{\partial V^2}V^2\sigma^2 dt \tag{12}$$

According to the definition of risk-free arbitrage portfolio, the net asset investment in the portfolio is 0 and self financing. Then, whenever an asset Ck is sold, the subject matter V held is x(t), and the value of the risk-free asset of this investment is a(t) = CK(t) - x(t)V. Here, H(t) refers to the income of the constructed hedging portfolio, and its immediate income is:

$$dH(t) = -dCk + x(t)dV(t) + [Ck(t) - x(t)V(t)]rdt \tag{13}$$

With dC_k and dV(t), we can get:

$$\begin{aligned} dH(t) = & -\left[\frac{\partial C_k(t)}{\partial V(t)}uVt + \frac{\partial C_k(t)}{\partial t} + \frac{1}{2}\frac{\partial^2 C_k(t)}{\partial V(t)^2}\sigma^2 V(t)^2\right]dt - \frac{\partial C_k(t)}{\partial V(t)}\sigma V(t)dz \\ & + x(t)[uV(t)dt + \sigma V(t)dz] + [C_k - x(t)V]rdt \end{aligned} \tag{14}$$

The immediate return of this portfolio is risk-free, that is, dz=0, $x(t) = \frac{\partial Ck(t)}{\partial V(t)}$.

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Then there

$$dH(t) = -\left[\frac{\partial C_k(t)}{\partial t} + \frac{1}{2}\frac{\partial^2 C_k(t)}{\partial V(t)^2}\sigma^2 V(t)^2 + rV(t)\frac{\partial C_k(t)}{\partial V(t)} - rC_k(t)\right]dt \quad (15)$$

Because it is a risk-free arbitrage portfolio, the return corresponds to the risk-free return. r is the risk-free interest rate, so dH(t)=rHdt.

Meanwhile, the actual net investment is 0, dH(0)=0=0, so H(0) and dH(t) are also 0. Similarly, the following formula

$$\left[\frac{\partial C_k(t)}{\partial t} + \frac{1}{2}\frac{\partial^2 C_k(t)}{\partial V(t)^2}\sigma^2 V(t)^2 + rV(t)\frac{\partial C_k(t)}{\partial V(t)} - rC_k(t)\right] \text{is } 0$$

Then when Ck(V,tk)=max{$C_{k+1}(V,t_k)$-I_k, 0} is the boundary condition, the n-k+1 order compound real option model is obtained:

$$C_k = VN_{n-k+1}(a_k, a_{k+1}, \ldots\ldots, a_n; F_k^{n-k+1}) - \sum_{m=k}^{n} \mathrm{I_m} e^{-rt_m} N_{m-k+1}(b_k, b_{k+1}, \ldots\ldots, b_m; F_k^{n-k+1}) \quad (16)$$

$a_k = b_k + \sigma\sqrt{T_k}$, k=1,……, n-1

$$b_k = \frac{\ln\frac{V}{V_K^*} + \left(r - \frac{1}{2}\sigma^2\right)T_k}{\sigma\sqrt{T_k}}, \text{ k=1,……,n}$$

Among them, I_k is the investment cost of the venture capitalist at stage k, which is the execution price of C_k.

At n-k+1 order, the expiration date of the call composite real option C_k is t_k.

In addition, $T_k = t_k$-t_0 is defined

V * by solving C_{K+1} (V, t_k) - I_k = 0, k = 1,..., n-1

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Nn(a1,...,an;F^n) and Nn(b1,...,bn;F^n) are both cumulative normal distribution functions of N-dimensional variables. F^n is a matrix of correlation coefficients of n variables.

When k=1, the n-order call compound real option is

$$C_1 = VN_n(a_1,...,a_n;\ F^n) - \sum_{m-1}^{n} \mathrm{I_m} e^{-rt_m} N(b_1,...,b_m;\ F^m) \quad (17)$$

When k=n-1, it is the previous second-order compound real option model.

3.4 Binary Tree Model

The aforementioned Geske model expands the Black-Scholes model, from a simple real option pricing model to a continuous multi-stage compound option pricing model, which expands the scope of application to a considerable extent and has made great progress.

However, the model still has some limitations, such as poor flexibility of assumed parameters, strict setting of boundary conditions, and no elastic correction factor. The scope of application of the calculation results is limited. And when the order increases, the calculation is inconvenient. Therefore, this paper introduces the binary tree model to verify the compound option pricing.

The basic principle of the binary tree method is that the price of the underlying asset changes in several periods during the validity or duration of the option, and it is assumed that the price change in each period has two possibilities of rising and falling, forming a variety of possible intermediate paths and results. See Fig 4.

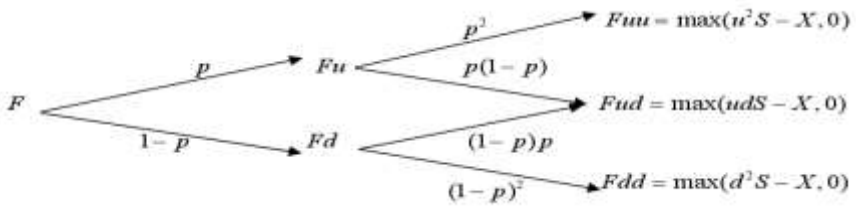

Fig 4: schematic diagram of binary tree

F is the beginning price, Fu and Fd are the end prices of the first period, Fuu and Fdd are the end prices of the second period, p is the probability of price increase in the first period, 1-p is the probability of price increase, and p is the first The probability that the price will rise during the period, 1-p is the

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probability that the price will rise, p^2 and p(1-p) are respectively the probability that the rising price Fu at the end of the first period will rise and fall in the second period, (1-p)p , $(1-p)p^2$ are the probability that the falling price Fd at the end of the first period will rise and fall in the second period, respectively. In addition, the values of u and d are relative values, which are multiples of rise and fall, respectively.

When the current period is one period, the model is

$$F = e^{-rT}[pF_u+(1-p)F_d] \tag{18}$$

When the current period is the second period, the model is

$$F = e^{-2rT}[p^2F_{uu}+2p(1-p)F_{ud} + (1-p)^2F_{dd}] \tag{19}$$

In this case, f refers to the price of the subject matter, r refers to the risk-free interest rate, t refers to the validity period or duration (the length of each period is t), Fu and Fd are the possible prices of the first period rising and falling respectively, and Fuu, Fud and Fdd are the three possible values of the second period respectively.

p is the rising probability of the underlying asset price, 1-p is the falling probability, the binary tree option pricing model is to calculate the value of the option based on the expected price in the future, which can be used to calculate the value of European options, or it can be used to calculate the value of American options-as long as The value of American options can be calculated by judging the necessity of early execution of options at the end of each period to calculate the value of options at the end of each period. Of course, for other special options, you can also evaluate the value of the option by similarly calculating the execution value of each period.

Here, we assume that the subject matter is dividend-free European option type, the current price is S, the agreed price corresponding to the option is X, the validity period of the option is divided into N periods, each period is increased by U times or decreased by D times, and the probability of increasing and decreasing in each period is P and 1-P.

Due to the n period, there will be i rises and n-i declines (n and i are non-negative integers). When the equity expires, the possible price of the subject matter is:

$$ST = Su^id^{n-I} \tag{20}$$

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If it is a call option, its value is:

$$\text{Max}(Su^i d^{n-i}-X, 0) \tag{21}$$

If it is a put option, its value is:

$$\text{Max}(X - Su^i d^{n-i}, 0) \tag{22}$$

The probability of rising I times and falling n-i times is $P^i (1-P)^{n-i}$.

Looking at the picture, you can see that, except for all cases where n periods are up or down, there is more than one path for other cases, and the number of paths is:

$$\frac{n!}{i!\,(n-i)!}$$

The total probability of any possible value (i times of increase and n-i times of decrease) when the above call or put option expires is:

$$\frac{n!}{i!(n-i)!}p^i(1-p)^{n-i}$$

Therefore, the maturity value of the option is:

$$\sum_{i=0}^{n}\left[\frac{n!}{i!(n-i)!}p^i(1-p)^{n-i}Max\left(Su^i d^{n-i}-X,0\right)\right] \tag{23}$$

The maturity value of the seller's option is:

$$\sum_{i=0}^{n}\left[\frac{n!}{i!(n-i)!}p^i(1-p)^{n-i}Max\left(X-Su^i d^{n-i},0\right)\right] \tag{24}$$

The buyer's valuation model C_n, which can be obtained for any (n) period, is:

$$C_n = e^{-nrT}\sum_{i=0}^{n}\left[\frac{n!}{i!(n-i)!}p^i(1-p)^{n-i}Max\left(Su^i d^{n-i}-X,0\right)\right] \tag{25}$$

It can be obtained that the selling value model P_0 for any (n) period is:

$$P_n = e^{-nrT}\sum_{i=0}^{n}\left[\frac{n!}{i!(n-i)!}p^i(1-p)^{n-i}Max\left(X-Su^i d^{n-i},0\right)\right]$$

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When the binary tree model is used to evaluate the option value, the exercise period of the option can be set to any number of change periods according to the need, so as to increase the possible number of the underlying asset price and the corresponding option value when the option expires. In principle, the greater the number of periods divided, the more likely the option can be enforced, and the more accurate the evaluation result will be. When it tends to the limit (the number of divided periods is infinite, and the length of each period is infinitely small), the result will be the same as the Black-Scholes formula.

IV. VALUATION ANALYSIS OF TWO-STAGE REAL OPTION METHOD

The difference between the future cash flow discount resulting from NPV investment and the cost of project investment.Generally speaking, NPV > 0 is worth investing and NPV < 0 is not. However, the real option method holds that even if NPV is less than 0, it is still worth investing as long as there is enough option value in the investment. For the start-up enterprises, NPV < 0 is the norm, and for venture capital, it is worth paying attention to. Generally speaking, in the early stage of the establishment of an enterprise, for the sake of future production and operation, early investment is needed, so emerging enterprises are often in a state of negative cash flow. According to NPV method, although it is in line with the theory from the financial point of view, it is not comprehensive enough. Therefore, this paper tries to evaluate this kind of enterprise by combining the real option method to evaluate the reasonable value of the enterprise every time it invests.

The NPV method has a reasonable side for the assessment of the status quo of the enterprise, but it does not consider the option value of the investment behavior itself. Therefore, the valuation of the investment in emerging enterprises in this article is: the sum of the NPV and the option value C at each investment point, NPV represents the current actual asset value of the enterprise, and the real option C represents the possible value of future assets. The sum of the two is closer to the true value of the emerging enterprise, namely:

Value of business at t time = $NPV_t + C_t$

At the initial stage of the enterprise, the enterprise needs to develop and invest in equipment to verify the feasibility of production and business model, at which time cash is net outflow. At this stage, the future value of enterprises is uncertain, and many factors, such as production, technology, business model and even market acceptance, have the possibility of huge fluctuations, so the value of real options also increases.

When the company enters the growth period after the start-up period, the cash outflow slows down and the inflow increases. Early investment and accumulation, trial and error make the product itself start to generate profit, even if NPV is still a net outflow, but because the product can contribute profits, it

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makes a net outflow Decrease, the value of NPV increases, but at this time, due to technical and market uncertainty, the value of real options has also decreased. When the enterprise enters the mature stage, when the product, technology and business conditions of the enterprise reach the mature stage, they have certain competitiveness and even advantages, can provide profits for the enterprise, cash inflows are positive, and the NPV value of the enterprise rises, but since the enterprise is generally in a stable growth stage at this time, the uncertainty in the future is further reduced.The value of real options also decreases. For ordinary venture capitalists, the enterprise valuation, especially NPV valuation, is higher at this time. However, due to the stable operation of the enterprise, the risks and uncertainties are greatly reduced, and the value of real options is also reduced. The exit time of venture capital is generally not later than the mature period of the enterprise.

In order to verify the effectiveness of the real option method, this article attempts to expand the sample of cases. Since most of the venture capital companies are non-listed companies, it is not easy to obtain real investment and financial information from public channels. Therefore, samples are selected from the new three-board market that is closer to emerging companies.

The sample range is from the list of enterprises in VC/PE Investment Details under Institutional Investment in Wind's new three-board statistics and is invested by the same venture investor for at least two rounds.

The first part of enterprises (see Table I and Table II) have two rounds of investment in the listing period, and the information is relatively complete, so the enterprise value at the real investment time is calculated separately. In the second part, enterprises lack some financial data before listing due to investment rounds (see Table III and Table IV).

Since January 15, 2018, the new third board trading method has changed from the original agreement transfer to the call auction. In theory, the price of all investments is based on the public price. This article only attempts to test the effectiveness of the new method. Therefore, it is assumed that an investor purchased the second part of the company’s equity investment at the public price on January 16, 2018 and January 16, 2020, and respectively estimated the two time points. value.

All transaction and financial information calculated in this paper is from Wind.

The risk-free yield in 2020 is calculated as 4% of the national debt yield (4.27% in 2018).FCFF is calculated by "Financial Analysis" item under the in-depth data of Wind's new three-board thematic statistics (a small number of companies only reported no annual report in mid-2019, then calculated the average of FCFF difference between the previous three years and the annual report, and then added as

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FCFF in 2019). WACC data is calculated by Wind's WACC calculator, using the WACC value at the beginning of the year as the current value. The present value of the company is the average stock price of the current year * the number of shares (January 16, 2020 is replaced by the average stock price in 2019 due to the early deadline), and the execution price is the closing price of the current day * the number of shares. If there is no actual transaction on that day, the price of the previous trading day shall prevail. The first stage of real options is unified to 2 years, and the second stage is assumed to be 5 years. The volatility rate is based on 2 years (504 trading days). The annualized rate of return is calculated. The reporting period is one year. If there is no volatility value in the current year, the volatility of the previous year will be substituted. Use Wind's historical volatility HVG tool to calculate the results. After 2020, the data related to future forecast operations, such as FCFF, CFI, and cost of capital, are obtained by linear regression fitting based on the data of the previous financial reporting years, as shown in Fig 5.

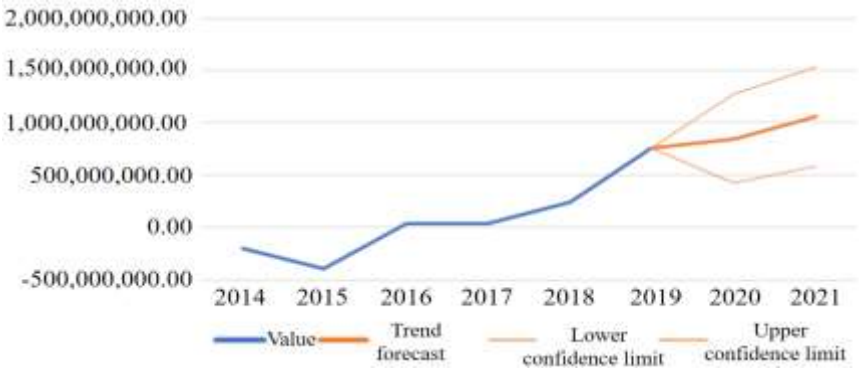

Fig 5: schematic diagram of fitting

See the table for settlement results.

TABLE I. Comparison of investment value in two stages

Name	Industry	NPV1 (ten thousand yuan)	NPV2 (ten thousand yuan)	Option value 1 (ten thousand yuan)	Option value 2 (ten thousand yuan)
Beijing Age	General equipment manufacturing industry	-10429.20	-18360.29	42569.61	27038.75
ST Hyundai	Special equipment manufacturing industry	28877.34	-4908.39	12548.81	121192.33
Beike Everbright University	Software and Information Technology Service industry	-6600.09	-2711.24	1178.96	3976.02

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Name	Industry	NPV1 (ten thousand yuan)	NPV2 (ten thousand yuan)	Option value 1 (ten thousand yuan)	Option value 2 (ten thousand yuan)
Northland	Pharmaceutical manufacturing industry	-11609.04	-13301.58	24063.10	44185.25
ST Zhonghai	Electrical machinery and equipment manufacturing industry	-39312.85	-38093.51	24035.44	105355.69
Hero mutual entertainment	Internet and related services	48459.36	-401583.10	117.17	35061.21
Creation ecology	Civil Engineering Construction industry	-22388.06	-28987.45	15488.54	59098.80
Jinrui Technology	Software and Information Technology Service industry	13.19	-441.91	9.48	1572.20
Jingying Media	Business Service industry	-3536.87	-2711.24	19.60	1613.55
Yuguo shares	Agricultural and sideline food processing industry	-39853.69	-46034.16	19752.89	16670.91
Dianmi Technology	Business Service industry	-13099.17	-22688.33	35587.50	29170.36
Ground Source Technology	Construction and installation industry	-6769.37	-3784.02	7486.05	12785.44
Kangze Pharmaceutical	Wholesale industry	-14131.36	-20730.23	81972.72	171191.16
Jie Fu equipment	General equipment manufacturing industry	-1195.95	-7187.48	3.51	6881.13
Adik	Instrument manufacturing industry	-1296.46	200.97	202.74	2026.63
CLP Kean	Software and Information Technology Service industry	-8469.68	-9035.48	1375.05	45071.07
Urban medicine	Retail industry	-15.03	-45825.85	1497.44	2018.02
Jiarui Technology	Software and Information Technology Service industry	-893.53	735.83	31.86	1259.02

It can be seen that according to the NPV method, most of the new third board enterprises are negative, and only 4 of the 18 enterprises have positive NPV at least at a certain stage. Obviously, VC and PE do not mainly use NPV method as investment basis.

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According to the real option method, the option price in each stage is positive. Since investment is generally regarded as a call option, the option price floor is 0. According to the above calculation of the total enterprise value, it is considered worthwhile to invest if the total enterprise value is greater than 0, and the results are shown in Table II.

TABLE II. Enterprise valuation results

Name	Industry	Enterprise valuation 1 (ten thousand yuan)	Enterprise valuation 2 (ten thousand yuan)
Beijing Age	General equipment manufacturing industry	32140.41	8678.46
ST Hyundai	Special equipment manufacturing industry	-16328.53	116283.93
Beike Everbright University	Software and Information Technology Service industry	-5421.13	1264.78
Northland	Pharmaceutical manufacturing industry	12454.05	30883.66
ST Zhonghai	Electrical machinery and equipment manufacturing industry	-15277.41	67262.18
Hero mutual entertainment	Internet and related services	48576.53	-366521.89
Creation ecology	Civil Engineering Construction industry	-6899.52	30111.34
Jinrui Technology	Software and Information Technology Service industry	22.67	1130.29
Jingying Media	Business Service industry	-3517.26	-1097.69
Yuguo shares	Agricultural and sideline food processing industry	-20100.80	-29363.25
Dianmi Technology	Business Service industry	22488.33	6482.03
Ground Source Technology	Construction and installation industry	716.68	9001.42
Kangze Pharmaceutical	Wholesale industry	67841.36	150460.94
Jie Fu equipment	General equipment manufacturing industry	-1192.45	-306.36
Adik	Instrument manufacturing industry	-1093.72	2227.60
CLP Kean	Software and Information Technology Service industry	-7094.63	36035.58
Urban	Retail industry	1482.42	-43807.83

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medicine			
Jiarui Technology	Software and Information Technology Service industry	-861.67	1994.85

According to the results, six of them are worth investing in both stages, and three of them are not worth investing in both stages. Considering that the above enterprises have actually obtained investment, it can be considered that the results are more in line with the reality than the NPV valuation method.

Based on assumptions, calculate the investment value of the NEEQ companies on January 16, 2018 and January 16, 2020. The results are shown in Table III.

TABLE III. Comparison of assumed investment value in two stages

Name	Industry	NPV1(ten thousand yuan)	NPV2 (ten thousand yuan)	Option value 1 (ten thousand yuan)	Option value 2 (ten thousand yuan)
ST Zhongke	Software and Information Technology Service industry	-1701.65	-10537.97	739.90	755.23
Card Union Technology	Software and Information Technology Service industry	-1047.70	10537.97	4299.64	2738.39
Wuhan University Technology	Chemical raw materials and chemical products manufacturing industry	-293.31	-6762.36	8123.75	12176.49
Dian Dian Ke	Software and Information Technology Service industry	-10406.84	-21527.26	13144.87	9432.33
Su Damingshi	Instrument manufacturing	3060.55	4684.85	2994.03	3772.59

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Name	Industry	NPV1(ten thousa nd yuan)	NPV2 (ten thousand yuan)	Option value 1 (ten thousand yuan)	Option value 2 (ten thousand yuan)
	industry				
Zheda Technology	Software and Information Technology Service industry	943.20	-14602.31	6652.44	12046.92
Zhongtian Sheep industry	Animal husbandry industry	-29162 .20	-47559.79	30270.49	38924.48
Kehui Technology	General equipment manufacturing industry	1077.0 2	-3401.12	851.97	4812.26
Yunna n Road and Bridge	Civil Engineering Construction industry	77491. 26	62023.33	14080.46	14256.15
Haobo New Materials	Waste comprehensive utilization of resources industry	-4628. 77	-140807.27	369.49	1488.04
Chinese World	Radio, TV, film and television recording production industry	-246.6 0	-749.10	157.88	773.10
Zhongbei Tong Magnetic	Non-ferrous metal smelting and rolling processing industry	-541.1 4	-347.94	8854.58	5398.12
Debon Engineerin g	Computer, communication and other electronic equipment manufacturing industry	-7971. 97	-12259.20	36318.83	29465.89
Jiuzhou Optoelectro nics	Electrical machinery and equipment manufacturing industry	-9660. 72	-14408.94	21.46	3074.34

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Name	Industry	NPV1(ten thousand yuan)	NPV2 (ten thousand yuan)	Option value 1 (ten thousand yuan)	Option value 2 (ten thousand yuan)
Universal navigation	Instrument and meter manufacturing industry	-1854.87	-10422.19	2264.29	4884.01
Haiyou New Materials	Rubber and plastic products industry	3542.70	11348.36	15021.20	76660.99
Keda automatic control	Software and Information Technology Service industry	-3937.10	-11778.69	16706.32	30731.47
World Tour Technology	Internet and related services	50.16	88.19	288.59	1099.01
Construction and installation industry	Building decoration and other construction industry	-3263.82	-22299.42	79310.85	54000.35
Zhitu Technology	Internet and related services	-300.67	-13166.34	6977.06	18644.32
Operation and maintenance power	Professional technical service industry	514.50	844.83	12741.87	11890.99
ST One Health	Sanitation	822.22	1450.81	690.09	6731.34
Hongli energy	General equipment manufacturing industry	-632.28	-2302.91	510.18	2021.70
Tianyun shares	Automobile manufacturing industry	-2692.73	-8316.47	296.51	26864.19
Yum Software	Software and Information Technology Service industry	-5016.85	-16700.47	27640.36	21733.14

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Long Chuang Design	Professional technical service industry	10074.18	12103.17	18696.66	69469.19
Tenai stock	Non-metallic mineral products industry	8875.33	22018.64	47553.57	24842.98
Silicon Valley Paradise	Capital market services	-110521.83	-644684.54	264980.58	321687.61
Tianyan Technology	Instrument and meter manufacturing industry	7761.92	8149.85	24455.37	45677.34
Immediately swim	Internet and related services	-2362.09	-6664.71	8637.01	10875.55
Heisby	Railway, ship, aerospace and other transportation equipment manufacturing industry	15448.73	30482.52	48852.54	9837.21
Bicool shares	Business Service industry	-6721.09	-8270.85	8195.30	8140.94
Compton	Computer, communication and other electronic equipment manufacturing industry	-35081.58	-35147.06	91924.33	19163.52
Kang Bite	Food manufacturing industry	-12693.29	-151109.27	97402.46	167607.94
Two-dimensional carbon	Non-metallic mineral products industry	-4160.78	-7813.05	4927.53	13388.01
Peacekeeping	Pharmaceutical manufacturing	467.37	1492.69	32442.02	32033.30

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Pharmaceut ical	industry				
Allianz Ruishi	Computer, communication and other electronic equipment manufacturing industry	5819.0 5	8165.86	5588.76	6141.06
Net letter linkage	Telecommunications, radio and television and satellite transmission services	73.75	1419.78	49.87	2768.31
Meitian Bio	Pharmaceutical manufacturing industry	7084.8 8	11284.44	6349.38	17621.23
Linghui shares	Special equipment manufacturing industry	-4927. 95	417.97	14018.31	22248.19
Futaihe	Automobile manufacturing industry	10430. 86	23475.45	17719.44	37243.91
Youmi Technology	Internet and related services	-2671. 70	-12760.75	42774.51	11110.98
Jie Shijie	Rubber and plastic products industry	-42813 .23	-61821.27	496926.94	239105.87
SECCO Star	Animal husbandry industry	-15932 .55	-99719.52	425645.35	284765.89
Huaqing Feiyang	Internet and related services	-13895 .67	-44071.36	85381.87	44470.82
Hechuang Technology	Software and Information Technology Service industry	-13390 .33	-12198.51	63806.10	140954.98
Zi Zhuhui	Building decoration	-18598	-159214.92	229041.87	94620.15

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Name	Industry	NPV1(ten thousa nd yuan)	NPV2 (ten thousand yuan)	Option value 1 (ten thousand yuan)	Option value 2 (ten thousand yuan)
	and other construction industry	6.44			
Shangxun information	Software and Information Technology Service industry	-769.4 3	-30205.37	11828.03	14074.77
Yuanda Special Materials	Metal products industry	15562. 37	17935.05	64764.13	5694.13
Good buy wealth	Capital market services	-32079 1.87	-570728.60	172008.48	219903.41
Insured in?	Business Service Industry	0.00	0.00	495768.23	512041.82
Yunchuang game	Software and Information Technology Service industry	-5835. 84	-16101.10	14043.93	42519.48
Chuan Robot	General equipment manufacturing industry	-556.7 1	-2169.83	14558.31	12522.98
Jiang Chen Intelligent	General equipment manufacturing industry	-5172. 26	-5170.54	15724.12	27955.09
Titan Technology	Research and experimental development	-14402 .15	-44405.68	153.25	30528.97
Future Internation al	Software and Information Technology Service industry	-3601. 12	-22751.60	0.01	21472.53
Jinyuan Electric	Electrical machinery and equipment manufacturing industry	-7510. 11	-11162.00	4331.87	10163.96

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Happy animation	Radio, TV, film and film and television recording production industry	-1877.76	-11227.63	19912.41	82029.50
Zhilan Yushu	Internet and related services	3459.20	-587594.68	57396.40	38417.12
Anqu shares	Retail industry	-90.31	5.98	298.74	832.86
Meiyi Beauty	Retail industry	13504.37	16079.64	16492.31	11518.81
Lemon wanglian	Software and Information Technology Service industry	-1768.32	1117.05	5728.11	35267.76
Ousai energy	Electrical machinery and equipment manufacturing industry	-880.94	4657.48	116464.35	7245.73
Gold United Star	Non-ferrous metal smelting and rolling processing industry	9090.86	8190.59	5010.55	12155.48
Elegant e-commerce	Retail industry	417.62	-107.45	952.03	8335.94
Yi Yun shares	SoftwareandInformation Technology Service industry	1710.88	965.81	50573.66	50573.66
Hongbang Water Saving	Water Conservancy Management industry	-1919.31	-4826.90	9792.16	278.89
Yijiajie	Internet and related services	3514.11	10150.86	2461.67	26572.02
Young's Fruit industry	Agriculture, forestry, animal husbandry and fishery service	-6895.64	-6884.99	25622.63	359002.29

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	industry				
Xinte Electric	Electrical machinery and equipment manufacturing industry	4452.7 5	-14534.43	24206.36	33257.66
Yongle Culture	Culture and Art industry	11059. 14	7399.32	479.79	38698.14
Tianyin Technology	Non-metallic mineral products industry	-234.4 1	-858.14	4043.42	17186.37
Lion China shares	Business Service industry	-642.7 8	-13682.85	88903.10	6215.39
Yilutong	Computer, communication and other electronic equipment manufacturing industry	4824.9 7	9047.39	13833.47	15586.76
Black gold age	Coal mining and washing industry	-44786 7.70	-934979.23	1130680.90	1175663.54
Haiyifeng	Business Service industry	-183.8 4	-495.87	739.68	1341.91
ST Quantum Flower	Building decoration and other construction industry	-6675. 37	-11107.08	20785.34	2789.93
Fu Baisheng	Wholesale industry	-1843. 15	-5450.59	243.58	15968.91
Haier Si	Pharmaceutical manufacturing industry	851.72	3045.26	41632.39	30082.17
Shengpa New Material	Rubber and plastic products industry	-4002. 11	-7197.44	64338.46	64338.46
Lan hai Xun tong	Software and Information Technology Service industry	8720.1 1	19356.86	8461.54	6390.15

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Name	Industry	NPV1(ten thousand yuan)	NPV2 (ten thousand yuan)	Option value 1 (ten thousand yuan)	Option value 2 (ten thousand yuan)
Lemon Micro Fun	Internet and related services	-10402.54	-13520.28	0.00	23065.61
Yite shares	Special equipment manufacturing industry	-571.33	-138.66	1175.13	5756.89
Daye Chuangzhi	Radio, TV, film and film and television recording production industry	-17340.01	-29338.63	303378.21	32206.85
Feiwo Technology	General equipment manufacturing industry	-13643.03	-33941.17	1554.72	22469.81
Tao che Wu you	Business Service industry	-104721.12	-165920.01	30909.59	71834.86
Tailai electricity	Electrical machinery and equipment manufacturing industry	972.71	1209.36	0.00	4864.38
Jiqun Medicine	Research and experimental development	-10438.52	-17436.04	6082.34	37371.62
Nuokang Medical	Special equipment manufacturing industry	-3889.60	-15579.38	2794.12	42286.98
Zesheng Technology	Pharmaceutical manufacturing industry	-86671.75	-191728.10	68599.65	223911.68
Renovation Baiji	Business Service industry	77.98	-4897.24	7550.19	15391.38
Union Currency	Other financial industries	-5196.19	-9113.09	0.00	29616.44
Interactive entertainment network	Internet and related services	-785.38	-2336.44	17788.38	17095.76

According to the calculation results, among the 93 enterprises, there are 61 with NPV < 0 in the first stage and 62 with NPV < 0 in the second stage, and nearly two-thirds of enterprises are not worth investing. Considering that the listing of the New Third Board requires enterprises to have outstanding

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main business and sustainable operation ability. The corporate governance structure is sound, and the operating conditions are standardized. These companies have also accepted at least two rounds of investment, and most of them should have a certain investment value. Therefore, this ratio is also quite different from reality. After considering the value of real options, re-estimate the value of the enterprise. The results are shown in Table IV.

TABLE IV. Enterprise value estimation

Name	Industry	Option value 1 (ten thousand yuan)	Option value 2 (ten thousand yuan)
ST Zhongke	Software and Information Technology Service industry	-961.75	-9782.74
Card Union Technology	Software and Information Technology Service industry	3251.95	13276.36
Wuhan University Technology	Chemical raw materials and chemical products manufacturing industry	7830.44	5414.13
Dian Dian Ke	Software and Information Technology Service industry	2738.03	-12094.93
Su Damingshi	Instrument manufacturing industry	6054.58	8457.44
Zheda Technology	Software and Information Technology Service industry	7595.64	-2555.40
Zhongtian Sheep industry	Animal husbandry industry	1108.28	-8635.31
Kehui Technology	General equipment manufacturing industry	1928.99	1411.14
Yunnan Road and Bridge	Civil Engineering Construction industry	91571.73	76279.49
Haobo New Materials	Waste comprehensive utilization of resources industry	-4259.28	-139319.23
Chinese World	Radio, TV, film and film and television recording production industry	-88.72	24.01
Zhongbei Tong Magnetic	Non-ferrous metal smelting and rolling processing industry	8313.44	5050.18
Debon Engineering	Computer, communication and other electronic equipment manufacturing industry	28346.86	17206.69
Jiuzhou Optoelectronics	Electrical machinery and equipment manufacturing industry	-9639.25	-11334.59
Universal navigation	Instrument and meter manufacturing industry	409.42	-5538.18
Haiyou New Materials	Rubber and plastic products industry	18563.89	88009.35
Keda automatic control	Software and Information Technology Service industry	12769.21	18952.78
World Tour	Internet and related services	338.75	1187.20

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Name	Industry	Option value 1 (ten thousand yuan)	Option value 2 (ten thousand yuan)
Technology			
Construction andinstallation industry	Building decoration and other construction industry	76047.02	31700.93
Zhitu Technology	Internet and related services	6676.39	5477.98
Operation and maintenance power	Professional technical service industry	13256.36	12735.82
ST One Health	Sanitation	1512.32	8182.15
Hongli energy	General equipment manufacturing industry	-122.10	-281.21
Tianyun shares	Automobile manufacturing industry	-2396.22	18547.72
Yum Software	Software and Information Technology Service industry	22623.51	5032.67
Long Chuang Design	Professional technical service industry	28770.84	81572.36
Tenai stock	Non-metallic mineral products industry	56428.89	46861.62
Silicon Valley Paradise	Capital market services	154458.75	-322996.94
Tianyan Technology	Instrument and meter manufacturing industry	32217.29	53827.19
Immediately swim	Internet and related services	6274.92	4210.85
Heisby	Railway, ship, aerospace and other transportation equipment manufacturing industry	64301.27	40319.72
Bicool shares	Business Service industry	1474.21	-129.91
Compton	Computer, communication and other electronic equipment manufacturing industry	56842.75	-15983.53
Kang Bite	Food manufacturing industry	84709.16	16498.66
Two-dimensional carbon	Non-metallic mineral products industry	766.76	5574.96
Peacekeeping Pharmaceutical	Pharmaceutical manufacturing industry	32909.40	33526.00
Allianz Ruishi	Computer, communication and other electronic equipment manufacturing industry	11407.81	14306.91
Net letter linkage	Telecommunications, radio and television and satellite transmission services	123.62	4188.09
Meitian Bio	Pharmaceutical manufacturing industry	13434.26	28905.67
Linghui shares	Special equipment manufacturing industry	9090.36	22666.16
Futaihe	Automobile manufacturing industry	28150.31	60719.36
Youmi Technology	Internet and related services	40102.81	-1649.77
Jie Shijie	Rubber and plastic products industry	454113.71	177284.59
SECCO Star	Animal husbandry industry	409712.80	185046.37
Huaqing Feiyang	Internet and related services	71486.20	399.46

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Name	Industry	Option value 1 (ten thousand yuan)	Option value 2 (ten thousand yuan)
Hechuang Technology	Software and Information Technology Service industry	50415.77	128756.47
Zi Zhuhui	Building decoration and other construction industry	43055.42	-64594.77
Shangxun information	Software and Information Technology Service industry	11058.60	-16130.60
Yuanda Special Materials	Metal products industry	80326.49	23629.18
Good buy wealth	Capital market services	-148783.39	-350825.19
Insured in?	Business Service Industry	495768.23	512041.82
Yunchuang game	Software and Information Technology Service industry	8208.09	26418.38
Chuan Robot	General equipment manufacturing industry	14001.60	10353.15
Jiang Chen Intelligent	General equipment manufacturing industry	10551.87	22784.55
Titan Technology	Research and experimental development	-14248.91	-13876.71
Future International	Software and Information Technology Service industry	-3601.11	-1279.08
Jinyuan Electric	Electrical machinery and equipment manufacturing industry	-3178.24	-998.04
Happy animation	Radio, TV, film and film and television recording production industry	18034.65	70801.87
Zhilan Yushu	Internet and related services	60855.60	-549177.56
Anqu shares	Retail industry	208.43	838.83
Meiyi Beauty	Retail industry	29996.68	27598.46
Lemon wanglian	Software and Information Technology Service industry	3959.79	36384.81
Ousai energy	Electrical machinery and equipment manufacturing industry	115583.41	11903.21
Gold United Star	Non-ferrous metal smelting and rolling processing industry	14101.41	20346.07
Elegant e-commerce	Retail industry	1369.65	8228.49
Yi Yun shares	Software and Information Technology Service industry	52284.54	51539.48
Hongbang Water Saving	Water Conservancy Management industry	7872.84	-4548.01
Yijiajie	Internet and related services	5975.77	36722.88
Young's Fruit industry	Agriculture, forestry, animal husbandry and fishery service industry	18727.00	352117.31
Xinte Electric	Electrical machinery and equipment manufacturing industry	28659.11	18723.23

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Name	Industry	Option value 1 (ten thousand yuan)	Option value 2 (ten thousand yuan)
Yongle Culture	Culture and Art industry	11538.93	46097.46
Tianyin Technology	Non-metallic mineral products industry	3809.01	16328.23
Lion China shares	Business Service industry	88260.32	-7467.46
Yilutong	Computer, communication and other electronic equipment manufacturing industry	18658.44	24634.15
Black gold age	Coal mining and washing industry	682813.19	240684.31
Haiyifeng	Business Service industry	555.85	846.04
ST Quantum Flower	Building decoration and other construction industry	14109.97	-8317.15
Fu Baisheng	Wholesale industry	-1599.58	10518.32
Haier Si	Pharmaceutical manufacturing industry	42484.11	33127.43
Shengpa New Material	Rubber and plastic products industry	60336.36	57141.02
Lan hai Xun tong	Software and Information Technology Service industry	17181.65	25747.00
Lemon Micro Fun	Internet and related services	-10402.54	9545.32
Yite shares	Special equipment manufacturing industry	603.80	5618.22
Daye Chuangzhi	Radio, TV, film and film and television recording production industry	286038.20	2868.22
Feiwo Technology	General equipment manufacturing industry	-12088.31	-11471.36
Tao che Wu you	Business Service industry	-73811.53	-94085.14
Tailai electricity	Electrical machinery and equipment manufacturing industry	972.71	6073.74
Jiqun Medicine	Research and experimental development	-4356.18	19935.57
Nuokang Medical	Special equipment manufacturing industry	-1095.47	26707.60
Zesheng Technology	Pharmaceutical manufacturing industry	-18072.09	32183.58
Renovation Baiji	Business Service industry	7628.17	10494.14
Union Currency	Other financial industries	-5196.19	20503.36
Interactive entertainment network	Internet and related services	17003.00	14759.32

After considering the value of real options, the number of companies that are not worth investing in the first stage is 18, and the number of companies that are not worth investing in the second stage is 24, which is an improvement over the pure NPV method.

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From the perspective of qualitative analysis, if the real option value is considered in the original NPV method, the judgment of enterprise investment value can be improved, and the valuation is closer to the reality.

V. CONCLUSION AND PROSPECT

This paper studies the real option model of equity valuation of high-tech start-ups from the perspective of venture investors. For venture capitalists, the most important thing is to make correct investment decisions. However, there is a lack of effective evaluation methods in the field of risk project value evaluation. The traditional discounted cash flow method shows great one sidedness and inadaptability. The backward evaluation methods have become a huge stumbling block to the development of China's venture capital industry. The traditional valuation of venture capital is based on the discounted cash flow of the cost and income of venture capital projects. As an investment decision-making method under uncertainty, it has great limitations, because it cannot fully consider the value of management flexibility that responds to risks and uncertainties in investment and business decisions. Real option theory can effectively reflect entrepreneurs' keen and flexible decision-making ability, correctly evaluate the complex changes of business strategy benefits under different risk conditions, and is more suitable for the decision-making process of venture capital. It is possible to identify items whose option value is greater than the net cash loss, so as to find more investment opportunities for the company and grasp investment projects more comprehensively. All option pricing models have their own assumptions, and the composite real option pricing model assumes the most stringent. In actual operation, the status of the industry and the core competitiveness are changing, and it is not enough to use traditional cash flow methods to value the entire enterprise. It is necessary to combine the value of extended options with the value of existing assets. Potential profit opportunities correspond to high risk, high growth and high technology. Incorporating the value of potential profit opportunities into enterprise valuation can accurately reflect the future development potential of high-tech start-ups. Real option method combines tangible assets, intangible assets and human resources to comprehensively evaluate high-tech start-ups in stages. It is a more comprehensive, accurate and forward-looking valuation method, which is of great significance to help high-tech start-ups successfully finance.

At present, China has entered a stage of high-quality development, and high-tech entrepreneurial enterprises have become the main force of economic development and industrial structure upgrading. At present, there are obvious deficiencies in the theoretical support and practical application of venture capital in China, and there is a lack of quantitative valuation system, which will hinder the development of high-tech start-ups to a certain extent. In view of this, this paper hopes to provide a feasible method for the valuation of high-tech start-ups through case studies.

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